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Did Playground Renovations Equitably Benefit Neighborhoods in Chicago?

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Abstract Between 2013 and 2016, the Chicago Park District renovated 327 playgrounds in need of repair across Chicago through a $44 million investment. This study evaluated whether short-term and longer-term impacts of renovations on park use and park-based moderate-to-vigorous physical activity (MVPA) differed by neighborhood income level and neighborhood concentration of Black residents. A total of 39 parks with renovated playgrounds and 39 matched comparison parks with playgrounds that needed repair but not selected for renovation in year 1 were studied. Three waves of observational data were collected at each park: baseline, 12 months post-renovation, and 24 months post-renovation. Difference-in-differences mixed-effects Poisson regression models estimated renovation effects. The effects of renovations differed by the income level and concentration of Black residents in the neighborhoods where parks were located. In low-income neighborhoods, renovations were associated with reductions in park use and park-based MVPA over the longer term. In contrast, renovations were associated with short- and longer-term increases in park use and park-based MVPA in medium-income neighborhoods and with longer-term increases in MVPA in high-income neighborhoods. Renovations were generally not associated with any changes in park use or park-based MVPA in high-percent Black neighborhoods, but they were associated with increased park use and park-based MVPA in low-percent Black neighborhoods. This study suggests playground renovations in Chicago may have had unintended consequences, increasing neighborhood income and racial disparities in park use and park-based MVPA. Future playground renovation efforts may need to allocate more resources for renovating the broader park where in disrepair, more intensely involve neighborhood residents, and employ complementary strategies such as additional park programming to ensure renovations benefit all neighborhoods.

Keywords Park · Physical activity · Equity · Race · Socioeconomic status

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Introduction

Physical activity is protective against a wide variety of chronic health conditions [1–3]. Parks are important public resources for leisure-time physical activity [4–6], with a study of 10 parks located in 5 US cities estimating that parks provided an average of 4000 h of use and 1500 h of moderate-to-vigorous physical activity (MVPA) per week [5]. Yet, in some cities, parks are less prevalent in low-income neighborhoods and neighborhoods of color than in higher income neighborhoods and White neighborhoods [7–9]. More commonly, parks that are located in low-income neighborhoods and neighborhoods of color suffer from neglect and insufficient funds for upkeep [8]. A number of studies have shown that parks in these neighborhoods tend to have poorer maintenance and be of lower quality [9–15]. Not surprisingly then, some research has demonstrated that park use and park-based MVPA are lower in low-income neighborhoods and neighborhoods of color [16–18] and that parks in these neighborhoods are underutilized by local residents for physical activity [19, 20].

With some exceptions [21, 22], most studies have found at least some evidence that park and playground renovations have positive effects on use or physical activity [23–33]. However, few have focused on understanding the equity impacts of park and playground renovations. Although they may not necessarily reduce any disparities in park use or MVPA unless targeted at low-income neighborhoods and neighborhoods of color, renovations may lead to similar benefits across neighborhoods in terms of use and MVPA. Yet, the theory of fundamental causes proposes, in part, that socially advantaged populations have more resources to leverage to take advantage of new developments to promote their health [34]. This perspective suggests that park and playground renovations may have inequitable benefits. For example, higher income and White neighborhoods may have more park programming and greater safety and their residents may have more time that enable them to make use of renovated parks and playgrounds. Low-income neighborhoods and neighborhoods of color may not have these same resources and thus may not benefit to the same extent from renovations.

Through the Chicago Plays! Initiative, between 2013 and 2016, the Chicago Park District invested $44 million to renovate 327 playgrounds in need of repair across Chicago. A noteworthy feature of the initiative was the engagement of community groups in the renovation process. Drawing on 39 of the 61 playgrounds ultimately selected for renovation during the Initiative's first year and matched comparison parks, we designed a study to examine the impact of park renovations on park use and park-based MVPA. Previously, our team reported that, in general, park use and park-based MVPA increased substantially in the first 12 months after renovation [28]. In this study, we evaluated whether short-term (12 months post-renovation) and longer-term (24 months post-renovation) impacts of renovations on park use and park-based MVPA differed by neighborhood income level and neighborhood concentration of Black residents.

