Quantitative Environmental Equity Analysis of Perceived Accessibility to Urban Parks in Osaka Prefecture, Japan

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Abstract

Environmental equity (EE) has become internationally recognized as an important research field, but in Japan limited quantitative research is available. In this paper we report the results of a quantitative study that tested whether objective and perceived accessibility to parks is disproportionately distributed between the affluent and the poor in Osaka Prefecture, Japan. Perceived accessibility is considered to be a more accurate accessibility measure which reflects the socio-cultural background of people. We find inequities in both accessibility measures, and using multiple logistic regression analysis, we clarified that perceived accessibility is shaped by a range of factors (i.e., income level, objective accessibility to parks, and people's perceptions of traffic accidents, crime, and the level of scenic beauty in the neighboring area). Our results provide some insight into remediation measures for the environmental inequity of perceived accessibility. Simply establishing a new urban park may not sufficiently increase the perceived accessibility of socioeconomically deprived groups. Identifying the underlying mechanisms that could explain how poverty-related factors undermine the perceived park accessibility or improving the quality of neighboring area are also important to ensure the effectiveness of remediation measures.

Keywords: Environmental equity; Perceived accessibility; Urban parks; Geographic information systems; Japan

2. Introduction

Environmental equity (EE) is defined as an equal burden of environmental risks or accessibility to amenities regardless of population characteristics, such as age, gender, ethnicity, and poverty level (EPA 1992, Jones et al. 2009a). EE is often related to health inequities and economic inequities, and these can all operate together (Pearce et al. 2010, O'Neill et al. 2003). For example, a disproportionate distribution of environmental risks or amenities may be a path to the magnification of health inequity (O' Neill et al. 2003, Nakaya 2011, Pearce 2005). Alternatively, a disproportionate siting of environmental risks or environmental amenities may affect land prices and/or residential choice (Saha and Mohai 2005, Been 1994), and consequently, magnify inequity between the affluent and the poor.

Historically, the term "Environmental Equity" originated from social movements against unequal burdens of environmental risks in the US. Before the 1980s, public opposition to the siting of waste facilities in several areas increased on account of more widespread awareness of the environmental risks, but originally citizen opposition was predominantly organized by the white middle class, and politically disempowered communities, such as minority groups, were not sufficiently represented (Bullard 1990, Dunlap and Mertig 1992). Following the path of least resistance in such communities due to their political vulnerability (i.e. limited access to resources and allies in governing authorities), environmentally risky facilities ended up being disproportionately sited in areas occupied by minority or deprived communities (Bullard and Wright 1987).

Since the 1980s, a social movement against environmental racism has developed. This has particularly focused around the view that non-white communities were disproportionately burdened with environmental risks from the siting of controversial facilities such as hazardous waste dumps, and this phenomenon was evidenced by several early studies (e.g. GAO 1983, Zimmerman 1993). Conceptual and research frameworks concerning EE were then expanded to integrate the goals of investigating and remedying the unequal distribution of a range of environmental risks and amenities between social groups.

A situation of environmental inequity (i.e., socially disadvantaged groups are more likely to be exposed to environmental pollution) has been found in Japan as well as historically in the USA (Terada 2006). The trigger of a social movement aimed at remedying such unequal burdens in Japan was the occurrence of several environmental pollution events that resulted from rapid industrialization. For example, the Ashio Copper Mine Mineral pollution incident in the latter part of the 19th century and Minamata disease in 1950s are all known as incidences of environmental contamination in which poor people were disproportionately affected (Shoji and Miyamoto 1964; Iijima 1987; Harada 2007). Kajita

(1988) stated that, in the Japanese context, the benefits and costs of large-scale development projects (e.g., industrial complexes and power stations) are prone to be disproportionately distributed in socioeconomically deprived areas.

A sizeable amount of past qualitative research in Japan has demonstrated that industrial waste management plants (Terada 2006), nuclear power stations (Fujikawa 2016), and industrial factories (Ikuta 2007) have the tendency to be located in socioeconomically deprived areas and cause a negative effect on local people's life and health. Nevertheless, quantitative research focused on the spatial relationship between population characteristics and environmental quality is still relatively sparse in Japan. Tanaka (2001) evaluated accessibility to a range of facilities for daily life (e.g. medical facilities, financial facilities, and parks) and found that students and elderly females have inferior access compared to workers and elderly males. Other quantitative case studies found a disproportionate distribution of environmental quality, including objective park accessibility (Yasumoto et al. 2014), access to sunlight (Yasumoto et al. 2012), and a combination of urban amenities (Uesugi and Yasumoto 2018).

