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Green space access and visitation disparities in the phoenix metropolitan area

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HIGHLIGHTS

- We examined distributive equity based on the use of green spaces.
- Access to local parks decreased as the percentage of the elderly population increased.
- Local park use increased as the percentage of children and the elderly increased.
- The results suggest that access and use can be different for the same group.
- Mobility data provide novel insights for park visit behavior.

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ABSTRACT

Previous green space equity studies have relied on access measures, such as the distance to, number of, or size of green spaces and have produced mixed results on green space disparities in the U.S. While the benefits of green spaces can be fulfilled when people visit them, attention to the differential use of green spaces has been less common. We examined green space inequalities using traditional access measures in order to understand which group has lower access to local parks and then investigated which urban residents visit local parks more using SafeGraph's mobility data. We found that the Phoenix metro area experiences green space access disparities by age group and (partially) income rather than by race and ethnicity. Access to local parks consistently decreased as the percentage of the elderly population increased in a neighborhood. However, the visit to local parks consistently increased as the percentage of children and the elderly increased. We discuss the implications of our findings for urban planning.

1. Introduction

The benefits of -urban green spaces such as parks on people's well-being have been well-documented (Chiesura, 2004; Francis, Wood, Knuiman, & Giles-Corti, 2012; Sugiyama et al., 2016; Wen, Zhang, Harris, Holt, & Croft, 2013). Urban green spaces, which serve as recreation resources, can contribute to greater physical activity and more positive health outcomes among residents (Bai, Stanis, Kaczynski, & Besenyi, 2013; Wen et al., 2013). Scholars have also explored the way exposure to nature is associated with increased psychological wellbeing and stress relief (Bratman, Hamilton, & Daily, 2012; Dobson et al., 2021; Hartig, Mitchell, De Vries, & Frumkin, 2014; Nutsford, Pearson, & Kingham, 2013; Selhub & Logan, 2012; Van den Berg et al., 2016). These physical and mental health benefits have been found in both adults (McCormack, Rock, Toohey, & Hignell, 2010; Roe et al., 2013) and children (Chawla, 2015; Rigolon, 2017). Health providers have even begun to write prescriptions for people to spend more time in nature, referred to often as a "nature pill" (James, Hess, Perkins, Taveras, & Scirica, 2017; Wessel, 2017).

However, not everyone in society experiences the benefits of green spaces equally. There is a growing body of literature on inequalities in access to green space across different social groups. Higher education, income, and urban vegetation were correlated positively in U.S. cities (Nesbitt, Meitner, Girling, Sheppard, & Lu, 2019). Further, U.S. cities with higher median incomes and lower percentages of Hispanic and non-Hispanic Black residents provide access to higher-quality parks than

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other cities (Rigolon, Browning, & Jennings, 2018). Green space access inequality was also observed at the census tract level within a city. For example, despite having significantly more access to parks, low-income communities (census tracts) in Kansas City had less access to quality parks with amenities, while high-minority communities had more parks with basketball courts, but fewer parks with trails (Vaughan et al., 2013). In Baltimore, Black communities have better access to parks within walking distance than Whites, but Whites have access to larger parks within walking distance than Blacks (Boone, Buckley, Grove, & Sister, 2009). Such disparities were also found among low-income and racial/ethnic minority neighborhoods at the census block group level. Nevertheless, the empirical results are mixed, as some studies have found a disparity in access to green space and others have found little or none (Abercrombie et al., 2008; Vaughan et al., 2013). Green space inequities at the neighborhood level have been studied frequently, but with greater inconsistency in the empirical findings than those at the city or census tract levels.

This study is situated in the literature focused on green space equity. We examine green space disparities by asking the following research questions:

1. Is access to local parks distributed equally across different neighborhoods based upon socioeconomic variables such as race, ethnicity, income, education, and age?
2. Which socioeconomic groups in neighborhoods visited local parks more frequently?

1.1. Inequalities in access to green space

To experience green spaces' mental, physical, and psychological benefits, people must be able to access the source of those benefits (i.e., quality green spaces). *Proximity* to parks is a traditional access measure that has been studied extensively in the literature (i.e., distance to the closest park; Rigolon, 2016). Many of the documented benefits of parks are enhanced for residents who live closer to parks. For example, Giles-Corti et al. (2005) found that people who live within walking distance of parks are three times more likely to get the recommended levels of daily exercise compared with those who do not live close to them. Close proximity to parks (and use of those parks) is also correlated with increased cardiovascular health and physical activity levels (Brown, Schebella, & Weber, 2014; Cohen et al., 2007). However, the benefits of living closer to parks have been inconclusive across different social groups (Rigolon, 2016) or occasionally favorable to low-income people or ethnic minority groups in some locations (e.g., Rigolon, 2017).

Rigolon (2016) defined *park acreage* using both the number and size of parks within a neighborhood. He also identified other variations in park acreage in the equity mapping literature, including the number of parks within a neighborhood, the number of acres of parks within a neighborhood, and the number of acres of parks per resident or child within a neighborhood (Rigolon, 2016). Rigolon's review of 49 previous studies (2016) concluded that there was clear evidence of inequality in park acreage. Low socioeconomic status and ethnic minority people in the U.S. have "… access to fewer parks, fewer acres of parks, and fewer acres of parks per 1000 residents or children than more affluent and white people" (Rigolon, 2016, p. 165). Given the findings on park acreage, disadvantaged groups may live in environments that provide relatively fewer natural resources (e.g., vegetation coverage) and facilities (e.g., fields, courts, paths, pools, and play structures) than advantaged groups, which may prevent them from reaping the health benefits that local parks provide equally.

