Open Access Library Journal
2025, Volume 12, e13998
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Assessing Income-Based Spatial Inequities in Playground Accessibility: A GIS-Driven Approach toward Inclusive Urban Planning in Oklahoma City

Reyhaneh Ahmadi, Kaveh Ghamisi

Christopher C. Gibbs College of Architecture, University of Oklahoma, Norman, USA
Email: Reyhaneh.ahmadi-1@ou.edu, Kaveh.Ghamisi-1@ou.edu

How to cite this paper: Ahmadi, R. and Ghamisi, K. (2025) Assessing Income-Based Spatial Inequities in Playground Accessibility: A GIS-Driven Approach toward Inclusive Urban Planning in Oklahoma City. *Open Access Library Journal*, **12**: e13998.
https://doi.org/10.4236/oalib.1113998

Received: July 22, 2025
Accepted: September 22, 2025
Published: September 25, 2025

Abstract

Walkable access to public playgrounds supports early childhood development and equitable public space use, yet coverage can be limited and uneven [1]. In Oklahoma City (2020), accessibility was quantified and its association with neighborhood poverty and the share of children under age 5 was evaluated. Public playgrounds were mapped and 0.25-mile (≈402 m) Euclidean buffers were generated and dissolved; population-weighted counts inside buffers were derived via ArcGIS Tabulate Intersection for each census block group (GEOID stored as 12-digit text). Outcomes were proportions in [0, 1] for all residents, residents at or below 150% of the federal poverty level (≤150% FPL), and children under age 5. Associations with poverty rate (≤150% FPL/total) and under-5 share (under-5/total) were estimated using OLS with HC3 robust errors and a fractional-logit GLM with denominator weights. Citywide access is uniformly low: 24.1% of all residents (156,864/649,821), 25.7% of ≤150% FPL residents (41,312/160,691), and 24.8% of children under age 5 (11,847/47,842) live within 0.25 miles. The in-buffer population is 26.3% low-income (24.8% citywide) and 7.5% under-5 (≈7.36% citywide). Regression effects are small in magnitude with near-zero fit; statistical significance depends on estimator (OLS vs. GLM), indicating that composition explains little relative to the spatial distribution of playgrounds; maps show clustering in the core and north-northwest, with coverage gaps in the south/southeast and fringe. Although accessibility is low citywide and warrants system-level expansion, equity efforts should explicitly prioritize residents at or below 150% FPL and children under age 5—especially where these populations co-locate and experience the most pronounced shortfalls.

Subject Areas

Urban Planning, GIS and Spatial Analysis, Public Health, Sustainable Infrastructure

Keywords

Accessibility, Walkability, Spatial Equity, Park Access, Playground Accessibility, Children, Low-Income Communities, Health Equity, GIS, Urban Planning

1. Introduction

In Piagetian theory, play primarily reflects assimilation: through symbolic play and, later, games with rules, children actively construct and refine cognitive schemas, making sense of their environment [2] [3]. The 1989 United Nations Convention on the Rights of the Child recognizes play as a fundamental right for all children [4]. Childhood obesity remains a critical public health challenge in the United States, often linked to inadequate opportunities for physical activity in neighborhood environments. Physical activity is associated with a lower risk of overweight and obesity in preschool children [5]. Together, these factors underscore the need for equitable access to safe, engaging outdoor play spaces.

For the purposes of this study, "children" refers specifically to those under age 5. This early-childhood group derives the greatest developmental benefit from nearby play opportunities but has the shortest independent walking capacity, making them especially sensitive to the absence of close playgrounds. Research shows that younger children, due to their developmental stage and need for adult supervision, typically travel shorter distances on foot compared to older children [6] [7]. As a result, the lack of a nearby public playground may disproportionately limit their opportunities for outdoor play, social interaction, and physical activity. While many planning guidelines set 0.25-mile as a standard for walkable access, evidence suggests that even this distance can pose a barrier for young children in environments with traffic, safety issues, or poor pedestrian infrastructure [8] [9].

Public playgrounds represent a vital component of urban infrastructure, supporting children's development and community well-being. Playgrounds offer children opportunities to interact with peers, develop skills and social norms, and practice age-appropriate risk-taking [10].

Given their importance, equitable access to playgrounds is a critical urban planning concern. Limited access may disproportionately affect vulnerable children, reducing developmental benefits [11]. This study addresses this concern by examining the spatial relationship between household income and young children's walkable access to public playgrounds in Oklahoma City, highlighting how spatial inequities in recreational infrastructure may exacerbate existing social and health disparities. Hereafter, "playgrounds" denotes all publicly accessible parks in the

Oklahoma City Open Data Portal Parks dataset; sites without fixed equipment are included, reflecting that open parks provide potential play opportunities.

Research Question and Hypothesis

This study investigates whether children's walkable access to public playgrounds in Oklahoma City is associated with their family's income level. The hypothesis posits that children from low-income families have reduced walkable access to public playgrounds, due to a mismatch between playground distribution and neighborhood-level child population needs in lower-income communities.

