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People living in disadvantaged areas faced greater challenges in staying active and using recreational facilities during the COVID-19 pandemic

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ABSTRACT

This study aimed to understand the perceived effects of the COVID-19 pandemic on physical activity, recreation walking, and use of recreational facilities; and if the COVID-19 pandemic amplified disparities in physical activity, recreational walking, and use of recreational facilities related to the levels of neighborhood disadvantage. Recreational walking and the use of neighborhood streets and green spaces significantly decreased in high deprivation areas but not in low deprivation areas during the pandemic. While COVID-19 has negatively affected overall recreational activities, the inequitable impact on recreational walking and use of outdoor recreational facilities has been more evident in disadvantaged neighborhoods with greater deprivation.

1. Introduction

Recreational walking is vital to meet physical activity recommendations (Carlson et al., 2018). Decreased physical activity increases the risk of leading chronic problems such as cardiovascular disease, obesity, diabetes, and depression (Kraus et al., 2019), thus potentially influencing the increased COVID-19 infection (Lippi et al., 2020). Inadequate physical activity can also lead to increased social isolation and mental health problems (Peçanha et al., 2020). In contrast, time spent outside and walking for recreational purposes is strongly associated with increased well-being and physical activity (Veitch et al., 2021). To meet physical activity needs, considerable attention has been paid to the role of neighborhood streets, urban greenspaces, and urban parks as important places for people to engage in physical and social activities (Macintyre et al., 2008). In particular, accessible green spaces and safe streets are necessary neighborhood resources for the equitable promotion of recreational walking.

The COVID-19 pandemic has significantly changed daily activities, including neighborhood resources for physical activity. Initial evidence has supported that people's transport-related physical and recreational physical activities have decreased due to the closure of non-essential businesses during the pandemic (Robinson et al., 2021). On March 1,

2020, a national emergency was declared in the U.S. due to the COVID-19 outbreak, and the World Health Organization declared the global spread of COVID-19 as a pandemic on March 11, 2020. Accordingly, the city and county of El Paso declared a state of emergency on March 13, 2020. Many recreational sites, including national and state parks and indoor businesses and recreational/exercise facilities closed or operated at a limited capacity during the pandemic.

Given the recent nature of COVID-19, the extant small body of research has reported inconsistent findings about the impacts of COVID-19 on recreational activities. Some studies have found negative effects of the pandemic on recreation visits due to lockdown and stay-at-home orders (Landry et al., 2021). People also voluntarily limited the use of outdoor recreational facilities due to the perceived risk of COVID-19 infections (Parady et al., 2020). However, some studies reported increased outdoor recreational activity during the pandemic (Venter et al., 2021). The limited availability of indoor leisure or recreational activities (e.g., shopping malls, museums, gyms) could have encouraged people to choose outdoor activities (Venter et al., 2020). This increased use of outdoor activities may also reflect residents' increased time for leisure activities after the COVID-19 breakout given that many residents were working from home or were unemployed, as well as the perception that outdoor activities were safer. Emerging epidemiological studies

Abbreviations: PA, Physical Activity; MVPA, Moderate-to-vigorous physical activity; DID, Difference-in-differences; SES, Socioeconomic status; ADI, Area Deprivation Index; HD, High disadvantage; LD, Low disadvantage.

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have indicated that the risk of disease transmission is relatively lower outdoors than indoors (Nishiura et al., 2020), which may have led to a higher comfort level for residents to engage in more outdoor activities. Although these studies provide insights on changes in physical activity during the COVID-19 pandemic, further research is needed to explore how and under what conditions the COVID-19 pandemic influenced the overall physical activity and outdoor recreational activities such as recreational walking and the use of outdoor recreational facilities.

Another body of research on COVID-19 has suggested that the pandemic accelerated health disparities. People with comorbidities such as diabetes, heart disease, and respiratory diseases have typically experienced more severe COVID-19 symptoms. In addition, these conditions have a disproportionately high prevalence among minorities, those with limited income, and those living in deprived areas (Grekousis et al., 2022; Ingraham et al., 2021). Studies have also shown that neighborhoods with a higher proportion of racial/ethnic minorities and low-income persons experienced higher rates of COVID-19 hospitalization and death (Bach-Mortensen and Degli Esposti, 2021), in part because racial minorities are less likely to have access to a primary care provider (Maura and de Mamani, 2017). A major question is whether and how pandemics may exacerbate these disparities.

COVID-19-related public health recommendations and policy measures may have unintentionally worsened the disparities due to the limited resources in areas with neighborhood low socioeconomic status (SES), compared with high neighborhood SES (Louis-Jean et al., 2020). Many states and cities, including the city of El Paso, have implemented procedures to reduce the spread of COVID-19, including social distancing practices, wearing masks in public areas, working from home, and closing city parks and public schools. Although these recommendations have been critical for ensuring general public safety, the restrictions have created new challenges for people with different socioeconomic and physical conditions. For example, the working-class may have found it challenging to follow social distancing practices when they needed to work in crowded working environments. In addition, those living in poor, stressful conditions and those raising young families were more likely to be negatively influenced by COVID-19-related restrictions such as working from home and school closures (Kim et al., 2020).

Even before COVID-19, health disparities and environmental injustice were major social challenges. Studies have documented that those living in deprived neighborhoods with limited physical activity resources and unsafe neighborhood conditions have relatively poor health status (Reijneveld et al., 2000) and engage in lower physical activity and walking (Jones et al., 2009). There is also abundant evidence of environmental injustice in the distribution and use of recreational spaces (Suárez et al., 2020; Wang et al., 2021). The opportunities to engage in outdoor recreational activities vary depending on the availability of recreational facilities/resources (e.g., parks, trails, neighborhood streets), which is often tied to the socio-economic circumstances of the area. Racial/ethnic minorities and low-income people have less access to green spaces, parks, and recreational programs than their counterparts (Wolch et al., 2005). Boone et al. (2009) found that park locations and sizes differed by race, indicating that areas with more Black residents had higher park congestion than areas with prominently White residents. These environmental disparities contribute to a widening health gap.

The underlying mechanism behind how the pandemic may exacerbate disparities in overall PA and recreational walking across different neighborhood socioeconomic conditions is a complex phenomenon that is yet to be understood. However, previous literature suggested that the COVID-19 pandemic can worsen the neighborhood-level disparities of PA and recreational activities. A recent study conducted by Yang and Xiang (2021) found that neighborhoods with lower poverty rates increased PA and walking during the COVID-19 pandemic. Another study reported that those living in socioeconomically disadvantaged neighborhoods are more likely to face financial hardship due to job loss

and other disproportionate burdens during the pandemic (Hu, 2020), which may result in the lack of time/motivation for health promotion efforts, compared to those living in socioeconomically advantaged neighborhoods. Another explanation is that neighborhoods with a high level of poverty, compared to their counterparts, tend to have fewer attractive sights, more crime, and more traffic, which are major environmental barriers to physical and mental health (Yang and Xiang, 2021). People may also engage in higher PA in their yards and gardens due to the closure of gyms and other recreational facilities during the pandemic (Hudda et al., 2020). However, such an opportunity is not available to many of those in disadvantaged neighborhoods, whose residence lacks a private yard or garden. García-Esquinas et al. (2021) confirmed that poor housing conditions like lacking a terrace or garden/yard were associated with unhealthier changes in PA during COVID-19.

