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Recreational response patterns by sociodemographic groups in a pandemic

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ABSTRACT

The COVID-19 pandemic has reinforced the importance of recreation as people flocked outdoors for socially distant activities. However, gaps remain in our understanding of how pandemics impact recreation and the unequal distribution of impacts across communities. Our study used cell phone data from Safegraph to explore census block level changes to local park visitation in California, USA, during the first 27 weeks of the pandemic. We utilized Latent Class Analysis to examine visitation based on sociodemographic groupings of race/ethnicity, income, and age. We found that African American communities experienced the largest decline in visitation and that communities with more Hispanic and Asian populations did not revert to prior visitation levels. Our work demonstrates the importance of recreation in communities and provides an easily interpretable method for evaluation to understand how humans use their environment.

RÉSUMÉ

La pandémie de COVID-19 a renforcé l'importance des loisirs, les gens se rendant en masse à l'extérieur pour des activités à distance sociale. Cependant, il reste des lacunes dans notre compréhension des répercussions des pandémies sur les loisirs et de la répartition inégale de ces répercussions entre les communautés. Notre étude a utilisé les données de téléphonie mobile de Safegraph pour explorer les changements de la fréquentation des parcs locaux au niveau des îlots de recensements en Californie, aux États-Unis, au cours des 27 premières semaines de la pandémie. Nous avons utilisé l'analyze de la structure latente pour examiner la fréquentation en fonction des groupes sociodémographiques de race/ethnicité, de revenu et d'âge. Nous avons constaté que les communautés afro-américaines ont connu la plus forte baisse de fréquentation et que les communautés comptant davantage de populations hispaniques et asiatiques n'ont pas retrouvé leurs niveaux de fréquentation antérieurs. Notre travail démontre l'importance des loisirs dans les communautés et fournit une méthode d'évaluation facile à interpréter pour comprendre comment les humains utilisent leur environnement.

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I. Introduction

The inequitable distribution of environmental amenities and disamenities, particularly in recreation and leisure activities, across sociodemographic groups is well documented (D'Evelyn et al., 2022; Rigolon et al., 2022; Wu, 2006). Ethnic and racial minorities are less likely to participate in outdoor recreation (Thomas et al., 2022a; Winter et al., 2020) and face more constraints to park use than non-minorities (Ghimire et al., 2014; Krymkowski et al., 2014). Similar disparate patterns have been found when investigating green space and recreational access (e.g., Rigolon, 2016). Socioeconomic barriers (time off work, entry, and parking fees) may also restrict recreational access (Ghimire et al., 2014). Additionally, cultural values can lead to differences in recreation styles and preferences (Flores & Sánchez, 2020; Floyd, 1998; L. Larson et al., 2014a). These pre-existing disparities combined with unequal crisis impacts could exacerbate differences among sociodemographic groups (García-López, 2018; Sotolongo et al., 2021). The COVID-19 pandemic underscored this concern by revealing how a crisis widened inequalities, affecting various aspects of life, including health, economic stability, and even recreation (Dass et al., 2022).

In January 2020, the United States of America (US) confirmed its first SARS-CoV-2 case, and by 13 March 2020, the nation issued a national emergency order (EO). During this time, the relative risks of indoor group activities (e.g., movies or restaurant dining) became a focal point, and such indoor choices were limited or eliminated to mitigate the spread of the virus (Lesser & Nienhuis, 2020). Social distancing, an effective way to slow infections by reducing social interactions and movement (Matrajt & Leung, 2020), was widely recommended (Davy, 2021). Stringent local government mandates like 'stay-at-home' orders were instituted, closing schools and non-essential businesses and banning large gatherings (Petherick et al., 2021). Within two days of the EO, California issued the first US state-wide stay-at-home order, requiring residents to stay home except for essential job duties or needs (American Journal of Managed Care [AJMC], 2021; CalMatters, 2020). As restrictions mounted, there was a noticeable pivot towards encouraging nature-based recreation. The Centers for Disease Control and Prevention (CDC) issued guidance recommending nature-based recreation rather than indoor activities (Honein et al., 2020). This remains an important issue as the COVID-19 pandemic enters an endemic phase (Townsend et al., 2023), and concerns mount that future pandemics may be more likely (Cohen, 2000; Mowatt, 2021; Tollefson, 2020).

As health-related risks of indoor activities became more pronounced during the pandemic, nature-based recreation, long valued for its physical and mental health benefits, became more important (Wolsko et al., 2019). In

a time marked by anxiety, social isolation, and widespread health concerns, the therapeutic qualities of the natural environment became more apparent (e.g., Abouk & Heydari, 2021; De Figueiredo et al., 2021; Pouso et al., 2021). Local parks, which largely remained open, became essential locations for people to be outdoors and recreate in a socially distanced manner. Engaging in outdoor activities offered an escape from the confines of home, providing physical exercise and a mental respite. Berdejo-Espinola et al. (2021) found that personal well-being, rather than social interaction, became a primary reason for green space visitation. Sloggy et al. (2023) found that the pandemic resulted in a temporary increase in recreation and leisure in wilderness areas in California, and Kantyka et al. (2023) noted that in Poland, outdoor recreation became 'more appreciated.' Time outdoors offered a sanctuary, helping individuals cope with the stress and uncertainty brought about by the pandemic and social distancing (Jackson et al., 2021).

