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Exploring associations between social interaction and urban park attributes: Design guideline for both overall and separate park quality enhancement

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ABSTRACT

Since the COVID-19 pandemic, social interaction in parks became important outdoor activity for urban residents to mitigate social isolation and achieve mental health benefits internationally. While literature primarily researched what park feature and characteristics influence the self-reported social interaction, the purpose of this study is to expand the overall park quality measurement by incorporating both objective and subjective park attributes from multiple aspects, and explored their associations with social interactive behaviors assessed through an established protocol. A case study in Utah was conducted to assess the relationships between both overall and separate park qualities and social interaction through hierarchical linear models (HLMs). The results indicated overall park quality was the most significant predictor of social interaction, followed by sub-areas, including green space and playground, and park size. Aesthetic features, maintenance and cleanliness can promote social interaction while numbers of facilities and amenities didn't show effects. The subjective attributes of park environment are more effective in influencing social interaction than the objectives. To assist municipal planners and policy makers to create socially harmonious and cohesive communities in various cities, we provided a general design guideline to encourage social interaction and promote health benefits through the enhancement of urban park quality.

1. Introduction

1.1. Park and health

With global urbanization and influx of population, urban residents experienced myriad physical and mental health issues due to lack of physical exercise and social isolation (Kweon et al., 1998). Urban parks and green spaces are increasingly acknowledged as significant public resources to mitigate these health issues by providing opportunities for physical activities and social interaction (Cao & Kang, 2019). Especially with the COVID-19 pandemic, existing social isolation and mental health issues have been exacerbated by the lockdowns and restrictions across countries. This resulted in increase in visitation and use of urban parks globally (Geng et al., 2021; Venter et al., 2021), and social interaction in urban parks become a significant outdoor activity for urban residents to mitigate social isolation and benefit their mental and psychological well-beings.

Most experimental evidence suggested park-based physical activities brought physical and psychological health benefits (Dong et al., 2023; Han et al., 2022). In addition to physical activities, other park uses also contribute to positive relationships between parks and health benefits, but has been ignored, such as social interaction (Askarizad & Safari, 2020). Not only by reducing the social isolation for the urban dwellers, literature suggested that social interaction in green space can reduce

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psychiatric morbidities, such as depression and anxiety, and contribute to overall well-being for human (Askarizad & Safari, 2020).

1.2. Park quality evaluation

Park design is an important factor in motivating or impeding specific park uses, including social interaction (Maas et al., 2009), and park quality is a comprehensive concept including park feature and characteristics to generalize the design of a park (Chen et al., 2019). As an experimental measure, park quality can be quantified according to the existence of various objective park attributes such as facilities and features, as well as subjective components such as general conditions and users' perceptions (Chen et al., 2019; Gidlow et al., 2012). Based on a rigorous review of the literature, most studies assess park quality according to the variety of facilities that can support users' activities, such as playgrounds and ball game fields (Chen et al., 2020). Researchers have also found amenities including seating, picnic tables, and bathrooms to be basic features expected by visitors (McCormack et al., 2010). Aesthetic features and natural elements such as landscaping, tree canopies, water features, and unprogrammed green space are also important among both children and adults (McCormack et al., 2010). Recent research also suggested maintenance and cleanliness were increasingly important for all park users, especially as they are perceived by users as indicators of park safety—an issue of paramount importance that impacts park visitation (Rigolon & Németh, 2018). Hughey et al. (2016) suggested incivilities reflecting safety concerns (e.g., dangerous locations, excessive animal waste, litter, noise, graffiti, and vandalism) were aspects that should be considered when evaluating park quality. Numerous instruments have been developed to measure park quality from the above-mentioned perspectives, such as the popular ones BRAT-DO (Bedimo-Rung et al., 2006) and EAPRS (Saelens et al., 2006), and the recent ones RECITAL (Knobel et al., 2021) and SPEAK (Lee, 2022). The purpose of most of these instruments was to assess the extent of park quality promoting physical activities.

1.3. Assessment of social interaction in parks

Individuals require places other than work and home, where they can meet others and establish relationships, for developing a local sense of community and establishing social ties within their neighborhood (Völker et al., 2006), and public park and green space can be inclusive places for people to meet and socialize (Kuo et al., 1998; Peters et al., 2010). Prior research indicated that most people do not feel comfortable communicating with strangers, so to stay within their familiar social groups (Rasidi et al., 2012). But the park environments made it easier for visitors to meet and make new friends, facilitating social interaction between people, attachment to place, and strengthening community' social cohesion (Peters et al., 2010). Social interaction described the degree of connectedness between two or more individuals (Moulay et al., 2017). Most existing studies have inquired about people's perceptions of contact and attachment with others (Clarke et al., 2023; Dadvand et al., 2019; Kemperman & Timmermans, 2014; Maas et al., 2009; Moulay et al., 2017; Salih & Ismail, 2018; Schmidt et al., 2019), the progressive tools and protocols can advance the traditional methods (Li & Yang, 2022). Meanwhile, observational studies provided objective measurements of social behaviors/activities happened in parks by counting the number of individuals engaged in different kinds of activities without defining their levels of social interaction or following a protocol (Campbell et al., 2016; Hillier et al., 2016; Peters et al., 2010; Rasidi et al., 2012). However, limited knowledge has been constructed in how the greenspace influencing the social interactive behaviors (Clarke et al., 2023; Van den Berg et al., 2019). Both the degree of social interaction and the number of socializing people should be considered as measurements of the social interactive behaviors/activities (Chen et al., 2023). Given its importance in human's well-being, the observational measurement of social interaction via a protocol in relation to the park environment needed to be advanced through additional research.

1.4. Park quality and social interaction

Prior literature stated that the quality of parks is more important than closer proximity to influence people to use a park for different purposes, including physical activity and social interaction (Kabisch & Haase, 2013; Kemperman & Timmermans, 2014; Van den Berg et al., 2019). Emerging studies have explored the associations between park quality and park uses but primarily from physical activity (Chen et al., 2020). While significant for the success of public places, quantitative exploration of the associations between social interaction and park quality, has received less attention than physical activities (Chen et al., 2020). Earlier study suggested that the park size and type were influential factors to stimulate park-based social interaction in Germany (Krellenberg et al., 2014). Recently, growing numbers of studies started to explore the relationships between attributes of park environment and social interaction. For example, researchers surveyed park users' evaluation on what park features that can encourage their social interaction in Australia (Rivera et al., 2021; Veitch et al., 2021; Veitch et al., 2022), and discovered the contributions to the self-reported social well-beings in China (Huang & Lin, 2023; Li et al., 2023). As the contribution of parks quality to social interaction and health benefits has been identified across countries (Wan et al., 2021), existing studies documented positive relationships between some specific park features and characteristics, such as the subjective attributes of greenery and the objective attributes of the presence of specific facilities, and social interaction (Coley et al., 1997; Kaplan & Kaplan, 1989; Rasidi et al., 2012), without incorporating different aspects of park attributes, and evaluate the overall park quality in relation to social interactive behaviors. Emerging research objectively evaluates the presented park visitors' social interaction behaviors and its associations between park attributes through observation method (Poppe et al., 2023). To strengthen the accuracy and efficiency of the observational measurement, some scholars noticed the necessity to employ an established protocol to assess social interaction, and used SOPARC which however were designed for physical activity not social interaction (Hillier et al., 2016; Schmidt et al., 2019).