2. Literature Review

2.1. Accessibility

Accessibility is a core neighborhood attribute shaping residents' quality of life [12]. In transportation and urban planning, it is treated as a hallmark of effective, efficient, and sustainable systems that connect people and firms such that activities, information, goods, and services can flow [13]. Building on foundational work, we view accessibility as the combined effect of land-use patterns, transport performance, time constraints, and person-specific factors [14] [15]. Accordingly, comprehensive accessibility extends beyond distance to include service characteristics (availability, affordability, reliability, safety, and timely, accurate information) [16]. In cities, the design and quality of transport networks condition people's ability to participate fully in community life [17].

Although recent transport research increasingly addresses the needs of specific groups (e.g., women, older adults, low-income households) [12], children's accessibility—especially to playgrounds—remains comparatively underexamined. Children typically travel shorter distances independently, depend more on adult accompaniment, and are more sensitive to perceived and objective safety risks. When policies overlook these differences, they miss a key determinant of children's physical, cognitive, and social development. Ensuring safe, nearby play spaces is therefore a shared priority for urban planners and public-health practitioners.

2.2. Playground and Child Development

Play is foundational to healthy child development, supporting imagination, motor coordination, and cognitive as well as emotional growth [1] [18]. From the earliest stages, play enables children to explore their surroundings, practice problem-solving, and work through developmental anxieties [18] [19]. It often involves role enactment and cooperative interaction with peers, which builds social competence [20].

Unstructured play, in particular, nurtures interpersonal skills such as cooperation, negotiation, conflict resolution, and self-advocacy [21]. Independent play also strengthens decision-making, allowing children to pursue self-selected activities at their own pace [1].

In urban settings, playgrounds—defined here as public parks—provide dedicated spaces that support diverse developmental processes. They facilitate multiskill practice, age-appropriate risk-taking, and peer-based learning [22]. They also encourage physical activity, a key factor in preventing childhood obesity and supporting healthy growth [9] [23].

The literature spans multiple themes: usability/accessibility [18] [24] [25]; disability-related barriers [21]; effects on adult activity levels [26]; and parental social interaction [27].

International planning practice shows varied strategies for equitable provision. In Indonesia, national standards specify walking-distance service radii for playground access—100 m at the RT scale and 1000 m at the RW scale [28]. Measures such as playground area per capita and local population density are also used to gauge crowding and service demand. Powers *et al.* examine access and use of municipal parks through an intersectionality lens [29], Moore and Lynch review usability and accessibility considerations [24], and in high-density cities, Siu, Wong, and Lam evaluate inclusive playground design and propose strategies to broaden access [22]. In the U.S., McCarthy *et al.* analyzed racial and ethnic disparities in playground availability and quality and found no significant disparities in their study context [23]. However, other work highlights the need to examine income-related differences in playground access, particularly in cities with many young children.

2.3. Playgrounds and Children's Health

Playgrounds contribute directly to children's physical, mental, and social health. Physical activity has been shown to reduce the risk of chronic diseases, improve mental well-being, and help maintain a healthy weight [30]. Both structured and unstructured outdoor play—walking, cycling, or free play—support recommended activity levels [31]. Proximity to parks and playgrounds is positively associated with higher activity levels and with psychosocial benefits such as increased community connectedness and improved mental health outcomes [32].

Certain types of play require outdoor settings. Parks and playgrounds provide environmental affordances that encourage a variety of movements and activities [33]. Rather than determining activity levels outright, park and playground features shape the nature, intensity, and duration of engagement [33].

Given rising rates of childhood obesity, accessible playgrounds represent a cost-effective public health intervention. Use is influenced by factors including accessibility, aesthetics, perceptions, and realities of safety (crime and traffic), and environmental comfort [34]. In low-income neighborhoods, playgrounds may be among the few free opportunities for physical activity [34].

2.4. Inequities in Access to Playgrounds

Parks and playgrounds are widely recognized as critical environmental amenities with social, health, and ecological benefits [8]. People who live closer to parks are significantly more likely to walk to them, highlighting the strong relationship between proximity and use [8].

Historically, the U.S. playground movement began in the late 19th and early 20th centuries as a reform initiative aimed at improving conditions for workingclass communities [35] [36]. While these early efforts expanded access, disparities remain entrenched. National studies consistently link disparities in physical activity and obesity to inequities in recreational infrastructure along racial, ethnic, and income lines [37] [38].

Research has shown that low-income areas often receive less investment and maintenance for parks and playgrounds compared to more affluent neighborhoods [39] [40] [41]. Environmental barriers—such as unsafe streets, inadequate lighting, and poor facility upkeep—further reduce use in disadvantaged communities [42] [43]. These disparities align with environmental justice concerns [44] [45], and the concept of "deprivation amplification", where socioeconomic disadvantage is compounded by limited access to supportive infrastructure [46] [47].

Most existing tools for assessing playgrounds and parks fail to fully address the needs of ethnic minority and low-income populations [48]. Moreover, few studies have explicitly analyzed walkable access to playgrounds in low-income neighborhoods, despite clear evidence of infrastructure disparities. Children in lower-income households may lack private yards or reliable transportation to reach distant parks, increasing dependence on nearby public facilities [49]. This dependence makes spatial mismatches between playground locations and areas of high child density a pressing public health and equity issue [50] [51].

