



Who benefits from urban green spaces during times of crisis? Perception and use of urban green spaces in New York City during the COVID-19 pandemic

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ABSTRACT

Urban green spaces (UGS) provide health benefits to city dwellers, which may be even more important during times of crisis such as the COVID-19 pandemic. However, lack of access to UGS or important features of UGS, in addition to concerns about UGS safety or maintenance, could prevent people from receiving these benefits. We designed an online survey to understand how people were using and perceiving UGS during the COVID-19 pandemic in New York City during the spring of 2020. The survey included questions about how people's visits to UGS and perceptions of the importance of UGS for their health had changed since the start of the pandemic, as well as the concerns people had and features of UGS they considered important. Of the 1372 people who took the survey, most respondents were concerned about a lack of social distancing and crowded UGS, and respondents with these concerns were less likely to visit UGS and had visited UGS less often during than before the pandemic. In addition, generalized linear models showed differences in some concerns and important features of UGS across gender, race and ethnicity, demonstrating the importance of considering specific community needs in UGS design and management. Although concerns about lack of access were not common in our study population, these also appeared to prevent people from using UGS, and were more common in certain areas of the city that were also hard-hit by COVID-19 in the beginning of the pandemic. To ensure that people can get health benefits from UGS during times of crisis, cities must eliminate barriers by providing equitable access to UGS, considering what amenities communities need from UGS, and provide consistent communication about public health policies.

1. Introduction

Urban green spaces (UGS), such as parks, gardens, and plazas, provide a number of potential benefits to city dwellers. Exposure to and use of UGS can improve physical and mental health through recreation and exercise (Kaczynski and Henderson, 2007) and decreased anxiety and stress (Cox et al., 2017; Hazer et al., 2018; Li et al., 2018; Tyrväinen et al., 2014). These physical and mental health benefits may become even more critical during times of crisis (van den Berg et al., 2010) such as the current novel coronavirus (SARS-CoV-2) pandemic (McCunn, 2020;

Samuelsson et al., 2020), as residents face heightened health-related and economic stress, grief, isolation, and limited mobility during the implementation of social distancing policies (Brooks et al., 2020). However, the use of UGS during the current pandemic may be limited by individuals' lack of access to UGS, in addition to temporary park and facilities closures and concerns about safety or overcrowding. This presents a unique challenge to city governments to decide how to safely and equitably manage UGS during a public health crisis.

Communities' use of UGS depends on a number of factors, including who has access to UGS, what amenities are provided, how well they

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match the needs of the community, and who feels safe and welcome to use them (Bedimo-Rung et al., 2005; Lee and Maheswaran, 2011; Rupprecht et al., 2015). Access to UGS is not distributed equally in many cities, with less green space often found in low-income communities of color, qualifying it as an environmental justice issue rooted in a history of structural racism and disinvestment in UGS (Rigolon, 2016). The same communities that have less UGS access also tend to have lower park “quality”, including funding for parks, maintenance and cleanliness, and the amenities (e.g. recreational facilities) that are provided (Conedera et al., 2015). Several recent studies have shown that perceptions of park quality, in addition to or even more than quantity of UGS, predict park usage and the health benefits that individuals can receive from parks (Akpinar, 2016; Brindley et al., 2019; Flowers et al., 2016). Cultural and individual differences (e.g. affinity towards nature) can lead to different perceptions of and preferences for UGS among urban populations (Fischer et al., 2018; Flowers et al., 2016; Gobster, 2002; Madureira et al., 2015; Rupprecht et al., 2015). Recognizing these differences is critical for providing the benefits of UGS to diverse residents (Frumkin et al., 2017; Hartig et al., 2014).

The COVID-19 (the disease caused by the SARS-CoV-2 virus) pandemic has changed people’s perceptions and use of UGS (Honey-Rosés et al., 2020; McCunn, 2020). Many cities, regions, and entire countries enacted temporary lockdowns (in addition to social distancing recommendations and mandates) to control the spread of the virus, leading to unprecedented reductions in mobility (Rutz et al., 2020) and temporary closure of public spaces (Slater et al., 2020). Some studies have found increases in park and natural area use during the pandemic, as residents seek relief from rising stress and anxiety and try to limit indoor activities with higher virus transmission risk (Grima et al., 2020; Kleinschroth and Kowarik, 2020; Lu et al., 2020; Venter et al., 2020). However, limited physical or perceived access to UGS, due to lack of nearby greenspace, closed facilities, or perceptions of not being welcome in UGS, could prevent people from using UGS during this crisis. In addition, concerns about the safety of visiting public spaces could reduce people’s ability or willingness to use UGS during the pandemic (Slater et al., 2020), limiting access to potential benefits from visiting UGS.

To better understand these evolving concerns and issues, we designed an online survey to assess how people were using and perceiving UGS during the early stages of the COVID-19 pandemic (May 13 to June 15, 2020). Our study focuses on New York City (New York, NY, hereafter “NYC”), the largest U.S. city and one of the hardest-hit regions in the U.S. in the spring of 2020 (Centers for Disease Control and Prevention, 2020a). The survey included questions about changes in people’s visits to UGS and perceptions of the importance of UGS for health since the start of the pandemic, as well as the concerns people had and features of UGS they considered important. We examined how responses to these questions varied across locations (city boroughs) and respondent demographics (gender and race/ethnicity) to understand how different groups of people were using and perceiving UGS. The results of this study have implications for funding, policy, and management of UGS in NYC, with potential applications to other cities, particularly during times of crisis.

2. Methods

2.1. Study area

NYC is the largest city in the United States with a population of approximately 8.4 million people (US Census Bureau, 2019). The city comprises five boroughs: Manhattan, Brooklyn, Queens, the Bronx, and Staten Island. NYC has over 1700 parks (NYC Parks 2020; <https://www.tpl.org/city/new-york-new-york>). NYC also has over 12,000 acres of natural areas, including wildlife refuges and eight public beaches (NYC Parks, 2020; <https://www.nycgovparks.org/about/>), and approximately 12,600 acres of public or “passive” open space (1.5 acres per 1000 residents) such as plazas and esplanades within the city limits (Harnik et al., 2016).

In response to COVID-19 outbreaks in NYC and nearby New Rochelle, NY, New York state authorities created a shelter-in-place mandate (“PAUSE”) in addition to social distancing policies that included restricted access or temporary closure of public parks, beaches, and other natural areas, beginning in March of 2020 (Angel et al., 2020; New York State Department of Health and Mental Hygiene, 2020). Our survey was active during a time period following some of the worst health impacts of the crisis, but before NYC reopened many non-essential businesses (e.g. indoor dining).

2.2. Survey design

We developed an online survey using Qualtrix to understand how people were using UGS during the early stages of the COVID-19 pandemic, whether people perceived UGS to be important for their health, and whether exposure to UGS was affecting mental health during this time. There were two versions of this survey: one which was sent out nationally and one that was specific to residents currently living in NYC. The NYC survey (analyzed in this study) was designed in partnership with the New York State Health Foundation, The Building Healthy Communities NYC program, and the Nature Conservancy of New York, who helped tailor questions and relevant language, including an emphasis on open spaces provided by the NYC Housing Authority (NYCHA). In the survey we used the terminology “parks and open spaces” (referred to here as UGS), which we defined as any public spaces with natural or managed vegetation, including parks, greenways, public gardens, and accessible wetlands, forest, prairies, and beaches.

The survey questions analyzed in this study came from three of the six sections of the survey (see Appendix A). The first set of questions (from Section 2) asked about participants’ use of UGS during the pandemic, including 1) how often participants had visited UGS in the last week, 2) how their participation in visiting UGS (in addition to other activities) had changed since the start of the pandemic, 3) which features were considered important for a UGS experience, 4) whether the UGS they visited most often provided each of the features they identified as important, and 5) what concerns, if any, the participant had with visiting UGS. Questions from Section 5 asked how important participants considered UGS to be for their mental and physical health, currently and before the COVID-19 crisis, respectively. Finally, in Section 6 we asked a series of demographic questions, including participants’ zip code, NYC borough and neighborhood, gender, age, race and ethnicity, education level attained, and household income. All questions were multiple choice, with the option to select multiple responses for questions identifying concerns and important features of UGS and racial identity. There was also an option to provide additional comments at the end of the survey. See Appendix A for exact wording of questions used in this study.

2.3. Survey distribution

We recruited survey participants using a combination of a convenience sample and snowball approach. We advertised the survey on social media (Twitter and Instagram) and distributed a link to the survey over email to listservs and networks, including those of our partner organizations (The New York State Health Foundation and The Nature Conservancy of New York). The survey was open to anyone over the age of 18 who resided in NYC.

2.4. Data analysis

We analyzed data from survey responses that answered at least 70 % of the survey questions to capture responses to the questions analyzed in this study (Appendix B Table 1). We compared the demographics of survey participants to data from the U.S. Census American Community Survey 5-year estimates 2015–2019 (U.S. Census Bureau, 2020) using Fisher’s tests. We examined the distributions of responses to identify the

most commonly selected concerns about and important features of UGS. We also coded write-in “other” responses about concerns and important features into themes using an emergent, inductive coding approach (Ryan and Bernard, 2003). To determine whether respondents perceived that they had access to their desired UGS features, we calculated the proportion of features that each respondent selected as important that they also said their most-visited UGS provides.

We were interested in how people’s concerns with visiting UGS, important features for UGS to provide, access to those important features, perceptions of UGS’s importance for their health, and frequency of UGS visits differed across populations. We therefore used generalized linear models to examine differences in responses to these questions across locations and demographics, focusing on NYC borough (Manhattan, Bronx, Queens, Brooklyn, and Staten Island), gender (female, male, and nonbinary), and non-exclusive, census-based race and ethnicity categories (Asian, Black or African American, Hispanic/Latinx, Native American [including American Indian or Alaska Native and Native Hawaiian or Pacific Islander], and white), all included as fixed effects. We were also interested in how perceptions of UGS (concerns, how well UGS provided important features, and perceived importance of UGS for health) affected how often people visited UGS and how this frequency changed during the pandemic. We thus included the following in models predicting UGS visit frequency and change in frequency: dummy variables coding whether respondents had selected particular concerns (lack of social distancing, crowded UGS, lack of access, and lack of safety); the proportion of important features provided by the most visited UGS; and an indicator of perceived importance of UGS, calculated as the mean of the numeric values (1–5 on a Likert scale from “Not at all important” to “Extremely important”) of responses to the four questions about the importance of UGS for health (Appendix B Table 1).

All data analysis was performed in R (R Core Team, 2020). We used the “polr” function in the “MASS” package (Venables and Ripley, 2002) to fit ordinal regressions for responses with ordered categories (importance of UGS for health, frequency and change in frequency of UGS visits) and the “glm” function using the “family = binomial” argument to fit logit regressions for binary responses (selected concerns and important features) and the proportion of features provided by the most visited UGS. Log ratios that did not overlap one (with confidence intervals calculated using the “confint” function) were considered significant. We tested for multicollinearity in models using the variance inflation factor (VIF) with the “vif” function in the “car” package (Fox and Weisberg, 2019). We found no evidence of collinearity in models, with all VIFs < 2.5. Some binomial models showed evidence of overdispersion, so we reran them using a “quasibinomial” family. Results are shown for binomial models only, since results did not differ substantially between any binomial and quasibinomial models. Figures were created using the “ggplot2” (Wickham, 2016) and “ggalluvial” (Brunson, 2017) packages in R.

3. Results

3.1. Survey respondents

In total, 1372 people took the NYC survey, and 1145 people completed over 70 % of the survey questions. Of these, over 70 % identified as female and 23 % as male, with ~2% (19 individuals) identifying as nonbinary; females were significantly overrepresented in the dataset compared to estimates from the U.S. Census (Fisher’s test simulated p-value < 0.001; Appendix C Fig. 1). Over 75 % of survey respondents identified as white (72 % as white only), 8% as Black, 7% as Asian, and 1% (11 individuals) as Native American. About 10 % of respondents identified as Latinx. This demographic makeup differs significantly from NYC residents (Fisher’s test simulated p-value < 0.001; Appendix B Fig. 2), of whom about 45 % identify as white, 26 % identify as Black, 15 % as Asian, 1% as American Indian or Pacific Islander, and 29 % as Latinx (U.S. Census Bureau, 2020).

Respondents were also biased towards young age (45 % in their twenties and thirties but only 7% over 65 years old; Appendix C Fig. 3), high income (40 % making at least \$100,000 per year; Appendix C Fig. 4), and high educational attainment (45 % held a master’s degree and 13 % had a professional degree or PhD; Appendix C Fig. 5). In contrast, the median age of NYC residents is 36.7 years and about 25 % of residents are over 65; 21 % of full-time workers in NYC earn over \$100,000 per year, and 16 % of residents hold a graduate or professional degree (U.S. Census Bureau, 2020).

Most responses came from Brooklyn (44 %) and Manhattan (32 %), with fewer from Queens (12 %), the Bronx (6%) and Staten Island (1%). Over 85 % of respondents stated that they use UGS.

3.2. Concerns about UGS

The most common concerns about visiting UGS selected by respondents were that “People are not practicing social distancing” (59 %) and that UGS were “Too crowded” (57 %) (Fig. 1). The most common write-in concerns (all <2% of respondents) were that people were not wearing masks, that public restrooms were lacking or closed, and that there was no available UGS close by or that nearby UGS were closed during the shelter-in-place order.