1.5. Research objectives

Although the research focuses on park quality addressing the social interaction have grown, there were still fewer studies employed an instrument to incorporate separate aspects of park attributes and comprehensively assess park quality in relation to the objective measure of social interactive behaviors. Additionally, limited study accurately measured park-based social interaction through an established protocol designed for the purpose, and explored the associations between social interaction and park quality, from the perspectives of overall and separate park qualities, incorporating both the subjective and objective park features and characteristics.

To address these research gaps, the purpose of this study is to expand the measurement of overall park quality incorporating different separate aspects, and explore their associations with social interaction assessed through an established systematic-observational protocol. Based on the exploration of the relationships between park quality and social interaction, this study targets to provide a comprehensive urban park quality enhancement guideline from the perspectives of overall and separate park qualities, incorporating both the subjective and objective park features and characteristics, to improve social interaction and contribute to social and mental health benefits across cities.

2. Methods

2.1. Study setting and sample

To achieve the research objectives, we conducted a case study in

Cache County, Utah, focusing on its urban areas (Logan City and North Logan City) to explore the associations between social interaction and park quality. Both measures were assessed through established protocols through systematic observational approach.

Logan and North Logan are adjacent cities with a total area of 25.4 mile^2, of which Logan is 17.9 mile^2 and North Logan is 7.1 mile^2. The total population in Logan is 52,420 and 10,705 in North Logan (United States Census Bureau, 2021). The population density is 2930 people per square mile and 17,152 households in Logan City, while 1501 people per square mile and 3513 households in North Logan (United States Census Bureau, 2021), the census variation resulted in the difference in the public resources distribution, including the urban parks.

According to the local Park and Recreation office, there are 47 parks in the study area, with varying sizes and functions. To avoid data bias, small parks (<0.5 acre) and parks with limited facilities and amenities were excluded from the analysis. A total of 30 parks were selected for use, including 28 parks in Logan and two in North Logan (Fig. 1).

2.2. Data collection and measures—park quality

Park quality was the independent variable (IV) in this study. According to the research objective, we employed a systematic observational tool measuring park quality addressing social interaction. According to a literature review on the existing park environment assessment tools, we found the majority measuring park quality/characteristics from the perspective of promoting physical activity (Bedimo-Rung et al., 2006; Crawford et al., 2008; Hoffimann et al., 2018; Kaczynski et al., 2012; Lee, 2022; Lee et al., 2005; Saelens et al., 2006), and no exiting one considering park quality focusing on social interaction. In addition, RECITAL (Knobel et al., 2021), POSDAT (Edwards et al., 2013), and Google Earth Pro (Taylor et al., 2011) were excluded from the process because these tools do not employ systematic observational methods, which recommended by the major research. Likewise, NGST (Gidlow et al., 2012) focuses on neighborhood parks with limited considerations of measurements of specific park settings.

To identify a reliable and valid on-site systematic observational tool (acknowledged as an effective method to assess park environment employed by most tools), we compared the other tools without a specific purpose and found Parks, Activity, and detected Recreation among Kids (PARK) tool was the most proper one for this study to explore associations between park quality and social interaction (Bird et al., 2015). Although PARK was originally designed for children, but established as a

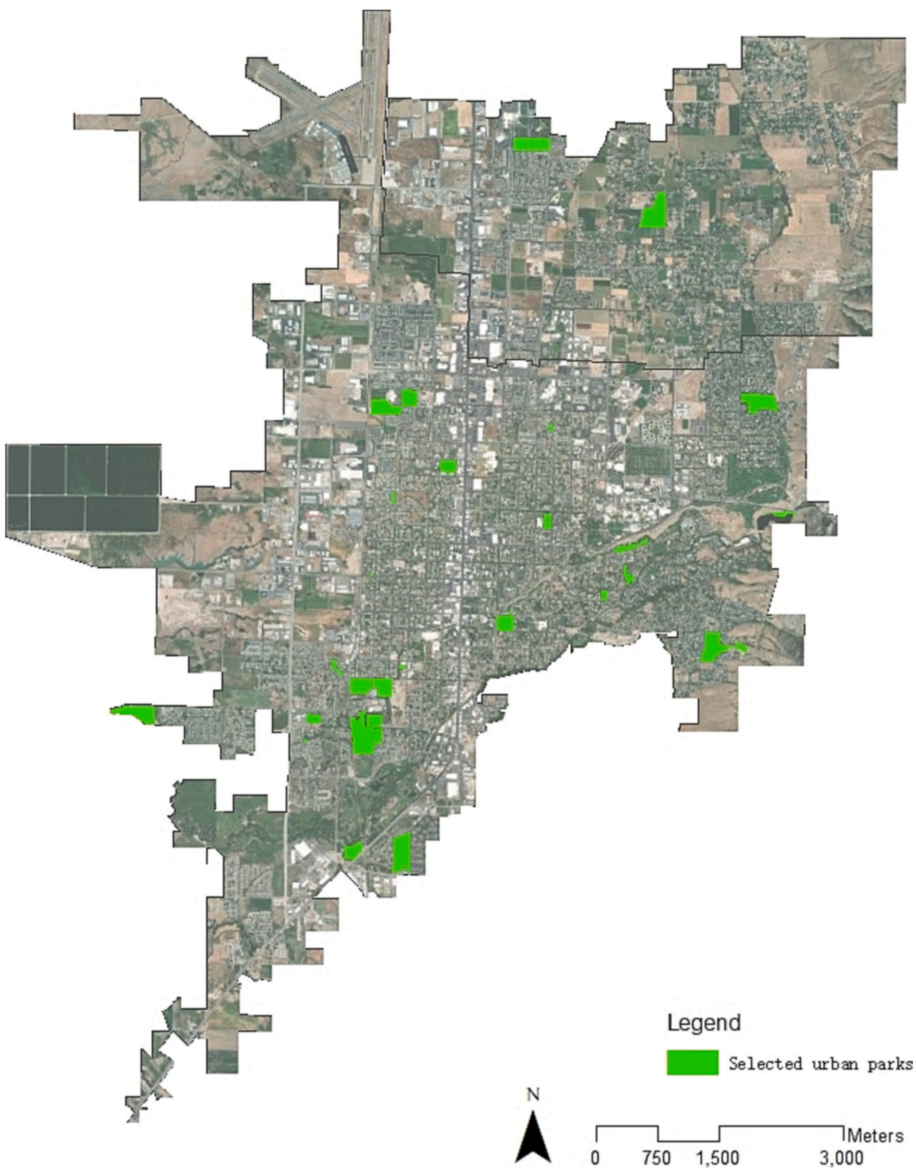

Fig. 1. Distribution of urban parks examined in Logan and North Logan, Utah.

reliable and valid tool to assess park quality for general population in consistent with POST tool (Broomhall et al., 2004). PARK tool assessed park environment from five domains identified as significant separate park features and characteristics in the other tools, including POST (Broomhall et al., 2004), PARA (Lee et al., 2005), BRAT-DO (Bedimo-Rung et al., 2006), and EAPRS (Saelens et al., 2006) through on-site systematic observation method without a specific purpose, such as for physical activity.

