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Urban Park Usage During the COVID-19 Pandemic

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Urban parks and green spaces provide a wide range of ecosystem services, including social interaction and stress reduction. When COVID-19 closed schools and businesses and restricted social gatherings, parks became one of the few places that urban residents were permitted to visit outside their homes. With a focus on Philadelphia, PA and New York City, NY, this paper presents a snapshot of the park usage during the early phases of the pandemic. Forty-three Civic Scientists were employed by the research team to observe usage in 22 different parks selected to represent low and high social vulnerability, and low, medium, and high population density. Despite speculation that parks could contribute to the spread of COVID-19, no strong correlation was found between the number of confirmed COVID-19 cases in adjacent zip codes and the number of park users. High social vulnerability neighborhoods were associated with a significantly higher number of COVID-19 cases ($p < 0.01$). In addition, no significant difference in the number of park users was detected between parks in high and low vulnerability neighborhoods. The number of park users did significantly increase with population density in both cities ($p < 0.01$), though usage varied greatly by park. Males were more frequently observed than females in parks in both high vulnerability and high-density neighborhoods. Although high vulnerability neighborhoods reported higher COVID-19 cases, residents of Philadelphia and New York City appear to have been undeterred from visiting parks during this phase of the pandemic. This snapshot study provides no evidence to support closing parks during the pandemic. To the contrary, people continued to visit parks throughout the study, underscoring their evident value as respite for urban residents during the early phases of the pandemic.

Keywords: Urban parks; park usage; green infrastructure; pandemic; COVID-19; civic scientists; social vulnerability; population density.

1. Introduction

Cities are particularly vulnerable to pandemics due to their high population density and global connectedness. Globalization, the worldwide integration of human activity, has contributed to accelerated spread of diseases through interconnected cities (Ali and Keil 2006). A single disease case can spread rapidly, triggering cascading impacts across functionally interdependent physical, social, and economic domains (Baklanov *et al.* 2018). When COVID-19, an infectious disease that causes respiratory tract infections, fevers, and other cold-like symptoms (Ludwig and Zarbock 2020) arrived in cities, it significantly altered human behavioral patterns. Schools and businesses closed, social gatherings were cancelled, and mobility was significantly curtailed, contributing to changes in air quality, greenhouse gas emissions, and wildlife behavior (Dilworth *et al.* 2020).

This paper focuses on the impact of COVID-19 on urban park usage during the initial stages of the pandemic. An important form of green infrastructure (GI), parks routinely supply a broad range of ecosystem services that enhance the social–ecological value of a territory. They provide habitat, support biodiversity, limit imperviousness, reduce urban heat islands, and produce social benefits at the individual, family, organization, and community levels (Svendsen 2011; Westphal 2003; Wolf 2008). There is also growing evidence that parks and other GI can improve physical and psychological health and well-being by promoting social contact, recreation, leisure, participation in clubs and other organizations, and other psychosocial processes that build trust, generate place attachment, social support, and feelings of belonging and empowerment (Jennings and Bamkole 2019; Ma *et al.* 2019; Zuniga-Teran *et al.* 2020). Because of the many ways that they can improve urban quality of life (Wolch *et al.* 2014), parks are often considered central elements to urban sustainability and resilience plans (Kramer 2014; Voghera and Giudice 2020).

However, as COVID-19 spread during the Spring of 2020, governmental policy limited social gatherings, and people spent more time at home, the role that parks would play during the pandemic became increasingly uncertain. On one hand, the social, recreational, and natural experiences offered by neighborhood parks could presumably help to mitigate the feelings of increased anxiety and isolation reported among the elderly (David 2020), children, and others. On the other hand, as they grew in popularity as a neighborhood destination, parks were also places of potential COVID-19 exposure. In the early phases of the pandemic, bench and playground surfaces, for example, were believed to potentially harbor and facilitate the transmission of this severely contagious virus (CDC_Newsroom 2020). Indeed, recent studies indicate that the coronavirus can last on metal and plastic surfaces for hours to days if the surfaces are not properly disinfected (Suman *et al.* 2020). At this unique time, social gatherings in parks were also viewed as opportunities for exchange of virus-containing respiratory droplets. As the number of COVID-19 cases continued to climb, economic hardship accelerated, and the summer approached, it also seemed plausible that homeless individuals and others who use green spaces as refuge (Modern_Healthcare 2020) would migrate to urban parks, increasing COVID-19 exposure risk for themselves, and eventually, the general public.

To investigate these potentially opposing roles, this study investigated park usage and COVID-19 case trends in Philadelphia, PA and New York City (NYC), NY – two East Coast cities impacted early in the US COVID-19 pandemic. Both cities were subject to a stay-at-home order starting on March 23rd (Cuomo 2020; Philadelphia 2020), during which non-essential businesses were closed, and people were urged not to leave their homes unless necessary. The restrictions continued until mid-June in NYC and early July for Philadelphia, overlapping with the beginning of the study. Despite these restrictions, people continued to use parks and other public spaces throughout the study period (Haigney 2020), and especially during the nationwide rallies and demonstrations precipitated by the May 25, 2020 murder of George Floyd, a black man killed at the hands of police in Minneapolis, MN.

Observations of park usage were collected exclusively by a group of Civic Scientists, who were employed and trained by the research team to log park usage and submit supporting photographs through a smart-phone accessible form. In recent years, digital technologies and other e-tools have made it easier to engage urban residents in this kind of distributed data collection effort (Farnham *et al.* 2017). In such applications, Civic Scientists can help to fill some of the gaps in municipal datasets, especially when engaged in intense data collection efforts near their homes. The approach also helps to add co-benefits to the research enterprise, namely by creating new opportunities for collaboration, and fostering a sense of empowerment among residents who are helping to co-generate knowledge and solutions to the challenges facing their communities. Financial compensation of the Civic Scientists seemed particularly appropriate, since COVID-19 was as much a health crisis as an economic one. During this period of wide-scale, abrupt, unemployment (Menton 2020), the need for distributed data collection created an opportunity to provide an economic stimulus within each study city.