There were some differences in concerns across gender, race/ethnicity, and borough (Fig. 1). Men responded that UGS did not meet their needs more often than women, and nonbinary respondents were more concerned than women about police presence and lack of adequate lighting in UGS. Latinx respondents were more likely than others to select a lack of park staff and “Not child-friendly” as concerns. Access to UGS was a greater concern in Brooklyn and Queens than in Manhattan, and concerns about crowded UGS and a lack of park staff also differed across boroughs (Appendix D Table 1).

3.3. Important features of UGS

“Places to walk / trails” and “Trees, shade” were selected as important features of UGS visits by over 85 % of respondents, and over half of respondents selected “Places to sit”, “Landscaping / maintained gardens, and/or “Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)” (Fig. 1). The most common write-in features (all <2% of respondents) were public restrooms, nature or wildlife (e.g. “Birds and squirrels”, “Natural environment to observe cycles of nature”), bicycle paths, and public art.

The features of UGS that people considered important varied across gender, with men less frequently selecting trails, water features, places for children to play, or “Educational opportunities (e.g. informational signage, guided trails)” while nonbinary respondents more frequently selected “Places to BBQ, cook food” and “Dog-friendly” than women (Fig. 1). Latinx respondents more frequently selected “Places to BBQ, cook food” and “Places to sit”, and Black respondents were less likely to select “Opportunities to view wildlife”. There were differences across boroughs in the number of respondents who selected “Landscaping / maintained gardens”, “Trees, shade”, “Places to sit”, and “Places to exercise / play sports” (Fig. 1; Appendix D Table 2).

On average, respondents stated that most of the features they deemed important for a UGS visit experience were provided by their most frequently visited UGS (mean 83 ± 24 %, median 100 %). However, respondents from Queens reported a significantly lower proportion of the features they consider important that were provided (Appendix D Table 2).

3.4. Importance of UGS for mental and physical health

Over eighty percent of respondents reported that UGS were either “extremely important” or “very important” for mental and physical health, respectively, but overall, UGS were considered more important for mental than physical health (Fig. 2). Men ranked UGS as less

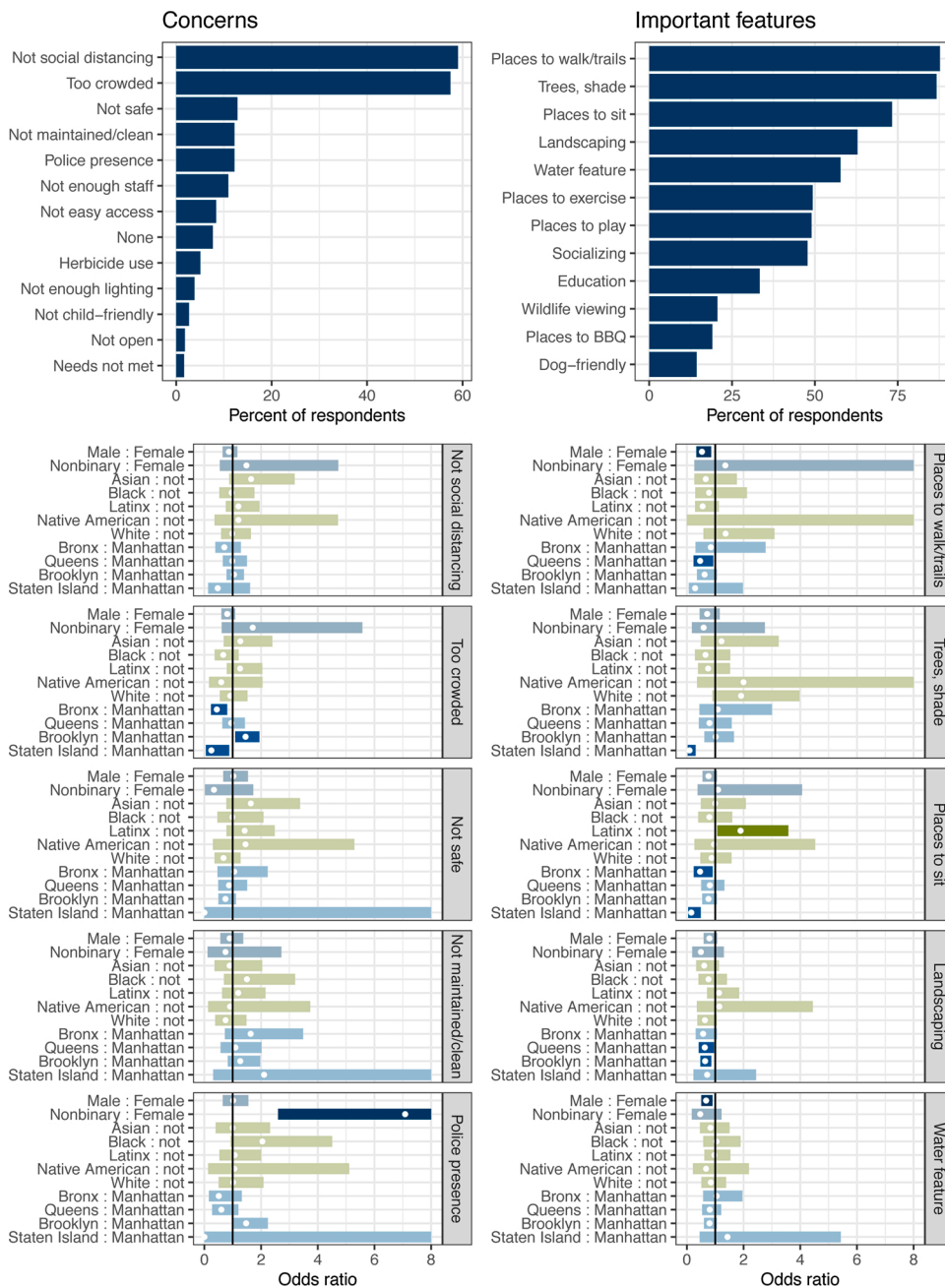


Fig. 1. Percent of respondents who selected each concern about visiting urban green space (UGS) (A) and important feature of UGS (G), and coefficients of binomial regressions predicting differences in these responses across gender, race/ethnicity, and NYC borough (B-F and H-L). Plots show the odds ratios of the given variables compared to their associated baseline group (e.g. Male : Female is comparing the relative likelihood of selecting the response for people who identified as male, compared to the baseline group Female). If a variable’s coefficient is not sufficiently different from the baseline group, the odds ratio takes a value of one (shown as a vertical black line for reference). Statistically significant differences (those where a variable’s 95 % confidence bounds do not overlap one) are shown in darker shades. Upper limits of confidence intervals are capped at 8 for ease of viewing; confidence intervals that reach 8 have higher upper limits (see Appendix D Table 1). Model responses are shown for the five most frequently selected concerns (B-F) and features (H-L). Results for other responses can be found in Appendix D Table 1.

important for both mental and physical health than did women and respondents from Queens ranked UGS as less important for mental and physical health than those from Manhattan. Black respondents ranked UGS as less important for mental and physical health than others and Asian respondents ranked UGS as less important than others for physical health only (Fig. 2).

On average, respondents reported that they consider UGS to be slightly more important for their mental and physical health now than they did before the start of the COVID-19 crisis. Although more than half of respondents reported no change in their assessment of UGS importance for mental or physical health (most of whom selected “extremely important” for both time periods), 39 % ranked UGS as more important for mental health now than before the pandemic and 36 % ranked UGS as more important for physical health now than before (Fig. 2).

3.5. UGS use during the pandemic

Approximately equal numbers of respondents reported that they increased (15 %) and decreased (14 %) their visitation of UGS during the pandemic, with fewer reporting that they started or stopped visiting UGS (Fig. 3; Appendix D Table 3). Asian and white respondents were more likely than others to increase their visitation of UGS during the pandemic. Respondents were less likely to increase their UGS visitation during the pandemic if they reported concerns about social distancing, access to UGS, or the safety of UGS (but not crowded UGS; Fig. 3).

Over 20 % of survey respondents reported that they had visited a UGS 3–4 times during the preceding week and another 20 % had visited about once per day (Fig. 3). Nonbinary respondents visited UGS more frequently than women and Latinx respondents visited UGS less frequently than others. People who considered UGS to be more important for their health and those whose most-visited UGS provides more of the features they deem important visited UGS more frequently, while

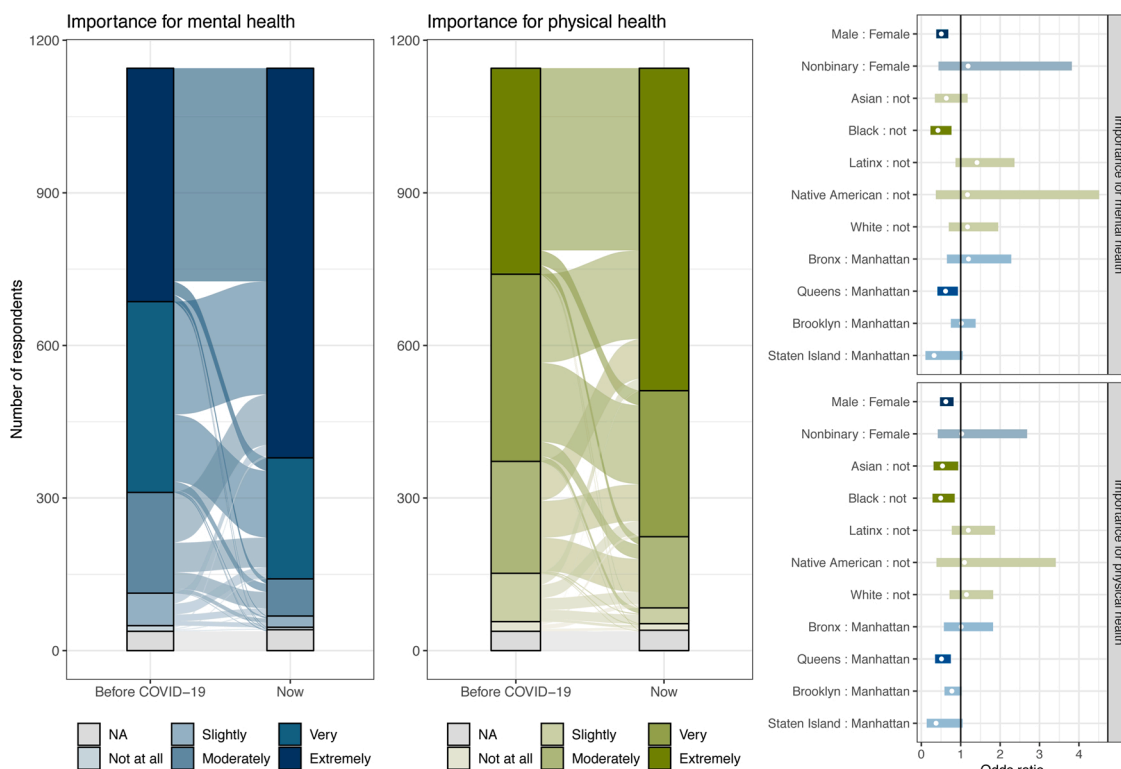


Fig. 2. Perceived importance of urban green space (UGS) for mental (A) and physical (B) health before (left-hand bars) and since (right-hand bars) the start of the COVID-19 pandemic and results of ordinal regressions predicting differences in current (since COVID-19) perceived importance across gender, race/ethnicity, and NYC borough (C). A and B show the number of respondents who selected each category of importance of UGS for health (ranging from “Not at all important” to “Extremely important”). Shaded areas between bars are made up of lines connecting individuals’ responses regarding the two time periods. Thicker shaded areas represent a larger proportion of respondents who made the same selections; for example, the largest proportion of respondents selected that parks were “Extremely important” both before and during the pandemic (darkest shaded area connecting the two top bars) for both mental and physical health. Model coefficients (C) are odds ratios comparing the relative likelihoods of respondents selecting a given response compared to a baseline group (e.g. Male : Female is comparing the relative likelihood of selecting the response for people who identified as male, compared to the baseline group Female). Coefficient estimates are shown as white dots and colored bars represent confidence intervals.

those concerned about social distancing, access to UGS, the safety of UGS, or crowded UGS visited UGS less frequently (Fig. 3).

4. Discussion

The COVID-19 pandemic has led to historic economic impacts, loss of life (Centers for Disease Control and Prevention, 2020b), long-term morbidity, and rates of unemployment not seen since The Great Depression, all of which have led to quantifiable stress among affected populations (Martin et al., 2020; Nicola et al., 2020). Indeed, health professionals have warned that the pandemic and associated stress and isolation are creating a mental as well as a physical health crisis (Twenge and Joiner, 2020; Vindegaard and Benros, 2020). During this time of crisis, UGS may be increasingly important for providing health benefits to city dwellers (McCunn, 2020). Our survey of over one thousand New Yorkers demonstrated that many people recognize the importance of UGS for their health, and that this recognition has increased since the start of the pandemic. The survey also showed that many New Yorkers who use UGS have continued to use them, even during the deadliest period of the pandemic for NYC thus far. However, we found that concerns about the safety of visiting UGS, a lack of UGS access, and a paucity of desired features can discourage people from using UGS and gaining associated health benefits. This may potentially further exacerbate the long-term negative health effects of the pandemic and disproportionate effects on Black, Latinx, and other often-marginalized groups (Andrasfay and Goldman, 2020). Our results point to some practical strategies for providing opportunities for receiving health benefits from UGS during times of crisis.