Methods

Design and Sample

We used a quasi-experimental design and difference-in-differences (DID) estimation method, studying 39 parks with renovated playgrounds and 39 matched comparison parks without renovated playgrounds [28]. The 39 intervention parks were located in 33 of Chicago's 77 community areas and were renovated between August and November 2013. Comparison parks were limited to those remaining 266 parks that needed repair but were not selected for renovation in year 1 of the initiative. Parks were matched on park size and features, proximity, neighborhood median household income, and neighborhood racial/ethnic composition. By spring 2014, nine original comparison parks were renovated and, thus, were classified as intervention parks at 12-month follow-up. By spring 2015, seven original comparison parks were renovated and thus were classified as intervention parks at 24-month follow-up. We collected three waves of data at each park: baseline, 12-month follow-up, and 24-month follow-up resulting in longitudinal data at the park level.

Measures

Park Use and Park-Based MVPA At each wave, the System for Observing Play and Recreation in Communities (SOPARC) [35, 36] was used to measure (a) park use defined by the number of people using the park, and (b) park-based MVPA defined by the number of park users engaged in MVPA. As described previously [28], at baseline (July–October 2013), trained raters collected data at each park on one weekday (Thursday or Friday) and one weekend day (Saturday). With the receipt of

additional study resources, data collection expanded to include an additional weekday for the 12-month follow-up (July–October 2014) and the 24-month follow-up (July–October 2015). Raters conducted four observations at each park on each selected day. On weekdays, raters completed two observations between 11 am and 3 pm and two observations between 3 pm and 7 pm. On weekend days, raters completed two observations between 9 am and 1 pm and two observations between 1 pm and 5 pm. For the observations, parks were divided into zones or small observation areas; each park had between one and eight zones. The same zones were used at each wave. In each zone, trained observers counted individuals and coded individual behavior into one of three activity levels (sedentary, walking/moderate intensity, and vigorous intensity) during brief left to right scans of each zone. Inter-rater reliability averaged 0.91 across baseline, 12-month, and 24-month follow-up raters. To construct our outcome variables for each data collection wave, daily counts were summed across time and park zones, and then averaged across days in order to derive the mean number of people observed per day at each park and the mean number of people engaged in MVPA per day at each park.

Neighborhood Income Level and Racial/Ethnic Composition Each park was geocoded to a census tract, which we used to represent the park's neighborhood. The 2011–2015 American Community Survey (ACS) 5-year estimate data characterized median household income and racial/ethnic composition. We categorized median household income based on the sample distribution as low (approximately 25% of sample), medium (middle 50% of sample), and high (approximately 25% of sample). Racial/ethnic composition was based on the percentage of residents who were non-Hispanic Black or African American, non-Hispanic White, and Hispanic or Latinx. We categorized neighborhoods into low, medium, or high for each group. These were < 20 (low), 20–80 (medium), and > 80 (high) for percentage non-Hispanic Black and percentage non-Hispanic White. Because of differences in the distributions in the city and our sample, we used < 10 (low), 10–50 (medium), and > 50 (high) for percentage Hispanic. Because the majority of parks were located in high-percent Black neighborhoods, we specifically examined differences by the concentration of Black residents in the neighborhood and controlled for other compositional differences.

Covariates As detailed previously [28], we controlled for the total number of crime incidents (on log scale) during the past 12 months within 0.25 mile of the park using Chicago Police Department data. We also controlled for several park characteristics: size in acres, quality (e.g., number of features) as measured by the Environmental Assessment of Public Recreation Spaces (EAPRS) tool [37], number of offered programs (on log scale), and physical disorder as measured by the mean of six observed items (e.g., litter, graffiti) rated on a 4-point Likert scale (none, a little, some, a lot). Another covariate was ambient temperature on observation days.

