DOCTORAL DISSERTATION

博士論文

Neighborhood Effects of Urban Facilities on Older Adults' Participation in Recreational Group Activities

(高齢者のレクリエーション活動参加に対する都市施設の近隣効果)

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Abstract
論文の内容の要旨

Neighborhood Effects of Urban Facilities on Older Adults' Participation in Recreational Group Activities
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Japan is facing the fastest rate of population aging in the world. To improve older adults' quality of life and health condition, the government aims to facilitate their participation in recreational group activities. Given that interventions related to land use are possible through urban planning, which affects all the people who reside in the area, urban facilities within older adults' neighborhoods can be considered a key factor in facilitating their participation. Previous studies suggest that there is a positive correlation between the number of facilities in a neighborhood and the participation of older adults; however, little is known about the optimal benefit of the number of facilities and their geographical distribution (the latter of which is especially important for a district plan for health promotion) on facilitating older adults' participation.

The major research objective of this dissertation is to clarify whether the development of urban facilities within neighborhoods can facilitate older adults' participation in recreational group activities, if so, how urban facilities affect. First, I take into account the nonlinear relationship between facility density and participation of older adults in hobby clubs and sports groups, and test whether there is a certain facility density that has the highest likelihood of increases in the frequency of activity participation. Second, I test the significance of the direct and indirect effects of the spatial agglomeration/dispersion of neighborhood facilities and their accessibility on the changes in the participation of older adults. Finally, I formulate an allocation problem which does not assume that people always participate in group activities and use the closest facility. Using the allocation model, I test which geographical settings of facilities and residents bring more activity participation.

When analyzing the effect of neighborhood facilities on the changes in activity participation, many factors must be considered. Chapter 2 briefly reviews previous studies and theories regarding behavior change and urban amenities, and the relationships between the two concepts. The literature review in the chapter elucidates several points of this dissertation's originality. I utilize panel data to test the effect of urban facilities within neighborhoods which allows me to measure intra-individual changes in the frequency of participation. The longitudinal study enables me to infer causal relationships between the neighborhood environment and older adults' participation based on the temporal precedence of causes. It also helps to exclude the self-selection bias that results from selective migration (i.e., people who consider participation an important attribute for life satisfaction migrate to an amenable neighborhood) when estimating the effect of neighborhood facilities. Differences in the effect of each type of neighborhood facilities are also considered. The neighborhood facilities are categorized based on the major destinations that are frequented by older adults when they go outside their homes. Furthermore, this dissertation mathematically solves an allocation problem, which takes into account the fact that some older adults go to facilities farther away.

Chapter 3 investigates the relationship between the changes in the density of neighborhood facilities and changes in older adults' participation in hobby clubs and sports groups. This chapter aims to test the nonlinear relationship between facility density and the increases in the frequency of activity participation. The results indicate that the density of urban facilities within neighborhoods is related to the increases or decreases in older adults' participation in recreational group activities, in addition to the frequency of their activity participation. In the case of food stores, an inverted U-shaped relationship between the facility density and the increases in the frequency of participation in sports groups is found, as compared to a U-Shaped relationship in the case of medical and welfare facilities.

Chapter 4 examines whether the geographical distribution of neighborhood facilities can facilitate older adults' participation in hobby clubs and sports groups, as well as their accessibility. The results show that both accessibility and the geographical distribution of facilities are related to increases in participation. The spatial agglomeration of eating places is found to increase opportunities for meeting friends and enable participation in both hobby clubs and sports groups; dispersed eating places, however, correlate with good relationships with neighbors, which facilitates sports group participation. Additionally, the agglomeration of food stores

is found to have a positive correlation with participation growth in sports groups. In general, accessibility to neighborhood facilities is found to increase older adults' participation; however, the accessibility of city parks is found to exhibit a negative indirect effect that is mediated by relationships with neighbors regarding participation growth in sports groups.

The U-shaped relationship of the density of medical and welfare facilities and the negative indirect effect of accessibility of city parks imply that some older adults hesitate to participate in group activities at facilities that are close to their home. Self-stigma can be a factor of why older adults hesitate to participate in group activities and why some of them opt to engage in a group activity at a facility farther away. Chapter 5 formulates an allocation problem, considering both accessibility and the self-stigma of group activity participation, which does not assume that people always participate in group activities and use the closest facility, and applies the model to the case of community salons. Using the allocation model considering both accessibility and self-stigma related to community salon participation, this chapter tests which geographical settings of facilities and residents bring more participation or more intergroup contact between people with and without self-stigma. The results indicate that there could be a segregation of activity groups between people with and without self-stigma. By comparing various solutions from different geographical settings of residents and facilities, I determine that a larger number of participants is expected in the case of concentrated residential location. Concentrated facility location, however, is found to be a geographical setting for more intergroup contact between people who have self-stigma and those who do not. In the case of an uneven distribution, people without self-stigma are less likely to sacrifice their accessibility to allocated facilities.

Chapter 6 concludes the findings obtained and discusses policy implications for facilitating older adults' participation in recreational group activities. The findings in this dissertation suggest that both building additional facilities and the choice of facility location within neighborhoods can be policy options for facilitating older adults' participation in recreational group activities. In this case, a broad range of facilities (both recreational and non-recreational facilities) should be considered. However, the findings also suggest that a larger number and better accessibility of facilities within neighborhoods do not always correlate to a growth in participation. Therefore, it is necessary to consider both the dynamics related to socializing, opportunities for new social connections, self-stigma related to group

activity participation, and accessibility to urban facilities, when policymakers discuss an amenable neighborhood for facilitating the participation of older adults in recreational group activities.

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Chapter 1

Introduction

1.1 Research Background and Motivation

1.1.1 Population Aging and Social Participation

According to the United Nations (2019), the number of older adults (people aged 65 years and older) has increased in recent years in many countries and is expected to continue to increase up to 2050. Figure 1.1 shows the percentage of people aged 65 years and older in six countries from 1950 to 2100. Japan has the fastest aging population in the world and the number of people aged 65 years and older will account for about 30% of the population by 2030. The following countries—Italy in 2035, Republic of Korea in 2040, and Singapore in 2045—are estimated to exceed the 30% level of people aged 65 years and older. No country in human history has experienced such a rapid demographic transition. Therefore, population aging creates new government responsibilities (such as minimizing the negative impact of population aging on social life), especially in the countries facing (or expected to face) severe population aging.

Successful aging has attracted much attention because of its importance in

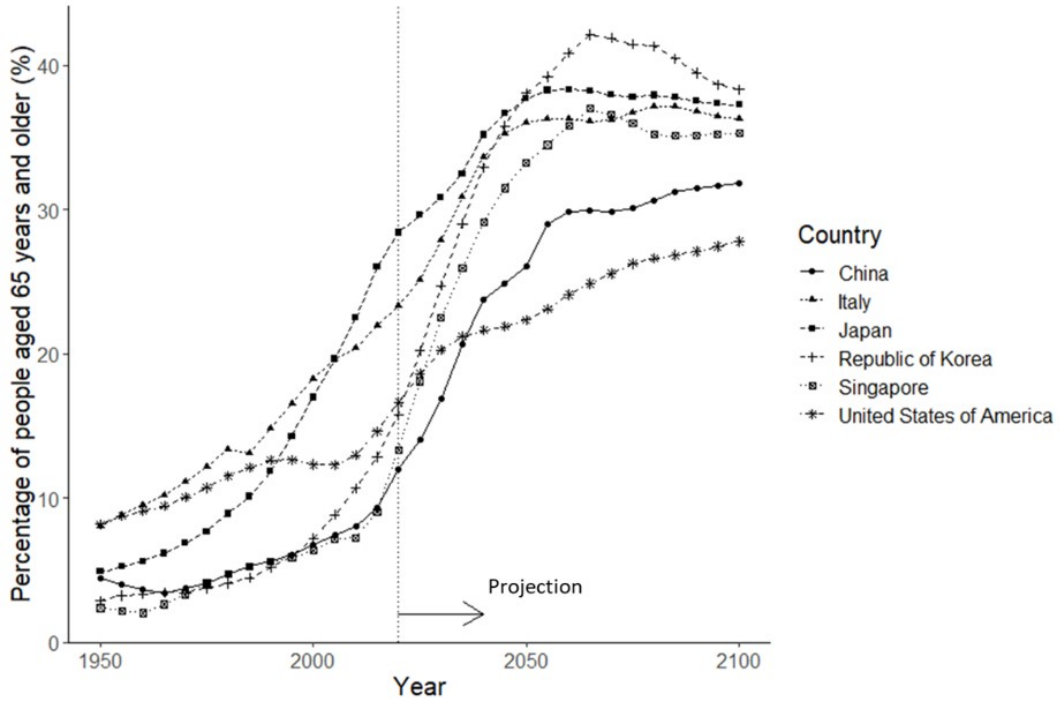

FIGURE 1.1: The percentage of people aged 65 years and older in each of the six countries. The number of people by five-year age group from 2020 is projected under an assumption of a medium-fertility variant. Data source: United Nations (2019), *World Population Prospects 2019*.

an aging society. According to Rowe and Kahn (1997), successful aging is the ability to maintain three key behaviors or characteristics while aging: 1) low risk of disease and disease-related disability; 2) high mental and physical function; and 3) active engagement with life. In other words, successful aging is based on the attitudes or efforts of an individual to remain health and socially engaged. From a sociological perspective, successful aging can also be defined as a system for improving the quality of life that enables people to pursue optimal aging, rather than just improvement in life expectancy or vitality itself (Featherman et al., 1990). Therefore, the term "successful aging" can be defined as the social efforts to achieve older adults' goals in life and improve their quality of life as well as their health condition.

Promoting social participation of older adults can be expected to not only enhance the intention to achieve their goals in life but also to prevent them from becoming disabled. The term "social participation" is defined as having social connections with other people while doing activities. Medical studies on the relationship between social participation and health have shown that older adults' social participation promotes the preservation of their physical and mental health condition (Corbett et al., 2018; Okura et al., 2017; Sirven and Debrand, 2012; Stjernborg, 2017; Thomas, 2011; Zhang and Wu, 2017) and provides them with a sense of fulfillment in their daily lives (Sano and Kyougoku, 2016). Moreover, people who engage in group activities gain more benefits than those who do activities alone or in one-on-one interactions (Haslam et al., 2014; Kanamori et al., 2016). Therefore, it is important to facilitate older adults' participation in group activities before they become disabled and to support the maintenance of their social network because social isolation itself is a major risk factor for mortality (Chiao et al., 2013; House et al., 1988) and dementia (Rafnsson et al., 2020).

People are more likely to get ill and require healthcare or medical service as they age (Ministry of Health, Labour and Welfare, 2012, 2013, 2018), thus the use of healthcare services increases. Even though there is diversity in the health condition of older adults (which results from individual heterogeneity in socioeconomic status, residential environment, and life stage experience), the high proportion of older adults can result in increased burdens, including both financial expenditure for healthcare and a decrease in the workforce (i.e., countries with fast population aging tend to show a high old-age dependency ratio, which is the number of older adults divided by the number in the working-age population). Even in a metropolitan area, it is projected that the number of older adults will overwhelm the capacity of healthcare services to handle the needs of older adults by

2040 (Japan Policy Council, 2015). To decrease the impact of population aging on the cost of healthcare, the Japanese government is attempting to facilitate older adults' social participation (Ministry of Health, Labour and Welfare, 2016a).

The activities of older people range from recreational activities (such as hobbies, sports activities, and learning) to working, volunteering, and religious activities (Levasseur et al., 2010; World Health Organization, 2007). Among those activities, people who participate in hobby clubs or sports groups gain greater benefits from maintaining their functional abilities (Fu et al., 2018; Kanamori et al., 2014; Vankova et al., 2016). Participation in recreational activities has a significant impact on the quality of life (Bishop-Fitzpatrick et al., 2017), and it becomes increasingly more beneficial across the later life course (Nimrod and Shrira, 2016). In Japan, however, there are definite gaps between the apparent need for hobby clubs or sports group activities and the actual participation of older Japanese adults (Cabinet Office, 2017). Therefore, the ways to facilitate older people's participation in recreational group activities should be discussed, especially in Japan.

1.1.2 Social Participation of Older Adults and Related Factors

Previous studies have suggested some factors which are related to the social participation of older adults. The factors can be summarized into two levels: individual-level and neighborhood-level factors.

Individual-level Factors

Most of the previous studies on activity participation have focused on its relationship with individual characteristics. Socio-demographic and socio-economic factors have been suggested as the individual-level characteristics which affect participation in group activities. For example, gender, educational and occupational

resources, household types, economic status, and health condition have been found to be related to older adults' participation (e.g., Bowling and Stafford, 2007; Bukov et al., 2002; Finkel et al., 2018; Haak et al., 2008; Hawkley et al., 2008; Lindström, 2006; Strain et al., 2002). Although these individual-level factors are related to activity participation, it is not feasible for policymakers to control the individual-level factors, especially the socio-demographic factors. Therefore, urban development has attracted considerable attention (Bowling and Stafford, 2007) owing to the fact that an amenable environment for activity participation affects all the people who reside in the area.

Neighborhood-level Factors

Owing to the shift in the distribution of population toward older ages, the age-friendly city is one of the popular policy approaches to the desirable city (Khan and Zaman, 2018). Age-friendly cities have been proposed to create the social and physical infrastructure that promotes the participation or engagement of human beings, including older adults (World Health Organization, 2007, 2015). Developing the social and physical environment can promote older adults' participation.

The neighborhood environment is key to facilitating involvement in group activities outside the home because adults' life spaces tends to shrink as they age (Barnes et al., 2007). This renders older adults' neighborhood environments important, especially for sustainable face-to-face social interaction. Therefore, an amenable environment around older people's homes is necessary even for those who are healthy in order to prevent a decrease in their social interaction.

Previous studies on the relationship between neighborhood environment and activity participation have suggested that activity participation is related to the social and physical environment (Table 1.1). The social environment has been

found to be related to activity participation and includes such factors as social barriers, socio-economic neighborhood characteristics, neighborhood security and safety, and social support (e.g., Christens and Speer, 2011; Clarke et al., 2011; Hand et al., 2012; Keysor et al., 2006; Levasseur et al., 2015; Van Brakel et al., 2012; Vaughan et al., 2016). However, similar to the individual-level factors, the social environment is difficult to control through urban planning despite its importance because it results from individual characteristics (i.e., social environment is formed by aggregations of individuals). In other words, it is not easy to directly modify the social environment through urban planning.

The target of urban planning is thus the physical environment (built environment). It is relatively easy to control, even though changes in the physical environment rarely occur immediately. The physical environment has been found to be related to activity participation in the following ways: accessibility of urban facilities, public transportation availability, mixed land use, population density, and walkability (e.g., Butts et al., 2012; Legh-Jones and Moore, 2012; Richard et al., 2009, 2013; Vaughan et al., 2016). Among the components of the physical environment (which have been found to show relationships to activity participation), an intervention related to urban facilities could possibly be held in a relatively short temporal term compared to other types of interventions (intervention in the urban facility is a building-scale; mixed land use is a district-scale; public transportation is across multiple districts). Urban facilities are essential and fundamental components of urban structure because they are the place where necessary services in daily life are provided. Therefore, this dissertation especially focuses on urban facilities.

TABLE 1.1: Neighborhood-level factors which affect older adults' participation in group activities.

Factors	Components
Physical environment	Accessibility of urban facilities
	Public transportation availability
	Mixed land use
	Population density
	Walkability
Social environment	Social barrier (negative social attitude)
	Socio-economic neighborhood characteristics
	Social supports
	Neighborhood security and safety

1.2 Research Objectives

Previous studies (e.g., Mouratidis, 2018a; Richard et al., 2013) have shown that a large number of urban amenities in a neighborhood where older adults live (i.e., close distance from their home to the facilities and many options available) is positively related to more participation of older adults in group activities. These studies have supposed a linear relationship between the number of facilities and the likelihood of activity participation or have simply compared the frequency of activity participation between people who reside far from the facilities and people who reside close to it. This indicates that the area that is most amenable for older adults to participate in group activities is where many urban facilities should possibly be located (such as the commercial center of a city). However, there can be a certain level of facility density (the number of facilities in an area) at which the impact on the increase in older adults' activity participation becomes small. Therefore, the nonlinear relationship between facility density and activity participation has to be tested. This will enable policymakers to further discuss the cost–benefit of

improving amenities to facilitate older adults' participation in recreational group activities.

From an urban planning perspective, the question of where the urban facilities should be located for more activity participation by older adults arises when planners determine the location of facilities in a neighborhood as well as the number of facilities. In other words, there could possibly be a benefit—in terms of older adults' participation in recreational group activities—from geographical distribution (spatial agglomeration/dispersion) of urban facilities, not from their accessibility or number. Therefore, the geographical distribution of urban facilities should be tested to determine if it is related to activity participation. This can broaden policy options for facilitating participation (long-term district planning through zoning which controls facility use in the area) other than through building additional facilities that provide places for recreational group activities.

On the other hand, the closest facility is not the only destination outside the home for group activities (York Cornwell and Cagney, 2017). The difference in the distance from older adults' homes to facilities for group activities creates confusion among urban planners about which geographical distribution of those facilities is better for residents in an area in terms of both ease of activity participation and distance to the facilities. If there is a tool that assesses participants' current allocation based on the population and facility distribution in a target area, urban planners could possibly discuss where to locate those facilities in the area. Therefore, an allocation problem—which does not assume that people always participate in group activities and use the closest facility—has to be mathematically formulated and solved for the assessment (comparing the current allocation of participants with the solution to the allocation problem).

In short, this dissertation aims to clarify whether urban facilities—in terms

of the number of facilities in older adults' neighborhoods and their location—affect the increase in older adults' participation in recreational group activities, if so, how they do. The research objectives are as follows:

- Test the nonlinear relationship between facility density and the increase in older adults' participation in hobby clubs and sports groups.
- Test the effect of the geographical distribution of urban facilities and their accessibility on older adults' participation in hobby clubs and sports groups.
- Formulate the allocation problem which does not assume that people always participate in group activities and use the closest facility.

1.3 Reserach Flow

The structure of this dissertation is illustrated in Figure 1.2. This chapter (Chapter 1) has explained the reasons for promoting older adults' participation in recreational group activities in the aging society. Several factors (both individual-level and neighborhood-level) which are related to activity participation have been reviewed. Moreover, the reason this dissertation especially focuses on urban facilities has been explained. It also has described the research objectives of this dissertation.

Chapter 2 reviews the theories regarding behavior change and their relationship with the neighborhood environment where people reside. The literature review points out the necessity of longitudinal studies which test the effect of urban facilities on the change in residents' participation in recreational group activities. Originality in this dissertation is also discussed.

Chapter 3 investigates the relationship between the density of neighborhood facilities and changes in the frequency of older adults' participation in hobby

clubs and sports groups. Interaction terms of the facility density in the base year and changes in the density are included to express nonlinear relationships between the frequency of activity participation and the facility density. The longitudinal analysis of two waves of panel data shows that there is a level of facility density at which the likelihood of increases in the frequency of activity participation has the highest value.

Chapter 4 examines whether the geographical distribution of neighborhood facilities as well as their accessibility can facilitate older adults' participation in hobby clubs or sports groups. Three waves of panel data are employed to estimate models for hobby clubs and sports groups. The analysis involves a latent growth curve model with full information maximum likelihood. Attitude factors—such as frequency of going outdoors, socializing with friends or neighbors, and neighborhood attachment—are used as the mediation factors that link the presence of facilities with activity participation. Temporal precedence is also considered to infer the causal relationship. The longitudinal analysis reveals that both the accessibility and the geographical distribution of facilities are related to participation.

The findings from Chapter 3 and 4 imply that some older adults hesitate to participate in group activities at facilities that are close to their home. Chapter 5 proposes an allocation problem which does not assume that people always participate in group activities and use the closest facility. Using the allocation model, I test which geographical settings of facilities and residents bring more activity participation. Solutions to the allocation problem are analyzed regarding activity participation, intergroup contact, and distance from participants' homes to allocated facilities. Findings from the simulation in a virtual city environment are discussed along with a comparison among different geographical settings of residents and facilities.

Chapter 6 concludes the findings obtained from Chapter 3 to 5 and discusses policy implications for facilitating older adults' participation in recreational group activities through developing neighborhood facilities. Moreover, the topics left for future research are discussed.

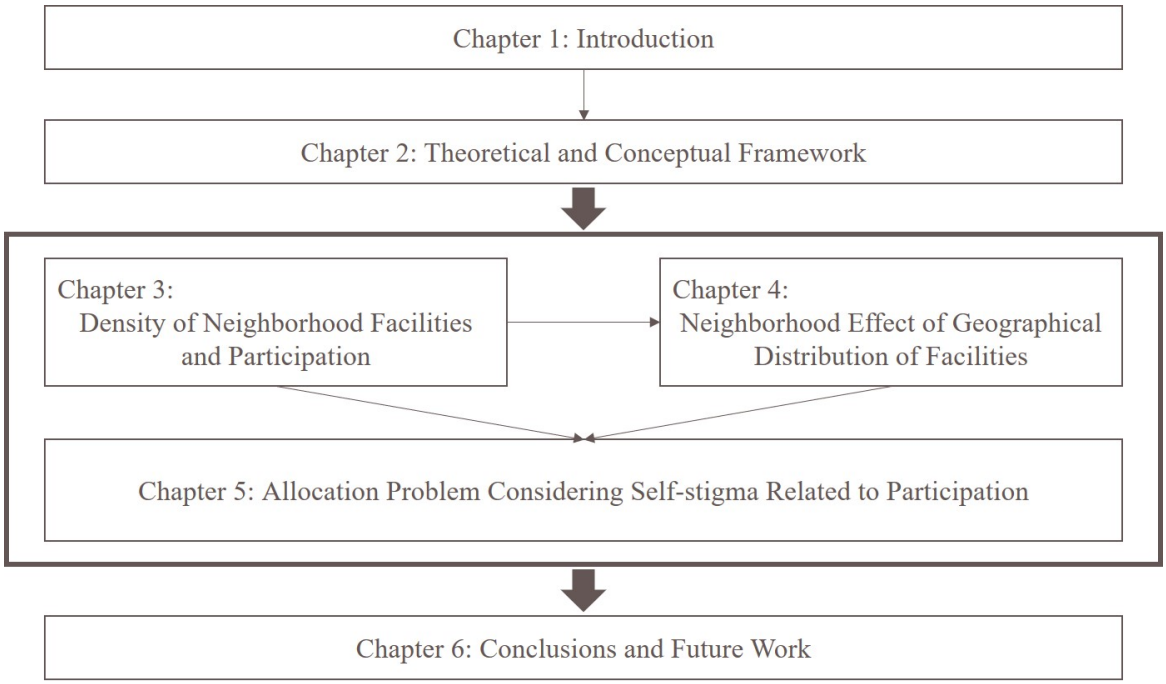

FIGURE 1.2: Structure of the dissertation.

Chapter 2

Theoretical and Conceptual Framework

2.1 Introduction

The main objective of this dissertation is to clarify how neighborhood facilities affect older adults' participation in recreational group activities. Therefore, the keywords of this dissertation can be listed as follows: (1) change in activity participation; (2) third places; and (3) association between activity participation and neighborhood facilities. Several theories regarding those keywords have been suggested in the fields of psychology and sociology. Those theories enable me to explore what has to be considered when analyzing the urban amenities so that it is easy for older adults to participate more in recreational group activities.

This chapter briefly reviews the major theories regarding behavior change, urban amenities, and their relationship. Section 2.2 describes the theoretical background of which factors change older adults' behavior (especially in terms of participation in recreational group activities). Section 2.3 explains the urban facilities which are the major destinations of older adults when they go outside the home.

Section 2.4 provides a theoretical framework for the association between neighborhood environment and residents' behavior. Section 2.5 summarizes the originality in this dissertation and is aimed to clarify the effect of the urban facilities within neighborhoods on older adults' participation in recreational group activities.

2.2 Behavior and Its Change

2.2.1 Why Behavior Change?

Older adults' participation in recreational group activities is a type of human behavior in later life, therefore, it can be discussed within the context of the theory regarding behavior and its change. Several studies—focusing on explaining what kinds of people are more likely to do a certain behavior—have shown that there are differences in behavior patterns among individuals. For example, Furnham (1981) has shown that extraverts are more likely to participate in social and physical activities. According to trait theory, personality is composed of traits (such as extraversion and introversion)—which are consistent over situations but differ across individuals—that influence social behavior (Argyle and Little, 1972). However, this approach describes and classifies individuals by their behavior patterns, rather than explaining their behavior change. The studies on behavior change consider the modifiability of behavior.

Gerontological studies have suggested theories regarding behavior change in people's later lives. The continuity theory of aging (Atchley, 1989) suggests that individuals show continuity in patterns of behavior as they age, despite changes in their health or situation. Older people use strategies—even though the way to apply strategies varies among individuals—in order to maintain continuity in their lifestyles (Baltes et al., 1980). Older adults have been found to show continuity

in their behaviors; furthermore, some of them find and start new activities (Agahi et al., 2006). On the other hand, disengagement theory (Cumming and Henry, 1961) suggests that aged people prepare for death, so they show withdrawal from social engagement. These indicate that behavior in individuals' later lives varies among them and the patterns of its change are also differed due to their circumstance (i.e., some of them could possibly start to participate in recreational group activities; others cease activity participation). Therefore, both inter- and intra-individual level differences have to be considered when discussing an amenable environment for older adults to increase their activity participation.

Even though those theories of aging clarify that people also actively live their lives in their later years, they rarely provide an answer to which factors can facilitate older adults' participation in recreational group activities through urban planning intervention. In other words, the continuity theory and the disengagement theory are descriptive summaries of behavior change in later life. On the other hand, behaviorism—such as molar behaviorism (Baum, 2002, 2012), intentional behaviorism (Foxall, 2007, 2008, 2017), and theoretical behaviorism (Staddon, 2017)—has tried to explain that certain external conditions result in the behaviors. The conditions also indicate the environment where certain behavior is easy to be changed or reinforced, not only a transient stimulus. Studies based on behaviorism imply that creating optimal conditions can facilitate individuals' behavior and this contribute to practices that aim to change behavior.