We found that most survey participants considered UGS to be *very* or *extremely important* for their health across all groups (gender, race/ethnicity, and borough) analyzed in this study. Notably, UGS were considered to be more important for mental than physical health. Some reviews and synthesis on the effects of green space on health have suggested stronger relationships with mental health impacts, including stress restoration, mood, and mental health disorders, than on physiological stress, morbidity, and other physical health measures (Kondo et al., 2018; Lee and Maheswaran, 2011). Access to UGS can encourage physical exercise, but UGS also have a variety of other uses that contribute to health and wellbeing, including socializing, community building, and fostering connections to nature (Lee and Maheswaran, 2011). In NYC in particular, parks are a critical social space contributing to perceptions of community quality and cohesion (Auyeung et al., 2016). With recognition that outdoor social interactions produce lower risk of disease transmission than indoor gatherings, UGS have become increasingly important venues for relieving social isolation and stress.

Several studies have found that people have used UGS more since the pandemic started (Grima et al., 2020; Kleinschroth and Kowarik, 2020; Lu et al., 2020; Venter et al., 2020). Our survey respondents visited UGS multiple times per week on average, but respondents were equally likely to increase or decrease their UGS visits during the pandemic. Our results suggest that concerns about COVID-19 were a factor, as these were the most frequently selected concerns about visiting UGS and respondents who were concerned about social distancing in UGS were more likely to decrease their visits to UGS. Lack of mask wearing was also a concern, and some respondents commented that they would like to see more clearly stated policies and more enforcement of social distancing and

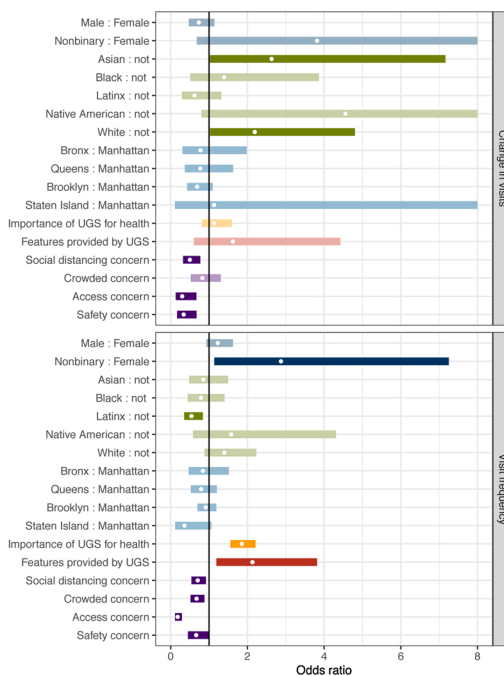
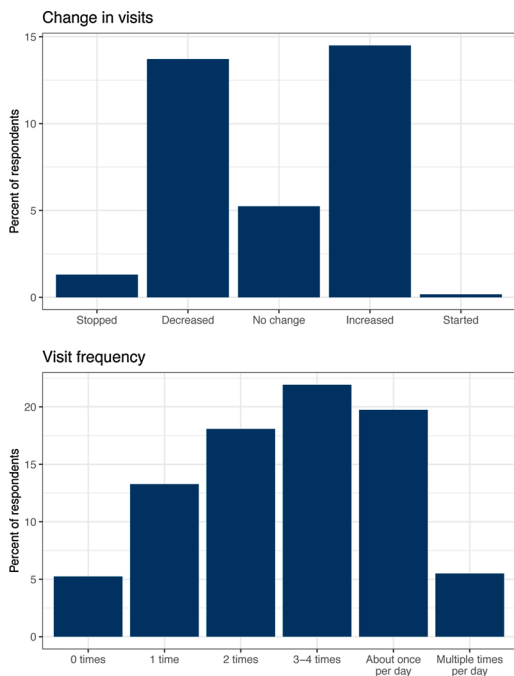


Fig. 3. Change in urban green space (UGS) visits since the start of the COVID-19 pandemic (A) and frequency of UGS visits within the week preceding survey participation (B). We compared UGS visit frequency and change in UGS visits during the pandemic across gender, race/ethnicity, and NYC borough and in relation to respondents' perceived importance of UGS for health, features provided by their most visited UGS, and concerns about visiting UGS (C-D). Model coefficients from ordinal regressions (C) are odds ratios comparing the relative likelihoods of respondents selecting a given response compared to a baseline group (e.g. Male : Female is comparing the relative likelihood of selecting the response for people who identified as male, compared to the baseline group Female). Coefficient estimates are shown as white dots and colored bars represent confidence intervals. Confidence intervals that do not overlap 1 (colored in darker shades) are considered significant differences between groups. Upper limits of confidence intervals are capped at 8 for ease of viewing; confidence intervals that reach 8 have higher upper limits (Appendix D Table 3).

mask wearing in parks. Here, the specific time and place of our study may have had an impact on the results. NYC had stricter lockdown policies than many U.S. cities, but less strict than many other regions, such as parts of Europe. New Yorkers may have been more wary, on average, of visiting UGS than people in less affected areas of the country or at later stages of reopening and more likely to wear masks than in other parts of the county where mask-wearing has been eschewed by political leaders.

Other factors also led to reduced UGS visits (compared to other respondents or pre-COVID-19 behaviors), including concerns about UGS access and safety and UGS that do not adequately meet people's needs. Access to UGS and the perceived safety of UGS were likely worsened by COVID-19, with park closures and potential virus spread from surfaces and strangers, but may also have been chronic issues unrelated to COVID-19 (e.g. over-policing, lack of neighborhood green space) that became prohibitive in the face of new stresses. Even when parks and other UGS have remained open, they have often had some areas or facilities (e.g. public restrooms, sports facilities, seating areas) that are closed. Partially opened or small parks, or large iconic parks that serve large populations, are likely to become crowded and cause stress for people looking for a reprieve, rather than a risk of infection, from going outside. Closed facilities could also make a UGS visit more difficult (e.g. visiting a park without a restroom or playground with small children) or simply less worthwhile. Addressing these factors could help encourage UGS users to continue to visit UGS during the pandemic; however, since few people who do not use UGS took our survey, we are limited in our ability to say that these actions would promote UGS use by people who are otherwise not inclined or able to use them. In addition, other factors that we did not specifically ask about may have been important deterrents from UGS use.

We found some key differences in perception and use of UGS across groups of people, as well as some inequalities that should be addressed in future UGS planning and management. Despite a strong bias in our sample population towards relatively high-income, educated, white women and the use of coarse census-based race and ethnicity categories that ignore cultural differences, we were able to detect some significant

differences in concerns (e.g. police presence) and important features of UGS (e.g. educational opportunities, wildlife, places to cook food) across groups. These differences demonstrate the importance of communication with and involvement of communities to find out what their UGS needs are (Gobster, 2002). Participatory planning processes and procedural justice reforms could help to increase feelings of inclusion and safety in UGS, particularly for historically marginalized communities such as Black Americans who are often assumed to be disinterested in nature and the environment, creating a cycle of exclusion from public spaces (Finney, 2014). Inequality in access, amenities, or inclusion in UGS could further exacerbate health inequities by limiting opportunities for outdoor exercise and stress restoration in nature (Hartig et al., 2014). Indeed, in our study, respondents from Queens reported more concerns about a lack of UGS access and a lack of the features they deemed important being provided by local UGS. This is consistent with recent research that found that neighborhoods in Queens were disproportionately impacted by COVID-19, in part because of increased social vulnerability in Western Queens (Choi et al., 2020).

4.1. Implications for UGS planning and management

For people to receive benefits from UGS during a public health crisis, the benefits of visiting a UGS need to outweigh the cost. The first barrier that cities can try to remove from this equation is to ensure that there is adequate and equitable access to UGS in the city. Even in NYC, a city with higher-than-average access to parks per capita compared to other U.S. cities (over 90 % of residents living within a 10-minute walk of a park; The Trust for Public Land, 2020), concerns about a lack of safe and easy access prevented people from visiting UGS. Access may be even more prohibitive in other cities. Although NYC has UGS distributed throughout the city, there are differences across neighborhoods in the size and quality of UGS (Miyake et al., 2010; Weiss et al., 2011). Access to larger parks or connected networks of parks may be particularly beneficial during the current pandemic because they offer greater ability to maintain social distance. In general, larger parks that are more accessible by public transportation receive more visitors (Hamstead

et al., 2018), but during the COVID-19 pandemic some typical methods of travel to UGS (e.g. subways) are considered high-risk, and traveling long distances to UGS is less feasible. Maintaining UGS access during the pandemic requires keeping UGS open and working to make public transportation systems safe (Slater et al., 2020). Further, ensuring equitable access likely requires increasing available open space in some areas (even in NYC). In the short term, cities can use open and slow streets to increase outdoor recreation areas in neighborhoods that need them, but in the long term, equitable access will require prioritizing underserved neighborhoods for creating new UGS (Slater et al., 2020).

A second barrier that may prevent people from visiting UGS in times of crisis is not getting what they need or expect from them. Many UGS provide some of the important features most commonly recognized by our respondents (i.e. trees, planted areas, places to sit and walk) just by being open, but other features that are important for some groups, including restrooms, playgrounds, and places to cook food, have been closed due to concerns about disease spread. In addition, budget constraints or concerns about staff safety can lead to a lack of UGS maintenance during times of crisis, leading to complaints about cleanliness and aesthetics. Maintaining facilities and keeping them open is important, to the extent that the risk it presents to staff and the public is deemed acceptable by public health experts (Slater et al., 2020). Such tradeoffs between providing benefits to UGS visitors and keeping people safe will be ongoing and potentially difficult to assess, especially when cities need to make decisions with incomplete information about the pandemic or other emergency situations. However, a real understanding of what communities need and want from UGS could be highly informative for determining priorities.

Finally, ensuring that people can get benefits from UGS requires that they are perceived as safe. Perceptions of safety are a major contributor to individuals' use of UGS, both in NYC (Weiss et al., 2011) and more broadly (Jansson et al., 2013). During the COVID-19 pandemic, perceived risks of contracting the virus (or even the stress of not knowing what behavior to expect from other visitors) may be enough to prevent people from visiting UGS. Concerns about a lack of social distancing and mask wearing were widespread in our survey. Although these concerns may have decreased with vaccinations and awareness that outdoor environments have relatively low disease transmission, they could be addressed by clear, consistent messaging about the potential benefits of UGS visits and what behaviors are expected of individuals during the pandemic (Slater et al., 2020). In comments, several survey respondents expressed a need for clear communication (e.g. signage at parks) for what behaviors were expected, particularly as information around the novel coronavirus evolved. Some respondents also expressed a desire for park staff to enforce recommended behaviors (e.g. by handing out masks). Public health agencies will need to determine what level of engagement with the public is safe for park staff, but there is a clear need for financial and informational support for UGS staff and for development of comprehensive and adaptable policy to address evolving public health crises in public spaces.

4.2. Limitations and future research needs

This study has several important limitations, partly due to the short time frame of study planning and implementation that was necessary to address the urgent question of how people were using UGS during the early stages of the COVID-19 pandemic; the timeliness of these results enabled us to share them with the NYC Mayor's Office of Climate Resiliency (MOCR) Rapid Research and Assessment (RRA) series (Kyrkjebø et al., 2021) for consideration in COVID-19 response planning. Our recruitment method was employed to receive responses rapidly, with the tradeoff of obtaining a relatively large but biased sample in a short time period. Many groups of people (including Black, Latinx, Asian, and other communities that have been most affected by the pandemic) were underrepresented in our dataset, limiting the

generalizability of our results and our insights into these communities' needs. Indeed, our overall results may have differed if we had been able to reach more participants from these groups. More research is needed to fully understand how to promote UGS use and its associated benefits for all city dwellers, including more comprehensive surveys and methods that elicit more detail on users' perceptions and needs, such as in-depth interviews and participatory planning. Future spatially explicit analysis could also help identify physical and geographic factors that influence UGS use and perceptions, examine the effects of individual park closures on overall park use, and identify important management considerations for individual UGS in NYC and other U.S. (Spotswood et al., 2021).

5. Conclusion

UGS can provide health benefits that may be all the more important for short-term relief during times of crisis and long-term preventative health. However, people can only get these benefits if they have adequate access to UGS, are able to get what they need from them, and feel safe there (Bedimo-Rung et al., 2005). During the COVID-19 pandemic, city and state governments have needed to quickly make decisions about how to keep people safe, including policies about the use of open spaces. Understanding how people perceive the risks and potential benefits associated with UGS can help to guide policies to ensure continued access and safety of residents. Our survey results support public health guidance that keeping UGS open, recognizing the specific needs of communities, and communicating consistent policy for pandemic-related behaviors are best practices for managing open space during the COVID-19 pandemic (Slater et al., 2020); these strategies will also be important to consider for future pandemics. Our findings also highlight the importance of determining the needs of diverse communities to guide UGS management, particularly during times of crisis when UGS play an important role in health and wellbeing.

Author contributions

Bianca Lopez: Conceptualization, Methodology, Investigation, Formal analysis, Writing- Original draft preparation, Visualization; Christopher Kennedy: Conceptualization, Funding acquisition, Investigation, Writing- Original draft preparation, Project administration; Christopher Field: Methodology, Visualization, Writing- Reviewing and Editing; Timon McPhearson: Conceptualization, Funding acquisition, Investigation, Writing- Reviewing and Editing

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.