California's stay-at-home order was lifted almost two months later, on May 8, allowing some lower-contact businesses to reopen. However, months after rescinding the stay-at-home order, not all activity patterns had returned to pre-COVID-19 levels. Jay et al. (2022) found that Whiter communities had a faster rebound in visitation to local parks; however, the study did not differentiate between non-White groups. Larson et al. (2021) investigated local park usage within North Carolina during COVID-19 and variations between different sociodemographic groups. They reported that social vulnerability and lower socioeconomic status were associated with more significant declines in pandemic visitation in July 2020 relative to the prior year. In an urban setting, Nay et al. (2022) found that while White and Asian respondents in Seattle, Washington, did not significantly change their urban recreation during the first six months of the pandemic, Blacks and Hispanics significantly decreased their visitation. The variation in sociodemographic group outcomes highlights how public health crises can differentially impact communities.

Many of the group disparities mentioned above do not paint a complete picture of differing behaviour since multiple dimensions of identity likely influence constraints or access to recreation. The theory of multiple hierarchy stratification posits that an individual's position in society is partially determined by strata associated with four attributes: socioeconomic status, race/ethnicity, gender, and age (Markides et al., 1990). This theory has been used to explore how multiple (dis)advantageous statuses may influence leisure preferences (Shinew et al., 1995), constrain leisure participation (Riddick & Stewart, 1994), and constrain outdoor recreation (Shores et al., 2007).[1] These constraints might prevent individuals from changing their recreation patterns during a crisis. This paper fills the gaps in the literature by exploring the distribution of impacts on recreation during and after a pandemic by varying types of communities. We link a theory of recreation

choice to an econometric estimation of park visitation and assess whether different communities responded to and recovered from the pandemic differently. Specifically, our research questions include the following: 1) what sociodemographic groups experienced similar impacts to local recreation during the pandemic, 2) are there any differences between impacts that are explained by sociodemographic factors, and 3) whether there were any differences in how the recreation activity of different sociodemographic groups recovered.

We utilized visitation to local parks within the demographically diverse US state of California between January 2019 and September 2020.[2] We constructed baseline visitation rates from pre-pandemic periods and utilized 27 weeks of pandemic data to assess visitation changes over time. We estimate heterogeneous changes in visitation by community type through a latent class logit (Williams & Kibowski, 2016) that categorizes census block groups (CBGs) by sociodemographic characteristics. This approach minimizes the need for multiple interactions across sociodemographic controls. It can readily be used within a parsimonious fixed effect ordinary least squares (OLS) estimation to control time-invariant unobservable characteristics such as park access. In summary, it ensures that the model can remain relatively simple while retaining substantial explanatory power. Given the potential intersection and accumulation of social and economic constraints, we construct a counterfactual exercise to predict visitation changes within a community type with a more (less) vulnerable population.

To our knowledge, we are the first to link a theoretically driven model of recreation choice within a multiple hierarchy framework to assess recreation in the context of behavioural changes during COVID-19 pandemic. This retrospective exploration offers insights that may shape responses to similar crises in the future by better understanding recreational patterns and community barriers. Given the differences in community response to local park utilization throughout the pandemic, we offer comments that could be addressed to facilitate equitable access to recreation opportunities. In particular, we connect our findings to previous results in the literature on potential policy implications.

The remainder of this paper is structured as follows. Section II discusses available data and the rationale behind the analysis of California. Section III introduces the theoretical model of recreational choice and operationalizes the empirical approach. In Section IV, we discuss and present our results and provide counterfactual visitation rate exercises to explore the impacts of income and age on recreation. We conclude in Section V by discussing our results, highlighting our study limitations, and offering avenues for future research.

II. Data

To assess differences in nature-based recreation patterns during COVID-19, we processed and merged aggregate cell phone data with 2019 CBG-level sociodemographic data from the American Community Survey (ACS, 2020). Throughout the pandemic, Safegraph offered anonymized and aggregated cell phone data for researchers working on COVID-19 problems (https://www.safegraph.com). The study area is spatially constrained to Safegraph data availability within California (Figure 1). We focus our analysis on California given the size of the state, the population, and the number of parks and recreational spaces (Monz et al., 2019). Furthermore, it is one of the US's most diverse regions for race, ethnicity, and income (Tolbert & Hero, 2001). For these reasons, California is an important and informative region for studying socioeconomic recreation patterns during a pandemic, and its diverse population enhances the external validity of extrapolating findings to other areas.