Empirical studies employing a longitudinal survey have shown that factors—such as changes in functional ability (Strain et al., 2002), psychosocial conditions (Lindström, 2006), and socio-economic neighborhood characteristics (Christens and Speer, 2011)—are related to changes in older adults' activity participation.

However, few longitudinal studies have examined the connection of the built environment with the social activities of older adults (Mazumdar et al., 2018). Therefore, little is known about whether the neighborhood environment is related to the change in the frequency of activity participation. This calls for a study testing whether building an amenable area for participation in recreational group activities can be a solution which results in an increase in older adults' activity participation.

2.2.2 Factors of Behavior Change

Studies from diverse perspectives have developed theories regarding behavior change (e.g., diffusion of innovation, theory of planned behavior, and social cognitive theory). Each of them provides a theoretical background explaining the factors that change individuals' behavior. Those theories are briefly reviewed, especially in the context of older adults' participation in recreational group activities.

Diffusion theory focuses on the spread of information, as well as individuals' responses within a community or a neighborhood (Rogers, 2003). Diffusion is a process in which information spreads over time among individuals. Indeed, socializing makes it easy for people to obtain nonredundant information (Granovetter, 1973). Owing to the diffusion of information, behaviors of individuals in a community can be affected through social interactions with people in other communities. In other words, socializing helps to obtain information about informal group activities, and this could possibly increase the opportunities for older adults to participate.

The theory of planned behavior—which is an extension of the theory of reasoned action—suggests that people's behaviors are affected by their intentions (Ajzen, 2001; Ajzen and Fishbein, 1980). It emphasizes that attitudes, perceived norms, and perceived behavioral control determine people's intentions (Ajzen,

1991; Fishbein and Ajzen, 2011). Attitude is a tendency of responses to behavior. In terms of activity participation, people who frequently go out (Sanders et al., 2005) and socialize (Perkins et al., 1996; Putnam, 2000) or have a high attachment to their neighborhood (Manzo and Perkins, 2006) could possibly have a positive attitude to participate in group activities; this may result in an increase in activity participation.

On the other hand, the perceived norm refers to the perceived social pressure to perform or not to perform a behavior; in addition, perceived behavioral control refers to the perceived ease or difficulty of performing the behavior (Ajzen, 1991). In the context of facilitating older adults' activity participation, people who frequently socialize can be invited to the community (this can be a type of social pressure) by others who engage in group activities and not only through information (as mentioned in the diffusion theory). Meanwhile, people hesitate to participate in a community activity when they consider themselves not capable of participating in the community owing to their health condition (Bukov et al., 2002; Strain et al., 2002). Capability shares the idea with the concept of self-efficacy from social cognition theory.

The social cognition theory—which is a theory of learning behaviors which explains that people can change behaviors by observing and imitating others—suggests that outcome expectancies and self-regulation (as well as self-efficacy) are the factors which compose the cognitive process when people learn a behavior (Bandura, 1977, 1988, 2001). The outcome expectancy is a factor indicating that people anticipate similar outcomes when they imitate others' behavior. Given that participation in group activities provides benefits in maintaining functional abilities and achieving life goals, those benefits can encourage older adults' health awareness, and this may facilitate their activity participation.

On the other hand, self-regulation explains that people control themselves through self-monitoring, goal-setting, and corrective self-reactions (Bandura, 1991). An individual can set an ideal self which is a goal based on the person's standard, and this affects the individual's behavior. In other words, if people consider that engaging in a particular group activity does not match with their goals, people do not consider participating in the group activity. Indeed, older adults who evaluate themselves as sufficiently energetic do not attend group activities—which are for health promotion—at community salons (Iwasaki et al., 2019).

2.3 Urban Facilities and Third Place

Urban facilities are the land uses and buildings which provide necessary services in daily life, and are one of the built environments with which urban planning is concerned. In terms of participation in recreational group activities (both recreational activities and social activities), facilities for socializing or those providing services necessary in daily life—as well as facilities providing places for recreational activities—could possibly result in changes in the attitudes and behaviors of residents.

As people age, the proportions of the destinations where people go in daily life changes. According to the survey conducted by the Ministry of Land, Infrastructure, Transport, and Tourism (2015), Japanese adults aged 70 and older show a high percentage of trips for shopping, dining, and receiving medical services (Figure 2.1). Given that people retire in their later life, the proportion of trips for shopping, dining, and receiving medical services in their daily lives increases. In particular, the importance of trips for receiving medical services increases as they age. These trip purposes are the major reasons why older adults go outdoors.

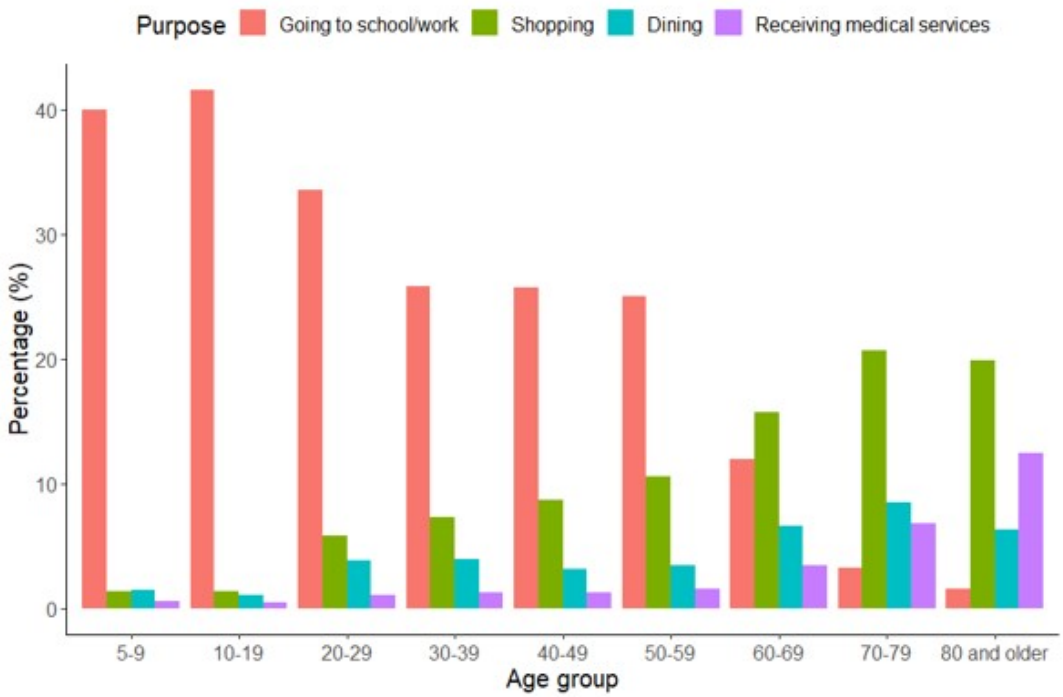

FIGURE 2.1: Major purposes of trips when the Japanese go outdoors in their daily lives. The percentage is calculated based on the trips of an individual on a weekday. Data source: Ministry of Land, Infrastructure, Transport, and Tourism (2015), *Nationwide Person Trip Survey 2015*.

The destinations for going outdoors can be characterized as third places—which are not the home (first place) nor work (second place)—indicating informal spaces where people socially interact (Oldenburg and Brissett, 1982; Oldenburg, 1999). Not only cafés and restaurants (Broughton et al., 2017), shopping malls (Schacht and Unnithan, 1991) and grocery stores (Gardner, 2011) can be the third place. Indeed, there is a wide variety of third places that range from community centers, cafés, and restaurants to parks and shopping malls (Jeffres et al., 2009). Encouraging the availability of third places throughout a community can be a method to foster social interactions in the community (Jeffres, 2010).

In terms of people's travel modes, the car is the preferred mode among people aged 20 and older (those who are able to have a driving license); however, the

share of walking increases in later life (Figure 2.2). The increase in the proportion of walking as a travel mode indicates that the neighborhood—an area that is easy to walk and navigate—plays an important role in maintaining the daily lives of older adults in terms of trips to the major destinations. In other words, urban facilities within neighborhoods that have the potential to be used as third places are important for supporting older adults to remain socially engaged.

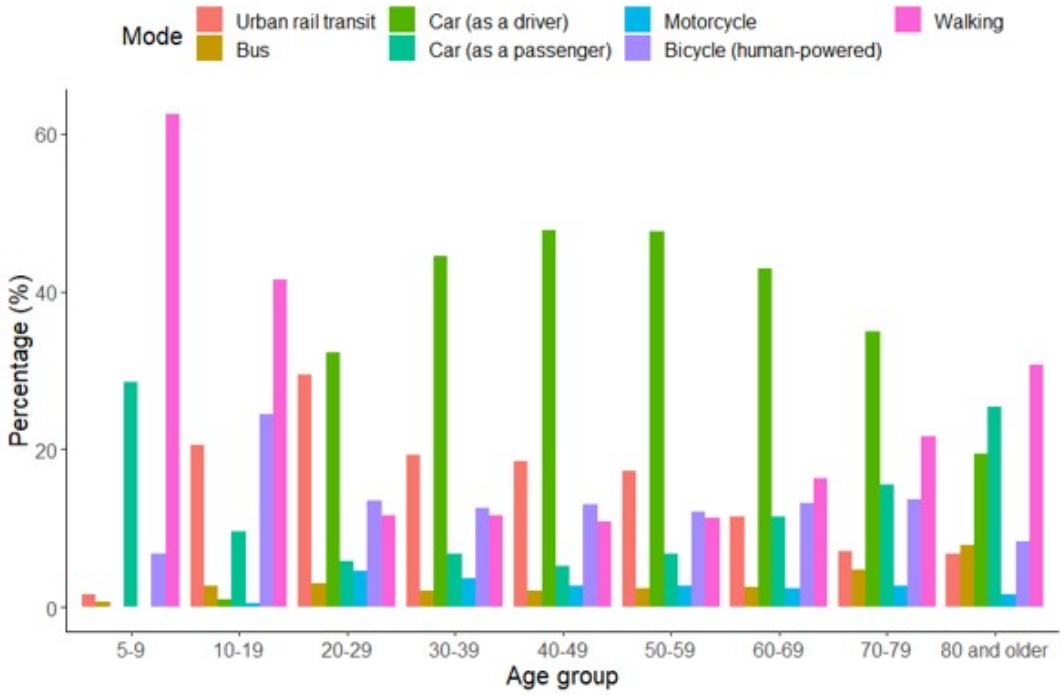

FIGURE 2.2: Travel mode share of each age group. The percentage indicates the travel mode share of an individual's trips on a weekday. Data source: Ministry of Land, Infrastructure, Transport, and Tourism (2015), *Nationwide Person Trip Survey 2015*.

Social marketing is a process that applies marketing principles and techniques to create, communicate, and deliver value to influence the target audience's behaviors that benefit society as well as the target audience itself (Lee and Kotler, 2011). From the social marketing perspective, high accessibility to the third place—which lessens the time- or distance-related burdens for older adults to go

outdoors and socialize—possibly increases the opportunity for participation in the group activities. However, some people may choose to avoid engaging in social activities at a certain type of third place, owing to the fact that they perceive the facility as not an appropriate place for themselves (Hickman, 2013). Therefore, the possible differences in the effect of each type of urban facility on older adults' activity participation have to be considered.

Previous studies (e.g., Anderson et al., 2017; Mouratidis, 2018a; Richard et al., 2013; Thornton et al., 2017) have tested the association between urban facilities and older adults' participation in group activities. However, few studies have tested which types of urban facilities within neighborhoods are important for facilitating older adults' activity participation, as well as whether there are differences in the effects of each type of group activity (hobby clubs and sports groups). A more thorough understanding of the effects of urban facilities enables policymakers to consider specific interventions related to the urban facilities to facilitate older adults' participation in recreational group activities.

2.4 Socioecological Framework and Neighborhood Effect

As urban planning aims to develop an environment where people reside (built environment), it can be focused on their environment facilitating activity participation, rather than a cognition process of people. Bronfenbrenner (1977, 1979) has developed ecological systems theory, emphasizing that an individual's surroundings explain and describe the person's behaviors. According to the ecological systems theory, the surroundings are composed of micro-, meso-, exo-, and macrosystems.

Those systems range from social network and physical environment to culture and ideology.

Socioecological studies investigate the relationships between social/physical environments and people's behaviors (Glass and McAtee, 2006; Oishi and Graham, 2010; Sallis et al., 2006). Studies employing a socioecological framework (e.g., Giles-Corti and Donovan, 2002; Michael et al., 2006) have attempted to answer the questions which ask whether a neighborhood where people reside affects their behaviors and, if so, how it does. However, most of them are employing a cross-sectional design, so it is hard to conclude that an amenable neighborhood where people reside facilitates the performance of a certain behavior. Instead, people who frequently perform the behavior are observed in the amenable neighborhood.

According to Oishi (2014), the socioecological studies can be classified into association, process, and niche construction studies. Association studies aim to identify the association between neighborhood environment and residents' behavior. Process studies elucidate neighborhood effects that indicate the mechanisms underlying the association. In terms of older adults' participation in recreational group activities, the association studies—which characterize most of the previous studies—rarely give pieces of evidence that are directly related to a conclusion which indicates that developing a neighborhood amenable to activity participation makes it easier for older adults to participate. On the other hand, the process studies (regarding behavior changes) provide hints for built environment interventions which aim to facilitate older adults' participation in recreational group activities, since the term "process" includes a causal relationship between neighborhood environment and behavior.

However, to make clear whether the neighborhood environment facilitates residents' activity participation, their migration to another neighborhood which is

more amenable—which corresponds to the niche construction—should be considered. When estimating the effect of the neighborhood environment, the process of selective migration could possibly cause over- or underestimation of the effect. Therefore, studies on the causal effect of neighborhood environment have to distinguish between the neighborhood effect and the residential relocation.

2.5 Originality in This Dissertation

Literature review in this chapter points out several issues which have to be considered when discussing the urban amenities that make it easier for older adults to participate more in recreational group activities. These are the issues indicating the originality in this dissertation.

First, few studies on the effect of urban facilities within neighborhoods have considered intra-individual changes in the frequency of activity participation. Conducting a longitudinal analysis using a panel data—which enables me to track changes in the frequency of participation of individuals in hobby clubs and sports groups—is an originality in this dissertation.

Second, previous studies have tested the association of urban facilities with older adults' participation in group activities; however, differences in the effect of each type of urban facility within neighborhoods are not sufficiently considered. I categorize the urban facilities within neighborhoods based on the major destinations of older adults when they go outdoors. In the longitudinal analysis, the types of urban facilities are included to clarify the differences in the effect of each.

Third, selective migration makes it difficult to discern whether neighborhood environment facilitates activity participation or whether people who prefer activity participation migrate to an amenable neighborhood. Through excluding

those who have moved to another neighborhood, this dissertation estimates the effect of urban facilities within neighborhoods on the changes in the frequency of older adults' participation in hobby clubs and sports groups.

Finally, some people may not attend a group activity that prevents functional decline because they do not want to be seen by neighbors as being elderly and needing support from others. This can be explained by the self-regulation which is a factor in the social cognition theory explaining behavior change (i.e., each person sets an ideal self, and this affects the individual's activity participation). Therefore, I consider a factor which explains why some older adults opt for engaging in a group activity at a facility farther away.

Chapter 3

Density of Neighborhood Facilities and Participation

3.1 Introduction

Older adults' participation in recreational group activities has been attracting attention owing to its effectiveness in preventing functional decline (Fu et al., 2018; Kanamori et al., 2014; Vankova et al., 2016). Older adults are less likely to participate in recreational group activities as they age (Finkel et al., 2018), this is especially the case in men. However, older adults' participation in group activities helps to maintain their social network. Therefore, both local and national governments—such as Akita (2017) and the World Health Organization (2007)—set policy aims which are to increase the older adults' participation in recreational group activities.

Homes, community centers, or third places are the locations where older people conduct and engage in group activities (Van den Berg et al., 2015). Third places are informal spaces where people interact socially (Oldenburg and Brissett, 1982), and they include not only public facilities but also commercial facilities such as shopping malls (Jeffres et al., 2009). These facilities are major destinations when

older adults go out in daily life (Ministry of Land, Infrastructure, Transport, and Tourism, 2015), and they are expected to contribute to the promotion of social interaction (Hickman, 2013; Mouratidis, 2018a). The distance older adults are able to walk tends to decrease as they age, and their walking ability is related to the frequency of going outdoors (Fujita et al., 2006). Therefore, the establishment of these facilities near older adults' homes could possibly be a solution to promote their activity participation.

Previous studies have shown that neighborhood environment is related to older adults' activity participation (Vaughan et al., 2016). In the case of neighborhood facilities, it has been found that accessibility to the facilities (such as grocery stores, recreational facilities, shopping malls, restaurants, cafés, medical facilities, etc.) is positively related to older adults' activity participation (Levasseur et al., 2011; Richard et al., 2009, 2013). In other words, the more accessible the urban facilities, the more easily older people can participate in group activities. However, if the distance to the facility is too short (e.g., if there are amenities on the ground floor of the residential buildings), going out to the destination may result in few opportunities for chance encounters or getting information about group activities. However, this has not been considered in previous studies.

On the other hand, most of the previous studies have used a cross-sectional design, rather than a longitudinal design (Hand and Howrey, 2019; Levasseur et al., 2011; Richard et al., 2009, 2013). Even though the cross-sectional surveys have shown that the density of neighborhood facilities is positively related to activity participation, it is not clear if building additional facilities in the neighborhood scale results in more participation of older adults. Therefore, a longitudinal survey is necessary to investigate how the changes in density of neighborhood facilities are related to the changes in activity participation of older adults. If the increases

in facility density are related to the increases in the frequency of activity participation, this provides empirical evidence that the establishment of urban facilities near older adults' homes is a policy option for facilitating their participation in recreational group activities.

This chapter investigates the relationship between the density of neighborhood facilities and older adults' participation in hobby clubs and sports groups using panel data. The rest of this chapter is organized as follows: Section 3.2 describes the target area and the data. Section 3.3 describes the analytic method. Section 3.4 provides the results and discussion. Section 3.5 concludes with some policy implications.

3.2 Target Area and Data

3.2.1 Dataset

Panel data—which was collected by the Japan Gerontological Evaluation Study (JAGES) in both 2010 and 2016—is employed for the longitudinal analysis. The targets of the JAGES survey are people aged 65 and older who do not need long-term nursing care services. The JAGES has conducted a nationwide survey targeting older adults in 31 municipalities in every three years from the 2010 survey, and the group surveyed about 180,000 people from 41 municipalities in 2016. The extraction was done by municipalities, and the randomly sampled older adults have been surveyed using questionnaires (see Kondo, 2016 for more details). Given that the responses surveyed in different years are linked by each person, the older adults' activity participation can be observed and traced using the panel data. Among the 20 municipalities surveyed in both 2010 and 2016 by the JAGES, Nagoya is one

of the three major metropolitan areas and has a high population density (70 people/ha). Given that the research objective in this chapter is to test whether older adults' activity participation is difficult to increase in areas where a facility density is too high, which indicates that the distance to the nearest facility is too short (Koshizuka, 1985), an area with a high level of facility density is required for the study area. Therefore, Nagoya is selected as the study area.

As shown in Figure 3.1, some responses are excluded owing that the participants have moved to another elementary school district within the study area (449 samples), in order to eliminate the effect of the relocation of their residence. The relocation of older adults' residences represents a process of selective migration. Some responses (2,407 samples) are also excluded owing to the missing data in the questionnaire items regarding the frequency of activity participation. If there are missing data in individual attributes other than participation in activities, these are included in the analysis as missing values. Consequently, the analytic samples consist of 3,881 samples. The number of samples per elementary school is 14.8 on average, and its standard deviation is 6.9. Nagoya is composed of 262 elementary school districts. In the case of 200 neighborhoods, the level of 10 samples in each neighborhood is found to be enough for model estimation without bias (Clarke and Wheaton, 2007). According to this standard, the number of samples is sufficient to estimate a model.

3.2.2 Outcome

The two dependent variables used are frequency of participation in hobby clubs and sports groups. These variables are assessed using items from the survey regarding how often the respondents have participated in activities at hobby clubs or sports groups. The frequency of activity participation is answered on six scales

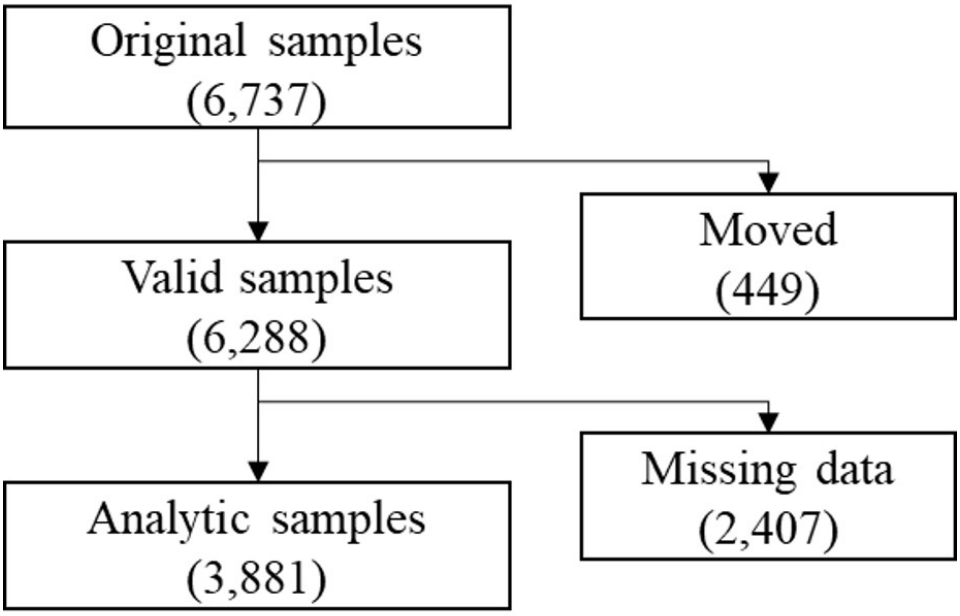

FIGURE 3.1: A flow chart summarizing the selection of analytic samples.

(four times a week or more, two to three times a week, once a week, once to three times a month, several times a year, not participating).

In order to secure a certain number of samples, the frequency of activity participation is reclassified into 3 categories: (1) once a week and more; (2) several times a month or year; and (3) not participating. More precisely, participating in group activities four times a week and more, two to three times a week, and once a week are grouped into "once a week and more", on the other hand, one to three times a month and several times a year are grouped into "several times a month or year". Not participating remains as a category "not participating". These reclassified categories correspond to the high and low frequency of activity participation and no participation, respectively. This enables the model to assess changes among the participation levels in terms of its frequency rather than changes within high frequency of activity participation.

3.2.3 Covariates

Characteristics of individuals—such as education, income, household types, walking ability, relationships with neighbors, and frequency of meeting friends—are used as the control variables, as well as their gender and age (Table 3.1). These are assumed to be time-invariant variables and the model uses the covariates measured in 2010. The percentage of males within the analytic samples is 50.7%, and the age on average and its standard deviation is 71.1 ± 4.66 (years).

3.2.4 Neighborhood Environment

The area where older adults spend their time in daily life can be regarded as two levels of areas (Nishino and Omori, 2014): (1) the elementary school district (a scale of area which older adults can easily navigate) and (2) the junior high school district (an area composed of two or three elementary school districts). The elementary school district in which individuals live is used as a neighborhood unit to investigate the relationship between activity participation and neighborhood environment. Figure 3.2 shows the 262 elementary school districts in Nagoya.

The neighborhood environment is assessed by the facility density, population density, and percentage of people aged 65 years and older estimated by each elementary school district (Table 3.2). Population density and percentage of people aged 65 years and older are calculated based on the census survey in 2010. The high population density and the high percentage of older adults indicate that there could be many peers with whom to conduct group activities, as well as great availability of urban services owing to the many populations.

Facility data from telephone directory data with associated location information (Zenrin Co. Ltd., Telepoint Pack!) for 2010 and 2016 are linked to the

TABLE 3.1: Individual characteristics (N = 3,881).

	n(%) or Mean ± Sandard Deviation
Gender	
Male	1,968 (50.7)
Female	1,913 (49.3)
Age	71.1 ± 4.66
Education (year)	
0–6	12 (0.3)
7–9	1,025 (26.4)
10–12	1,593 (41.0)
≥13	1,206 (31.1)
Missing	45 (1.2)
Income (million JPY per a year)	
0–1	139 (3.6)
1–2	443 (11.4)
2–3	926 (23.9)
3–4	1,167 (30.1)
≥4	980 (25.3)
Missing	226 (5.8)
Household types	
Living alone	523 (13.5)
Living with others	3,335 (85.9)
Missing	23 (0.6)
Walking ability	
Able to walk over 15 minutes	3,311 (85.3)
Disable to walk over 15 minutes	332 (8.6)
Missing	238 (6.1)
Relationships with neighbors	
Help each other	1,275 (32.9)
Have conversations	2,039 (52.5)
No communication	319 (8.2)
Missing	248 (6.4)
Meeting friends	
Once/week and more	2,125 (54.7)
Several/month or year	1,376 (35.5)
No meeting	306 (7.9)
Missing	75 (1.9)

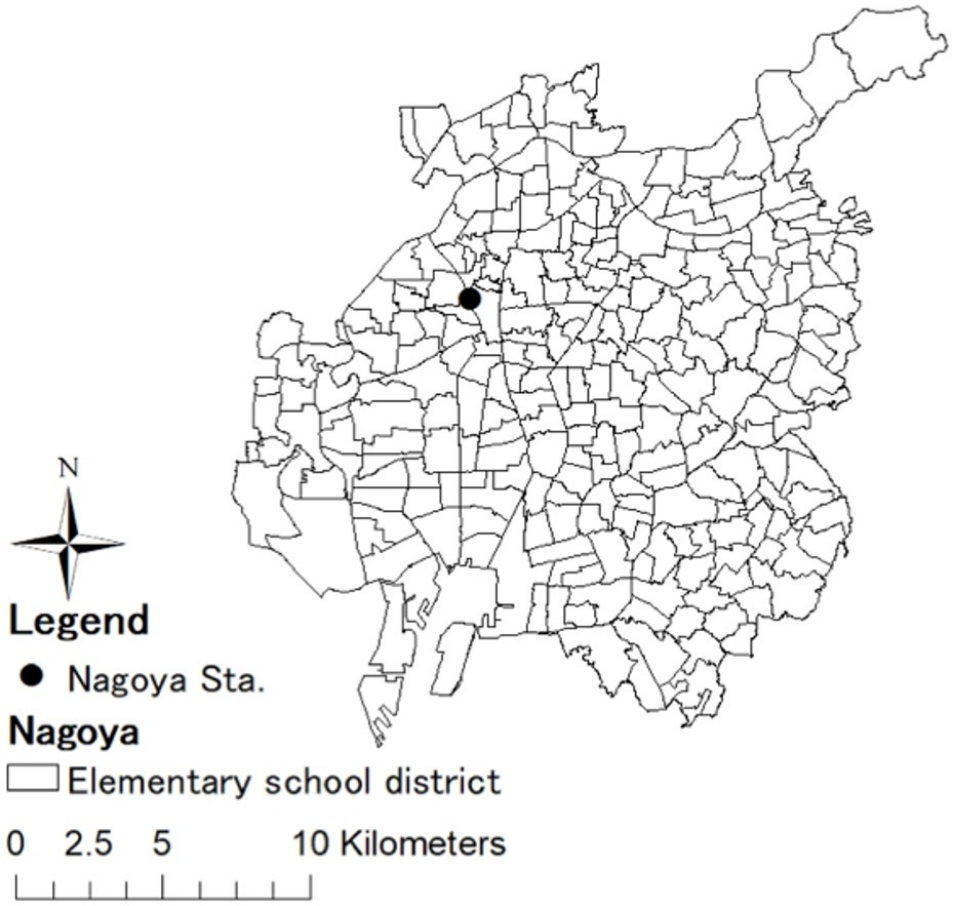

FIGURE 3.2: Nagoya and its 262 elementary school districts.

questionnaire responses in order to assess the density of facilities in the neighborhood and its change. Facilities are grouped into (1) recreational facilities (libraries, movie theaters, adult education classes, karaoke boxes, sports facilities, fitness clubs, mahjong clubs, community centers, etc.); (2) eating places (cafés, pubs, restaurants); (3) medical and welfare facilities (hospitals, welfare facilities for older adults) or (4) food stores (grocery stores, convenience stores, and supermarkets). These facilities are used as places for older adults to go out or interact. The number of public recreational facilities is smaller than other categories such as food stores. Therefore, the recreational facilities include both public and private recreational facilities. Public recreational facilities account for less than 10% of the number of

TABLE 3.2: Neighborhood-level variables.