3. Case Study: Oklahoma City, Oklahoma

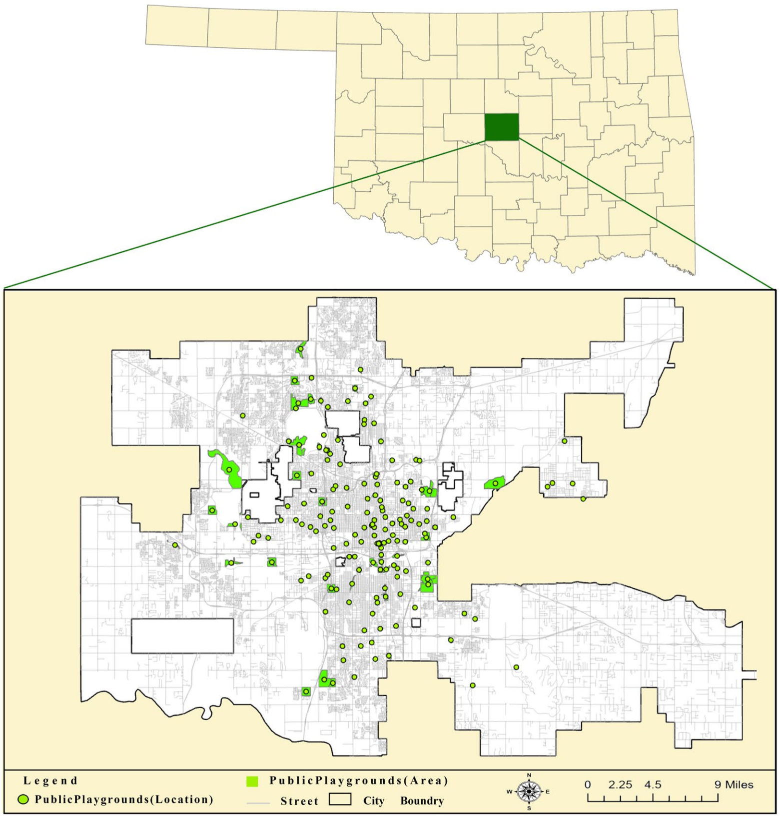

Figure 1. Location of public playgrounds in Oklahoma City.

Oklahoma City is a large, fast-growing U.S. city with an expansive, low-density urban form. Local guidance notes that—even where sidewalks exist—busy arterials, difficult intersections, and freeways interrupt natural pedestrian routes, fragmenting everyday walking trips for children and caregivers [52]. In this study, "playgrounds" denotes all publicly accessible parks recorded in the Oklahoma City Open Data Portal (Parks) dataset. **Figure 1** shows their distribution: clusters in the core and north–northwest, with broad gaps in southern, southeastern, and peripheral areas—implying longer walk distances for many households.

External indicators align with this pattern: fewer than 50% of residents live within a 10-minute walk of a park, and the city's overall Walk Score indicates car-dependence [53] [54]. This context motivates quantifying block-group-level walkable park ("playground") access and testing whether access varies with neighborhood poverty (≤150% FPL) and the share of children under age 5. Note on comparability: this study uses 0.25-mile Euclidean buffers, whereas ParkScore reports 10-minute network walksheds; percentages are not directly comparable.

4. Methods

4.1. Data Sources

This study analyzed 2020 U.S. Census block groups [55] intersecting the 2020 Oklahoma City administrative boundary [56]. Demographic variables were drawn from the 2020 American Community Survey (ACS) 5-year estimates at the block-group level [57]: 1) Total population; 2) Residents at or below 150% of the federal poverty level (≤150% FPL); 3) Children under age 5. The Census GEOID was stored as 12-digit text to preserve leading zeros and ensure accurate joins.

Public parks (operational definition). Data were downloaded from the Oklahoma City Open Data Portal (Parks) [58], and clipped to the 2020 city boundary. In this study, "playgrounds" denotes all publicly accessible parks in that dataset; parks are treated as potential play spaces even when no fixed playground equipment is present.

Quality control. We removed exact duplicate park features before dissolve, repaired invalid geometries as needed, and verified that aggregated ACS counts were internally consistent across merged tables prior to modeling.

4.2. Spatial Processing

All spatial processing was performed in ArcGIS Pro. We generated 0.25-mile (≈402 m) Euclidean buffers around park polygons ("playgrounds") and dissolved overlaps to prevent double counting. Layers were projected to NAD 1983/UTM Zone 14N (EPSG: 26914) to ensure accurate distance and area measurement. While network measures can capture crossings, barriers, and sidewalk continuity, the Euclidean metric is used here for comparability with prior citywide studies and because sidewalk/crossing data coverage is uneven. Areal apportionment to block groups using Tabulate Intersection is described in §4.3.

