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Shared streets, park closures and environmental justice during a pandemic emergency in Denver, Colorado

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ABSTRACT

Introduction: During the COVID-19 pandemic many municipalities closed or limited access to parks. A few also added new shared streets for citizens to recreate. This large and unprecedented change in the ability of residents to use green space provides an important case for assessing how emergency planning processes might differentially impact minority groups.
Methods: Using the case of park closures and shared streets expansion in Denver, Colorado in March and April of 2020, this analysis evaluates how walking time and density of use at parks changed for different minority and income groups based on estimating park visits for residential blocks.
Results: The analysis demonstrates that minority and low income groups were not disproportionately impacted by initial closures. Shared streets provide net decreases across the city in terms of travel time and density for recreational space usage, though there is some indication benefits were not equally distributed.
Conclusion: The result emphasizes the importance of modern planning efforts and community engagement in ensuring equitable urban resilience while highlighting the potential for shared streets to provide more recreational accessibility if they can be equitably located.

1. Introduction

The COVID-19 pandemic dramatically changed how urban residents interacted with natural amenities within cities. As cities and states across the U.S. issued COVID-19 stay-at-home orders in March and April of 2020, the orders generally exempted outdoor exercise ("The Council of State Governments | Home" n. d.). Increased numbers of people at home with no work also resulted in increased visitations to local parks and greenspaces, resulting in municipal efforts to restrict attendance (Stangeland 2020). For example, the City of Denver closed all parking lots at parks in an effort to "minimize social activities". At the same time, the city parks department issued a notice to utilize only neighborhood parks and closed parking lots.

Neighborhood parks are not evenly distributed, but tend to disproportionately benefit white populations (Jennifer R. Wolch et al., 2014; Rigolon and Németh 2018). While different groups might use parks for different purposes, access to parks and greenspace is an important aspect of creating equitable urban spaces (Talen, 1997). Accordingly, the call to visit neighborhood parks might have had unintended equity impacts. While we assess how closing parks or limiting access might impact equity, Denver's solution to the overcrowding at some parks was notable. Not only did it close parks, but the city of Denver attempted to adaptively respond to the crisis by opening shared streets.

Shared streets programs give precedence on streets to pedestrians over cars, meaning cars can use the streets for parking and local

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travel but must adapt to use of the streets by pedestrians (Polus and Craus 1988). During the pandemic, Denver, along with Seattle and Minneapolis converted streets into shared access or in some cases completely closed roads to cars, increasing the availability of walkable urban space. However, because of emergency declarations in the cities and limited public engagement processes during the pandemic, the response, while innovative, did not necessarily include a meaningful public engagement process about where to site such shared streets. Modern park siting and planning generally require public meetings, engagement, and planning (Abbott 2013; Lucy 1981). Closures alone might have provided an environmental justice concern but the adding of shared street space in a closed administrative setting raises further questions about whether certain groups are more likely to benefit due to a lack of pathways to engage on where shared streets should be located (Daley and Reames 2015). Using the case of Denver, Colorado, this analysis estimates municipal park visits under initial closures and with added shared streets to evaluate if park closures and new transportation patterns created equitable outcomes or reduced social disparities in access to recreational amenities.

Relying on block group level data from the American Community Survey (ACS,), shapefiles from the City and County of Denver describing residential block locations and park locations, and routing distance capabilities allowed by the Open Source Routing Machine (*Osrm-Backend* n.d., "Denver Open Data Catalog" n. d.), this analysis applies hierarchical regression analysis to test whether specific ethnic and racial classifications are disproportionately impacted by the changes controlling for pre-pandemic park access. It does not assess whether parks are differentially sited but instead uses geographic calculations to evaluate how limiting visits to nearest parks might differentially impact different groups (Schlosberg 2007). Second, it evaluates whether opening streets to residents is likely to be associated with reduced travel to parks for all citizens.

This article proceeds with a detailed rationale used to set up three hypotheses regarding park limits, shared streets, and equity. In section three, methodology and data sources are described in detail. In section four, results are characterized, before they are situated in the theory within section five. In conclusion, the article provides actionable recommendations for reducing inequities in case of future pandemics.

2. Rationale

Parks provide for improved psychological well-being of local citizens (Scopelliti et al., 2016; Larson et al., 2016). Parks allow activity and spacing in compact urban zones effectively decreasing density. Municipal decision making such as zoning and permitting are fundamentally about creating spaces between people and property uses (Merry 1987). Here, greenpaces play a vital role in separation. However, one of the final motivations for parks is the primary reason that cities closed them in COVID-19. Research on park values demonstrates the social connections made in parks are the strongest driver of use (Seaman et al., 2010). Parks are social gathering places in cities where citizens go to engage with family and friends, a critical part of environmental wellbeing (Biedenweg et al., 2017/6; Sturm and Cohen 2014). A number of studies have provided evidence that living near parks is associated with improved physical outcomes (Wolch et al., 2011; Lachowycz and Jones 2011).

2.1. Distributive justice

Parks policy provides a case of distributive and procedural environmental justice concerns, where distributive justice is reflected in access and availability of parks and procedural justice is observed in planning processes (Kronenberg et al., 2020; Smiley et al., 2016).

Parks are not evenly distributed throughout cities. Parks in places like Denver, Colorado, the case for this study, tend to occur in wealthy, white neighborhoods (Rigolon and Németh 2018). Generally high property values and quality of parks are strongly correlated (Crompton 2001). The presence of parks itself can even push out minority residents: recent research indicates that greenways especially which create linear park amenities may be a driver of gentrification (Rigolon and Németh 2020). Where "just-green-enough" policies promoted pocket parks and small community greenspaces in an attempt to limit gentrification (Curran and Hamilton 2012), COVID-19 provided a temporary gap in this policy.

While planning decisions in major cities often consider demographics, the large-scale closing of parks for safety reasons during the COVID-19 pandemic is unprecedented in US history. Even during the 1918 pandemic, there is little evidence of cities closing municipal park spaces at the rate they did in 2020 (Hatchett et al. 2007). However cities did not just close parks—they responded to the challenge of spacing people by adding shared streetspace, in effect, creating added parkspace throughout the city on what are usually transportation corridors. Accordingly, the initial COVID-19 surge in U.S. cities was at once a time of reduced access to parkspace and a changing definition of what parkspace could entail. Shared streets, open to pedestrians, bikers, and local traffic became part of the urban space in Denver, Colorado, Seattle, Washington, and Minneapolis, Minnesota.

In one sense the rapid expansion of available space by converting streets could be seen as increasing access and availability for low-income and minority communities; however, this ignores two critical aspects. First, the distribution of these openings relative to closures matters for whether distributive justice is achieved. Second, the rapid openings and closings often neglect procedural justice which we expect would weaken the potential for restorative environmental justice.

2.2. Procedural and restorative justice

The environmental justice literature has long considered justice extending beyond direct impacts to process (Schlosberg 2009; Daley and Reames 2015). Because governments often fail to fully reflect the communities they represent, best-practice is for administrators to engage diverse citizens in planning (Forkenbrock, Sheeley, and National Cooperative Highway Research Program 2004). In contrast, COVID-19 park closure decisions during the Spring 2020 pandemic almost universally lacked engagement and participatory processes. Among the 25 largest US at the start of the crisis, almost all adjusted park use in some fashion, though the authors could find no evidence of any community engagement in these decisions.

Existing literature on public participation indicates that most participants in public meetings and complaint processes are older, male, and homeowners (Einstein et al., 2019; White and Trump 2016; Tam et al., 2006). Despite the fact that certain demographics are most likely to participate in citizen engagement processes (Einstein et al. 2019), efforts at community engagement and participation remain a vital part of ensuring equitable planning (Denhardt and Denhardt 2007; Roberts 2015; Schudson 2015). Even if certain voices dominate the planning process, the exclusion of all voices might have a comparatively larger effect by allowing existing patterns to continue without comment ("Public Space and Diversity: Distributive, Procedural and Interactional Justice for Parks" 2016;). We highlight next how gaps in procedural justice may create distributional equity concerns in the case for this study.