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Appendix A Questions from online survey used for the study.

We developed an online survey using Qualtrix to understand how people were using UGS during the early stages of the COVID-19 pandemic, whether people perceived UGS to be important for their health, and whether exposure to UGS was affecting mental health during this time. There were two versions of this survey: one which was sent out nationally and one specific to residents currently living in NYC. The NYC survey (analyzed in this study) was designed in partnership with the New York State Health Foundation, The Building Healthy Communities NYC program, and the Nature Conservancy of New York, who helped tailor questions and relevant language, including an emphasis on open spaces provided by the NYC Housing Authority (NYCHA). We recruited survey participants using a combination of a convenience sample and snowball approach. We advertised the survey on social media (Twitter and Instagram) and distributed a link to the survey over email to listservs and networks, including those of our partner organizations (The New York State Health Foundation and The Nature Conservancy of New York).

Questions analyzed in this study are shown in bold below.

Perception and Use of Urban Parks and Open Space in New York City During COVID-19 Social Distancing

Thank you for your interest!

The Urban Systems Lab and partners at the New York State Health Foundation, Building Healthy Communities NYC, and The Nature Conservancy are carrying out a study on the importance of urban parks, open space, and other green spaces (indoor plants, balconies, terraces, green roofs, private gardens, etc.) in New York City during the Covid-19 crisis. The main goal of this study is to understand how people are using and perceiving urban parks and open space during the pandemic and how this may affect their mental and physical wellbeing. Even if you are not interested in urban parks and open space, if you live in New York City, we want to hear from you!

The results of this study will potentially inform NYC policy, design, and management of urban parks and open space to better meet communities' needs.

Important: Please fill out the survey only once. It is expected to take about 10 to 15 minutes to complete. You may skip questions and may exit the survey at any time. Only people 18 and over should respond to this questionnaire. Study results are solely for research purposes and no information that can personally identify you will be collected. We will be collecting survey responses until May 31, 2020.

Contact: Dr. Timon McPhearson is responsible for this study, and can be contacted regarding any question about the project or the methods (urbansystemslab@newschool.edu). If you have any questions about your rights as a research subject, you may reach out to the New School Office of Research Support (hrpp@newschool.edu).

Section 1 of 7 (Consent)

1. I confirm that I am willing and able to participate in this study and am over the age of 18. [a check box to tick and provide consent]

2. I confirm that I am a New York City resident and/or am currently living in New York City. [check box]

Section 2 of 7 (Social distancing context)

“Social distancing” for the purposes of this survey refers to physical distancing (~6 feet) or measures taken to reduce the number of times people come into close contact with each other to prevent the spread of COVID-19.

3. Are you currently practicing social distancing? [option to select one response]

- Yes
- No

2a. If Yes... -> then participant goes to Question 3.

2a. If No... -> Have you participated in social distancing over the past few months?

- Yes
- No

If No... then participant goes to Question. 4. If Yes, Question 3.

4. What is the total length of time that you have practiced social distancing? [option to select one response]

- < 1 week
- 1-2 weeks
- 2-4 weeks
- 4-6 weeks
- > 6 weeks

5. In the last week, how many times have you left your home? [option to select one response]

- 0 times
- 1 time
- 2 times
- 3-4 times
- About once per day
- Multiple times per day

6. On a scale from 1 to 5, how safe do you feel it is to go outside in your neighborhood?

- 1 (Not safe at all)

- 2
- 3
- 4
- 5 (Very safe)

7. In general, do you feel able to maintain social distancing (at least 6 feet away from others) when you go outside in your neighborhood?

- Yes
- No
- Not sure

8. Currently, which outdoor locations do you feel you have safe and easy access to? (Check all that apply)

- Public park
- Community garden
- Public plaza
- NYCHA outdoor space
- Private yard or garden (belonging to your household)
- Private patio, porch, terrace, balcony (belonging to your household)
- Shared yard, courtyard, garden, rooftop
- Sidewalk
- Street opened for social distancing
- Bike path
- Natural area
- Beach
- Other [a space to type an answer]
- None

Section 3 of 7 (Nature-related activities)

The following questions refer to parks and open space, which include any public spaces or NYCHA outdoor spaces with natural or managed vegetation, including parks, greenways, community gardens, and accessible wetlands, forests, and beaches.

9. Since the start of the Covid-19 crisis, how has your participation in the following activities changed compared to what you did before? (Select one answer for each activity)

(continued on next page)

(continued)

	I don't participate in this activity	Started during Covid-19 crisis	Increased during Covid-19 crisis	No change	Decreased during Covid-19 crisis	Stopped during Covid-19 crisis
Visiting parks or open space						
Using NYCHA open space						
Going on walks						
Outdoor recreation (hiking, swimming, boating, biking)						
Outdoor exercise (e.g. running)						
Walking a dog						
Gardening						
Birdwatching / observing wildlife						
Caring for indoor plants						
Observing nature through a window						
Fishing						
Other activity [space to write answer]						

10. Currently, how would you typically get to the park or open space that you visit most often?

- Car or motorcycle (including taxi or rideshare)
- Bus
- Train
- Bicycle
- Walking
- Other [space to write in answer]

11. Currently, how long does it take you to travel to the park or open space that you visit most often?

- <5 minutes
- 5–10 minutes
- 10–20 minutes
- 20–30 minutes
- 30–45 minutes
- 45–60 minutes
- >1 hour
- Unsure

12. In the last week, how many times did you visit a park or open space?

- 0 times
- 1 time
- 2 times
- 3-4 times
- About once per day
- Multiple times per day

13. On average, how much time did you spend in a park or open space during recent visits?

- < 30 minutes
- 30–60 minutes
- 1–2 hours
- 2–4 hours > 4 hours

14. When was the last time you visited a park or open space?

- 1 week ago
- 2 weeks ago
- 3 weeks ago
- 4 weeks ago
- > 4 weeks ago

15. The last time you visited a park or open space, how did it affect your mood?

- Greatly improved
- Somewhat improved
- No effect
- Made somewhat worse
- Made much worse
- Not sure

16. The last time you visited a park or open space, how did it affect your stress level?

- Greatly improved
- Somewhat improved
- No effect
- Made somewhat worse
- Made much worse
- Not sure

17. The last time you visited a park or open space, did you socialize with people in the following groups?

- Family members
- Friends
- Neighbors
- Strangers
- Friends
- Not applicable

18. In general, which of the following do you think are important for a park or open space experience? (Check all that apply)

- Landscaping / maintained gardens, flowers, or lawn
- Socializing, spending time with others
- Place for children to play
- Dog-friendly
- Places to sit
- Places to walk / trails
- Places to exercise, play sports
- Places to BBQ, cook food
- Educational opportunities (e.g. informational signage, guided trails)
- Opportunities to view wildlife
- Trees and shade
- Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)
- Other: [space to write in answer]

- None of the above

19. Does the park or open space that you visit most often provide the following benefits? (Check all that apply)

- Landscaping / maintained gardens, flowers, or lawn
- Socializing, spending time with others
- Place for children to play
- Dog-friendly
- Places to sit
- Places to walk / trails
- Places to exercise, play sports
- Places to BBQ, cook food
- Educational opportunities (e.g. informational signage, guided trails)
- Opportunities to view wildlife
- Trees and shade
- Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)
- Other: [space to write in answer]
- None of the above

20. Currently, what concerns, if any, do you have with visiting parks or open space? (Check all that apply)

- I do not have easy access
- Too crowded
- Does not meet my needs
- Not being maintained
- People are not practicing social distancing
- Not child-friendly
- Not open during the times I would like to go
- Not enough lighting
- Use of chemicals to control weeds
- Not enough park staff
- Too much police presence
- It does not feel safe
- Other [space to write in answer]

21. Do you have additional safety concerns beyond those you selected in the previous question? [space to write in answer]

22. What factors limit your access to parks or open space?

Section 4 of 7 (Mental health)

23. In the last few weeks, have you felt unhappy or depressed more or less than usual?

- Much less than usual
- Somewhat less than usual
- The same as usual
- Somewhat more than usual
- Much more than usual

24. In the last few weeks, have you lost sleep over worry more or less than usual?

- Much less than usual
- Somewhat less than usual
- The same as usual
- Somewhat more than usual
- Much more than usual

25. In the last few weeks, have you been more or less able to concentrate than usual?

- Much less than usual
- Somewhat less than usual
- The same as usual
- Somewhat more than usual
- Much more than usual

26. In the last few weeks, have you been more or less able to enjoy everyday activities than usual?

- Much less than usual
- Somewhat less than usual

- The same as usual
- Somewhat more than usual
- Much more than usual

Section 5 of 7 (Importance of greenspace)

27. On a scale of 1 to 5: Before the Covid-19 crisis, how important did you think parks and open space were for your mental health? [option to select one response]

- 1 (Not important at all)
- 2
- 3
- 4
- 5 (Very important)

28. On a scale of 1 to 5: Before the Covid-19 crisis, how important did you think parks and open space were for your physical health? [option to select one response]

- 1 (Not important at all)
- 2
- 3
- 4
- 5 (Very important)

29. On a scale of 1 to 5: Currently, how important do you think parks and open space are for your mental health? [option to select one response]

- 1 (Not important at all)
- 2
- 3
- 4
- 5 (Very important)

30. On a scale of 1 to 5: Currently, how important do you think parks and open space are for your physical health? [option to select one response]

- 1 (Not important at all)
- 2
- 3
- 4
- 5 (Very important)

31. Is there a particular park or open space experience that has affected you during the Covid-19 crisis, either positively or negatively? If so, please describe here.

Section 6 of 7 (Impacts of covid-19)

32. Where are you currently living? [option to select one response]

- In my primary home
- In my secondary home or vacation home
- In a relative's or friend's home
- Other [space to type an answer]

33. Which best describes your current housing: [option to select one response]

- Group home
- Senior living home
- Single family home, unattached to another building
- Single family home, attached to another building
- Two-family home / duplex
- Small apartment building (less than 7 stories)
- High rise condo or apartment building (More than 7 stories)
- Other [space to write in answer]

34. Do you live in public housing? [check box]

35. How many people in the following age groups currently reside in your household, including yourself? [option to select one response for each category] Children (less than 18 years old)

- 1
- 2

- 3
- 4
- 5
- 6
- 7
- 8 or more

Adults (18-59 years old)

Older adults (more than 59 years old)

36. Do you consider yourself or anyone in your household to be at risk of severe health impacts from Covid-19? (Check all that apply)

- Yes, I am
- Yes, someone else in my household is
- No

37. How has your net household income shifted during the Covid-19 crisis? [option to select one response]

- It has been extremely reduced
- It has been moderately reduced
- It has stayed constant
- It has increased
- Not applicable

Section 7 of 7 (Demographics)

38. In what ZIP code are you currently located? [a space to enter zip code]

39. What borough and neighborhood do you live in?

40. What is your age? [option to select one response]

- 18 - 24
- 25 - 39
- 40 - 64
- 65 - 79
- > 79 years old

41. What is your gender? [space to write response]

- Male
- Female
- Nonbinary
- Other [space to write in answer]

42. Do you identify as Hispanic, Latino, or of Spanish origin? [option to select one response]

- Yes
- No

43. What race do you identify as? (Check all that apply)

- American Indian or Alaska Native
- Asian
- Black or African American
- Native Hawaiian or Other Pacific Islander
- White
- Other [space to write in answer]

44. What is the highest degree or level of education you have completed? (If you're currently enrolled in school, please indicate the highest degree you have received.)

- Less than a high school diploma
- High school degree or equivalent (e.g. GED)
- Some college, no degree
- Associate degree (e.g. AA, AS)
- Bachelor's degree (e.g. BA, BS)
- Master's degree (e.g. MA, MS, MEd)
- Professional degree (e.g. MD, DDS, DVM)
- Doctorate (e.g. PhD, EdD)

45. What was your annual household income level before the Covid-19 crisis? [option to select one response]

- Less than \$20,000
- \$20,000 to \$34,999
- \$35,000 to \$49,999
- \$50,000 to \$74,999
- \$75,000 to \$99,999
- \$100,000 to \$149,999
- \$150,000 to \$200,000
- \$200,000 or more
- Prefer not to answer

46. Is there anything you would like to add to your responses? (Optional)

Appendix B. Information on survey question variable coding for data analysis.

Table 1. Variables used in data analysis

Question	Variable type	Use in models
Concerns about UGS	Multiple binary responses (yes/no)	Response; Predictors for UGS visits models (binary variables representing selection of individual concerns: I do not have easy access; People are not practicing social distancing; Too crowded; It does not feel safe)
Important features of UGS	Multiple binary responses (yes/no)	Response
Features provided by UGS	Multiple binary responses (yes/no); Analyzed as a proportion of "Important features" also selected as "Provided features"	Response; Predictor for UGS visits models (proportion of selected "Important features" also selected as "Provided features")
Importance of UGS for mental health (current)	Ordered factor; Converted to numeric (1-5) for calculation of index of affinity to UGS	Response; Used in calculation of predictor for UGS visits models (index of affinity to UGS, mean of all importance for health responses)
Importance of UGS for physical health (current)	Ordered factor; Converted to numeric (1-5) for calculation of index of affinity to UGS	Response; Used in calculation of predictor for UGS visits models (index of affinity to UGS, mean of all importance for health responses)
Importance of UGS for mental health (pre-Covid-19)	Ordered factor; Converted to numeric (1-5) for calculation of index of affinity to UGS	Response; Used in calculation of predictor for UGS visits models (index of affinity to UGS, mean of all importance for health responses)
Importance of UGS for physical health (pre-Covid-19)	Ordered factor; Converted to numeric (1-5) for calculation of index of affinity to UGS	Response; Used in calculation of predictor for UGS visits models (index of affinity to UGS, mean of all importance for health responses)
Frequency of UGS visits	Ordered factor	Response
Change in frequency of UGS visits	Ordered factor	Response
Race	Multiple binary responses (yes/no)	Predictor
Ethnicity	Binary response (yes/no)	Predictor
Gender	Factor	Predictor
Borough	Factor	Predictor

Appendix C. Survey respondent demographics and comparison to census data.