2. Materials and Methods

The project employed 43 Civic Scientists to study 22 parks in neighborhoods that represented low to high vulnerability and population density. Of the 22 parks, 15 were in Philadelphia and seven were in NYC. The procedures used to select parks, and to recruit and train the Civic Scientists are described in this section. The COVID-19 case trend data used in this study is also described.

2.1. *Park selection*

A GIS analysis was performed using the Center for Disease Control's Social Vulnerability Index (CDC SVI) to select parks in neighborhoods with varying vulnerabilities. In this dataset, indicators from the US Census Bureau's 2014–2018 American Community Survey five year estimates were used to quantify vulnerability (Figure 1) (CDC 2018).

The CDC SVI shapefile includes rankings of each census tract in the country according to each indicator, as well as an aggregate ranking based on all 15 indicators. The country-wide shapefile was clipped to Philadelphia and NYC counties so that census tracts in the two cities could be further compared on a relative scale. In both cities, more census tracts were classified as at or above the 90th percentile national ranking (e.g., 500 out of 2,486 Census tracts, or 20%) than in any other category. Parks in neighborhoods with census tracts classified as at or above the 90th percentile national ranking were classified as "high vulnerability", whereas parks located in census tracts that fell within the 50th percentile and below were classified as "low vulnerability" (Table 1). Census tracts in between were classified as "medium vulnerability". Medium vulnerability census tracts were removed from the analysis. Within the cohort of parks selected in each

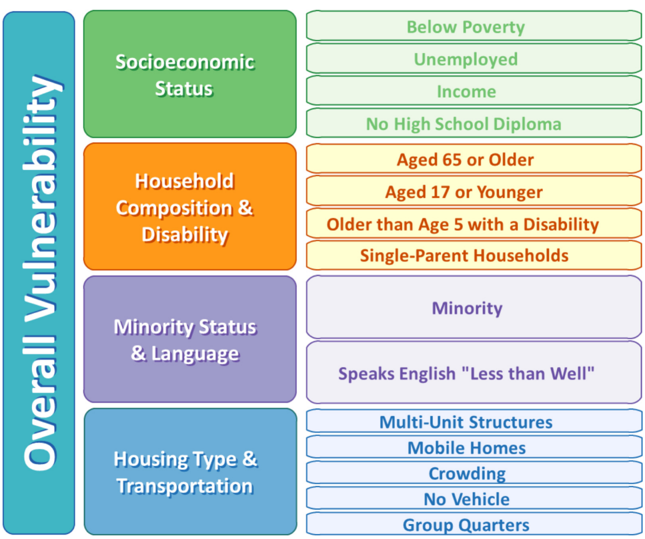


Figure 1. CDC SVI Vulnerability Indicators (CDC 2018)

Table 1. Percentile Breakdown of SVI Ranking for Philadelphia and NYC

SVI Ranking of Census Tracts in Philadelphia and NYC			
Percentile	Count	Percent of Total	Category
0–0.09	33	1.3%	Low vulnerability
0.1–0.19	99	4.0%	Low vulnerability
0.2–0.29	173	7.0%	Low vulnerability
0.3–0.39	184	7.4%	Low vulnerability
0.4–0.49	192	7.7%	Low vulnerability
0.5–0.59	261	10.5%	Medium vulnerability
0.6–0.69	321	12.9%	Medium vulnerability
0.7–0.79	370	14.9%	Medium vulnerability
0.8–0.89	353	14.2%	Medium vulnerability
0.9–1	500	20.1%	High vulnerability
Total	2,486	100%	

classification, social vulnerability characteristics varied. It should also be noted that the populations of both cities generally exhibit many characteristics linked to high vulnerability (e.g., minority populations, no vehicle, multi-unit structures, below poverty, etc.), suggesting that all the parks selected for this study are generally among higher vulnerability neighborhoods compared to the rest of the country.

Population densities (Figures 2 and 3) were derived by dividing 2014–2018 population estimates from the American Community Survey by the census tract area. Both datasets were included in the CDC SVI shapefile. The resultant distribution of population density values was split into three general categories: "low density" defined as $< 5,791$ people per km^2 ($< 15,000$ people per square mile), "medium density" defined as 5,791–19,305 people per km^2 (15,000–50,000 people per square mile), and "high density" defined as $> 19,305$ people per km^2 ($> 50,000$ per square mile). Since Philadelphia is generally less dense than NYC, low and medium density neighborhoods were studied through the Philadelphia sites, while medium and high-density neighborhoods were studied through the NYC sites.

Both datasets were joined in GIS to identify census tracts that fell into the following six composite classifications:

- High density, low vulnerability (NYC only),
- High density, high vulnerability (NYC only),
- Medium density, low vulnerability (Philadelphia and NYC),
- Medium density, high vulnerability (Philadelphia and NYC),
- Low density, low vulnerability (Philadelphia only),

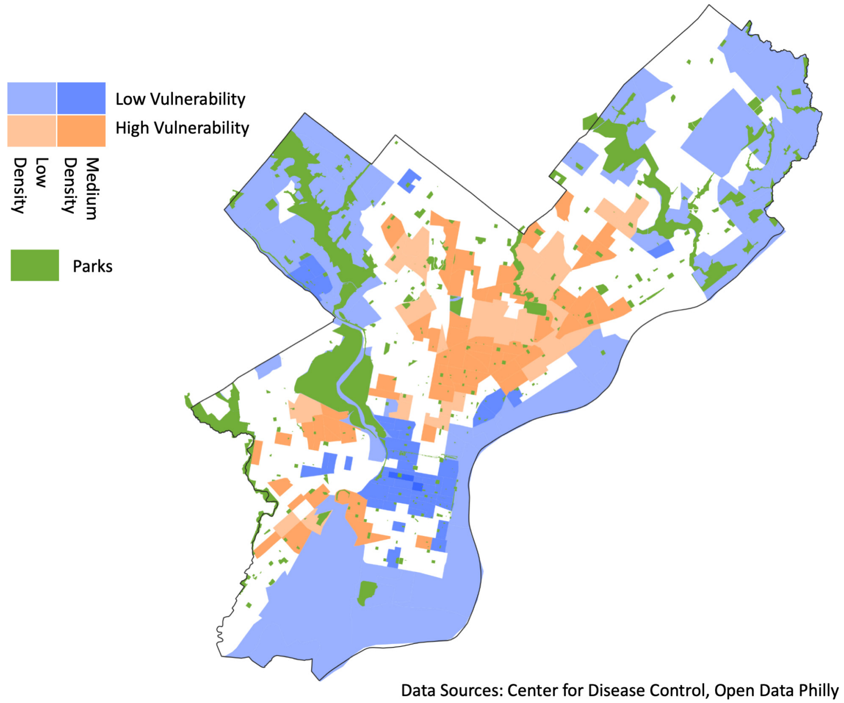


Figure 2. Map of Philadelphia with Social Vulnerability and Population Density Variables, with Parks

- Low density, high vulnerability (Philadelphia only).