The above studies have improved our understanding of the disparities in overall health and behavior across different neighborhood socioeconomic conditions during the COVID-19 pandemic. However, it remains unclear how and to what extent the COVID-19 pandemic, coupled with area deprivation, have impacted the amount and pattern of PA and outdoor recreation walking. The aims of this self-reported retrospective community study are to examine 1) the perceived effects of the COVID-19 pandemic on physical activity and recreation walking (frequency and location); and 2) if the COVID-19 pandemic amplified disparities in physical activity, recreational walking, and use of recreational facilities across neighborhoods with different levels of deprivation. Using a difference-in-differences (DID) method, we hypothesized that physical activity, recreational walking, and use of recreational facilities were more likely to decrease during the COVID-19 pandemic, especially among residents living in areas with high-disadvantage (HD) compared to those in regions with low-disadvantage (LD) areas.

2. Materials and methods

2.1. Overview

This study focuses on a sample of participants living in El Paso, Texas, located along the U.S.–Mexico border. El Paso includes diverse neighborhoods with varying recreational resources and neighborhood deprivation levels, making it an ideal site for this research. Its heterogeneous neighborhood and population characteristics allow us to detect meaningful differences in the impact of COVID-19 on physical activity across different populations and neighborhoods. Based on the 2017 Behavioral Risk Factor Surveillance System (BRFSS) prevalence and trends data (Centers for Disease Control and Prevention, 2017), 44.6% of the population in El Paso county did not meet the recommended level of physical activity (150 min weekly of moderate to vigorous physical activity). In addition, about 35.6% of the total adult population were overweight or obese. El Paso is home to diverse people with respect to race/ethnicity and immigrant status, and it is economically polarized. Residents are primarily Hispanic: 81.4% Hispanic origin and 11.6% non-Hispanic White (U.S. Census Bureau, 2019). The median household income of the city of El Paso was \$47,568. Thus, El Paso requires special attention from policymakers, given the unique characteristics in geographic location and population health contexts.

A prominent geographic feature in El Paso is Franklin Mountains State Park, which extends from the northern part of El Paso to the downtown area, dividing the northern part of El Paso into the west and east sides. This state park provides the local community with the largest urban park (26,627 acres) in the El Paso region. According to the City of El Paso and Recreation Department, the city has more than 220 parks used for walking, jogging, and bicycling located throughout the city. El Paso is also ranked one of the ten safest U.S. cities with a population of over 500,000 residents (CQ Press, 2014).

2.2. Data collection approach and study eligibility

This study uses retrospective self-reported survey data, a research project funded by the U.S. National Institutes of Health (#R01CA228921). This survey was administered online during the COVID-19 pandemic between July–August 2020 to gather data on participants' experiences before and during the COVID-19 pandemic. It captured participants' demographics, socioeconomic status, and daily life changes influenced by the COVID-19 pandemic. Questions about the impact of COVID-19 were asked twice, first about a typical week immediately before COVID-19 and second about a typical week since COVID-19. For questions related to before COVID-19, respondents were asked to recall their physical activity and travel behavior in a typical week and day immediately before COVID-19 became a national emergency on March 1, 2020, and major changes were implemented in El Paso after a state emergency declaration on March 13, 2020. Similarly, for questions related to during COVID-19, respondents were asked to consider a typical week and day since major shelter-in-place recommendations and business restrictions were first implemented in El Paso in response to COVID-19. These instructions and definitions were clearly stated and highlighted in the questionnaire.

Eligible criteria for this survey only included participants who lived in El Paso, TX, and who were not full-time students. Participants were recruited from the existing participant pool from the Active El Paso study to ensure feasibility and timely completion of the survey. While the respondents came from selected areas (covering 2/3 of the entire city) within El Paso, they included fairly representative and diverse samples appropriate for this study. This sample frame included 2,481 subjects, but only 1,046 responded to the survey and provided an email address. After checking data completion and quality, we retained 725 participants for analysis, including those who completed more than 67% of the survey items, provided a valid home address, and took at least 15 min to complete the survey (as logged by Qualtrics, the online survey platform we used). Five additional participants were further excluded because the Area Deprivation Index (ADI), a pivotal study variable, was suppressed for the Census block groups where these participants resided due to low population/housing. Thus, a final sample of 720 respondents was used for analysis.

2.3. Outcome measures

The survey asked about physical activity, recreational walking, and use of recreational facilities before and during the COVID-19 pandemic with the following questions: (a) On average, how many days and minutes did/do you engage in any moderate-to-vigorous physical activity (MVPA)? (b) On average, how many days and minutes did/do you walk for recreation, sports, exercise, or leisure? and (c) During a typical week, how many times did/do you use the following locations (i.e., neighborhood streets or sidewalks, parks or trails/paths, natural green spaces or near water features) when you walk for recreation, sports, exercise, or leisure purposes? In addition to asking about their use of outdoor recreational facilities, the survey also asked about indoor recreational facilities they used for physical activity (e.g., gyms, shopping malls, and home equipment).

The questions used for the outcome variables were adapted from the short form of the International Physical Activity Questionnaire (IPAQ). For each outcome, respondents were asked to recall the number of days and the average minutes of MVPA and recreational walking per day. Total MVPA (min/week) and recreational walking (min/week) were computed by multiplying the number of days by the number of minutes. Due to the extreme values found for MVPA and recreational walking, we excluded outliers for MVPA (1,725+ minutes per week) for recreational walking (1,018+ minutes per week) before and during the COVID-19 pandemic based on having 3+ standard deviations (SD) of the mean.

2.4. Area deprivation measures

Neighborhood deprivation was measured using the ADI, a validated index used to rank neighborhoods by socioeconomic characteristics (Singh, 2003). The ADI is a factor-based index using 17 variables about poverty (e.g., median family income, income disparity, families below poverty level, households without a motor vehicle), education (e.g., population with at least a high school education), housing quality (e.g., owner-occupied housing units, median monthly mortgage), and employment indicators (e.g., employed persons in white-collar occupations) based on the 5-year estimates of the 2019 U.S. Census American Community Survey (Kind and Buckingham, 2018). A higher ADI indicates higher levels of deprivation associated with lower socioeconomic status. In contrast, a lower ADI indicates lower levels of deprivation and higher socioeconomic status. By using the ADI national rank (0–100), we created a binary indicator to categorize the data into high deprivation (ADI >85) versus low deprivation (ADI ≤85). The cutoff ADI of 85 for the binary categorization was based on the median ADI score of all census block groups (n = 439) within El Paso. The ArcGIS 9.2 Geographical Information System (GIS) was used to geocode the home locations of the survey respondents, so the corresponding census block groups could be identified to compute the ADI.