4.3. Areal Apportionment (Population-Weighted)

Because buffers and census block-group boundaries do not coincide, we used ArcGIS Pro's Tabulate Intersection tool to compute, for each block group i, the share of its land area lying inside the dissolved 0.25-mile buffer (W_i). We then applied W_i to block-group counts to obtain population-weighted counts inside the buffer:

$$\tilde{T}_i = W_i \cdot T_i;\ \ \tilde{P}_i = W_i \cdot P_i;\ \ \tilde{U}_{i,5} = W_i \cdot U_{i,5}$$

Here T_i, P_i, and $U_{i,5}$ are the total, ≤150% FPL, and under-5 populations of block group i. This approach assumes uniform population density within each block group, a standard simplification in small-area accessibility studies.

4.4. Data Integration and Quality Control

Block groups were keyed by 12-digit GEOID (state-county-tract-block group). GEOIDs were cleaned to preserve leading zeros, normalized to 12 digits, and stored as text. We merged the population-weighted tables to a single GEOID index, verified one-to-one join integrity, and cross-checked citywide sums against the figures above. Visual spot checks confirmed spatial alignment of joins.

4.5. Measures and Outcome Construction (Citywide Shares and Per-Block-Group Proportions)

Citywide shares:

$$y_{\_\text{total}} = \left(\Sigma_{\_i}\tilde{T}_{\_i}\right) / \left(\Sigma_{\_i}T_{\_i}\right)$$

$$y_{\_\text{poverty}} = \left(\Sigma_{\_i}\tilde{P}_{\_i}\right) / \left(\Sigma_{\_i}P_{\_i}\right)$$

$$y_{\_\text{u5}} = \left(\Sigma_{\_i}\tilde{U}_{i,5}\right) / \left(\Sigma_{\_i}U_{i,5}\right)$$

Per-block-group outcomes:

$$y_{\_\text{total},i} = \tilde{T}_{\_i} / T_{\_i}$$

$$y_{\_\text{poverty},i} = \tilde{P}_{\_i} / P_{\_i}$$

$$y_{\_\text{u5},i} = \tilde{U}_{i,5} / U_{i,5}$$

Here, $y_{\_\text{total},i}$ is the share of all residents in block group i who live within 0.25-mile of a public playground (*i.e.*, $\tilde{T}_i / T_i$). This is our overall accessibility measure and is reported alongside subgroup measures for residents ≤150% FPL and children under age 5. Each outcome is a proportion in [0, 1]. Units with a zero denominator in a category (e.g., $P_i = 0$) are excluded from that category. Note: Citywide shares are population-weighted by construction (ratio of sums) and are not the unweighted mean of block-group proportions.

4.6. Statistical Analysis

Model specification; Because areal apportionment uses a common weight W_i for all subgroups, the within-block-group outcomes are identical wherever denominators are nonzero: $y_{\text{total},i} = y_{\text{poverty},i} = y_{\text{u5},i} = W_i$. Subgroups with zero denominators (e.g., $P_i = 0$ or $U_{i,5} = 0$) are excluded from their respective models. For each outcome, accessibility was regressed on neighborhood composition using the following specification:

$$y_i = \beta_0 + \beta_1 \cdot \text{poverty\_rate}_i + \beta_2 \cdot \text{under5\_share}_i + \varepsilon_i$$

where $\text{poverty rate}_i = P_i / T_i$ and $\text{under5\_share}_i = U_{i,5} / T_i$. Outcomes and predictors were fractions in [0, 1]. Predictors are scaled to [0, 1]; thus a +10 percentage-point change corresponds to +0.10 in the predictor.

Data handling; Records with a zero denominator for a given outcome (e.g., $P_i = 0$ for poverty) were excluded from that outcome's analysis. Where a block group lay entirely outside the buffer, the corresponding numerator was set to 0 so that $y_i = 0$ whenever the denominator > 0.

Estimators; Primary estimates used ordinary least squares (OLS) with HC3 robust standard errors. As a sensitivity check, fractional logit GLMs (logit link) were fit with denominator (frequency) weights equal to the relevant totals (total population, ≤150% FPL, under-5). Denominator (frequency) weights equal to the relevant group totals make the GLM's average marginal effects interpretable as population-weighted percentage-point changes in accessibility. Inference and reporting; For OLS, results are reported as unstandardized coefficients, HC3 standard errors, two-sided p-values ($\alpha = 0.05$), R^2, and adjusted R^2. For GLM, results include log-odds coefficients, p-values, average marginal effects (AME) expressed as percentage-point change in accessibility per +10 percentage-point change in the predictor, and McFadden's pseudo-R^2. Average marginal effects (AME) are computed as sample-average partial effects (*i.e.*, the marginal effect is evaluated for each unit and then averaged).

Sample sizes (final); OLS models use n = 523 block groups for each outcome; fractional-logit GLM models use n = 529 (denominator weights applied).

Diagnostics; Checks included range validation for [0, 1], influence screening, and a qualitative map-based comparison of residual patterns (Optional: if a block-group contiguity matrix is provided, residual spatial autocorrelation can be assessed using Moran's I and, if needed, spatial HAC errors).

5. Results

5.1. Citywide Accessibility

Population-weighted coverage is uniformly low on the city scale. See Table 1 for citywide totals and access rates.