Building on this consideration, we conducted a quantitative EE analysis of both objective and perceived accessibility to urban parks in Osaka Prefecture, Japan. Urban parks are one of the most important amenities in a city particularly for human health and safety. For example, as a case study by Takano et al. (2002) found that accessibility to green spaces was positively associated with the longevity of the elderly in Tokyo, Japan. Several mechanisms have been proposed through which such places might provide positive effects on health. Parks provide opportunities for physical activity (Hanibuchi et al. 2011) and reduce the risk of air and noise pollution, fires, and earthquakes (Hirata 2004). Furthermore, they have the potential to enhance psychological health via restorative effects (van den Berg 2016, Kaplan 1993). In addition, De Vries et al (2013) have identified that streetscape greenery is positively associated with perceived social cohesion at the neighborhood level.

An important consideration is that socially disadvantaged populations are potentially more vulnerable to deprivation of green space accessibility (Maas et al. 2006, Maas et al. 2009, van den Berg et al. 2016). For example, in a Dutch study it was found that perceived general health of people of lower socioeconomic status was more susceptible to green space accessibility that those who were more affluent (Maas et al. 2006). This is of concern given that several studies found that green space (including urban park) accessibility is disproportionately distributed among social groups (Jones et al. 2009a, Wolch et al. 2005, Sister et al. 2007, Yasumoto et al. 2014).

Whilst the level of international research on EE of park accessibility has been rapidly expanding there remains a need to better understand the policy implications. To date past studies significantly used objective accessibility measures to test the EE of parks (Wolch et al. 2005; Sister et al. 2007), but perceived accessibility measures have been rarely considered.

Perceived accessibility to parks describes the degree to which people perceive to have access to parks within reasonable distance. Perceived accessibility reflects an individual's population characteristics, lifestyle, and neighboring environment. Hence, it can be a more accurate measure of people than objective accessibility (Wang et al. 2015a, Ball et al. 2008). Some research found that perceived accessibility to parks may be a more optimal predictor of park usage than objective park accessibility (Wang et al. 2015b). Wang et al. (2015a) found that in both Australian and Chinese cities, the poor have a worse perceived accessibility to parks than the affluent. Because perceived accessibility is influenced by the different sociocultural backgrounds of each area, they suggested that understanding the factors that shape perceived accessibility is essential to improving people's perceived accessibility.

Considering these findings of past studies, distribution of perceived accessibility to parks should be important from the perspective of EE. Jones et al. (2009b) found that in Bristol, UK, the poor had better objective accessibility to parks than the affluent. Nevertheless, the poor had worse perceived accessibility compared to the affluent. This study indicated that to achieve EE with respect to park accessibility, comprehensive measures are necessary, not only in terms of provisions of accessibility to parks, but also improvement in other factors (e.g., quality of parks and safety in neighboring areas) that may influence perceived accessibility.

As stated above, in Japan, quantitative EE studies is sparse, and even studies on the factors that influence perceived accessibility to parks is limited. An approach based on perceived accessibility measure would play an important role in identifying the status of EE and developing recommendations to enhance EE.

We set three research goals in this paper. First, we tested whether EE of objective accessibility to parks existed in Osaka Prefecture, Japan. Second, as an alternative accessibility measure, we investigated the situation of EE in perceived accessibility to parks. Finally, we identified what factors have a statistically significant effect in shaping people's perceived accessibility. The work was undertaken in the hope that it will contribute insights into efficient potential measures to reduce the unequal distribution of perceived accessibility to parks.

3. Methodology

3.1. Study area

The study area of this research is the Densely Inhabited District (DID) in Osaka Prefecture, Japan (Figure 1). Osaka Prefecture has the second highest population density and GDP among the 47 prefectures in Japan and suffers from a shortage of parks and green spaces due to intensive urbanization. Many people in the highly urbanized and populated area in Osaka Prefecture deem green spaces to be limited compared to suburban or mountainous areas (Osaka Prefectural Government, 2012), and thus it is predicted that those areas have a potentially high demand for accessibility to parks. Considering this background, DID was selected as the sample area for this study. In fact, as Figure 1 shows most urban parks have been opened within the DID.

< Figure 1 about here>

3.2. Data

To test the objective accessibility to parks, we generated two sets of data: an urban park map of Osaka Prefecture and data on the distribution of the poverty level in each area. To generate the urban park map, locational information of parks in 2010 in Osaka Prefecture was obtained as point data from the National Land Numerical Information download service (Geospatial Information Authority of Japan, 2018). This data contains names, locations, areas, and the years of operation for the urban parks in the study area. From "Detailed data collection maps 2012", provided by ESRI Japan Inc., we extracted polygon data from each park, and matched it with the point data above using GIS. Because the map data from ESRI Japan did not cover all parks, the parks without polygon data were assumed to have a round shape. The radius of each park was calculated from the park area, and a round-shape polygon was generated to represent each park (Figure 1). We generated manually the polygons of some parks that have substantially different shape from a round shape.

3.3. Analysis of objective accessibility

For each small census area (called "Chocho-aza" in Japanese), the objective accessibility to parks was measured. A service area analysis based on the road network (ESRI, 2018) was used to measure objective park accessibility from the centroid of each small census area. The road network distance was restricted to 800 m because past studies considered 800 m (approximately 10 mins walk) to be a suitable walking distance (Hilsdon et al. 2015, Dalton et al. 2016). 'Data collection road network 2012' (ESRI Japan Inc.) which represents the road network in 2011 in Osaka Prefecture was applied.