Data Analysis

To determine whether renovation effects varied by neighborhood income level and concentration of Black residents, we used DID mixed-effects Poisson regression models [38], controlling for the aforementioned covariates. A mixed-effects Poisson regression model is a generalized linear mixed model suitable for count outcomes with correlated errors and over-dispersion. The model included a random intercept to account for repeated park observations over time. Log link, the default link for Poisson models, warrants interpretation of exponentiated regression coefficients as rates of change per one unit increase in a covariate. The main regressors of park use and park-based MVPA were wave (baseline as reference group, 12 months, 24 months), group (control parks as reference group, renovated parks), neighborhood income level or concentration of Black residents (low income or low-percent Black as reference group, medium, high), and all their interaction terms. When testing for differences by neighborhood income level, we controlled for neighborhood racial/ethnic composition, and vice versa. To facilitate interpretation, we approached the modeling of change over time in the two outcomes via two separate models: short-term (12 months post-renovation) and longer-term (24 months post-renovation).

In the models, all main effects should be interpreted as conditional on values of other variables that are part of the 3-way interaction. All lower-order two-way interaction terms are interpreted as conditional on the value of the third variable. For example, the two-way interaction between wave and group is a differential effect at the reference value of the neighborhood characteristic. The 3-way interactions between group, wave, and neighborhood characteristic test our main research

question: whether renovation effects on outcomes over time differed by neighborhood income level or concentration of Black residents. The wave by group interaction term is also useful in interpreting our findings; it shows differences over time between groups in low-income neighborhoods (or low-percent Black neighborhoods). The other model parameters can be interpreted as follows. The term wave shows differences over time in comparison parks located in low-income (or low-percent Black) neighborhoods. The term group shows differences between renovated and comparison parks at baseline in low-income (or low-percent Black) neighborhoods. The terms for neighborhood income level or concentration of Black residents in the neighborhood show differences by these characteristics in comparison parks at baseline. The group by neighborhood characteristic interaction terms show whether baseline group differences vary by income level or concentration of Black residents. The wave by neighborhood characteristic interaction terms show differences across neighborhood characteristics in change over time in comparison parks. These models are sometimes referred to as a triple difference (DDD) model. We summed parameter estimates using the MARGINS command in STATA in order to derive renovation effects for particular subgroups of parks, defined by neighborhood income level or concentration of Black residents.

Results

Descriptive Statistics

Table 1 shows descriptive statistics for the study variables at baseline (wave 0). At baseline, the average number of daily park users was 32.5 (± 44.5), and the average number of daily park users engaged in MVPA was 14.7 (± 20.8). One-fourth of parks were in neighborhoods with a median household income of $27,572 or less; half of parks were in neighborhoods with a median household income between $28,478 and $57,895; and one-fourth were in neighborhoods with a median household income of at least $60,100. Overall, 38.5% of parks were located in neighborhoods with < 20% Black residents, 12.8% of parks were in neighborhoods with 20–79% Black residents, and 48.7% of parks were in neighborhoods with ≥ 80% Black residents. On average, parks in our sample were small neighborhood "tot" lots, with an average park size of 3.9 acres, two features, and 33 programs offered per year.

Table 1 Descriptive statistics at baseline ($n = 78$).

Variable	Statistic
Park use or number of users Mean (SD)	32.5 (44.5)
Park-based MVPA or number of users engaged in MVPA Mean (SD)	14.7 (20.8)
Neighborhood characteristics	
Median household income, *n* (%)	
Low: $12,333–27,572	20 (25.6)
Medium: $28,478–57,895	39 (50.0)
High: $60,100–121,541	19 (24.4)
Percent Non-Hispanic Black, *n* (%)	
Low: < 20%	30 (38.5)
Medium: 20–79%	10 (12.8)
High: ≥ 80%	38 (48.7)
Percent Non-Hispanic White, *n* (%)	
Low: < 20%	42 (53.9)
Medium: 20–79%	29 (37.2)
High: ≥ 80%	7 (9.0)
Percent Hispanic, *n* (%)	
Low: < 10%	54 (69.2)
Medium: 10–49%	17 (21.8)
High: ≥ 50–100%	7 (9.0)
Annual number of crimes Mean (SD)	661.7 (688.2)
Park characteristics	
Park size (acres) Mean (SD)	3.9 (6.7)
Park quality score Mean (SD)	18.5 (5.4)
Number of park programs Mean (SD)	33.2 (66.0)
Physical disorder score Mean (SD)	1.8 (1.6)
Temperature (F) Mean (SD)	74.3 (6.2)

Short- and Longer-Term Effects of Playground Renovation by Neighborhood Income Level

Table 2 shows models estimating short- and longer-term effects of playground renovations by neighborhood income level, controlling for neighborhood racial/ethnic composition. Short-term effects on park use and park-based MVPA are shown in the left panel; longer-term effects on park use and park-based MVPA are shown in the right panel. We begin with short-term effects on park use, displayed in the top left panel. Given our study objective, we focus on results from the wave by group term and the 3-way interaction term (wave by group by neighborhood income level).