- All residents: 156,864 of 649,821 → 24.1% within 0.25 miles.
- ≤150% FPL: 41,312 of 160,691 → 25.7%.
- Under-5: 11,847 of 47,842 → 24.8%.

These near-identical rates indicate a coverage constraint rather than a citywide compositional disparity under the Euclidean-buffer metric. Composition inside buffers; ≤150% FPL among in-buffer residents is 26.3% (41,312/156,864), close to the citywide share 24.8%. Interpretation: The share of low-income residents inside buffers (26.3%) closely matches the citywide low-income share (24.8%), and the under-5 share is similarly close (7.5% vs 7.36%). See **Table 2** for in-buffer composition. At the citywide level this points to coverage as the binding constraint; disparities arise mainly from where gaps are located, not from broad compositional bias (Model fit is negligible across outcomes (R^2 and McFadden pseudo-$R^2 \approx 0.00$ - 0.001), so we emphasize AMEs and near-zero fit over nominal significance).

Table 1. Population-weighted playground accessibility in Oklahoma City (2020).

Group	Total	In-buffer	Access (%)
Total Population (2020)	649,821	156,864	24.1
≤150% FPL population	160,691	41,312	25.7
Children under 5	47,842	11,847	24.8

Table 2. Composition of residents inside the 0.25-mile playground buffers (population-weighted).

Group	In-buffer count	Access (% of that group citywide)	Share of buffer pop (%)
Total Population (2020)	156,864	24.1	100
≤150% FPL population	41,312	25.7	26.3
Children under 5	11,847	24.8	7.5

5.2. Spatial Distribution and Patterns

At the city scale, playground access follows a clear core-periphery divide. Facilities cluster in the inner core and the north-northwest corridor, while large contiguous gaps appear across the south, southeast, and peripheral fringe. These patterns, together with uniformly low citywide coverage (Section 5.1), indicate a coverage-driven constraint rather than broad compositional bias.

Figure 2 shows the in-buffer footprint of populated areas. Coverage follows the core/northwest pattern; holes are visible along the southern arc.

Figure 3 shows outside-buffer zones are extensive in the south/southeast, and on peripheral tracts, aligning with the low citywide access rate.

Figure 4 shows higher-poverty clusters in the south/southeast. Several overlap with out-of-buffer areas in **Figure 3**, marking equity-priority candidates for new sites and Safe Routes upgrades.

Figure 5 shows elevated child shares in portions of the south/southeast and selected west-side neighborhoods. Where these coincide with out-of-buffer areas, access gaps are more consequential.

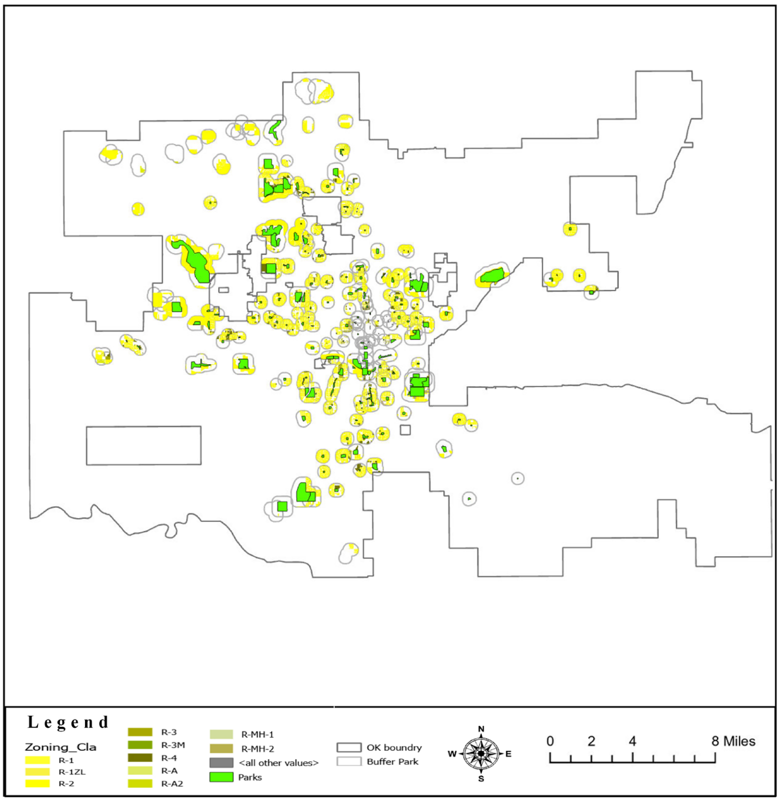

Figure 2. Residential areas within the 0.25-mile buffer.