	Mean ± SD
Population density (people/ha)	89.1 ± 33.6
Percentage of people who aged 65 years and older	0.21 ± 0.04
Facility density (facilities/ha)	
Recreational facilities	0.12 ± 0.13
Eating places	0.50 ± 0.72
Medical and welfare facilities	0.18 ± 0.16
Food stores	0.13 ± 0.11
Changes in facility density (facilities/ha)	
Recreational facilities	-0.02 ± 0.03
Eating places	-0.11 ± 0.12
Medical and welfare facilities	0.00 ± 0.04
Food stores	-0.02 ± 0.04

Note. The neighborhood is organized by the 262 elementary school districts in which individuals live. SD: standard deviation.

entire recreational facilities.

3.3 Analytic Method

Based on the reclassified categories, the changes in the frequency of activity participation of individual i living in area j between 2010 and 2016 are defined as follows:

$$\Delta y_{ij} = \begin{cases} 3 & \text{if } y_{ij}^{2016} - y_{ij}^{2010} > 0 \\ 2 & \text{if } y_{ij}^{2016} - y_{ij}^{2010} = 0 \\ 1 & \text{if } y_{ij}^{2016} - y_{ij}^{2010} < 0 \end{cases} \tag{3.1}$$

where y_{ij}^{2010} and y_{ij}^{2016} indicates the frequency of activity participation of individual i living in area j in 2010 and in 2016, respectively. Consequently, the changes in the

frequency of activity participation are defined as "increase" if $\Delta y_{ij} = 3$, "no change" if $\Delta y_{ij} = 2$, and "decrease" if $\Delta y_{ij} = 1$.

A multilevel ordinal logistic regression is used because of the non-uniformity of samples and their hierarchical structure, as well as ordinal dependent variables. The regression model can be expressed as follow.

$$\log \frac{p(\Delta y_{ij} \geq c | X_s, Z_t, u_j)}{p(\Delta y_{ij} < c | X_s, Z_t, u_j)} = \alpha_c + \sum_s \beta_s X_s + \sum_t \gamma_t Z_t + u_j \tag{3.2}$$

where categories for the changes in the frequency of participation are denoted by c ($\in \{1, 2, 3\}$) and α_c indicates the intercept for the category c. The random effect (which controls the effects of other unobserved neighborhood-level variables of area j) is denoted by u_j. The number of individual- and neighborhood-level variables are denoted by s and t, respectively. Coefficient β_s indicates s-th individual-level variable X_s and γ_t denotes t-th neighborhood-level variable Z_t.

The individual-level variables (a set of X_s) are composed of both y_{ij}^{2010} and control variables (such as gender, age, education, income, household types, walking ability, relationships with neighbors, and frequency of meeting friends). Owing to the fact that there could possibly be differences in the increases and/or decreases (among the levels of the frequency of activity participation), y_{ij}^{2010} is included in the model. Meanwhile, neighborhood-level variables (a set of Z_t) are composed of demographic neighborhood-level variables (both population density and percentage of people aged 65 years and older) and those regarding facility density. In addition, the neighborhood-level variables regarding facility density are composed of density of existing (observed in 2010) neighborhood facility of type k in area j (which is denoted by F_{jk}), change in density between 2010 and 2016 (which is denoted by ΔF_{jk}), and interaction term of the two ($F_{jk}\Delta F_{jk}$). Given that the interaction term is included, each neighborhood-level variable is mean-centered to avoid

multicollinearity issues. All the facility related variables are included at the same time.

The interaction term enables the model to express a non-linear relationship between the frequency of activity participation and the facility density. The interaction term has a positive value when both F_{jk} and ΔF_{jk} (mean-centered variables) have positive or negative values. When the interaction term is positively related to the change in the frequency of activity participation, more likelihood of participation is shown in the neighborhood where the number of facilities increases in the area with high density of existing facilities or their number decreases in the area with low density; this indicates a U-shaped relationship. On the other hand, the interaction term has a negative value when either F_{jk} or ΔF_{jk} has a positive value and the other has a negative value. When the interaction term shows a negative coefficient, more likelihood of participation is shown in the neighborhood where the number of facilities decreases in the area with high density of existing facilities or their number increases in the area with low density; this indicates an inverted U-shaped relationship. In this case, there could possibly be a certain facility density which has the highest likelihood of increases in the frequency of activity participation.

The model tests the relationships between the neighborhood environment and changes in the frequency of activity participation. From the model, $p(\Delta y_{ij} = 3)$—indicating that the probability of increases in the frequency of activity participation—can be expressed as a function of F_{jk} and ΔF_{jk}. Given that the model expresses Δy_{ij} using F_{jk} and ΔF_{jk}, the function can be denoted by $\Delta y_{ij}(F_{jk}, \Delta F_{jk})$. The amount of changes in $p(\Delta y_{ij} = 3)$ when the facility density slightly increases is the marginal effect of density of neighborhood facilities, and it is defined as follow:

$$\text{Marginal effect} = \frac{\partial p(\Delta y_{ij}(F_{jk}, \Delta F_{jk}) = 3)}{\partial F_{jk}}. \tag{3.3}$$

The marginal effect enables the model to find the density where the likelihood of increases in the frequency of activity participation has the highest/lowest value.

In terms of facilitating older adults' participation in recreational group activities, a sufficient level of facility density F_{jk}^{*} can be defined as the density where the likelihood of increases in the frequency of activity participation has the highest value. The sufficient level F_{jk}^{*} is found by an extremum $\widehat{F_{jk}}$ where the marginal effect is equal to 0.

$$\frac{\partial p(\Delta y_{ij}(F_{jk}, \Delta F_{jk}) = 3)}{\partial F_{jk}} = 0, \qquad \text{where } F_{jk} = \widehat{F_{jk}} \;\; (0 \leq \widehat{F_{jk}} \leq \max F_{jk}) \tag{3.4}$$

Since it is hard to solve $\widehat{F_{jk}}$ analytically, it is numerically solved.

In summary, the analysis is conducted in three steps (Figure 3.3). First, multilevel ordinal logistic regression models test the relationship between older adults' participation in hobby clubs and sports groups and density of neighborhood facilities using panel data. It also tests if there is a nonlinear relationship between them. Finally, it estimates the density of facilities where the likelihood of increases in the frequency of activity participation has the highest value based on the model, and it visualizes the neighborhoods where the sufficient number of facilities locates.

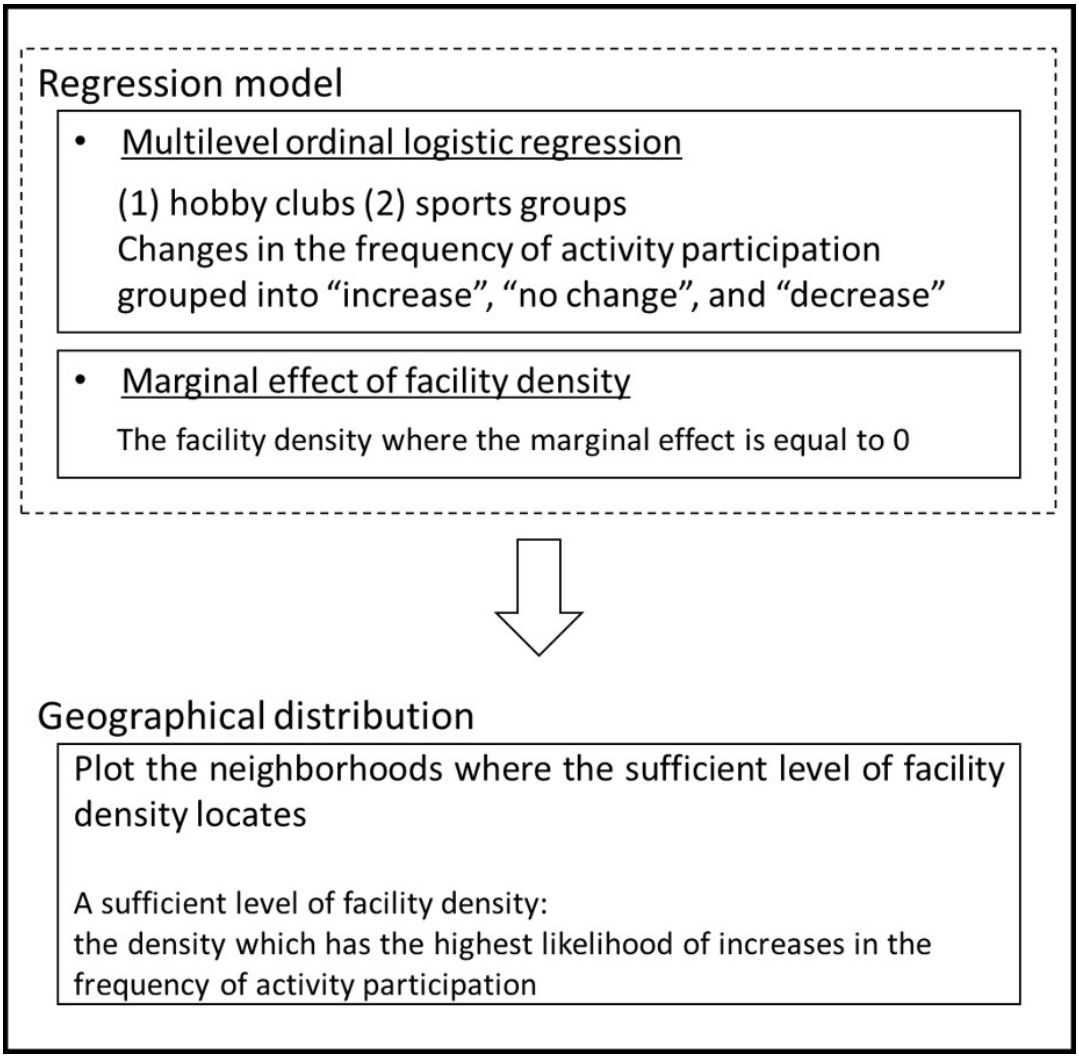

FIGURE 3.3: Framework of the analyzing methodology.

3.4 Results and Discussion

3.4.1 Change in the Frequency of Activity Participation between 2010 and 2016

Table 3.3 shows the frequency of participation in hobby clubs and sports groups in 2010 and 2016. Comparing the frequency of participation between the two time points, more people have been found not to be participating in hobby clubs, even

TABLE 3.3: Frequency of participation in recreational group activities.

	2010	2016
Hobby clubs		
Once/week and more	1,073 (27.6)	1,094 (28.2)
Several/month or year	935 (24.1)	843 (21.7)
Not participating	1,873 (48.3)	1,944 (50.1)
Sports groups		
Once/week and more	1,002 (25.8)	1,129 (29.1)
Several/month or year	399 (10.3)	482 (12.4)
Not participating	2,480 (63.9)	2,270 (58.5)

though the number of people participating at least once a week has been slightly increased (once a week and more: 1,073 to 1,094; several times a month or year: 935 to 843; not participating: 1,873 to 1,944). On the other hand, in the case of sports groups, the number of participants is found to be increased (once a week and more: 1,002 to 1,129 people; several times a month or year: 399 to 482 people; not participating: 2,480 to 2,270).

Table 3.4 shows the changes in the frequency of activity participation by each level of participation frequency in 2010. In the case of the frequency of participation in hobby clubs, older adults are found to show increases (620 responses; 16.0%), no changes (2,563 responses; 66.0%), and decreases (698 responses; 18.0%). On the other hand, in terms of the frequency of participation in sports groups, older people are found to show increases (552 responses; 14.2%), no changes (2,968 responses; 76.4%), and decreases (361 responses; 9.3%). This indicates that older adults who do not need long-term nursing care services are able to keep participating in group activities, and some of them find and start new activities (Agahi et al., 2006).

TABLE 3.4: Changes in the frequency of participation in recreational group activities from 2010 to 2016.

	Increase	No change	Decrease
Hobby clubs			
Once/week and more	-	660 (17.0)	413 (10.6)
Several/month or year	237 (6.1)	413 (10.6)	285 (7.3)
Not participating	383 (9.9)	1,490 (38.4)	-
Total	620 (16.0)	2,563 (66.0)	698 (18.0)
Sports groups			
Once/week and more	-	756 (19.5)	246 (6.3)
Several/month or year	108 (2.8)	176 (4.5)	115 (3.0)
Not participating	444 (11.4)	2,036 (52.5)	-
Total	552 (14.2)	2,968 (76.4)	361 (9.3)

3.4.2 Relationships between Participation and Facility Density

Table 3.5 shows the odds ratios (e^{γ_t}) estimated by the model. The odds ratio for the population density (people/ha) indicates the likelihood of change in the frequency of activity participation when 100 units increase, and the odds ratio for the percentage of older adults indicates the likelihood of change when the percentage increases by 1%. Regarding the facility densities (people/ha), odds ratios are the likelihood of change in the participation frequency when a facility is additionally built in an area comprised 10 ha.

Residents living in a neighborhood with a larger population have been found to be more likely to have relationships with those living in the same neighborhood (Boessen et al., 2018). However, population density and percentage of older adults are found to show insignificant relationships with the changes in the frequency of participation in hobby clubs and sports groups. In an urban area that is densely populated (such as Nagoya), differences in population density and the percentage of older adults between the neighborhoods are not related to the ease of older

TABLE 3.5: Estimates [and 90% Confidence Intervals] for the odds ratio (e^{γ_t}) of the changes in the frequency of participation in hobby clubs and sports groups (N = 3,881).

	(1) Hobby clubs	(2) Sports groups
Population density[a]	0.94 (0.76–1.17)	0.83 (0.64–1.07)
Percentage of people who aged 65 and older[b]	1.00 (0.99–1.01)	0.99 (0.97–1.01)
Facility density		
Recreational facilities	0.80 (0.69–0.93)*	0.76 (0.63–0.91)*
Eating places	1.05 (1.01–1.08)*	1.10 (1.05–1.14)*
Medical and welfare facilities	1.11 (1.02–1.20)*	0.94 (0.86–1.04)
Food stores	0.89 (0.76–1.03)	0.90 (0.76–1.08)
Changes in facility density		
Recreational facilities	0.69 (0.52–0.92)*	0.68 (0.48–0.96)*
Eating places	1.07 (0.98–1.16)	1.01 (0.91–1.12)
Medical and welfare facilities	1.00 (0.79–1.25)	0.70 (0.54–0.92)*
Food stores	0.95 (0.71–1.27)	1.34 (0.95–1.91)
Facility density × Changes in facility density		
Recreational facilities	1.03 (0.94–1.13)	1.01 (0.91–1.13)
Eating places	1.00 (1.00–1.00)	1.01 (1.00–1.01)
Medical and welfare facilities	1.08 (1.00–1.17)*	1.10 (1.00–1.20)*
Food stores	0.91 (0.77–1.08)	0.78 (0.64–0.96)*
AIC	5972.836	4784.692

Note. [a] Odds ratio when 100 units (people/ha) increase. [b] Odds ratio when the percentage increases by 1%. Odds ratio other than [a] and [b] is when 0.1 units (facility/ha) increase. *p <0.1.

adults' participation in recreational group activities. In other words, older residents living in urban areas do not suffer from a lack of colleagues or peers for conducting group activities. This suggests that the number of candidates for being group activity members does not have a critical impact on the likelihood of the increase in the participation frequency once the number reaches a certain level.

Both the density of existing recreational facilities and their changes are found to show a negative relationship with the increase in participation in hobby clubs or sports groups (for hobby clubs, odds ratio: 0.80, 0.69, respectively; for sports groups, odds ratio: 0.76, 0.68, respectively). Even though public recreational facilities such as community centers function as places for facilitating social interactions among older adults (Hino and Ishii, 2014; Makino and Imai, 1999), most of the recreational facilities include private facilities (such as karaoke boxes, fitness clubs, and adult education classes). Although private recreational facilities provide activities that meet a variety of needs, this suggests that it is hard to build social interaction in these facilities; in addition, it could possibly be an obstacle.

On the other hand, the area with a high density of eating places is found to be positively associated with the increases in the frequency of participation in hobby clubs and sports groups (for hobby clubs, odds ratio: 1.05; for sports groups, odds ratio: 1.10). In the case of densely developed urban areas, there are few places where older people can be relaxed and have conversations; however, eating places—such as cafés, pubs, and restaurants—provide opportunities for social interaction which promote their participation in sports groups, as well as hobby clubs.

However, the increases in the density of eating places are found to show an insignificant relationship with the increases in the participation frequency. Although eating places provide places for social interaction, they do not have the

function of forming new social connections, so the increased number of eating places in the neighborhood may not lead to further participation in group activities. Therefore, if the local government aims to encourage activity participation through eating places, it is necessary to create opportunities for collaboration with operators of the eating places.

In terms of medical and welfare facilities, the relationships of facility density with the increases in participation frequency are found to be different between hobby clubs and sports groups. In the case of hobby clubs, older adults—living in an area with high density of existing medical and welfare facilities—are found to be more likely to participate (odds ratio: 1.11). In the areas with high density of existing medical and welfare facilities, older adults are found to show a positive relationship with the increases in participation in hobby clubs when the density further increases (odds ratio: 1.08). Indeed, interventions through collaboration with local health sectors provide opportunities for older adults to participate in hobby activities (Haseda et al., 2019; Hosokawa et al., 2019).

On the other hand, in the case of sports groups, increases in the density of medical and welfare facilities are found to show a negative relationship with the increases in the participation frequency (odds ratio: 0.70). However, in the area with high density of existing medical and welfare facilities, older adults are found to show a positive relationship with the increases in participation in sports groups when the density further increases (odds ratio: 1.10). These are possible reasons why the density of medical and welfare facilities is related to participation in sports groups, even though the analytic samples included are older adults who do not need long-term nursing care services.

In the neighborhood where the number of older adults who have limited functional ability is relatively small, people living in the neighborhood—including

healthy older adults—possibly have a negative image of participation in recreational group activities. Therefore, it is difficult for the participation frequency to increase because of the fear of their peers' negative judgement of them. In other words, there could possibly be factors making older adults hesitate to participate. However, as the number of medical and welfare facilities increases, both the presence of older people who have limited functional ability and the activity participation for prevention of functional disability become more common, and older adults possibly start to have health awareness which positively influences participation in activity. On the other hand, in the neighborhood with a low density of medical and welfare facilities, people are less likely to have a negative image of activity participation. Therefore, they show more likelihood of increased participation frequency, compared with neighborhoods where factors making older adults hesitate to participate in group activities exist. Consequently, there is a U-shaped relationship between density of medical and welfare facilities and increases in the frequency of participation in sports groups (i.e., a higher likelihood of increases in participation frequency in the neighborhood with both a low- and high-level of facility density; and relatively lower likelihood in the neighborhood with a middle level of facility density).

In the case of food stores, older adults—living in the neighborhood where the number of facilities increases in the area with high density of existing facilities or their number decreases in the area with low density—are found to be more likely to participate in sports groups (odds ratio: 0.78). This suggests that there may be a sufficient level of food stores density for facilitating older adults' participation in sports groups. The high density of food stores means that the average distance to the destination is short when leaving the home in daily life. In this case, there

are few opportunities for social interaction and conversation. As an extreme example, people living in residential–commercial buildings—which are the residential buildings with commercial uses on the ground floor—can easily visit these for grocery shopping, but going out rarely creates opportunities for chance encounters or getting information of sports group activities owing to the short distance to the ground floor. The same is true on a neighborhood scale. On the other hand, if the distance on average is too long, the willingness to go out will decrease, therefore, the likelihood of an increase in participation frequency also decreases.

An extremum of the probability of the increase in participation frequency is found only in the case of medical and welfare facilities and food stores. Figure 3.4 and 3.5 show the neighborhoods (elementary school districts are colored black) with facility density where the likelihood of the increase in activity participation is close to the extremum (i.e., the marginal effect on the increases in participation frequency is close to 0). The density of medical and welfare facilities—where the likelihood of increases in the frequency of participation in hobby clubs and sports groups has the lowest value—is estimated to be around 0.18 facilities/ha. In the case of food stores, the density—where the likelihood of increases in the frequency of participation in hobby clubs and sports groups has the highest value—is estimated to be around 0.22 facilities/ha. In terms of their geographical distribution, neighborhoods with facility density (both medical and welfare facilities and food stores) close to the extremum are found to be located more than 2 km away from the station at Nagoya which is close to the commercial center of Nagoya.

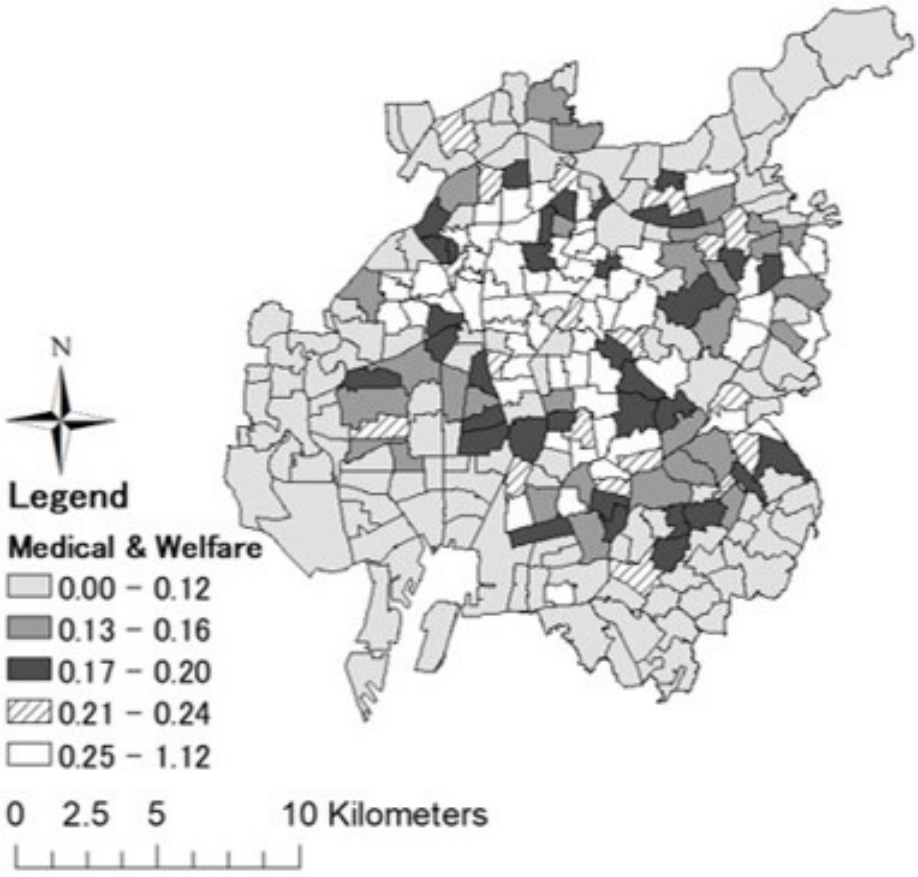

FIGURE 3.4: Elementary school districts with the density of medical and welfare facilities where the likelihood of the increase in the frequency of participation in hobby clubs and sports groups is close to the local minimum (black colored areas).