1.2. Green space visitation

In measuring access, existing research has relied on distance indicators (e.g., proximity to green spaces; the number and size of parks within walking distance) as well as park quality indicators (e.g., size, safety, accessibility), which are more difficult to define and measure than proximity measures (Ahn, Kim, Lucio, Corley, & Bentley, 2020; Corley et al., 2018). While both park proximity and quality are good proxy measures for access that can influence park visitation, they do not indicate automatically that residents will visit or use the parks. Green space visitation is an access measure (Rigolon, 2016), but also a park use measure. People who visit green spaces more frequently have greater social cohesion, and those who make extended visits have a lower rate of depression and high blood pressure (Shanahan, Bush, Gaston, Lin, Dean, Barber, & Fuller, 2016). Such social or health benefits may be enhanced when people "visit" parks for activities, exercises, or other uses (e.g., enjoying nature), not just have access to nearby parks for a potential visit or use. However, evidence of the association between distance and park visitation was mixed in the limited studies that have used self-reported park visitation data (Cohen et al., 2009; Petrunoff et al., 2021). Proximity to green spaces can influence park visitation. Still, park visitation needs to be examined independently as a measure of access to, or use of, green spaces to identify the complex process and relation between park access, visit and use, and people's wellbeing and health effects.

Park visitation count data have been collected through (self-reported) park use surveys (e.g., Shanahan et al., 2016) or estimates of numerous data points from multiple sources, such as automatic traffic counters, ferry tickets, flyover counts, and some park employees who count people manually (National Park Service (2022), 2022). Measuring park visitation using these data collection methods is time-consuming, costly, and limited when trying to include a large number of parks (Ding, Li, & Sang, 2022). The need for easy and inexpensive methods to measure park or recreational visitation has led researchers to take advantage of online information, such as crowd-sourced photographs (e.g., Sessions, Wood, Rabotyagov, & Fisher, 2016). Recently, mobility data from mobile phones have emerged as a promising data source to examine park visitation (Geng, Innes, Wu, & Wang, 2021; Guo et al., 2019; Jay, Heykoop, Hwang, Phil, De Jong, Kennedy, & Kondo, 2021; Venter, Barton, Gundersen, Figari, & Nowell, 2020).

Because data providers such as SafeGraph and Google made smartphone-based mobility data available to the public and researchers only recently during COVID-19, attention to distributive equity in green space use by analyzing mobility data was less common in the literature before the pandemic. Recent studies that have examined park visitation during the COVID-19 pandemic or response policies to the pandemic (e.g., a Shelter-in-Place Order) using mobility data have not focused necessarily on equity across different social groups or communities (Ding et al., 2022; Yang et al., 2021). However, Jay and colleagues (2021) reported that the reopening of parks in 2020 was associated with more visits to park service areas on the part of a greater proportion of White residents. Nevertheless, their subgroup analysis focused on race and ethnicity without examining further other socioeconomic variables that are known to be associated with park visits or use, such as age, education, and income (Ahn et al., 2020). Accordingly, there is a lack of evidence about the way different social groups visit parks in non-disaster situations using rich mobility data. We filled the gap in this literature by focusing on urban residents' visits to local parks at the neighborhood level.

2. Research hypotheses

These studies demonstrate certain trends in the literature that we used to develop three hypotheses for park proximity, the number of parks, and park size by race, ethnicity, and income at the neighborhood (census block group) level.

- Hypothesis 1: Disadvantaged socioeconomic groups (race, ethnicity, and income) have similar access to local parks as advantaged groups when access is measured in distance.

- Hypothesis 2: Disadvantaged socioeconomic groups (race, ethnicity, and income) have similar access to local parks as advantaged groups when access is measured as the number of local parks.
- Hypothesis 3: Disadvantaged socioeconomic groups (race, ethnicity, and income) have less access to large local parks (measured by park size) than advantaged groups.

In addition to these hypotheses, we examined two more socioeconomic variables: education and age. We included education (the percent of people without a high school diploma; low education group) because of a recent finding of education's effect on distributional green equity in U.S. cities (Nesbitt et al., 2019). We also included the percent of children under 18 and of people in the 65 and over age groups because the major users of parks are children and the elderly (Sundevall & Jansson, 2020). Additionally, Cutts, Darby, Boone, and Brewis (2009) reported a negative correlation between the likelihood that a neighborhood has access to parks and the percentage of the population under 18 years old in the Phoenix metro area. However, we did not specify hypotheses for education and age because of limited findings on the variables in the green space equity literature that we reviewed.

3. Data and methods

3.1. Study context: phoenix metropolitan area

Environmental justice researchers have scrutinized the City of Phoenix or the Phoenix metropolitan area in Arizona in the U.S. because of disproportionate environmental burdens there on racial and ethnic minorities (Campbell, Peck, & Tschudi, 2010; Chun, Kim, & Campbell, 2012) and also green space disparity (Cutts et al., 2009; Ibes, 2015).