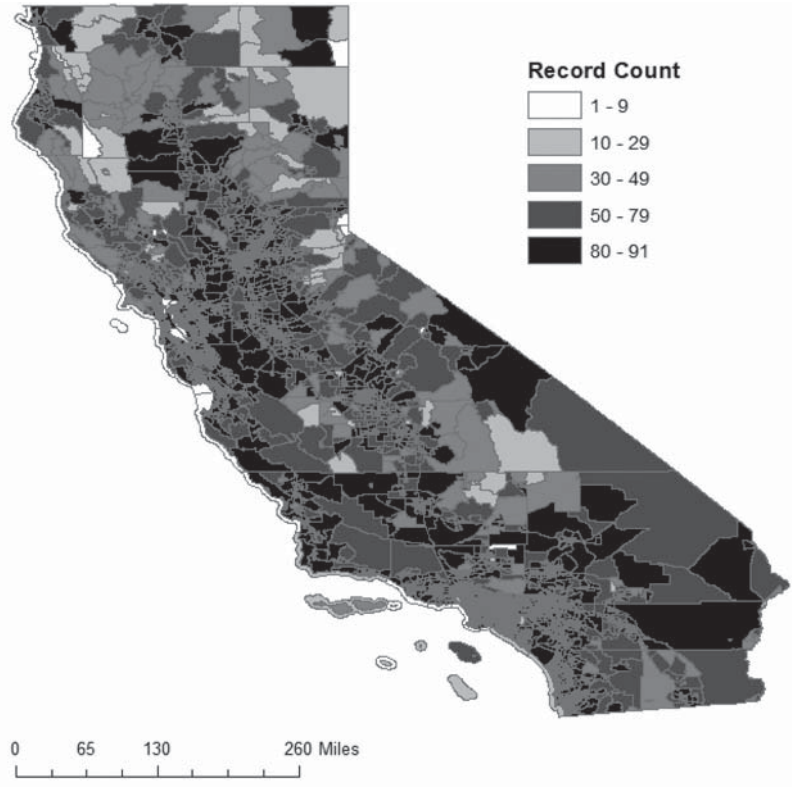

Figure 1. Safegraph Data Coverage. To ensure privacy, Safegraph does not provide data for spatial units when too few markers are collected. While some highly rural areas are lacking coverage, many census block groups are represented with at least 55% of available weekly data. Darker grey colourations represent census block groups with more available data.

Safegraph data provided weekly aggregated and anonymized visits to locations, called points of interest (POI), via cell phone data. Safegraph 'home' locations were constructed based on each device's overnight location. Visitation data were then aggregated based on Safegraph's analysis of cell phone tower signals, which were processed and attributed as trips to POIs from home locations.[3] Each POI is categorized via the North American Industry Classification System (NAICS). For this analysis, we utilized visits to parks and outdoor recreational designations using NAICS code 712,190 ('nature parks and other similar institutions'). Although this NAICS code also contains national and state parks and national forests, these locations were dropped to focus on more accessible parks closer to population centres. Typically, these areas do not require entry fees and stayed open (at least the park stayed open, even if associated facilities were closed) throughout the pandemic.[4] To identify which observations were inside national and state parks, the Safegraph POI map was overlayed with the USGS Protected Areas Database (U.S. Geological Survey [USGS], 2020), which contains all federal, state, and municipal protected areas, as well as tribal lands and private land designations. POI identified as within the national and state parks and national forests were dropped. This resulted in an aggregated weekly visitation count from each CBG to local parks and outdoor spaces. Due to potential identification and privacy concerns, individual device data and geographic areas with too few visitation records are not provided. Data exclusions due to identification concerns may thus result in the loss of data for an entire CBG or exclude CBGs for a specific week(s) where visitation counts are limited, creating an unbalanced panel. Those anonymity restrictions excluded a few rural areas (Figure 1), but Safegraph coverage extended to most of California's more densely populated areas. All of California's 23,212 CBGs had available sociodemographic data, with an average population of 1,686 residents per CBG. We trim small and large CBGs with populations under 500 and over 10,000. Visitation data were captured between 01/01/2019 and 09/21/2020, with an average CBG producing 14.1 recreational visitors per thousand residents per week (Table 1). The EO enacted on 13 March 2020, allowed the creation of a weekly trend variable from 0 to 27. Baseline visitation is captured where the EO is coded as a 0, corresponding to all weeks before the EO. Positive values of EO reflect the week number since the EO (designated as weeks since emergency order (WSEO)).

Differences in weather conditions over time and space can impact nature-based recreation. Weekly weather controls (mean temperature and precipitation) were aggregated at the county level based on data from PRISM Climate Group, Oregon State University (2014). Daily precipitation volume was summed by week, creating a variable that measured the total volume of rainfall by county by week.

Table 1. Summary statistics.

Variable	Mean	SD	Min	Max	N
Visitors per 1,000 residents	14.10	12.24	0.42	1,901	1,435,699
COVID-19 Deaths	1.72	5.86	-	47	1,433,307
COVID-19 Cases	122.17	401.45	0	3,158	1,433,307
Temperature (C)	17.23	5.76	−1.94	35.34	1,435,699
Precipitation (in.)	1.34	2.03	-	24.21	1,435,699
Total Population	1,686.42	840.60	500	9,872	1,435,699
% White	60.96	22.66	-	100	1,435,699
% Black	5.61	9.83	-	100	1,435,699
% Asian	14.19	16.84	-	94	1,435,699
% Hispanic	37.15	25.92	-	100	1,435,699
% Age 0 to 19	24.65	6.74	-	81	1,435,699
% Age 55 and up	27.36	9.80	-	100	1,435,699
% Income less than $25k	15.94	12.41	-	100	1,435,110
% Income over $200k	12.29	14.11	-	85	1,435,110

Descriptive summary statistics for available data.