3.5 Conclusion

This chapter investigates the relationship between the density of neighborhood facilities and changes in the frequency of older adults' participation in hobby clubs and sports groups. The results—from the analysis using panel data to consider self-selection bias—indicate that the density of urban facilities is related to the increases or decreases in older adults' participation in recreational group activities, not just the frequency of their activity participation. In other words, building additional facilities in urban areas at neighborhood scale can be a solution to promote the

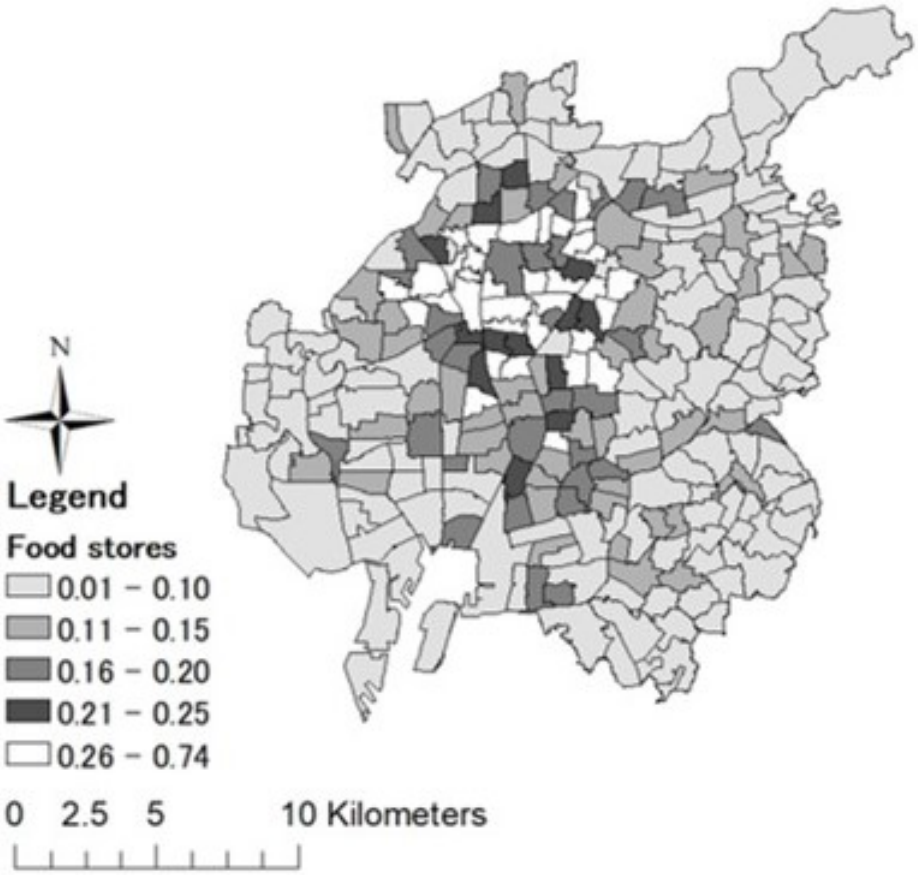

FIGURE 3.5: Elementary school districts with a sufficient level of density of food stores in terms of older adults' participation in sports groups. Black colored areas indicate the neighborhoods with facility density where the likelihood of the increase in the frequency of participation in sports groups is close to the local maximum.

participation of older adults in recreational group activities, even though its impact on facilitating activity participation could possibly decrease.

In the case of food stores, an inverted U-shaped relationship between the facility density and the increases in the frequency of participation in sports groups has been found (i.e., a closer distance to the food stores is not always better in terms of facilitating older adults' participation in sports groups). In an aging society, it is necessary to consider the opportunities which form new social connections, as well as the proximity to food stores, when policymakers consider the neighborhood

environment where residents can easily go for grocery shopping. For example, in addition to online shopping and home delivery services, it is necessary to pay attention to the social exchanges involved in shopping for the older adults who are unable to go shopping.

The results in this chapter suggest that there could possibly be a sufficient level of urban facilities within neighborhoods. However, when planning the location of facilities in a neighborhood, it is necessary to determine not only the number of facilities but also the location of facilities. In other words, it is necessary to consider geographical distribution of urban facilities in a neighborhood. The relationship between the geographical distribution of urban facilities and older adults' participation in recreational group activities has to be addressed; this will be discussed in the next chapter.

On the other hand, there are some limitations since the facility density (the density of unweighted point features) has been used to assess each type of facility. When building urban facilities, the scale and attractiveness of each facility are important, as well as the number of facilities. Related to the scale and attractiveness of facilities, the distance of their influence may vary for the each. Further studies which consider these issues are required.

Chapter 4

Neighborhood Effect of Geographical Distribution of Facilities

4.1 Introduction

Many scholars (e.g., Fu et al., 2018; Vankova et al., 2016) have shown that participation in hobby clubs or sports groups decreased older people's potential of being functionally disabled. Individuals participating in group activities also gained greater benefits than when doing the same activities alone (Kanamori et al., 2016). It is thus important to facilitate healthy older adults' participation in recreational or physical group activities before they become disabled.

Age-friendly cities propose the creation of social and physical infrastructure which promotes the participation or engagement of human beings, including older adults (World Health Organization, 2007). Developing the social and physical environment can promote the participation of older adults. Neighborhood facilities (such as parks, community centers, cafés, restaurants, pubs, and food stores) are the place where older adults engage in group activities outside the home (Van den Berg et al., 2014). Levasseur et al. (2015) note in a systematic review that having

sufficient urban facilities in older adults' neighborhood allows these groups to remain socially engaged. Richard et al. (2013) show a positive relationship between increased activity participation and shorter distances from an individual's home to neighborhood facilities. Therefore, increasing the number of these facilities in a neighborhood where older adults live is a solution to build an amenable area for activity participation.

From an urban planning perspective, the geographical distribution of facilities—as well as the number of facilities—should be considered when planners determine the location of facilities in a neighborhood. The spatial agglomeration of facilities may benefit—especially in terms of economic aspects (McCann and Folta, 2009; Porter, 2000)—from the agglomeration itself, rather than the accessibility or the number of neighborhood facilities. Facility location theories suggest two core components when planners determine the location of facilities: efficiency and equity (McAllister, 1976). Location decisions for efficiency seek to either minimize the average travel distance or maximize the accessibility; on the other hand, location decisions for equity aim to maximize coverage within a desired distance (Church and ReVelle, 1976; Owen and Daskin, 1998). The spatial dispersion of facilities refers to the geographical distribution of spacing between facilities as a result of equity-oriented facility location, with spatial agglomeration its counterpart (Figure 4.1).

Japan's population decline (Ministry of Land, Infrastructure, Transport, and Tourism, 2017) means that it is difficult to increase the number of urban facilities because building additional facilities at the neighborhood scale causes higher management costs for service providers in cases where there are few migrations to the neighborhood (owing to the unmet supply and demand balance in the long-term).

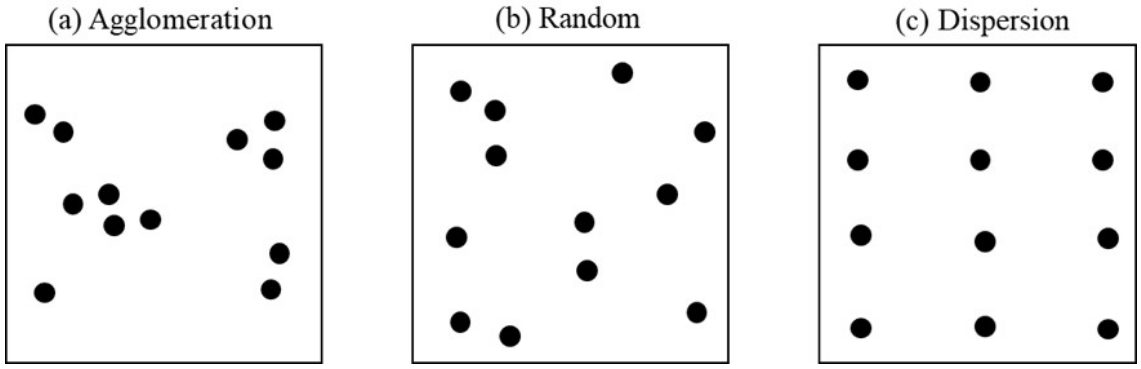

FIGURE 4.1: Illustration of the spatial agglomeration/dispersion of facilities in the case of 12 facilities.

If geographical distribution of facilities is related to participation, long-term district planning through zoning (which controls the facility use in the area) can be an alternative policy option. However, the spatial agglomeration of facilities may lead to regional disparities in service provision not only in rural areas but also in urban areas, as seen in food deserts (Choi and Suzuki, 2013), for example. Therefore, the geographical distribution of facilities is an important feature of the built environment. As a result, the social benefits of the spatial agglomeration/dispersion of urban facilities in terms of increasing participation in hobby clubs or sports groups should be tested, in order to discuss the efficient location of urban facilities in each neighborhood within the bounds of a fixed budget. Indeed, this will support long-term district planning.

Despite the importance of the geographical distribution of facilities as a component of the built environment, few studies have considered this issue. Instead, previous studies (Ewing and Cervero, 2010; Gidlow et al., 2019; Lane et al., 2020; Zhou et al., 2017), including those conducted in the public sector (City of New York, 2010; Udell et al., 2014; World Health Organization, 2015), have focused on questions of residential density, land use mix, destination accessibility, and presence of available facilities. This lack of interest in spatial agglomeration/dispersion

calls for a study testing the impact of the geographical distribution of facilities on participation in hobby clubs or sports groups. Therefore, this chapter tests the significance of the direct and indirect effects of the geographical distribution of facilities and their accessibility.

The chapter is structured as follows. Section 4.2 describes how the neighborhood facilities can affect older adults' activity participation and develops analytic concept. Section 4.3 explains the data used and outlines the methodological approach. Section 4.4 explores the results of the analysis. Section 4.5 discusses the main contributions and policy implications.

4.2 Direct and Indirect Effect of Neighborhood Facilities on Participation

Previous socioecological studies (e.g., Gan, 2017; Small and Adler, 2019) have proposed a theoretical framework by which the physical environment around residents' homes influences (both directly and mediated by the social environment) their behavior. Oishi (2014) has categorized the socio-ecological framework into three types: association, process, and niche construction study. Association study aims to identify the association between neighborhood environment and residents' behavior, meanwhile, process study elucidates the mechanisms (neighborhood effect) underlying the association. However, to discern whether the neighborhood environment promotes participation, migration of residents to an amenable neighborhood (niche construction) should be considered.

Empirical studies on the neighborhood effect of urban facilities have found (both direct and indirect) links between neighborhood facilities and activity participation. Urban parks and community centers provide places for recreational

activities and are positively related to more opportunities for participation in recreational activities (Anderson et al., 2017; Jim and Chen, 2006). On the other hand, availability of recreational facilities is positively associated with the frequency of going outdoor (Thornton et al., 2017), and the frequency of going outdoor mediates the association between accessibility to urban facilities and activity participation of older adults (Julien et al., 2015). The urban facilities (which are also perceived as communal space) also have a positive indirect effect on residents' frequent activity participation, mediated by providing places for socializing (Cabrera and Najarian, 2015; Mouratidis, 2018a) and enhancing their neighborhood attachment (Zhu and Fu, 2017). In conclusion, the previous studies suggest that urban facilities have neighborhood effect on activity participation, mediated by going outdoors, socializing, and neighborhood attachment.

The frequency of going outdoors (Sanders et al., 2005), socializing with friends or neighbors (Perkins et al., 1996; Putnam, 2000), and neighborhood attachment (Manzo and Perkins, 2006) are suggested as the attitudes that increase activity participation. Going outdoors (Legh-Jones and Moore, 2012) and socializing (Granovetter, 1983) increase older adults' opportunities to attain information of informal group activities or invitations. High neighborhood attachment is related to more meaningful and memorable experiences in the neighborhood and encourages activity participation (Madgin et al., 2016). Therefore, those attitude factors can be used as the mediation factors that link between the presence of facilities and activity participation not by providing places for recreational activities. In addition, "indirect effect" is the process that is caused by the mediation factors, rather than the presence of facilities providing places for recreational activities that directly affect the ease of participation. The indirect effects broaden policy options for health promotion through more participation which has not resulted from the

presence of facilities (providing recreational activity programs).

Based on the possible pathway of neighborhood effects (Figure 4.2), this chapter tests the direct and indirect effect of neighborhood facilities on older adults' participation in hobby clubs or sports groups. It is assumed that urban facilities affect participation in hobby clubs or sports groups differently because it is hard to conduct sports group activities at facilities (such as food stores, cafés, restaurants, and pubs), on the other hand, hobby clubs have relatively loose constricts (for instance, comparing the area where those activities are conducted between ground golf and board games, sports groups require more space than hobby clubs).

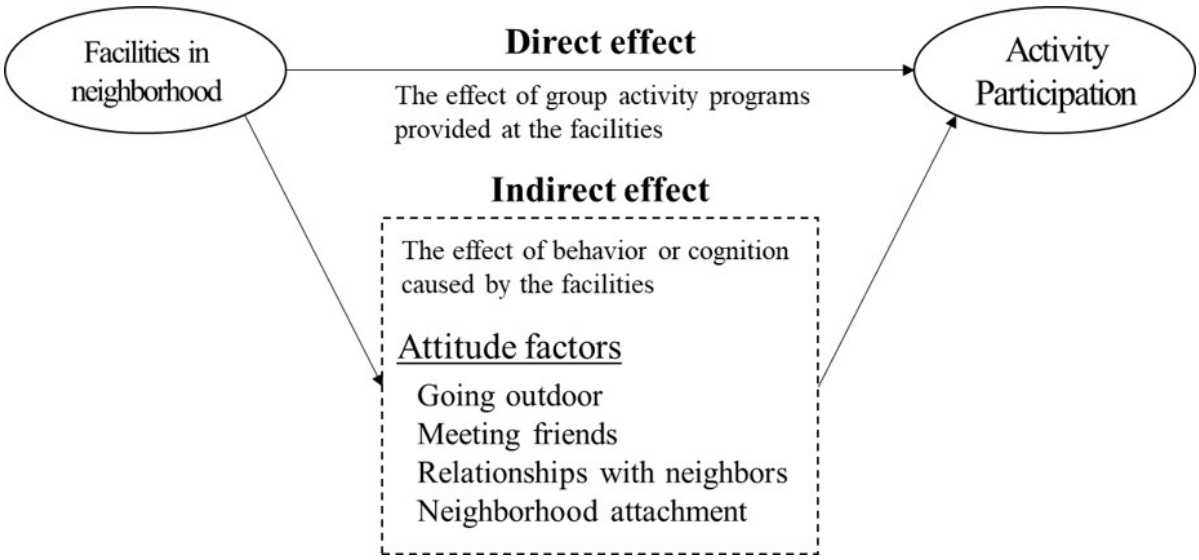

FIGURE 4.2: The pathway of neighborhood effects on participation in hobby clubs and sports groups.

Although it is suggested that the neighborhood facilities may directly and indirectly affect activity participation, most of the previous studies used a cross-sectional design, rather than a longitudinal design, and demonstrate the relationship between neighborhood facilities and social participation, not the causal relationship (Levasseur et al., 2015; Mazumdar et al., 2018). It is difficult to discern

whether the neighborhood environment promotes participation or whether people who consider participation an important attribute for life satisfaction migrate to an amenable neighborhood. It is therefore necessary to test the causal relationship for more solid evidence and the reasons for an improvement of the neighborhood environment. Given that cross-sectional studies have difficulties in avoiding the self-selection bias, this study employs a longitudinal design.

The contribution of this study is threefold. First, it provides new insights into whether the geographical distribution of facilities affects older adults' participation in hobby clubs and sports groups. Second, it considers self-selection bias and tests the effect of the geographical distribution of facilities and their accessibility. Finally, it hints at causal relationships between neighborhood environment and participation in hobby clubs or sports groups based on the temporal precedence of causes, which is important for effective health promotion policy.

4.3 Methods

4.3.1 Data

Panel data from 2010, 2013, and 2016 representing part of the JAGES field sites is employed. The survey involves 10 municipalities in Aichi Prefecture, including urban, suburban, and rural areas (Figure 4.3). As of 2010, the study area comprises 71,800 ha and is home to 3,109,000 residents, 20.7% of whom are aged 65 years and older (Statistics Bureau of Japan, 2012). The population density per elementary school district of Nagoya, the most populated city in the prefecture, is 82.98 ($\pm$ 31.31) people/ha on average; on the other hand, the average population density in other areas is 22.36 ($\pm$ 17.12) people/ha.

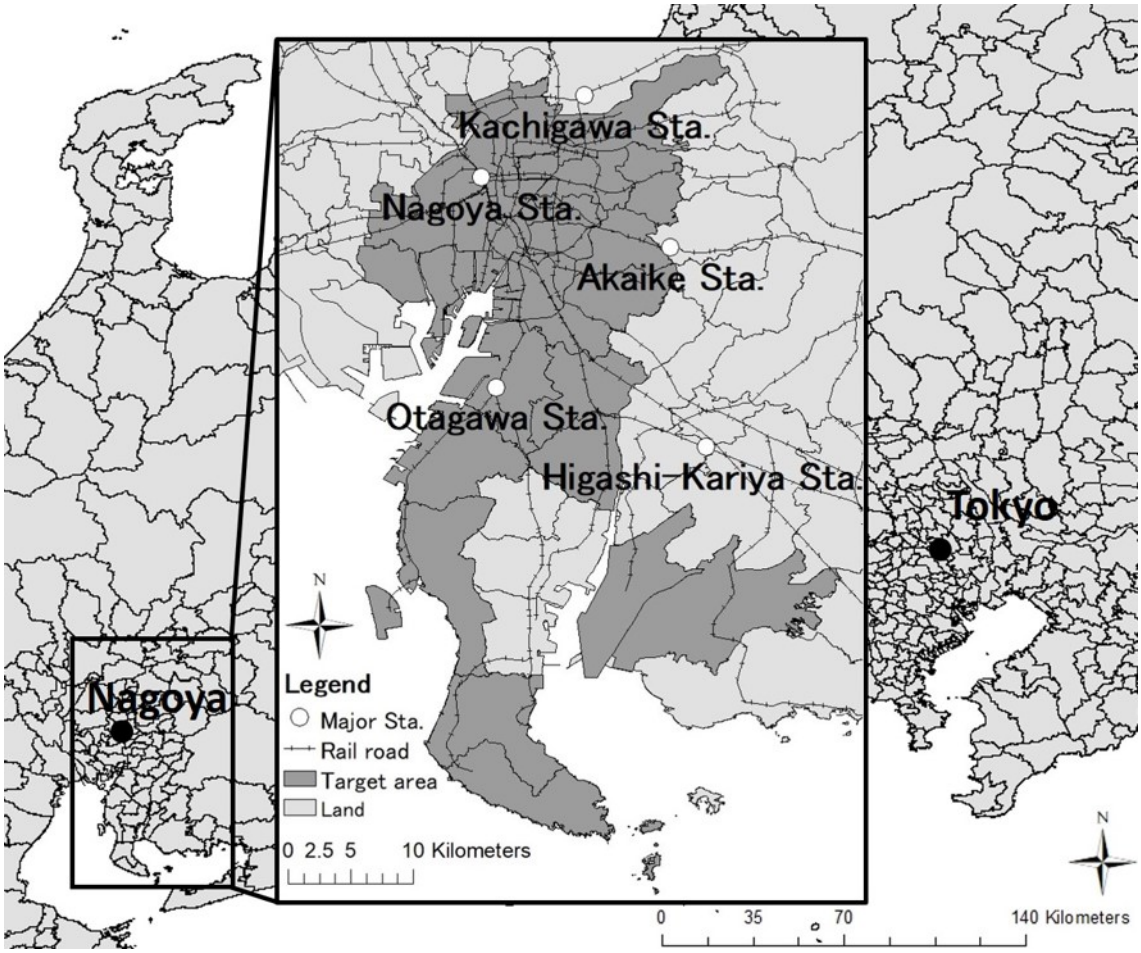

FIGURE 4.3: Location of the target area and its geographical relationship with Tokyo, the capital city of Japan.

The targets of the JAGES survey are people aged 65 years and older who do not need long-term nursing care services. Some responses are excluded as the participants have moved to another elementary school district within the study area (1,313 samples), as the study's aim is to estimate the effect of the neighborhood environment without residential relocation, which represents a process of selective migration. Consequently, the analytic sample for this study consists of 20,151 samples from the original 21,464 (those who have answered all waves of the questionnaire; see Figure 4.4 for more details). The median number of respondents per

elementary school district is 27.

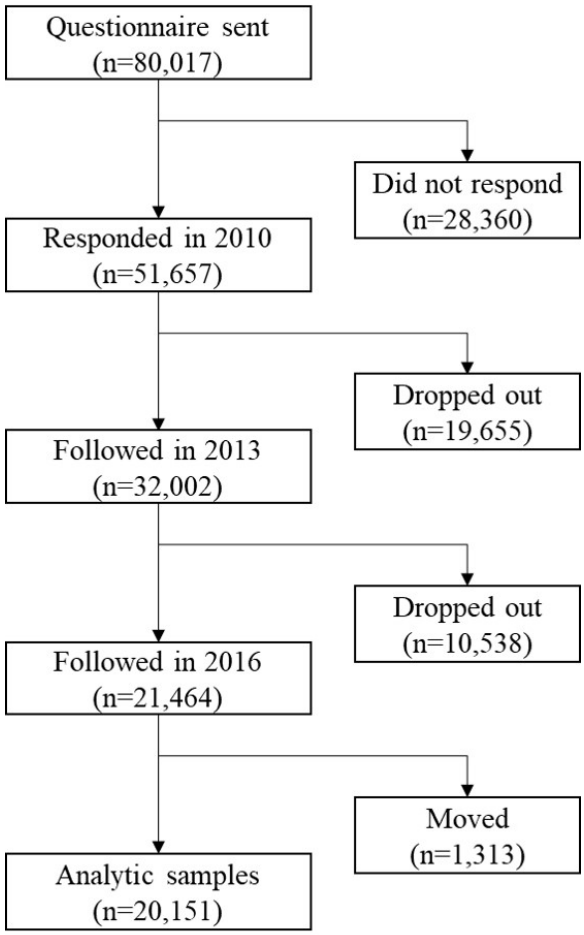

FIGURE 4.4: A flow chart summarizing the selection of analytic samples.

Facility data from the Ministry of Land, Infrastructure, Transport, and Tourism, alongside telephone directory data with associated location information (Zenrin Co. Ltd., Telepoint Pack!) for 2010 (the base year), are linked to the questionnaire responses in order to assess the accessibility of facilities and their geographical distribution by each district. Facilities are grouped into: (1) city parks; (2) community centers; (3) eating places (cafés, pubs, and, restaurants); and (4) food stores (grocery stores, convenience stores, and supermarkets). These types of facilities are major

destinations when going out in daily life, walking for leisure, and/or meeting people outside the home (Hickman, 2013; Jeffres et al., 2009; Oldenburg and Brissett, 1982; Van den Berg et al., 2014). Facilities such as medical clinics or nursing homes are excluded because our research targets are older adults who do not need nursing care.

4.3.2 Outcome

There are three waves of self-reported participation in group activities. The two dependent variables used are frequency of participation in hobby clubs and sports groups. These variables are assessed using items from the survey regarding how often the respondents have participated in activities at hobby clubs or sports groups. The response options for both hobby clubs and sports groups range from 1 (no participation) to 6 (four times a week and more) and are the same in every wave (Table 4.1). The representative pastimes of hobby clubs are activities such as gardening, playing board games, and study groups for computer literacy. In the case of sports groups, walking, exercising, golf, and ground golf are the representative physical group activities. People rend a room at community centers with their rent fee or membership subscription or participate in group activities in public open spaces such as city parks.

4.3.3 Mediation Variables

Frequency of going out, frequency of meeting friends, neighborhood attachment, and relationships with neighbors are used as mediation variables (Table 4.2). For frequency of going out or meeting friends, the possible responses range from 1 (not going out or not meeting, respectively) to 6 (four times a week and more).

TABLE 4.1: Frequency of participation (N=20,151).

	Wave 1 (2010)	Wave 2 (2013)	Wave 3 (2016)
Hobby clubs: "How often have you participated in activities at hobby clubs?"			
4 times/week	457 (2.3)	732 (3.7)	1,075 (5.3)
2–3 times/week	2,030 (10.1)	1,624 (8.1)	2,033 (10.1)
Once/week	2,286 (11.3)	1,688 (8.4)	1,723 (8.6)
1–3 times/month	2,643 (13.1)	2,738 (13.6)	2,548 (12.6)
Several/year	1,442 (7.2)	1,287 (6.4)	1,026 (5.1)
Not participating	8,050 (39.9)	9,106 (45.2)	8,909 (44.2)
Missing	3,243 (16.1)	2,966 (14.7)	2,837 (14.1)
Sports groups: "How often have you participated in activities at sports groups?"			
4 times/week	437 (2.2)	970 (4.8)	1,160 (5.8)
2–3 times/week	1,787 (8.9)	1,725 (8.6)	1,833 (9.1)
Once/week	1,546 (7.7)	1,370 (6.8)	1,281 (6.4)
1–3 times/month	867 (4.3)	999 (5.0)	1,042 (5.2)
Several/year	621 (3.1)	708 (3.5)	622 (3.1)
Not participating	11,109 (55.1)	11,169 (55.4)	10,354 (51.4)
Missing	3,784 (18.8)	3,210 (15.9)	3,859 (19.2)

Neighborhood attachment is assessed with a five-level Likert item ranging from 1 (strongly disagree) to 5 (strongly agree). The response options for relationships with neighbors offer the following four categories: 1 (We do not have communication); 2 (We say hello); 3 (We have conversations); and 4 (We help each other).

4.3.4 Neighborhood Environment

The neighborhood is organized by the 339 elementary school districts in which individuals live. An elementary school district corresponds to a geographical area that is easy for older adults to navigate (Hanibuchi et al., 2008) and represents a neighborhood unit (Perry, 1998). The average area of an elementary school district in Nagoya (262 districts) is 1.25 ($\pm$ 0.90) square kilometers, compared to 5.08 ($\pm$ 3.28) square kilometers on average in other areas (77 districts).

The physical neighborhood environment is assessed by the accessibility of facilities and their geographical distribution (Table 4.3; see Figure 4.5 for more details of spatial agglomeration/dispersion of facilities by each elementary school district); then both are calculated using ArcGIS 10.5. This includes both public and private facilities. Given that public facilities such as city parks and community centers manifest a more dispersed geographical distribution than private facilities in general, this study only considers the geographical distribution of private facilities, eating places, and food stores, which are usually located on the basis of economic theory.

The accessibility of facilities is estimated using spatial kernel density, because the density of facilities (facilities per area) ordinarily used does not include facilities near the fringe of an area. The accessibility of facility type k in district j, A_j^k is defined as the sum of the predicted density at point p included in district j divided by the area S_j (square kilometers) of district j (see Equation 1). The predicted

TABLE 4.2: Candidates for the mediation variables (N=20,151).