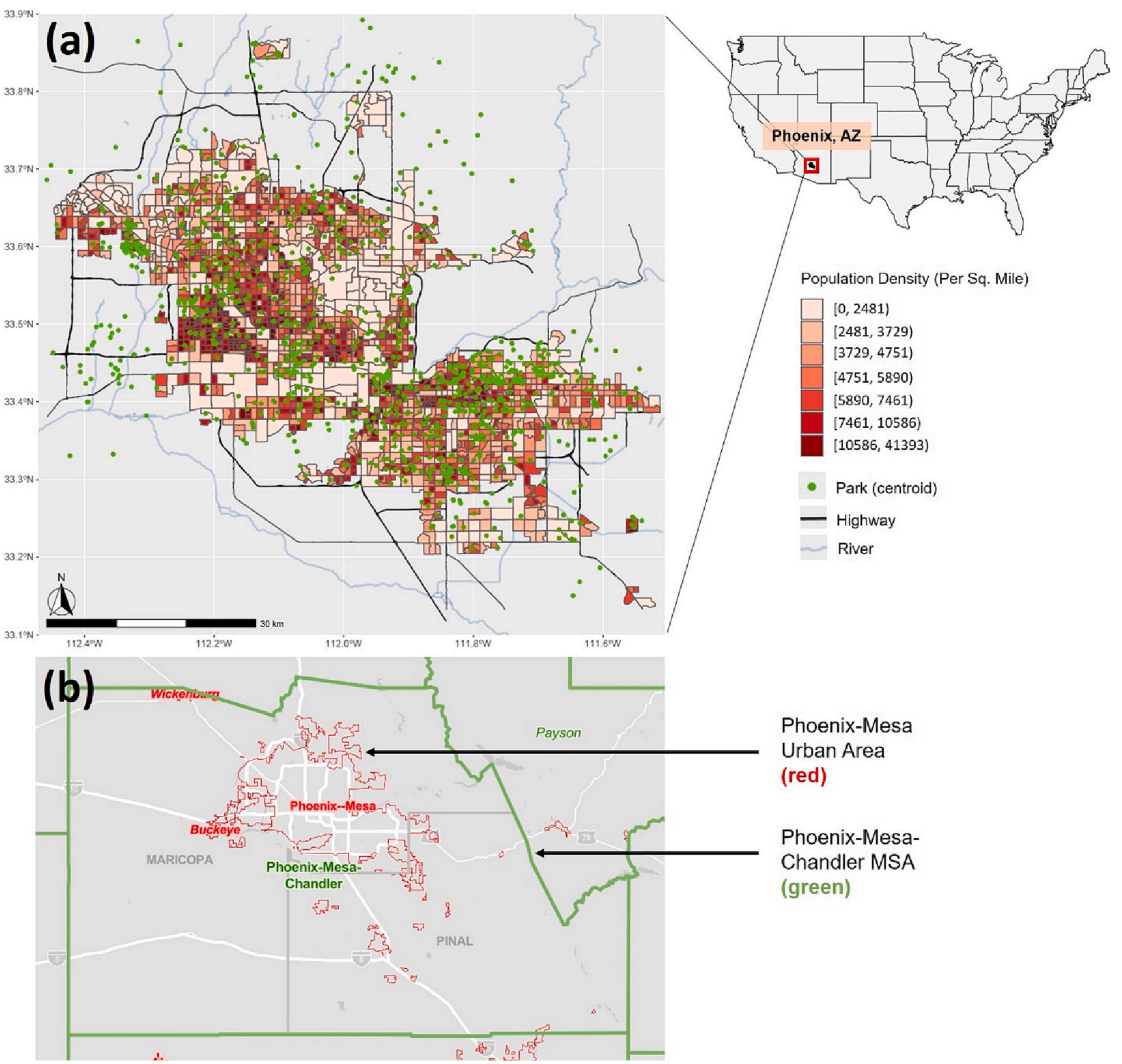

Fig. 1. The study location in the US: (1) the population density of CBGs, the centroid of parks, highways, and rivers; (2) the red boundary shows the location of neighborhoods in the Phoenix-Mesa urban area and the green boundary shows the Phoenix MSA where parks are included for investigation. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Fig. 1(a) shows the location of the Phoenix metropolitan area. Specifically, the Phoenix-Mesa-Chandler Metropolitan Statistical Area (hereafter Phoenix MSA) in Fig. 1(b) includes all of Maricopa County (the fourth largest county in the U.S. in 2022) and Pinal County. The Phoenix MSA encompasses 14,569 square miles, which was home to approximately 68% (over 4.9 million) of the state of Arizona's population (over 7.3 million) in 2021 (U.S. Census Bureau, 2021). The majority of people (over 4.1 million; 83%) within the Phoenix MSA lives in the Phoenix-Mesa urban area (U.S. Census Bureau, 2021). We examined parks within the boundary of the Phoenix MSA to which residents in the Phoenix-Mesa urban area have access or visited in 2019 (before COVID-19).

3.2. Data

We used data from SafeGraph (www.safegraph.com) to identify parks (destination) in the Phoenix MSA and the residential location of park visitors from the Phoenix-Mesa urban area (origin; at the Census Block Group (CBG) level). SafeGraph is a data vendor which provides anonymous mobile phone location data collected from about 10% of devices in the U.S. (Squire, 2019). SafeGraph's dataset includes over 7 million Places Of Interest (POIs) where devices were detected. Specifically, SafeGraph collects and manages park POIs in the U.S. and Canada (e.g., latitude and longitude, physical address, and postal code) and partners with the Trust for Public Land (TPL; https://www.tpl.org/). TPL is a non-profit organization that has provided U.S. park data and information to researchers and the public. The SafeGraph dataset that we analyzed includes parks that meet the TPL's park inclusion criteria (Trust for Public Land, 2022): 1) publicly owned local, state, and national parks, trails, and open space; 2) school parks with a joint-use agreement with the local government, and 3) privately owned parks that are managed for full public use. The dataset does not include parks in gated communities, private golf courses, private cemeteries, school parks or playgrounds without active joint-use agreements, and zoos, museums, and professional sports stadiums. Park POIs also have attributes such as the number of visitors, the number of visits, and the distance from visitors' home locations based on weekly mobile device tracking. Using the CBG identifier in the SafeGraph dataset, we further collected the demographic and socioeconomic variables of each CBG from the 2015–2019 American Community Survey 5-year estimates (See Table 1). Note that SafeGraph data are more granular than Google Mobility Reports (county level) and are provided to researchers free of charge.