The geographic distribution of the associated census tracts in Philadelphia and NYC is shown along with the location of all parks, in Figures 2 and 3.

Parks located within or adjacent to the Census tracts in each of the six composite classifications were further analyzed to identify residential parks that could be easily observed by a Civic Scientist. Large parks like Prospect Park in Brooklyn, NY, and Fairmount Park in Philadelphia, were excluded from the study as it would not have been logistically feasible for the Civic Scientists to observe usage across the entire park. Parks located > 0.5 km from a residential building were also excluded, to control for residential accessibility across the study sites.

Residential parks in Philadelphia were found to be generally smaller in area than those found in NYC. Only parks of < 5.6 ha ($55{,}742\,\mathrm{m}^2$) were considered in Philadelphia, an area corresponding to roughly twice the size of Rittenhouse Square, (one of five original parks planned by William Penn in the late 17th century). In NYC, only parks < 24.3 ha ($242{,}649\,\mathrm{m}^2$), or about the size of Astoria Park, were included in the study.

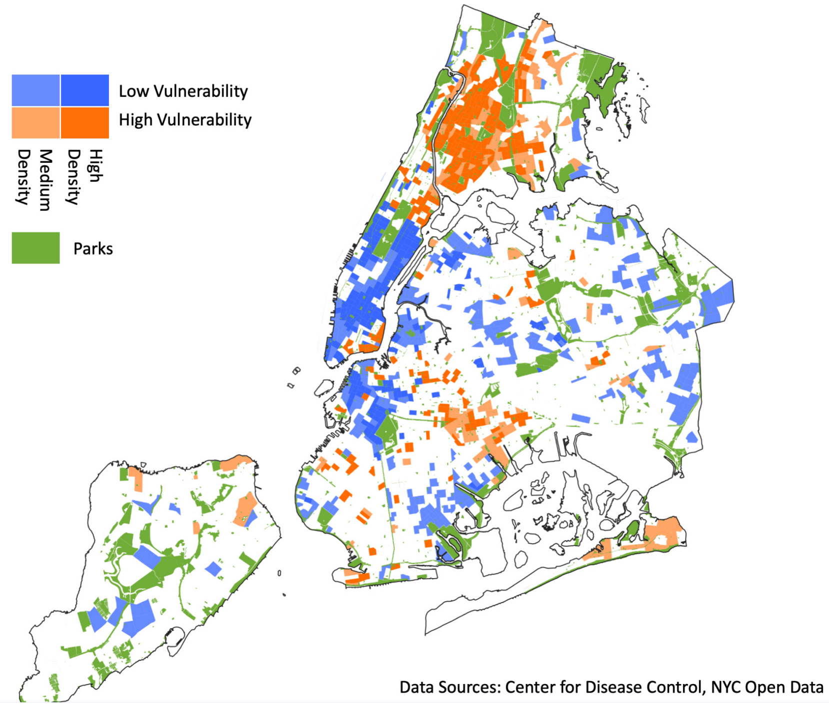


Figure 3. Map of NYC with Social Vulnerability and Population Density Variables, with Parks

In both cities, green spaces classified as triangles, strips, malls and parkways were also excluded from the study, since such spaces are not likely to attract visitors. Playgrounds in both cities were also excluded, since at the beginning of the study, these were officially closed due to COVID-19 precautions.

An Advisory Committee was convened to assist the research team in further filtering the parks. The Advisory Committee included representatives of the NYC Department of Parks and Recreation, Philadelphia Parks and Recreation, USDA Forest Service, Trust for Public Land, Natural Areas Conservancy, Jefferson University, Johns Hopkins University, Drexel University, and Temple University. Based on other site suitability considerations, this group narrowed down the list to 10–20 parks per category per city.

2.2. *Civic scientist outreach and selection*

To recruit a diverse cohort of potential Civic Scientists, the research team used a snowball sampling approach approved by the Drexel Institutional Research Board (IRB). An application form with a map of the parks of interest was posted on a website. On the form, applicants were required to provide basic demographic information (age, race and ethnicity, income, etc.) and an anonymous email address with no identifiable information. No personal information about the applicants or final selected Civic Scientists was collected at any point during the study by the research team, and the anonymous email addresses represented the only means of communication between them. An email advertising the position was circulated among non-governmental organizations in both cities, identified through previous work by the US Forest Service in NYC (Svendsen *et al.* 2016), and from a list of registered community organizations with service areas that overlapped with the selected parks in Philadelphia (RCO 2020).

On the application form, applicants were invited to select a park they wanted to observe from the list of pre-selected parks but were also permitted to write in the name of another park in their own neighborhood. In total, 300 applications were received for study of 85 different parks across the two cities. Applications were not received for all the pre-selected parks. The response rate of applications was higher in Philadelphia than in NYC. The final selection sought to identify two Civic Scientists with at least one park in each density-vulnerability category. For parks with more than two applicants, the research team prioritized applicants who were unemployed, and attempts were made to diversify the Civic Scientists associated with each park by gender, income, and race/ethnicity. Some substitutions were made during the study from the list of applicants, as some of the originally selected Civic Scientists voluntarily dropped out.

2.3. *Data collection plan for the Civic Scientists*

Civic Scientists were asked to make two sets of observations per day at a designated park. Each Civic Scientist was assigned two windows of time during which to complete their observations (30 minutes of observations within each four-hour interval), e.g., 6–10 am and 2–6 pm, or 10 am –2 pm and 6–10 pm. This phasing ensured that observations were made throughout the day in each park.