Based on state and local health agency reports, county-level COVID-19 cases and mortality data from The New York Times (The New York Times, 2021) were linked to each CBG. Case count data consists of records confirmed by a government agency. Mortality count data were constructed by aggregating individuals who died and were confirmed to have COVID-19 and where the cause of death was confirmed to be COVID-19 or ambiguous (i.e., a car crash victim with COVID-19 would not be counted in the mortality results). Detailed summary statistics are provided in Table 1, illustrating the time-varying and time-invariant characteristics of CBGs and county data.

Sociodemographic data comes from the ACS, which provides a snapshot of CBG characteristics based on statistical interpolation of annual survey results conducted by the US Census Bureau (ACS, 2020). Race and ethnicity metrics include estimated CBG percentages for White, Black, Asian, Hispanic, and Other. Due to the overlap in racial and ethnic classification amongst Hispanics, the percentages do not sum to one. In California, the average CBG is 61.0% White, 37.5% Hispanic, 14.2% Asian, and 5.6% Black. Some CBGs are highly homogenous, while others have substantial racial and ethnic diversity. Income data is based on total household earnings over a 12-month period and is divided into income groupings. An estimated 15.9% and 12.3% of households earn less than $25,000 or over $200,000, respectively. The ACS also provides data on the number of residents in age groups by CBG. Similar to our treatment of income, we altered this variable to the percentage of residents within a CBG who are children[5] and those 55 years or older. Over 24% of CBG residents in our sample are younger than 19 years of age, while 27.4% are 55 or older. Our final dataset is an unbalanced panel that consists of visitation data per CBG, by week, in California between 01/01/2019 and 09/21/2020.

III. Theoretical and empirical model

To inform our analysis, we developed a simple model of recreational choice, considering varying levels of physical risk (e.g., getting sick) by activity. Individuals aim to maximize their well-being (U) by allocating time between low-risk recreation (l) and other activities that have higher risk levels (h). In this model, low-risk recreation includes activities like staying at home or spending time outdoors. We use a basic formula to represent this:

$$U(l,h) = l^{\alpha}h^{\beta} \tag{1}$$

In eqn. 1, α and β are scale parameter preferences for low-risk recreation and other activities. These preferences can vary across individuals and can be influenced by factors such as weather, individual characteristics, access to parks, and perceptions of risk. In these models, α (and β) can be influenced by observable characteristics such as access to outdoor parks, current (recent) weather conditions, perceptions of localized risks, and individual factors.

Given data constraints, we do not have individual-level characteristics but we do observe community attributes. If community traits affect risk perceptions, we can include these attributes in our model using a latent class analysis (LCA). This involves classifying communities into distinct groups based on observable sociodemographic traits. This classification process models the probability of a community belonging to a specific group based on its characteristics.[6] This also serves to address our first research question, which is whether there are any distinct socio-demographic groups that are affected in a similar way by the pandemic. To assign a group (c) to each CBG, we utilized the generalized structural equation model (GSEM) Stata (StataCorp, 2023)[7] routine based upon the percentage of White, Hispanic, Asian, and Black residents (for more information on LPA, see Williams & Kibowski, 2016). We instructed the routine to assign each CBG to one of five classifications based on the highest predicted likelihood of class inclusion. Although the routine was given the number of classifications, we did not give it instruction with respect to what each classification would look like. Instead, the routine picked what the five classifications would be, and then sorted each CBG into a classification. The number of classifications chosen was based on a visual inspection of group composition. Increasing the number of groups leads to more similarly constituted groups without clear delineations.

To move from a theoretical construct to an empirical model, we aggregate individual recreational choices into CBG totals by week. We incorporate risk measures (Cases and Deaths) both as linear and squared terms. This helps control for extreme values in both variables. We interact case and death counts with WSEO to account for how risk impacts may have evolved

throughout the pandemic. Linear and squared temperature and precipitation variables are also included to account for extremely hot or wet weeks. We include other demographic controls that might impact recreational choices such as the percentage of children and elderly residents and the percentage of low and high-income residents. We also control for variations in visitation due to the time of year by including month-fixed effects that account for differences in visitation between months. Lastly, we normalize the visitors per CBG to a rate of visitors per week per 1,000 residents to facilitate analysis across CBGs of different sizes. This allows us to specify equation 2 in the following form:

$$\begin{aligned}\frac{(Visitors\ x\ 1,000)}{Population_{cw}} &= \beta_0 + Cases_{cw}(\beta_1^A + \beta_1^B WSEO_w + \beta_1^C WSEO_w^2) \\ &+ Deaths_{cw}(\beta_2^A + \beta_2^B WSEO_w + \beta_2^C WSEO_w^2) \\ &+ \beta_3^A Temp_{cw} + \beta_3^B Temp^2{}_{cw} + \beta_4^A Precip_{cw} + \beta_4^B Precip^2{}_{cw} \\ &+ \sum_{i=1}^{4} Group_c^i(\beta_{4+i}^A + \beta_{4+i}^B WSEO_w + \beta_{4+i}^C WSEO_w^2) \\ &+ \sum_{k=1}^{11} \beta_9^k Month_w^k + \beta_{10}^A WSEO_w + \beta_{10}^B WSEO^2{}_w \\ &+ Inc25k(\beta_{11}^A + \beta_{11}^B WSEO_w + \beta_{11}^C WSEO_w^2) \\ &+ Inc200k(\beta_{12}^A + \beta_{12}^B WSEO_w + \beta_{12}^C WSEO_w^2) \\ &+ Age19(\beta_{13}^A + \beta_{13}^B WSEO_w + \beta_{13}^C WSEO_w^2) \\ &+ Age55(\beta_{14}^A + \beta_{14}^B WSEO_w + \beta_{14}^C WSEO_w^2) + \varepsilon_{cw}\end{aligned} \tag{2}$$