3.3. Measures

3.3.1. Access to Local Parks

We defined ***local parks*** as those within walking distance (i.e., 1 km) of a CBG (i.e., neighborhood), which is measured by the distance between a CBG's centroid and the nearest point of the park boundary. There can be more than one park within walking distance. Then, access to local parks was examined in two ways: the number of parks and the total acreage (size) of parks within walking distance. Fig. 2 presents maps that show access to local parks by CBGs in the Phoenix-Mesa urban area. Darker colors represent a larger number of, or larger, local parks for each CBG. While a large number of local parks is clustered in CBGs in the fourth quadrant (i.e., Tempe) of Fig. 2(a), there are several long, striped concentrated neighborhood areas that follow canal trails (Arizona canal and Grand canal) in the second quadrant (i.e., northern Phoenix) in Fig. 2(b). Note that we defined all parks (including local parks) within the Phoenix MSA used in our park visit analysis as ***metro parks***.

3.3.2. Park visitation

Because SafeGraph data provide the count of devices detected in CBGs, not the count of visits, we used normalization procedures that the SafeGraph team developed (SafeGraph, 2020). For the normalized visits, the device count is divided by the number of devices detected in CBG i, year y, and week t, and then multiplied by the CBG i population. This number is then multiplied by the visit-visitor ratio to account for a device owner's multiple visits to the same park (see the equation below).

$$Normalized\ Visit_{ijyt} = \underbrace{\frac{Device\ Count_{ijyt}}{Device\ Residing_{iyt}} \times Census\ Population_i}_{Normalized\ \ Visitor_{ijyt}} \times \frac{Visit_{jyt}}{Visitor_{jyt}}$$

For the park visit analyses, we divided a CBG's weekly normalized visits by its population (i.e., per capita visits each week). We then summed per capita visits to parks within the Phoenix MSA that Phoenix residents visited during the weeks between January 1 and December 31, 2019

Table 1
Descriptive statistics of the dataset.

	Obs.*	Mean	St. Dev.	Min	Max
Park Access					
Distance to the closest park (meter)	2,102	624.12	554.74	0	4,430.80
Number of local parks	2,102	2.53	2.13	0	15.00
Total acreage of local parks (acre)	2,102	723.76	4,247.84	0	49,709.26
Per capita visits to local parks[a]	2,100	3.34	3.53	0	33.98
Per capita visits to metro parks[b]	2,100	19.79	6.45	0.74	54.64
Ratio of local to metro park visits	2,100	0.15	0.14	0	0.89
Census Block Groups Characteristics					
Population	2,102	1,635.75	774.70	0	7,788.00
% Non-white	2,100	0.21	0.15	0.00	0.85
% Hispanic	2,100	0.30	0.25	0	1.00
Per capita income ($)	2,099	32,881.98	18,053.28	1,175.00	168,302.00
% People without a high school diploma	2,100	0.14	0.14	0	1.00
Median Age	2,099	39.26	12.65	16.10	82.00
% Children under 18	2,100	0.22	0.11	0	0.54
% People 65 and over	2,100	0.17	0.19	0	0.97
% Housing unit without a vehicle	2,096	0.07	0.09	0	0.76
Population density per square mile	2,102	6,406.97	4,578.35	0	41,393.84
Neighborhood age (year)	2,016	1,978.10	99.21	0	2,013.00

* Obs. (Observations): The number of Census Block Groups (CBGs) without missing values. The Phoenix-Mesa urban area has a total of 2102 CBGs.
a. Local parks: parks within 1 km radius of CBG center.
b. Metro parks: all parks within the Phoenix MSA.