2.3. The case of Denver's closed parks

Denver, Colorado serves as an ideal case for testing disparate impacts of parks closures and the creation of shared streets, largely due to its rapid gentrification, and stereotypical outdoorsy values. Denver's recent gentrification process has been labelled as green, indicative of values placed on sustainability and preserving natural capital that might have unintended consequences of displacing existing residents (Sbicca 2019; Bryson 2013). In essence, preserving greenspace and creating parks has in some cases been a tool of displacement (Sbicca 2019). While the city has formally adopted policies that promote distribution of parks across the city, existing resources matter, and previous studies have demonstrated parks were not equally distributed or accessible prior to the pandemic (Rigolon and Németh 2018).

Denver Mayor Michael Hancock instituted a stay at home order on Monday, March 23 which left parks open but closed playgrounds and facilities. Regardless, city parks remained busy, resulting in civic action to limit visits. Denver first closed parking lots at parks. Finally, it began to close certain parks that the City identified as problematic for social gathering.

Denver, Colorado's municipal code demands citizens be given the right to vote on park de-designation, the power to close parks in emergencies is solely held by the parks administration (Denver Municipal Code 39-2-g). Accordingly, it was not necessarily surprising that park closures did not involve public comment. Despite the city having invested in small parks in traditional Latinx and Black communities to limit gentrification ("just-green-enough" policies), local pocket parks were largely closed as they were deemed inappropriate for the one allowed use for parks—outdoor exercise. Connecting this with Denver's adoption of just-green-enough policies, we predicted low socioeconomic status groups would have to travel further to reach a useable park space.

H1. *Low-income, Hispanic, Asian, and Black populations will face a lower accessibility to parks relative to other groups following park closures.*

The rationale for park closures was that the spaces became congested during the initial period of the stay-at-home orders. If existing theories that park space being more lacking among certain groups are true, then these same groups should face higher density at parks and other natural resources amenities, even relative to previous conditions (Rigolon and Németh 2018; Sbicca 2019). Accordingly, the authors expect that low socioeconomic status populations will be most likely to face both decreased accessibility to parks and increased congestion.

H2. *Low-income, Hispanic, Asian, and Black populations will face a greater congestion at parks relative to other groups following park closures.*

2.4. Opening shared streets

In response to crowding at parks, the City of Denver simultaneously began to open streets to shared recreational use, creating new walking spaces largely in response to public complaints and pressure. Given who the city is most likely to have heard complaints from regarding access and congestion, high-income, home-owning, and low minority neighborhoods would be most likely to benefit from the creation of new recreational spaces or closure modifications.

H3. *Low income, Black, Asian, and Hispanic groups will face longer travel times and higher use frequencies with implementation of shared streets.*

Our rationale for this hypothesis is based on the procedural justice rationale highlighted earlier but is also supported by qualitative evidence of the case.[1] Denver Streets Partnership was the initial proponent of streets being opened to pedestrians and cyclists during COVID-19, advocating for the opening of Speer Boulevard—a major diagonal boulevard through the city as added recreational space. The group also ran a survey of Denver residents, showing preferences for opening streets in Sloans Lake, a number of east-west street closures crossing Capitol Hill and Congress Park, and some connecting City park to downtown, while closing streets in parks.

[1] While most land-use and transportation changes require some sort of public engagement process partially in an attempt to ensure community support and protection of at-risk groups (Wilson et al. 2008; Fung 2015), the linear street opening lacked such processes that exist for almost all other Denver land use changes but instead was based on direct comment and dialogue with certain groups and via social media, rather than outreach directed at multiple communities. City of Denver, "Park and Facility Projects". https://www.denvergov.org/content/denvergov/en/denver-parks-and-recreation/planning/park-facility-projects.html, accessed April 20, 2020.

While the group's plans for closures were ultimately different than those adopted by Denver, the similarities bear consideration. Denver closed all streets within parks to cars, and opened 11th and 16th to pedestrians—all actions suggested by the Denver Streets Partnership's survey (COVID-19 Resources,). All of these shared streets were also in post-gentrified or relatively wealthy neighborhoods. Later additions (included in this analysis) added to the space in other communities, but the initial changes were concentrated in the dense, mostly white areas of downtown and Capital Hill. The goal of these policies was likely not justice but reducing congestion.

In a video released on April 3, Denver Mayor Michael Hancock announced concerning opening streets to traffic, "We've heard from you on twitter, and other forms of social media, that this was important to you. We heard you," (Hancock, 2020). The Mayor then went on to outline the plan to open streets to pedestrians. Given the lack of any outward-facing sign of engagement with diverse communities and an inability to reach out to residents to identify needs; the city's action might tend to benefit those who are most likely to call their city council members or use communication services to affect change (Brewer 2007; Thomas 2013).

3. Methodology

To test hypotheses one through three, this article evaluates the association between neighborhood characteristics (independent variables) and park access and user density (dependent variables) under both park closure and shared street pandemic response scenarios. The unit of analysis is City of Denver street-block center locations for every residential address ($n > 7900$). These point locations map a block center location for every address in the City of Denver ("Denver Open Data Catalog"). Street residential blocks are simply the result of street intersection (100 block, 200 block per street in each north, south, east, and west direction). For measures of demographics for these potential addresses, we rely on block group measures—the smallest geographic unit with publicly available demographic data from the American Community Survey ($n = 482$). The following sections describe model dependent variables, independent variables, and control variables.

3.1. Dependent variable 1: access

While there are multiple possible measures of accessibility, the analysis relies on travel time to the nearest park because it is among the more common metrics of accessibility (Miller 2018) and fits the established planning goal for Denver, being that all citizens live within 10 min of a "quality" park (Sachs 2019). Second, an advantage of our walk-time routing approach as opposed to nearest distance approaches is it avoids challenges of railroad tracks and freeways that might create the illusion of a park nearby that actually requires significant travel to access. When just using a nearest distance approach, the litany of train tracks, rivers, and freeway barriers in Denver proved problematic.

For each residential block in Denver County, we use the Open Source Routing Machine (OSRM) to estimate the travel time to the nearest park (*Osrm-Backend* n.d.). We identified nearest parks using R and the *sf* package, finding the three closest possibilities (Pebesma n.d.; Brunsdon and Comber 2018). We then calculated the travel time in OpenStreetMaps from the residential block center to the park allowing the person to follow walkable routes, keeping the shortest travel time. This can be thought of as having one person from each block walking to a nearest park via the walking suggestions provided by Open Street Maps.

To identify nearest parks given pandemic closures, we created a second parks dataset reflecting park closures. In this modified dataset, we only include parks that have a quarter mile of trails or sidewalks corresponding to the walking distance of one lap around a traditional outdoor track. We chose to limit parks based on walkability to reflect on the closures of parks facilities and general space, as well as directives from the city about how parks should be used.[2] Accordingly, our closure data reflects distance to the nearest parks department pedestrian path with a quarter mile of walkable distance.

For each block in the city we calculate three travel times. The first reflects times to parks before the pandemic. The second reflects estimated times at the start of the stay-at-home period. The third reflects distances to parks in the closure dataset, with added shared streets during the stay-at-home period.[3] For a comparison of these measures, see Fig. 1. All spatial calculations and estimates were made in the R program sf while distance calculations were made via Docker and OSRM (Pebesma n.d.; Team and Others 2013; Osrm-Backend n.d.).