The observations were recorded in a Qualtrics survey form, accessible on a smart phone. The form included questions about how many people were observed in the park during each 30 min observation period. The form also included observations of COVID-risky behavior (e.g., participating in contact sports, not wearing a mask, coughing without covering, etc.). The Civic Scientists were asked to characterize the frequency with which these behaviors were observed as "never", "occasionally", "moderately", "frequently", or "not applicable/can't tell". Additionally, space was provided for open-ended comments and Civic Scientists were required to submit blurred photos to back up quantitative observations.

Civic Scientists were compensated $10 per entry at the end of each week via a PayPal account linked to their anonymous email address.

Table 2. The Study Period in Philadelphia and NYC

	Study Start Date	Original Study End Date	Extended Study End Date
Philadelphia	Thursday May 7th	Wednesday July 1st	Thursday July 9th
NYC	Thursday May 14th	Wednesday July 8th	Thursday July 16th

The study period duration (roughly May 7th to July 16th, Table 2) differed slightly by city, and overlapped with the Black Lives Matter protests in early June that led to both cities enforcing curfews for eight days. During this period, the Civic Scientists were instructed to make observations only when safe. An eight-day extension was included at the official end of the study to allow Civic Scientists who had missed entries to make them up.

2.4. *COVID-19 case trend data*

Daily COVID-19 testing data from Philadelphia and NYC was obtained from Open Data Philly and Open Data NYC, respectively. The datasets included the number of total positive and negative COVID-19 test results for each day per zip code. Each studied park was assigned a dataset based on its location. Parks that spanned two zip codes were assigned data from both. In order to normalize the COVID-19 case data across all the parks, the case rate per 1,000,000 people was calculated using the population of the corresponding zip code (based on population estimates from the 2014–2018 American Community Survey five-year estimates). Knowing the daily total number of cumulative cases per 1,000,000, the number of daily new cases was calculated by subtracting the previous day's cases from the cumulative total.

2.5. *Data collection, processing and analysis*

Although data was collected in a total of 22 parks (15 in Philadelphia and seven in NYC), for the time periods shown in Table 2, the most consistent daily observations were made in ten Philadelphia parks and six NYC parks, and from 5/22/20 to 7/9/20 only. Data collected in only these parks and during that period were included in the analysis (for a list of the final parks included in the analysis see the parks in Table 3).

The final selection of parks included in the study (Table 3) encompassed communities of low density/low vulnerability; medium density/low vulnerability; medium density/high vulnerability; and high density/high vulnerability. Parks in low density/high vulnerability and high density/low vulnerability neighborhoods did not receive sufficient applications to be included in the study. Because of

Table 3. Philadelphia and NYC Parks Included in the Study

City	Official Park Name	Park Name Abbreviated	Size (m^2)	Density	Vulnerability
Philadelphia	Penn Treaty Park	Penn Treaty	51,314	Low	Low
	Sabatino de la Noce	Sabatino	2,587	Low	Low
	Fox Chase School Playground*	Fox Chase*	6,932	Low	Low
	Lovett Park	Lovett	4,962	Low	Low
	Konrad Square*	Konrad*	4,112	Medium	Low
	Julian Abele Park	Julian	1,158	Medium	Low
	Cianfrani Park	Cianfrani	2,464	Medium	Low
	Cedar Park	Cedar	3,395	Medium	Low
	Washington Square Park	Washington	29,090	Medium	Low
	Matthias Baldwin Park	Matthias	8,709	Medium	Low
	Norris Square*	Norris*	25,903	Medium	High
	Fairhill Square	Fairhill	11,584	Medium	High
	Harrowgate Park	Harrowgate	19,879	Medium	High
	Cliveden Park*	Cliveden*	24,089	Medium	High
	Drexel Park*	Drexel*	10,117	—	—
NYC	McCarren Park	McCarren	146,778	Medium	Low
	McGolrick Park	McGolrick	36,659	Medium	Low
	Hunter's Point Park	Hunter's Point	42,589	Medium	Low
	Tremont Park*	Tremont*	60,827	Medium	High
	Coffey Park	Coffey	33,583	High	High
	Rufus King Park	Rufus King	46,265	High	High
	Claremont Park	Claremont	153,348	High	High

Notes: *denotes parks that were excluded from the analysis. Drexel Park does not have a density or vulnerability rating because it was a suggestion from an applicant rather than a pre-selected park.

a lower initial response rate, the NYC study started one week later than the Philadelphia study, and was completed one week later than the Philadelphia study. A photo from each Philadelphia park and NYC park selected for analysis, can be seen in Figures 4 and 5, respectively.

Observation count

The number of observed park users recorded in different categorical bins (e.g., None, 1–5, 6–10, 11–20, 21–50, 51–100, >100) was transformed to numeric variables using an average value of the category range (e.g., a value of 8 for "6–10" bin).

Adjusted daily count

The parks differed in terms of the number of observations made on each day. The goal to obtain four, independent 30-min counts of users in each park each day (one 30-min period during each 4 h observation period) was rarely achieved due to

Figure 4. Philadelphia Parks Included in the Study

missing entries. However, two independent, 30 min, counts in each park for nearly every day during the study period were available, where more than two counts were available on a given day, the total observed users from all available counts were summed and divided by the appropriate factor to develop an estimate for two

Figure 5. NYC Parks Included in the Study

periods (e.g., the total from four counts was divided by two; the total from three counts was divided by 1.5). This two-period daily count, referred to as the "adjusted daily count", is thus used to facilitate comparison of park usage between parks.

7-day moving average of adjusted daily count and confirmed COVID-19 new cases

To compare daily COVID-19 cases with the adjusted daily count of observed park users, the 7-day moving average for both the confirmed COVID-19 cases (new cases per million) and the adjusted daily count of observed park users (current day + six preceding days/7) were computed.

Statistical analysis

The statistical analysis was performed in R version 3.6.3 (R Core Team 2020). The normality assessment of the data using the Shapiro–Wilk test yielded p values less than 0.05 for most of the data, indicating it was not normally distributed. All further statistical analysis thus used non-parametric tests.