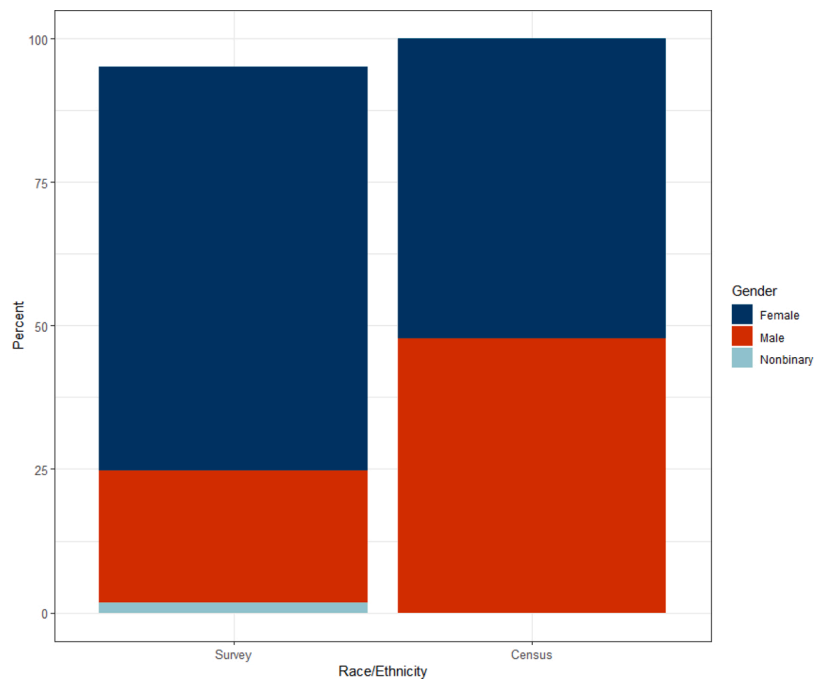


Figure 1. Approximately 70% of survey respondents were women, compared to about 50% of New York City residents. Census data for comparison came from the U.S. Census Bureau American Community Survey estimates from 2015-2019 (U.S. Census Bureau, 2020).

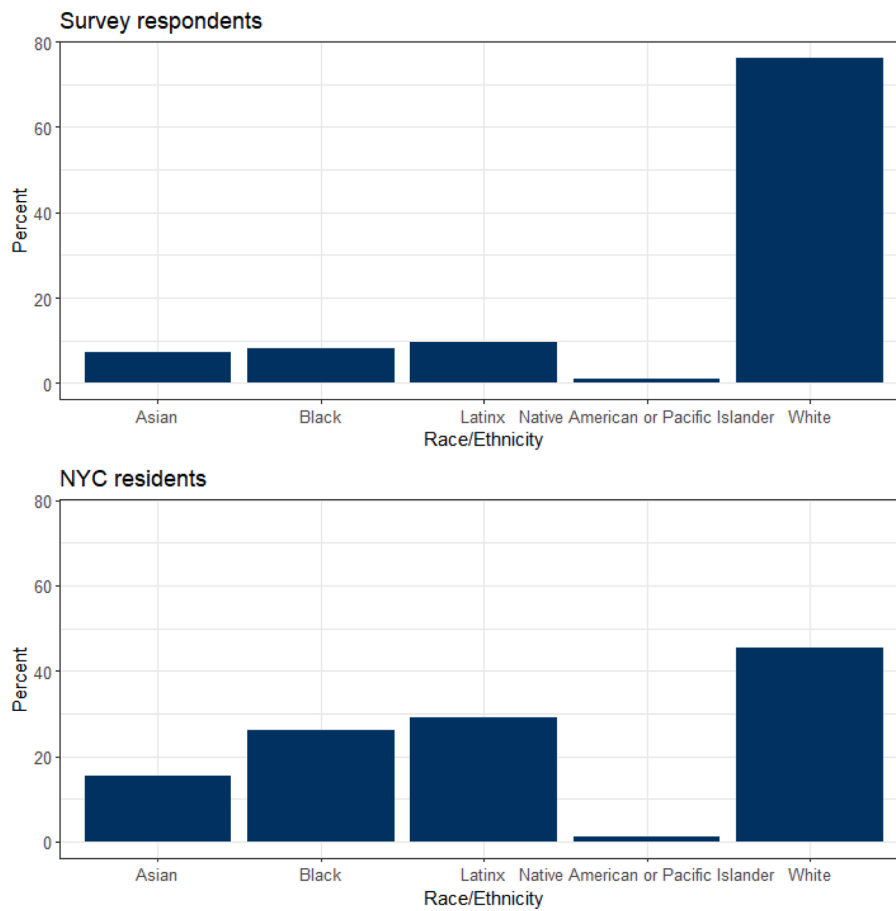


Figure 2. Survey respondents were mostly white, and underrepresented Asian, Black, and Latinx residents of New York City (NYC). Data on the

demographics of NYC residents came from the U.S. Census Bureau American Community Survey estimates from 2015-2019 (U.S. Census Bureau, 2020).

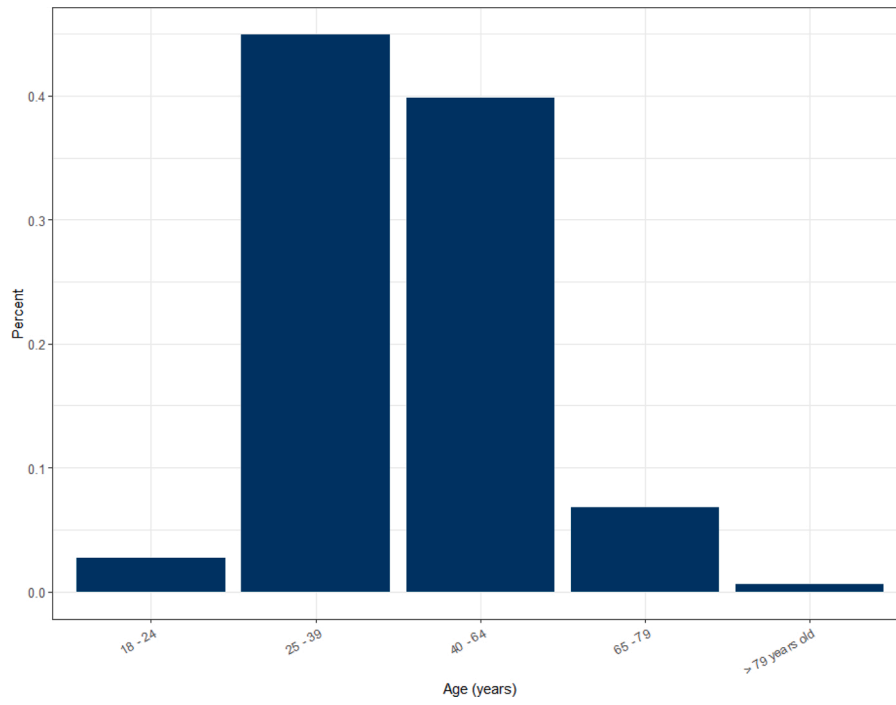


Figure 3. Age distribution of survey respondents.

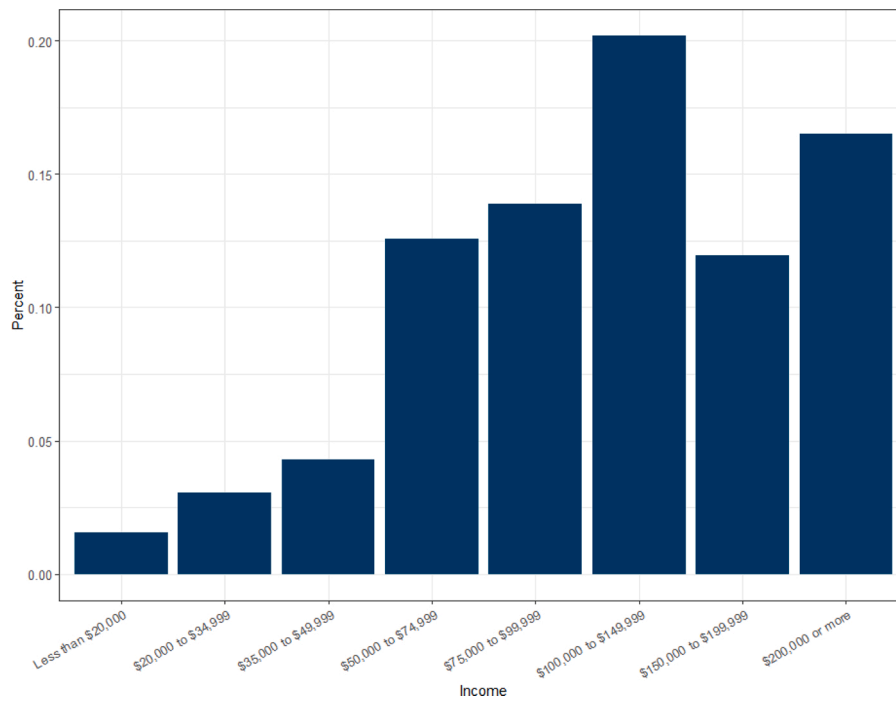


Figure 4. Income distribution of survey respondents.

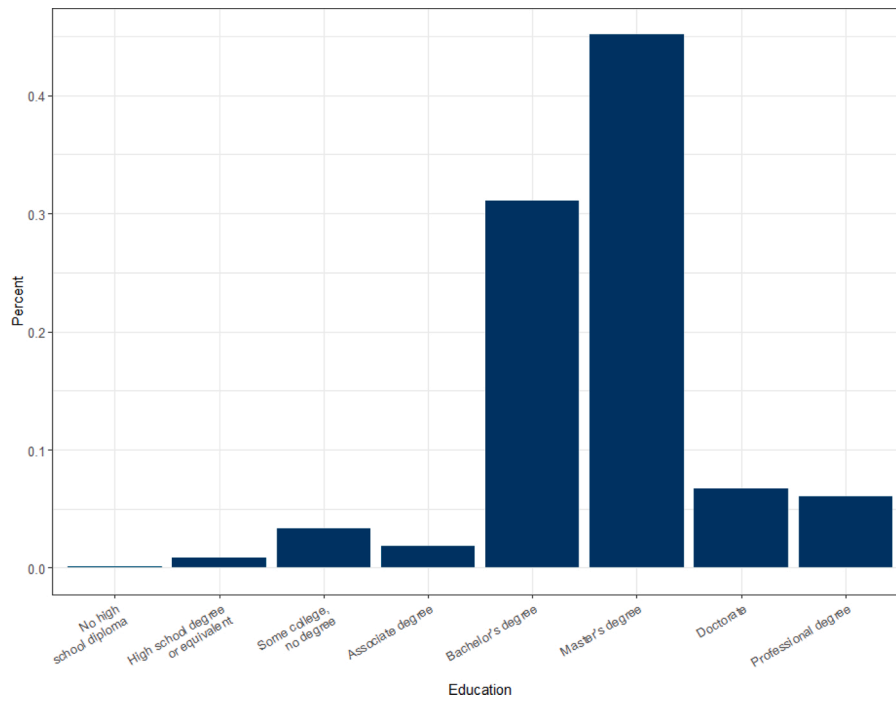


Figure 5. Distribution of educational attainment among survey respondents.

Appendix D. Model results.

Table 1. Results of model predicting responses to the question “Currently, what concerns, if any, do you have with visiting parks or open space?”