3.2. Dependent variable 2: use frequency and congestion

Because the park closures were intended to limit user congestion at local parks, we also needed to calculate estimated how residential blocks are assigned to each park. Allowing a single park to have one single count may ignore the potential for clustering of use in certain parts of the park especially for large parks and regional trails. To account for this we fit a hexagon grid (described as parks-

[2] During the outbreak, Denver closed playgrounds, benches, tennis courts, picnic tables, basketball courts and other facilities–all park facilities except for general space and walking paths were closed. The city also disallowed shared equipment such as frisbees and footballs meaning even places like sports fields were generally locked. While grass open spaces were open, exercise was the only legal use, as defined by the stay-at-home order issued by the city. And Denver puts signs on grass requesting people not use that space as trail space. Accordingly, our model reflects distance to pedestrian paths accounting for a one quarter mile of walkable distance managed by the parks department.

[3] Finally, since Denver added shared streets as linear recreational space during the stay-at-home period, the authors added shared streets to the pandemic closure data based on coding new park polygons overlapping the shared streets in Google Earth. We then recalculated park travel distances and park locations with these new polygons included.

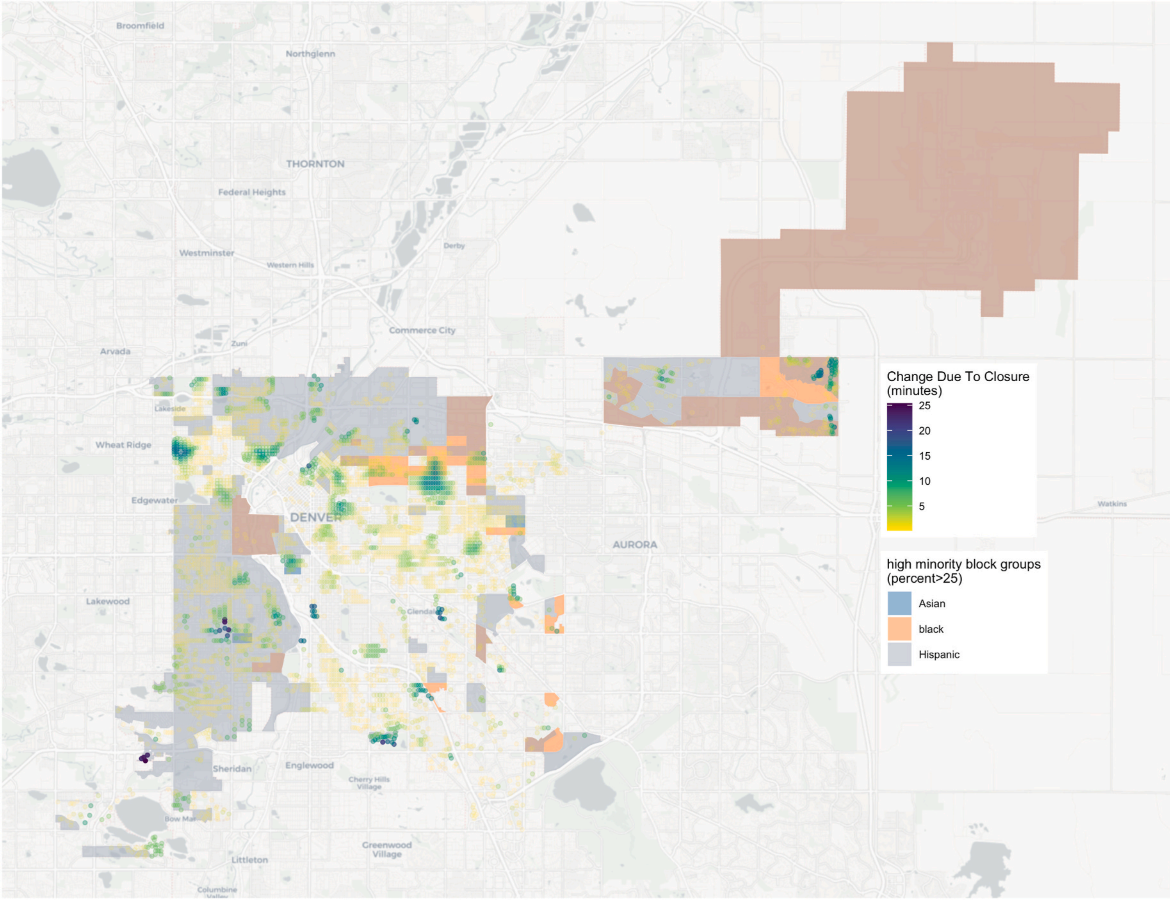

Fig. 1. Difference between pre-pandemic and initial park closure walking time to the nearest park modeled across Denver, Colorado with minority block groups shaded.

polygons) to park space in Denver using the R program sf to allow division of the city into equal sized park zones (Pebesma n.d.; Brunsdon and Comber 2018). Aiming for hexagons approximately 250 m in diameter fit to pre-COVID-19 park usage, we generated a 2431 grid-cell lattice to cover Denver parks. Each residential block was then assigned to visit a parks-polygon in each of the time periods, resulting in a different congestion outcome depending on which polygon was visited in which time period. The initial polygon visit frequencies are mapped onto parks in Fig. 2, expressed as a count of residential blocks visiting a specific hexagon.[4] This measure is henceforth described as “use frequency” and is intended to capture relative congestion at parks. Like with park access, we calculate three user frequency values for each residential block: pre-pandemic, closure, and shared street measures of the variable.

3.3. Explanatory variables

For demographic variables related to income and minority status, we rely on five primary variables at the census block-group levels derived from the 2014 to 2018 5 year American Community Survey (“Denver Open Data Catalog” n. d., Bureau, 2018). We chose our demographic variables based on dominant demographic patterns in Denver.

First, to highlight potential for racial and ethnic gaps in park access, measures of percent of block groups identifying as Hispanic, Black, or Asian are included.[5] We also included a small suite of other demographic indicators, aiming for a parsimonious, non-collinear model. Specifically, we utilize the population density in terms of people per census block group area, median household income, and

[4] By eliminating pocket parks and constraining park-usage to just trails, the expected use density at parks would increase drastically. Is this assumption reasonable? Given that Denver parks have signs demanding users use designated trails for activity (some of the largest parks had signs asking users to stay on designated paths) the authors believe it reflects the dominant usage patterns in parks during COVID-19.

[5] By including Hispanic, Black, and Asian as demographic categories we capture the most significant racial (white/black) divide and two largest ethnic divides (Hispanic/non-hispanic, Asian/non-Asian) in the city. No other single categorization on race or ethnic lines accounts for more than 1% of the population and given common geographic colocation of minority groups, we feared including further groups may increase potential for multicollinearity.

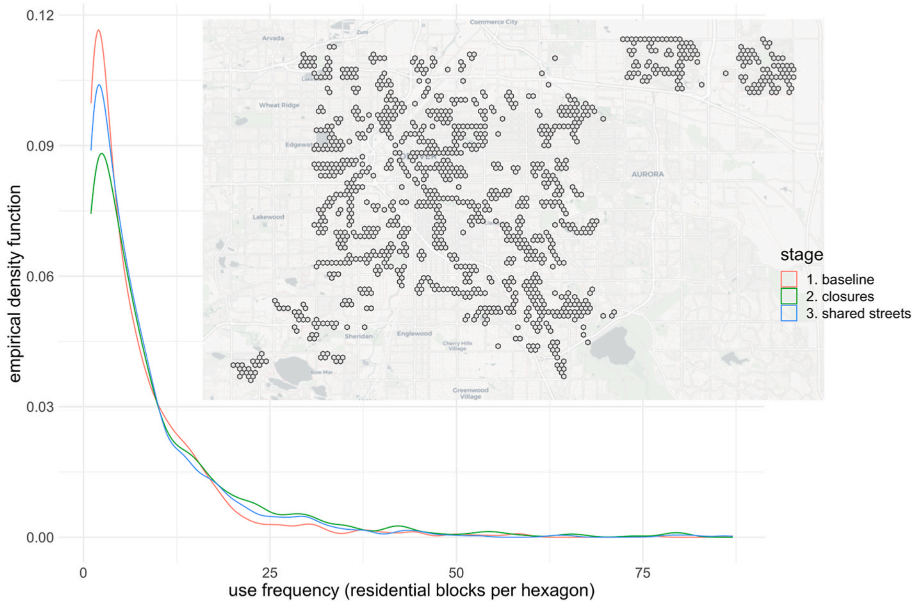

Fig. 2. Polygon grid used to fit density for local park usage. The measure for each polygon (in map) is residential block visitors per hexagon, with empirical density across hexagons illustrated by the plot.

percent of the population over the age of 65. Natural logarithmic transformations are used on all variables and each is standardized (converted to standard deviations) so that posteriors are directly comparable based on standard deviations. Descriptive statistics for these variables are included in Table 1, which also demonstrates counts of random effect levels.