2.5. Covariates

To control for potential confounding factors associated with area deprivation and the outcome variables, we included individual and neighborhood factors that were likely to be associated (Duncan and Mummery, 2005; Mota et al., 2005). The individual sociodemographic variables included the following: age, gender, race/ethnicity (non-Hispanic Whites or others), education (college degree or more and others), marital status (married or living with a partner, divorced/widowed/separated, or never married), household income (<\$20,000, \$20,000–\$39,999, \$40,000–\$59,999, \$60,000–\$79,999, \$80,000–\$99,999, \$100,000+), and employed status (employed or not before and during the COVID-19 pandemic). The individual health factors were captured with self-reported general health conditions (1: poor, 2: fair, 3: good, 4: very good, and 5: excellent before and during the COVID-19 pandemic), and concerns about COVID-19 (yes or no). Since the COVID-19 pandemic has had a significant effect on the employment status and health condition (Angelucci et al., 2020) that potentially lead to decreased PA, we considered these two variables as time-varying covariates. For neighborhood covariates, we included the presence of outdoor recreational facilities (no presence, either parks or natural green spaces, and both parks or natural green spaces) and indoor recreational facilities (no presence, either gyms or shopping malls, and both gyms or shopping malls). We also included two perceived neighborhood environments, neighborhood aesthetics and neighborhood crime. Neighborhood aesthetics was assessed using the following survey item: “there are attractive natural sights (such as landscaping, views), buildings/homes in my neighborhood sights/buildings/homes were included in my neighborhood” (agree or disagree). Neighborhood crime was also assessed using the following survey item: “There is a high crime rate in my neighborhood” (agree or disagree). The definition of neighborhood in this questionnaire was the area within a 10-15-min walk from a participant's home.

2.6. Statistical analysis

The outcome variables, participants' MVPA, recreational walking, and use of a recreational facility, were compared between before COVID-19 and during COVID-19 measures using paired t-tests to explore their potential differences in the impact of COVID-19 between the HD and LD groups. By using a binary indicator of ADI, we considered those living in high deprivation areas as “cases” and those living in low deprivation areas as “comparisons” in this study. By including the

comparison group, we could examine the before and during COVID-19 differences in the outcome variables between the case and comparison groups using a DID test. This approach is advantageous over methods such as a before-and-after, case-comparison study, and interrupted time-series design. We then performed a difference-in-differences test to examine our hypothesis that the COVID-19 impact on physical activity, recreational walking, and use of recreational facilities would be stronger for those living in more disadvantaged areas (cases = HD) compared to those living in less disadvantaged areas (comparisons = LD). Finally, after checking normality and multicollinearity, we used multivariate Poisson random-effects regression models with heteroscedasticity-robust standard errors to estimate the impact of COVID-19 on MVPA, recreational walking, and the use of recreational facilities by adjusting for the covariates. We also tested fixed-effects models, which showed nearly identical results compared to the results from the random-effects models. Therefore, we only report the results from the random-effects models in the main body of this paper. Additionally, the Hausman test confirmed that the random-effects models were more suitable. We estimated parameters with Eq (1) below:

$$Y_{it} = \beta_0 + \beta_1 T + \beta_2 ADI + \beta_3 T \times ADI + \beta_4 Covariates + \varepsilon_{it} \quad (Eq 1)$$

Y_{it} is each outcome (physical activity, recreational walking, and use of each recreational facility) observed for participant i at time T (where 0 = before-COVID-19 and 1 = During-COVID-19); ADI is a binary variable to indicate whether participant i was in the HD group (value of 1) or the LD group (value of 0) based on the ADI score. β_0 is the coefficient for estimating the before COVID-19 average; β_1 captures the average change in outcomes before and during the COVID-19 pandemic among both HD and LD groups; β_2 represents the mean difference in outcomes between the HD and LD groups in both time periods; β_3 is an interaction term, DID estimator, that accounts for the difference in the changes over time between the two groups; and β_4 is the coefficient for each covariate. ε_{it} is the individual-level error term using robust standard errors recommended by Cameron and Trivedi (2009) to avoid heteroskedasticity. If β_3 is statistically significant, it can be concluded that the COVID-19 pandemic impacted the recreational walking and physical activity levels differently between the HD and LD groups. Each model was adjusted for all covariates. The variance inflation factor (VIF) test was used to assess potential multicollinearity problems among the predictors, and the results showed no serious problems (all VIFs were lower than 4). Model performance was also assessed using Akaike information criterion (AIC). All analyses were conducted using Stata 16.0.

3. Results

3.1. Characteristics of the participants

Table 1 shows the descriptive statistics of demographic characteristics of the HD, LD, and total participant groups. Overall, the average age was 44.5 (SD = 0.5), and 67.5% were female. A total of 14.4% were non-Hispanic White, which is slightly higher than citywide percentage of 12.8%, 50.1% held a college degree or above (similar to 52.4% at the city level) according to the 2019 U.S. Census. More than half of the respondents reported an annual household income below \$40,000, which is lower than citywide median of \$47,568. Overall, our sample was comparable to the general population in the city of El Paso in terms of the key demographic and socioeconomic variables, which were further tested during the analysis process. Among the 720 respondents, half of them (n = 353, 49%) lived in high disadvantaged areas according to the above-the-median ADI score of all census block groups in El Paso, which was shown in Fig. 1. This showed that our study sample was spatially well-balanced within the entire city of El Paso. Regarding the difference between the HD and LD groups, there was a higher education level (p < 0.001) and a higher household income (p < 0.001) in the LD group compared to the HD group. Significant case-comparison differences were found for the before-COVID-19 perceptions of the neighborhood

Table 1

Descriptive Statistics: Demographics and recreational walking behavior between high disadvantaged areas and low disadvantaged areas before COVID-19.