The Mann–Whitney–Wilcoxon test was performed to test for: (a) differences in park usage between the parks (each park was compared to every other park in the study in a pairwise analysis), (b) differences in female and male park users between the parks, and p values were adjusted using the Bonferroni *post-hoc* test to correct for multiple comparisons. To further assess differences in park usage and park categories, data pooled by social vulnerability and population density were statically compared using Mann–Whitney–Wilcoxon test.

The strength and direction of association between the seven-day moving average of adjusted count of observed daily park users and the number of confirmed COVID-19 cases (new cases per million) for each park were evaluated using Spearman's rank-order correlation coefficients (r_s). Correlation coefficients between ± 0.8 and ± 1.0 were considered to be strong, while those between ± 0.5 and ± 0.8 were considered to be moderate, and those less than ± 0.5 were considered to be weak.

3. Results

3.1. *Comparison of park usage and COVID-19 cases between parks*

A comparison of the observed park users in Philadelphia and NYC by park is presented in Figure 6. The adjusted daily count of observed park users (as defined previously) is represented with time series bar charts in Figures 6(a) and 6(b), for Philadelphia and NYC, respectively. Separate columns are provided for each park.

Of the 10 parks in Philadelphia, the highest number of users was observed in Washington Square Park, and the lowest in Cedar Park. Of the six sites in NYC,

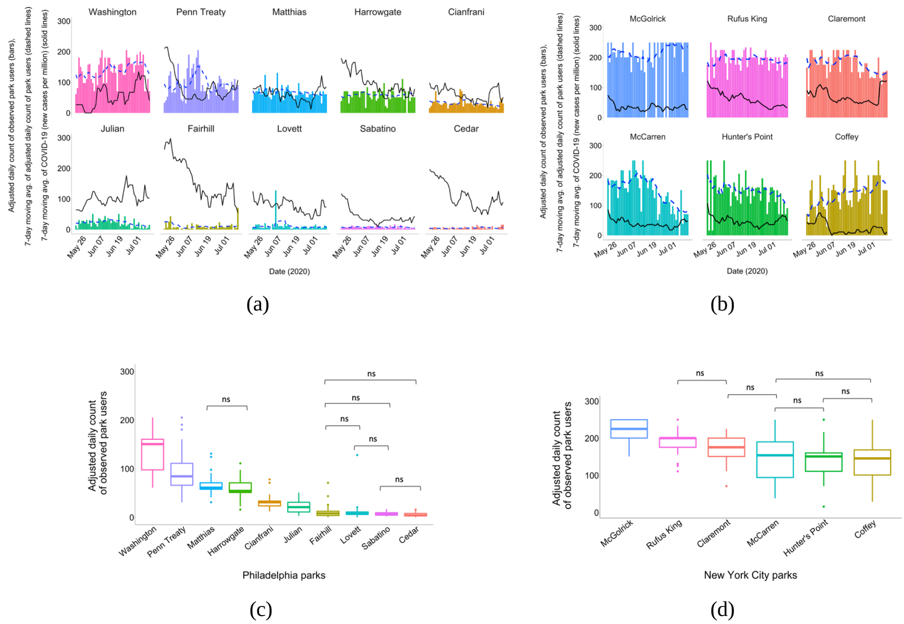


Figure 6. Adjusted Daily Count of Observed Park Users in Philadelphia and NYC During the Study Period: (a) Bar Charts Illustrate the Adjusted Daily Count of Observed Users in Philadelphia Parks, the Dashed and Solid Lines Indicate the 7-day Moving Average of the Adjusted Daily Count of Park Users and COVID-19 Cases (New Cases per Million), Respectively, (b) Bar Charts Illustrate the Adjusted Daily Count of Observed Users in NYC Parks Along with the 7-day Moving Average of Daily Park Users and New COVID-19 Cases (New Cases per Million), (c) Box Plot Showing the Distribution of Adjusted Daily Count of Observed Park Users in Philadelphia, and (d) Box Plot Showing the Distribution of Observed Adjusted Daily Count of Park Users in NYC. Statistically Significant Differences in Park Usage Between the Parks were Determined Using Mann–Whitney–Wilcoxon, and p Values Were Adjusted Using the Bonferroni *post-hoc* Test to Correct for Multiple Comparisons; $p < 0.05$ Was Considered Statistically Significant.

Notes: ns denotes not significant and only not significant are shown with brackets and labeled in box plots. The middle part of the box plot is interquartile range (IQR denotes distance between the third and first quartiles). The line near the middle of the box represents the median. The lower and upper hinges correspond to the first and third quartiles (the 25th and 75th percentiles: values below which percentage of data fall). The upper whisker extends from the hinge to the largest value no further than 1.5 * IQR from the hinge. The lower whisker extends from the hinge to the smallest value at most 1.5. * IQR of the hinge.

McGolrick Park and Coffey Park posted the highest and the lowest counts, respectively. For reference, cumulative totals for these four parks were 6760, 252, 9862, and 6908 park users, respectively.

The dashed and solid lines trend indicate the seven-day moving average of the adjusted daily count of observed park users and the number of confirmed

COVID-19 cases (new cases per million), respectively. The box plots (Figures 6(c) and 6(d)) indicate the distribution of adjusted daily count of observed park users for Philadelphia and NYC, respectively, and are color coordinated with the bar charts by park.

With few exceptions, the number of users differed significantly ($p < 0.05$) between pairs of Philadelphia parks (Cedar–Sabatino, Cedar–Fairhill, Sabatino–Lovett, Sabatino–Fairhill, Lovett–Fairhill, Harrowgate–Matthias, shown with brackets and labeled ns: not significant in Figure 6(c)). The number of users also differed significantly between pairs of NYC parks (with Coffey–Hunter's Point, Coffey–McCarren, Hunter's Point–McCarren, McCarren–Claremont, Claremont–Rufus King as exceptions labeled "ns" in Figure 6(d)).