3.4. Modeling approach

We use a multilevel Bayesian spatial model to assess posterior predictions (observed relationships given data) for travel time and use frequency, controlling for pre-pandemic measures. The advantage of a Bayesian approach here is it allows updating the model based on new data. Accordingly, the models for travel time and use frequency can provide prior knowledge for the impact shared streets have on access. However, in both cases, the results control for the pre-pandemic baseline, such that each policy can be assessed relative to as things were prior to the pandemic. By controlling for pre-pandemic distance, we an actively also assess the association between pre-pandemic conditions and pandemic conditions. This approach thus requires fitting a model for travel time and a model for use frequency, but updating the underlying data to assess how changing closure conditions impact observed relationships.[6]

In the first model, park travel time is regressed on demographic variables at the block group level, controlling for park distance in the pre-COVID-19 period: this model tests hypothesis one.[7] If minority and low income groups are differentially impacted by closures, we would expect positive coefficients for travel time to the nearest park. We then refit the model with the outcome variable calculated using shared street travel time, but using the previous fit to inform priors. This provides a partial test of hypothesis three. We repeat this procedure replacing travel time with density, testing hypothesis two, where we could expect our demographic covariates to be greater than zero for closures and shared streets policies.

As a series of Bayesian models, the coefficients are presented in terms of 95% credible intervals. This range captures the most probable range of a one unit change of an explanatory variable on the dependent variable. Generally speaking, credible intervals containing zero are assumed to present weak evidence of a difference associated with the variable. Accordingly, if park closures differentially harm minority or low income groups, we would expect credible intervals greater than and not containing zero for these covariates. Second if shared streets worsen distributive equity rather than improve equity (H3), we would expect credible intervals greater than and not containing zero for these covariates.

We assume that explanatory variables are linked to the dependent variables by a Gaussian likelihood. For use frequency, a natural logarithmic transformation provided the best fit, so results can be interpreted in terms of percent change in the count residentials

[6] We use penalized complexity priors for initial modeling.

[7] Controlling for previous park travel is critical because previous research suggests minority groups face greater distances to parks; however, we note that if we do a first stage model of pre-pandemic park distance as the dependent variable, none of the demographic classifications we use are statistically related to distance. Accordingly, in the models we rely on main effects between demographic classifications and distance, not interactions.

Table 1
Descriptive statistics, levels, and role in models.

Basic descriptive statistics					
Variable	Source	N	Mean	SD	Transformation in model
Park distance-minutes-Pre-pandemic	OSRM	7994	5.97	4.59	identity
Park distance-minutes-closures	OSRM	7994	7.18	5.08	identity
Park distance-minutes-shared streets	OSRM	7993	6.51	4.85	identity
Park use rate-pre-pandemic (blocks/hexagon)	Calculated, sf	7876	18.80	17.01	ln
Park use rate-closures (blocks/hexagon)	Calculated, sf	7921	24.23	20.03	ln
Park use rate-shared streets (blocks/hexagon)	Calculated, sf	7923	20.45	18.34	ln
% Asian	ACS 2014–2018 (Bureau, 2018)	7995	3.00	4.38	Ln +1
% Hispanic	ACS 2014–2018	7995	28.93	25.15	Ln +1
Median household income ($)	ACS 2014–2018	7995	79,214.94	41,171.79	Ln +1
Population density (people/block group area (sq meters))	ACS 2014–2018	7995	3.05e-03	0.001	ln
% Black	ACS 2014–2018	7995	7.86	11.26	Ln +1
% Age >65	ACS 2014–2018	7995	15.70	10.99	Ln +1
Block group	Random effect, 481, unique observations, level for all ACS 2014–2018 data				
Residential block	Random effect, spde spatial effect (Lindgren et al. 2011), unit of analysis (Denver Open Data Catalog Residential Block Points,)				
Park density grid hexagon	Random effect, Besag-York-Mollie spatial effect (Besag et al. 1991).				

blocks sharing a nearest park after exponentiating coefficients.[8]

Because of the potential for spatial confounding and hierarchical homogeneity, we fit multilevel models with random effects. Second, we allow for spatial homogeneity by using the Stochastic Partial Differential Equations approach implemented in the R program INLA (Lindgren et al., 2011; Rue et al., 2012). Specifically, residential blocks near other blocks are likely to be similar in dependent and independent variables. By constructing a lattice of point centers for block groups and constructing a latent field across Denver County, this approach recognizes and addresses correlation in the errors for these observations. Finally many explanatory variables described in the next section are at the block group level. Accordingly, block group random effects are used to model homogeneity across residential block locations (Blangiardo et al., 2013). Finally, when modeling use frequency as an outcome, it is important to include a random effect for pre-pandemic park visit hexagons, recognizing the spatial correlation of neighboring hexagons.[9]

3.5. Interpreting results

Each model controls for pre-pandemic visit travel time, allowing independent assessment of how both closures and shared street policies relate to pre-pandemic conditions. Results are presented in the form of 95% credible intervals of the posterior distribution. For all explanatory variables, the credible interval can be interpreted as the range capturing 95% of the probability of posterior marginal effects, or the average effect of the independent variable on the dependent variable. Credible intervals greater than zero would be assumed to have a greater than 95% probability that a one standard deviation change in the variable is associated with an increase in use frequency or travel time.

4. Results

4.1. Travel time to parks

4.1.1. Park closures

All tabular results are provided in the appendix Table A1 and Table A2. Here, this analysis presents credible intervals which allow visual assessment of significance based on whether the range captures zero. Fig. 3 shows model fixed effect credible intervals for travel time to the nearest park under initial closures and shared streets variations in park travel time for a one unit change in each variable.

Under the initial park closure observations (darker distributions), most demographic variables are not significantly predictive of larger change in park accessibility, with credible intervals containing zero. Second, for the included demographic variables we observe many competing effects. While percent of population over age 65, percent Black, and percent Hispanic are negatively associated with travel time to parks, median household income and percent Asian are positively associated with travel time. However, none of the resulting credible intervals are significantly different from zero. Overall, this provides little support for hypothesis one.

The lack of support for our hypothesis is amplified by the low practical significance of the observed change. In no case was a one

[8] Despite the count nature of minutes, a Gaussian model provided better fit based on conditional predictive ordinate (C.P.O.) diagnostics.

[9] We use a Besag-York-Mollie model (Besag et al., 1991). From a modeling perspective this is not ideal as there is homogeneity at the polygon visit level in both the pre-pandemic and post-pandemic period. To alleviate this park random effects. This did not result in a different modeling result so we followed a similar pattern as for the travel time models.