Then we calculated three metrics: the number of parks, the total park area, and the park area per capita within each of the 800 m road network distance. The total population of each corresponding small census area was extracted from the 2010 Japanese Census. These metrics were computed using the ‘container’ method. This method identified all facilities within a specific area and aggregated quantitative characteristics of all of the facilities (see Talen and Anselin 1998).

In the Japanese Census white collar workers are categorized into three types (i.e. administrative and managerial workers, professional and engineering workers, and clerical workers) with the first two being the highest income groups. At a small census level, we extracted the percentage of the two groups (called “professional and managerial workers” hereafter) from the 2010 Japanese Census (Figure 1) as the affluence indicator. Then, we categorized the indicator into quintiles. From the lowest quintile to the highest quintile, numbers (1 to 5) were added to each quintile (i.e., the least affluent group was numbered 1, and the most affluent group was numbered 5). To test the trend of EE, we examined the correlation between these numbers and the three objective accessibility measures by calculating Spearman's rank correlation coefficients.

3.4. Questionnaire survey and analysis of perceived accessibility

To measure the perceived accessibility to parks and determine the factors that may affect the measure, a questionnaire survey was conducted in January 2010 in Osaka Prefecture. Demographic characteristics such as age, gender, and household income were also asked within the survey. A twostage stratified sampling was applied to choose the target individuals who would receive the questionnaire. First, Osaka Prefecture was divided into four parts: Osaka city, northern, eastern, and southern areas. Then, each small census area was classified into one of 12 types in terms of Japanese geodemographics, provided by Acton Wins Co., Ltd. Therefore, all small census areas were categorized into 48 strata (4 × 12). Then 160 small census areas were chosen from the 48 strata. Based on the population aged 20 or over (extracted from the 2005 Japanese census), we calculated the proportional share of each small census areas assigned to each stratum. Next, from an address list for direct mail, provided by Acton Wins Co., Ltd, approximately 40 households were randomly selected in each small census area, and questionnaires were sent to them.

In each selected household, we requested one person (aged 20 or over), whose birthday comes first after January 1, to be chosen as a respondent following the birthday selection method. As a result, a total of 2527 people returned the questionnaire. The respondent rate was around 40%, excluding oneperson households in which the person is less than 20 years old.

The questionnaire survey was originally designed as a part of a research project to investigate a range of factors, including noise pollution and social cohesion, which may shape social inequality in health in the whole Osaka Prefecture. Since our research focus is urban park accessibility, it was necessarily to distinguish between urban and rural areas. Dominant green spaces in urban areas are typically urban parks, whilst agricultural lands are dominant in rural settings, indicating the importance of this context as a determinant of greenspace use (Parks et al. 2003). To focus on urban park accessibility, in this research respondents whose residences were located within the DID were chosen. In total, 2345 respondents were selected as a sample for statistical analysis.

Table 1 shows the questions within the survey. We asked for information relating to gender, age, household income, level of perceived accessibility to parks, and perception of their neighboring area in terms of traffic accident risk, crime risk, conservation of scenic beauty, and social cohesion. Table 1 also reports the percentage of the number of respondents against the overall sample for each age and gender group as well as the corresponding values in the study area, DID, extracted from the 2010 Japanese Census. The comparison showed that the percentage of people aged over 60 that responded to the questionnaire is higher than the proportion of the actual population, while the percentage of people aged in their 20s and 30s who responded is less. The overall sample is, therefore, slightly biased toward elderly people.

<Table 1 about here>

Perceived accessibility to parks was measured by a question (see Table 1), and five possible answers were prepared: ‘1. Sufficient’; ‘2. Relatively sufficient’; ‘3. Some, but not sufficient’; ‘4. None’; and ‘5. I don’t know’. These were categorized into a binary outcome of superior vs inferior perceived accessibility. Within these selections, 1 and 2 were categorized as superior perceived accessibility, while 3, 4, and 5 were categorized as inferior perceived accessibility. Selection 5 was categorized into the inferior perceived accessibility as this indicates a lack of recognition of neighboring parks and limited perception of park accessibility.

The annual income of each household (18 categories) was asked through the mail questionnaire. To adjust for household size, the reported annual household income was divided by the square root of the number of household members so that an equivalent household income measure could be constructed. The equivalent household income was then categorized into quintile groups. To test equity of perceived accessibility, we conducted cross tabulation and constructed a line graph to identify magnitudes in the perceived park accessibility across the different income groups. A test for trend was also conducted using logistic regression analysis.

3.5. Logistic regression models to predict perceived accessibility

To identify the factors affecting the prediction of perceived accessibility to parks, we developed three multilevel logistic regression models using the hierarchical data; individual respondents (level 1 units) were clustered in small census areas (level 2 units). All three models are random intercept models to control for unknown regional factors at the scale of the small census areas. The outcome variable was set as the binary superior/inferior outcome variable.