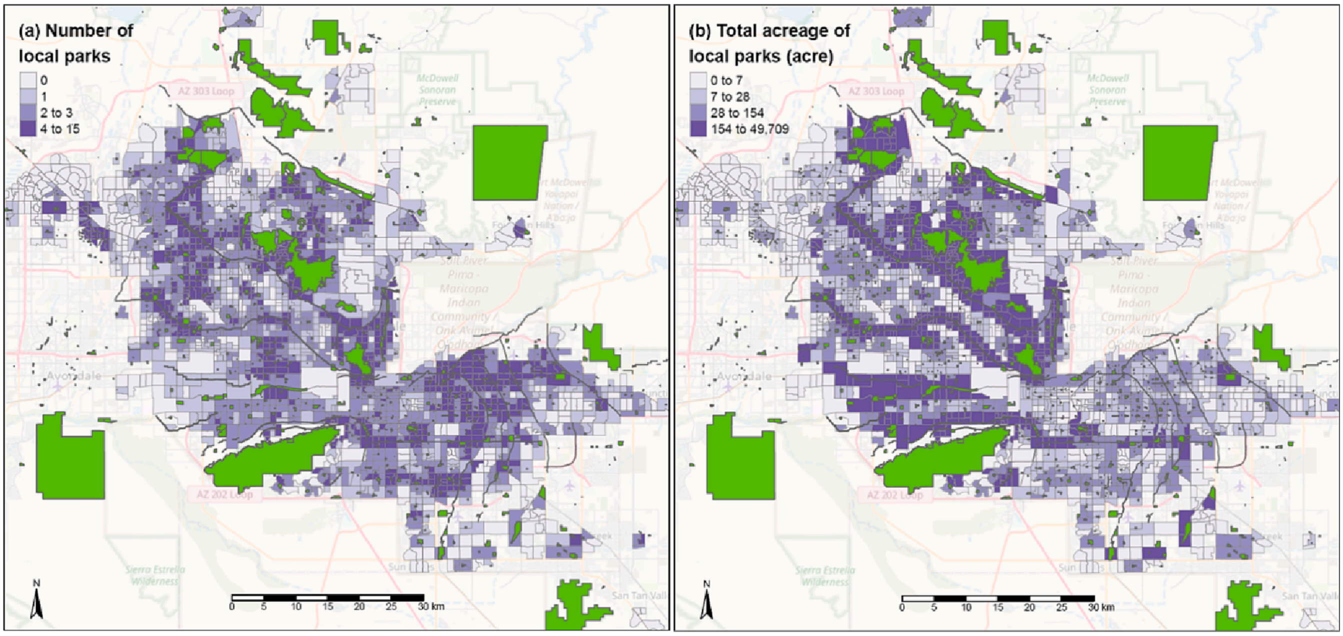

Fig. 2. The number and total acreage of local parks for neighborhoods in the Phoenix-Mesa urban area. Green polygons represent parks. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

(***metro park visits***). Based on the definition of local parks in 2.3.1, we subset visits to parks within walking distance from each CBG and measured ***local park visits*** during the same period. Fig. 3(a) presents the per capita visits to local parks, while Fig. 3(b) shows the per capita visits to metro parks. Fig. 3(c) shows the ratio of local park visits to metro park visits to measure the relative use of local parks among alternatives in the metro area. In Fig. 3, the darker the color of a CBG, the larger the number, or ratio, of park visitation.

3.3.3. Socioeconomic variables

We focused on investigating access and use by socioeconomic variables, such as race, ethnicity, income, education, and age. The race variable was disaggregated as the percent of White residents (78% in the 2018 American Community Survey) and non-White residents (22%). We combined all non-White residents because the percent of the group—which includes Black, Asian, Native American, and other races in the area—was only approximately 22% in the study area. White refers to all residents of any ethnicity who identify as White for their racial classification. This variable includes both Hispanic Whites and non-Hispanic Whites. The Hispanic variable refers to all residents of any race who identify as Hispanic. Those who identified themselves as Hispanic were grouped under Hispanic ethnicity regardless of their race, and thirty percent of people self-identified as Hispanic ethnicity. Economic status was measured using income and education variables. Specifically, we used per capita income and the percent of the population without a high school diploma (low education group). We included two age groups given their need for local parks (particularly in the study area): the percent of children under 18 and the percent of the elderly (i.e., 65 years old and over). We also included the percent of housing units without a vehicle, population density, and neighborhood age—the median year for built structures in a given area—to control these variables' influence.

3.4. Spatial autoregressive analysis

We analyzed the associations between access/use to local parks and neighborhood characteristics using spatial autoregressive (SAR) models because non-spatial regression models can suffer from the issue of spatial dependence—i.e., observations among spatial neighbors are often more similar than expected randomly (e.g., Chun et al., 2012; Kim & Chun, 2019). In SAR models, the neighboring relation is captured in an n-by-n adjacency matrix of spatial weights, in which elements (w_{ij}) represent a measure of the connection between locations i and j. Various spatial specifications can be considered to take spatial dependence into account. We specified our model with SAR lag models based upon Anselin (2005) model selection rule, which calls for comparison of a series of Lagrange multiplier test statistics between models. We estimated the following SAR lag model:

$$y = \rho \boldsymbol{W} y + \boldsymbol{X} \boldsymbol{\beta} + \boldsymbol{e}$$

in which the usual Ordinary Least Square (OLS) model is complemented by a term $\rho \boldsymbol{W} y$ that combines the spatially lagged dependent variable ($\boldsymbol{W} y$) and the spatial autoregressive coefficient (ρ; Rho). $\boldsymbol{W}$ is the $n \times n$ spatial weight matrix constructed from the Queen contiguity criterion of the first order. $\boldsymbol{\beta}$ is the $k \times 1$ vector of covariates. $\mathbf{X}$ is the $n \times k$ matrix consisting of observations on covariates, and $\boldsymbol{e}$ is $n \times 1$ errors distributed independently and identically.

4. Results

We explain the results of the green space equity analysis using SAR lag models below. All models in our results included a significant Rho value, which implies that dependent variables (access to park and park visit measures) are influenced by the values of CBG's adjacent neighbors for those variables. Additionally, the Variance Inflation Factors (VIF) of socioeconomic variables in the models were<5, which is a threshold used commonly to ensure that there is no multicollinearity issue (see Table 2).

4.1. Access to local parks

Table 3 shows the results of access to local parks across neighborhoods with different socioeconomic status. We found no statistically significant association between three access measures to local parks and race or ethnicity variables. Instead, access to local parks differed by age groups in all three models. In Model (1), a 1% increase in the percent of children corresponded with an increase of 2.18 m in distance to the nearest park when other variables were controlled. Similarly, a 1% increase in the percent of the elderly corresponded with an increase of