We evaluated the quality of parks from both the separate park quality perspectives as well as incorporating the separate park qualities into the overall park quality (Hughey et al., 2016). To embrace both the objective and subjective aspects of a park, PARK audited park quality from the presence of park features and characteristics, conditions of the park, and people's perception and impression of the park (Chen et al., 2019). The measures of PARK tool were classified into separate features and characteristics (separate park quality) identified as important for park activities in other park audit tools: facility (e.g., tennis court, basketball court, and badminton) (Gidlow et al., 2012; Saelens et al., 2006), amenity (e.g., sitting benches, equipment rental, and drinking fountain) (Gidlow et al., 2012; Lee et al., 2005), aesthetic feature (e.g., water features, decorative elements) (Bedimo-Rung et al., 2006; Saelens et al., 2006), maintenance & cleanliness (e.g., pool condition, toilet condition, and adjacent streets with traffic calming measures) (Kaczynski et al., 2012; Rigolon & Németh, 2018), and incivility (e.g., safe measures, graffiti, and vandalism) (Knobel et al., 2021; Lee et al., 2005; Taylor et al., 2011). Additionally, the PARK tool contains short questions to assess the park's condition and people's impressions. Sample questions include: "Is the park safe?" and "Is this park attractive?"

We used the modified version of the PARK tool to assess all the identified parks ($n = 30$). Following the protocol, those separate park qualities—facility, amenity, aesthetic feature, cleanliness & maintenance, and incivility—were respectively audited and scored. The dimensionality of separate park qualities is assessed by the maximum likelihood factor analysis. All the factors account for >80 % of the target variance, which illustrates a good empirical and conceptual fit. Overall park quality was calculated from the sum of a standardized version of the above-calculated separate park qualities.

2.3. Data collection and measures—social interaction

As the dependent variable (DV), social interaction in urban parks was evaluated via a systematic observational protocol, the Systematically Observing Social Interaction in Parks (SOSIP) (Chen et al., 2023). SOSIP classified outdoor social interactive behaviors into 6 levels. The levels included (1) Solitary (an individual who is alone and uninterested or unaware of others); (2) Unoccupied (an individual is alone but interested in or observing others); (3) Onlooker (a group of individuals sitting and observing others playing but do not take part in the activity or communicate with each other); (4) Parallel (individuals are in a group activity, but they are more interested in the activity than their partners); (5) Associative (individuals in a group and interact with others, but in an unorganized and uncoordinated manner); and (6) Cooperative (a group of individuals engage with others in an organized activity). The points of 1 to 6 were assigned to the levels in the above sequence. For each observation, the group size and level of social interaction of different groups of people were recorded with the sub-areas where they presented within the park, such as green space, paved open space, sports area, pathway, playground, etc. According to the SIS determining the levels of social interaction, SOSIP allows systematic evaluation of people's interactive social behaviors by considering both their levels of social interaction and group size.

With the approval of the Institutional Review Board from Utah State University, a group of four trained observers scanned the target parks to locate all park users for momentary congregation of park users in discrete groups following SOSIP. We subdivided the park into sub-areas and scan these areas for an accurate counting of park users' data, including their level of social interaction, group size, and sub-areas where social activities happened. The microclimate conditions including weather and temperature were also recorded and created as control variables. We conducted six site observations at each park and recorded social interaction scores at two-time intervals (10:00 am – 2:00 pm and 2:00 pm – 6:00 pm) on three different days (a weekday, Saturday, and Sunday). In total, we conducted 180 site observations and found 1908 different social groups of people presented in the parks during these observations. The social interaction score (SIS) for each group was calculated by timing the group size and the corresponding level/score in the social interaction scale for that group. The sub-areas where the corresponding social behaviors happened in the park were coded as dummy variables and included in the analysis.

2.4. Analysis

This study explored the association between park quality and social interaction through the hierarchical linear model (HLM), because the variables displayed hierarchical characters. Each park was observed for six times, and there were often more than one social groups in each observation, which leaded to the DV—social interaction a hierarchical data structure nested under the IV—park quality. HLM model addressed the dependence among the different observations within an area and produce accurate coefficients and standard error estimates (Raudenbush & Bryk, 2002). The HLM model divided the variance of the dependent variable into Level 1 (the separate social groups during each observation), Level 2 (the independent observations for each park), and Level 3 (the parks). The sample size of the variable in level 3 is 30 and met the numeric requirement for a regression analysis, which can account for a good portion of the variance at that level.

With the establishment of the HLM, proper regression needs to be determined to study the association between park quality and social interaction. People's park usages and activities as well as the distribution of park attributes may be influenced by their distance from other parks and cause spatial autocorrelation (Chen et al., 2019; Conway et al., 2010). The issue of spatial autocorrelation was detected to influence the results of park quality distribution (Chen et al., 2019). It can be biased to analyze a spatial dataset with a statistical regression because the statistical regression analysis assumed that all observations in the dataset were independent (Anselin & Bera, 1998). The test of spatial autocorrelation of the dataset was necessary for the social interaction dataset. If spatial autocorrelation existed, a spatial regression analysis was more appropriate than statistical regression to analyze the dataset that had spatial autocorrelation character. Furthermore, the Hierarchical Spatial Autoregressive Model in the HSAR package of R can be used to study the association between social interaction and park quality to simultaneously address the inaccuracies caused by the multilevel data structure and spatial autocorrelation (Dong et al., 2016). If no spatial autocorrelation was detected, the HLM analysis can be conducted from the Unconditional Model in R (Kleiman, 2017) (Fig. 2).

3. Results

3.1. Sample characteristics

The sample characteristics of the DVs, IVs, and the continuous control variables were shown in Table 1, through descriptive statistics analyzed in SPSS. The nominal variables were created as dummy variables and coded as sub-areas of a park (green space: GS; paved open space: POS; sports area: SA; pathway: PW; playground: PG; waterfront: WF; others: O), park type (community park: C; greenway: G; neighborhood park: N; special use park/facility: S; pocket park: P), weather (sunny: S; rainy/cloudy: R), weekday/weekend (weekday: A; Saturday: B; Sunday: C), time (10:00 am – 2:00 pm: A; 2:00 pm – 6:00 pm: B). The dummy variables were also controlled in the statistical analysis.

To keep all the variables in a consistent unit, we standardized them

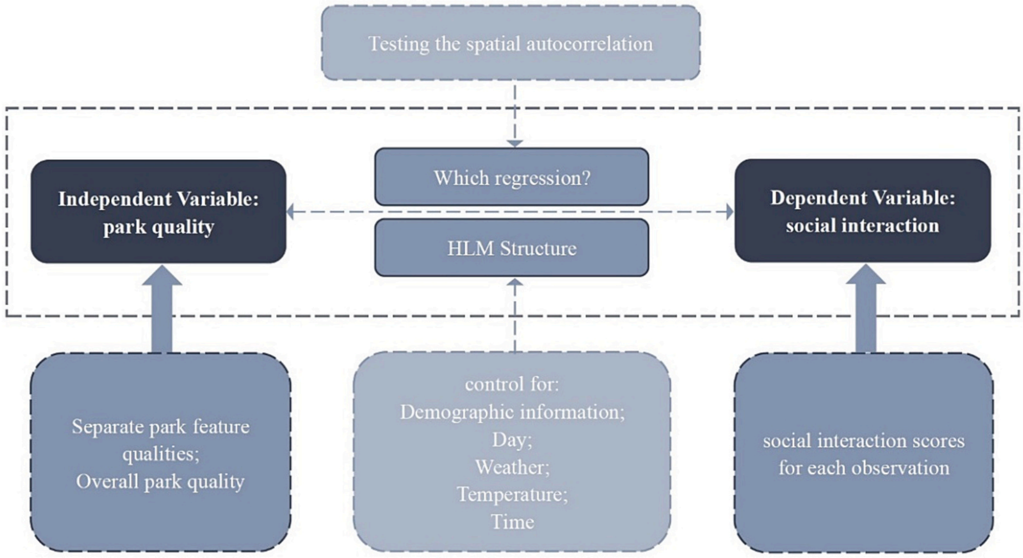

Fig. 2. Research framework and flowchart.