The first model (model 1) incorporated quintile groups of equivalent household income to examine how household income level affects perceived accessibility, after the effects of gender and age were controlled for.

The second model (model 2) employed an additional explanatory variable, objective accessibility to parks, to test two questions. First, we examined whether the magnitude of objective accessibility affects perceived accessibility (Wang et al. 2015a). Second, after the effect of objective accessibility was controlled for, we examined whether household income influences perceived accessibility.

A service area analysis based on the road network (ESRI, 2018), as stated above, was used to measure objective park accessibility from the residence of each respondent. Again, the road network distance from a residence was restricted to 800 m (Hilsdon et al. 2015, Dalton et al. 2016) since we predefined 'neighboring area' on the questionnaire sheet as 10 – 15 mins walking distance from the residences of the respondents (10 mins walk corresponds to approximately 800 m on foot. See Table 1). Then, the 'Container' method as described above was used to identify the total park area within each service area. For road network data, 'Data collection road network 2012' (ESRI Japan Inc.) was again applied.

Furthermore, several past studies have postulated or found that perceived accessibility was affected by the risk perception of traffic and crime, conservation of scenic beauty, and magnitude of social cohesion in the community (Wang et al. 2015a, Jones et al. 2009b, Wang et al. 2015c). Adding these variables, we developed the third model (model 3). The independent variables were dichotomized for brevity of the table.

In the questionnaire we asked magnitude of the risk perception of both traffic and crime(Table 1). The answers '4. Relatively impossible' and '5. Impossible' were categorized as the group of high-risk perception.

We also asked the perception of conservation of neighboring scenic beauty, (Table 1). Answers of '1. Many exist' and '2. Exist' were categorized into the group of the perception that the community's scenery is impaired. The magnitude of social cohesion was asked (Table 1), and the answer of '4. We have almost no communication' was selected as the group of low social cohesion.

In this study, we used ArcGIS ver.10.5 (ESRI Japan Inc.) for GIS studies. The software package R ver. 3.2.3. with package "lme4 (function of glmer)" (Bates 2015) was used to undertake the multilevel logistic regression analysis. All other statistical analyses including the descriptive analysis and the correlation test were done performed using SPSS ver. 25.0 (IBM Inc.).

4. Result

We found that there was environmental inequity in objective accessibility to parks (Table 2). The result shows that small census areas with a higher percentage of professional and managerial workers tend to have superior accessibility in terms of the three metrics. This trend is particularly clear when the overall park area is considered. The mean value of the park area per capita shows a less clear trend, partly due to several small census areas having small populations but large park areas and, consequently, high per capita values. The median per capita values are therefore more reliable. The result made it clear that potentially intervention is necessary to reallocate the accessibility of the amenity.

<Table 2 about here>

Environmental inequity in perceived accessibility was also found. Figure 2 demonstrates that people with lower income have a more inferior perceived accessibility, which demonstrates the inequity of perceived accessibility to parks. The test for trend also shows there is a negative and statistically significant trend between income level and superior perceived accessibility.

<Figure 2 about here>

Table 3 reports the results of logistic regression analysis. As indicated in model 1, after controlling for gender and age, the poorest group has significantly lower perceived accessibility to parks compared to the most affluent group.

<Table 3 about here>

In model 2, which integrated the objective accessibility to the parks demonstrated in model 1, a positive association between total park area and odds of having a superior perceived accessibility was found. Furthermore, even after the effect of objective accessibility of parks was controlled, income level still had a significant effect (i.e. the lowest income group is significantly lower than the rest).

According to model 3, the risk perception of traffic and crime and the impaired beauty of scenery in the neighboring areas had a significant negative effect on perceived accessibility, even after the income levels and objective accessibility were controlled. In other words, the quality of the neighboring area is important to determine perceived accessibility. A significant effect of social cohesion was not found.

All models (1–3), consistently showed that only the lowest income group has a significant and negative effect compared to the reference (the highest income group), while middle income groups do not. Furthermore, both gender and age were consistently insignificant across all three models.

The AIC (Akaike information criterion) improved from model 1 to 3. Also, the AIC of the random intercept models were substantially better than the corresponding ones without random effect terms showing that these were a more appropriate fit to the data. The size (variance) of the random effect decreased successively from model 1 to 3, as anticipated, due to the integration of neighborhood characteristics.

In addition, a parallel lines test using an interaction between income and objectively measured accessibility was not statistically significant, indicating the assumption of parallel lines was not violated.

5. Discussion

We found environmental inequity of objective accessibility to parks in Osaka Prefecture. This result accords with past studies from both outside and inside Japan (e.g. Jones et al. 2009a; Wolch et al. 2005; Sister et al. 2007; Yasumoto et al. 2014). It was also evident that even perceived accessibility is disproportionately distributed between the poor and the affluent through cross tabulation analysis

(Figure 2). As a more important analysis, we conducted logistic regression to clarify the factors which affect perceived accessibility (Table 3).