(continued on next page)

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Response	Predictor	Comparison	LogRatio	P-value
People are not practicing social distancing		(Intercept)	1.73	0.048 *
People are not practicing social distancing	Gender	Male : Female	0.864	0.334
People are not practicing social distancing	Gender	Nonbinary : Female	1.494	0.455
People are not practicing social distancing	Race/ethnicity	Asian : not Asian	1.646	0.128
People are not practicing social distancing	Race/ethnicity	Black : not Black	0.964	0.903
People are not practicing social distancing	Race/ethnicity	Latinx : not Latinx	1.212	0.422
People are not practicing social distancing	Race/ethnicity	White : not White	0.98	0.939
People are not practicing social distancing	Borough	Bronx : Manhattan	0.711	0.26
People are not practicing social distancing	Borough	Queens : Manhattan	0.986	0.947
People are not practicing social distancing	Borough	Brooklyn : Manhattan	1.044	0.77
People are not practicing social distancing	Borough	Staten Island : Manhattan	0.471	0.226
Too crowded		(Intercept)	1.61	0.085
Too crowded	Gender	Male : Female	0.809	0.162
Too crowded	Gender	Nonbinary : Female	1.664	0.354
Too crowded	Race/ethnicity	Asian : not Asian	1.273	0.449
Too crowded	Race/ethnicity	Black : not Black	0.664	0.178
Too crowded	Race/ethnicity	Latinx : not Latinx	1.233	0.382
Too crowded	Race/ethnicity	White : not White	0.925	0.762
Too crowded	Borough	Bronx : Manhattan	0.428	0.006 **
Too crowded	Borough	Queens : Manhattan	0.951	0.81
Too crowded	Borough	Brooklyn : Manhattan	1.458	0.011 *
Too crowded	Borough	Staten Island : Manhattan	0.247	0.043 *
It does not feel safe		(Intercept)	0.238	0 ***
It does not feel safe	Gender	Male : Female	1.021	0.923
It does not feel safe	Gender	Nonbinary : Female	0.343	0.306

(continued on next page)

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It does not feel safe	Race/ethnicity	Asian : not Asian	1.631	0.193
It does not feel safe	Race/ethnicity	Black : not Black	0.988	0.975
It does not feel safe	Race/ethnicity	Latinx : not Latinx	1.448	0.203
It does not feel safe	Race/ethnicity	White : not White	0.669	0.213
It does not feel safe	Borough	Bronx : Manhattan	1.08	0.845
It does not feel safe	Borough	Queens : Manhattan	0.867	0.621
It does not feel safe	Borough	Brooklyn : Manhattan	0.74	0.144
		Staten Island :		
It does not feel safe	Borough	Manhattan	0	0.975
Not being maintained / kept clean		(Intercept)	0.151	0 ***
Not being maintained / kept clean	Gender	Male : Female	0.891	0.61
Not being maintained / kept clean	Gender	Nonbinary : Female	0.74	0.694
Not being maintained / kept clean	Race/ethnicity	Asian : not Asian	0.891	0.793
Not being maintained / kept clean	Race/ethnicity	Black : not Black	1.5	0.297
Not being maintained / kept clean	Race/ethnicity	Latinx : not Latinx	1.19	0.578
Not being maintained / kept clean	Race/ethnicity	White : not White	0.748	0.399
Not being maintained / kept clean	Borough	Bronx : Manhattan	1.623	0.221
Not being maintained / kept clean	Borough	Queens : Manhattan	1.096	0.775
Not being maintained / kept clean	Borough	Brooklyn : Manhattan	1.267	0.285
Not being maintained / kept clean	Borough	Staten Island :		
		Manhattan	2.108	0.355
Too much police presence		(Intercept)	0.118	0 ***
Too much police presence	Gender	Male : Female	1.013	0.953
Too much police presence	Gender	Nonbinary : Female	7.097	0 ***
Too much police presence	Race/ethnicity	Asian : not Asian	0.998	0.997
Too much police presence	Race/ethnicity	Black : not Black	2.049	0.075
Too much police presence	Race/ethnicity	Latinx : not Latinx	1.071	0.837
Too much police presence	Race/ethnicity	White : not White	1.015	0.968
Too much police presence	Borough	Bronx : Manhattan	0.509	0.199
Too much police presence	Borough	Queens : Manhattan	0.599	0.169
Too much police presence	Borough	Brooklyn : Manhattan	1.472	0.066
		Staten Island :		
Too much police presence	Borough	Manhattan	0	0.974
Not enough park staff		(Intercept)	0.106	0 ***
Not enough park staff	Gender	Male : Female	1.262	0.296
Not enough park staff	Gender	Nonbinary : Female	0.988	0.988
Not enough park staff	Race/ethnicity	Asian : not Asian	0.832	0.705

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Not enough park staff	Race/ethnicity	Black : not Black	0.859	0.724	
Not enough park staff	Race/ethnicity	Latinx : not Latinx	2.066	0.014	*
Not enough park staff	Race/ethnicity	White : not White	1.105	0.786	
Not enough park staff	Borough	Bronx : Manhattan	2.394	0.02	*
Not enough park staff	Borough	Queens : Manhattan	0.939	0.846	
Not enough park staff	Borough	Brooklyn : Manhattan	0.848	0.474	
		Staten Island :			
Not enough park staff	Borough	Manhattan	1.799	0.466	
I do not have easy access		(Intercept)	0.048	0	***
I do not have easy access	Gender	Male : Female	0.924	0.769	
I do not have easy access	Gender	Nonbinary : Female	1.238	0.787	
I do not have easy access	Race/ethnicity	Asian : not Asian	1.42	0.485	
I do not have easy access	Race/ethnicity	Black : not Black	2.345	0.08	
I do not have easy access	Race/ethnicity	Latinx : not Latinx	0.55	0.19	
I do not have easy access	Race/ethnicity	White : not White	0.847	0.702	
I do not have easy access	Borough	Bronx : Manhattan	1.316	0.653	
I do not have easy access	Borough	Queens : Manhattan	4.904	0	***
I do not have easy access	Borough	Brooklyn : Manhattan	2.44	0.004	**
		Staten Island :			
I do not have easy access	Borough	Manhattan	0	0.985	
Use of chemicals to control weeds		(Intercept)	0.103	0	***
Use of chemicals to control weeds	Gender	Male : Female	0.714	0.352	
Use of chemicals to control weeds	Gender	Nonbinary : Female	1.896	0.417	
Use of chemicals to control weeds	Race/ethnicity	Asian : not Asian	1.342	0.594	
Use of chemicals to control weeds	Race/ethnicity	Black : not Black	0.591	0.425	
Use of chemicals to control weeds	Race/ethnicity	Latinx : not Latinx	1.025	0.962	
Use of chemicals to control weeds	Race/ethnicity	White : not White	0.566	0.245	
Use of chemicals to control weeds	Borough	Bronx : Manhattan	0.61	0.533	
Use of chemicals to control weeds	Borough	Queens : Manhattan	1.106	0.81	
Use of chemicals to control weeds	Borough	Brooklyn : Manhattan	0.747	0.365	
		Staten Island :			
Use of chemicals to control weeds	Borough	Manhattan	3.739	0.112	
Not enough lighting		(Intercept)	0.095	0	***
Not enough lighting	Gender	Male : Female	0.949	0.889	
Not enough lighting	Gender	Nonbinary : Female	4.206	0.037	*
Not enough lighting	Race/ethnicity	Asian : not Asian	0.377	0.249	
Not enough lighting	Race/ethnicity	Black : not Black	1.392	0.566	

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Not enough lighting	Race/ethnicity	Latinx : not Latinx	0.579	0.351	
Not enough lighting	Race/ethnicity	White : not White	0.526	0.227	
Not enough lighting	Borough	Bronx : Manhattan	1.657	0.353	
Not enough lighting	Borough	Queens : Manhattan	0.729	0.544	
Not enough lighting	Borough	Brooklyn : Manhattan	0.539	0.092	
Not enough lighting	Borough	Staten Island : Manhattan	1.722	0.624	
Not child-friendly		(Intercept)	0.004	0	***
Not child-friendly	Gender	Male : Female	1.478	0.348	
Not child-friendly	Gender	Nonbinary : Female	0	0.992	
Not child-friendly	Race/ethnicity	Asian : not Asian	1.122	0.917	
Not child-friendly	Race/ethnicity	Black : not Black	0.578	0.64	
Not child-friendly	Race/ethnicity	Latinx : not Latinx	4.033	0.006	**
Not child-friendly	Race/ethnicity	White : not White	7.508	0.078	
Not child-friendly	Borough	Bronx : Manhattan	1.223	0.807	
Not child-friendly	Borough	Queens : Manhattan	0.576	0.406	
Not child-friendly	Borough	Brooklyn : Manhattan	0.653	0.319	
Not child-friendly	Borough	Staten Island : Manhattan	0	0.994	
Not open during the times I would like to go		(Intercept)	0.03	0	***
Not open during the times I would like to go	Gender	Male : Female	1.029	0.956	
Not open during the times I would like to go	Gender	Nonbinary : Female	3.156	0.287	
Not open during the times I would like to go	Race/ethnicity	Asian : not Asian	1.286	0.775	
Not open during the times I would like to go	Race/ethnicity	Black : not Black	0.351	0.381	
Not open during the times I would like to go	Race/ethnicity	Latinx : not Latinx	1.019	0.981	
Not open during the times I would like to go	Race/ethnicity	White : not White	0.627	0.545	
Not open during the times I would like to go	Borough	Bronx : Manhattan	1.02	0.986	
Not open during the times I would like to go	Borough	Queens : Manhattan	1.432	0.575	
Not open during the times I would like to go	Borough	Brooklyn : Manhattan	0.924	0.877	
Not open during the times I would like to go	Borough	Staten Island : Manhattan	0	0.991	
Does not meet my needs		(Intercept)	0.008	0	***
Does not meet my needs	Gender	Male : Female	3.594	0.01	*
Does not meet my needs	Gender	Nonbinary : Female	4.69	0.166	
Does not meet my needs	Race/ethnicity	Asian : not Asian	1.39	0.757	
Does not meet my needs	Race/ethnicity	Black : not Black	1.328	0.8	
Does not meet my needs	Race/ethnicity	Latinx : not Latinx	0.556	0.581	
Does not meet my needs	Race/ethnicity	White : not White	0.868	0.883	
Does not meet my needs	Borough	Bronx : Manhattan	1.426	0.765	
Does not meet my needs	Borough	Queens : Manhattan	2.038	0.36	
Does not meet my needs	Borough	Brooklyn : Manhattan	1.685	0.391	
Does not meet my needs	Borough	Staten Island : Manhattan	7.63	0.09	

Table 2. Results of model predicting responses to the question “In general, which of the following do you think are important for a park or open space experience?”

Response	Predictor	Comparison	LogRatio	P-value	
Places to walk / trails		(Intercept)	17.956	0	***
Places to walk / trails	Gender	Male : Female	0.529	0.008	**
Places to walk / trails	Gender	Nonbinary : Female	1.446	0.724	
Places to walk / trails	Race/ethnicity	Asian : not Asian	0.631	0.325	
Places to walk / trails	Race/ethnicity	Black : not Black	0.751	0.551	
Places to walk / trails	Race/ethnicity	Latinx : not Latinx	0.572	0.101	
Places to walk / trails	Race/ethnicity	White : not White	1.281	0.542	
Places to walk / trails	Borough	Bronx : Manhattan	0.916	0.874	
Places to walk / trails	Borough	Queens : Manhattan	0.465	0.028	*
Places to walk / trails	Borough	Brooklyn : Manhattan	0.622	0.088	
		Staten Island :			
Places to walk / trails	Borough	Manhattan	0.288	0.125	
Trees, shade		(Intercept)	7.496	0	***
Trees, shade	Gender	Male : Female	0.714	0.16	
Trees, shade	Gender	Nonbinary : Female	0.613	0.469	
Trees, shade	Race/ethnicity	Asian : not Asian	1.195	0.705	
Trees, shade	Race/ethnicity	Black : not Black	0.648	0.302	
Trees, shade	Race/ethnicity	Latinx : not Latinx	0.762	0.425	
Trees, shade	Race/ethnicity	White : not White	1.862	0.094	
Trees, shade	Borough	Bronx : Manhattan	1.13	0.799	
Trees, shade	Borough	Queens : Manhattan	0.798	0.501	
Trees, shade	Borough	Brooklyn : Manhattan	1.017	0.946	
		Staten Island :			
Trees, shade	Borough	Manhattan	0.093	0	***
Places to sit		(Intercept)	4.799	0	***
Places to sit	Gender	Male : Female	0.763	0.108	
Places to sit	Gender	Nonbinary : Female	1.1	0.871	
Places to sit	Race/ethnicity	Asian : not Asian	0.997	0.994	
Places to sit	Race/ethnicity	Black : not Black	0.793	0.512	
Places to sit	Race/ethnicity	Latinx : not Latinx	1.89	0.037	*
Places to sit	Race/ethnicity	White : not White	0.873	0.657	
Places to sit	Borough	Bronx : Manhattan	0.465	0.021	*
Places to sit	Borough	Queens : Manhattan	0.811	0.393	
Places to sit	Borough	Brooklyn : Manhattan	0.762	0.113	
		Staten Island :			
Places to sit	Borough	Manhattan	0.157	0.002	**
Landscaping / maintained gardens, flowers, or lawn		(Intercept)	4.104	0	***
Landscaping / maintained gardens, flowers, or lawn	Gender	Male : Female	0.795	0.129	

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Landscaping / maintained gardens, flowers, or lawn	Gender	Nonbinary : Female	0.497	0.151	
Landscaping / maintained gardens, flowers, or lawn	Race/ethnicity	Asian : not Asian	0.61	0.113	
Landscaping / maintained gardens, flowers, or lawn	Race/ethnicity	Black : not Black	0.763	0.389	
Landscaping / maintained gardens, flowers, or lawn	Race/ethnicity	Latinx : not Latinx	1.141	0.583	
Landscaping / maintained gardens, flowers, or lawn	Race/ethnicity	White : not White	0.633	0.085	
Landscaping / maintained gardens, flowers, or lawn	Borough	Bronx : Manhattan	0.577	0.076	
Landscaping / maintained gardens, flowers, or lawn	Borough	Queens : Manhattan	0.631	0.03	*
Landscaping / maintained gardens, flowers, or lawn	Borough	Brooklyn : Manhattan	0.643	0.003	**
Landscaping / maintained gardens, flowers, or lawn	Borough	Staten Island : Manhattan	0.715	0.568	
Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)		(Intercept)	2.176	0.004	**
Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)	Gender	Male : Female	0.679	0.009	**
Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)	Gender	Nonbinary : Female	0.465	0.114	
Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)	Race/ethnicity	Asian : not Asian	0.837	0.555	
Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)	Race/ethnicity	Black : not Black	1.043	0.89	
Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)	Race/ethnicity	Latinx : not Latinx	0.956	0.846	
Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)	Race/ethnicity	White : not White	0.855	0.534	
Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)	Borough	Bronx : Manhattan	1.027	0.931	