Table 1
Descriptive statistics of the variables (the demographic control variables are in the census block group unit).

	Mean	SD	Range
Independent variables (IVs)			
Park size	7.7	7.3	(0.46, 25.18)
(standardized*)	0	1	(−0.96, 2.39)
Facility	45.11	17.15	(0, 73.1)
(standardized*)	0	1	(−2.18, 1.68)
Amenity	54.46	19.66	(0, 86)
(standardized*)	0	1	(−1.63, 1.76)
Aesthetic feature	57.16	21.34	(0, 88.9)
(standardized*)	0	1	(−2.28, 1.69)
Maintenance & cleanliness	55.03	18.89	(0,100)
(standardized*)	0	1	(−2.61, 1.80)
Incivility	55.18	19.17	(0, 86)
(standardized*)	0	1	(−2.24, 1.29)
Overall park quality	53.3	17.15	(0, 78)
(standardized*)	0	1	(−2.51, 1.60)
Control variables (continuous)			
Temperature	16.62	5.53 1	(7, 29)
(standardized*)	0		(−1.30, 2.25)
Total population density	4732.32	6095.02	(0, 33,065)
(standardized*)	0	1	(−0.78, 4.65)
Children population density	939.51	830.14	(0, 4199.34)
(standardized*)	0	1	(−1.13, 3.93)
Minority density	868.71	1208.61	(0, 7474.82)
(standardized*)	0	1	(−0.72, 5.45)
Unemployment (%)	36.36	9.52	(17.61, 61.07)
(standardized*)	0	1	(−1.97, 2.60)
Renter rate (%)	49.51	30.96	(0, 100)
(standardized*)	0	1	(−1.60, 1.63)
Building size (%)	58.91	28.22	(3.90, 100)
(standardized*)	0	1	(−1.95, 1.46)
Dependent variable (DVs)			
SIS	78.60	112.30	(0, 873)
(standardized*)	0	1	(−0.58, 6.40)
SIS for each group	21.46	46.49	(0, 480)
(standardized*)	0	1	(−0.46, 9.86)

* Standardized to 1 scale.

into the 1 scale. The histograms with normal curves indicated that the skewness of DVs (SIS and SIS for each group) and IVs (park quality) were between −1 and 1, while the control variables of park size and temperature were normally distributed. For the DVs, the SIS was the aggregated social interaction score for each observation, while the SIS for each group was the social interaction score for each group nested in each observation. The SIS for each group was the DV in the 3-level HLM, while the SIS was the DV in the 2-level HLM as a reference.

3.2. Testing spatial autocorrelation

To identify which regression will be used to analyze the dataset under the hierarchical structure, the spatial weights matrix across the setting was set up and six Moran's I analysis was conducted to test whether the DV in the six different observations is spatially autocorrelated. From the six Moran's I analysis, only two out of six rejected the null hypothesis that the social interaction score was randomly independently distributed in the setting with a significant *p-value*. The DV—social interaction scores in four observations were randomly distributed in the area, which met the criteria to be analyzed via the traditional statistical regression. Then, the two observations that rejected the null hypothesis were further tested through the Lagrange Multiplier Statistics to identify the extent of the spatial autocorrelation. The Lagrange Multiplier Statistics diagnosed that there is no significant *p-value* for the Spatial Error Model or the Spatial Lag Model for the two observations. These results suggested that the OLS model should be used to analyze the social interaction scores in the other two observations.

In summary, there was no spatial autocorrelation in most of the observations. For the other two groups of observation that presented spatial autocorrelation, the Lagrange Multiplier Statistics illustrated that the OLS analysis was the most suitable regression analysis. Because the HLM was based on OLS regression while extending the original OLS to accommodate the multilevel data structure, the HLM analysis with the OLS regression was applicable for the social interaction dataset and adequately addressed the issue of spatial autocorrelation.

3.3. HLM analysis

The first step in the HLM analysis was to test the unconditional model in R. The result of the unconditional model (*p-value* = 0.003) showed a significant between-observation variation under the multilevel structure, which supported the use of the multilevel modeling for this dataset. The random slope was more appropriate for this study than the fixed slope, because the IV—park quality is the higher-level unit (level 3) in the hierarchical structure, it allowed the intercept and/or slope to vary randomly across a higher-level. As the fixed slope assumed that the same value to be applied to all the higher-level units, compared to the fixed, the random coefficients modeling should be used to explore the associations between park quality (level 3) and the social interaction scores (level 1).

With the "lme4" package in R programming language, the first random coefficients 3-level HLM was conducted to study the statistical relationships between the overall park quality and social interaction scores while another random coefficients 3-level HLM identified which separate park qualities were related to the social interaction scores (Tables 2 and 3). Both the overall park quality and the separate park qualities were included in the third 3-level HLM regression and to compare associations with social interaction. While making the DV consistent, Table 2 illustrated the estimate variance of Leve 1, Level 2, and Level 3 in the three HLM models with different IVs.

The estimates of HLM 1 indicated that 15 % of the variance of SIS can be attributed to level 3, park quality variance. Among the IV in HLM 1, overall park quality was the most important predictor of SIS. Following the overall park quality, park size is another important predictor (Table 3). In HLM 2, the IVs include the separate park quality but do not include the overall park quality, and indicated that 13 % of the variance of SIS can be attributed to park quality variance. Among the independent variables in HLM 2, the aesthetic feature was the strongest predictor of SIS followed by cleanliness and maintenance and the park size (Table 3). Both the overall and separate park quality were included as the IVs in the HLM 3 to explore the relationships with social interaction, and indicated that 13 % of the variance of SIS can be attributed to park quality variance. Among the independent variables in HLM 3, overall park quality was the strongest predictor of SIS to a statistically significant extent followed by park size and aesthetic feature. The variable of Maintenance & cleanliness was not statistically significant in HLM3 (Table 3).

After identifying a significant correlation between the two separate park qualities (aesthetic features and cleanliness & maintenance) and social interaction score, a further HLM analysis was conducted to explore which park features and characteristics contributing to the two separate park qualities were related to the social interaction score. The HLM model accounted for 9 % of the SIS can be attributed to park quality level variance. According to the results (Table 4), most park features of aesthetic features, were significantly correlated with the SIS. Attractiveness and decorative elements were the most significant predictor of the DV. Also, most contributors of maintenance & cleanliness were also correlated with SIS but the coefficient sizes were generally smaller than those in aesthetic feature.

4. Discussion

Park and green space have been discovered benefiting social interaction by providing outdoor natural spaces for people to meet and gather (Enssle & Kabisch, 2020; Jennings & Bamkole, 2019; Mullenbach et al., 2022). Well-designed parks and green open spaces can encourage urban residents to socialize from the lockdowns of COVID-19 (Knobel et al., 2021; Lu & Giuliano, 2023). Multiple dimensions of park features and characteristics have been synthesized in relation to park-based social interaction (Clarke et al., 2023; Wan et al., 2021). To advance the measurement of social interaction, this study employed a newly established protocols—SOSIP to objectively assess park users' social interactive behaviors by considering both the size of the social groups and their corresponding levels of social interaction (Chen et al., 2023). After reviewing the identified park features and characteristics associated with social interaction internationally (Chen et al., 2020), this study further provided a comprehensive assessment of separate aspects of park quality considering both objective and subjective components of park features and characteristics, including facility, amenity, aesthetic features, maintenance and cleanliness, and incivilities, as well as the overall park quality generalizing the separate aspects.