	Mean (S.E)/Frequency (%)			Δ Change	p-value
	Total (n = 720)	HD (n = 353)	LD (n = 367)		
Individual covariate					
Age ^a	44.56 (0.52)	43.96 (0.72)	45.13 (0.76)	-1.17 (1.05)	0.265
Female	477 (67.66%)	235 (67.34%)	242 (67.98%)	-0.64%	0.855
Non-Hispanic White	104 (14.44%)	44 (12.46%)	60 (16.35%)	-3.89%	0.138
College degree or more	351 (50.1%)	145 (42.27%)	206 (57.38%)	-15.11%	<.001
Marital status					
Married or living with a partner	387 (54.58%)	178 (51%)	209 (58.06%)	-7.06%	0.112
Divorced, widowed, or separated	128 (18.05%)	64 (18.34%)	64 (17.78%)	0.56%	
Never married	194 (27.36%)	107 (30.66%)	87 (24.17%)	6.49%	
Household income					
<\$20,000	180 (27.65%)	118 (36.99%)	62 (18.67%)	18.32%	<.001
\$20,000-\$39,999	184 (28.26%)	93 (29.15%)	91 (27.41%)	1.74%	
\$40,000-\$59,999	110 (16.9%)	51 (15.99%)	59 (17.77%)	-1.78%	
\$60,000-\$79,999	73 (11.21%)	29 (9.09%)	44 (13.25%)	-4.16%	
\$80,000-\$99,999	52 (7.99%)	15 (4.7%)	37 (11.14%)	-6.44%	
\$100,000+	52 (7.99%)	13 (4.08%)	39 (11.75%)	-7.67%	
Employed (Before)	467 (64.86%)	222 (62.89%)	245 (66.76%)	-3.87%	
Employed (After) ^b	398 (55.28%)	186 (52.69%)	212 (57.77%)	-5.08%	0.171
Health condition (before)	3.4 (0.03)	3.37 (0.05)	3.43 (0.05)	-0.06 (0.07)	0.4116
Health condition (after) ^b	3.16 (0.04)	3.12 (0.06)	3.2 (0.06)	-0.08 (0.08)	0.301
Concerns about COVID-19	460 (64.16%)	233 (66.38%)	227 (62.02%)	4.36%	0.224
Neighborhood covariate					
Outdoor recreations					
No presence	181 (25.82%)	95 (27.62%)	86 (24.09%)	3.53%	0.418
Either parks or green spaces	345 (49.22%)	161 (46.8%)	184 (51.54%)	-4.74%	
Both parks and green spaces	175 (24.96%)	88 (25.58%)	87 (24.37%)	1.21%	
Indoor recreations					
No presence	283 (40.37%)	166 (48.26%)	117 (32.77%)	15.49%	<.001
Either gyms or shopping malls	176 (25.11%)	95 (27.62%)	81 (22.69%)	4.93%	
Both gyms and shopping malls	242 (34.52%)	83 (24.13%)	159 (44.54%)	-20.41%	
Neighborhood aesthetics	400 (56.26%)	163 (47.11%)	237 (64.93%)	-17.82%	<.001
Neighborhood crime	209 (30.87%)	122 (37.89%)	87 (24.51%)	13.38%	<.001

Note: categorical variables using a chi-square test was used to compare the results between the two groups; and neighborhoods were grouped into 2 deprivation levels: neighborhoods with ADI values in the top 50% were classified as high disadvantaged (HD) while those in the lower 50% were classified as low disadvantaged (LD).

^a Continuous variable using Student T-test.

^b Time-variant variables.

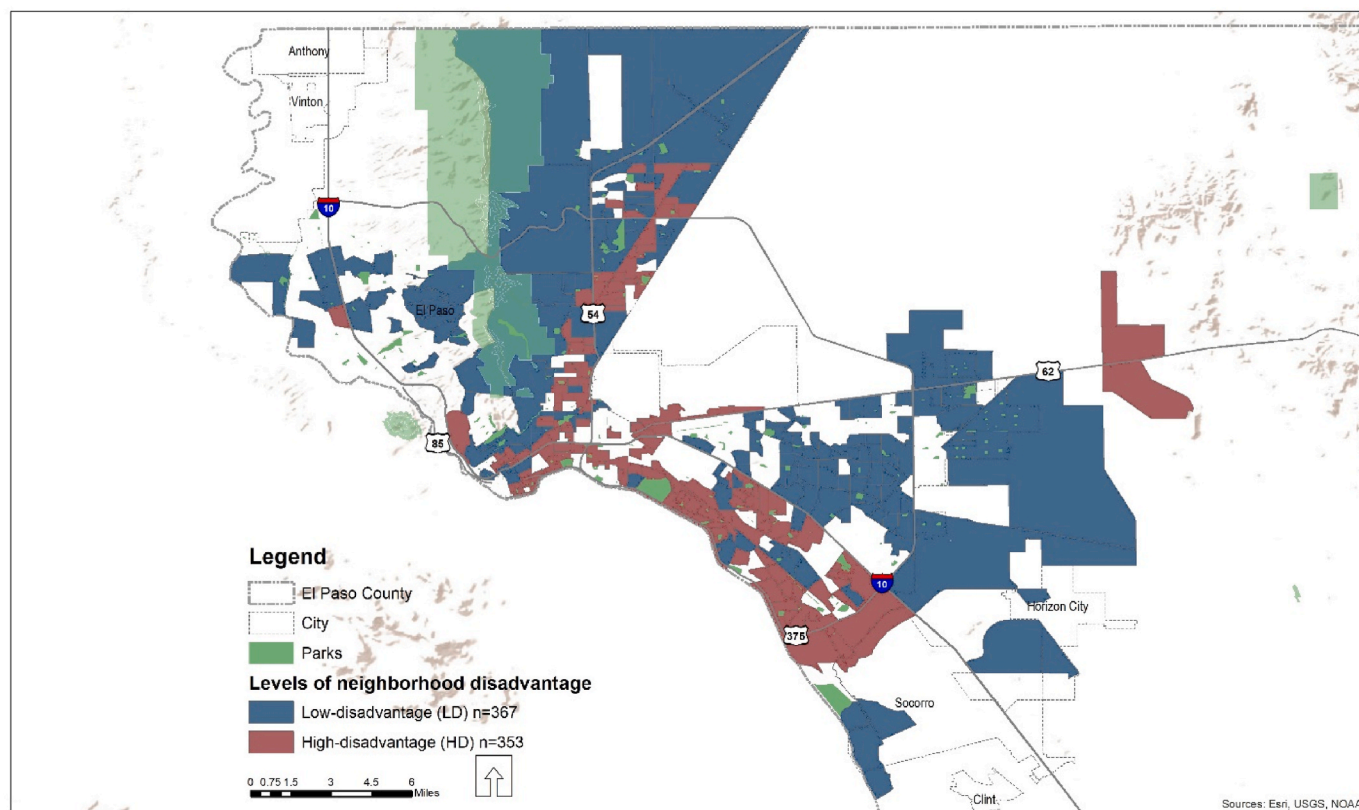


Fig. 1. Location of participants by block group and the levels of neighborhood deprivation based on the median score of area deprivation index.

environment. For example, 64.9% reported having attractive natural sights or buildings in their neighborhoods in the LD group compared to HD group (47.1%). The HD group reported greater concern about crime than the LD group (37.9% vs. 24.5%, $p < 0.001$). No differences were found between the HD and LD groups in the presence of parks and natural green spaces, but gyms and shopping malls were more available areas where the LD group lived.

3.2. HD-LD group differences in COVID-19 impacts on physical activity outcomes

Table 2 summarizes the participants' PA, recreational walking, and use of recreational facilities for the HD, LD, and total participant groups before and during the COVID-19 pandemic. For the total sample, most of the item values significantly decreased during COVID-19 compared to before COVID-19. Specifically, the average minutes of MVPA per week decreased from 197.89 (S.E. = 10.79) to 153.93 (S.E. = 10.32), while the average minutes of recreational walking per week decreased from 122.68 (S.E. = 6.08) to 103.34 (S.E. = 6). The number of visits to parks, green spaces, gyms, and shopping centers also significantly decreased during the COVID-19 pandemic. However, no significant differences were found before compared to during COVID-19 in the use of neighborhood streets and home exercise equipment.