Table 2 Regression model estimates of differences in short- and longer-term effects of playground renovations on park use and park-based moderate-to-vigorous physical activity (MVPA) by neighborhood income level.

	12 months (short-term)		24 months (longer-term)	
	Coef.	Std. Err.	Coef.	Std. Err.
Park use				
Wave (ref: Pre-renovation/baseline)	0.703	(0.123)***	− 0.257	(0.159)
Group (ref: Comparison parks)	0.706	(0.259)**	0.598	(0.216)**
Wave by group	− 0.787	(0.141)***	− 0.666	(0.173)***
Neighborhood income (ref: Low)				
Medium	0.129	(0.268)	− 0.368	(0.271)
High	0.219	(0.368)	− 1.049	(0.393)**
Wave by neighborhood income				
12 (or 24) months by medium income	− 1.074	(0.139)***	− 0.763	(0.190)***
12 (or 24) months by high income	− 0.152	(0.185)	0.143	(0.231)
Group by neighborhood income				
Intervention group by medium income	− 0.837	(0.302)**	− 0.599	(0.236)*
Intervention group by high income	− 1.129	(0.294)***	0.170	(0.254)
Wave by group by neighborhood income				
Intervention group by 12 (or 24) months by medium income	1.229	(0.164)***	1.519	(0.217)***
Intervention group by 12 (or 24) months by high income	0.784	(0.212)***	0.969	(0.266)***
Park-based MVPA				
Wave (ref: Pre-renovation/baseline)	0.838	(0.174)***	0.092	(0.214)
Group (ref: Comparison parks)	0.954	(0.288)**	1.217	(0.253)***
Wave by group	− 0.764	(0.201)***	− 1.575	(0.252)***
Neighborhood income (ref: Low)				
Medium	0.165	(0.290)	− 0.241	(0.281)
High	0.581	(0.382)	− 0.705	(0.388)
Wave by neighborhood income				
12 (or 24) months by medium income	− 0.897	(0.199)***	− 1.102	(0.254)***
12 (or 24) months by high income	− 0.271	(0.252)	− 0.604	(0.324)
Group by neighborhood income				
Intervention group by medium income	− 1.111	(0.341)**	− 1.218	(0.283)***
Intervention group by high income	− 1.309	(0.343)***	− 0.535	(0.304)
Group by wave by neighborhood income				
Intervention group by 12 (or 24) months by medium income	1.338	(0.234)***	2.717	(0.310)***
Intervention group by 12 (or 24) months by high income	0.672	(0.288)*	2.135	(0.381)***

*$p < 0.05$ ** $p < 0.01$ ***$p < 0.001$

Ref, reference group; *Coeff*, coefficient; *S.E.*, standard error

Covariates include park size in acres (log), average daily temperature, neighborhood racial/ethnic composition, physical disorder, number of programs over a year (log), crime count in quarter-mile radius around park (log), and quality of park features (EAPRS tool)

Whereas short-term changes in park use differed between renovated parks and comparison parks in low-income neighborhoods ($b = -0.787$, $p < 0.001$), there was essentially no short-term change in park use in renovated parks in low-income neighborhoods ($0.703 + -0.787 = -0.085$, $p = 0.33$) (Table 2). As evidenced by the 3-way interaction term results, the short-term effect of renovation on park use differed by neighborhood income level. Renovation was associated with an increase in park use in medium-income

neighborhoods and high-income neighborhoods, relative to low-income neighborhoods (1.229, $p < 0.001$; 0.784, $p < 0.001$, respectfully). The short-term increase in use of renovated parks relative to comparison parks located in medium-income neighborhoods was significant ($-0.787 + 1.229 = 0.441$, $p < 0.001$).