From longitudinal evidence, Yasumoto et al. (2014) found that the establishment of parks by the government in deprived areas with limited parks can be the most effective measure to remedy the inequity of objective park accessibility. However, perceived accessibility is considered a more accurate measure for people's park usage than objective accessibility, and simply increasing the provision of parks may not result in improved perceived accessibility (Wang et al. 2015b). Perceived accessibility is shaped by not only objective park accessibility, but also a range of socio-cultural and personal factors, as shown in Table 3. Our findings provide some insights into potential remediation measures to improve environmental inequity.

First, comparing model 1 and model 2, we found that providing urban parks in deprived areas might not be a sufficient measure alone to improve perceived accessibility. Poverty at the household level also negatively influences perceived accessibility, and thus it is important to understand how povertyrelated factors discourage perceived accessibility.

Although in this research, such causal mechanisms of how poverty negatively influences perceived accessibility were not investigated, several possible reasons for this relationship can be suggested. One reason may be that quality of the parks near the deprived group might be worse (e.g., not well maintained or less green spaces) than the parks in other communities, and these might lower perceived accessibility in these communities (Jones et al. 2009b).

Alternatively, personal characteristics of deprived people might affect accessibility, such as available leisure time, lifestyle and activity levels, or general health status, which might be lower than those for other groups (Wang et al. 2015a). Lack of efficient traffic modes, such as a bicycle, may also be associated with lower perceived accessibility of poor people (Wang et al. 2015a). Further research is required to understand these mechanisms. In this study, when compared to the most affluent group, only the most deprived group had significantly lower perceived accessibility (Table 3), and research should focus on this group.

Second, as model 3 clarified (Table 3), the perception of risk of traffic accidents and crime, and impaired beauty of scenery in neighboring areas negatively affect perceived accessibility. Therefore, decision-making regarding the establishment of new parks must consider the quality of neighboring areas; otherwise, the supply of a new park may not necessarily improve local people's perceived accessibility. This is important to enhance EE.

Mortality caused by traffic accidents is a major public health concern, and road safety is recognized as a social equity issue (WHO 2004). In studies outside Japan, motor vehicle accidents tend to impact disproportionately on poor people (Kendrick 1993, Dougherty et al. 1990). Therefore, reducing traffic accidents may be particularly important in deprived areas. Such efforts may also improve the perception of park accessibility in poorer communities, which could enhance the environmental equity of park accessibility. Specifically, past studies show that a reduction in traffic volume and traffic speeds, and provision of traffic controls, such as signals to cross the road and pedestrian crossings, may contribute to reducing the perception of risk of traffic accidents (Rothmana et al. 2015; Rankavat and Tiwari 2016).

Likewise, reducing crime levels and improving safety and scenic aesthetics may improve perceived accessibility. To mitigate the perception of risk of crime, placement of street lamps, more frequent patrols by police officers, and positive interaction with citizens (Peña-García et al. 2015; Montolio and Planells-Struse 2015) are suggested as potential helpful measures. Nakamata and Abe (2016) found that to preserve scenic beauty there are some prevention measures against littering, such as siting a security camera, flowerbed, and signboard, and removal of pre-existing littering. Waste left on the streets may contribute to the perception of crime risk as well (Shimada et al. 2004).

Third, the result of model 3 indicates that provision of urban parks (more than 1ha) within an 800 m road network improves the perceived accessibility of neighboring people. It may be difficult, however, to consistently obtain such large open spaces in highly populated urban areas to build a park because of the shortage or high price of land parcels. Nevertheless, the long-term view is that the cumulative effects of a policy framework to provide parks in poor areas which have less park accessibility would contribute to EE.

A concern may be that providing a park may raise land prices in the surrounding area and attract affluent people to the district, and consequently backfire the remedy for the inequity. However, a study by Yasumoto et al. (2014) conducted in Yokohama city, Japan, found such gentrification has little effect on reallocation of social groups, although similar study is yet untested in our study area.

There are several limitations regarding the methodology. Firstly, for objective accessibility we focused only on urban parks. However, in the questionnaire survey we asked a question to measure perceived accessibility: “In your neighboring area, are there green spaces or open spaces with free access, such as a park?” Therefore, this implies that not only urban parks, but also other types of open spaces with free access such as a well-maintained riverbed are included, although such open spaces should be limited in the context of DID in Osaka Prefecture, one of the most urbanized areas in Japan.

Secondly, we focused only on the number and area of parks to calculate objective accessibility; other quality measures were not integrated. For example, sports facilities and ecosystems including green spaces inside a park could also have important value for park users and communities (Hirata 2004).

Thirdly, perceived accessibility is often measured through a questionnaire survey, and thus it is represented as categorical data (see Table 1). In this study perceived accessibility was reclassified as a binary variable, and logistic regression analyses were applied, but we recognize there will be some variability in perceptions within the two binary categories.