3.2. *Comparison between vulnerability and density categories*

The box plots in Figure 7 (top panel) display the distribution of the 7-day moving average of the adjusted daily count of observed park users pooled by social vulnerability (Figure 7(a)) and population density (Figure 7(b)) in each city. Figure 7 also displays the distribution of the 7-day moving average number of confirmed COVID-19 cases (new cases per million) pooled by social vulnerability (Figure 7(c)) and population density (Figure 7(d)) in each city.

No significant differences were observed in the 7-day moving average of park users' count between parks in high and low vulnerability neighborhoods, in either city. However, comparison of the 7-day moving average of confirmed COVID-19 cases (new cases per million) indicated that parks in high vulnerability neighborhoods were indeed associated with higher case counts compared to parks in the low vulnerability category ($p < 0.01$).

Although social vulnerability did not yield differences in park usage, significant differences in the 7-day moving average of park users was observed between parks in low and medium density neighborhoods in Philadelphia, and between parks in medium and high-density neighborhoods in NYC ($p < 0.01$). Statistically significant differences in the 7-day moving average of confirmed COVID-19 cases were observed between parks in low and medium-density neighborhoods in Philadelphia ($p < 0.01$), but not between medium and high-density parks in NYC.

3.3. *Comparison of female and male park users*

Figures 8(a) and 8(b) depict the distribution of adjusted daily count of observed female and male park users in Philadelphia and NYC parks during the study period, respectively. In general, no significant differences in male and female usage

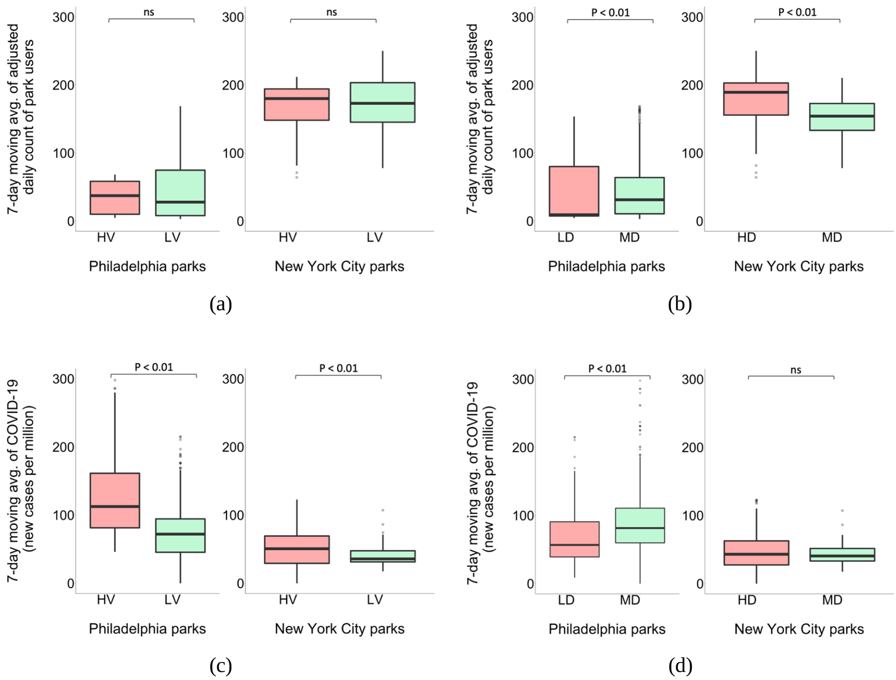
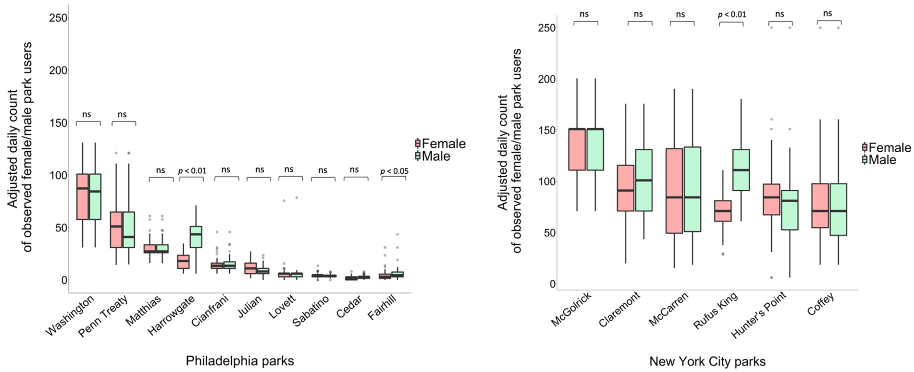


Figure 7. Box Plots Showing the Distribution of the 7-day Moving Average of Adjusted Daily Count of Observed Park Users and Confirmed Covid-19 Cases (New Cases per Million), for Data Pooled Together for Social Vulnerability and Population Density in Philadelphia and NYC Parks During the Study Period: (a) The Distribution of the 7-day Moving Average of Adjusted Daily Count of Observed Park Users Pooled for Social Vulnerability, (b) The Distribution of the 7-Day Moving Average of Adjusted Daily Count of Observed Park Users Pooled for Population Density, (c) The Distribution of the 7-Day Moving Average of Confirmed Covid-19 Cases (New Cases per Million) Pooled for Social Vulnerability, and (d) The Distribution of the 7-Day Moving Average of Confirmed Covid-19 Cases (New Cases per Million) Pooled for Population Density. Brackets Represent Significance (ns: Not Significant)

Notes: HV: high vulnerability; LV: low vulnerability; LD: low density; MD: medium density, and HD: high density.

were observed, with the exceptions of Fairhill Square ($p < 0.05$) and Harrowgate parks ($p < 0.01$) in Philadelphia, and Rufus King Park ($p < 0.01$) in NYC.

Gender differences were examined by pooling female and male park users by social vulnerability and population density. In parks in low vulnerability neighborhoods (Figures 9(a) and 9(b)), no statistical differences between female and male park users were observed in either city. By contrast, the number of male park users was statistically higher than female park users in parks in high vulnerability neighborhoods in both cities ($p < 0.01$).