In terms of HD and LD differences, MVPA and recreational walking showed a steep decrease only for the HD group (Δ mean Change = -52.11 , S.E. = 20.21 min/week for MVPA and Δ mean Change = -31.96 , S.E. = 11.78 min/week for recreational walking). Even during the COVID-19 pandemic, there were significant differences in the duration of recreational walking between the HD and LD groups (mean difference = -27.12 , S.E. = 12.08 min/week) although there were no disparities in the duration of recreation walking between the two groups. Compared to the period before COVID-19, we also found that the frequency of recreational use of neighborhood streets and green spaces

did not significantly decrease during COVID-19 for the LD group but significantly decreased for the HD group (Δ mean Change = -0.91 , S.E. = 0.32 time/week for use of neighborhood streets; Δ mean Change = -0.4 , S.E. = 0.1 time/week for use of green spaces). We only found a disparity in the use of neighborhood streets between the HD and LD groups (mean difference = -1.84 , S.E. = 0.58 min/week) during the COVID-19 pandemic but not before COVID-19. The number of park visits significantly decreased in both the HD and LD groups. In terms of indoor recreational areas, the use of gyms and shopping malls significantly decreased for both the HD and LD groups during the COVID-19 pandemic. There were no significant differences in home exercise equipment before compared to during COVID-19 for both the HD and LD groups.

3.3. Difference-in-differences estimate: interactions between the impact of COVID-19 and area deprivation

Table 3 depicts the model estimations for the DID regressions that examine whether the differences before and during COVID-19 in PA and recreational walking varied based on the neighborhood deprivation level measured with ADI. After adjusting for individual and neighborhood covariates, we observed a significant difference in recreational walking before and during the COVID-19 pandemic in neighborhoods (DID = -0.29 , $p = 0.013$) between the high and low disadvantaged areas (HD group: adjusted mean of 130.84 min–95.55 min vs. LD group: adjusted mean of 123.55 min–120.69 min). Fig. 2 shows a different outcome trend in that the LD group reported a minimal change in the duration of recreational walking while the HD group reported a significant decrease. Additionally, general health changes ($\beta = 0.596$, $p < 0.001$) and neighborhood aesthetics ($\beta = 0.365$, $p = 0.006$) were significantly associated with the change in MVPA after adjusting for individual and neighborhood covariates. Among the individual or neighborhood factors, the general health change ($\beta = 0.319$, $p = 0.026$)

Table 2

Descriptive Statistics: Changes in PA, recreational walking, and use of recreational facilities of participants living in more and less disadvantaged areas before and during the COVID-19 pandemic (n = 720).

	Before COVID-19 (T1)	During COVID-19 (T2)	Δ Change* (During- Before)
	Mean (S.E)	Mean (S.E)	Mean (S.E)
MVPA (min/week)			
Total	197.89 (10.79)	153.93 (10.32)	-43.96** (14.93)
HD (>50% ADI)	195.77 (14.95)	143.66 (13.59)	-52.11* (20.21)
LD (≤50% ADI)	199.95 (15.57)	163.77 (15.45)	-36.18 (21.94)
HD- LD	-4.17 (21.13)	-20.11 (21.13)	
Recreation walking (min/week)			
Total	122.68 (6.08)	103.34 (6)	-19.34* (8.55)
HD (>50% ADI)	121.35 (8.37)	89.39 (8.29)	-31.96** (11.78)
LD (≤50% ADI)	123.94 (8.82)	116.51 (8.61)	-7.43 (12.33)
HD- LD	-2.59 (12.07)	-27.12* (12.08)	
Neighborhood streets			
Total	3.16 (0.27)	2.81 (0.3)	-0.36 (0.41)
HD (>50% ADI)	2.78 (0.26)	1.88 (0.18)	-0.91** (0.32)
LD (≤50% ADI)	3.53 (0.47)	3.71 (0.57)	0.18 (0.74)
HD- LD	-0.75 (0.57)	-1.84** (0.58)	
Parks			
Total	1.59 (0.1)	0.96 (0.08)	-0.63** (0.13)
HD (>50% ADI)	1.65 (0.12)	0.97 (0.13)	-0.68** (0.18)
LD (≤50% ADI)	1.54 (0.16)	0.95 (0.11)	-0.59** (0.19)
HD- LD	0.12 (0.18)	0.03 (0.19)	
Natural green spaces			
Total	0.56 (0.07)	0.31 (0.05)	-0.25** (0.09)
HD (>50% ADI)	0.65 (0.08)	0.25 (0.05)	-0.4** (0.1)
LD (≤50% ADI)	0.48 (0.1)	0.38 (0.1)	-0.1 (0.14)
HD- LD	0.17 (0.12)	-0.13 (0.12)	
Gyms or fitness			
Total	0.97 (0.09)	0.34 (0.11)	-0.62** (0.14)
HD (>50% ADI)	0.87 (0.1)	0.27 (0.06)	-0.61** (0.12)
LD (≤50% ADI)	1.06 (0.14)	0.42 (0.2)	-0.63* (0.25)
HD- LD	-0.18 (0.2)	-0.16 (0.2)	
Shopping centers			
Total	1.27 (0.13)	0.35 (0.06)	-0.92** (0.14)
HD (>50% ADI)	1.19 (0.14)	0.38 (0.08)	-0.81** (0.16)
LD (≤50% ADI)	1.35 (0.22)	0.32 (0.08)	-1.03** (0.23)
HD- LD	-0.16 (0.2)	0.07 (0.2)	
Home equipment			
Total	1.35 (0.12)	1.83 (0.25)	0.47 (0.27)
HD (>50% ADI)	1.53 (0.18)	2.13 (0.44)	0.6 (0.47)
LD (≤50% ADI)	1.17 (0.15)	1.52 (0.22)	0.34 (0.26)
HD- LD	0.36 (0.38)	0.62 (0.39)	

Note: *: Post mean-Pre mean; T-test and * p < 0.05, **p < 0.01; HD: those living in high disadvantaged areas and LD: those living in low disadvantaged areas.

was the only significant predictor of the change in recreational walking.

Table 4 shows the DID regression results that examined whether the before and during COVID-19 difference in the number of visits to outdoor recreational areas and indoor recreational areas varied based on the neighborhood deprivation level (ADI). The interaction effects (ADI binary and COVID-19 period) were statistically significant in predicting the use of neighborhood streets (DID = -0.453, p = 0.003) and natural green spaces (β = -0.767, p = 0.026). Fig. 3 indicates that the difference in the use of neighborhood streets between the HD (the red line) and LD (the blue line) groups diverged widely before and during the COVID-19 pandemic. Specifically, the frequency in the use of neighborhood streets steadily decreased in the HD group but moderately increased in the LD

Table 3

Random-effects Poisson regression DID estimates of the effects of the COVID-19 pandemic on participants' MVPA and recreational walking based on area deprivation levels.