	Wave 1 (2010)	Wave 2 (2013)	Wave 3 (2016)
Going outdoor: "How often do you go outdoors?"			
4 times/week	12,040 (59.7)	15,497 (79.9)	14,595 (72.4)
2–3 times/week	4,951 (24.6)	3,332 (16.5)	3,851 (19.1)
Once/week	1,268 (6.3)	558 (2.8)	717 (3.6)
1–3 times/month	501 (2.5)	381 (1.9)	597 (3.0)
Several/year	133 (0.7)	45 (0.2)	95 (0.5)
Not going	60 (0.3)	27 (0.1)	82 (0.4)
Missing	1,198 (5.9)	311 (1.5)	214 (1.1)
Meeting friends: "How often do you meet with your friends?"			
4 times/week	2,860 (14.2)	3,668 (18.2)	3,625 (18.0)
2–3 times/week	4,821 (23.9)	4,276 (21.2)	4,353 (21.6)
Once/week	3,418 (17.0)	2,636 (13.1)	2,781 (13.8)
1–3 times/month	3,786 (18.8)	3,177 (20.7)	4,152 (20.6)
Several/year	2,777 (13.8)	3,173 (15.7)	3,075 (15.3)
No meetings	1,205 (6.0)	1,200 (6.0)	1,545 (7.7)
Missing	1,284 (6.4)	1,021 (5.1)	620 (3.1)
Neighborhood attachment: "Would you (strongly) agree/disagree that you feel attached to the neighborhood where you live?"			
Strongly agree	5,809 (28.8)	5,281 (26.2)	5,716 (28.4)
Agree	10,668 (52.9)	11,068 (54.9)	10,772 (53.5)
Moderately agree	2,402 (11.9)	2,602 (12.9)	2,518 (12.5)
Disagree	664 (3.3)	691 (3.4)	680 (3.4)
Strongly disagree	89 (0.4)	106 (0.5)	128 (0.6)
Missing	519 (2.6)	403 (2.0)	337 (1.7)
Relationships with neighbors: "What kind of relationship do you have with your neighbors?"			
Help each other	2,694 (13.4)	2,375 (11.8)	3,200 (15.9)
Have conversations	11,637 (57.7)	11,724 (58.2)	12,086 (60.0)
Say "Hello" (greetings)	4,330 (21.5)	4,450 (22.1)	4,304 (21.4)
No communication	177 (0.9)	199 (1.0)	242 (1.2)
Missing	1,313 (6.5)	1,403 (7.0)	319 (1.6)

TABLE 4.3: Neighborhood-level variables.

	Mean ± SD
Population density	70.42 ± 38.77
Accessibility (spatial kernel density)	
City parks	2.39e-04 ± 1.66e-04
Community centers	6.35e-05 ± 4.45e-05
Eating places	2.50e-03 ± 3.96e-03
Food stores	6.48e-04 ± 6.15e-04
Spatial agglomeration (average nearest neighbor ratio)	
Eating places	0.64 ± 0.24
Food stores	0.93 ± 0.37

Note. For spatial agglomeration, a value smaller than 1 describes a clustered distribution. The neighborhood is organized by the 399 elementary school districts in which individuals live. SD: standard deviation.

density is estimated using the distance $d_l^k(x,y)$ from facility l of type k to a random point p located at (x,y), and the bandwidth h (see Equation 2). The bandwidth h of the kernel is set at 500 meters, which is a scale of walkable distance, being about a 10-minute walking distance for older adults (Weber, 2016). A high value for accessibility at the neighborhood level indicates not only proximity to facilities but also more options for people living in the area to choose between which are within the walkable distance.

$$A_j^k = \frac{1}{S_j} \iint\limits_{(x,y)\cap S_j} f(d_l^k(x,y),h)\,\mathrm{d}x\,\mathrm{d}y \tag{4.1}$$

$$f(d_l^k(x,y),h) = \frac{3}{\pi h^2} \sum_{d_l^k(x,y)\le h}^{n} \left[1 - \left\{\frac{d_l^k(x,y)}{h}\right\}^2\right]^2 \tag{4.2}$$

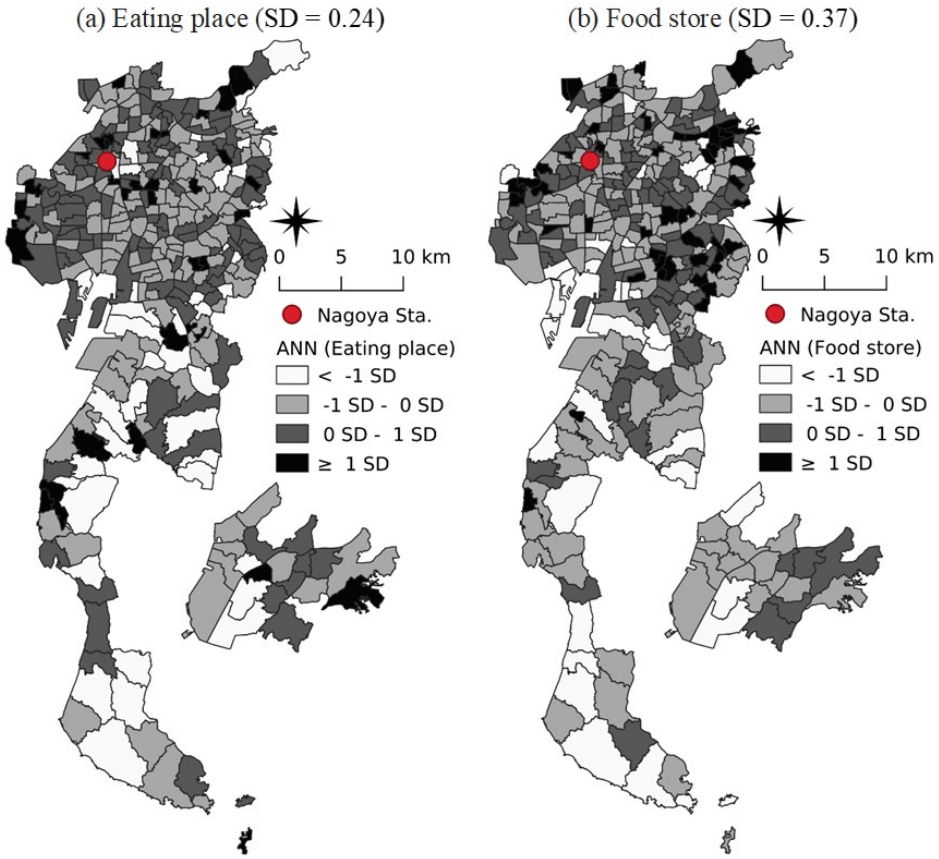

FIGURE 4.5: The average nearest neighbor ratio (ANN) of facilities (eating places and food stores) by each elementary school district. A larger value of the average nearest neighbor ratio means that the facilities are relatively dispersed; by contrast, a smaller value describes a clustered distribution. SD: standard deviation.

Average nearest neighbor ratio (Clark and Evans, 1954) and Ripley's K function (Ripley, 1977) are two representative indices to estimate the spatial point pattern. There is no need to define an additional parameter to estimate a single value for the spatial point pattern for the average nearest neighbor ratio, whereas Ripley's K characterizes spatial point patterns at multiple distance scales. This study therefore employs the average nearest neighbor ratio to estimate the spatial agglomeration/dispersion of facilities by each neighborhood. The ratio is calculated

by the observed mean distance $\sum_{l=1}^{n} d_{ll'}^{k} / n_j^k$ between a facility l and its nearest facilities l', divided by the expected mean distance with a certain facility density ρ_j^k of type k in a district j, assuming that the facilities are randomly distributed (see Equation 3). Spatial agglomeration/dispersion is rarely related to the number of facilities because the ratio considers the facility density ρ_j^k. The value of the average nearest neighbor ratio (i.e., close to 1) means that the facilities are randomly distributed; by contrast, a larger or smaller value than 1 describes a dispersed or clustered distribution, respectively.

$$ANN_j^k = \frac{d_{\text{observed}}}{d_{\text{expected}}} = \frac{\sum_{l=1}^{n} d_{ll'}^{k} / n_j^k}{0.5 / \sqrt{\rho_j^k}} \tag{4.3}$$

4.3.5 Covariates

Possible confounding factors from the respondents' demographic and socioeconomic status—gender, age, education, income, household types, fear of falling, self-rated health, body mass index, and depression (assessed using a short form of the geriatric depression scale: GDS 15 and a cut-off value of 6), car availability, and public transportation availability—are used as the control variables (Table 4.4). These are assumed to be time-invariant variables.

TABLE 4.4: Individual characteristics (N=20,151).

	n(%) or Mean ± Standard Deviation
Gender	
Male	9,157 (45.4)
Female	10,994 (54.6)
Age	72.02 ± 5.02
Education (year)	
0–6	179 (0.9)
7–9	8,778 (43.6)

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Individual characteristics (continued from previous page)

	n(%) or Mean ± Standard Deviation
10–12	6,957 (34.5)
≥13	3,636 (18.0)
Missing	601 (3.0)
Income (million JPY per a year)	
0–1	1,095 (5.4)
1–2	2,436 (12.1)
2–3	4,419 (21.9)
3–4	3,105 (15.4)
≥4	6,905 (34.3)
Missing	2,191 (10.9)
Household types	
Living alone	2,061 (10.2)
Living with others	17,587 (87.3)
Missing	503 (2.5)
Fear of falling	
Have a fear of falling	7,468 (37.1)
Do not have a fear of falling	11,519 (57.2)
Missing	1,164 (5.8)
Self-rated health	
Very good	2,721 (13.5)
Good	14,546 (72.2)
Bad	2,298 (11.4)
Very bad	259 (1.3)
Missing	327 (1.6)
BMI	
Underweight (<18.5)	1,143 (5.7)
Normal (18.5–23.0)	9,079 (45.1)
Overweight (23.0–25.0)	4,716 (23.4)
Obese (≥25.0)	4,108 (20.4)
Missing	1,105 (5.5)
Geriatric depression scale (GDS 15)	
Depressive (≥6 score)	3,306 (16.4)

Continued on next page

Individual characteristics (continued from previous page)

	n(%) or Mean ± Standard Deviation
Non-depressive (<6 score)	16,845 (83.6)
Car availability	
Available	11,399 (56.57)
Not available	8,752 (43.43)
Public transportation availability	
Available	17,982 (89.2)
Not available	1,017 (5.0)
Missing	1,152 (5.7)

4.3.6 Analysis

A latent growth curve model (using R-4.0.1 and lavaan, a package for structural equation modeling), which is a multilevel model with latent variables, is used for the mediation model with longitudinal data (Hox and Stoel, 2005). As shown in Figure 4.6, the values of the intercept and the slope refer to the frequency of activity participation in the base year and the change in the frequency of activity participation, respectively. The direct paths and the indirect paths are specified to infer a causal relationship (temporal priority of causes). Given that the survey is conducted every three years, the factor loading is set to be equally spaced, with three years as the time unit (0, 1, 2). Two different models are estimated for the three repeated measures of hobby clubs and sports groups. The neighborhood-level variables are included separately and standardized due to multicollinearity among the accessibility variables, even though the spatial agglomeration does not show collinearity (Table 4.5). The population density at the neighborhood level is included to adjust the degree of urbanization. The model is fitted using an estimator, maximum likelihood with the Huber–White robust standard error for the robustness of estimation. Full information maximum likelihood approach—which

provides unbiased parameter estimates under both missing completely at random and missing at random (Enders and Bandalos, 2001)—is used owing to missing values.

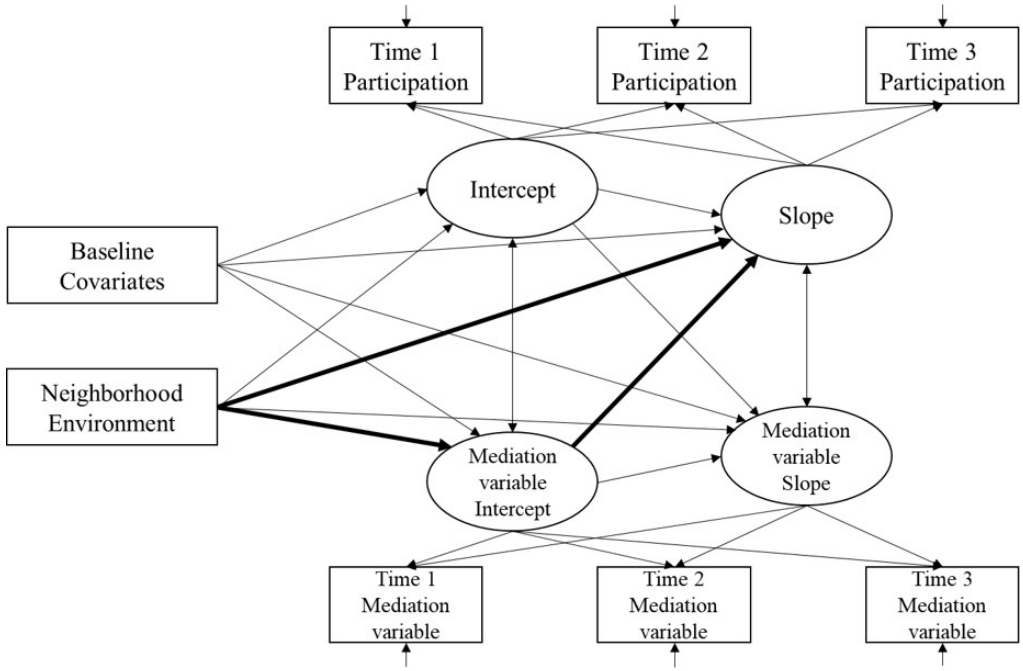

FIGURE 4.6: Latent growth curve model inferring the direct and indirect effects of the neighborhood environment on changes in participation.

Based on the models, the analysis is conducted in three steps. First, the model tests the pathways from mediation factors to participation. An additional analysis is also conducted to understand the relationship of the initial status of a mediation variable with the trajectory of each construct. Finally, the model tests the direct and indirect effects of the neighborhood environment on changes in participation using the bootstrap method, which conducts resampling many times with replacement (MacKinnon et al., 2004).

TABLE 4.5: Correlations among neighborhood-level variables.

	(a)	(b)	(c)	(d)	(e)	(f)	(g)
(a) Population density	1.00						
Spatial kernel density							
(b) City parks	0.51^{***}	1.00					
(c) Community centers	0.51^{***}	0.30^{***}	1.00				
(d) Eating places	0.40^{***}	0.13^{*}	0.38^{***}	1.00			
(e) Food stores	0.59^{***}	0.26^{***}	0.52^{***}	0.81^{***}	1.00		
Average nearest neighbor ratio							
(f) Eating places	0.13^{*}	0.15^{**}	0.09	-0.09	0.02	1.00	
(g) Food stores	0.24^{***}	0.29^{***}	0.14^{**}	0.02	-0.02	0.17^{**}	1.00

Note. The value indicates Pearson correlation coefficient. The neighborhood is organized by the 339 elementary school districts in which individuals live. $^{*}p$ <0.05, $^{**}p$ <0.01, $^{***}p$ <0.001.

4.4 Results

4.4.1 Changes in the Frequency of Activity Participation

Table 4.6 shows the changes in the frequency of participation in hobby clubs or sports groups by each level of participation frequency in 2010. The average change in the frequency of participation in hobby clubs is slight over time, but the frequency of participation in sports groups increases by more than that of hobby clubs on average. Previous studies have reported reduced frequency of participation over time (Finkel et al., 2018). However, there are definite gaps between the apparent need for hobby clubs or sports group activities and the actual participation of older Japanese adults (Cabinet Office, 2017). Given that our study sample comprises three waves of healthy older adults, the individuals included are able to participate in group activities.

TABLE 4.6: Changes in the frequency of participation in recreational group activities from 2010 to 2016.

	n	Increased	Not changed	Decreased
Hobby clubs (2010)				
4 times/week	421	-	175	246
2–3 times/week	1,880	315	682	883
Once/week	2,108	531	590	987
1–3 times/month	2,430	660	968	802
Several/year	1,274	421	260	593
Not participating	6,858	1,424	5,434	-
Total	14,971	3,351	8,109	3,511
Sports groups				
4 times/week	378	-	261	117
2–3 times/week	1,547	353	727	467
Once/week	1,354	422	456	476
1–3 times/month	749	246	243	260
Several/year	535	201	101	233
Not participating	9,116	1,588	7,528	-
Total	13,679	2,810	9,316	1,553

4.4.2 Model Fit

A model estimated for the hobby clubs is found to fit the observed data well (chi-square: 3086.66; root mean square error of approximation: $0.029 < 0.08$; standardized root mean square residual: $0.012 < 0.08$; comparative fit index: $0.969 > 0.90$). A model estimated for the sports groups also fits well (chi-square: 2738.56; root mean square error of approximation: $0.027 < 0.08$; standardized root mean square residual: $0.013 < 0.08$; comparative fit index: $0.974 > 0.90$).

4.4.3 Pathways from Mediation Factors to Participation

Figure 4.7 shows a path diagram from mediation factors to participation in hobby clubs. The intercept of going out and meeting friends shows a significant relationship with the slope of participation in hobby clubs (0.077 and -0.219, respectively). The initial status of going out is positively related to increased participation in hobby clubs. In comparison, initial status with respect to meeting friends is negatively related to increased participation in hobby clubs.

Figure 4.8 shows a path diagram from mediation factors to participation in sports groups. The intercept of relationships with neighbors and meeting friends shows a significant relationship with the slope of participation in sports groups (0.081 and -0.070, respectively). The initial status of relationships with neighbors is positively related to changes in participation in sports groups. However, the initial status of meeting friends shows a negative relationship with increased participation in sports groups, the same result as for the model for hobby clubs.

Although both models show a negative value for the coefficient between the initial status of meeting friends and increased participation, the high frequency of

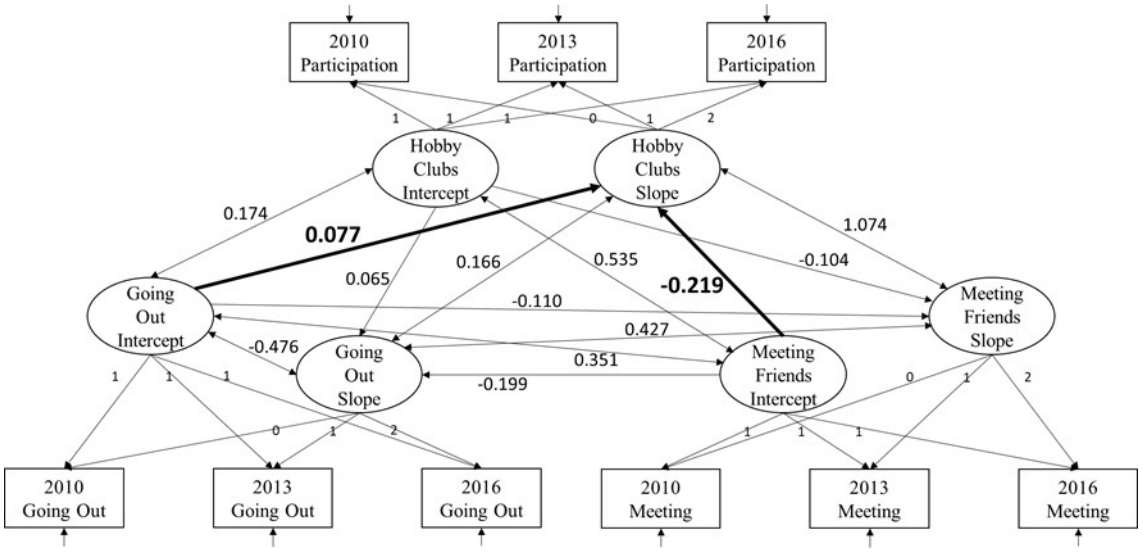

FIGURE 4.7: Pathways from mediation factors to participation in hobby clubs and their standardized coefficients. Gender, age, education, income, household types, fear of falling, self-rated health, body mass index, depression, car availability, public transportation availability, and population density are adjusted. All parameters shown are p <0.05. For convenience, factors of neighborhood attachment and relationship with neighbors that do not have significant relationships (p ≥0.05) with the slope factor of participation in hobby clubs are not displayed.

meeting friends does not indicate a decrease in participation. Rather, the results indicate a difference in the magnitude of change in participation. Table 4.7 presents the mean trajectory of participation in hobby clubs and sports groups by each construct of the initial status of meeting friends. The five-level constructs are grouped by 0.5 SD or 1.5 SD above and below the mean of the initial status of meeting friends. Frequent meetings with friends are found to prevent diminished participation in hobby clubs, and also facilitate increased participation in sports groups, even though the growing speed subsequently slows (this implies that there could possibly be a ceiling effect).

TABLE 4.7: Model-implied growth trajectories of participation as a function of a five-level construct of the initial status of meeting friends (N=20,151).

	n	Time 1 (2010)	Time 2 (2013)	Time 3 (2016)	Change (2010–2016)
Hobby clubs					
Highest	1,047	3.733	3.733	3.734	0.001
High	6,038	2.970	2.998	3.025	0.055
Average group	6,586	2.316	2.317	2.319	0.004
Low	4,913	1.635	1.626	1.618	−0.018
Lowest	1,567	1.170	1.156	1.142	−0.029
Sports groups					
Highest	1,141	3.100	3.253	3.407	0.306
High	5,922	2.465	2.623	2.780	0.315
Average group	6,552	1.878	1.992	2.105	0.227
Low	4,984	1.398	1.478	1.558	0.160
Lowest	1,552	1.080	1.119	1.158	0.078

Note. The five-level constructs are grouped by 0.5 SD or 1.5 SD above and below the mean of the intial status of meeting friends. Change corresponds to the difference between the value at Time 1 (2010) and at Time 3 (2016). SD: standard deviation.

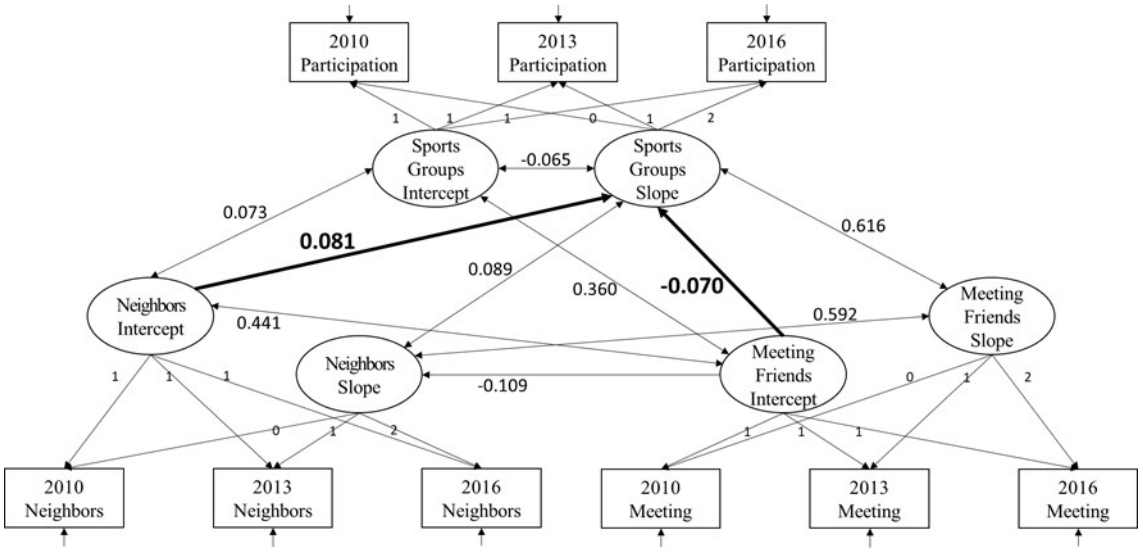

FIGURE 4.8: Pathways from mediation factors to participation in sports groups and their standardized coefficients. Gender, age, education, income, household types, fear of falling, self-rated health, body mass index, depression, car availability, public transportation availability, and population density are adjusted. All parameters shown are p <0.05. For convenience, factors of neighborhood attachment and relationship with neighbors that do not have significant relationships (p ≥0.05) with the slope factor of participation in sports groups are not displayed.

4.4.4 Mechanism of Neighborhood Effect

Our key interest—the direct and indirect effects of neighborhood environment on changes in participation—is estimated based on the model and tested using the bootstrap method. Tables 4.8 and 4.9 provide summaries of the standardized direct and indirect effects on changes in participation in hobby clubs and sports groups, respectively.

The accessibility of city parks shows a positive direct effect (0.063) on increased participation in hobby clubs. For the indirect effect, the accessibility of city parks and community centers shows a positive indirect effect on increased participation in hobby clubs, mediated by meeting friends (0.004) and going out (0.003). The good or poor accessibility of eating places and food stores does not

TABLE 4.8: Standardized direct and indirect effects of neighborhood environment on changes in participation in hobby clubs (N=20,151).

	Direct effects	Indirect effects	
		Meeting friends	Going out
High accessibility			
City parks	0.063^{**}	0.004^{*}	0.000
Community centers	0.018	0.001	0.003^{*}
Eating places	-0.013	-0.001	0.000
Food stores	-0.022	-0.004	0.001
Spatially dispersed pattern			
Eating places	-0.014	-0.008^{***}	-0.001
Food stores	-0.013	0.001	0.001

Note. For convenience, the factors of relationships with neighbors and neighborhood attachment that do not have significant relationships with the slope factor of participation in hobby clubs are not displayed. Neighborhood-level variables are included separately. Gender, age, education, income, household types, fear of falling, self-rated health, body mass index, depression, car availability, public transportation availability, and population density are adjusted. Significance levels for direct and indirect effects are bootstrap approximations. Bootstrap replications = $1,000$. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

TABLE 4.9: Standardized direct and indirect effects of neighborhood environment on changes in participation in sports groups (N=20,151).

	Direct effects	Indirect effects	
		Meeting friends	Relationships with neighbors
High accessibility			
City parks	0.042*	0.002	−0.007**
Community centers	0.025	0.000	0.000
Eating places	0.005	0.000	0.000
Food stores	0.002	−0.001	0.002
Spatially dispersed pattern			
Eating places	0.007	−0.002*	0.003*
Food stores	0.014	0.001	−0.002*

Note. For convenience, the factors of going out and neighborhood attachment that do not have significant relationships with the slope factor of participation in sports groups are not displayed. Neighborhood-level variables are included separately. Gender, age, education, income, household types, fear of falling, self-rated health, body mass index, depression, car availability, public transportation availability, and population density are adjusted. Significance levels for direct and indirect effects are bootstrap approximations. Bootstrap replications = 1,000. $^{*}p < 0.05$, $^{**}p < 0.01$.

show significant differences in terms of participation in hobby clubs after adjusting the population density; this is probably related to the number of facilities in the neighborhood.