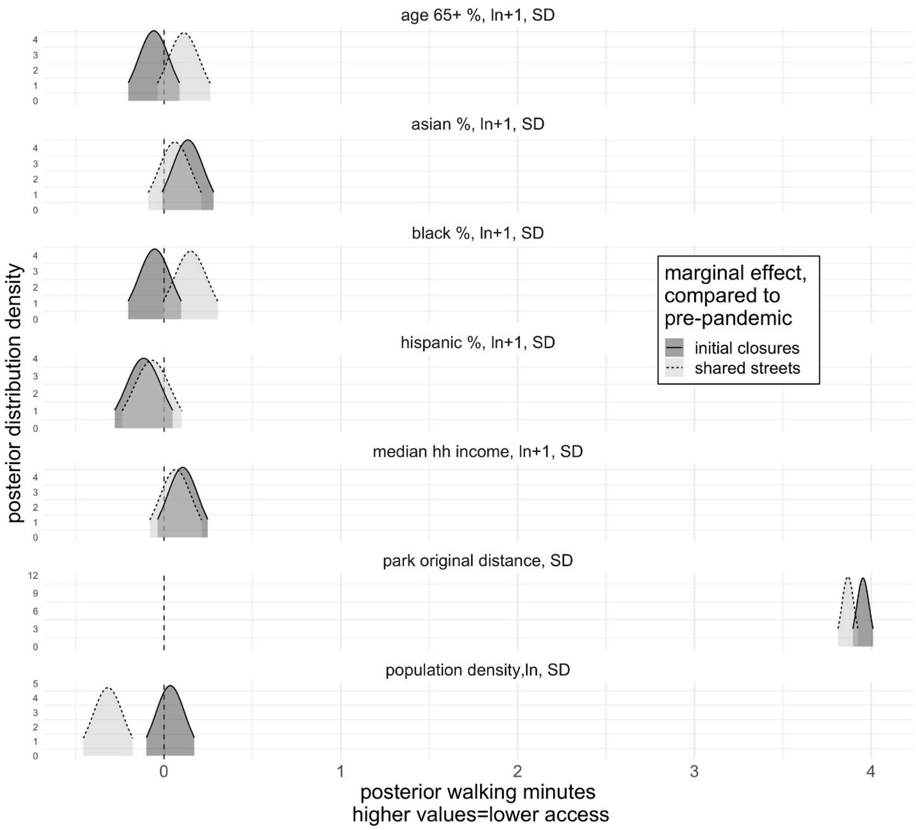

Fig. 3. Travel time to park credible intervals. Measured in minutes. Fixed effect marginals limited to the 95% credible interval.

standard deviation change in a demographic variable associated with more than a 30 s increase in travel time. Instead, travel time prior to the pandemic is the largest predictor of travel time under closures—block groups with long travel times prior to the pandemic faced larger travel times during the pandemic. For each one standard deviation or 4.5 min increase in pre-pandemic travel time, we observe a 3.8 min increase in the walking time to parks during COVID-19 under the initial closure scenario. Accordingly, based on model results, park closures lower access for almost all residents but not necessarily differently for any one group.

4.1.2. Shared streets

The model intercept indicates the COVID-19 closures are associated with a mean walk time of over 7 min as shown in Fig. 4. Updating the model to reflect data with shared streets as possible park space, we find the predicted travel time to the nearest park is lower on average, fewer than 6.6 min. Importantly, this provides strong evidence that controlling for demographics and pre-pandemic conditions, travel time to parks is lower with shared streets added to the city. The mean estimate of over 40 s lower average travel time with shared streets compared to closures alone (difference between intercepts for travel time).

Looking at other variables however, we observe relatively little shift in travel time associated with any demographic group with the exception of Black populations and populations over the age of 65. While as in the case of the closures no demographic variables fully exclude zero from the credible interval (lower bound for % Black = –0.03), we do note that shared streets likely matter for the distribution of park resources overall. While groups might not be statistically harmed, shared streets do not result in travel time improvements for minority groups, and in a few cases, such as that of % Black, the predicted impact of minority status moves towards worse access. This suggests the policies did not redistribute park resources for traditionally marginalized communities.

Part of this may be where shared streets provided benefits in the model. According to Fig. 3, shared streets generally benefit high population density areas, with a one unit increase in population density being associated with a decrease of between 9 and 29 s. Again, while this is a minor change in walking distance, we note that high population density areas were not necessarily differentially disadvantaged by closures of parks. Yet, denser areas seemed to benefit most from the change to shared streets policies.

4.2. Use frequency

Fig. 5 provides credible intervals for models estimating park use frequency (for tabular results see Table A2). Under initial closures, we observe percent Asian, percent Hispanic and percent Black at the block group level is associated with lower use frequency of nearest park areas. As none of these credible intervals contain zero, this indicates that these groups, counter to hypothesis two, may face lower

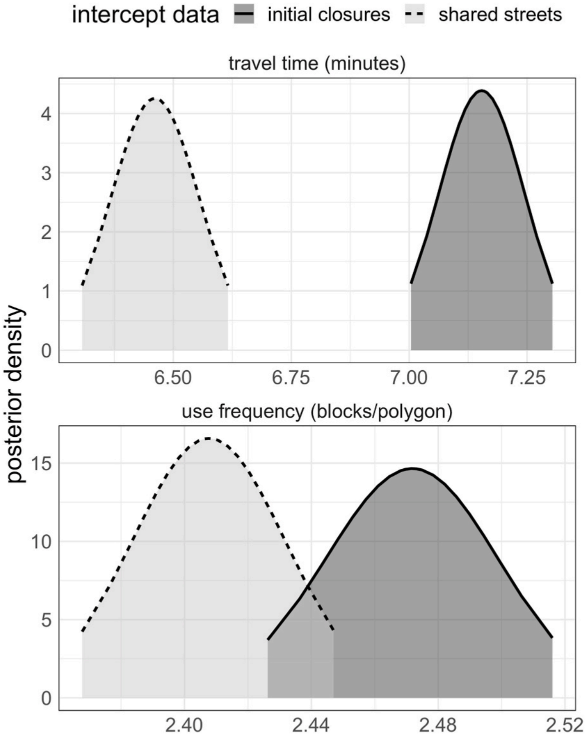

Fig. 4. Intercepts for travel time and use frequency. Shared streets generally associated with improvements compared to closures only.

density of use of parks during the pandemic. In fact, based on the results of the model, the trend observed for all minority and economic classifications is opposite the expected finding at least at the distribution mean providing little to no support for hypothesis two.

Perhaps unsurprisingly, the model also indicates high population density neighborhoods were more likely to face high use frequency under initial closures. Finally, pre-pandemic use frequency was the strongest predictor of use density during the pandemic.

The addition of shared streets does corespond with shifts in the Asian, Black and Hispanic covariates towards higher mean values. The distribution for initial closures and shared streets is not independent as we see the same block groups in each sample. Accordingly, the shift in model results is notable. While we observe minority rates associated with statistically significant lower density controlling for pre-pandemic travel time, including shared streets, that effect is obviated, and we instead observe a credible interval below 0 for only percent Asian population.

Incorporating shared streets, pre-pandemic use frequency is more strongly correlated with use frequency. One way of interpreting this finding is with shared streets, pre-pandemic conditions were an even stronger predictor of park use frequency than under closures, reflecting a move away from the patterns created by closures. Because shared streets were partially motivated by congestion in use, it is notable that population density itself became less predictive of use density (for city blocks) than it had been with just closures. Compared to only closing parks, using shared streets was thus potentially effective in ensuring residents in the most densely populated areas of Denver could recreate while socially-distanced from each other.

However, the results are also indicative of a policy that was not equal in its distribution. While under initial park closures minority groups had somewhat of an advantage in terms of use frequency, under the shared streets paradigm, the credible intervals for demographics all attenuate towards 0 and most contain 0. Essentially, controlling for original park use frequency, demographics fail to be indicative of any differences in allocation of park space once shared streets are added. This is not the same as statistical significance—a point we bring up in the discussion. Our analysis instead tells a more nuanced story: even if groups are not differentially harmed by shared streets policies, they do not necessarily benefit in the same manner.