Results for short-term renovation effects on park-based MVPA are shown in the bottom left panel (Table 2), and results are similar. Once again, whereas the short-term change in park-based MVPA differed between renovated parks and comparison parks in low-income neighborhoods (-0.764, $p < 0.001$), no short-term change in park-based MVPA in renovated parks in low-income neighborhoods was observed (0.074, $p = 0.53$). The short-term effect of renovation on park-based MVPA differed by neighborhood income level. Relative to low-income neighborhoods, renovation was associated with a short-term increase in park-based MVPA in both medium-income neighborhoods (1.338, $p < 0.001$) and high-income neighborhoods (0.672, $p < 0.05$). Similar to the finding for park use, the short-term increase in MVPA in renovated parks relative to comparison parks located in medium-income neighborhoods was significant (0.574, $p < 0.001$).

Table 2 also shows results for longer-term effects of renovation on park use (top right panel) and park-based MVPA (bottom right panel) by neighborhood income level. The longer-term change in park use differed between renovated parks and comparison parks in low-income neighborhoods (-0.666, $p < 0.001$), with park use decreasing longer term in renovated parks located in low-income neighborhoods (-0.923, $p < 0.001$). As indicated by the 3-way interaction terms in the top right panel, the longer-term effect of renovation on park use differed by neighborhood income level. Longer term, renovation was associated with an increase in park use in medium-income neighborhoods and high-income neighborhoods relative to low-income neighborhoods (1.519, $p < 0.001$; 0.969, $p < 0.001$, respectively). The longer-term increase in use of renovated parks relative to comparison parks located in medium-income neighborhoods was significant (0.853, $p < 0.001$).

As shown in the bottom right panel (Table 2), this pattern of results is consistent for longer-term changes in park-based MVPA. One difference is the longer-term increases in MVPA for renovated parks relative to comparison parks located in medium-income neighborhoods and high-income neighborhood were both significant (1.142, $p < 0.001$; 0.559, $p = 0.04$, respectively).

Short- and Longer-Term Effects of Playground Renovations by Concentration of Black Residents in the Neighborhood

Table 3 shows models estimating short- and longer-term effects of playground renovations by concentration of Black residents in the neighborhood, controlling for neighborhood income level and other racial/ethnic composition. Short-term effects on park use and park-based MVPA are shown in the left panel; longer-term effects on these two outcomes are shown in the right panel. We begin with the short-term effects of renovation on park use, reported in the top left panel (Table 3).

Short-term change in park use differed between renovated and comparison parks located in low-percent Black neighborhoods (0.710, $p < 0.001$), with short-term park use increasing in renovated parks in low-percent Black neighborhoods (0.604, $p < 0.001$). As evidenced by the 3-way interaction term results, the short-term effect of renovation on park use differed by neighborhood concentration of Black residents. Renovation was associated with a decrease in park use in high-percent Black neighborhoods, relative to low-percent Black neighborhoods (-0.903, $p < 0.001$). The short-term decrease in use of renovated parks relative to comparison parks located in high-percent Black neighborhoods was significant (-0.192, $p = 0.03$).

In general, short-term results are similar for park-based MVPA (Table 3, bottom left panel). One exception is that the change in MVPA in renovated parks relative to comparison parks located in high-percent Black neighborhoods was not significant (-0.082, $p = 0.51$).

The right panel of Table 3 shows results for longer-term effects of renovation on park use and park-based MVPA by neighborhood concentration of Black residents. Change in park use over the longer term did not differ significantly between renovated parks and comparison parks located in low-percent Black neighborhoods (0.211, $p = 0.167$). Moreover, the 3-way interaction terms in the top right panel reveal that the short-term effect of renovation on park use did not differ by neighborhood concentration of Black residents ($p > 0.05$).

As shown in the bottom right panel (Table 3), longer-term change in park-based MVPA was higher in renovated parks in low-percent Black neighborhoods (0.677, $p = 0.002$). The increase in MVPA over the longer term

Table 3 Regression model estimates of differences in short- and longer-term effects of playground renovations on park use and park-based moderate-to-vigorous physical activity (MVPA) by neighborhood concentration of Black residents.