	MVPA		Recreational Walking	
	Unadjusted	Adjusted	Unadjusted	Adjusted
	Beta (S.E)	Beta (S.E)	Beta (S.E)	Beta (S.E)
Time	-0.25** (0.055)	-0.073 (0.072)	-0.181** (0.052)	-0.023 (0.07)
ADI	-0.037 (0.109)	0.096 (0.13)	-0.118 (0.095)	0.057 (0.133)
Time X ADI	-0.119 (0.112)	-0.036 (0.115)	-0.246* (0.106)	-0.291* (0.118)
Individual covariate				
Age ^a	0.007 (0.004)	0.006 (0.005)	0.012** (0.003)	0.01 (0.005)
Female	-0.197 (0.117)	-0.236 (0.138)	-0.104 (0.107)	-0.084 (0.122)
Non-Hispanic White	0.167 (0.152)	-0.099 (0.194)	0.293* (0.129)	-0.147 (0.155)
Education				
College degree or more	0.108 (0.111)	0 (0.135)	0.022 (0.096)	0.012 (0.115)
Marital status				
Divorced, widowed, or separated	0.037 (0.17)	0.005 (0.174)	0.035 (0.138)	0.047 (0.152)
Never married	0.047 (0.123)	-0.011 (0.141)	-0.153 (0.113)	-0.066 (0.135)
Household income				
\$20,000-\$39,999	0.052 (0.15)	0.012 (0.169)	0.019 (0.14)	0.009 (0.159)
\$40,000-\$59,999	0.402* (0.162)	0.088 (0.21)	0.111 (0.159)	-0.121 (0.19)
\$60,000-\$79,999	-0.003 (0.195)	-0.504* (0.242)	0.035 (0.176)	-0.181 (0.218)
\$80,000-\$99,999	0.442* (0.219)	-0.005 (0.28)	0.248 (0.178)	-0.075 (0.223)
\$100,000+	0.293 (0.185)	-0.103 (0.26)	0.384* (0.196)	0.05 (0.235)
Employed ^b	0.095 (0.14)	-0.048 (0.123)	0.1 (0.15)	-0.09 (0.18)
Health condition ^b	0.583** (0.107)	0.596** (0.122)	0.318** (0.119)	0.319* (0.144)
Concerns about COVID-19	-0.056 (0.112)	-0.031 (0.132)	-0.215* (0.1)	-0.136 (0.11)
Neighborhood covariate				
Outdoor recreations				
Either parks or green spaces	0.053 (0.132)	-0.059 (0.149)	0.052 (0.117)	-0.034 (0.136)
Both parks and green spaces	0.101 (0.145)	0.157 (0.209)	-0.08 (0.141)	-0.103 (0.179)
Indoor recreations				
Either gyms or shopping malls	-0.055 (0.155)	-0.019 (0.172)	0.184 (0.127)	0.213 (0.137)
Both gyms and shopping malls	0.168 (0.119)	0.134 (0.161)	0.174 (0.107)	0.182 (0.134)
Neighborhood aesthetics	0.329** (0.105)	0.365* (0.134)	0.23* (0.097)	0.21 (0.114)
Neighborhood crime	-0.036 (0.122)	0.281 (0.165)	-0.269* (0.104)	-0.002 (0.133)
Constant		2.845** (0.525)		3.336** (0.583)
Observation		965		1,034
Within-person		527		565
AIC		48,259.75		43,182.77

Note: Coefficient (Standard errors) and * p < 0.05, **p < 0.01; ADI: area deprivation index.

^a continuous variable
^b time-variant variables.

group. We also found a steeper decrease in the use of natural green spaces before and during the COVID-19 pandemic in the HD group, compared to the LD group. Additionally, none of the individual and neighborhood covariates was associated with the change in the use of

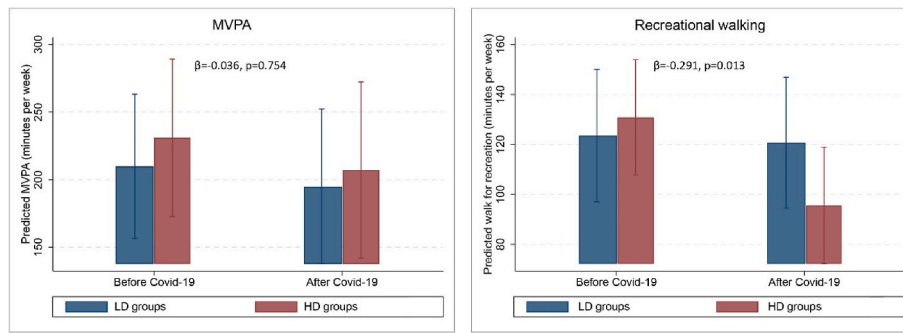


Fig. 2. The effects of the COVID-19 pandemic on MVPA and recreational walking between HD groups and LD groups using a DID approach.

Table 4
Random-effects Poisson regression DID estimates of the effects of the COVID-19 pandemic on participants' use of recreational facilities.

	Outdoor recreation areas			Indoor recreation areas		
	Neighborhood streets	Parks or trails	Natural green spaces	Gyms or fitness	Shopping centers	Home equipment
	Beta (S.E)	Beta (S.E)	Beta (S.E)	Beta (S.E)	Beta (S.E)	Beta (S.E)
Time	0.086 (0.096)	-0.494** (0.144)	-0.207 (0.266)	-0.848 (0.655)	-1.505** (0.316)	0.309** (0.115)
ADI	-0.075 (0.124)	-0.016 (0.143)	0.087 (0.257)	0.016 (0.241)	-0.467** (0.164)	0.001 (0.188)
Time # ADI	-0.453** (0.154)	-0.008 (0.181)	-0.767* (0.345)	-0.106 (0.678)	0.648 (0.407)	-0.11 (0.16)
Constant	0.741* (0.378)	-0.176 (0.475)	0.421 (0.824)	-4.545** (1.111)	0.701 (0.515)	-0.545 (0.6)
Observation	1,018	964	922	945	940	936
Within-person	555	529	504	517	515	513
AIC	4,376.16	2,804.13	1,215.99	1,698.09	2,088.34	2,445.65

Note: Coefficient (Standard errors), adjusted for all individual and neighborhood covariates; and * $p < 0.05$, ** $p < 0.01$; ADI: area deprivation index.