5. Discussion

5.1. Impacts of park closures

While we established our hypothesis that minority and low income groups would face increased travel time relative to other groups

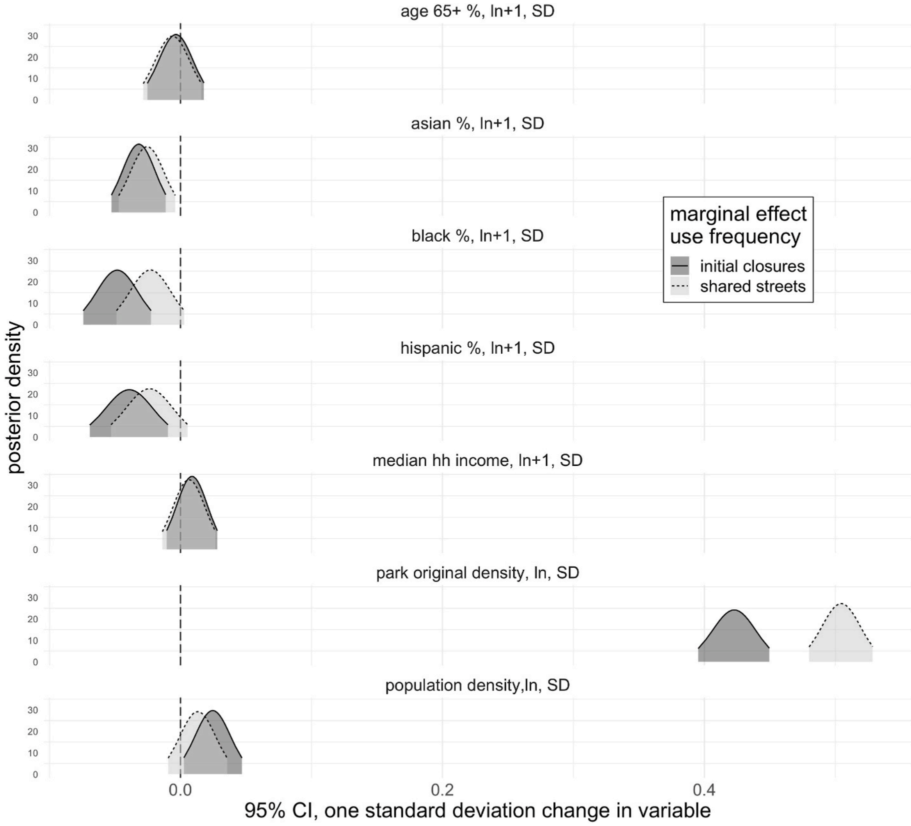

Fig. 5. Use frequency at park credible intervals. Measured in ln rate of residential blocks to gridded closest park hexagons. Fixed effect marginals limited to the 95% credible interval.

with pandemic park closures, this article finds little to no support for that expectation. Specifically, minority and low income groups are not disproportionately impacted by the initial COVID-19 park closures.[10] In terms of use frequency of parks, minority block groups appear to be less harmed by park closures than lower minority block groups which also indicates a failure to support hypothesis two.

We suggest a partial reason for these findings is the nature of patterns of racial settlement in Denver, whereby racial minorities have largely been pushed to the periphery of the county especially in the northeast and west (Rigolan et al., 2018). Given historical settlement, current gentrification, and redlining patterns in Denver, the suggestion here is that traditional African American communities in North Park Hill and Five Points have limited park access and are closer to the urban core than many of the Hispanic and Asian communities who tend to live in the periphery of the city (Fig. 1). This raises a question of whether accessible parks in either area could also be of lower quality compared to parks available to other residents. Because we only included parks based on walkability, other attributes that might be beneficial are not evaluated in this paper.

5.2. *Impacts of shared streets*

With shared streets policies, we observed somewhat contradictory trends across minority groups which again could be the result of patterns of racial settlement. Yet, we believe it is critical to note that Black and age 65+ populations did not appear to share in the benefits of shared streets at the same levels as other groups, as indicated by increases in their predicted park travel times once shared streets are included. Both shared streets and park closure models relied on the same starting address and set of parks other than shared streets, thus, the credible intervals from the initial closures and shared streets models are not independent. We might expect that if shared streets were equally dispersed the posterior predictions would be equivalent. Accordingly, the shift in credible intervals is startling and suggestive of an underlying pattern in where shared streets were implemented.

Second, it is critical to note that the effect of percent Black in the shared streets dataset on travel time was just 1.8 s below zero at its lower bound, indicating that while we did not find a difference with 95% confidence, our model predicted Black residents would derive a reduced benefit from shared streets. While 95% confidence is certainly the standard for scientific publication, we believe that this

[10] We do note for discussions sake that we observed a nearly significant relationship for % Asain at the block group level, though the relationship did not meet the standard 95% level of confidence.

result is indicative of a potential difference that might be better evidenced with use surveys in future analysis.

Finally, because we initially made hypotheses in response to baseline conditions (as closures were temporary), our finding here provides only weak support of hypothesis three. Hypothesis three is only supported if we use pandemic closures as the reference for the change, not if we compare local use to pre-pandemic use. If anything, shared streets likely regenerated pre-pandemic conditions by eliminating changes created by closures. There is no evidence in our model that shared streets had any impact on alleviating existing injustices in the distribution of recreational amenities.

Part of this was likely intentional, but highlights a failure of adaptive responses to address existing health inequities in communities. Given a lack of public engagement and outreach in which streets to open, or environmental justice assessment meant to ensure such changes benefit groups independent of their ability to engage and participate, the decision may have reflected the city's internal assessment of where street openings might provide the greatest benefit for local density while also providing the least impact towards car-travel. In the case of Denver the locations of the shared streets initially connected predominantly young, white neighborhoods to popular parks in Denver—Sloans Lake, City Park, and Cheeseman Park. Only the later expansion of road closures to Northeast and West Denver effectively added street space in areas where there were not parks previously. Accordingly, the decision may have emerged from crowding at parks, rather than a deep assessment of how adding park space could benefit multiple communities. One weakness of our study is we do not observe internal processes in decision making within the city that could have driven how shared streets were allocated, but instead we only observe resulting estimates of impacts.

In terms of differences between use frequency and travel time, we note that in terms of practical significance, shared streets policies did little to alleviate negative impacts created by closing parkspace to general use. In both cases of travel time and user rates, we observed that residential areas faced longer walk times and higher user rates compared to when all parks are open. Here, we also note that we did not measure actual use density, or actual walks to park. Accordingly, our findings reflect best estimates given the data, and may place too much explanatory potential in the underlying built environment rather than individual or culturally defined variables that could create varying park choice and use patterns.

6. Conclusion

In terms of the change to Denver's built environment made during COVID-19, the adding of shared streets demonstrates the ability of cities to respond to crisis by adopting best design practices but we suggest more needs to be done to ensure equitable distribution of such benefits (Karndacharuk et al., 2014). In this article we find that shared streets help to alleviate the crowding at parks while marginally reducing travel distance. Moreover, we do not identify significant disadvantages in how either park closures or shared street policies were implemented, so long as we control for pre-pandemic access.

Accordingly, we highlight that the effort by Denver to add shared streets was useful and should be adopted by other cities as it did reduce shared use frequency and travel time compared to closed-parks alone. However, we add that such policies could be used to move beyond traditional patterns of park distribution as they provide an opportunity to correct injustices and improve the park space access of all residents. Even though shared streets and closures were not damaging to urban equity, they also highlight a need for ongoing engagement in how to implement such policies in a manner that can build more equitable cities. Emergency planning, even mid-crisis, can actively consider the environmental justice implications of actions and how to enhance the health equity of urban systems.