	12 months (short-term)		24 months (longer-term)	
	Coef.	Std. Err.	Coef.	Std. Err.
Park use				
Wave (ref: Pre-renovation/baseline)	− 0.107	(0.086)	0.491	(0.160)**
Group (ref: Comparison parks)	− 0.461	(0.133)**	− 0.419	(0.106)***
Wave by group	0.710	(0.103)***	0.211	(0.152)
Neighborhood percent Black (ref: Low)				
Medium	0.239	(0.437)	− 0.742	(0.511)
High	− 0.545	(0.651)	− 0.921	(0.808)
Wave by neighborhood percent Black				
12 (or 24) months by medium-percent Black	− 0.128	(0.266)	− 0.633	(0.446)
12 (or 24) months by high-percent Black	0.161	(0.109)	− 1.293	(0.170)***
Group by neighborhood percent Black				
Intervention group by medium-percent Black	− 0.190	(0.296)	1.059	(0.242)***
Intervention group by high-percent Black	0.861	(0.222)***	1.185	(0.153)***
Wave by group by neighborhood percent Black				
Intervention group by 12 (or 24) months by medium-percent Black	− 0.523	(0.289)	− 0.409	(0.466)
Intervention group by 12 (or 24) months by high-percent Black	− 0.903	(0.139)***	0.262	(0.195)
Park-based MVPA				
Wave (ref: Pre-renovation/baseline)	0.157	(0.123)	0.255	(0.214)
Group (ref: Comparison parks)	− 0.636	(0.177)***	− 0.395	(0.146)**
Wave by group	0.670	(0.149)***	0.677	(0.214)**
Neighborhood percent Black (ref: Low)				
Medium	0.031	(0.481)	− 0.771	(0.501)
High	− 1.025	(0.678)	− 0.834	(0.746)
Wave by neighborhood percent Black				
12 (or 24) months by medium-percent Black	− 0.251	(0.395)	− 0.002	(0.689)
12 (or 24) months by high-percent Black	0.126	(0.157)	− 0.713	(0.232)**
Group by neighborhood percent Black				
Intervention group by medium-percent Black	0.104	(0.378)	1.332	(0.319)***
Intervention group by high-percent Black	1.260	(0.270)***	1.385	(0.212)***
Wave by group by neighborhood percent Black				
Intervention group by 12 (or 24) months by medium-percent Black	− 0.716	(0.423)	− 1.516	(0.714)*
Intervention group by 12 (or 24) months by high-percent Black	− 0.752	(0.198)***	− 0.402	(0.268)

*$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

Ref, reference group; *Coeff*, coefficient; *S.E.*, standard error

Covariates include park size in acres (log), average daily temperature, neighborhood income, neighborhood percent White and percent Latinx residents, physical disorder, number of programs over a year (log), crime count in quarter-mile radius around park (log), and quality of park features

in renovated parks located in low-percent Black neighborhoods was significant (0.932, $p < 0.001$). The 3-way interaction terms reveal that the longer-term effect of renovation on park use differed by neighborhood concentration of Black residents. Relative to low-percent Black neighborhoods, renovation was associated with lower park-based MVPA in medium-percent Black neighborhoods (− 1.516, $p = 0.034$). Overall,

the longer-term change in MVPA in renovated parks relative to comparison was not significant in medium-percent Black neighborhoods (− 0.839, $p = 0.22$) or high-percent Black neighborhoods (0.276, $p = 0.08$).

Discussion

The Chicago Park District invested over $44 million between 2013 and 2016 through the Chicago Plays! Initiative to improve 327 playgrounds in need of repair. These playgrounds were disproportionately located in low-income neighborhoods and neighborhoods with high concentrations of Black residents. One goal of the investment was to increase use of these parks and the opportunity for MVPA. We found that the effects of renovations differed by neighborhood income level and neighborhood concentration of Black residents. Specifically, in low-income neighborhoods, renovations were associated with no significant changes in the short term and with reductions in park use and park-based MVPA over the longer term. In contrast, renovations were associated with short- and longer-term increases in park use and park-based MVPA in medium-income neighborhoods and with longer-term increases in MVPA in high-income neighborhoods. Moreover, in general, renovations were not associated with any changes in park use or park-based MVPA in high-percent Black neighborhoods, but they were associated with increased park use and park-based MVPA in low-percent Black neighborhoods. Thus, the renovations may have had unintended consequences, increasing neighborhood income and racial disparities in park use and park-based MVPA.