Finally, our sample is slightly biased toward elderly people (Table 1). As Kaczynski et al. (2009) mentioned, elderly people are more likely to be sensitive to park accessibility compared to middleaged adults because the latter group tend to work full-time away from their homes. Therefore, the participants of this study may be relatively more sensitive to park provision compared to the population of Osaka Prefecture. For the multiple logistic regression analysis, we controlled the effect of age using the logistic regression analysis, and the results were all insignificant for the three models (Table 3).

Another important facet of the issue of EE in terms of perceived accessibility is whether characteristics of neighboring areas appear to mediate the relationship between poverty and perceived accessibility to parks. For example, the poor tend to live in unsafe areas, which may discourage park usage. Such interdependency needs to be explored using additional tests, such as casual mediation analysis, for further understanding of EE in terms of perceived accessibility. Whilst we have focused on area effects using multi-level analysis within the logistic regression models, another direction of future research could be the fitting of more complex spatial models to consider factors like contiguity or the distance between areas.

In this paper we focused on Osaka Prefecture, Japan. It is suggested that further EE studies of perceived accessibility are conducted in other areas both inside and outside the country. This is particularly important as a direction for future research because perceived accessibility could be shaped by the unique sociocultural background in each area (Wang et al. 2015a). Therefore, if different factors are observed to have a significant effect on perceived accessibility between sample areas, it is important to consider the reason and background to allow an improved understanding of EE in the accessibility of parks (Wang et al. 2015a).

It is also important to note that factors may be differently associated according to poverty levels. For example, it may be that associations between illegally dumped litter and perceptions of crime are stronger in more deprived communities. If this is the case, the existence of one problem may subsequently magnify another, and impact perceived accessibility further.

Not only distributional issues for other environmental amenities but environmental risks have been often discussed based on objective measures, but the importance of perceived measures has been relatively neglected in EE studies. It was found that there is discordance between objective and perceived measures of air pollution and urban noise (Orru et al. 2018, Verbeek 2018). Indeed Orru et al. (2018) stated that perceived measure of air pollution may be better indicator to predict health risk perception, symptoms or diseases, compared to objective air pollution exposure. As our research also indicated the importance of considering perceived accessibility measures to remedy environmental inequity, we suggest that EE studies based on perceived environmental quality should be extended to environmental risks or other urban amenities.

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Table 1. Population characteristics of respondents and descriptive statistics of the questionnaire survey ('neighboring area' in the questions was defined as 10 – 15 mins distance on foot from the housing locations of the respondents and stated in the questionnaire sheet)

	Questionnaire		Census
Population characteristics	N	%	(%)
Gender Male	1294	55.2	(48.4%)
Female	994	42.4	(51.6%)
No answer	57	2.4	
Age 20s	98	4.2	(13.8%)
30s	140	6.0	(18.2%)
40s	236	10.1	(16.8%)
50s	389	16.6	(14.2%)
60s	758	32.3	(18.4%)
70 or over	658	28	(18.6%)
No answer	66	2.8	
Annual household income (million yen)			
< 200	364	15.5	
≥200, < 400	807	34.4	
≥ 400, < 600	466	19.9	
≥ 600, < 800	265	11.3	
> 800	389	16.6	
No answer	54	2.3	
Questions	N	%	
Q1. In your neighboring area, are there green spaces or open spaces with free access, such as a park?			
1. Sufficient	508	21.7	
2. Relatively sufficient	808	34.5	
3. Some, but not sufficient	774	33.0	
4. None	188	8.0	
5. I don't know	15	0.6	
No answer	52	2.2	
Q2. In your neighboring area, can you go out on foot without worrying about traffic accident risk?			
1. Possible	670	28.6	
2. Relatively possible	845	36.0	
3. Neither agree or disagree	489	20.9	

4. Relatively impossible	219	9.3
5. Impossible	75	3.2
No answer	47	2.0
Q3. In your neighboring area, can you go out at night on foot without worrying about crime risk?		
1. Possible	351	15.0
2. Relatively possible	914	39.0
3. Neither agree or disagree	700	29.9
4. Relatively impossible	262	11.2
5. Impossible	69	2.9
No answer	49	2.1
Q4. Is there any place in your neighboring area where graffiti and garbage stand out?		
1. Many exist	26	1.1
2. Exist	531	22.6
3. Few exist	1462	62.3
4. None	214	9.1
5. I don’t know	60	2.6
No answer	52	2.2
Q5. How is the relationship between your family and neighbors?		
1. We have a cooperative relationship (e.g., consult other) with neighbors in daily life	474 each	20.2
2. We do not have a cooperative relationship with neighbors, but we talk to each other (e.g., a small talk, stand talking)	1097	46.8
3. We rarely talk with neighbors, but we greet each	651 other	27.8
4. We have almost no communication	72	3.1
No answer	51	2.2

Along with the ratios of gender and age groups of the respondents, the ratios of the corresponding population characteristics of the actual population in the study area were also reported in the right row (extracted from the 2010 Japanese Census).