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Appendix. Tabular Model Results

Table A1
Fixed Effects.

Dependent variable	Data	id	mean	sd	Lower CI (2.5%)	Upper CI (97.5%)
Travel time	Closures	b0	7.15	0.09	6.97	7.33
Travel time	Closures	scale log med_hh_inc + 1	0.11	0.09	−0.06	0.27
Travel time	Closures	scale log % asian + 1	0.13	0.09	−0.04	0.31
Travel time	Closures	scale log % hispan + 1	−0.12	0.10	−0.31	0.08
Travel time	Closures	scale log population density	0.04	0.08	−0.13	0.20
Travel time	Closures	scale pre-covid minutes	3.95	0.03	3.88	4.02
Travel time	Closures	scale log % black + 1	−0.05	0.09	−0.23	0.13
Travel time	Closures	scale log % age65p + 1	−0.06	0.09	−0.23	0.11
Travel time	Shared Streets	b0	6.46	0.09	6.28	6.65
Travel time	Shared Streets	scale log med_hh_inc + 1	0.07	0.09	−0.11	0.24
Travel time	Shared Streets	scale log % asian + 1	0.06	0.09	−0.12	0.24
Travel time	Shared Streets	scale log % hispan + 1	−0.07	0.10	−0.27	0.13

(continued on next page)

Table A1 (*continued*)

Dependent variable	Data	id	mean	sd	Lower CI (2.5%)	Upper CI (97.5%)
Travel time	Shared Streets	scale log density	−0.32	0.08	−0.48	−0.15
Travel time	Shared Streets	scale log % black + 1	0.15	0.09	−0.03	0.33
Travel time	Shared Streets	scale pre-covid minutes	3.87	0.03	3.80	3.93
Travel time	Shared Streets	scale log % age65p + 1	0.11	0.09	−0.07	0.29
Use frequency	Closures	b0	2.47	0.03	2.42	2.52
Use frequency	Closures	scale log med_hh_inc + 1	0.01	0.01	−0.01	0.03
Use frequency	Closures	scale log % asian + 1	−0.03	0.01	−0.06	−0.01
Use frequency	Closures	scale log % hispan + 1	−0.04	0.02	−0.08	0.00
Use frequency	Closures	scale log density	0.02	0.01	0.00	0.05
Use frequency	Closures	scale log % black + 1	−0.05	0.02	−0.08	−0.02
Use frequency	Closures	scale log pre-covid park user density	0.42	0.02	0.39	0.45
Use frequency	Closures	scale log % age65p + 1	0.00	0.01	−0.03	0.02
Use frequency	Shared Streets	b0	2.41	0.02	2.36	2.45
Use frequency	Shared Streets	scale log med_hh_inc + 1	0.01	0.01	−0.02	0.03
Use frequency	Shared Streets	scale log % asian + 1	−0.03	0.01	−0.05	0.00
Use frequency	Shared Streets	scale log % hispan + 1	−0.02	0.02	−0.06	0.01
Use frequency	Shared Streets	scale log density	0.01	0.01	−0.01	0.04
Use frequency	Shared Streets	scale log % black + 1	−0.02	0.02	−0.05	0.01
Use frequency	Shared Streets	scale log pre-covid park user density	0.50	0.01	0.48	0.53
Use frequency	Shared Streets	scale log % age65p + 1	−0.01	0.01	−0.03	0.02

Table A2
Random Effect Descriptives for Hyperparameters.

Model	Dataset	Parameter	mean	sd
Travel time	Closures	Precision for the Gaussian observations	0.29	0.00
Travel time	Closures	Precision for block group	0.28	0.02
Travel time	Closures	Range for i (spde)	0.14	0.28
Travel time	Closures	Stdev for i (spde)	0.20	0.20
Travel time	Shared streets	Precision for the Gaussian observations	0.31	0.00
Travel time	Shared streets	Precision for block group	0.26	0.01
Travel time	Shared streets	Range for i (spde)	0.09	0.13
Travel time	Shared streets	Stdev for i (spde)	0.27	0.25
Use Frequency	Closures	Precision for the Gaussian observations	7.39	0.13
Use frequency	Closures	Precision for hexagon (iid component)	2.63	0.17
Use frequency	Closures	Precision for hexagon (spatial component)	118.29	105.23
Use frequency	Closures	Precision for block group	22.83	2.98
Use frequency	Closures	Range for i (spde)	0.14	0.27
Use frequency	Closures	Stdev for i (spde)	0.20	0.20
Use frequency	Shared streets	Precision for the Gaussian observations	6.99	0.13
Use frequency	Shared streets	Precision for hexagon (iid component)	4.00	0.22
Use frequency	Shared streets	Precision for hexagon (spatial component)	2193.17	2012.34
Use frequency	Shared streets	Precision for block group	19.70	2.31
Use frequency	Shared streets	Range for i (spde)	0.15	0.28
Use frequency	Shared streets	Stdev for i (spde)	0.19	0.20

References

Abbott, John, 2013. Sharing the City: Community Participation in Urban Management. Routledge.
American Community Survey (ACS). SAGE research methods. n.d. Accessed May 1. https://doi.org/10.4135/9781412963947.n16.
Besag, Julian, York, Jeremy, Mollié, Annie, 1991. Bayesian image restoration, with two applications in spatial statistics. Ann. Inst. Stat. Math. 43 (1), 1–20.
Biedenweg, Kelly, Scott, Ryan P., Scott, Tyler A., 2017/6. How does engaging with nature relate to life satisfaction? Demonstrating the link between environment-specific social experiences and life satisfaction. J. Environ. Psychol. 50, 112–124.
Blangiardo, Marta, Cameletti, Michela, Baio, Gianluca, Rue, Håvard, 2013. Spatial and spatio-temporal models with R-INLA. Spatial Spatio Temporal Epidemiol. 7, 39–55. December.
Brewer, Brian, 2007. Citizen or customer? Complaints handling in the public sector. Int. Rev. Adm. Sci. 73 (4), 549–556.
Brunsdon, Chris, Lex Comber, 2018. An Introduction to R for Spatial Analysis and Mapping. SAGE.
Bryson, Jeremy, 2013. The nature of gentrification. Geogr. Compass 7 (8), 578–587.
COVID-19 resources | denver streets partnership. n.d. Accessed May 1, 2020. https://www.denverstreetspartnership.org/covid/.
Bureau, U.S.C., 2018. American Community Survey 2014-2018 5-Year Estimates.
Crompton, John L., 2001. The impact of parks on property values: a review of the empirical evidence. J. Leisure Res. 33 (1), 1–31.
Curran, Winifred, Hamilton, Trina, 2012. Just green enough: contesting environmental gentrification in greenpoint, brooklyn. Local Environ. 17 (9), 1027–1042.
Daley, Dorothy M., Reames, Tony G., 2015. "Public Participation and Environmental Justice." *Failed Promises*. https://doi.org/10.7551/mitpress/9780262028837.003.0006.
Denhardt, Janet Vinzant, Denhardt, Robert B., 2007. The New Public Service: Serving, Not Steering. M.E. Sharpe.
Denver open data catalog. n.d. Accessed April 29, 2020. https://www.denvergov.org/opendata.
Denver open data catalog: residential block points. n.d. Accessed May 1, 2020. https://www.denvergov.org/opendata/dataset/city-and-county-of-denver-residential-block-points.