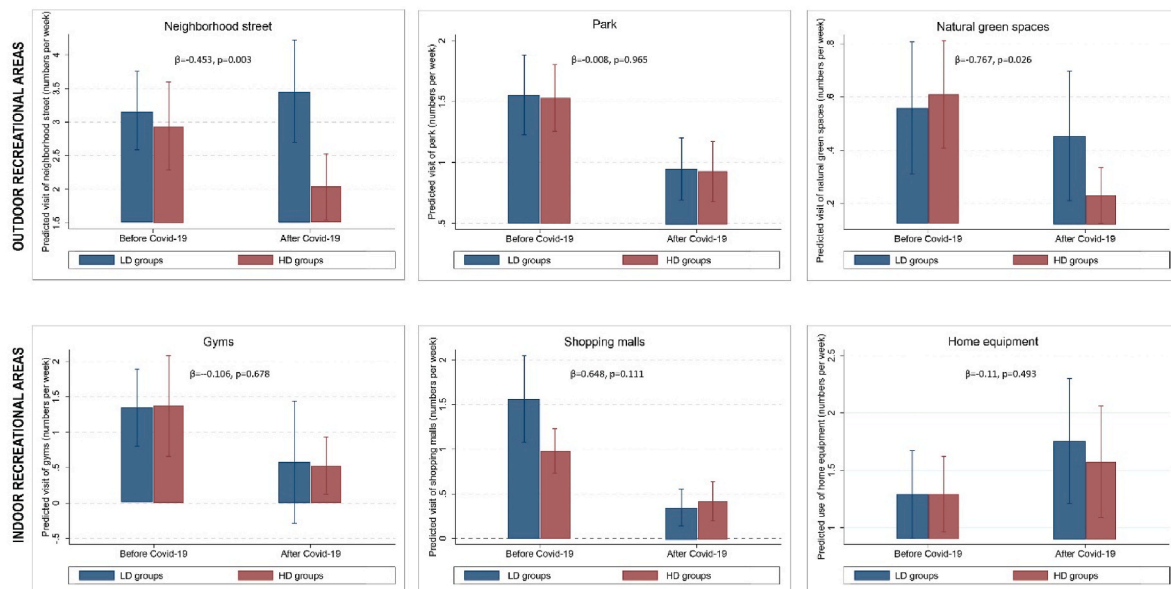


Fig. 3. The effects of the COVID-19 pandemic on the use of outdoor and indoor recreational facilities between HD groups and LD groups using a DID approach.

recreational facilities, which is not reported in Table 4.

4. Discussion

Our study aimed to identify how and to what extent a global pandemic such as COVID-19 may influence physical activity, recreational walking behavior, and use of recreational facilities among residents in the city of El Paso and investigate the role of neighborhood deprivation differences to explain disparities in daily behavioral lifestyle outcomes. First, we found that residents in El Paso significantly decreased their MVPA by approximately 22%, duration of recreational

walking by 16%, and overall use of recreational resources during the COVID-19 pandemic. Some studies have found increased outdoor recreational activities due to more time at home and to compensation of closure of indoor activities and reduced physical activity (Venter et al., 2020). However, considerable research has reported the negative impacts of the COVID-19 pandemic on physical activity due to the national and local “shelter-in-place” and “stay-at-home” orders, closures, and restrictions, and increased concerns about spreading COVID-19 (Meyer et al., 2020). Consistent with these studies (Coughenour et al., 2020; Dunton et al., 2020), our study found evidence supporting significant negative impacts of the global pandemic on recreational walking and

MVPA during the COVID-19 surge in July 2020 among residents living in El Paso, Texas, a major Mexico-US border city.

In addition to the negative impacts of COVID-19 pandemic on physical activity and recreational walking behavior, another main finding of our study is the disparate impacts of the COVID-19 pandemic on those living in disadvantaged areas. We found that the impact of the COVID-19 pandemic on physical activity and recreational walking was significantly greater for those living in more disadvantaged areas (e.g., the HD group). After adjusting for individual and neighborhood covariates, the HD group showed a large reduction in the overall duration of weekly MVPA (adjusted $\Delta = -23.89$ min/week) and recreational walking (adjusted $\Delta = -35.29$ min/week) but the LD group reported only marginal changes in their MVPA (adjusted $\Delta = -14.8$ min/week) and almost no change in their recreational walking (adjusted $\Delta = -2.86$ min/week).

Further research is warranted to understand the mechanism of how the COVID-19 pandemic interacts with neighborhood SES in influencing PA and recreational walking. Our results suggested that disparities in PA and recreational walking during the pandemic are, in part, attributable to compositional and contextual effects of the neighborhood's SES. First, the neighborhood effect on PA and recreational walking using ADI is compositional, because of the socioeconomic characteristics of the individuals who live there (Ross and Mirowsky, 2008). Compared with less disadvantaged areas, participants residing in more disadvantaged areas in our study were less educated and more likely to face household financial security in terms of annual household income of less than \$20,000 (see Table 1). Several studies had confirmed that low education and low income were significantly associated with higher levels of inactivity (Beenackers et al., 2012). Especially, those living in more disadvantaged areas tend to face more financial challenges and COVID-19 related challenges that may increase symptoms of anxiety and depression as well as decrease PA and recreational activities (Gur et al., 2020; Yang and Xiang, 2021).

Beyond compositional characteristics of area deprivation, consistent with other studies (Turrell et al., 2010) this study provided further evidence of significant area differences in PA and recreational walking supporting significant contextual effects. Those residents living in HD areas had more concerns about crime and reported poorer neighborhood aesthetics ($p < 0.001$), compared to those living in LD areas. We also found that neighborhood aesthetics was significantly associated with changes in PA after adjusting for the covariates and associated with changes in recreational walking in the unadjusted model. More disadvantaged areas or low-income neighborhoods often lack safety attributes and neighborhood aesthetics, which contribute to physical inactivity (van Lenthe et al., 2005). Yang and Xiang (2021) also found that people living in neighborhoods with a low poverty level were more likely to observe increased aesthetics and decreased traffic during the COVID-19 pandemic.

The COVID-19 pandemic may influence in equal use of outdoor recreational facilities by where people live, which was possibly associated with the disparities of PA and recreational walking by neighborhood SES. We found that the LD group increased their use of neighborhood streets (adjusted $\Delta = +0.29$ times/week) but the HD group reported decreased use of neighborhood streets (adjusted $\Delta = -0.9$ times/week). We also found an approximately four times greater decrease in the use of natural green spaces for the HD group (adjusted $\Delta = -0.38$ times/week) while only a minimal decrease in use of natural green spaces (adjusted $\Delta = -0.1$ times/week) for the LD group. This disparity of using outdoor recreational facilities is possibly because that high-income neighborhoods are more likely to have better sidewalk conditions (e.g., clean and well-maintained), better quality of natural green spaces, less crime, more favorable esthetics, and better access to recreation facilities (Lovasi et al., 2009). Such environmental inequalities may encourage the residents in less disadvantaged areas to be engaged in physical activity and walking on their neighborhood streets even during the pandemic. Inequalities in community-level streets and

green space management due to disparate budget cuts during the COVID-19 pandemic could have exacerbated the inequalities in access to well-maintained and clean neighborhood streets and green spaces between low- and high-income areas (Geary et al., 2021).