The latent classification implicitly controls for sociodemographic data, which were time-invariant in our data. Concerns regarding differential access between groups can be alleviated in equation 2 through a fixed effects estimation, which eliminates time-invariant measures such as park placement. However, this transformation will remove all other time-invariant measures, including group classification, age, and income concentrations. Vaccines were unavailable during the study period, so vaccination rates were not included in our model.

IV. Results

Interpretation of the community classifications is important for our recreational choice context. The mean group compositions of all five types are pictured on the top row of Figure 2. Group 1 was composed of CBGs that were highly homogenous and predominantly White

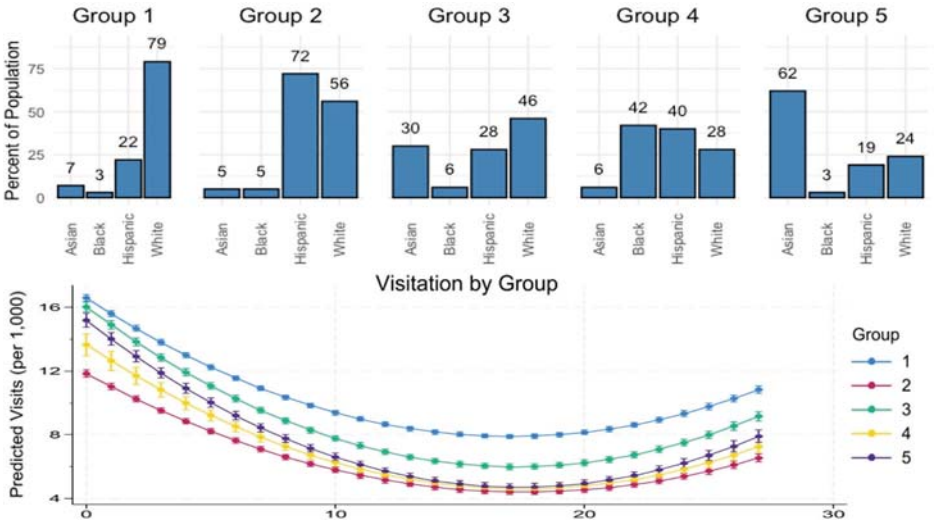

Figure 2. Group Composition and Visitation. Racial/ethnic groups visitation changes to local parks during the COVID-19 pandemic. The top row displays the ethnic/racial composition of each of the five groups formed via latent classification analysis (LCA). The bottom row displays the expected number of weekly visitors per 1,000 census block group residents since the United States' emergency order (WSEO) on March 13, 2020 (week = 0).

residents (N = 10,541). This group composition represents the most common neighbourhood in our visitation data. Group 2 was primarily Hispanic and White residents (N = 6,575). Group 3 was primarily White but included some Asian and Hispanic residents (N = 3,641). Group 4 was composed of neighbourhoods with primarily Black residents but also included a relatively large number of White and Hispanic residents (N = 1,008). Lastly, Group 5 was communities of predominantly Asian residents with little heterogeneity (N = 1,447).

Selected regression results for the five community types are presented in Table 2, where the three columns correspond to alternative estimation decisions. In column 1, we report the estimation of equation 1 using random effects to control for within-group correlation over time. This approach assumes that no unobserved, time-invariant effects correlate with our controls of interest. In column 2, we estimate equation 5 using fixed effects, which eliminates the individual group intercepts, as well as other concerns with park access and neighbourhood amenities. The group interaction with WSEO remains and provides a check to ensure that bias in the random effects estimation is not impacting inference. In column 3 we re-estimate column 1 and include the additional income and age strata to assess the layering effects of varying identities.[8]

We find that overall, all communities recreated at lower rates at the onset of the pandemic. The base impact, which corresponds to group 1 ('White') communities suggests that during the week after the emergency order, on

Table 2. Empirical results.