Einstein, Katherine Levine, Palmer, Maxwell, Glick, David M., 2019. Who participates in local government? Evidence from meeting minutes. Perspect. Polit. 17 (1), 28–46.
Forkenbrock, David J., Sheeley, Jason, National Cooperative Highway Research Program, 2004. Effective Methods for Environmental Justice Assessment. Transportation Research Board.
Fung, Archon, 2015. Putting the public back into governance: the challenges of citizen participation and its future. Publ. Adm. Rev. 75 (4), 513–522.
Hancock, Michael, April 4 2020. Twitter. n.d, Accessed May 1, 2020. https://twitter.com/MayorHancock/status/1246193113611280386.
Hatchett, Richard J., Mecher, Carter E., Lipsitch, Marc, 2007. Public health interventions and epidemic intensity during the 1918 influenza pandemic. Proc. Natl. Acad. Sci. U. S. A 104 (18), 7582–7587.
Karndacharuk, Auttapone, Douglas, J Wilson, Dunn, Roger, 2014. A review of the evolution of shared (street) space concepts in urban environments. Transport Rev. 34 (2), 190–220.
Kronenberg, Jakub, Haase, Annegret, Łaszkiewicz, Edyta, Antal, Attila, Baravikova, Aliaksandra, Biernacka, Magdalena, Dushkova, Diana, et al., 2020. Environmental justice in the context of urban green space availability, accessibility, and attractiveness in postsocialist cities. Cities 106, 102862. November.
Lachowycz, K., Jones, A.P., 2011. Greenspace and obesity: a systematic review of the evidence: greenspace and obesity review. Obes. Rev.: Offi. J. Int. Assoc. Stud. Obes. 12 (5), e183–e189.
Larson, Lincoln R., Jennings, Viniece, Cloutier, Scott A., 2016. Public parks and wellbeing in urban areas of the United States. PloS One 11 (4), e0153211.
Lindgren, Finn, Rue, Håvard, Lindström, Johan, 2011. An explicit link between Gaussian fields and Gaussian markov random fields: the stochastic partial differential equation Approach. J. Roy. Stat. Soc. B Stat. Methodol. 73 (4), 423–498.
Lucy, William, 1981. Equity and planning for local services. J. Am. Plann. Assoc.. Am. Plann. Assoc. 47 (4), 447–457.
Merry, Sally Engle, 1987. Crowding, conflict, and neighborhood regulation. In: Altman, Irwin, Abraham, Wandersman (Eds.), Neighborhood and Community Environments. Springer US, Boston, MA, pp. 35–68.
Miller, Eric J., 2018. Accessibility: measurement and application in transportation planning. Transport Rev. 38 (5), 551–555.
Osrm, Backend. Github. n.d., Accessed April 29, 2020. https://github.com/Project-OSRM/osrm-backend.
Pebesma, Edzer n.d.. Simple features for R [R package sf version 0.9-2]. Accessed April 30, 2020. https://CRAN.R-project.org/package=sf.
Polus, A., Craus, J., 1988. Planning considerations and evaluation methodology for shared streets. Transport. Q. 42.
Public space and diversity: distributive, procedural and interactional justice for parks. In: The Routledge Research Companion to Planning and Culture, vols. 315–30, 2016. Routledge.
Rigolon, Alessandro, Németh, Jeremy, 2018. "What shapes uneven access to urban amenities? Thick injustice and the legacy of racial discrimination in Denver's parks. J. Plann. Educ. Res. July, 0739456X18789251.
Rigolon, Alessandro, Németh, Jeremy, 2020. Green gentrification or 'just green enough': do park location, size and function affect whether a place gentrifies or not? Urban Stud. 57 (2), 402–420.
Roberts, Nancy C., 2015. The Age of Direct Citizen Participation. Routledge.
Rue, H., Martino, S., Lindgren, F., 2012. The R-inla project. *R-INLA*. http://www.R-Inla.Org. https://scholar.google.com/scholar?q=r+inla+project&btnG=&hl=en&as_sdt=0%2C48.
Sachs, David, 2019. Denver's new 20-year plan for parks and rec imagines a greener future – and more plans. Denverite. May 21, 2019. https://denverite.com/2019/05/20/denvers-new-20-year-plan-for-parks-and-rec-imagines-a-greener-future-and-more-plans/.
Sbicca, Joshua, 2019. Urban agriculture, revalorization, and green gentrification in denver, Colorado. Res. Polit. Sociol.: Politics of Land 24. https://www.academia.edu/download/57613841/Green_Gentrification_UrbanAg_Pre-Publication_Copy.pdf.
Schlosberg, David, 2007. Ecological Reflexivity, Engagement, and Institutions: Implementing Environmental and Ecological Justice." Defining Environmental Justice. https://doi.org/10.1093/acprof:oso/9780199286294.003.0008.
Schlosberg, David, 2009. Defining Environmental Justice: Theories, Movements, and Nature. Oxford University Press.
Schudson, Michael, 2015. The Rise of the Right to Know: Politics and the Culture of Transparency, 1945-1975. Harvard University Press.
Scopelliti, M., Carrus, G., Adinolfi, C., Suarez, G., Colangelo, G., Lafortezza, R., Panno, A., Sanesi, G., 2016. Staying in touch with nature and well-being in different income groups: the experience of urban parks in bogotá. Landsc. Urban Plann. 148, 139–148. April.
Seaman, Peter J., Jones, Russell, Ellaway, Anne, 2010. "It's not just about the park, it's about integration too: why people choose to use or not use urban greenspaces. Int. J. Behav. Nutr. Phys. Activ. 7, 78. October.
Smiley, Kevin T., Sharma, Tanvi, Steinberg, Alan, Hodges-Copple, Sally, Jacobson, Emily, Matveeva, Lucy, 2016. More inclusive parks planning: park quality and preferences for park access and amenities. Environ. Justice 9 (1), 1–7.
Stangeland, Biljana, 2020. How to evaluate the success of the COVID-19 measures implemented by the Norwegian government by analyzing changes in doubling time. medRxiv. https://www.medrxiv.org/content/10.1101/2020.03.29.20045187v1.abstract.
Sturm, Roland, Cohen, Deborah, 2014. Proximity to urban parks and mental health. J. Ment. Health Pol. Econ. 17 (1), 19–24.
Talen, E., 1997. The social equity of urban service distribution: an exploration of park access in Pueblo, Colorado, and Macon, Georgia. Urban Geogr. 18, 521–541.
Tam, Vivian WY., Tam, C.M., Zeng, S.X., Chan, K.K., 2006. Environmental performance measurement indicators in construction. Build. Environ. 41 (2), 164–173.
Team, 2013. R Core, and Others. R: a language and environment for statistical computing. ftp://ftp.uvigo.es/CRAN/web/packages/dplR/vignettes/intro-dplR.pdf.
The council of state governments | home. n.d. Accessed April 29, 2020. http://csg.org.
Thomas, John Clayton, 2013. Citizen, customer, partner: rethinking the place of the public in public management. Publ. Adm. Rev. 73 (6), 786–796.
White, Ariel, Kris-Stella Trump, 2016. The promises and pitfalls of 311 data. Urban Aff. Rev. 54 (4), 794–823. https://doi.org/10.1177/1078087416673202. November.
Wilson, Sacoby, Hutson, Malo, Mujahid, Mahasin, 2008. How planning and zoning contribute to inequitable development, neighborhood health, and environmental injustice. Environ. Justice 1 (4), 211–216.
Wolch, Jennifer, Jerrett, Michael, Reynolds, Kim, McConnell, Rob, Chang, Roger, Dahmann, Nicholas, Brady, Kirby, Frank, Gilliland, Su, Jason G., Berhane, Kiros, 2011. Childhood obesity and proximity to urban parks and recreational resources: a longitudinal cohort study. Health Place 17 (1), 207–214.
Wolch, Jennifer R., Byrne, Jason, P Newell, Joshua, 2014. Urban green space, public health, and environmental justice: the challenge of making cities 'just green enough. Landsc. Urban Plann. 125, 234–244.