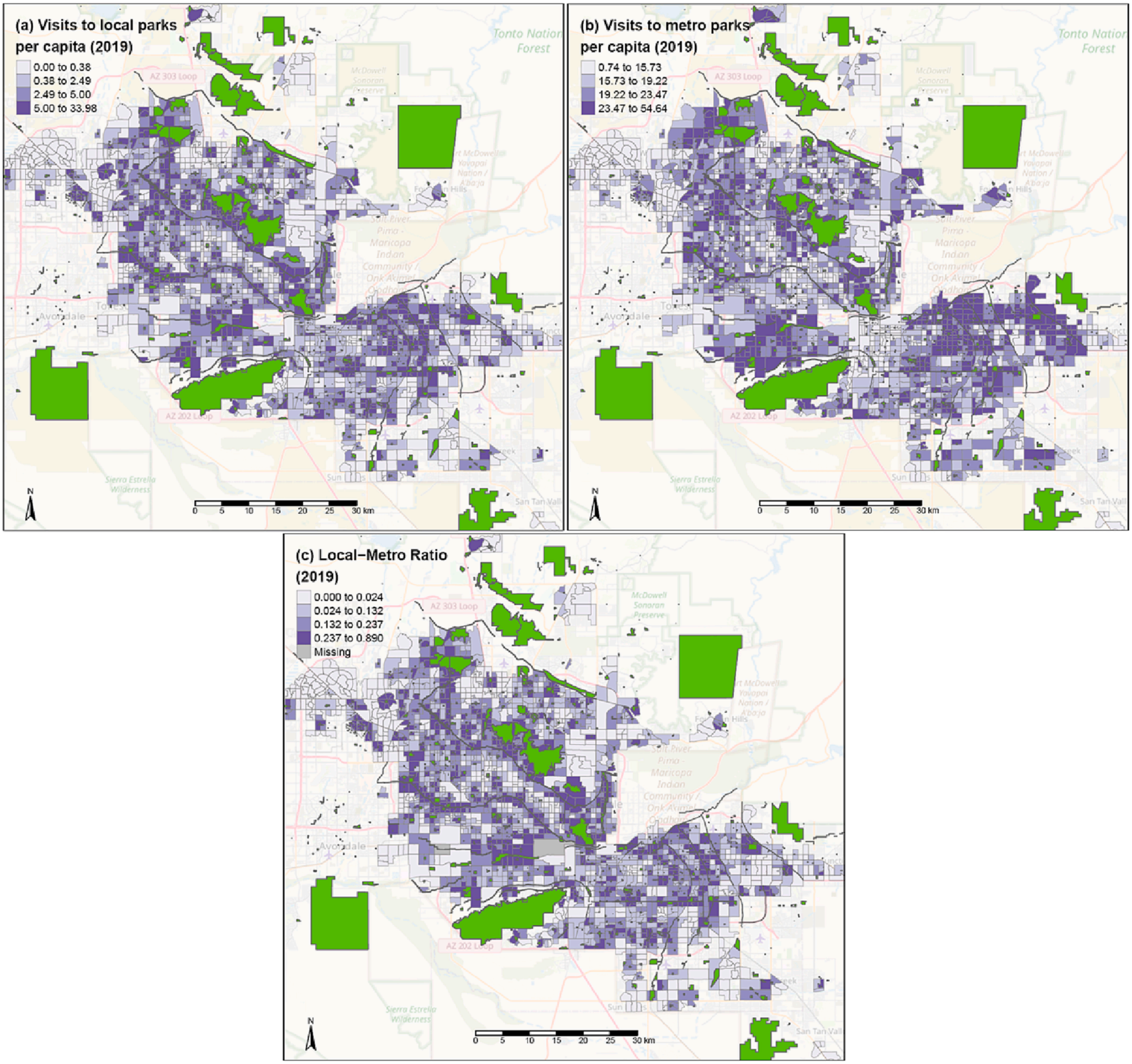

Fig. 3. Per capita visits to local or metro parks and the ratio between local park visits and metro park visits in 2019. Green polygons represent parks. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 2
Variance Inflation Factors (VIF) for independent variables in Table 4.

	VIF
ln(distance to the closest park)	1.29
Number of local parks	1.73
ln(Total acreage of local parks)	1.75
% Non-white	1.54
% Hispanic	4.93
ln(Per capita income)	3.32
% People without a high school diploma	4.42
% Children under 18	2.34
% People 65 and over	2.30
% Housing unit without a vehicle	1.36
ln(Population density)	1.51
Neighborhood age	1.36

Note: VIF for variables in Table 3 were similar.
"ln" is the natural log of the variable.

3.63 m in distance to the nearest park. In Model (2), a 1% increase in the elderly population in a neighborhood corresponded with a 0.008 decrease in the number of local parks. As population density in a neighborhood increased, the number of local parks increased. In Model (3), an increase in per capita income was associated positively with the local parks' total acreage within walking distance, as more affluent neighborhoods had larger local parks in total acreage. Further, a 1% increase in the elderly population corresponded with a 0.70% decrease in the parks' total acreage, and neighborhoods built later had local parks with a smaller total acreage.

To summarize, we found that traditional access measures yield green space disparities by age group (the elderly for all three access measures and children under 18 for the distance measure only) and in part by income (only for size), but not by race or ethnicity. We cannot reject hypotheses 1 and 2 for race, ethnicity, and income variables. Hypothesis 3 was supported for income, but not for race and ethnicity. Instead, our

Table 3
Spatial lag model results for access to local parks across different socioeconomic status neighborhoods.

	(1)Distance to the closest park(meter)			(2)Number of local parks			(3)ln(Total acreage of local parks)		
	Coef.	SE	Stat. Sig.	Coef.	SE	Stat. Sig.	Coef.	SE	Stat. Sig.
% Non-white	3.303	63.748		0.024	0.233		0.124	0.285	
% Hispanic	−1.476	67.136		0.013	0.246		−0.148	0.300	
ln(Per capita income)	−20.079	27.658		−0.058	0.101		0.304	0.124	*
% People without a high school diploma	−81.875	112.490		−0.383	0.412		0.741	0.504	
% Children under 18	218.302	107.729	*	−0.728	0.395		−0.644	0.482	
% People 65 and over	363.403	62.001	***	−0.830	0.225	***	−1.201	0.275	***
% Housing unit without a vehicle	−164.560	98.903		−0.001	0.361		−0.361	0.442	
ln(Population density)	−13.565	13.130		0.197	0.048	***	0.081	0.059	
Neighborhood age	1.375	0.663		−0.003	0.002		−0.010	0.003	***
Rho	0.776	0.016	***	0.840	0.013	***	0.778	0.016	***
Constant	−2347.989	1384.881		6.452	5.068		17.217	6.221	**
N	2095			2095			2095		
Log Likelihood	−15400.740			−3686.311			−4070.618		
Wald Test (df = 1)	2363.608***			4251.692***			2369.187***		
LR Test (df = 1)	1194.234***			1545.704***			1165.629***		
AIC	30825.490			7396.622			8165.235		
Nagelkerke pseudo R2	0.538			0.565			0.491		

Note: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
"ln" is the natural log of the variable.

findings suggested that in the Phoenix-Mesa urban area, the elderly population had less access to local green space, regardless of the way access is measured. Further, neighborhoods with a larger percentage of children under 18 lived farther from the closest local park.