It is also noteworthy that the use of parks, gyms, and shopping malls significantly decreased during the COVID-19 pandemic for both the HD and LD groups. It may be that all residents avoided visiting indoor recreational facilities (i.e., gyms and shopping malls) regardless of the area deprivation where they lived due to the perceived risk of COVID-19 and associated measures such as closures, restricted and limited-capacity operations, and mask mandates (Joseph et al., 2021). In addition, effective March 10, 2020, city parks were closed with the exception of trails and walking paths, which impacted all residents regardless of the area deprivation where they lived. Although there was no significant increase in the use of home exercise equipment in both the HD and LD groups, recent studies have highlighted the importance of home fitness apps and home gym equipment (e.g., indoor bike, treadmill) to maintain physical and mental well-being during the COVID-19 pandemic (Nyenhuis et al., 2020).

Contrary to expectation, this study revealed no evidence suggesting spatial inequalities in the presence of outdoor recreational areas (i.e., parks or natural green spaces) between low deprivation areas and high deprivation areas in our study community of El Paso. Residents in more disadvantaged areas had equal or more access to and use of parks and green spaces before the COVID-19 pandemic, and they had similar access to outdoor recreational facilities. This is inconsistent with a previous national study on spatial disparities in green space coverage (Wen et al., 2013), which reported that census tracts with higher poverty had lower exposure to green spaces. The difference in El Paso may be due to the unique geographic context with the Franklin Mountains State Park covering a significant proportion of the land area in the city, providing easy and affordable resources especially for those who are economically disadvantaged. Despite the lack of evidence of spatial inequalities in outdoor recreational areas across the neighborhoods in our study, we found more indoor recreational facilities and slightly higher use of indoor recreational facilities (i.e., gyms and shopping malls) in less disadvantaged areas before the COVID-19 pandemic. This finding is somewhat consistent with previous studies showing that people in high socioeconomic neighborhoods were more likely to use indoor recreational facilities compared to those in low socioeconomic neighborhoods (Giles-Corti and Donovan, 2002).

4.1. Limitations

A few limitations of this study that are typical of community-based environmental studies should be acknowledged. First, generalization may be limited as this study was conducted on one urban area in TX, located along the U.S.–Mexico border. Second, we used a retrospective survey administered during the COVID-19 pandemic, relying on respondents' recalled self-reports of past physical activity and walking patterns for the before COVID-19 data. While recalling daily routine behaviors has generally been shown to be reasonably reliable, especially when the intervention is a major/significant event such as COVID-19 in this case (Ghesquière et al., 2021; Schuch et al., 2021), there may still be recall bias. Participants may also have different time frames in mind when responding to our survey questions referring to the before and during COVID-19 pandemic timeline. Such inconsistencies could have introduced additional measurement bias especially for the pre-COVID-19 daily activity questions. A potential seasonal mismatch between the before and since COVID-19 timeframe is another limitation. While we tried to reduce this issue by using a "typical" week, respondents might have referred to different seasons such as the winter months prior to the mid-March national emergency declaration and the spring months for the since-COVID-19 questions. However, we do not believe our hypotheses (testing the PA impacts shown as "decreased" levels since COVID-19) is compromised since the spring season typically

favors higher PA levels. Additionally, we were unable to employ objective measures (e.g., accelerometer and GPS) to collect outcome data due to the retrospective nature of this study, making it subject to potential bias associated with the self-report method.

Another limitation is that we only considered one typical week before COVID-19 and one typical week during COVID-19. Data from multiple time points could have offered additional insights, especially given the dynamic and evolving nature of the COVID-19 pandemic. However, collecting such data would pose an excessive burden on the respondents and thus could reduce the response and completion rates. It could also increase the recall bias by asking respondents to recall multiple time points with unclear or less meaningful differences between them. Additionally, we were only able to collect responses from participants with internet access as we had to rely on online surveys to follow the restricted COVID-19 research protocols required by the University. Not allowing an in-person option can lead to selection bias. The respondents were also recruited from a parent study so that potential impact of attending the parent study prior to this study may exist due to potential intervention of related knowledge and perception on physical activity. Finally, we were unable to measure the changes in neighborhood environmental conditions during COVID-19 and the quality and affordance of each recreational facility. We acknowledge that this is a limitation in the current study but calls for further investigation of the mechanisms of how and to what extent neighborhood attributes may interact with the COVID-19 pandemic in influencing the changes in physical activity, recreational walking, and the use of each recreational facility.

4.2. Policy implications

Urban planners, social scientists, public health experts, and policy-makers have had a longstanding interest in addressing disparities in exposure to health risks and in the availability of healthy resources such as public open spaces and recreational spaces. However, spatial disparities continue to remain in most communities in the U.S. For example, the low-income group with poor access to green spaces and PA resources were more likely to have health problems (Day, 2006). Disparities in access to PA facilities and resources are directly associated with unequal opportunities for healthy lifestyles and with increased health risks in disadvantaged areas (Day, 2006). Our findings provide new evidence that the COVID-19 pandemic accelerated health disparities associated with the impacts on physical and recreational activities, which were important coping mechanisms during COVID-19. Because the impact of COVID-19 was not equally distributed, policymakers should consider the contribution of neighborhood resources (e.g., safe local streets and green spaces) as important social determinants of health. The availability of recreational facilities as well as the quality and maintenance of such facilities could contribute to the disparities in terms of the impact of COVID-19 on recreational walking. For example, routine cleaning and disinfection were necessary for outdoor recreational facilities during the COVID-19 pandemic because people frequently touched hard surfaces and objects, such as handrails and benches. Creating safe and attractive environments has also the potential to mitigate health disparities associated with the impact of COVID-19 on physical/recreational activities. Thus, it is important for each neighborhood to not only have easy access to green spaces and walkable streets, but also to ensure the safety and attractiveness of the spaces to improve the safe and equitable use through the design and maintenance of these resources. Finally, the recent surge in the COVID-19 delta variant highlights the need for long-term policy and equity planning efforts to adopt affordable and equitable designs of neighborhood streets and outdoor spaces to cope with global pandemics and future hazards while promoting daily PA and walking.

5. Conclusion

Recreational walking and outdoor recreational facilities are important to support people's physical activity and mental health (Blair et al., 2004). Especially in these unprecedented times of uncertainty and stress, regular physical activity such as recreational walking in the neighborhood is a safe and affordable way to stay active and reduce social isolation. However, these activities have significantly declined due to the fear of COVID-19 infections and preventive measures that limit travel and gathering activities. Efforts to reduce the transmission of COVID-19 have had unintended adverse consequences on health and well-being, especially for those living in disadvantaged areas with limited access to health resources. This retrospective study indicates that the COVID-19 pandemic has had a negative impact on recreational walking and use of recreational facilities, but the impact has not been equal across different neighborhoods. Residents in more disadvantaged areas were more likely to decrease the time spent in recreational walking and visits to outdoor recreational sites than those in less disadvantaged areas. Although further research is needed to analyze the predictors of the changes in recreational walking due to COVID-19, the provision of safe and attractive recreational facilities, especially in disadvantaged areas, appear important to help mitigate health disparities. Our results are aligned with the increasing call to provide accessible nature and safe neighborhood streets to promote the health and well-being of urban residents, and mitigate negative COVID-19 impacts during peak, post-peak, and post-pandemic periods.

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