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Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)	Borough	Queens : Manhattan	0.809	0.303
Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)	Borough	Brooklyn : Manhattan	0.801	0.123
Water feature (e.g. river, lake, pond, ocean, fountain, sprinkler, pool)	Borough	Staten Island : Manhattan	1.436	0.558
Places to exercise, play sports		(Intercept)	0.801	0.396
Places to exercise, play sports	Gender	Male : Female	1.303	0.072
Places to exercise, play sports	Gender	Nonbinary : Female	0.774	0.597
Places to exercise, play sports	Race/ethnicity	Asian : not Asian	0.936	0.824
Places to exercise, play sports	Race/ethnicity	Black : not Black	1.222	0.493
Places to exercise, play sports	Race/ethnicity	Latinx : not Latinx	0.947	0.808
Places to exercise, play sports	Race/ethnicity	White : not White	1.115	0.656
Places to exercise, play sports	Borough	Bronx : Manhattan	1.217	0.51
Places to exercise, play sports	Borough	Queens : Manhattan	0.857	0.445
Places to exercise, play sports	Borough	Brooklyn : Manhattan	1.339	0.038 *
Places to exercise, play sports	Borough	Staten Island : Manhattan	0.925	0.891
Place for children to play		(Intercept)	0.905	0.703
Place for children to play	Gender	Male : Female	0.738	0.038 *
Place for children to play	Gender	Nonbinary : Female	0.757	0.564
Place for children to play	Race/ethnicity	Asian : not Asian	0.87	0.639
Place for children to play	Race/ethnicity	Black : not Black	0.901	0.722
Place for children to play	Race/ethnicity	Latinx : not Latinx	1.242	0.336
Place for children to play	Race/ethnicity	White : not White	1.192	0.472
Place for children to play	Borough	Bronx : Manhattan	0.89	0.697
Place for children to play	Borough	Queens : Manhattan	1.384	0.111
Place for children to play	Borough	Brooklyn : Manhattan	1.076	0.603
Place for children to play	Borough	Staten Island : Manhattan	0.879	0.821

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Socializing, spending time with others		(Intercept)	0.879	0.624
Socializing, spending time with others	Gender	Male : Female	0.914	0.536
Socializing, spending time with others	Gender	Nonbinary : Female	2.117	0.143
Socializing, spending time with others	Race/ethnicity	Asian : not Asian	0.996	0.991
Socializing, spending time with others	Race/ethnicity	Black : not Black	0.894	0.703
Socializing, spending time with others	Race/ethnicity	Latinx : not Latinx	0.858	0.497
Socializing, spending time with others	Race/ethnicity	White : not White	1.178	0.505
Socializing, spending time with others	Borough	Bronx : Manhattan	0.685	0.214
Socializing, spending time with others	Borough	Queens : Manhattan	0.957	0.826
Socializing, spending time with others	Borough	Brooklyn : Manhattan	1.162	0.285
Socializing, spending time with others	Borough	Staten Island : Manhattan	0.411	0.149
Educational opportunities (e.g. informational signage, guided trails)		(Intercept)	0.732	0.246
Educational opportunities (e.g. informational signage, guided trails)	Gender	Male : Female	0.706	0.03 *
Educational opportunities (e.g. informational signage, guided trails)	Gender	Nonbinary : Female	1.734	0.258
Educational opportunities (e.g. informational signage, guided trails)	Race/ethnicity	Asian : not Asian	1.251	0.457
Educational opportunities (e.g. informational signage, guided trails)	Race/ethnicity	Black : not Black	0.704	0.252
Educational opportunities (e.g. informational signage, guided trails)	Race/ethnicity	Latinx : not Latinx	1.44	0.112
Educational opportunities (e.g. informational signage, guided trails)	Race/ethnicity	White : not White	0.678	0.121

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Educational opportunities (e.g. informational signage, guided trails)	Borough	Bronx : Manhattan	1.849	0.043	*
Educational opportunities (e.g. informational signage, guided trails)	Borough	Queens : Manhattan	0.943	0.784	
Educational opportunities (e.g. informational signage, guided trails)	Borough	Brooklyn : Manhattan	0.991	0.953	
Educational opportunities (e.g. informational signage, guided trails)	Borough	Staten Island : Manhattan	0.905	0.872	
Opportunities to view wildlife		(Intercept)	0.331	0.001	**
Opportunities to view wildlife	Gender	Male : Female	0.946	0.757	
Opportunities to view wildlife	Gender	Nonbinary : Female	1.511	0.453	
Opportunities to view wildlife	Race/ethnicity	Asian : not Asian	0.707	0.371	
Opportunities to view wildlife	Race/ethnicity	Black : not Black	0.243	0.003	**
Opportunities to view wildlife	Race/ethnicity	Latinx : not Latinx	0.706	0.259	
Opportunities to view wildlife	Race/ethnicity	White : not White	1.045	0.891	
Opportunities to view wildlife	Borough	Bronx : Manhattan	1.624	0.177	
Opportunities to view wildlife	Borough	Queens : Manhattan	0.899	0.667	
Opportunities to view wildlife	Borough	Brooklyn : Manhattan	0.825	0.261	
Opportunities to view wildlife	Borough	Staten Island : Manhattan	1.817	0.31	
Places to BBQ, cook food		(Intercept)	0.185	0	***
Places to BBQ, cook food	Gender	Male : Female	1.243	0.23	
Places to BBQ, cook food	Gender	Nonbinary : Female	4.241	0.003	**
Places to BBQ, cook food	Race/ethnicity	Asian : not Asian	0.77	0.494	
Places to BBQ, cook food	Race/ethnicity	Black : not Black	1.548	0.192	
Places to BBQ, cook food	Race/ethnicity	Latinx : not Latinx	1.823	0.017	*
Places to BBQ, cook food	Race/ethnicity	White : not White	0.906	0.736	
Places to BBQ, cook food	Borough	Bronx : Manhattan	1.268	0.5	
Places to BBQ, cook food	Borough	Queens : Manhattan	0.989	0.968	

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Places to BBQ, cook food	Borough	Brooklyn : Manhattan	1.411	0.059	
Places to BBQ, cook food	Borough	Staten Island : Manhattan	0.889	0.883	
Dog-friendly		(Intercept)	0.126	0	***
Dog-friendly	Gender	Male : Female	0.799	0.301	
Dog-friendly	Gender	Nonbinary : Female	2.868	0.042	*
Dog-friendly	Race/ethnicity	Asian : not Asian	1.515	0.3	
Dog-friendly	Race/ethnicity	Black : not Black	0.991	0.983	
Dog-friendly	Race/ethnicity	Latinx : not Latinx	1.079	0.809	
Dog-friendly	Race/ethnicity	White : not White	1.424	0.308	
Dog-friendly	Borough	Bronx : Manhattan	1.846	0.101	
Dog-friendly	Borough	Queens : Manhattan	0.56	0.087	
Dog-friendly	Borough	Brooklyn : Manhattan	1.056	0.781	
Dog-friendly	Borough	Staten Island : Manhattan	0.92	0.917	
Proportion of important features provided by most visited urban green space		(Intercept)	3.523	0	***
Proportion of important features provided by most visited urban green space	Gender	Male : Female	1.151	0.482	
Proportion of important features provided by most visited urban green space	Gender	Nonbinary : Female	1.124	0.857	
Proportion of important features provided by most visited urban green space	Race/ethnicity	Asian : not Asian	1.315	0.48	
Proportion of important features provided by most visited urban green space	Race/ethnicity	Black : not Black	0.96	0.91	
Proportion of important features provided by most visited urban green space	Race/ethnicity	Latinx : not Latinx	0.962	0.891	
Proportion of important features provided by most visited urban green space	Race/ethnicity	White : not White	1.569	0.138	
Proportion of important features provided by most visited urban green space	Borough	Bronx : Manhattan	0.723	0.373	
Proportion of important features provided by most visited urban green space	Borough	Queens : Manhattan	0.604	0.043	*
Proportion of important features provided by most visited urban green space	Borough	Brooklyn : Manhattan	1.038	0.849	
Proportion of important features provided by most visited urban green space	Borough	Staten Island : Manhattan	0.778	0.735	

Table 3. Results of model predicting responses to the questions “Currently, how important do you think parks and open space are for your mental health?” and “Currently, how important do you think parks and open space are for your physical health?”

Response	Predictor	Comparison	LogRatio	Lower bound (2.5%)	Upper bound (97.5%)	
Importance of urban green spaces for mental health	Gender	Male : Female	0.509	0.38	0.684	*
Importance of urban green spaces for mental health	Gender	Nonbinary : Female	1.198	0.441	3.85	
Importance of urban green spaces for mental health	Race/ethnicity	Asian : not Asian	0.634	0.347	1.171	
Importance of urban green spaces for mental health	Race/ethnicity	Black : not Black	0.424	0.234	0.766	*
Importance of urban green spaces for mental health	Race/ethnicity	Latinx : not Latinx	1.422	0.877	2.374	
Importance of urban green spaces for mental health	Race/ethnicity	White : not White	1.17	0.697	1.942	
Importance of urban green spaces for mental health	Borough	Bronx : Manhattan	1.207	0.657	2.294	
Importance of urban green spaces for mental health	Borough	Queens : Manhattan	0.616	0.411	0.926	*
Importance of urban green spaces for mental health	Borough	Brooklyn : Manhattan	1.018	0.75	1.378	
Importance of urban green spaces for mental health	Borough	Staten Island : Manhattan	0.324	0.106	1.049	
Importance of urban green spaces for physical health	Gender	Male : Female	0.623	0.475	0.817	*
Importance of urban green spaces for physical health	Gender	Nonbinary : Female	1.029	0.42	2.694	

References

- Akpinar, A., 2016. How is quality of urban green spaces associated with physical activity and health? *Urban For. Urban Green.* 16, 76–83. <https://doi.org/10.1016/j.ufug.2016.01.011>.
- Andrasfay, T., Goldman, N., 2020. Reductions in 2020 US life expectancy due to COVID-19 and the disproportionate impact on the Black and Latino populations. *Proc. Natl. Acad. Sci.* 118 <https://doi.org/10.1073/pnas.2014746118>.
- Angel, S., Lamson-Hall, P., Salazar Tamayo, M.M., 2020. *Coronavirus and the Cities: Explaining Variations in the Onset of Infection and in the Number of Reported Cases and Deaths in US Metropolitan Areas As of 27 March 2020*. New York University. Marron Institute of Urban Management.
- Auyeung, D.N., Campbell, L.K., Johnson, M., Sonti, N.F., Svendsen, E., 2016. Reading the landscape: Citywide social assessment of New York City parks and natural areas in 2013–2014. In: *Social Assessment White Paper No. 2*, vol. 69. New York Department of Parks and Recreation, New York, NY, pp. 1–69.
- Bedimo-Rung, A.L., Mowen, A.J., Cohen, D.A., 2005. The significance of parks to physical activity and public health: a conceptual model. *Am. J. Prev. Med.* 28, 159–168. <https://doi.org/10.1016/j.amepre.2004.10.024>.
- Brindley, P., Cameron, R.W., Ersoy, E., Jorgensen, A., Maheswaran, R., 2019. Is more always better? Exploring field survey and social media indicators of quality of urban greenspace, in relation to health. *Urban For. Urban Green.* 39, 45–54. <https://doi.org/10.1016/j.ufug.2019.01.015>.
- Brooks, S.K., Webster, R.K., Smith, L.E., Woodland, L., Wessely, S., Greenberg, N., Rubin, G.J., 2020. The psychological impact of quarantine and how to reduce it: rapid review of the evidence. *Lancet* 395, 912–920. [https://doi.org/10.1016/S0140-6736\(20\)30460-8](https://doi.org/10.1016/S0140-6736(20)30460-8).
- Brunson, J.C., 2017. Ggalluvial: layered grammar for alluvial plots. *J. Open Source Softw.* 5 <https://doi.org/10.21105/joss.02017>.
- Centers for Disease Control and Prevention, 2020a. Geographic differences in COVID-19 cases, deaths, and incidence—United States, February 12–April 7, 2020. *Morbidity and Mortality Weekly Report* 69, pp. 465–471. <https://doi.org/10.15585/mmwr.mm6915e4>.
- Centers for Disease Control and Prevention, 2020b. *Excess Deaths Associated With COVID-19* [WWW Document]. URL https://www.cdc.gov/nchs/nvss/vsr/covid19/excess_deaths.htm (accessed 8.13.20).
- Choi, A., Velasquez, J., Welch, W., 2020. Queens Neighborhoods Hardest Hit by Virus Home to Many Service Workers [WWW Document]. THE CITY. URL <https://www.thecity.nyc/2020/4/2/21210380/queens-neighborhoods-hardest-hit-by-virus-home-to-many-service-workers> (accessed 8.13.20).
- Conedera, M., Del Biaggio, A., Seeland, K., Moretti, M., Home, R., 2015. Residents' preferences and use of urban and peri-urban green spaces in a Swiss mountainous region of the Southern Alps. *Urban For. Urban Green.* 14, 139–147. <https://doi.org/10.1016/j.ufug.2015.01.003>.
- Cox, D.T.C., Shanahan, D.F., Hudson, H.L., Plummer, K.E., Siriwardena, G.M., Fuller, R. A., Anderson, K., Hancock, S., Gaston, K.J., 2017. Doses of neighborhood nature: the benefits for mental health of living with nature. *BioScience* biw173. <https://doi.org/10.1093/biosci/biw173>.
- Finney, C., 2014. *Black Faces, White Spaces: Reimagining the Relationship of African Americans to the Great Outdoors*. UNC Press Books, Chapel Hill, NC.