4.2. Local park visitation

Our results for local park visitation are illustrated in Table 4. We examined per capita visits to local parks (i.e., without considering alternative parks within the Phoenix MSA) and the relative use of local parks among all parks in the Phoenix MSA. In Model (1), we found that the distance, number, and size of local parks were associated statistically significantly with local park visits. This suggests that access to local parks was correlated strongly with local park visits. In addition to the access measures, the age variable was statistically significant. A 1% increase in the percent of children under 18 corresponded with a 1.47% increase in local park visits when other variables were controlled. The percent of the elderly population was associated statistically significantly with visits to local parks as well. A 1% increase in the percent of people age 65 and over corresponded with a 0.35% increase in local park visits when other variables were controlled.

Model (2) examines the ratio of local park visits to metro parks. The higher the ratio, the higher the relative use of local parks among all parks in the Phoenix MSA. Again, access measures (distance, number, and size) were associated positively and significantly with the ratio. As the distance to the closest local park increased, the ratio of local park

Table 4
Spatial lag model results for park visits across different socioeconomic status neighborhoods.

	(1) ln(per capita visits to local parks)			(2) Ratio of local to metro park visits		
	Coef.	SE	Stat. Sig.	Coef.	SE	Stat. Sig.
ln(distance to the closest park)	−0.146	0.008	***	−0.024	0.002	***
Number of local parks	0.067	0.007	***	0.010	0.001	***
ln(Total acreage of local parks)	0.105	0.006	***	0.016	0.001	***
% Non-white	−0.147	0.090		0.008	0.017	
% Hispanic	−0.110	0.094		−0.022	0.018	
ln(Per capita income)	−0.056	0.039		−0.024	0.008	**
% People without a high school diploma	0.119	0.159		0.009	0.030	
% Children under 18	0.903	0.152	***	0.100	0.029	***
% People 65 and over	0.300	0.089	***	0.089	0.017	***
% Housing unit without a vehicle	−0.177	0.139		−0.003	0.027	
ln(Population density)	0.033	0.019		−0.003	0.004	
Neighborhood age	−0.002	0.001		−0.0002	0.0002	
Rho	0.397	0.022	***	0.397	0.025	***
Constant	4.260	1.972	*	0.652	0.376	
N	2,095			2,095		
Log Likelihood	−1526.957			1940.163		
Wald Test (df = 1)	311.895***			260.962***		
LR Test (df = 1)	265.498***			207.441***		
AIC	3083.915			−3850.325		
Nagelkerke pseudo R2	0.631			0.520		

Note: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Here we refer "local parks" as parks within 1 km from the center of each CBG in the study area, and "metro parks" as all parks in the Phoenix MSA regardless of whether they locate in within or beyond 1 km. The ratio in Model (2) was calculated by dividing visits to "local park" by visits to "metro parks" for each CBG. "ln" is the natural log of the variable.

visits decreased. As the number, or size of, local parks increased, the ratio of local to metro park visits increased. We also found that an increase in per capita income decreased the relative use of local parks. Similar to Model (1), the relative use of local parks also increased as the percentage of children under 18 and people over 65 increased. A 1% increase in the population of children corresponded to a 0.10% increase in the relative use of local parks, while for each 1 percent increase in the elderly population, the relative use of local parks increased by 0.09%.

To summarize, 1) better access to local parks (distance, number, and size) increased visits to them, 2) visits to, and the ratio of, local parks increased consistently as the percentage of children under 18 and the percentage of the elderly increased, and 3) in addition to age groups, the relative use of local parks tends to decrease as per capita income increases.

5. Discussion

We explored access to and use of local parks within walking distance (within 1 km) in the Phoenix metropolitan area. Three findings are worthy of mention. First, unlike our hypotheses, we did not find distributive inequities by race and ethnicity using the traditional access measures (distance, number, and size). We also did not find inequity by race and ethnicity with respect to park visits. Second, green space access inequity was observed most consistently by age group: 1) neighborhoods with a larger percentage of children under 18 were farther from the closest local park, but this was the only access measure that was significant for this group, and 2) neighborhoods with an increased percentage of people 65 years and over were disadvantaged in all three local park access measures (Table 3). Third, we saw an increase in visits to local parks in neighborhoods with a larger percentage of children under 18 and people 65 and over (both absolutely and relative to metro parks; Table 4). Our results showed that while children and the elderly had significantly less access to green spaces, they were the groups who visited them more than others. The results suggest that the traditional way of understanding parks and access are limited because use and access may display different patterns for the same group. This finding is relevant in the global context as scholars focusing on other cities or countries can utilize this information to reframe the way they think about access and use (Jones, Hillsdon, & Coombes, 2009; Seaman, Jones, & Ellaway, 2010). Mobility data such as SafeGraph—other countries may also have access to mobility data similar to SafeGraph in the U.S. (e.g., Mears, Brindley, Barrows, Richardson, & Maheswaran, 2021; Xiao, Wang, & Fang, 2019)—can add novel insights on the important topic of park visitation patterns within other countries.