Significant associations between overall park quality, followed by park size and specific sub-areas (green space and playground) with social interaction were disclosed in this study. For the separate park qualities, social interaction was only influenced by aesthetic features and maintenance & cleanliness. As most existing research ignored

Table 2
The estimate variance and residual results for Leve 1, Level 2, and Level 3 in the three HLM models with different IVs.

	HLMs		
	HLM1: SIS with overall park quality	HLM2: SIS with separate park quality	HLM3: SIS with overall and separate park quality
The estimate variance for level 1 (social group)	0	0	0
The estimate variance for level 2 (observation)	0.23	0.18	0.15
The estimate variance for level 3 (park)	3.57	3.46	3.50
Residual	20.09	22.98	23.28
Total variance	23.89	26.62	26.93

Table 3
The random coefficients HLM results of social interaction scores with overall and separate park qualities.

Intercept	HLM		
	HLM1: SIS with overall park quality	HLM2: SIS with separate park quality	HLM3: SIS with overall and separate park quality
Level 3			
Facility		1.98	2.62
Amenity		−1.8	−2.23
Aesthetic		8.02**	5.64*
Maintenance & cleanliness		5.02*	3.16
Incivility		−0.31	−3.66
Overall	8.62**		12.07**
Park size	5.31*	5.23*	7.01*
Sub-area (GS)	4.97*	3.10	4.65*
Sub-area (PG)	5.18*	4.78*	5.02*
Level 2			
Week B	25.58**	24.87**	25.02**
Week C	11.79**	11.02**	11.63**
Temperature	−0.68	−0.34	−0.47
Weather S	13.74*	12.66**	11.82**
Time B	2.69	1.78	1.32

Sub-area (GS): Green space; Sub-area (PG): Playground; Week B: Saturday; Week C: Sunday; Weather S: Sunny; Time B: 2:00 pm–6:00 pm.
** $P < 0.001$.
* $P < 0.05$.

Table 4
The random coefficients HLM results of social interaction scores with the specific park features and characteristics.

Park feature and characteristics of aesthetic features		Park feature and characterisics of maintenance & cleanliness	
Cultural elements	2.86*	Traffic calming	1.34
Sportive aquatic activities	1.17	Pedestrian facilitation	0.78
Visible houses	−0.53	Safe measures	1.86*
Visible street	0.44	Pool condition	2.08*
Decorative elements	3.82**	Toilet condition	2.34*
Landscaping	3.22*	Chalet condition	−1.27
Water feature	2.37*	Water sprinkler condition	2.05*
Attractiveness	4.31**	Safety	3.76**

** $P < 0.001$.
* $P < 0.05$.

incorporating different park features and characteristics from both objective and subjective aspects, this study suggested that overall park quality encompassing multiple park attributes gained more importance than a single park feature or characteristics in promoting people's social interaction. Rather than focusing on a specific aspect, we recommend planners and policymakers to consider the enhancement of overall park quality through incorporating various perspectives that can effectively increase the number and levels of individuals' social behaviors/activities and consequently benefit residents' mental health and enhance the social cohesion of the community. More importantly, we found to enhance social interaction in parks through park planning and design was a sophisticated process, and we advocated additional efforts toward advancing the knowledge in this field, such as caring the social needs of elderly and children. Beyond the placement of a particular facilities, amenities, or any other separate park attributes, more efforts need to be devoted to exploring the complexity of how to improve overall park quality including considering both the physical and non-physical aspects influencing people's social interaction in parks and green open space. Table 5 presented a generalized design guideline for park quality to promote social interaction in urban parks.

Among the separate park qualities that contributing to the overall park quality, we found aesthetic features were most effective in increasing the number of participants and the level of social interaction (Table 5). Maintenance & cleanliness were unstable factors to predict social interaction. In this study, the statistics implied that aesthetic features (e.g., landscaping, tree canopies/shelters, water features, and green space) can attract more people to the park and engage in higher levels of socialization. These findings were consistent with the literatures that natural landscaping and the maintenance levels significantly influence park-based social interaction (Clarke et al., 2023; Coley et al., 1997; De Vries et al., 2013; Kaplan & Kaplan, 1989; Kuo et al., 1998; Wan et al., 2021). In addition, the current study offered insights into the associations between park features & characteristics and social interaction. Landscape features were identified as an important motivator for people's social interactive behaviors in this study, which were consistent with the findings in previous studies (Coley et al., 1997; Kaplan & Kaplan, 1989).

Contrary to the literature (Rasidi et al., 2012), we disclosed that facilities and amenities alone cannot encourage more people to socialize in parks. Recent research indicated play facilities, such as playground can make children be socially engaged in parks (Veitch et al., 2021). The presence of facilities, such as ball game fields, can be supportive of people's physical activities (Chen et al., 2022; Veitch et al., 2022) but has limited effect in encouraging people's social interactive behaviors in this case. Amenity, including seating, paths, parking lots, and restrooms, are not effective elements for attracting individuals to make friends reported from the results. As the social benefits become increasingly crucial in motivating people to visit the urban green space (Uzonnah et al., 2023), these findings have important implications on future capital investment on facilities and amenities in urban parks. If part of the planning goal is to attract people to socialize and benefit their mental health, such as the small neighborhood and pocket parks with limited space for people to exercise but can create a comfortable social space, increasing the number of facilities and amenities might not provide added values for park users' social interaction.

Literature suggested that specific facilities and amenities can encourage social interaction (Jennings & Bamkole, 2019), such as the positive relationships between playgrounds, shelters, seats, play courts, and pathways and social interaction (Kaźmierczak, 2013; Moulay et al., 2017; Rasidi et al., 2012). However, this study claimed that the investment on park facilities and amenities cannot attract more social groups and improve the levels of social interaction in urban park. Compared to a park with a certain high separate quality, park users tended to socialize in overall high-quality urban parks. Simultaneously, this study illustrated that park users tended to engage in social activities in playgrounds and green space, which supported by previous discoveries that the existence of some facilities like playgrounds can motivate children to be socially engaged (Veitch et al., 2021). All the findings implied that a park well-equipped with facilities and amenities may not encourage social interaction, but the sub-areas like green space and playground in a park created more opportunities for park users' social activities. With these divergent conclusions, more experimental studies and the systematic studies are needed to explore the disagreement for different target population in the future and determine the placement and arrangement of play facilities and the play settings/zones, such as the playground and green space, to bring positive influences on people's social interactive activities.