(a) (b)

Figure 8. Box Plots Depicting the Distribution of Adjusted Daily Count of Female and Male Park Users: (a) in Philadelphia and (b) NYC. Brackets Represents Significance (ns Denotes Not Significant)

When considering population density, (Figure 9(c)), no statistical differences were observed between the number of female and male park users in parks in low and medium density neighborhoods in Philadelphia, nor were any gender usage differences detected in the parks in medium density neighborhoods in NYC. However, a statistically significant difference was observed between the number of female and male park users in the parks in high-density neighborhoods of NYC (Figure 9(d)), with greater usage by males.

3.4. *Correlation between the number of park users and COVID-19 cases*

Table 4 summarizes the Spearman's correlation coefficients indicating the strength and direction of association between the seven-day moving average of adjusted daily count of observed park users and the seven-day moving average of confirmed COVID-19 cases (new cases per million) for Philadelphia and NYC. No strong correlation was detected between the seven-day moving average of adjusted daily count and confirmed COVID-19 cases (new cases per million) in either city. The results are inconsistent and inconclusive, indicating moderate and significant direct correlations for Washington ($r_s = 0.62$), Lovett ($r_s = 0.6$); moderate and significant inverse correlation for Penn Treaty ($r_s = -0.59$) and Cedar ($r_s = -0.66$) parks in Philadelphia (all in low vulnerability neighborhoods of either medium or low density), followed by weak positive and/or negative correlation for the rest of the parks in both cities.

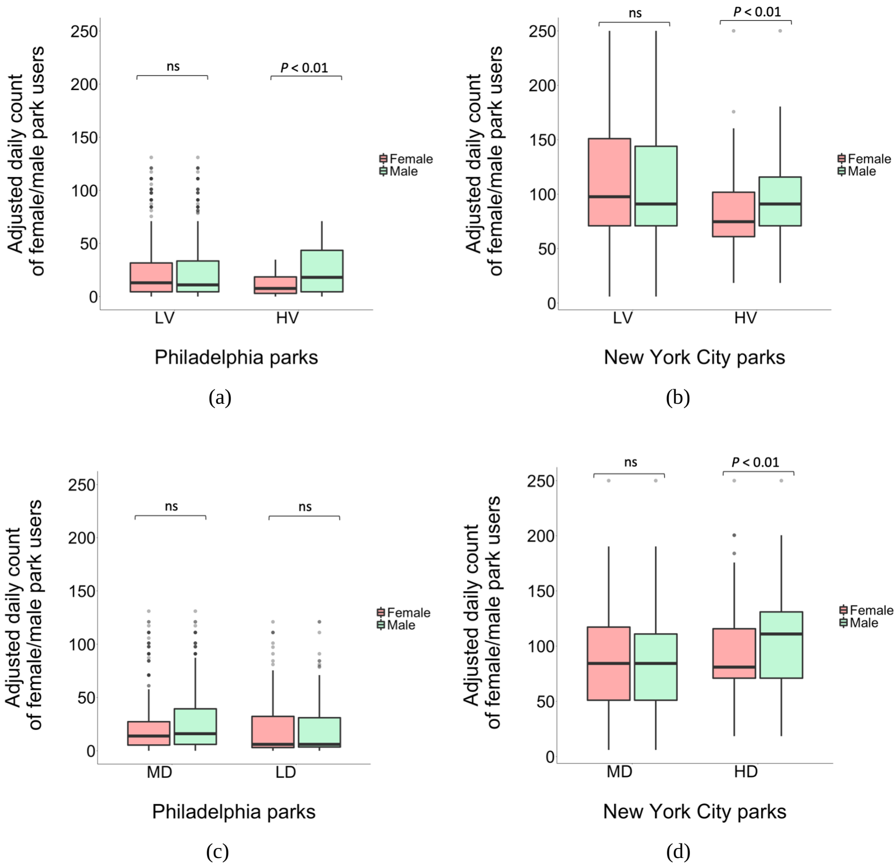


Figure 9. Box Plots Showing the Distribution of Adjusted Daily Count of Observed Female and Male Park Users During the Study Period. Data Pooled Together for Social Vulnerability for (a) Philadelphia Parks, (b) NYC Parks. Data also Pooled for Population Density for (c) Philadelphia Parks, and (d) NYC Parks. Brackets Represents Significance (ns: Not Significant)

Notes: HV: high vulnerability, LV: low vulnerability, LD: low density, MD: medium density, and HD: high density.

Relevant behavioral observations are shown in Figure 10. Overall, only a small percentage of park users, 22.7% and 1.2%, never wore masks in Philadelphia and NYC, respectively. The majority of park users were observed to not engage frequently in risky behavior. Only 0.7% and 0.9% of park users were observed to frequently cough or spit without covering their mouths, and only 1.6% and 12.9% of people were observed frequently participating in contact sports in Philadelphia and NYC, respectively.

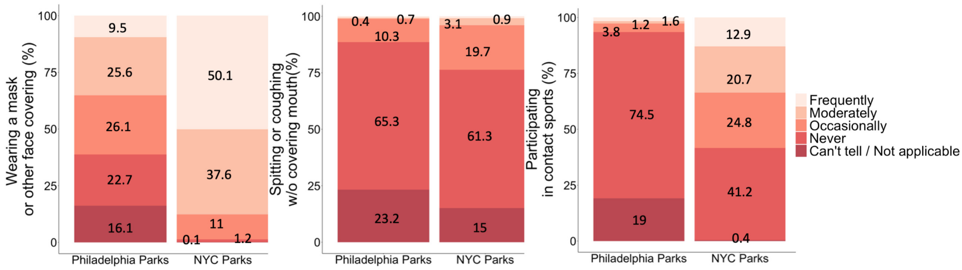


Figure 10. Observed COVID-19 Risky Behavior from Park Users

Table 4. Spearman's Correlation Coefficient (r_s) Between 7-day Moving Average of Adjusted Daily Count of Observed Park Users and 7-day Moving Average of Confirmed COVID-19 (New Cases per Million) for Philadelphia and NYC Parks: r_s between ± 0.8 and ± 1.0 strong, r_s between ± 0.5 and ± 0.8 moderate, and r_s less than ± 0.5 weak