The park visit measure revealed children and elderly groups' need for local parks in the Phoenix metro area. Even when the resources (e.g., local parks) are distributed equitably, such socially vulnerable neighborhoods may require greater park resources (i.e., larger and higher quality) given their high use of local parks. This becomes more troubling when the groups who have less access to local parks are those who visit them more often. These groups' need for greater park resources is bound to grow. However, different age groups may need different types of parks (Sundevall & Jansson, 2020). Children may appreciate parks where they can enjoy both less planned or less maintained nature and playgrounds (Jansson, Sundevall, & Wales, 2016). The elderly may find that other factors are critical for their park use, such as accessibility (paths and seating), safety, and social contact with others (Sang, Knez, Gunnarsson, & Hedblom, 2016). Urban planners may consider differential needs of these groups in their provision of urban parks.

This suggestion is consistent with Talen (2010) argument for more (and better) urban green spaces in areas of high social needs in the Phoenix area. The needs-based equality dimension differs from the group-based equality dimension, in that the former values, and places greater weight on, the different groups' needs, while the latter values only different groups' identities, which have been subject to discrimination and marginalization when distributive decisions are made (Stone, 2012). As Boone and colleagues stated (2009), "… [n]eeds-based assessments… serve a practical purpose by targeting a public good, in this case parks, to those groups who are most likely to use it or need (because of limitation based upon age, ability, or resources) access to green space within walking distances" (p. 744). Our study adds evidence to support this voice in the greenspace equity literature. We argue that Phoenix metro's urban planners need to consider the importance of better access to local parks in neighborhoods with a higher proportion of children, the elderly, or the less affluent.

Our argument about increasing resources should not be interpreted merely as greater provision of access to parks for children and seniors. According to Dobson et al. (2021), proximity to green space is not associated with mental wellbeing on its own (see Houlden, Weich, & Jarvis, 2017). Instead, the *quality* of the space is more important for health outcomes than the number of green spaces (e.g., see De Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013). The characteristics of park quality that were most important in increasing physical activity in the parks were maintenance (i.e., well-maintained parks increase activity), feelings of safety in the park, a relaxing atmosphere, easy accessibility, and the presence of shade trees (Costigan, Veitch, Crawford, Carver, & Timperio, 2017). Cutts et al. (2009) highlighted the way the benefits of living close to parks may be offset by lower quality parks (e.g., because of crime) and other unfavorable aspects of the neighborhoods (e.g., a high proportion of fast-food restaurants in the area). We believe that the quality of existing parks may also be increased significantly through maintenance or investments in amenities. For example, in Phoenix, tree shade and other structures to reduce exposure to the sun can increase the quality of a park area significantly without a significant budget increase. Urban planners can prioritize local parks in those areas to improve the quality of parks. We suggest improving the quality of those existing local parks, particularly in neighborhoods with a higher proportion of children and the elderly, given their high visitation.

The dilemma of our argument for urban planners is that the composition of neighborhoods (e.g., more or fewer elderly and more or fewer children) is fluid and can change over time. We acknowledge that this fluidity is accurate and neighborhoods can increase in age over time if residents do not move away. While the current need for local parks in the Phoenix metro area may be greater in communities with a higher proportion of seniors and children, those demographics can change. City planners cannot (or should not) make decisions about park provision based solely upon current neighborhood composition and disparities observed because parks and green spaces are often built to fulfill the need for ecosystem services at the city scale. Yet, we believe that these demographic patterns, and the corresponding variables related to park use and visitation, are important for city planners to measure over time. Population composition can change relatively quickly as people move, and it is expensive to change infrastructure, such as parks, to reflect demographic changes. Therefore, a larger question is how to plan infrastructure, address the city's equity needs (in access and use) for certain social groups at the present time while acknowledging changing demographics.

Several limitations need to be mentioned. First, we relied on an emerging data source (SafeGraph's mobility data) to track residents' park visitation in neighborhoods. An argument can be made that any new dataset should be validated by comparison to traditional data sources for park use (such as surveys and systematic observation). While this approach is largely desirable, we also recognize that these traditional data sources have limitations in their ability to capture park visitation data. Given the novelty of the mobility data, we examined green space disparities using traditional proximity-based access measures and triangulated our results with previous studies in the area (Cutts et al., 2009; Talen, 2010). Second, while park use may be an alternative proxy for park quality other than size (acreage), we acknowledge that it may still lack other complex components necessary to define park quality properly (Ahn et al., 2020; Corley et al., 2018). Mobility data may offer unique opportunities that traditional data sources may not be able to provide, such as the broad coverage of parks and the granularity of park visitation over time and space. However, the data may still be unable to capture local park needs and urban residents' demands fully, and our study does not explain why the age groups visit local parks more (because our data cannot answer this question). We believe that this analysis with park visitation data provides an opportunity to examine the relation between park quality and use, as well as between green space disparities and health effects in the future.

6. Conclusion

The environmental justice literature seeks to distribute environmental benefits and burdens equally among all people. The basic assumption is that equitable distribution can provide equitable access to environmental amenities, and hence equal environmental benefits. However, equal distribution of access may not necessarily mean equal distribution for use (Talen, 2010). Our results demonstrated that there can be green space access disparity for vulnerable groups, but these very groups may be those who visit parks more than others. In the Phoenix metro area, this was neighborhoods with a higher proportion of children under 18 and the elderly. Identifying green space access disparity by age group was possible without park visit data; however, park visitation data allowed us to identify further these groups' significantly higher use of local parks and the drastic contrast between the groups' access and use.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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