This divergence of the findings may also result from the different measurements of park environments, such as facilities and amenities. While previous studies focused on single park features or characteristics like seats, play courts, and pathways, this study expended the research scope to park quality measurement by embracing both the objective and subjective aspects of park environments and grouped them into separate categories. For example, the measure of facility in this study counted the existence of specific park attributes, such as ball game fields, and considered the conditions of these facilities according to auditors' impression. It should be noted that some park features and characteristics categorized as aesthetic features in this study were aligned with some of the facilities defined in those literature. The inconsistent definition of park attributes might cause the differences in the conclusions (Clarke et al., 2023; Taylor & Hochuli, 2015), so we recommended to employ a protocol/instrument/tool to evaluate the elements in a standardized manner to reduce the disagreement in measurements. A review of park assessment tools indicated that most of the existing tools were designed to measure park quality from the perspective of promoting physical activity (Chen et al., 2020). Popular ones such as BRAT-DO (Bedimo-Rung et al., 2006) and EAPRS (Saelens et al., 2006) fall under this category. We employed an established instrument—PARK (Bird et al., 2015) to systematically measure park quality incorporating various park attributes without a specific criteria. However, this study focused on assessing park quality from the perspective of encouraging social interaction, a tool evaluating the quality of the park environment for the purpose of benefiting social interaction should be addressed in the future research. Additionally, various assessing approaches for social interaction may also cause the inconsistency in the conclusions. While the previous studies inquired social interaction through residents' perceptions (Maas et al., 2009; Seeland et al., 2009; Skjœveland, 2001) or by counting the number of gathering people to indicate social interaction (Hillier et al., 2016; Rasidi et al., 2012; Schmidt et al., 2019), this study employed SOSIP protocol objectively measuring park-based social interactive behaviors/activities considering both the size of social groups as well as their corresponding level of social interaction (Chen

Table 5
Design guideline of park quality to promote social interation.

Significance to social interaction	Park quality
Most significant	Overall park quality (genializing separate park qualities: facility, amenity, aesthetic features, maintenance & cleanliness, incivility) Sub-areas within the park including green space and playground Park size
Significant	Aesthetic features (attractiveness, decorative elements, landscaping, cultural elements, water feature) Maintenance & cleanliness (safety, toilet condition, pool condition, water sprinkler condition)
Not significant	Some separate park quality (the existence of facility, amenity, incivility) Some specific park features including aesthetic features and maintenance & cleanliness (sportive aquatic activities, visible house and street, traffic calming, pedestrian facilitation, chalet condition)

et al., 2023). The inconsistent conclusions among the different measurements of social interaction indicated the significance of employing an established protocol to objectively assess social interactive behaviors in a standardized manner, rather than indirectly reflecting park-based social interaction from the number of park visitors or the residents' self-reported connections with neighbors and friends.

Urban residents valued the sense of welcoming and safe park environment that can encourage their social interactions especially after the COVID pandemic (Lu & Giuliano, 2023). Aesthetic features and maintenance & cleanliness indicated as useful elements to support people's social interaction identified in this current study. Aesthetic features were identified as cultural elements, the environment adjacent to the park, the landscaping, decorative elements, water features, and the level of attractiveness perceived by the auditors (Bird et al., 2015). Cleanliness & maintenance of a park was assessed based on the conditions of the park and its facilities as well as that of the adjacent environments. In line with the assessment of aesthetic features, the auditors' perception of the park's conditions accounted for >35 % of the weight in assessing the maintenance & cleanliness of the park. But for facility and amenity, the auditors' perceptions only occupied <12 % of the weight. The significant differences between the importance of people's perception in evaluating separate park qualities need to be noticed, so we can conclude that the subjective components (e.g., the general condition and the visitors' perceptions of the park) played a more important role in encouraging social interaction than the objective components (e.g., the presence of various facilities and amenities) in this case study. Considerable literature also proved the subjective components of park environment, such as the perception of safety, which acknowledged as key factors to influence social interaction (Dinnie et al., 2013; Hong et al., 2018; Liu et al., 2020; Rasidi et al., 2012; Wan et al., 2021), perceived greenness (De Vries et al., 2013; Sugiyama et al., 2008) played important roles in facilitating social interaction. In the future, when the park designers aim to benefit urban dwellers' health status through improving the opportunities for social interaction in parks, serving the park user's subjective perceptions and feeling through elevating the aesthetic quality and cleanness & maintenance conditions might be more useful than the physical dimensions, such as increasing the numbers of facilities and amenities (Samsudin et al., 2022). In addition to considering visitors' experiences in parks, future planners and designers should also embrace the cultural elements of a park, which may become an effective strategy to create sense of attachment that elicited conversations among visitors (Xin et al., 2020). Other design elements such as landscaping, water features, and an adorable surrounding area, can bring more people to socialize in the park (Clarke et al., 2023; Wan et al., 2021). Maintenance & cleanliness presented another challenge in park management due to budget constraints or largely ignored (Chen et al., 2022), but this study strongly suggested that well-maintained and neatly managed parks can be attractive to people who visit parks for serendipitous interactions with other people. However, policymakers and stakeholders should be reminded by this research that follow-up works, especially the park management and maintenance after the planning and design can be more important than what has already been constructed in the parks, especially for the park visitors seeking the opportunities for healthier social lives and creating cohesive and harmonious communities.

5. Conclusion

This study expended the scope of park quality measurement addressing social interaction, by considering different aspects of both objective and subjective park attributes, and further being genialized into the overall park quality. To achieve an efficient and accurate measurement of social interaction, a newly established protocol was employed to quantify park-based social interactive behaviors and explored the associations between park quality (overall and separate park qualities) and social interaction in urban parks settings. Through the advancement of both measures, we disclosed an improvement in the overall park quality could substantially contribute to both the levels and numbers of participants' social activities. Park users tended to engage in social activities in some specific sub-areas within a park, including playground and green space. But it is noticeable that merely increasing the presence of specific facilities and amenities in parks has limited effects on encouraging social interaction. Among the separate park qualities, aesthetic feature and cleanliness & maintenance were the significant contributors to social interaction. The subjective components of the park design weighed more importance than the objectives in attracting people to socialize in the parks. The creation of safe and clean park environment can effectively encourage park users' social activities. A design guideline was provided for planners and policymakers across urban settings to enhance the outdoor social interaction and contributed to a healthy and socially cohesive community through effective park quality enhancement.

CRediT authorship contribution statement

Shuolei Chen: Writing – original draft, Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Visualization. **Ole Sleipness:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Keith Christensen:** Conceptualization, Methodology, Validation, Supervision, Project administration. **Bo Yang:** Conceptualization, Validation, Supervision. **Keunhyun Park:** Methodology, Validation, Visualization. **Ryan Knowles:** Methodology, Software, Validation. **Zhuoheng Yang:** Investigation, Data curation, Visualization. **Hao Wang:** Resources, Supervision, Funding acquisition.

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Data availability

Data will be made available on request.

References

Anselin, L., & Bera, A. (1998). Spatial dependence in linear regression models with an introduction to spatial econometrics. In *Handbook of applied economic statistics*. New York, USA: Marcel Dekker.

Askarizad, R., & Safari, H. (2020). The influence of social interactions on the behavioral patterns of the people in urban spaces (case study: The pedestrian zone of Rasht Municipality Square, Iran). *Cities, 101*, Article 102687.

Bedimo-Rung, A. L., Gustat, J., Tompkins, B. J., Rice, J., & Thomson, J. (2006). Development of a direct observation instrument to measure environmental characteristics of parks for physical activity. *Journal of Physical Activity and Health, 3* (s1), S176–S189.

Bird, M. E., Datta, G. D., Van Hulst, A., Kestens, Y., & Barnett, T. A. (2015). A reliability assessment of a direct-observation park evaluation tool: The parks, activity and recreation among kids (PARK) tool. *BMC Public Health, 15*(1), 906.

Broomhall, M., Giles-Corti, B., & Lange, A. (2004). *Quality of public open space tool (POST)*. Perth, Australia: School of Population Health, The University of Western Australia.

Campbell, L. K., Svendsen, E. S., Sonti, N. F., & Johnson, M. L. (2016). A social assessment of urban parkland: Analyzing park use and meaning to inform management and resilience planning. *Environmental Science & Policy, 62*, 34–44.