Table 2. The relationship between objective accessibility to parks and percentage of professional and managerial workers

Professional and managerial workers (%)	Total number of parks		Total park area (ha)		Park area per capita (m^2)	
	Average	Median	Average	Median	Average	Median
1st (least affluent)	5.7	5	5.7	1.5	394	22
2nd	5.5	5	5.7	1.5	83	16
3rd	5.6	5	7	1.6	188	17
4th	6	5	8.5	1.8	148	22
5th (most affluent)	6.3	6	10.7	2.5	303	36
Direction of trend	+ ***		+ ***		+ ***	

1st: Quintile with the lowest professional and managerial workers (%)

5th: Quintile with the highest professional and managerial workers (%)

Direction of trend (+, positive and -, negative) is also reported

*** : $P < 0.01$

Table3. Logistic regression models to predict superior perceived accessibility to urban parks

	Model 1		Model 2		Model 3	
	OR	95%CI	OR	95%CI	OR	95%CI
Male	1	Reference	1	Reference	1	Reference
Female	0.95	(0.80, 1.15)	0.97	(0.81, 1.16)	1.00	(0.83, 1.21)
Age group						
＜40	1	Reference	1	Reference	1	Reference
≧40,＜65	0.90	(0.74, 1.12)	0.92	(0.75, 1.13)	0.90	(0.73, 1.11)
≧65	1.12	(0.91, 1.39)	1.11	(0.90, 1.37)	1.06	(0.86, 1.31)
Quintiles of household income						
1st: Poorest	0.70***	(0.53, 0.95)	0.71***	(0.53, 0.95)	0.72***	(0.54, 0.97)
2nd	0.81	(0.61, 1.10)	0.81	(0.61, 1.10)	0.84	(0.62, 1.13)
3rd	0.88	(0.65, 1.20)	0.91	(0.67, 1.23)	0.92	(0.68, 1.25)
4th	1.15	(0.86, 1.54)	1.17	(0.88, 1.57)	1.19	(0.89, 1.60)
5th: Most affluent	1	Reference	1	Reference	1	Reference
Total park area within 800m						
0ha			1	Reference	1	Reference
＞0ha,≦1ha			1.70	(0.89, 3.24)	1.73*	(0.91, 3.31)
＞1ha,≦2ha			3.18***	(1.60, 6.33)	3.29***	(1.65, 6.57)
＞2ha,≦3ha			3.72***	(1.83, 7.54)	3.84***	(1.89, 7.80)
＞3ha			4.32***	(2.22, 8.43)	4.51***	(2.31, 8.82)
Risk perception on traffic					0.66***	(0.48, 0.89)
Risk perception on crime					0.74**	(0.55, 1.00)
Impaired beauty of scenery					0.81*	(0.64, 1.01)

Weak relationship with neighbors			0.83	(0.49, 1.40)
Variance of the random effect	0.981	0.614	0.61	
AIC	2889	2863	2845	