	(1) Random Effects	(2) Fixed Effects	(3) Random Effects
WSEO	−1.1636***	−1.1637***	−1.5622***
$WSEO^2$	0.0342***	0.0342***	0.0471***
% Age <19			0.0912***
% Age < 19 X WSEO			0.0055*
% Age > 55			−0.0369***
% Age > 55 X WSEO			0.0116***
% Income < $25 K			−0.0641***
% Income < $25 K X WSEO			0.0025***
% Income > $200 K			0.1098***
% Income > $200 K X WSEO			−0.0076***
COVID Cases	−0.0047***	−0.0048***	−0.0047***
COVID Cases X WSEO	0.0007***	0.0007***	0.0007***
COVID Deaths	−0.2916***	−0.2898***	−0.2894***
COVID Deaths X WSEO	−0.0376***	0.0375***	0.0376***
Mean Temperature (C)	0.1290***	0.0784***	0.0836***
Mean $Temperature^2$ (C)	−0.0026***	−0.0017***	−0.0022***
Precipitation (in)	−0.7355***	−0.7453***	−0.7601***
$Precipitation^2$ (in)	0.0427***	0.0437***	0.0452***
Group 2	−5.5550***		−4.7511***
Group 2 X WSEO	0.1973***	0.1976***	0.1723***
Group 2 X $WSEO^2$	−0.0066***	−0.0066***	−0.0058***
Group 3	−0.3278 +		−0.5643**
Group 3 X WSEO	−0.1914***	−0.1924***	−0.1435***
Group 3 X $WSEO^2$	0.0053***	0.0054***	0.0003***
Group 4	−4.3605***		−2.9412 ***
Group 4 X WSEO	0.0276	0.0265	−0.0154
Group 4 X $WSEO^2$	−0.0017	−0.0017	0.0003
Group 5	−0.9618***		−1.4068***
Group 5 X WSEO	−0.2392***	−0.2412***	−0.1863***
Group 5 X $WSEO^2$	0.0065***	0.0066***	0.0048***
N	1,433,020	1,433,020	1,432,432
R^2	0.11	0.07	0.13
Time Effects	Month	Month	Month

All empirical estimates include monthly time controls and vary by use of random effects (columns 1,3), fixed effects (column 2), and inclusion of (dis)advantageous controls for income and age. *p < 0.1 *p < 0.05, **p < 0.01, ***p < 0.001

average, visitation to local parks decreased by 1.1 visits per 1,000 residents ($\frac{\partial Visits}{\partial WSEO} = -1.1636 + 0.0684 * WSEO$). The positive and significant effect on $WSEO^2$ informs us that visitation declines did begin to rebound after the emergency order declaration. The interaction between the group indicator and $WSEO^2$ informs us of average differences in response rates by community types. For example, the predominantly Asian group (Group 5) had a more pronounced immediate decrease (an additional 0.24 decline per 1,000 residents) but had a slightly faster rebound (0.013*WSEO) relative to the base community. Group 2 had less of an immediate decline relative to the base group but failed to recover as quickly. In addition to changes in local park visitation during the pandemic, we also report differences in base visitation pre-pandemic among community groups. Groups 2 and 5 produced 5.6 and 4.4 fewer visits per 1,000 per week residents than the base community. Whereas Groups 3 and 5 recreated less frequently at local parks than Group 1, the decline is not as severe. Graphical representations of starting visitation and predicted visitation changes throughout the

pandemic by sociodemographic group are presented in the bottom row of Figure 2. The graph illustrates the discussion points above, highlighting different starting recreation visits and changes in recovery. The predominantly White group (Group 1) both started and ended with higher average visitation than all other groups. Conversely, the predominantly Asian group (Group 5) experienced the most significant decline among all types of communities. The low R^2 statistics indicate that there was still a large amount of unmodeled variation in our visitation data. However, given the statistical significance of our sociodemographic variables of interest, as well as the coefficient on the WSEO variable, we can still determine that these had a statistically significant impact on visitation.

On average, results show that pandemic information signals were associated with changes in recreating patterns. Communities were less likely to recreate outdoors as local COVID-19 cases rose, as evidenced by the negative coefficients on the case and death controls. We find differences in these adaptive responses as the pandemic progresses. As time elapsed beyond the emergency order, confirmed COVID-19 case counts were associated with increasing patterns in outdoor recreation. However, as confirmed deaths related to COVID-19 increased later in the pandemic, visitation lessened. Our results suggest these effects attenuate over time, given the sign on the quadratic term.

We report the expected effects of weather impacts on visitation rates. As the mean temperature in a county rises, so too does visitation to local parks. However, the negative sign on the quadratic temperature control suggests diminishing effects are associated with rising temperatures. Cumulative precipitation is associated with lower visitation rates, and this effect also attenuates as precipitation volumes rise.

We turn to column 3 of Table 2 to interpret the potential issues of intersectionality associated with pandemic visitation patterns. We find that communities with more children visited local parks at higher rates. Every one percent increase in the percentage of CBG residents under 19 is associated with a 0.09 increase in visitation. During the pandemic, outdoor recreation amongst these younger communities also increased relative to older communities. Older communities, as measured by the percentage of CBG residents over 55, were associated with lower visitation rates overall. Every one percentage increase in the share of residents over 55 is associated with a 0.04 decrease in mean visitation per 1,000 residents. Communities with higher shares in this age group are associated with higher visitation rates during the pandemic. Communities with a higher share of households earning less than $25 K were also associated with lower visitation rates. On average, every one percent increase in the low-income earners is associated with 0.06 fewer visitors per 1,000 residents. Interestingly, these

Table 3. Changes in vulnerable characteristics.