Evidence on the equity effects of large physical activity interventions in general and playground and park renovations in particular is sparse [39]. A Boston, MA, study examined whether park renovation rates differed by neighborhood socioeconomic disadvantage and playground quality and found equitable rates of renovation in disadvantaged and other neighborhoods according to need [40]. Another recent study examined the impact of introducing new play spaces in deprived neighborhoods in Rotterdam, the Netherlands, on youth physical activity [41]. They found weak evidence ($p < 0.10$) suggesting that reducing the distance to the nearest play space increased outdoor physical activity to a greater extent among children of parents with lower education. The effect of reduced distance to the nearest play space on outdoor play did not differ by family income or ethnicity. To the best of our knowledge, this is the first study to examine differences in the effects of playground renovations on use and physical activity by neighborhood socioeconomic and racial characteristics.

There are multiple potential explanations for our findings. First, it is possible that the renovation particulars were not what residents of low-income neighborhoods and Black neighborhoods wanted and did not meet their needs. Previous research has highlighted the importance of engaging community members in efforts to improve population health [42]. The importance of incorporating community members' preferences in the design and renovation of parks in particular is increasingly recognized to promote park use and park-based physical activity, and to ensure equity [43, 44]. The community groups that applied to receive park renovations in the first round of the Chicago Plays! Initiative were tasked with reaching out to community members (e.g., via online/door-to-door surveys, social media, meeting presentations) to ensure that the final selection of newly installed playground equipment met the needs of the majority of residents. However, the actual level of resident input across neighborhoods may have varied significantly and, in some instances, resulted in the exclusion of key community members or groups [45, 46]. For example, it is unknown at what level youth were involved in the renovation decision process. Research has shown positive impacts of engaging youth in community improvements that are designed to directly benefit them [47].

Second, low-income Black neighborhoods in Chicago lost population during the study period. Concerns about violence, cost of living, and closing or under-resourced schools contributed to low- and middle-income and Black families leaving Chicago's west and south sides [48–50]. Thus, decline in the number of people using parks over time may, in part, reflect fewer people living in these neighborhoods.

Third, renovating playgrounds may not be enough to offset other deterrents to park use. If other features in the park were in disrepair or had few attractive amenities, renovation of the playground alone may not be enough to encourage greater use. While we controlled for crime incidents near the parks, this measure may not have adequately captured residents' perceptions regarding or

concerns related to social disorder (e.g., public drinking) or violence in and near the parks [51–53], which may dissuade use. The renovations addressed the physical infrastructure, but did not address inadequate park security or park programming, which may be necessary to increase park use or park-based MVPA [20, 54, 55].

Strengths of the study include systematic observations of use and PA level, examination of both short-term and longer-term effects up to 24 months, and the socioeconomic and racial/ethnic diversity of the park neighborhoods. Still it is important to keep in mind some study limitations. This is a repeated cross-sectional study; we did not track behaviors of the same individuals over time, only parks. Moreover, while well distributed across the city, the park sample is relatively small, which reduced statistical power.

In conclusion, this study addressed an important research gap by examining whether playground renovations equitably benefited neighborhoods in Chicago with respect to use and MVPA. Our finding that positive impacts of playground renovations on park use and park-based MVPA were confined to higher income neighborhoods and low-percent Black neighborhoods suggests that complementary strategies may be needed to ensure renovations benefit all neighborhoods. The findings suggest the importance of intense involvement of neighborhood residents in renovations to help ensure they meet residents' needs and preferences. Another implication is that playground renovations may need to be coupled with wider renovations across the park, additional park programming, efforts to address the social environment, and/or behavioral interventions, to enable residents to take advantage of this new resource. Rather than equal funding per park, policies should allocate more funding for parks with the fewest resources and greatest disrepair. These enhancements should be incorporated and evaluated in future playground renovation programs.

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