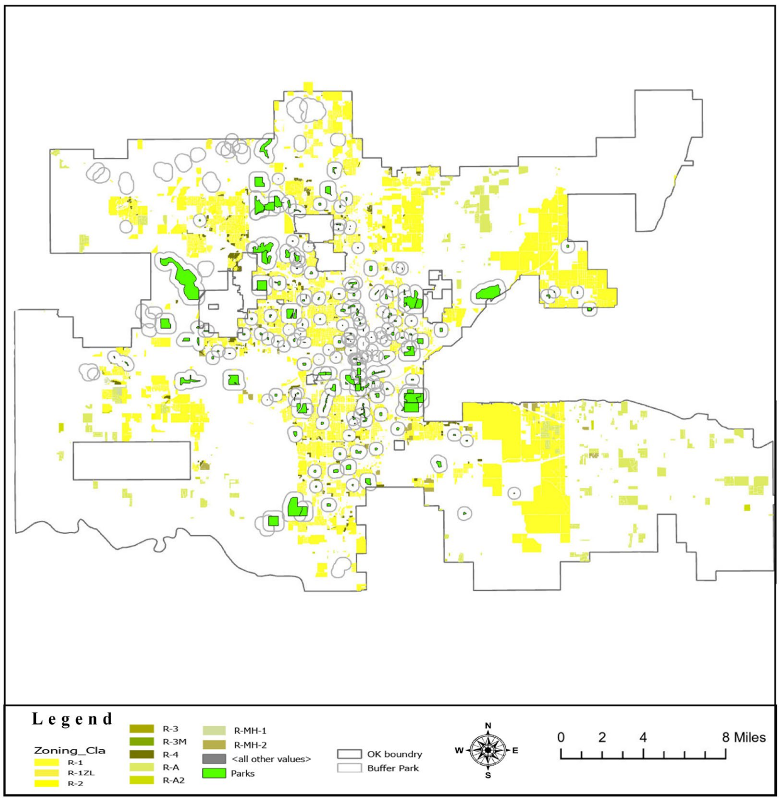

Figure 3. Residential areas outside the 0.25-mile buffer.

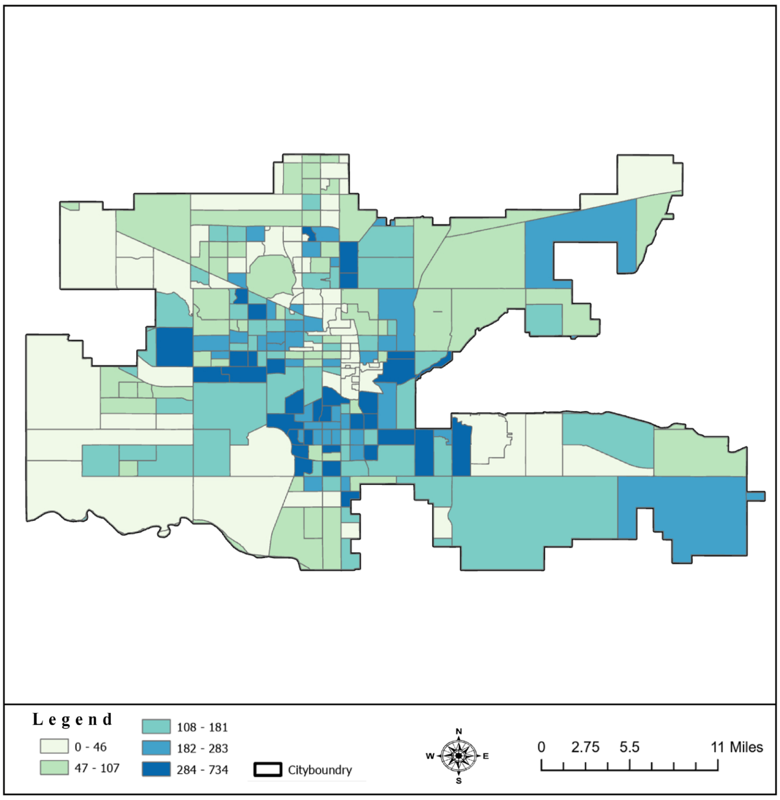

Figure 4. Share of residents ≤150% FPL by block group (choropleth).