	GROUP 1				GROUP 5			
WSEO	0	9	18	27	0	9	18	27
At Means	17.3	11.7	10.6	11.2	15.9	9.0	7.8	9.5
−1 SD Income < $25 K	18.2	12.3	11.2	12.1	16.3	9.3	8.1	9.8
+1 SD Income < $25 K	16.2	10.9	9.8	10.1	15.4	8.6	7.4	9.0
−1 SD Age 55+	17.8	11.5	10.2	11.1	15.0	8.3	7.2	9.2
+1 SD Age 55+	16.9	12.0	11.0	11.4	16.8	9.8	8.4	9.8
−1 SD Income < $25 K & Age 55+	18.6	12.1	10.8	11.9	15.4	8.6	7.5	9.5
+1 SD Income < $25 K & Age 55+	15.7	11.1	10.2	10.3	16.3	9.4	8.0	9.4
	Mean	Min	Max	SD	Mean	Min	Max	SD
% Income < $25 K	13.4	–	85.3	11.0	12.7	–	77.2	11.2
% Age 55 +	31.7	–	98.2	10.5	29.2	0.2	55.7	7.7

Mean weekly counterfactual visitation (per 1,000 residents) with changes in vulnerable groups.

communities were associated with lower reductions in visitation during the pandemic. Communities with a higher share of households earning more than $200k were, on average, associated with higher visitation rates pre-pandemic.

IV.i Counterfactual exercise – multiple hierarchy stratification

There are reasons to believe that certain strata of identity may layer to impact recreational responses in our setting. There is no significant variation between CBGs in several important sociodemographic classifications (e.g., gender, percentage of seniors, etc.). To further explore how these dynamics of community type and concentration of vulnerable groups affect park visitation, we perform a simple counterfactual exercise for Groups 1 and 5 (largely homogenous groups). This counterfactual aims to identify the magnitude of potential barriers that are not captured through the latent classification. We begin with the empirical specification from column 3, Table 2, individually for each group (G = 1 and 5). We first calculate average visitation rates at four intervals: pre-pandemic (w = 0), 9 weeks, 18 weeks, and 27 weeks into the pandemic.

We next create a counterfactual visitation rate by independently increasing (decreasing) the percentage of residents earning less than $25 K by a standard deviation (SD).[9] For example, to assess the impact of an increased concentration of low-income residents in predominantly White neighbourhoods on park visitation during a pandemic, we estimate equation 3:

$$VisitRate = \breve{X}^{G}_{cw}\hat{\beta} | (G = 1, X_{Low\,Income} = X_{Low\,Income} + 1SD, w = \{0, 9, 18, 27\}) \tag{3}$$

We repeat this exercise, reducing the number of low-income households. We conclude this exercise by artificially changing the concentrations of adults over 55. Table 3 provides these results and the SD used in each

counterfactual assessment. Our results are mixed based on the group under examination. For the predominantly White group (Group 1), increases in the concentration of low-income residents decreased mean visitation (pre-pandemic) from 17.3 per 1,000 residents per week to 16.2 per 1,000 residents per week. Decreasing the concentration of low-income residents in this neighbourhood type produces an uptick in the mean visitation rates. We observe a similar effect with the concentrations of residents over the age of 55. Decreasing the number of residents in this age category is associated with a slight increase in mean visitation rates. Together, we see that even in the least vulnerable community composition (Group 1), income and age are correlated with changes in visitation rates during the pandemic. The gap in visitation between older and lower-income residents declines in this community as the most affluent residents seemingly alter visitation rates more quickly.

We see some differences in visitation patterns in the predominantly Asian group (Group 5). Lowering the concentration of low-income residents is associated with a rise in predicted visitation rates, similar to Group 1. However, increasing concentrations of residents over 55 in predominantly Asian neighbourhoods is associated with more park visitation, not less. In this instance, vulnerable stratifications do not appear to layer and impede or constrain recreational choices pre- or post-pandemic.

V. Discussion and conclusion

Equitable access to outdoor nature-based recreation is a priority for policymakers and land managers (Sánchez et al., 2020; Xiao et al., 2022). Understanding how the COVID-19 pandemic impacted different communities is paramount to delivering on this priority, especially since the pandemic disproportionately affected low-income and minority populations (Russette et al., 2021). Even before COVID-19, safety concerns and limited resources influenced outdoor recreation for these groups (Martin et al., 2023). Furthermore, the literature suggests that income influences recreational choices (Powers et al., 2020; Washburne, 1978). During the pandemic, Hispanic and Black communities suffered greater economic distress than White communities due to their higher representation in sectors more vulnerable to job losses (Gould et al., 2020). These groups were also more likely to be classified as essential workers, who typically have lower wages and cannot work remotely (Blau et al., 2021). Additionally, differing attitudes and trust towards government-mandated restrictions may have contributed to the observed differences in recreational behaviour. Nadelson et al. (2014) demonstrated that minority groups often hold distinctly different attitudes to those of the general population, shaped by emotional and historical contexts.[10]

Changes in visitation to local parks, which largely stayed open during the first few months of the pandemic, have been a frequent area of study (Geng et al., 2021). We assessed local park visitation before and during the early stages of the COVID-19 pandemic in California, a large state with diverse regions and populations. Our analysis utilized latent classifications to group similar communities by demographics, allowing us to control for income and age distributions in an OLS regression. This approach helped assess how multiple barriers may compound to influence recreational changes during a crisis.[11] Our results contribute to the understanding of equity in nature-based recreation (see Byrne et al., 2009; Winter et al., 2020), showing that sociodemographic discrepancies extend beyond use patterns and into crisis responses. While differences in crisis response are widely observed in the disaster literature (Thomas et al., 2022b; Chakraborty et al., 2019), our assessment of park visitation during a pandemic is novel.