***P < 0.01 **P < 0.05 * P < 0.1

OR : Odds ratio 95%CI：95% confidence interval

AIC: Akaike information criterion

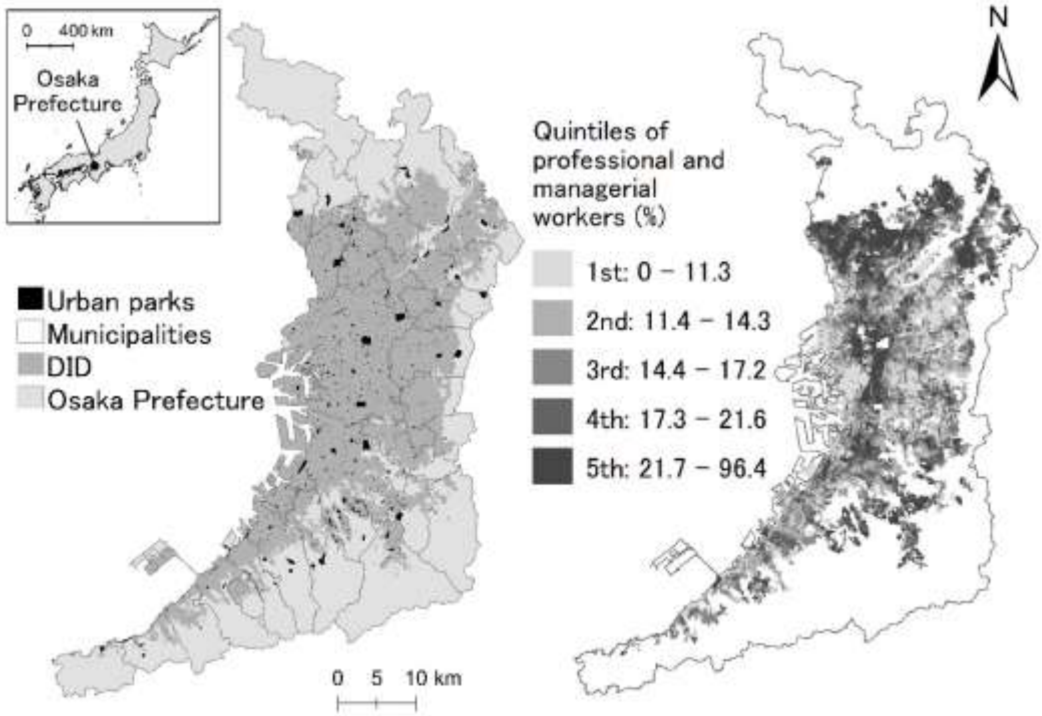

Fig. 1 Study area (DID in Osaka prefecture) and distribution of urban parks and professional and managerial workers (%)

1st: Quintile with the lowest professional and managerial workers (%)

5th: Quintile with the highest professional and managerial workers (%)

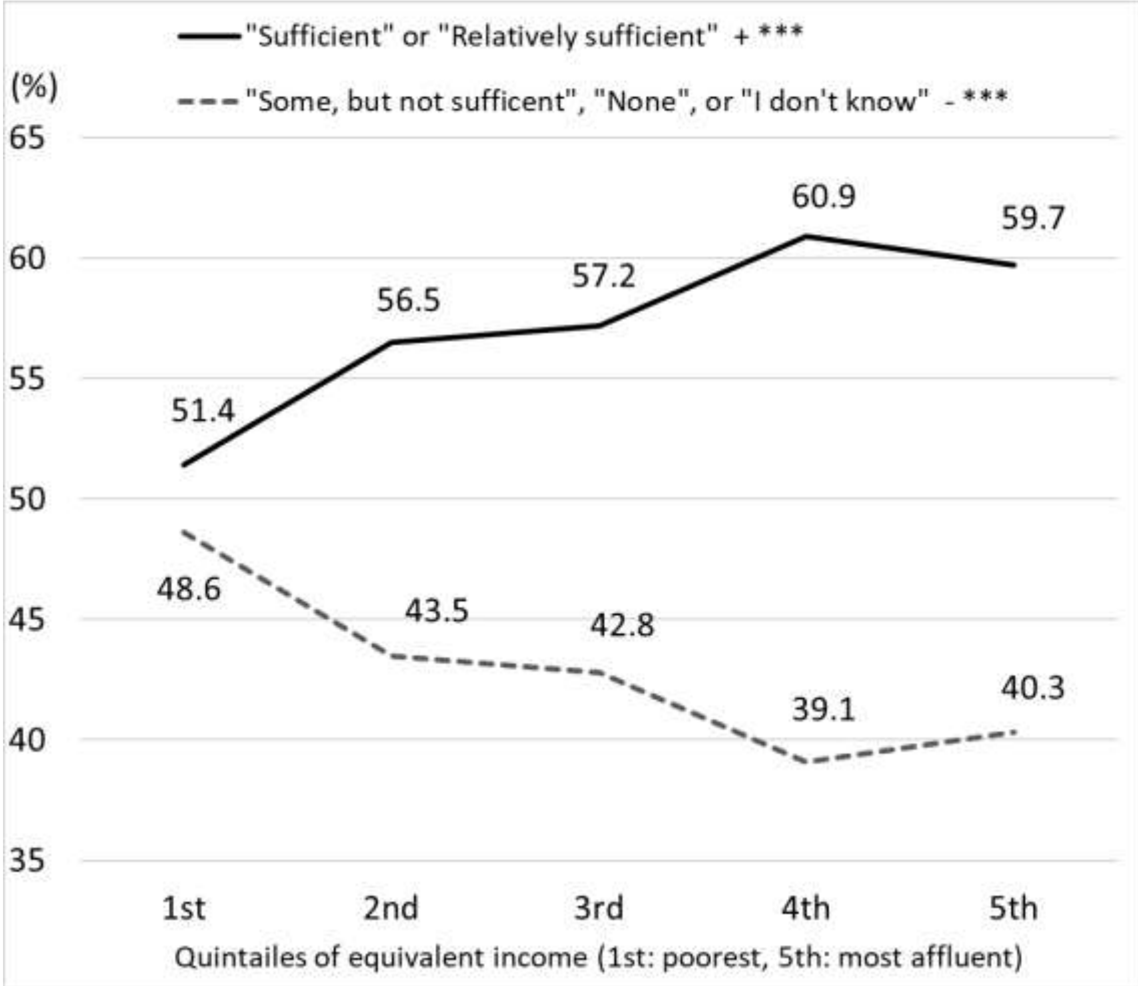

Fig. 2 The relationship between perceived accessibility to parks and equivalent household income and result of test for trend

***P < 0.01

+ : positive trend   - : negative trend