In the case of sports groups, the accessibility of city parks shows a positive direct effect (0.042); however, the indirect effect mediated by relationships with neighbors is negative (-0.007). Although relationships with neighbors are found to positively affect growth in participation in sports groups, poorer accessibility is related to closer relationships with neighbors.

The more clustered eating places are positively related to the greater likelihood of an increase in participation in hobby clubs, mediated by the frequency of meeting friends (-0.008). For the sports groups, the indirect effect mediated by meeting friends shows similar results to that of hobby clubs. The area with clustered eating places is positively related to the growth in participation in sports groups mediated by the frequency of meeting friends (-0.002). However, in the case of the indirect effect mediated by relationships with neighbors, the area with dispersed eating places is positively related to the growth in participation in sports groups (0.003). In the case of the indirect effect of the spatial agglomeration of facilities mediated by relationships with neighbors, those living in an area with clustered food stores are found to be more likely to participate in sports groups (-0.002).

4.5 Discussion

4.5.1 Main Findings

This study has demonstrated that both the accessibility and the spatial agglomeration/dispersion of facilities are related to older Japanese adults' participation

in hobby clubs or sports groups. City parks and community centers, where older adults conduct group activities, increase their participation in hobby clubs both directly and indirectly; on the other hand, eating places and food stores, where group activities are rarely provided, indirectly increase their frequency of participation in hobby clubs (and the same is true of sports groups). Even though the city parks have been found to exhibit the greatest direct effect, the indirect effects of eating places and food stores also should be considered as interventions for more participation in hobby clubs or sports groups, especially in the area with sufficient city parks. A broad range of facilities, including both recreational and non-recreational versions, should be considered when policymakers discuss policies or interventions to promote participation.

Good accessibility in general renders an amenity preferable and helps older adults to participate easily (Levasseur et al., 2015). However, the accessibility of city parks has been found to exhibit a negative indirect effect mediated by relationships with neighbors on growth in participation in sports groups. This implies that older people are often hesitant to show their sports activities to other residents in their neighborhood, especially if they have close relationships with their neighbors. Even though close relationships with neighbors encourage older adults to participate in sports group activities, they opt against engaging in activities that can be conducted at the park in their neighborhood where they have close relationships with their neighbors. Therefore, good spatial accessibility does not always imply straightforward participation, and there are both positive and negative impacts of close relationships with neighbors—especially in Japan—on participation in sports groups.

Apart from the accessibility of facilities, the spatial agglomeration of eating places enables older adults to feel that they can meet with friends more frequently

and participate in either hobby clubs or sports groups. Given that accessibility to eating places increases opportunities for social interaction (Mouratidis, 2018a), the agglomeration of eating places is also related. A clustered pattern of eating places indicates a concentration of destinations for meeting friends, increasing opportunities to meet close to an eating place. This means that older adults will not worry that there will be no vacant tables, enabling them to go out to areas where eating places are concentrated. Greater opportunities for social interaction increase opportunities for participation in hobby clubs and sports groups, too. The agglomeration of eating places only slightly increases the frequency of going outdoors.

In the case of sports groups, the relationship between the spatial agglomeration of eating places and participation is more complicated. The spatial agglomeration of eating places offers a benefit in terms of the convenience of meeting friends, thereby increasing participation in sports groups. At the same time, the spatial dispersion of eating places enables people to build relationships with neighbors, thereby increasing opportunities for participation in sports groups. A dispersed pattern of eating places indicates a wider coverage of sites of social interaction; hence many older adults can benefit from the availability of places for communication with neighbors. Therefore, it is hard to conclude which geographical distribution of eating places is better for stimulating participation in sports groups, meaning that dynamics (such as frequency of meeting friends and having relationships with neighbors) need to be considered when planners discuss neighborhood effects.

In the case of food stores, participation in sports groups is negatively affected by the dispersion of food stores, mediated by relationships with neighbors. Food stores have been found to show dispersed patterns more in urban areas than in rural areas. This tendency owes to the large number of food stores, including

convenience stores, based in large populations and high levels of foot traffic in urban areas and car-oriented mega-markets in rural areas. Paradoxically, a concentration of food stores stimulates people to use other areas with different purposes, such as sports or neighboring activities. Thus, it may be inferred that there is a trade-off relationship between the coverage area of food stores within walkable distance and open spaces where people can do sports activities in a group.

In terms of mediation factors, differences have been identified between increased participation in hobby clubs and sports groups (i.e., regularly going out and having relationships with neighbors have been found to contribute to more frequent participation in hobby clubs and sports groups, respectively). This indicates that it is easier to participate in hobby clubs without a solid purpose (such as strong health consciousness) than sports groups; hence the high frequency of going outdoors, which provides more opportunities to attain information about group activities, has been found to manifest a positive relationship with increased participation in hobby clubs rather than sports groups. Sports activities such as ground golf and golf also require equipment (clubs and balls) to participate, which is easy for each neighborhood unit to own and maintain. Sports group activities therefore require a relatively strong relationship between neighbors, especially in Japan, whereas hobby clubs are usually focused on recreational purposes.

Population decline means that the sustainability of urban services is an issue. Compact cities that maintain urban services despite a reduction in population have thus attracted considerable attention (Bramley et al., 2009; Mouratidis, 2018b). Therefore, population decline could possibly make it difficult to build additional facilities in each neighborhood. Given that spatial agglomeration/dispersion of facilities are related to an increase in participation, the choice of facility location can be an alternative policy option for facilitating older adults' participation in

recreational group activities. In this case, support for neighborhood facilities (in the form of monetary subsidies, for example) may help private entrepreneurs who manage necessary service facilities to continue their operation or act as an incentive to move to another location. Policymakers might be able to weigh the costs and benefits of building additional facilities versus those of supportive policies for neighborhood facilities in facilitating older adults' participation in recreational group activities; combining both may also be an option.

4.5.2 Limitations

This study has considered the effect of the spatial agglomeration of neighborhood facilities on growth in participation, but it has been marked by several limitations. One is that the index used to estimate spatial agglomeration did not include residential distribution, rendering it difficult to determine the relationship between the distance from the homes of older adults to facilities and spatial agglomerations, which may have a complex effect on changes in participation. Further research is required to identify the relationship between participation, proximity, and the spatial agglomeration of facilities.

Another limitation is the possible existence of a relationship with the spatial agglomeration of multiple facility types. Even though the spatial agglomeration of facilities has not been found to show a strong collinearity with other neighborhood-level variables, there may be a tendency for a facility type to be located near another facility type, potentially resulting in an amenable environment for multiple purposes of going out (i.e., going to the hospital in the morning, participating in hobby clubs in the afternoon, and going shopping and for dinner afterwards). The collocation and spatial agglomeration of multiple facility types has to be considered.

In addition, there is the modifiable areal unit problem (Fotheringham and Wong, 1991). The distance that the spatial agglomeration of facilities can affect is unclear. This study has tested the effect of spatial agglomeration in an elementary school district, yet spatial agglomeration can affect multiple school districts, and the range may vary for the facility type. A more detailed assessment of the effect of spatial agglomeration should address the range.

Moreover, given that our study sample tends to have good health, physical and cognitive disabilities could possibly be the confounders affecting one's decision regarding where to live as well as whether to participate in hobby clubs or sports groups, even though self-rated health and depression are included as confounders.

Chapter 5

Allocation Problem Considering Self-stigma of Participation

5.1 Introduction

The number of older adults (people aged 65 years and older) has increased rapidly in recent years in many countries and is expected to continue to increase up to 2050; among those countries, Japan has the fastest aging population (United Nations, 2019). Empirical studies (e.g., Thomas, 2011) suggest that social participation decreases the risk of physical and cognitive problems, which increase as people age. In addition, people who engage in group activities gain more benefits than those who do activities alone or in one-on-one interactions (Haslam et al., 2014; Kanamori et al., 2016). Therefore, to decrease the impact of population aging on healthcare expenditure, the Japanese government attempts to facilitate older adults' social participation (Ministry of Health, Labour and Welfare, 2016a). In order to provide opportunities for social interactions among older residents, community salons are proposed as a resident-centered community intervention (Hikichi et al., 2015; Haseda et al., 2019), and they are examples of preventive healthcare services (Hikichi et al., 2017; Hosokawa et al., 2019).

Studies on location–allocation problems deal with the association between the location of facilities and service-receivers and discuss how the facilities can best provide services and benefits for the service-receivers. In particular, the potential facility where individuals receive services is given as the solution to the allocation problem (which is a subproblem of the location–allocation problem). Previous studies on the location–allocation problem of healthcare service have supposed that every person is allocated to the closest facility to their home and receives preventive healthcare services (Dogan et al., 2020; Gu et al., 2010; Verter and Lapierre, 2002; Zarrinpoor et al., 2017). Although developing the facilities for group activities in older adults' neighborhood facilitates their participation (Haseda et al., 2019), the closest facility is not the only destination outside the home for group activities (York Cornwell and Cagney, 2017). Therefore, the allocation problem should take into account the fact that some older adults possibly go to facilities that are farther away, as well as the fact that some of them may not attend any group activities. However, this has not been mathematically solved.

This chapter aims to formulate the allocation problem (which does not assume that people always participate in group activities and use the closest facility) in terms of older adults' participation in group activities. Using the allocation model, policymakers can simulate how best to facilitate older adults' participation based on the population and facility location in a target area. The model also enables local service agents—such as comprehensive community care centers in the public sector that aim to facilitate older adults' participation for health promotion (as well as policymakers)—to assess participants' current allocation in their service area by comparing it with the model-driven allocation.

This chapter is structured as follows. First, I describe group activities in community salons and which factors can explain why not everyone engages in

the group activities or goes to the closest facility. The third section explains the model used in the study and outlines the analytic framework. The fourth section explores the results of the analysis and the final section discusses the study's main contributions and limitations.

5.2 Community Salons, Group Activity Participation, and Self-stigma

Community salons offer diverse activities that are physical or cognitive strengthening; socializing; and hobby/recreational activities (Nakagawa and Kawachi, 2019). Especially in the case of exercising or cognitive strengthening, healthcare professionals—such as nurses or therapists (not only volunteers)—support and engage in the activities (Ministry of Health, Labour and Welfare, 2016b). Given that the community salons provide exercising for both prevention and recreational activities, the facilities can be perceived by older people as places where they receive preventive healthcare or enjoy recreational activities.

Unlike other preventive healthcare services, such as flu shots, cancer screenings or blood tests, which are directly and immediately related to prevent life-threatening diseases, activity participation gradually affects people's health conditions. Therefore, it can be expected that people rarely consider activity participation as a highly prioritized daily routine owing to its requirement for long-term engagement. However, activity participation also provides benefits in terms of social capital, resulting in more opportunities for social support, another link for social interactions, and prevention of noncommunicable diseases. Therefore, strategies for more participation are necessary despite its limitation.

Even though older adults are interested in group activities that prevent functional decline, some of them say that they will not attend the program because they do not want be seen by their neighbors, with whom they have close relationships, as being elderly and needing support from others. Indeed, older adults opt against attending group activities at community salons because they perceive themselves sufficiently energetic (Iwasaki et al., 2019). Stigma is defined as the co-occurrence of all the following components—labeling a group, stereotyping the labeled group, separation of the labeled group from others, status loss which refers devaluation owing to the labeling, and discrimination owing to the negative stereotypes related to the labeled group (Link and Phelan, 2001). Self-stigma, which is also called internalized stigma, is defined as the internalization of the stigma related to a group (Corrigan et al., 2009; Quinn et al., 2015). The self-stigma does not necessarily result from other people's labeling, rather it comes from their own perception, and a person with self-stigma believes the negative stereotypes related to a group to be true of himself or herself (Corrigan et al., 2009; Quinn et al., 2015). In the context of participation in group activities at community salons, the definition of stigma and self-stigma can be applied as follows: (1) labeling and separation (people who engage in group activities at community salons and those who do not); (2) stereotyping (the community salon is a place where people receive healthcare); (3) status loss (people receiving healthcare are not healthy and energetic); (4) discrimination (not being healthy and energetic is dishonorable); and (5) internalization (an individual believes that the stereotype can be applied to himself/herself, if he/she engages in a group activity at a community salon). Therefore, the self-stigma related to community salon participation, which causes labeling avoidance, can be a factor explaining why some older adults hesitate to engage in group activities at community salons.

Self-stigma may also be a factor of why some older adults opt for engaging in a group activity at a facility farther away. In general, people are more likely to go to a destination with a shorter distance (better accessibility) from their home. Accessibility is defined as the ease of navigation for a resident to a given destination (Talen, 2003). On the other hand, at the facility with better accessibility, the possibility of meeting one's neighbors is also high. In terms of self-stigma, engaging in a group activity at a facility farther from one's home decreases the probability of a person meeting their neighbors at the same facility. Thus, there can be a trade-off relationship between accessibility and self-stigma, and the allocation problem should be discussed with the aim to achieve more participation of those with self-stigma.

Meanwhile, intergroup contact (through sharing experiences or perceptions between people with self-stigma and those who do not) is one of the major interventions for reducing self-stigma (Corrigan and Penn, 1999; Mittal et al., 2012; Pettigrew and Tropp, 2006). Intergroup contact reduces the stigma that comes from lack of information (Link and Cullen, 1986) and also has greater effects than other interventions (Corrigan and Fong, 2014). Sharing nonredundant information among people who have different backgrounds enables older adults to access informal social support (Granovetter, 1983) when they need help as they age. In terms of the sustainable participation of older adults, an assignment of participants for intergroup contact can be a solution. The term "assignment of participants" indicates an intervention that involves participants who have self-stigma engaging in group activities with people who do not have self-stigma and are not their neighbors. Meanwhile "allocation" decides the facility where participants engage in group activities and is affected by both accessibility, the impact of self-stigma, and the priority of the assignment for intergroup contact. The assignment of participation for

intergroup contact can also be considered within the allocation model.

In summary, self-stigma can be a factor of why older adults hesitate to participate in group activities and why some of them opt to engage in a group activity at a facility farther away. On the other hand, the assignment of participants for intergroup contact keeps older adults from meeting their neighbors at the same facility and facilitates the participation of older adults who are interested in group activities but have self-stigma. The location of residents' homes and facilities matter because accessibility and self-stigma (as well as assignment for intergroup contact) are related to the distance between homes and the facilities or between homes, respectively. Therefore, the geographical distribution of residents' homes and the facility has to be considered when we discuss the allocation problem. Given that it is hard to measure self-stigma (Vogel et al., 2006; Stevelink et al., 2012) and it is also difficult to only compare the difference between the distribution of residents and facilities available, I simulate the allocation model in a virtual city environment. The virtual city environment enables me to assume both the characteristics of residents and the location of their home—such as whether they have self-stigma and where they live—as well as the facility's location.

This study contributes as follows. First, it formulates the allocation problem (considering both accessibility and the self-stigma of group activity participation), which shows that people engage in group activities not only at the closest facility from their home but also at facilities that are farther away. It also tests which geographical settings of facilities and residents bring more participation or more intergroup contact. Finally, it checks whether people—especially existing participants (those who do not have self-stigma)—are allocated to a facility farther away for more participation and/or more intergroup contact.

5.3 Methods

5.3.1 Formulation of the Mathematical Problem

Utility of Participants

Participants are divided into two groups: those who have self-stigma and those who do not. The utility of an individual U_i is assumed to be an additive function owing to the convenience in calculation. I suppose that the utilities are equally weighted in terms of fairness between those two groups. Therefore, a non-weighted linear combination of the summation of utility of people within those two groups indicates the summation of utility of each individual.

The utility function of an individual U_i can be formulated as a weighted summation of benefit from activity participation B_p, inconvenience of distance to facility $C_{d_{ij}}$, cost of self-stigma $C_{\text{stig}_{ij}}$, and priority of assignment for intergroup contact $A_{\text{cont}_{ij}}$ (see Equation 5.1).

$$U_i = \begin{cases} B_{p_i} - C_{d_{ij}} & \text{if } \rho_i = 0 \\ B_{p_i} - C_{d_{ij}} - \alpha C_{\text{stig}_{ij}} + \beta A_{\text{cont}_{ij}} & \text{if } \rho_i = 1 \end{cases} \tag{5.1}$$

where the binary variable ρ_i indicates a factor that has a value: "1" if an individual i has self-stigma; "0" otherwise. A smaller weight of $C_{d_{ij}}$ which corresponds to individuals' mobility improvements, indicates that participants can navigate longer distances, so the impact of accessibility decreases. Given that the mobility improvements of individuals are not this study's major interest, I assume that the weight of $C_{d_{ij}}$ is fixed to 1 for the convenience, therefore I only consider the weight parameters of $C_{\text{stig}_{ij}}$ and $A_{\text{cont}_{ij}}$. The parameters α and β (take a value from 0 to 1) correspond to the impact of self-stigma on the utility and the level of priority of

assignment for intergroup contact, respectively. In addition, both the impact of self-stigma and the priority of assignment for intergroup contact are assumed to influence only the utility of people who have self-stigma.

Benefit from Activity Participation

The target of the model is those who are interested in group activities. Therefore, it is assumed that each individual gains benefit from activity participation. I also assume that the benefit from activity participation is equal among participants. The benefit is defined as follows:

$$B_{p_i} = \begin{cases} 1 & \text{if } \sum_{j \in J} x_{ij} = 1 \\ 0 & \text{otherwise} \end{cases}. \tag{5.2}$$

The decision variable x_{ij} (which have a value of 0 or 1) indicates whether an individual i is allocated to a facility j. A set of facilities where individuals are allocated is denoted by J. If an individual decides not to attend social activities, then the individual cannot gain a benefit.

Inconvenience of Distance to Facilities and Distance-decay Function

As the forms of distance-decay functions, the following four are representative and generally used to assess the accessibility to facilities: rectangular function; power function; negative exponential function; and Gaussian function. However, the power and exponential functions tend to decay too rapidly at short travel distances (Ingram, 1971; Fotheringham, 1983; Guy, 1983) compared with the Gaussian form, even though the accessibility will probably not be very different between short-distance trips. Therefore, the distance-decay function in this study is set to be the Gaussian form. The inconvenience of distance can be set to the accessibility

subtracted from 1 (under an assumption that people use local transportation, such as bus or subway, so the inconvenience slightly increases when the distance from an older person's home to an allocated facility is too far for them to walk). The inconvenience from an individual i to an allocated facility j is defined as follow:

$$C_{d_{ij}} = x_{ij}(1 - e^{-d_{ij}^2}). \tag{5.3}$$

Cost of Self-stigma

The cost of self-stigma is defined as the expected number of neighbors meeting at the same facility j where an individual i is decided to be allocated. Previous empirical studies explain the relationship between social network and geographical proximity (Latané et al., 1995; Sharmeen et al., 2014; Tillema et al., 2010). Those empirical studies have shown that the high frequency of face-to-face social interactions and greater social ties are related to the geographical proximity between a person and others. Assuming that neighbors living near to an individual have closer relationships, the expected number of neighbors meeting at the same facility is defined as follows:

$$C_{\text{stig}_{ij}} = \rho_i x_{ij} \sum_{i' \in I \setminus \{i\}} x_{i'j} e^{-d_{ij}^2}, \tag{5.4}$$

where the relationships with each neighbor are weighted by distance between two individuals, with Gaussian form as the accessibility to facilities. A set of individuals who are the target of allocation is denoted by I.

Priority of Assignment for intergroup contact

The intergroup contact is defined as the expected number of people (who do not have both self-stigma and close relationships) meeting at the same facility j for an individual i who has self-stigma. In the same way as the definition of the cost of self-stigma, the relationships between a person and others are weighted by distance between two individuals with Gaussian form (see Equation 5.5). To express the strategy to build connections among those who do not have close relationships (including those who have self-stigma and those who do not), the Gaussian form subtracted from 1 is used.

$$A_{\text{cont}_{ij}} = \rho_i x_{ij} \sum_{i' \in I \setminus \{i\}} x_{i'j}(1-\rho_i)(1-e^{-d_{ij}^2}) \tag{5.5}$$

Allocation Model

For the allocation model, a mixed integer quadratic programming is used. The objective is to maximize the summation of utility U_i of individual i. I use two types of decision variables. As previously mentioned, a binary variable x_{ij} indicates a decision of whether an individual i is allocated to a facility j. The variable y_i is a binary decision, which indicates that an individual i does not engage in group activities. Given that group activities require a certain number of participants and facilities have a maximum capacity, the number of people allocated to a facility is set to be a value between s_j (minimum number of participants requirement) and S_j (capacity of facilities). In addition, the distance from older adults' homes to an allocated facility is not further than h, which corresponds to the maximum distance that is easy for older adults to navigate. If the utility of an individual i is a negative

value, an individual i decides not to attend social activities ($y_i = 1$; $U_i = 0$). The formation of the allocation model can be expressed as follows:

Objective:

$$\max \sum_{i \in I} U_i \tag{5.6}$$

subject to:

$$U_i = \max\{B_{p_i} - C_{d_{ij}} - \alpha C_{\text{stig}_{ij}} + \beta A_{\text{cont}_{ij}}, 0\} \qquad \text{for } \forall i \in I \tag{5.7}$$

$$\sum_{j \in J} x_{ij} + y_i = 1 \qquad \text{for } \forall j \in J \tag{5.8}$$

$$s_j \leq \sum_{i \in I} x_{ij} \leq S_j \qquad \text{for } \forall j \in J \tag{5.9}$$

$$d_{ij} x_{ij} \leq h \qquad \text{for } \forall i \in I \tag{5.10}$$

$$x_{ij}, y_i \in \{0, 1\} \qquad \text{for } \forall i \in I, \forall j \in J \tag{5.11}$$

$$0 \leq \alpha, \beta \leq 1 \tag{5.12}$$

No individual is permitted to be allocated to multiple facilities. Individuals are also not permitted to withdraw from attending group activities and be allocated to a facility at the same time.

5.3.2 Settings for the Virtual City and the Scenario-based Simulation

The residents (who are interested in group activities) and facilities (where people conduct group activities) are set to be distributed in a 2 km $\times$ 1 km area, which is a scale of two neighborhood districts. The density of residents and facilities are set to be 60 people and 6 facilities per square kilometer in the case of even distribution; 30 or 90 people and 3 or 9 facilities per square kilometer when those are unevenly distributed, respectively (Figure 5.1). A neighborhood (1 km $\times$ 1 km) corresponds to the unit of a certain density of residents/facilities. The locations of residents and facilities are uniformly and independently (randomly) generated in an area unit. The number of people with self-stigma is set to be 10 people (counted as the residents). I assume that they are evenly distributed in both cases (even and uneven distribution of residents) because people living in a populated area are less likely to have self-stigma (Stewart et al., 2015; Townley et al., 2017).

Based on the even and uneven densities regarding residents and facilities, we set four scenarios: (1) even distribution (both residents and facilities are evenly distributed); (2) concentrated facility location (only facilities are unevenly distributed); (3) concentrated residential location (only residents are unevenly distributed); and (4) uneven distribution (both residents and facilities are unevenly distributed). These are to see the differences in the results of the allocation model among the four scenarios.

5.3.3 Analysis

The model is simulated in a virtual city environment. Given that there are few group activities with less than five participants (Nagoya Council of Social Welfare,

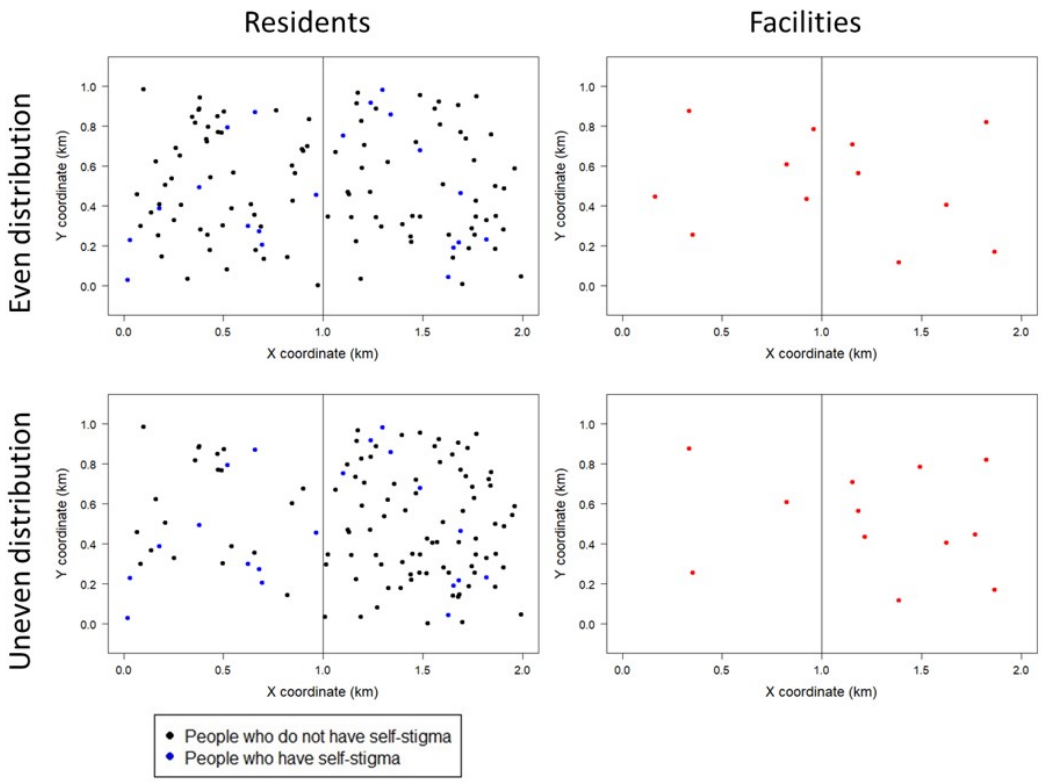

FIGURE 5.1: Geographical distribution settings of residents and facilities in the virtual city.