Cao, J., & Kang, J. (2019). Social relationships and patterns of use in urban public spaces in China and the United Kingdom. *Cities, 93*, 188–196.

Chen, S., Sleipness, O., Christensen, K., Yang, B., & Wang, H. (2023). Developing and testing a protocol to systematically assess social interaction with urban outdoor environment. *Journal of Environmental Psychology, 102008*.

Chen, S., Sleipness, O., Xu, Y., Park, K., & Christensen, K. (2020). A systematic review of alternative protocols for evaluating non-spatial dimensions of urban parks. *Urban Forestry & Urban Greening, 126718*.

Chen, S., Sleipness, O. R., Christensen, K. M., Feldon, D., & Xu, Y. (2019). Environmental justice and park quality in an intermountain west gateway community: Assessing the spatial autocorrelation. *Landscape Ecology, 34*(10), 2323–2335.

Chen, Y., Zhang, B., Li, M., Zhou, R. Z., & Xu, Z. (2022). Concatenating daily exercise routes with public sports facilities, bicycle lanes, and green spaces: A feasibility analysis in Nanjing, China. *Land, 11*(12), 2251.

Clarke, M., Wallace, C., Cadaval, S., Anderson, E., Egerer, M., Dinkins, L., & Platero, R. (2023). Factors that enhance or hinder social cohesion in urban greenspaces: A literature review. *Urban Forestry & Urban Greening, 127936*.

Coley, R. L., Sullivan, W. C., & Kuo, F. E. (1997). Where does community grow? The social context created by nature in urban public housing. *Environment and Behavior, 29*(4), 468–494.

Conway, D., Li, C. Q., Wolch, J., Kahle, C., & Jerrett, M. (2010). A spatial autocorrelation approach for examining the effects of urban greenspace on residential property values. *The Journal of Real Estate Finance and Economics, 41*, 150–169.

Crawford, D., Timperio, A., Giles-Corti, B., Ball, K., Hume, C., Roberts, R., Andrianopoulos, N., & Salmon, J. (2008). Do features of public open spaces vary according to neighbourhood socio-economic status? *Health & Place, 14*(4), 889–893.

Dadvand, P., Hariri, S., Abbasi, B., Heshmat, R., Qorbani, M., Motlagh, M. E., … Kelishadi, R. (2019). Use of green spaces, self-satisfaction and social contacts in adolescents: A population-based CASPIAN-V study. *Environmental Research, 168*, 171–177.

De Vries, S., Van Dillen, S. M., Groenewegen, P. P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science & Medicine, 94*, 26–33.

Dinnie, E., Brown, K. M., & Morris, S. (2013). Reprint of "Community, cooperation and conflict: Negotiating the social well-being benefits of urban greenspace experiences". *Landscape and Urban Planning, 118*, 103–111.

Dong, G., Harris, R., & Mimis, A. (2016). *HSAR: An R package for integrated spatial econometric and multilevel modelling*. GIS Research UK.

Dong, L., Jiang, H., Li, W., Qiu, B., Wang, H., & Qiu, W. (2023). Assessing impacts of objective features and subjective perceptions of street environment on running amount: A case study of Boston. *Landscape and Urban Planning, 235*, Article 104756.

Edwards, N., Hooper, P., Trapp, G. S. A., Bull, F., Boruff, B., & Giles-Corti, B. (2013). Development of a Public Open Space Desktop Auditing Tool (POSDAT): A remote sensing approach. *Applied Geography, 38*, 22–30.

Enssle, F., & Kabisch, N. (2020). Urban green spaces for the social interaction, health and well-being of older people—An integrated view of urban ecosystem services and socio-environmental justice. *Environmental Science & Policy, 109*, 36–44.

Geng, D. C., Innes, J., Wu, W., & Wang, G. (2021). Impacts of COVID-19 pandemic on urban park visitation: A global analysis. *Journal of Forestry Research, 32*(2), 553–567.

Gidlow, C. J., Ellis, N. J., & Bostock, S. (2012). Development of the neighbourhood green space tool (NGST). *Landscape and Urban Planning, 106*(4), 347–358.

Han, S., Song, D., Xu, L., Ye, Y., Yan, S., Shi, F., & Du, H. (2022). Behavior in public open spaces: A systematic review of studies with quantitative research methods. *Building and Environment, 109444*.

Hillier, A., Han, B., Eisenman, T. S., Evenson, K. R., McKenzie, T. L., & Cohen, D. A. (2016). Using systematic observations to understand conditions that promote interracial experiences in neighbourhood parks. *Urban Planning, 1*(4), 51.

Hoffimann, E., Campelo, D., Hooper, P., Barros, H., & Ribeiro, A. I. (2018). Development of a smartphone app to evaluate the quality of public open space for physical activity. An instrument for health researchers and urban planners. *Landscape and Urban Planning, 177*, 191–195.

Hong, A., Sallis, J. F., King, A. C., Conway, T. L., Saelens, B., Cain, K. L., … Frank, L. D. (2018). Linking green space to neighborhood social capital in older adults: The role of perceived safety. *Social Science & Medicine, 207*, 38–45.

Huang, W., & Lin, G. (2023). The relationship between urban green space and social health of individuals: A scoping review. *Urban Forestry & Urban Greening, 127969*.

Hughey, S. M., Walsemann, K. M., Child, S., Powers, A., Reed, J. A., & Kaczynski, A. T. (2016). Using an environmental justice approach to examine the relationships between park availability and quality indicators, neighborhood disadvantage, and racial/ethnic composition. *Landscape and Urban Planning, 148*, 159–169.

Jennings, V., & Bamkole, O. (2019). The relationship between social cohesion and urban green space: An avenue for health promotion. *International Journal of Environmental Research and Public Health, 16*(3), 452.

Kabisch, N., & Haase, D. (2013). Green spaces of European cities revisited for 1990–2006. *Landscape and Urban Planning, 110*, 113–122.

Kaczynski, A. T., Wilhelm Stanis, S. A., & Besenyi, G. M. (2012). Development and testing of a community stakeholder park audit tool. *American Journal of Preventive Medicine, 42*(3), 242–249.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. CUP Archive.

Kaźmierczak, A. (2013). The contribution of local parks to neighbourhood social ties. *Landscape and Urban Planning, 109*(1), 31–44.

Kemperman, A., & Timmermans, H. (2014). Green spaces in the direct living environment and social contacts of the aging population. *Landscape and Urban Planning, 129*, 44–54.

Kleiman, E. (2017). Understanding and analyzing multilevel data from real-time monitoring studies: An easily-accessible tutorial using R. Retrieved from: https://psyarxiv.com/xf2pw/.

Knobel, P., Dadvand, P., Alonso, L., Costa, L., Español, M., & Maneja, R. (2021). Development of the urban green space quality assessment tool (RECITAL). *Urban Forestry & Urban Greening, 57*, Article 126895.

Krellenberg, K., Welz, J., & Reyes-Päcke, S. (2014). Urban green areas and their potential for social interaction–a case study of a socio-economically mixed neighbourhood in Santiago de Chile. *Habitat International, 44*, 11–21.

Kuo, F. E., Sullivan, W. C., Coley, R. L., & Brunson, L. (1998). Fertile ground for community: Inner-city neighborhood common spaces. *American Journal of Community Psychology, 26*(6), 823–851.