City	Park Name	r_s	p
Philadelphia	Cedar	−0.66	< 0.01
	Cianfrani	−0.05	0.737
	Fairhill	0.25	0.083
	Harrowgate	−0.17	0.233
	Julian	−0.06	0.671
	Lovett	0.60	< 0.01
	Matthias	−0.21	0.151
	Penn Treaty	−0.59	< 0.01
	Sabatino	−0.18	0.215
	Washington	0.62	< 0.01
NYC	Claremont	0.03	0.86
	Coffey	−0.40	< 0.01
	Hunter's Point	0.22	0.13
	McCarren	0.00	0.99
	McGolrick	−0.03	0.84
	Rufus King	−0.11	0.46

4. Discussion

No significant differences were observed in the park usage between parks in low and high vulnerability neighborhoods in either city. However, COVID-19 cases were higher in high vulnerability neighborhoods. This observed association between social vulnerability and COVID-19 risk has been reported by the CDC, which states that, "counties with more social vulnerabilities, particularly those with a higher percentage of racial and ethnic minority residents, high-density housing structures, and crowded housing units, were at a higher risk for becoming a COVID-19 hotspot" (Dasgupta *et al.* 2020).

Park usage increased significantly with population density in both cities, but COVID-19 cases only increased with density in Philadelphia. Additional research is required to tease out these discrepancies. It could be that population density is only a partial determinant of COVID-19 cases below the threshold corresponding to our medium value, after which other factors become more important. At the same time, more densely populated neighborhoods likely trigger more park visits, regardless of the ambient COVID-19 case load. The discrepancy could also be attributed to other differences in the two cities. Given its larger geographic size and overall population, it could be that in NYC other forms of exposure to COVID-19 are more problematic than the exposure experienced in parks.

In most parks, gender differences in usage were not detected. However, in both cities, male park usage was higher in high vulnerability neighborhoods. In NYC, male park usage was higher in higher population density neighborhoods. In a study on social–ecological dynamics surrounding crime in urban green spaces, Sreetheran and van den Bosch (2014) found that females displayed more defensive behavior toward crime compared to males, suggesting that female park users have higher fear levels of crime and opt to avoid potentially threatening situations. Whether this phenomenon explains the gender usage differences observed in certain parks would require additional research into all other risk factors at play in parks in high vulnerability neighborhoods.

Though a more extensive epidemiological study is required, this research provided no evidence that park usage contributed to COVID-19 spread. As mentioned previously, the number of park visitors increased with density in Philadelphia, as did the number of confirmed COVID-19 cases. However, a strong correlation between confirmed COVID-19 cases in the adjacent zip codes and the number of park visitors was not detected in either city. Park users were also generally not observed to engage in risky behavior associated with elevated risk of COVID-19 transmission. Other researchers (Goldstein 2020) observed no surge in the number of COVID-19 cases after the large protests in June, which brought large numbers of people into public spaces, like parks. Though more work is needed, together these observations suggests that the positive value of parks as a place of respite from the pandemic may have far outweighed their potential for COVID-19 exposure.

This same sentiment is echoed in the emerging COVID-19 literature. The importance of green spaces for urban communities has been widely discussed, and even more distinctly demonstrated during the COVID-19 pandemic. Studying the change in usage and perception of urban green spaces as a result of the quarantine restrictions, Ugolini *et al.* (2020) reported that although a decrease in park usage in countries where the pandemic stuck hardest (Italy and Spain) was observed, green spaces were still regularly visited. People treated them as a "place of personal refuge within the city", with motives behind park visits shifting from "non-essential reasons", such as socializing or observing nature to more essential ones, such as physical exercise. Another study, conducted by Kleinschroth and Kowarik (2020), using Google Trends data, reported rising interest in short-distance outdoor activities and a sudden increase in searches for "go on a walk" right after the quarantine restrictions were set in, in mid-March, indicating a greater need for green space access.

Despite the challenges associated with life in an urban neighborhood, the CDC underscores the importance of outdoor time for mental and physical health, especially during a pandemic. They recommend building more parks where they are lacking, while also prohibiting vehicles from using certain streets to create more opportunities for recreation (Slater *et al.* 2020).

Anecdotally, and from the literature, it appears that the pandemic has increased urban residents' appreciation of local green spaces. The parks were visited regularly during these early days of the pandemic, and no evidence of their contributing to the spread of the virus was uncovered.

5. Conclusions

This study sought to demonstrate, through civic science, the impact of COVID-19 on the urban park usage (an important form of GI) in Philadelphia, PA and NYC, NY in the United States. There is little dispute that parks provide a wide range of ecosystem services. However, during the early days of the pandemic, there was speculation that parks could increase transmission of COVID-19. Forty-three anonymous Civic Scientists were employed by the research team to monitor the park usage in 22 parks, representing low to high social vulnerability and population density in both cities. The study represented an initial attempt to characterize park usage during the initial stages of the COVID-19 pandemic.

The study was limited in that data was only collected in two cities during a limited time period of the spring and summer, and also due to the fact that no baseline park usage statistics were available to compare park usage observed during this time to pre-pandemic times. Additionally, the study excluded large parks, and factors other than vulnerability and density were not factored into the selection of sites. The findings are also limited by the fact that the reported observations are not the actual *daily* numbers of park users, but rather a proxy for the actual number of park users that enabled comparison across parks.

Furthermore, it is worth noting that some of the observations made by the Civic Scientists, such as mask wearing, are subjective, and only provide a course indicator of potentially risky behavior of park users.

Nonetheless, it is noteworthy that no significant differences were observed in the seven-day moving average of park users between parks in low and high vulnerability neighborhoods in both Philadelphia and NYC. By contrast, the seven-day moving average of confirmed COVID-19 cases was significantly higher in parks in high vulnerability neighborhoods. The number of park users increased with density in Philadelphia, and so did the number of confirmed COVID-19 cases. However, no strong correlation was observed between COVID-19 cases and the number of park users. The results support the view that parks continue to provide various ecosystem services despite the pandemic. Ongoing research will focus on the experiences of the Civic Scientists during the data collection, and especially the value of this paid research as a form of economic stimulus.

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