2019), the minimum number of participants requirement s_j is set to be 5. The capacity of facilities S_j is tested in the case of both 10 and 25—indicating a capacity that is exactly adjusted to the population of the virtual city and a capacity that is higher than the number of participants in many group activities (about 70%) at community salons (Nagoya Council of Social Welfare, 2019), respectively—and no capacity limitation. The maximum distance from an individual's home to an allocated facility is set to be 1 km, which is an average distance that older adults navigate for daily routines or social interactions (York Cornwell and Cagney, 2017). Cartesian distances are considered. The parameters α and β (which have a value from 0 to 1) are tested with 0.1 intervals. The numerical settings for all parameters are summarized in the Table 5.1 and 5.2.

TABLE 5.1: Parameters of the allocation model.

Parameters	
α	Impact of self-stigma on the utility: 0, 0.1, 0.2, $\cdots$, 1.0
β	Priority of assignment for intergroup contact: 0, 0.1, 0.2, $\cdots$, 1.0
h	A parameter indicating walkable distance: 1km
s_j	Minimum number of participants required to do a group activity at a facility j: 5
S_j	Capacity of a facility j: 10, 25, and ∞
ρ_i	1 if an individual i has self-stigma; 0 otherwise

TABLE 5.2: Settings of the virtual city.

(Residents, Facilities)		Facilities	
		Even	Uneven
Residents [yes/no][a]	Even	([10/50], 6), ([10/50], 6)	([10/50], 3), ([10/50], 9)
	Uneven	([10/20], 6), ([10/80], 6)	([10/20], 3), ([10/80], 9)

Note. The settings are displayed by each unit (1km $\times$ 1km) of the virtual city (2km $\times$ 1km). The values indicate the number of residents or facilities in a neighborhood which corresponds to the unit (1km $\times$ 1km) of a certain density of residents or facilities. [a] The number of residents who have self-stigma (yes) and do not (no) is displayed.

The simulation is conducted in three steps (Figure 5.2). First, I test the difference in both the percentage of participants (activity participation) and the percentage of people who engage in group activities with people who do not have self-stigma (intergroup contact) among people who have self-stigma, when parameters change under a circumstance of even distribution. I also check whether there is a penalty for existing participants, which is assessed by the distance from the individual's home to the allocated facility. Finally, I compare the results of four scenarios in terms of activity participation, intergroup contact, and distance to the allocated facility.

To execute the model, Python (ver. 3.7.7) and Gurobi solver (ver. 9.0.2) are used. The solution is obtained using a branch and cut algorithm. The lower bound converges toward a certain value rapidly, while the upper bound does so slowly. This indicates that the model is too difficult to obtain a single feasible solution. Therefore, the model is terminated after 10,000 seconds of calculation—using two processors (Intel Xeon Silver 4210, 20 cores and 40 threads).

5.4 Results

5.4.1 Sensitivity Analysis under Even Distribution of Residents and Facilities

Changes in the Impact of Self-stigma

Figure 5.3 shows both the percentage of activity participation and that of intergroup contact by each capacity level of facilities when the impact of self-stigma changes. People with self-stigma are more likely to participate in group activities

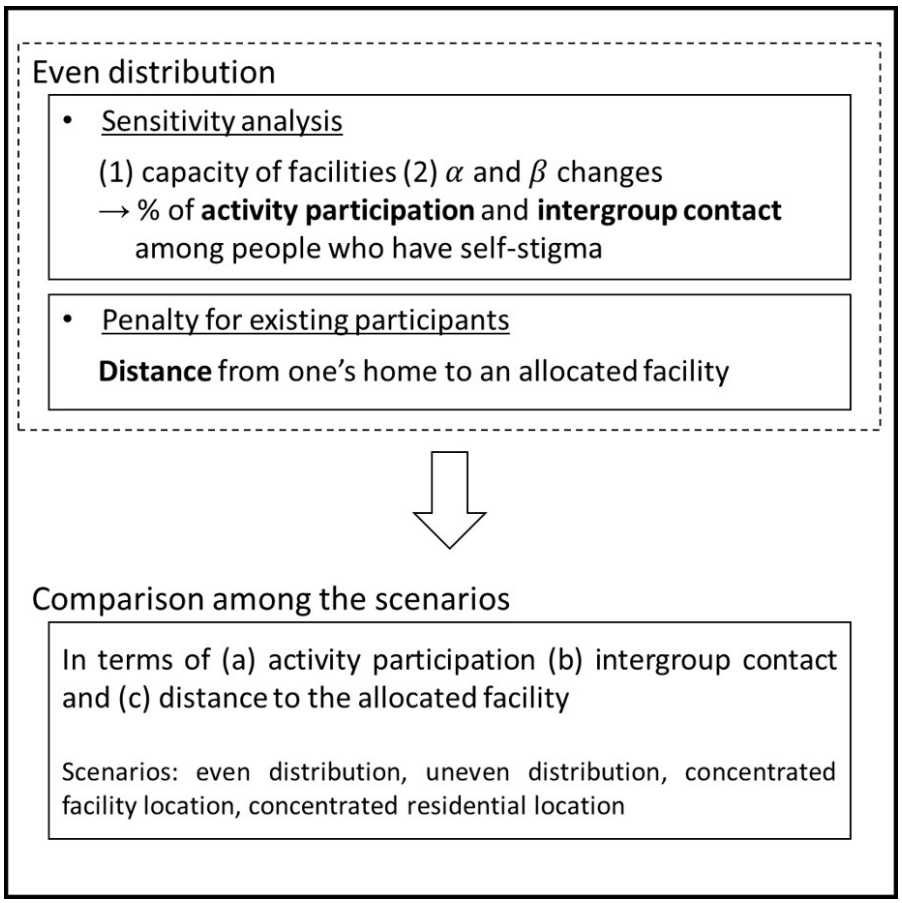

FIGURE 5.2: Framework of the sensitivity analysis and the simulation comparing the four scenarios. Activity participation indicates the percentage of people who participate in group activities among those who have self-stigma. Intergroup contact indicates the percentage of participants who have self-stigma engaging in group activities with those who do not have self-stigma.

when the impact of self-stigma is small; however, there are differences in the percentage of activity participation between the capacity levels of facilities. More people with self-stigma tend to participate in group activities in the case of large capacity ($S_j = 25$) than in the case of capacity adjusted exactly to population ($S_j = 10$). In addition, the percentage of activity participation in the case of extremely large capacity ($S_j = \infty$) completely matches with the percentage in the case of large capacity ($S_j = 25$). Therefore, there is a limitation in the capacity of facilities to gain

greater benefits in terms of more participation of people who have self-stigma, even though a larger capacity of facilities gives greater benefits than a smaller capacity.

In terms of the percentage of people who have intergroup contact, there is a time-lag in the increase compared to the percentage of participants. It shows that there are individuals who have self-stigma who participate in group activities only with people who also have self-stigma; this is true even when the impact of self-stigma is small (e.g., compare between the case of $\alpha = 0.3$ and $\alpha = 0.1$). As a result, there could possibly be a segregation of activity groups between those who have self-stigma and those who do not, even though the smaller impact of self-stigma results in more participation of people with self-stigma.

Changes in the Priority of Assignment for Intergroup Contact

Figure 5.4 shows both the percentage of participants (among people who have self-stigma) and their percentage engaging in group activities with people who do not have self-stigma when the priority of assignment for intergroup contact changes. The capacity of facilities is set to 25 for the comparison. People with self-stigma are more likely to participate in group activities when the priority of assignment for intergroup contact is high. In addition, the increasing speed of activity participation percentage (when the impact of self-stigma is small) is faster than that of the bigger impact. Given that the allocation is prioritized for intergroup contact, most of the participants with self-stigma engage in group activities with people without self-stigma. Especially in the case of a greater impact of self-stigma, participants who have self-stigma are more likely to engage in a group activity with those who do not have self-stigma.

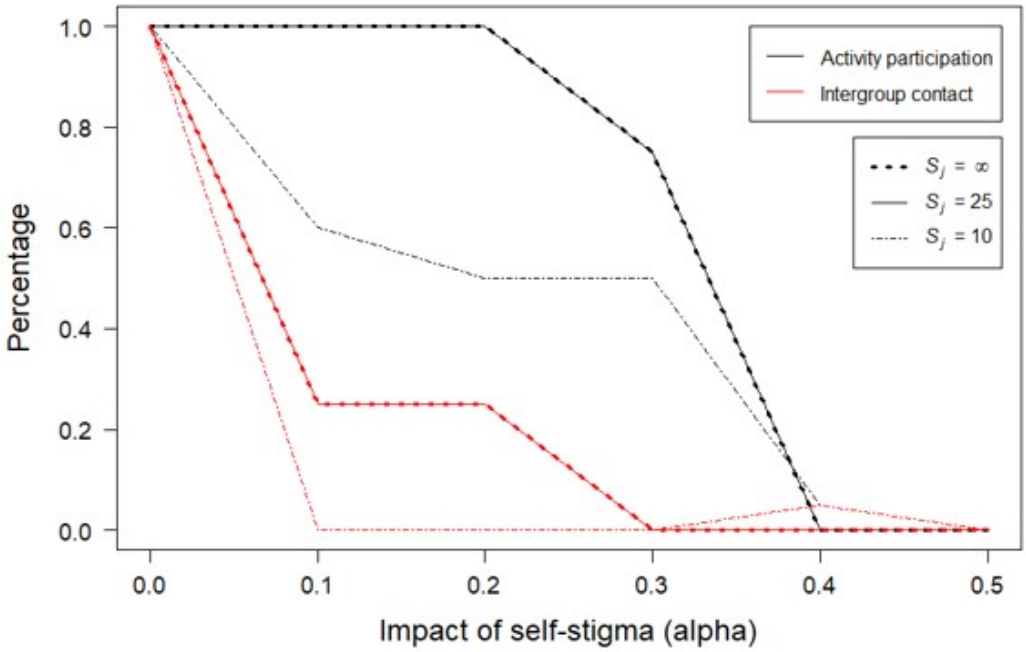

FIGURE 5.3: The percentage of activity participation and the percentage of intergroup contact when the impact of self-stigma changes. Activity participation indicates the percentage of people who participate in group activities among those who have self-stigma. Intergroup contact indicates the percentage of participants who have self-stigma engaging in group activities with those who do not have self-stigma. The results for the people who have self-stigma are displayed. S_j indicates the capacity of facilities.

Distance from Participants' Home to Allocated Facilities

Even though a small impact of self-stigma or high priority for the intergroup contact results in more participation of those with self-stigma, it also sacrifices existing participants' accessibility to facilities (distance from their homes to allocated facilities). Figure 5.5 shows the distribution of distance to the allocated facilities by each setting of α and β. As seen in the case that (α, β) is equal to (0.5, 0.2), existing participants (those who do not have self-stigma) are allocated to facilities near their home (under 0.2 km), while people who have self-stigma are allocated to facilities at a farther distance (over 0.4 km). However, as the impact of self-stigma becomes

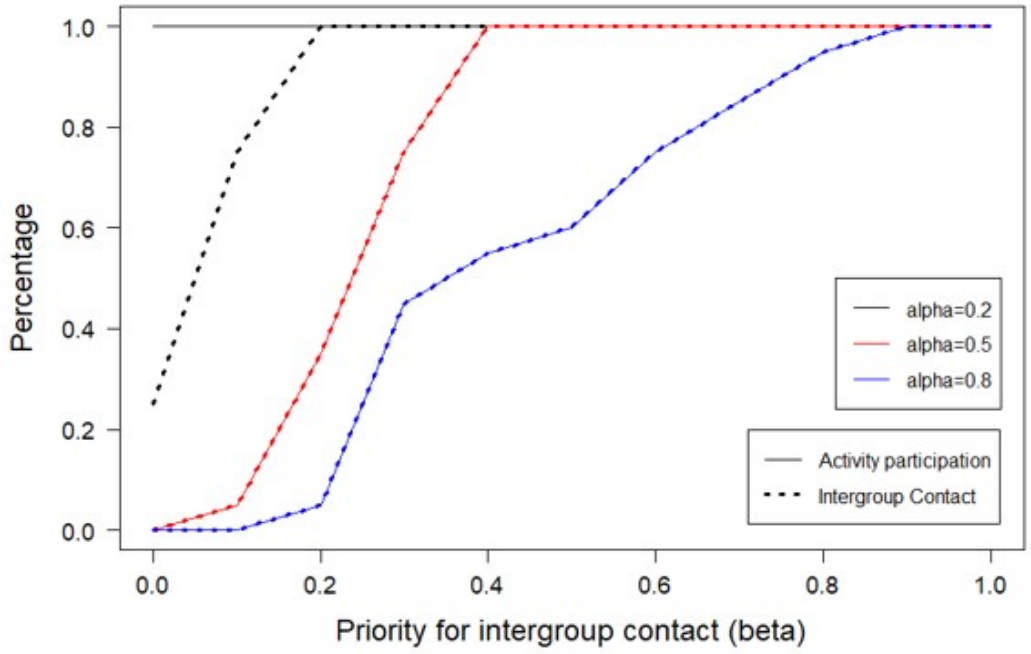

FIGURE 5.4: The percentage of activity participation of intergroup contact when the priority of assignment for intergroup contact changes. Activity participation indicates the percentage of people who participate in group activities among those who have self-stigma. Intergroup contact indicates the percentage of participants who have self-stigma engaging in group activities with those who do not have self-stigma. The capacity of facilities is fixed to 25. The results for the people who have self-stigma are displayed.

smaller or the level of priority for intergroup contact becomes higher, the range of distance (to an allocated facility) of those two groups becomes similar. Given that people who have self-stigma rarely participate in group activities when (α, β) is equal to (0.8, 0.2), participants (who do not have self-stigma) are more likely to be allocated to the closest facility. This indicates that some existing participants could possibly be allocated to a facility farther away for greater social benefits, such as more participation and more intergroup contact.

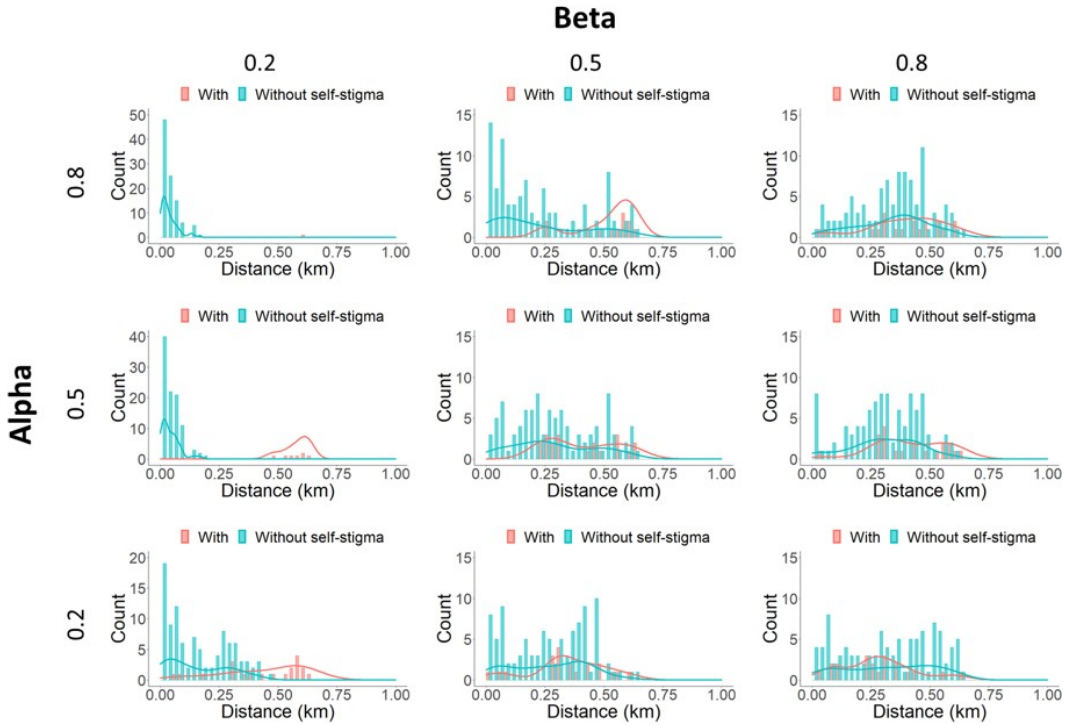

FIGURE 5.5: The distribution of distance to the allocated facilities. Alpha and beta correspond to the impact of self-stigma and the priority of assignment for intergroup contact, respectively. The bin width of each histogram is set to be 0.25.

5.4.2 Comparison among the Four Scenarios

Figure 5.6 shows the percentage of participants among people who have self-stigma and the percentage of them who engage in group activities with those who do not have self-stigma by each distribution scenario when the impact of self-stigma changes. The capacity of facilities is fixed to 25 for the comparison. Both activity participation and intergroup contact show higher percentage in the case of concentrated residential location than concentrated facility location at any level of the impact of self-stigma.

However, it is difficult to compare other pairs of scenarios overall because their order becomes different by the level of the impact of self-stigma. Therefore, for each scenario, the area below the line of intergroup contact (denoted by Δ_1) and

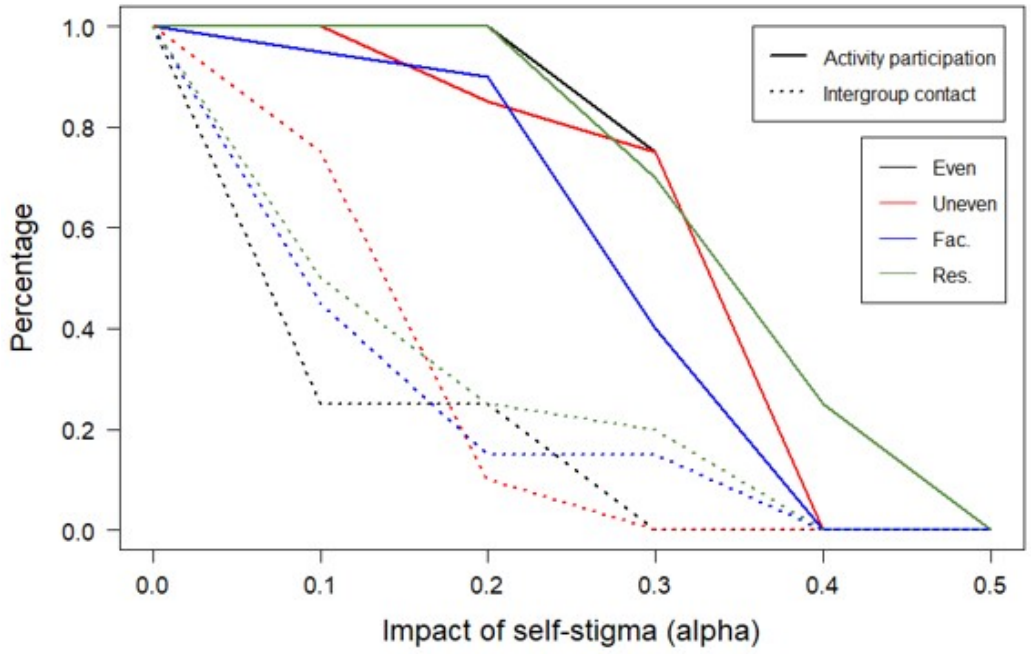

FIGURE 5.6: Differences among scenario in the percentage of activity participation and intergroup contact. Activity participation indicates the percentage of people who participate in group activities among those who have self-stigma. Intergroup contact indicates the percentage of participants who have self-stigma engaging in group activities with those who do not have self-stigma. The results for the people who have self-stigma are displayed. Even: even distribution; Uneven: uneven distribution; Fac.: concentrated facility location; Res.: concentrated residential location. The capacity of facilities is fixed to 25.

that between lines of activity participation and intergroup contact (denoted by Δ_2) are used to assess the overview of each. Figure 5.7 summarizes the calculated areas by each scenario. To assess which distribution scenario is superior to other scenarios in terms of the easiness for people who have self-stigma to engage in group activities with people who do not have self-stigma, the area ratio (Δ_1/Δ_2) is used[1].

[1]Two indices, $\Delta_1/(\Delta_1+\Delta_2)$ and Δ_1/Δ_2, can be considered to assess the potential to have intergroup contact. The followings compare the two indices. Let $\lambda = \Delta_1/(\Delta_1+\Delta_2)$ and $\mu = \Delta_1/\Delta_2$, then $1/\lambda = (\Delta_1+\Delta_2)/\Delta_1 = 1+\Delta_2/\Delta_1 = 1+1/\mu = (\mu+1)/\mu$. Therefore, $\lambda = \mu/(\mu+1)$. Given that the area below the line does not have negative values, λ and μ always have non-negative values ($0 \leq \lambda \leq 1$ and $0 \leq \mu$). λ and μ are bijective, therefore, both indices mean the same. On the other hand, the value of μ is more sensitive to changes in Δ_1 than that of λ. Therefore, Δ_1/Δ_2 is a more appropriate index than $\Delta_1/(\Delta_1+\Delta_2)$ to assess the differences among scenario.

The higher value of Δ_1/Δ_2 corresponds to the higher potential to have intergroup contact when an individual with self-stigma participates in group activities. In the case of concentrated facility location, Δ_1/Δ_2 has the highest value (0.833), but the lowest value (0.444) in the case of even distribution. This indicates that the concentrated facility location is a geographical setting for intergroup contact. On the other hand, people with self-stigma are more likely to participate in group activities only with people who also have self-stigma (i.e., participants at each facility are more likely to be homogeneous), in the case of even distribution—as well as uneven distribution and concentrated residential location—compared with the concentrated facility location. However, a larger number of participants (who have self-stigma) is expected in those cases (especially in the case of concentrated residential location).

Figure 5.8 shows the percentage of activity participation and intergroup contact for each scenario when both the impact of self-stigma and the priority for intergroup contact change. Similarly to the case of even distribution, people who have self-stigma tend to participate in group activities, and they engage in a group activity with those who do not have self-stigma owing to the high priority of assignment for intergroup contact. People who have self-stigma do not participate in group activities when (α, β) is equal to (0.5, 0.0) (as displayed in Figure 5.6), they are found to participate when (α, β) is equal to (0.5, 0.2), and the concentrated facility location has more participants than other scenarios. A similar trend is also found in the case where (α, β) is equal to (0.8, 0.2) and (0.8, 0.5). This indicates that the concentrated facility location is the geographical setting in which more participants who have self-stigma are expected to engage in group activities with those who do not have self-stigma when the assignment is prioritized for intergroup contact.

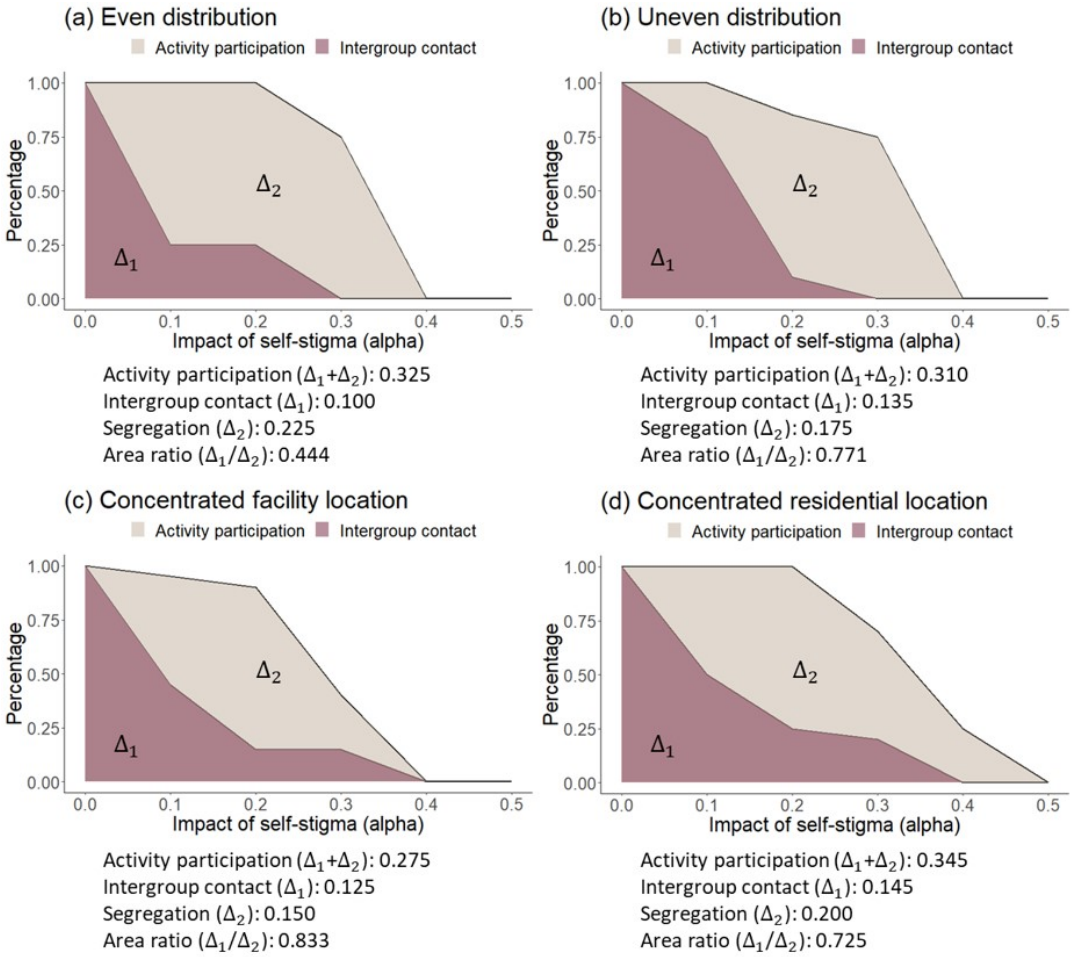

FIGURE 5.7: Assessment for the overview by each scenario.The area below the line of intergroup contact is denoted by Δ_1, and Δ_2 corresponds to the area between two lines of activity participation and intergroup contact.