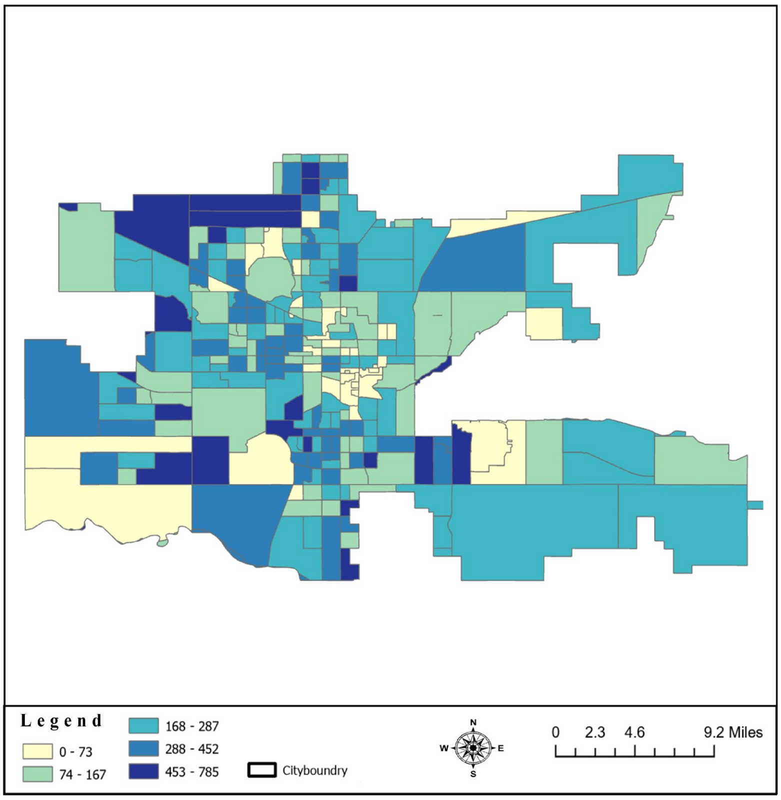

Figure 5. Share of children under age 5 by block group.

Figure 6 visualizes the joint pattern of poverty (≤150% FPL) and under-5 share by block group. High-high tiles (black) concentrate in the inner core—especially south-central and near-east corridors—with additional pockets in the near-south. Low-low areas (gray/blue-gray) dominate the outer west and far-north fringe. Child-heavy but lower-poverty blocks (blues) are evident in parts of the northwest and southwest, whereas poverty-heavy but older blocks (yellows) run through portions of the central belt. Cross-reading with the "outside-buffer" map (Figure 3) shows that several high-high blocks in the southeast and south-central remain outside 0.25-mile buffers—priority candidates for new playgrounds and Safe Routes investments.

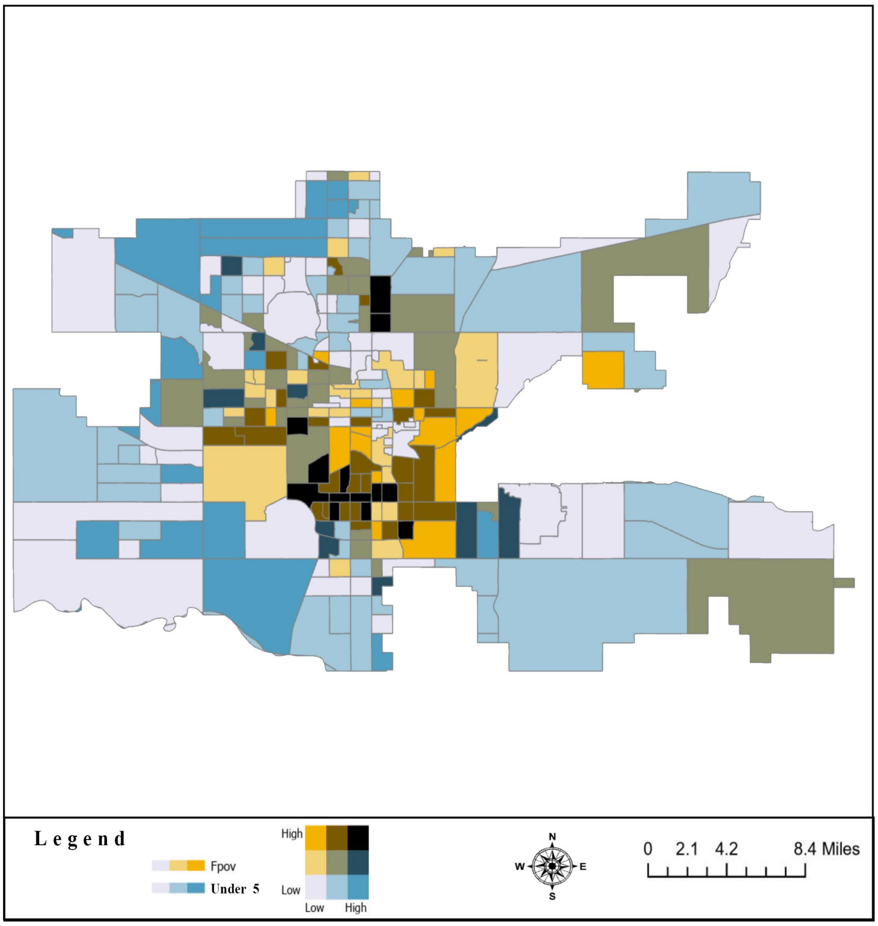

Figure 6. Spatial co-distribution of poverty and under-5 population by block group, Oklahoma City (2020).

Figure 7 shows facility intensity peaks in the inner core and north-northwest and drops steeply toward the south, southeast, and far-north fringe. This surface mirrors Figure 2, Figure 3: where density thins, large residential areas remain outside the 0.25-mile catchment, reinforcing a coverage-limited system.

Read alongside Figures 2-7, the spatial evidence yields four conclusions: 1) Accessibility shortfalls are spatially concentrated—most acute in the south/

southeast and peripheral fringe; 2) Overlaps between outside-buffer areas and high-poverty or child-dense blocks (**Figures 3-5**) identify equity-critical geographies; 3) Joint high-need blocks that remain outside buffers (**Figure 6**) should be first-tier candidates for new playgrounds, paired with targeted pedestrian-safety upgrades, thereby making near-miss areas truly walkable; and 4) the kernel-density gradient (**Figure 7**) indicates that expanding coverage—rather than shifting neighborhood composition—is the primary lever to raise access citywide. Taken together, these patterns are consistent with a coverage-led strategy in which facility supply increases in the south/southeast and peripheral corridors, with concurrent remediation of "last-block" pedestrian barriers (e.g., sidewalk and crossing completions) to translate nominal proximity into realized, safe walk access.