- Fischer, L.K., Honold, J., Botzat, A., Brinkmeyer, D., Cvejić, R., Delschammar, T., Elands, B., Haase, D., Kabisch, N., Karle, S.J., Laforteza, R., Nastran, M., Nielsen, A. B., van der Jagt, A.P., Vierikko, K., Kowarik, I., 2018. Recreational ecosystem services in European cities: sociocultural and geographical contexts matter for park use. *Ecosyst. Serv.* 31, 455–467. <https://doi.org/10.1016/j.ecoser.2018.01.015>.
- Flowers, E.P., Freeman, P., Gladwell, V.F., 2016. A cross-sectional study examining predictors of visit frequency to local green space and the impact this has on physical activity levels. *BMC Public Health* 16, 420. <https://doi.org/10.1186/s12889-016-3050-9>.
- Fox, J., Weisberg, S., 2019. *An {R} Companion to Applied Regression*, third edition. Sage, Thousand Oaks CA.
- Frumkin, H., Bratman, G.N., Breslow, S.J., Cochran, B., Kahn Jr., P.H., Lawler, J.J., Levin, P.S., Tandon, P.S., Varanasi, U., Wolf, K.L., Wood, S.A., 2017. Nature Contact and Human Health: A Research Agenda. *Environ. Health Perspect.* 125, 075001 <https://doi.org/10.1289/EHP1663>.
- Gobster, P.H., 2002. Managing urban parks for a racially and ethnically diverse clientele. *Leis. Sci.* 24, 143–159. <https://doi.org/10.1080/01490400252900121>.
- Grima, N., Corcoran, W., Hill-James, C., Langton, B., Sommer, H., Fisher, B., 2020. The importance of urban natural areas and urban ecosystem services during the COVID-19 pandemic. *PLoS One* 15, e0243344. <https://doi.org/10.1371/journal.pone.0243344>.
- Hamstead, Z.A., Fisher, D., Ilieva, R.T., Wood, S.A., McPhearson, T., Kremer, P., 2018. Geolocated social media as a rapid indicator of park visitation and equitable park access. *Comput. Environ. Urban Syst.* 72, 38–50. <https://doi.org/10.1016/j.compenurbysys.2018.01.007>.
- Harnik, P., Martin, A., Treat, M., 2016. 2016 City Park Facts [WWW Document]. Trust for Public Land. URL <https://www.tpl.org/sites/default/files/2016%20City%20Park%20Facts.0.pdf> (accessed 8.13.20).
- Hartig, T., Mitchell, R., de Vries, S., Frumkin, H., 2014. Nature and health. *Annu. Rev. Public Health* 35, 207–228. <https://doi.org/10.1146/annurev-publhealth-032013-182443>.
- Hazer, M., Formica, M.K., Dieterlen, S., Morley, C.P., 2018. The relationship between self-reported exposure to greenspace and human stress in Baltimore, MD. *Landsc. Urban Plan.* 169, 47–56. <https://doi.org/10.1016/j.landurbplan.2017.08.006>.
- Honey-Rosés, J., Anguelovski, I., Chireh, V.K., Daher, C., van den Bosch, C.K., Litt, J.S., Mawani, V., McCall, M.K., Orellana, A., Oscilowicz, E., Sánchez, U., Senbel, M., Tan, X., Villagomez, E., Zapata, O., Nieuwenhuijsen, M.J., 2020. The impact of COVID-19 on public space: an early review of the emerging questions – design, perceptions and inequities. *Cities Health* 0, 1–17. <https://doi.org/10.1080/23748834.2020.1780074>.
- Jansson, M., Fors, H., Lindgren, T., Wiström, B., 2013. Perceived personal safety in relation to urban woodland vegetation—A review. *Urban For. Urban Green.* 12, 127–133. <https://doi.org/10.1016/j.ufug.2013.01.005>.
- Kaczynski, A.T., Henderson, K.A., 2007. Environmental correlates of physical activity: a review of evidence about parks and recreation. *Leis. Sci.* 29, 315–354. <https://doi.org/10.1080/01490400701394865>.
- Kleinschroth, F., Kowarik, I., 2020. COVID-19 crisis demonstrates the urgent need for urban greenspaces. *Front. Ecol. Environ.* 18, 318–319. <https://doi.org/10.1002/fee.2230>.
- Kondo, M.C., Fluehr, J.M., McKeon, T., Branas, C.C., 2018. Urban green space and its impact on human health. *Int. J. Environ. Res. Public Health* 15, 445. <https://doi.org/10.3390/ijerph15030445>.
- Kyrkjebo, N., Parris, A., Barnes, J., Azaroff, I., Balk, D., Baptista, A.I., Braneon, C., Calabrese, W., Codrington, T., Colon, J., Gandhi, F., George, M., Goffman, P., Gundlach, J., Carr, R.H., Holt, N., Horton, R., Jahangir, A., Ken-Opurum, B., Knowlton, K., Leichenko, R., Maher, N., Marcotullio, P., Matte, T., McComas, K., McKay, S.K., McPhearson, T., Moss, R., Nordenson, G., Pawlowski, T., Rajkovich, N., Reed, K.A., Schoeman, L., Shapiro, J., Spiegel-Feld, D., Tchen, J., Towers, J., Wagner, G., 2021. Rapid research and assessment on COVID-19 and climate in New York City. *J. Extrem. Events* 2150010. <https://doi.org/10.1142/S234573762150010X>.
- Lee, A.C.K., Maheswaran, R., 2011. The health benefits of urban green spaces: a review of the evidence. *J. Public Health (Bangkok)* 33, 212–222. <https://doi.org/10.1093/pubmed/fdq068>.
- Li, D., Deal, B., Zhou, X., Slavenas, M., Sullivan, W.C., 2018. Moving beyond the neighborhood: daily exposure to nature and adolescents' mood. *Landsc. Urban Plan.* 173, 33–43. <https://doi.org/10.1016/j.landurbplan.2018.01.009>.
- Lu, Y., Zhao, J., Wu, X., Lo, S.M., 2020. Escaping to nature in pandemic: a natural experiment of COVID-19 in Asian cities. *SocArXiv*. <https://doi.org/10.31235/osf.io/rq8sn>.
- Madureira, H., Nunes, F., Oliveira, J.V., Cormier, L., Madureira, T., 2015. Urban residents' beliefs concerning green space benefits in four cities in France and Portugal. *Urban For. Urban Green.* 14, 56–64. <https://doi.org/10.1016/j.ufug.2014.11.008>.
- Martin, A., Markhvida, M., Hallegatte, S., Walsh, B., 2020. Socio-economic impacts of COVID-19 on household consumption and poverty. *Econ. Disasters Clim. Chang.* 4, 453–479. <https://doi.org/10.1007/s41885-020-00070-3>.
- McCunn, L.J., 2020. The importance of nature to city living during the COVID-19 pandemic: considerations and goals from environmental psychology. *Cities Health* 1–4. <https://doi.org/10.1080/23748834.2020.1795385>.
- Miyake, K.K., Maroko, A.R., Grady, K.L., Maantay, J.A., Arno, P.S., 2010. Not just a walk in the park: methodological improvements for determining environmental justice implications of park access in New York City for the promotion of physical activity. *Cities Environ.* 3 (1), 1–17. <https://doi.org/10.15365/cate.3182010>.
- New York City Department of Parks and Recreation, 2020. Frequently Asked Questions : NYC Parks [WWW Document]. URL <https://www.nycgovparks.org/about/faq> (accessed 8.13.20).
- New York State Department of Health and Mental Hygiene, 2020. New York State on PAUSE [WWW Document]. URL <https://coronavirus.health.ny.gov/new-york-stat-e-pause> (accessed 7.17.20).
- Nicola, M., Alsafi, Z., Sohrabi, C., Kerwan, A., Al-Jabir, A., Iosifidis, C., Agha, M., Agha, R., 2020. The socio-economic implications of the coronavirus and COVID-19 pandemic: a review. *Int. J. Surg.* 78, 185–193.
- R Core Team, 2020. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.
- Rigolon, A., 2016. A complex landscape of inequity in access to urban parks: a literature review. *Landsc. Urban Plan.* 153, 160–169. <https://doi.org/10.1016/j.landurbplan.2016.05.017>.
- Rupprecht, C.D.D., Byrne, J.A., Ueda, H., Lo, A.Y., 2015. 'It's real, not fake like a park': residents' perception and use of informal urban green-space in Brisbane, Australia and Sapporo, Japan. *Landsc. Urban Plan.* 143, 205–218. <https://doi.org/10.1016/j.landurbplan.2015.07.003>.
- Rutz, C., Loretto, M.-C., Bates, A.E., Davidson, S.C., Duarte, C.M., Jetz, W., Johnson, M., Kato, A., Kays, R., Mueller, T., Primack, R.B., Ropert-Coudert, Y., Tucker, M.A., Wikelski, M., Cagnacci, F., 2020. COVID-19 lockdown allows researchers to quantify the effects of human activity on wildlife. *Nat. Ecol. Evol.* 4, 1156–1159. <https://doi.org/10.1038/s41559-020-1237-z>.
- Ryan, G.W., Bernard, H.R., 2003. Techniques to identify themes. *Field methods* 15, 85–109.
- Samuelsson, K., Barthel, S., Colding, J., Macassa, G., Giusti, M., 2020. Urban Nature As a Source of Resilience During Social Distancing Amidst the Coronavirus Pandemic. *OSF Preprints*. <https://doi.org/10.31219/osf.io/3wx5a>.
- Slater, S.J., Christiana, R.W., Gustat, J., 2020. Recommendations for keeping parks and green space accessible for mental and physical health during COVID-19 and other pandemics. *Prev. Chronic Dis.* 17, E59. <https://doi.org/10.5888/pcd17.200204>.
- Spotswood, E., Benjamin, M., Stoneburner, L., Wheeler, M., Beller, E., Balk, D., McPhearson, T., Kuo, M., McDonald, R., 2021. Who has nature during the pandemic? COVID-19 cases track widespread inequity in nature access across the United States. *Review*. <https://doi.org/10.21203/rs.3.rs-203637/v1>.
- The Trust for Public Land, 2020. New York Park Score [WWW Document]. URL <https://www.tpl.org/city/new-york-new-york> (accessed 10.28.20).
- Twenge, J.M., Joiner, T.E., 2020. US Census Bureau-assessed prevalence of anxiety and depressive symptoms in 2019 and during the 2020 COVID-19 pandemic. *Depress. Anxiety* 37, 954–956. <https://doi.org/10.1002/da.23077>.
- Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y., Kagawa, T., 2014. The influence of urban green environments on stress relief measures: a field experiment. *J. Environ. Psychol.* 38, 1–9. <https://doi.org/10.1016/j.jenvp.2013.12.005>.
- U.S. Census Bureau, 2020. American Community Survey, 2015–2019 American Community Survey 5-Year Data Profile, New York City [WWW Document]. URL <https://data.census.gov/cedsci/profile?g=1600000US3651000> (accessed 7.27.21).
- U.S. Census Bureau, 2019. US Census Bureau 2019 National and State Population Estimates [WWW Document]. URL <https://www.census.gov/newsroom/press-kits/2019/national-state-estimates.html> (accessed 8.13.20).
- van den Berg, A.E., Maas, J., Verheij, R.A., Groenewegen, P.P., 2010. Green space as a buffer between stressful life events and health. *Soc. Sci. Med.* 70, 1203–1210. <https://doi.org/10.1016/j.socscimed.2010.01.002>.
- Venables, W.N., Ripley, B.D., 2002. *Modern Applied Statistics With S*, fourth edition. Springer, New York.
- Venter, Z., Barton, D., Gundersen, V., Figari, H., Nowell, M., 2020. Urban nature in a time of crisis: recreational use of green space increases during the COVID-19 outbreak in Oslo, Norway. *Environ. Res. Lett.* 15, 104075 <https://doi.org/10.1088/1748-9326/abb396>.
- Vindegaard, N., Benros, M.E., 2020. COVID-19 pandemic and mental health consequences: systematic review of the current evidence. *Brain Behav. Immun.* 89, 531–542. <https://doi.org/10.1016/j.bbi.2020.05.048>.
- Weiss, C.C., Purciel, M., Bader, M., Quinn, J.W., Lovasi, G., Neckerman, K.M., Rundle, A. G., 2011. Reconsidering access: park facilities and neighborhood disamenities in New York City. *J. Urban Health* 88, 297–310. <https://doi.org/10.1007/s11524-011-9551-z>.
- Wickham, H., 2016. *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag, New York.