Figure 5.9 shows the box plots that indicate distance distribution (from participants' homes to allocated facilities) by each group (participants with and without self-stigma). The box plots display the mean, median and the upper and lower quartiles of distance from the participants' homes to the allocated facility. The narrower range between the upper and lower quartiles indicates that the distribution has the smaller variance. In terms of distance distribution, the same tendencies (which are of the even distribution) are found in every scenario (e.g., people who

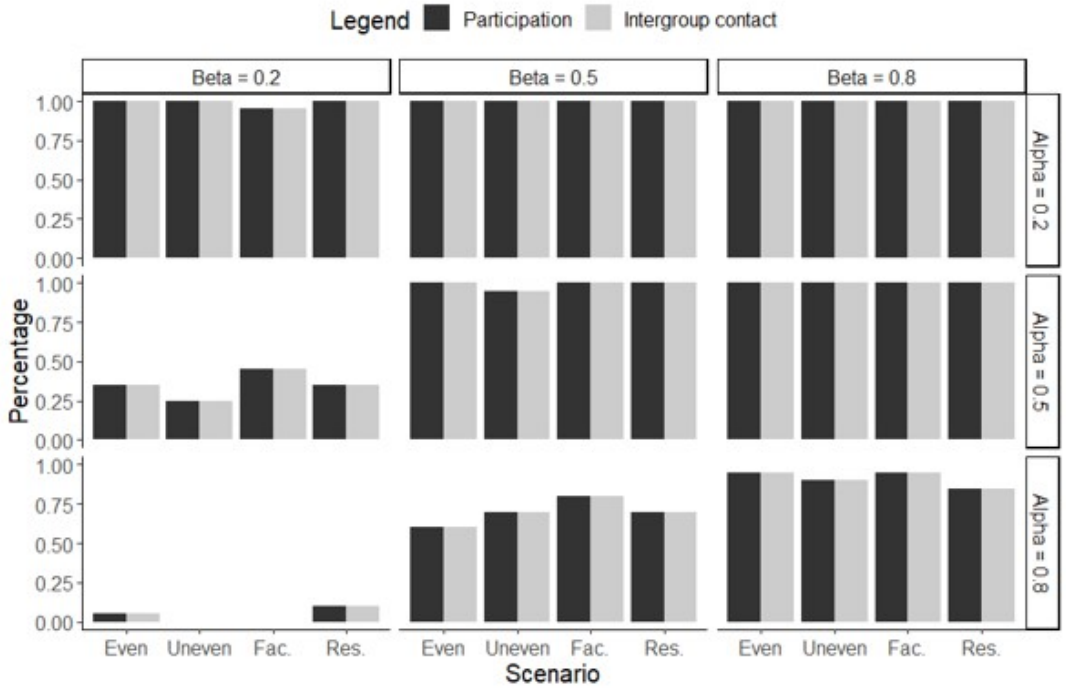

FIGURE 5.8: Differences among scenarios in the percentage of activity participation and intergroup contact. Alpha indicates the impact of self-stigma. Beta indicates the priority for intergroup contact. The capacity of facilities is fixed to 25. Even: even distribution; Uneven: uneven distribution; Fac.: concentrated facility location; Res.: concentrated residential location.

have self-stigma are allocated to facilities farther away, while people who do not have self-stigma are allocated to facilities near their home; the range of distance of those two groups becomes similar when the impact of self-stigma becomes smaller or the level of priority for intergroup contact becomes higher). On the other hand, differences in the distance distribution among the scenarios are also found. Existing participants (people who do not have self-stigma) of concentrated facility location have higher values in the mean, median and the upper and lower quartiles of distance (i.e., most of the existing participants tend to be allocated to farther facilities) than other scenarios when the level of priority for intergroup contact is

high ($\beta = 0.8$); however, this is not true at lower priority. In the case of uneven distribution, existing participants (people who do not have self-stigma) are less likely to sacrifice their accessibility to allocated facilities than those of other scenarios for greater social benefits (i.e., both the mean and median distance of existing participants tend to be closer than other scenarios; the higher and lower quartile tend to have lower and higher value, respectively). Although there are differences in the distance distribution among the scenarios, most of the participants (both people who have self-stigma and those who do not) are allocated to the facilities within a walkable distance (600 m).

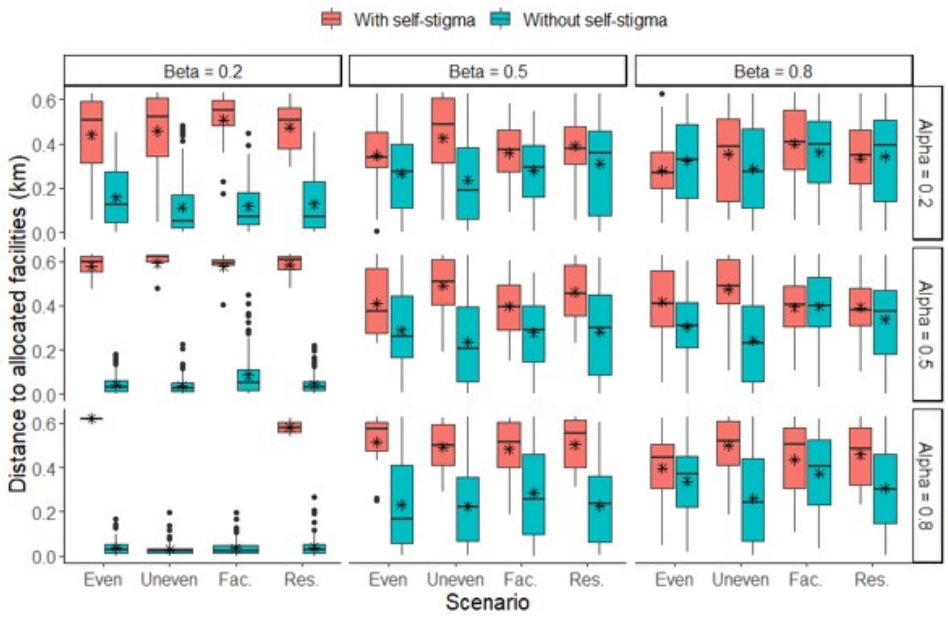

FIGURE 5.9: Differences among scenarios in the distance distribution of participants who have self-stigma and do not. Alpha indicates the impact of self-stigma. Beta indicates the priority for intergroup contact. Asterisks used in the box plots are correspond to the mean distance by each group (people who have self-stigma and do not). The capacity of facilities is fixed to 25. Even: even distribution; Uneven: uneven distribution; Fac.: concentrated facility location; Res.: concentrated residential location.

5.5 Discussion

5.5.1 Main Findings

This chapter has formulated the mathematical optimization problem regarding the allocation of group activity participants to facilities. Using the allocation model considering both accessibility and self-stigma, it can be expressed that people engage in group activities at not only the closest facility to their home but also a farther facility. People who have self-stigma have been found to be more likely to participate in group activities when the impact of self-stigma is small. Even though the number of people with self-stigma engaging in group activities with people who do not have self-stigma also increases when the impact of self-stigma becomes smaller, some of them have been found to keep engaging in group activities with only people who also have self-stigma.

The segregation between participants (both those with and without self-stigma) implies that the groups where people with self-stigma engage can select their activity content, which satisfies their preference. Given that people who have self-stigma opt against being seen by neighbors as being elderly and needing healthcare services, they possibly prefer and engage in group activities that are more vigorous and more recreational. Therefore, the reason why older adults engage in other group activities rather than programs at community salons is not only their interest (which is a process of selection) in activity contents, but also avoidance (which is a process of elimination).

Even though both the small impact of self-stigma and the high priority of assignment to intergroup contact result in more participation of people with self-stigma, they could possibly lead to existing participants (people who do not have self-stigma) having to sacrifice their accessibility to allocated facilities. However,

all the participants of every scenario have been found to be allocated to facilities within a walkable distance, therefore the allocated facilities are easy enough to navigate even though they are not the closest. Amongst the scenarios, uneven distribution has been found to have the least disadvantages (in terms of the distance) for the existing participants, as well as increasing the participation of those who have self-stigma (besides intergroup contact). Given that the distance that is easy to navigate for older adults decreases as they age, uneven distribution can be suggested as the geographical setting for the sustainable participation of older adults in group activities, especially when both accessibility and self-stigma are considered.

An area of high population density possibly has greater availability of local facilities for daily living or physically accessible features (such as sidewalks), therefore, high population density makes it easy for older adults (both with and without mobility limitation) to engage in social activities (Hand and Howrey, 2019). Transforming a low-density city into a compact city can be one option to maintain the service level of the area, especially in an area which people do not migrate into. However, the migrations of residents and facilities for group activities do not always take place at the same time (a scenario where either residents or facilities migrate in advance is the worst possible case), leading to concentrated residential location or concentrated facility location, respectively. As the comparison among scenarios indicates, migration of residents (concentrated residential location) can be prioritized to facilities (concentrated facility location) in terms of more participation when policymakers opt for transforming a local area into one of high population and facility density (uneven distribution).

On the other hand, the concentrated facility location has been found to be the geographical setting for more intergroup contact between people who have

self-stigma and those who do not. In an area where the facilities are concentrated (but not the residents), assignment to intergroup contact of participants with self-stigma may have greater benefits because the intergroup contact increases the opportunities to share nonredundant information with each other and to receive informal social support. Therefore, policymakers should consider both the geographical distribution (of residents and facilities), the impact of self-stigma, and intergroup contact when they discuss how the policies for older adults' social participation can best result in more social benefits.

5.5.2 Limitations

Several limitations of this study should be acknowledged. I simulated the allocation model in a virtual city environment. Therefore, it is hard to conclude that differences in geographical distribution of facilities and residents (as well as reduced impact of self-stigma and assignment to intergroup contact and relocation of facilities and residents) affect older adults' participation and intergroup contact in real cities. Further studies are required to test the usefulness of those interventions and the validity of the model's applications to real cities for solid empirical evidence.

When the allocation model is applied to real cities, some modifications regarding distance or self-stigma can be considered because we used Cartesian plane distance and a binary variable (indicating whether an individual has self-stigma or does not) to simplify the model. For example, network distance can be used instead of Cartesian because it is the most accurate and expresses the real world (Logan et al., 2019). Furthermore, the binary variable can also be modified as a continuous variable that corresponds to a scale of having self-stigma for an individual if it is measurable (although there are several issues with indices measuring self-stigma:

Vogel et al., 2006, Stevelink et al., 2012). Those modifications and applications to real cities should be addressed in future work.

I assumed that there is the best time for group activities and simplified the allocation problem being spatial allocation. However, many community salons and facilities for group activities provide many programs by each facility for a day at different time. Participants can be allocated to the same facility but different group activities at different time. Therefore, the model should be combined with the scheduling problem so it can be extended to spatio-temporal allocation problem.

In addition, I assumed that the benefit from activity participation is equal among participants. However, there are diverse types of group activities, and those activities possibly give different levels of benefits. To extend the allocation model tested in this study to the location-allocation model for multiple types of facilities for group activities, the different levels of benefits from engaging in different types of activities should be included into the model.

Chapter 6

Conclusions and Future Work

6.1 Review of the Research Objectives and Findings

Japan is facing the fastest rate of population aging in the world. To improve older adults' quality of life and health condition, the government aims to facilitate their participation in recreational group activities. Given that interventions related to land use are possible through urban planning, which affects all the people who reside in the area, urban facilities within older adults' neighborhoods can be considered a key factor in facilitating their participation. Previous studies suggest that there is a positive correlation between the number of facilities in a neighborhood and the participation of older adults; however, little is known about the optimal benefit of the number of facilities and their geographical distribution (the latter of which is especially important for a district plan for health promotion) on facilitating older adults' participation.

The major research objective of this dissertation is to clarify whether the development of urban facilities within neighborhoods can facilitate older adults' participation in recreational group activities, if so, how urban facilities affect. First, I take into account the nonlinear relationship between facility density and participation of older adults in hobby clubs and sports groups, and test whether there is a

certain facility density that has the highest likelihood of increases in the frequency of activity participation. Second, I test the significance of the direct and indirect effects of the spatial agglomeration/dispersion of neighborhood facilities and their accessibility on the changes in the participation of older adults. Finally, I formulate an allocation problem which does not assume that people always participate in group activities and use the closest facility. Using the allocation model, I test which geographical settings of facilities and residents bring more activity participation.

When analyzing the effect of neighborhood facilities on the changes in activity participation, many factors must be considered. Chapter 2 briefly reviews previous studies and theories regarding behavior change and urban amenities, and the relationships between the two concepts. The literature review in the chapter elucidates several points of this dissertation's originality. I utilize panel data to test the effect of urban facilities within neighborhoods which allows me to measure intra-individual changes in the frequency of participation. The longitudinal study enables me to infer causal relationships between the neighborhood environment and older adults' participation based on the temporal precedence of causes. It also helps to exclude the self-selection bias that results from selective migration (i.e., people who consider participation an important attribute for life satisfaction migrate to an amenable neighborhood) when estimating the effect of neighborhood facilities. Differences in the effect of each type of neighborhood facilities are also considered. The neighborhood facilities are categorized based on the major destinations that are frequented by older adults when they go outside their homes. Furthermore, this dissertation mathematically solves an allocation problem, which takes into account the fact that some older adults go to facilities farther away.

Chapter 3 investigates the relationship between the changes in the density of neighborhood facilities and changes in older adults' participation in hobby clubs

and sports groups. This chapter aims to test the nonlinear relationship between facility density and the increases in the frequency of activity participation. The results indicate that the density of urban facilities within neighborhoods is related to the increases or decreases in older adults' participation in recreational group activities, in addition to the frequency of their activity participation. In the case of food stores, an inverted U-shaped relationship between the facility density and the increases in the frequency of participation in sports groups is found, as compared to a U-Shaped relationship in the case of medical and welfare facilities.

Chapter 4 examines whether the geographical distribution of neighborhood facilities can facilitate older adults' participation in hobby clubs and sports groups, as well as their accessibility. The results show that both accessibility and the geographical distribution of facilities are related to increases in participation. The spatial agglomeration of eating places is found to increase opportunities for meeting friends and enable participation in both hobby clubs and sports groups; dispersed eating places, however, correlate with good relationships with neighbors, which facilitates sports group participation. Additionally, the agglomeration of food stores is found to have a positive correlation with participation growth in sports groups. In general, accessibility to neighborhood facilities is found to increase older adults' participation; however, the accessibility of city parks is found to exhibit a negative indirect effect that is mediated by relationships with neighbors regarding participation growth in sports groups.

The U-shaped relationship of the density of medical and welfare facilities and the negative indirect effect of accessibility of city parks imply that some older adults hesitate to participate in group activities at facilities that are close to their

home (Figure 6.1). Self-stigma can be a factor of why older adults hesitate to participate in group activities and why some of them opt to engage in a group activity at a facility farther away from their home. Chapter 5 formulates an allocation problem, considering both accessibility and the self-stigma of group activity participation, which does not assume that people always participate in group activities and use the closest facility, and applies the model to the case of community salons. Using the allocation model considering both accessibility and self-stigma related to community salon participation, this chapter tests which geographical settings of facilities and residents bring more participation or more intergroup contact between people with and without self-stigma. The results indicate that there could be a segregation of activity groups between people with and without self-stigma. By comparing various solutions from different geographical settings of residents and facilities, I determine that a larger number of participants is expected in the case of concentrated residential location. Concentrated facility location, however, is found to be a geographical setting for more intergroup contact between people who have self-stigma and those who do not. In the case of an uneven distribution, people without self-stigma are less likely to sacrifice their accessibility to allocated facilities.

6.2 Policy Implication

The findings in this dissertation suggest that the development of urban facilities within neighborhoods can help promote older adults' participation in hobby clubs and sports groups. However, even though increasing the number of neighborhood facilities can facilitate their participation, population decline could possibly make policymakers less willing to build additional facilities in each neighborhood

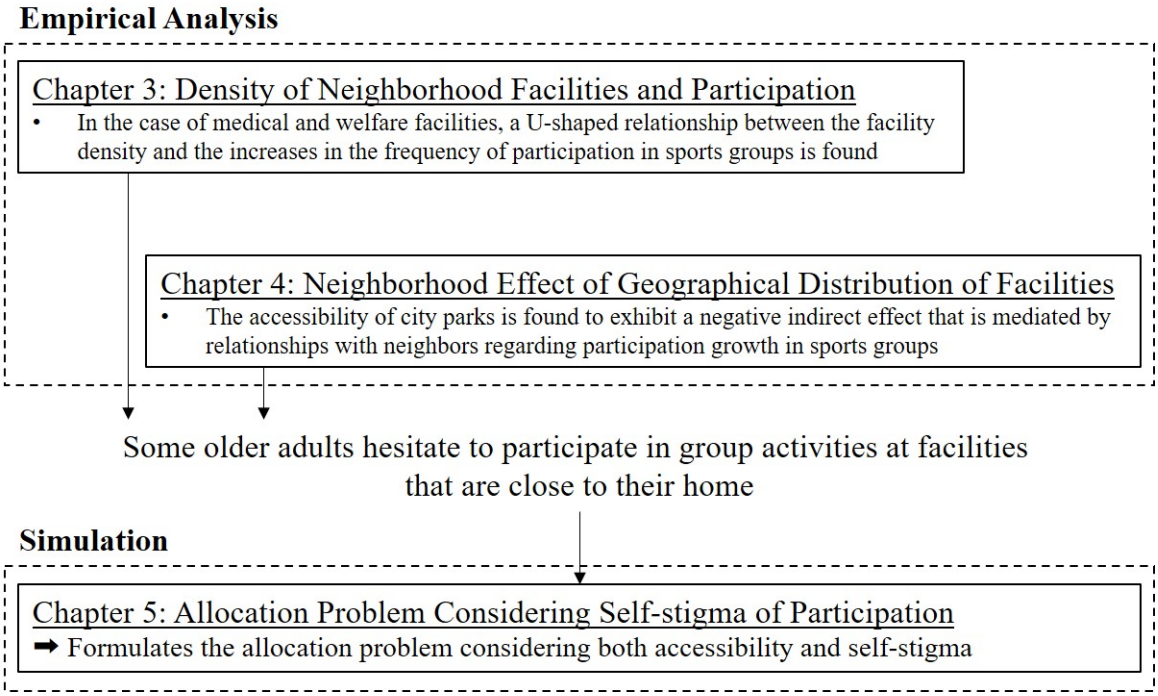

FIGURE 6.1: The findings from Chapter 3 and 4 and their relationships with the objective of Chapter 5.

of older adults. Given that both accessibility and geographical distribution of facilities are related to an increase in participation, long-term district planning through zoning, which controls the facility use in the area, can be an alternative policy option for facilitating older adults' participation in recreational group activities. In this case, support for neighborhood facilities (in the form of monetary subsidies, for example) may help them to continue operation at the current address or act as an incentive to move to another location within the neighborhood. Policymakers might be able to weigh the costs and benefits of building additional facilities versus those of supportive policies for neighborhood facilities in facilitating older adults' participation in recreational group activities; combining both may also be an option.

Both recreational and non-recreational types of urban facilities within neighborhoods have been found to affect older adults' participation in hobby clubs and

sports groups. Given that city parks have been found to exhibit the greatest effect, it is important to provide places for recreational activities in areas where people are less likely participate in recreational group activities. On the other hand, eating places and food stores, which are facilities for socializing or those providing services necessary in daily life, also have been found to increase older adults' activity participation. Therefore, a broad range of facilities should be considered when policymakers discuss policies or interventions to promote participation in recreational group activities. Policymakers might be able to weigh the costs and benefits of building each type of facilities, and consider which type(s) of facilities can be the target(s) of policies for facilitating older adults' participation in recreational group activities. For example, in an area which has sufficient city parks or has difficulty to build additional city parks, considerations regarding the development of non-recreational facilities (cafés, restaurants, grocery stores, etc.) could assist in building a more amenable neighborhood for participation in recreational group activities.

However, the findings also suggest that a larger number and better accessibility of facilities within neighborhoods do not always correlate to a growth in participation. For example, cafés and restaurants in a neighborhood can provide places for social interaction, but the increased number of those facilities may not directly increase participation in group activities. In addition, a short distance to the food stores might rarely create opportunities for chance encounters or for obtaining information about group activities when older adults go outdoors for grocery shopping. Furthermore, older adults may not engage in activities at the park in their neighborhood where they have close relationships with their neighbors. Therefore, when urban planners discuss the amenable area for participation, it is necessary to consider the dynamics related to socializing and opportunities for new

social connections, as well as the accessibility to urban facilities.

Furthermore, the findings suggest that there could be some sort of self-stigma involved when older adults opt against participating in group activities at the facilities within the neighborhood where they reside. Therefore, both self-stigma and accessibility to facilities providing places for recreational group activities should be considered when policymakers discuss the geographical distribution of facilities.

6.3 Future Work

Although this dissertation raises new concerns regarding district planning for the health promotion policy, several limitations should be acknowledged.

The analyses in Chapter 3 and 4 target a specific study area or focus only on urban facilities, therefore, thoughtful consideration is required to apply the findings to another area. The study area in Chapter 3 is one of the three major metropolitan areas with a high population density, therefore, the relationship—that older adults' activity participation is difficult to increase in areas where a facility density is too high—could possibly not be found in areas with a low population and facility density. In the case that some older adults hesitate to participate in group activities at close facilities, different tendencies could possibly be found owing to the reasons as follows: lower negative impact of the facilities because of a low facility density; a higher likelihood of people living in areas with a low population density to consider neighbors' eyes because of closer relationships with them. The possible difference in trends of the relationships should be considered. Chapter 4 expands the study area to 10 municipalities in Aichi Prefecture, however, the chapter focuses only on urban facilities, as in Chapter 3. In other

words, the analyses in Chapter 3 and 4 could not sufficiently consider other possible neighborhood-level variables. Density and spatial agglomeration/dispersion of urban facilities in a neighborhood could possibly be surrogate indicators of other neighborhood-level variables. Even though random effect is used to consider those unobserved neighborhood-level variables, the random effect does not take into account possible confounding variables and mediation variables. Therefore, future studies should compare the trends of neighborhood effect among areas with comprehensive consideration regarding other neighborhood-level variables, including socio-economic neighborhood characteristics and road networks, not only urban facilities.

Furthermore, this dissertation considers five types of urban facilities: city parks and community centers as representative recreational facilities (private recreational facilities are included in Chapter 3); eating places, food stores, medical and welfare facilities as major destinations of older adults when they go outdoors. However, informal places for recreational group activities are not sufficiently considered in this study because the information regarding temporary uses of vacant tenants and activities outside urban facilities is difficult to be obtained. Those temporary or informal uses of places could be a way how older adults conduct and engage in group activities (Garvin et al., 2013; Kawakita and Urayama, 2004). Therefore, qualitative studies exploring how people use space, as well as further data collection regarding the temporary or informal uses, are necessary. In this case, perceptions and values of people, including tenant-owners, toward participation in group activities and places for the activities should also be considered.

Given that it is difficult to get detailed information about the geographical location of older adults' homes, elementary school districts where older adults reside are used as a neighborhood unit; therefore, it is unclear exactly how far away

the urban facilities can be to still have an effect on older adults' participation. In other words, there is a modifiable area unit problem (Fotheringham and Wong, 1991). The scale, service quality, and attractiveness of each facility could also be related to the distance each can affect, but these aspects are not considered in this dissertation. Further studies regarding the neighborhood unit and the range of effect of urban facilities, as well as the attractiveness of facilities, are necessary to address these issues.

Additionally, one can assume that older adults go to neighborhood facilities by walking and public transportation, since the elementary school district is within a geographical area that is easy for older adults to navigate. The analysis in Chapter 4 considers individuals' car and public transportation availability, as well as their frequency of going outdoors, and assesses the accessibility of neighborhood facilities based on a scale of walkable distance. The model in Chapter 5 employs a distance-decay function, which assumes that older adults use transportation when the distance is too far for them to walk. Indeed, people's traveling modes affect their social relations and trip frequencies (Böcker et al., 2017; Ryan and Wretstrand, 2019; Utsunomiya, 2020; Van den Berg et al., 2016). However, the distance from the older adults' homes to facilities and their mode of travel to arrive at the destinations are not sufficiently considered in this dissertation. Given that transportation enables older adults to go to facilities that are located outside the neighborhood where they live, both the location of the destinations and their methods of travel should be addressed further. Those issues could possibly be considered by analyzing the relationship with (attractiveness weighted) accessibility to urban facilities located in multiple elementary school districts next to the elementary school districts where older adults reside or by setting different neighborhood units for each travel mode. People using a car may have little opportunity to obtain information

about a group activity or be invited from other people during the trip. However, the maximum distance that urban facilities can affect could be increased when considering people's transportation methods to get to the facilities; the range of effect may also shift when modes of transportation change, or when a lifestyle change occurs. Future work exploring the effect of the travel mode and urban amenities could expand the policy options available, not only in regards to district planning through zoning, but also as it relates to transportation policy.

Furthermore, this dissertation only considers the effect of each type of neighborhood facilities; therefore, it is not clear which combination of multiple facility types within a neighborhood promote older adults' participation. Given that zoning is a method to divide an area into zones and regulate facility use, there could possibly be spatial heterogeneity in the types of urban facilities within the neighborhood (for example, shopping malls, grocery stores, and restaurants are less likely to be located in a low-rise residential zone). There may also be a tendency for a facility type to be located near another facility type, potentially resulting in an amenable environment with multiple reasons to go outdoors. Even though analyses in this dissertation highlight that the geographical distribution of facilities affects older adults' participation, little is known regarding which scale of zones within a neighborhood and the geographical distribution of their multiple facility types, as well as which combinations of multiple facility types within a zone, provide greater benefits for participation of older adults in recreational group activities. Further studies should consider the geographical distribution of multiple types of building uses, including urban amenities and homes.

Longitudinal analyses in this dissertation take into account selective migration and estimate the neighborhood effect of urban facilities. However, issues related to the causality are not sufficiently considered (for example, which causal

factors make some older adults reluctant to attend group activities at the closest facility; whether those factors are related to the location of facilities where they go). Regarding the factors of why some older adults hesitate to attend group activities at a facility that is close to their home, this dissertation (in Chapter 5) only considers one factor: self-stigma related to community salon participation. However, there could be other factors related to the phenomenon. Both self-esteem and self-efficacy that are related to intention to participate in group activities, as well as gaps in the service quality, attractiveness, and group activity contents among facilities, should be considered. Qualitative studies exploring how residents perceive urban facilities within their neighborhoods, as well as experimental studies which are to test the neighborhood effect, should be conducted, and more thoughtful consideration regarding the causality and mechanism is necessary.

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