We report that an increase in households earning $25,000 or more in a community resulted in higher pre-pandemic visitation rates but larger immediate declines in park visitation rates. This contradicts the findings of Venter et al. (2020), who found that higher-income communities could increase park visitation due to workplace changes and school closures. Wealthier households may have more alternatives to outdoor recreation and are more likely to travel beyond local parks for true social distancing (Ji et al., 2022).[12] For all groups, higher income is associated with greater pre-pandemic visitation and a larger decline during the pandemic, with varying magnitudes depending on the community's racial and ethnic characteristics. This highlights the importance of considering intersectionality in empirical analysis.

Our findings indicate that pandemic-induced changes to local park visitation were unequally distributed across racial/ethnic and income groups. While pre-pandemic visitation rates varied by community sociodemographics, these differences persisted and, in some cases, widened during the pandemic. Within 27 weeks of the EO issuance, visitation rates in majority-White neighbourhoods showed the largest rebound towards pre-pandemic levels. However, neighbourhoods with higher proportions of Hispanic or Asian residents did not see recreation levels recover as quickly. Our results show that racial and ethnic characteristics relate to responses to the EO, suggesting sociodemographic differences in communities' awareness of and response to public authorities' communication. This is in line with recent studies that have shown that there are differences between how different sociodemographic groups coped with the pandemic personally or in a community setting (e.g., Alizadeh & Sharifi, 2021; Morgado et al., 2022). Furthermore, our results expanded on this general finding by showing that recovery patterns differed between sociodemographic groups. Hansen et al. (2023) found that proximity to

recreational opportunities and transportation availability impacted COVID-19 recreation activities, and resulted in permanent habit changes; however, the study was conducted in Sweden which pursued different containment policies than the United States during the pandemic. Public authorities may need to consider these factors when designing and implementing local outreach strategies. Our results also provide a basis for future research that wants to see how varied levels of park access can impact communities differently.

The analysis in this study had several limitations. The data used in this research included pre-pandemic patterns and 27 weeks of visitation post-EO. Although the analysis period was sufficient for capturing declines and recoveries in visitation for most communities, more data on visitation might provide additional insights into visitation patterns. Next, LCA-based models do not produce the effects of marginal increases in sociodemographic variables. While using LCA in recreation studies (e.g., Baerenklau, 2010) is still relatively new, we believe the results are more interpretable than linear regression with significant interaction terms and could aid in policy-based discussions for differences in recreation outcomes (Meyerhoff et al., 2019). Next, it is important to note that we cannot attribute recreational patterns to individuals; rather, we estimate changes in recreation patterns at an aggregated (census block group) level. Lastly, this study's cell phone data (Safegraph) limits coverage in rural and less-densely developed areas to protect individual identities.

The concern about recreation and adaptation during a pandemic remains salient as many expect the likelihood of pandemics to rise in the future, given human development, deforestation, and greater socio-ecological interconnectedness (Cohen, 2000; Mowatt, 2021; Tollefson, 2020). Several avenues of future research could extend our analysis. Our results highlight that when emergencies occur, differences across groups can lead to disparities in recreation responses, implying that future research needs to consider sociodemographic differences more carefully, especially those at the intersection of race/ethnicity and income. Expanding our analysis to include an endemic recovery across a greater spatial and scale might provide additional interesting and important insights. Further research might provide insights into whether social distancing and avoidance of local parks has become permanent for some sociodemographic groups or if their recovery is extremely gradual. Lastly, individual household data (recreational patterns or qualitative surveys) could be used to provide greater details into the drivers behind observed visitation changes throughout the COVID-19 pandemic, including assessing additional sociodemographic impacts like gender and education.

Notes

1. This concept is closely related to intersectionality and suggests that multiple identities or layers compound to affect social experiences and equality in various situations, including recreational choices.
2. Based on data availability.
3. In order to focus on local park visitation, we have removed data where the cell phone home location is not in California.
4. National and state parks and national forests are also more likely to be remote than local parks, which would have less reliable cell phone data coverage.
5. Defined here as 19 years or younger.
6. This approach requires the researcher to select the number of groups to split the data into. Then, the researcher specifies the characteristics used to determine grouping. A logit model is then used to predict which group each CBG belongs to.
7. The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.
8. A complete set of controls, including quadratic effects, is available from senior author.
9. We constrain counterfactual neighbourhood compositions to be between 0 and 100%.
10. For example, Black Americans tend to be more skeptical of science than White Americans, largely due to historical discrimination of Blacks in the medical field (e.g., the Tuskegee syphilis study; Corbie-Smith et al., 2002); although current experiences of racism (Penner et al., 2009) continue to compound these feelings of mistrust. Hispanics have similarly experienced medical mistreatment (e.g., forced sterilization; Stern et al., 2017) and continue to experience discrimination in both healthcare and everyday life.
11. The importance of such controls can be seen in Randler et al. (2020), who show that the quality of accessible and nearby greenspaces is an important influence on pandemic recreation.
12. For example, Larson et al. (2014b) found that higher-income individuals more frequently used gyms and recreation centres. However, these locations were closed during the stay-at-home order, prompting many higher-income households to switch to home gyms and/or online exercise classes (Dunton et al., 2020).

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