Kweon, B. S., Sullivan, W. C., & Wiley, A. R. (1998). Green common spaces and the social integration of inner-city older adults. *Environment and Behavior, 30*(6), 832–858.

Lee, H.-S. (2022). Developing and testing the senior park environment assessment in Korea (SPEAK) audit tool. *Landscape and Urban Planning, 227*, Article 104545.

Lee, R. E., Booth, K. M., Reese-Smith, J. Y., Regan, G., & Howard, H. H. (2005). The Physical Activity Resource Assessment (PARA) instrument: Evaluating features, amenities and incivilities of physical activity resources in urban neighborhoods. *International Journal of Behavioral Nutrition and Physical Activity, 2*(1), 13.

Li, H., Ta, N., Yu, B., & Wu, J. (2023). Are the accessibility and facility environment of parks associated with mental health? A comparative analysis based on residential areas and workplaces. *Landscape and Urban Planning, 237*, Article 104807.

Li, S., & Yang, B. (2022). Social media for landscape planning and design: A review and discussion. *Landscape Research, 47*(5), 648–663.

Liu, B., Chen, Y., & Xiao, M. (2020). The social utility and health benefits for older adults of amenity buildings in China's urban parks: A Nanjing case study. *International Journal of Environmental Research and Public Health, 17*(20), 7497.

Lu, Y., & Giuliano, G. (2023). Where do people meet? Time-series clustering for social interaction levels in daily-life spaces during the COVID-19 pandemic. *Cities, 104298*.

Maas, J., Van Dillen, S. M., Verheij, R. A., & Groenewegen, P. P. (2009). Social contacts as a possible mechanism behind the relation between green space and health. *Health & Place, 15*(2), 586–595.

McCormack, G. R., Rock, M., Toohey, A. M., & Hignell, D. (2010). Characteristics of urban parks associated with park use and physical activity: A review of qualitative research. *Health & Place, 16*(4), 712–726.

Moulay, A., Ujang, N., & Said, I. (2017). Legibility of neighborhood parks as a predicator for enhanced social interaction towards social sustainability. *Cities, 61*, 58–64.

Mullenbach, L. E., Larson, L. R., Floyd, M. F., Marquet, O., Huang, J. H., Alberico, C., … Hipp, J. A. (2022). Cultivating social capital in diverse, low-income neighborhoods: The value of parks for parents with young children. *Landscape and Urban Planning, 219*, Article 104313.

Peters, K., Elands, B., & Buijs, A. (2010). Social interactions in urban parks: Stimulating social cohesion? *Urban Forestry & Urban Greening, 9*(2), 93–100.

Poppe, L., Van Dyck, D., De Keyser, E., Van Puyvelde, A., Veitch, J., & Deforche, B. (2023). The impact of renewal of an urban park in Belgium on park use and park-based physical activity: A natural experiment. *Cities, 140*, Article 104428.

Rasidi, M. H., Jamirsah, N., & Said, I. (2012). Urban green space design affects urban residents' social interaction. *Procedia-Social and Behavioral Sciences, 68*, 464–480.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (vol. 1). Sage.

Rigolon, A., & Németh, J. (2018). A QUality INdex of Parks for Youth (QUINPY): Evaluating urban parks through geographic information systems. *Environment and Planning B: Urban Analytics and City Science, 45*(2), 275–294.

Rivera, E., Timperio, A., Loh, V. H., Deforche, B., & Veitch, J. (2021). Important park features for encouraging park visitation, physical activity and social interaction among adolescents: A conjoint analysis. *Health & Place, 70*, Article 102617.

Saelens, B. E., Frank, L. D., Auffrey, C., Whitaker, R. C., Burdette, H. L., & Colabianchi, N. (2006). Measuring physical environments of parks and playgrounds: EAPRS instrument development and inter-rater reliability. *Journal of Physical Activity and Health, 3*(s1), S190–S207.

Salih, S., & Ismail, S. (2018). Determining the factors affecting social interaction in the parks of Baghdad city, Iraq. *ArchNet-IJAR, 12*(3).

Samsudin, R., Yok, T. P., & Chua, V. (2022). Social capital formation in high density urban environments: Perceived attributes of neighborhood green space shape social

capital more directly than physical ones. *Landscape and Urban Planning, 227*, Article 104527.
Schmidt, T., Kerr, J., & Schipperijn, J. (2019). Associations between neighborhood open space features and walking and social interaction in older adults—A mixed methods study. *Geriatrics, 4*(3), 41.
Seeland, K., Dübendorfer, S., & Hansmann, R. (2009). Making friends in Zurich's urban forests and parks: The role of public green space for social inclusion of youths from different cultures. *Forest Policy and Economics, 11*(1), 10–17.
Skjœveland, O. (2001). Effects of street parks on social interactions among neighbors: A place perspective. *Journal of Architectural and Planning Research*, 131–147.
Sugiyama, T., Leslie, E., Giles-Corti, B., & Owen, N. (2008). Associations of neighbourhood greenness with physical and mental health: Do walking, social coherence and local social interaction explain the relationships? *Journal of Epidemiology & Community Health, 62*(5), e9.
Taylor, B. T., Fernando, P., Bauman, A. E., Williamson, A., Craig, J. C., & Redman, S. (2011). Measuring the quality of public open space using Google earth. *American Journal of Preventive Medicine, 40*(2), 105–112.
Taylor, L., & Hochuli, D. F. (2015). Creating better cities: How biodiversity and ecosystem functioning enhance urban residents' wellbeing. *Urban Ecosystem, 18*, 747–762.
United States Census Bureau. (2021). American fact finder. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml#none.
Uzonnah, O. E., Chukwu, I. N., & Ibem, E. O. (2023). Influence of perceived social benefits on motives for visiting urban green infrastructure spaces in small and medium-sized towns in Southeast Nigeria. *Cities, 135*, Article 104240.
Van den Berg, M. M., van Poppel, M., van Kamp, I., Ruijsbroek, A., Triguero-Mas, M., Gidlow, C., … Maas, J. (2019). Do physical activity, social cohesion, and loneliness mediate the association between time spent visiting green space and mental health? *Environment and Behavior, 51*(2), 144–166.
Veitch, J., Ball, K., Flowers, E., Deforche, B., & Timperio, A. (2021). Children's ratings of park features that encourage park visitation, physical activity and social interaction. *Urban Forestry & Urban Greening, 58*, Article 126963.
Veitch, J., Ball, K., Rivera, E., Loh, V., Deforche, B., Best, K., & Timperio, A. (2022). What entices older adults to parks? Identification of park features that encourage park visitation, physical activity, and social interaction. *Landscape and Urban Planning, 217*, Article 104254.
Venter, Z. S., Barton, D. N., Gundersen, V., Figari, H., & Nowell, M. S. (2021). Back to nature: Norwegians sustain increased recreational use of urban green space months after the COVID-19 outbreak. *Landscape and Urban Planning, 214*, Article 104175.
Völker, B., Flap, H., & Lindenberg, S. (2006). When are neighbourhoods communities? Community in Dutch neighbourhoods. *European Sociological Review, 23*(1), 99–114.
Wan, C., Shen, G. Q., & Choi, S. (2021). Underlying relationships between public urban green spaces and social cohesion: A systematic literature review. *City, Culture and Society, 24*, Article 100383.
Xin, C., Luyuan, L., & Pieter, U. (2020). Taking "social relations" as a cultural ecosystem service: A triangulation approach. *Urban Forestry & Urban Greening, 55*, Article 126790.