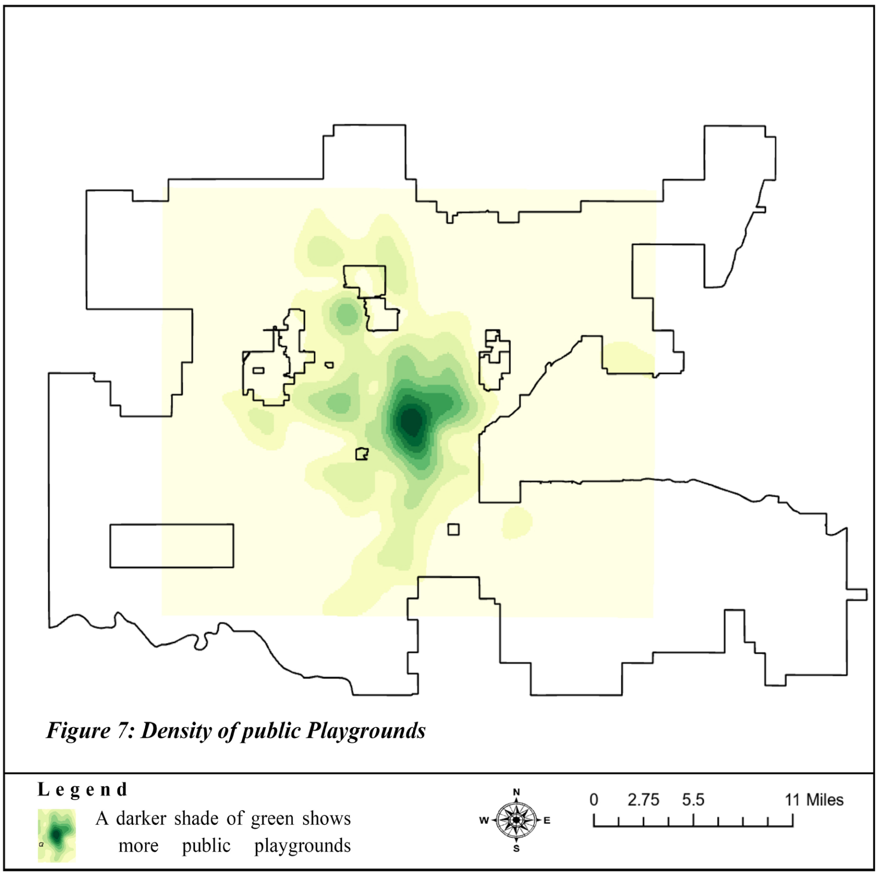

Figure 7. Kernel density of playgrounds (higher values indicate facility clustering).

5.3. Regression Analysis

Bivariate patterns: In what follows, $y_{\_\text{total}}$ denotes the overall share of residents within 0.25-mile of a playground; $y_{\_\text{poverty}}$ and $y_{\_\text{u5}}$ are the analogous shares for ≤150% FPL residents and under-5 children. **Charts 1-3** show slopes close to zero between neighborhood poverty rate and each accessibility outcome. Models were estimated on n = 523 block groups for OLS and n = 529 for GLM per outcome.

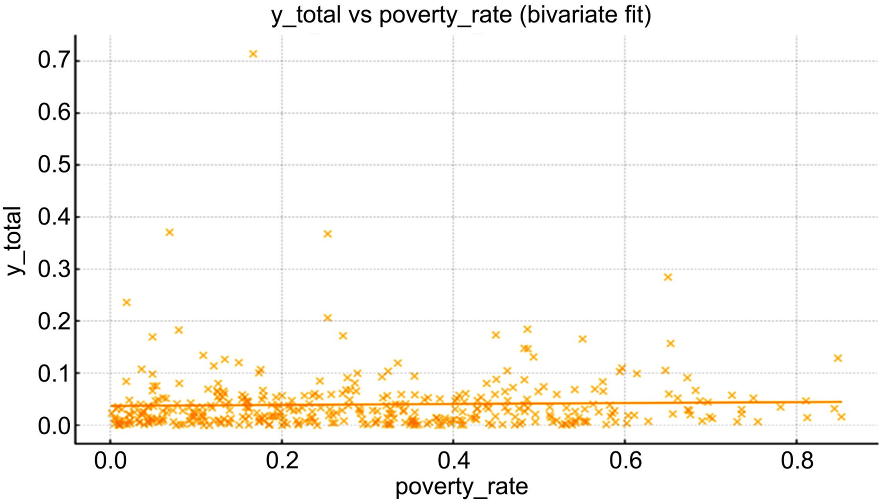

Chart 1. Total accessibility vs. poverty rate (bivariate scatter with OLS fit).

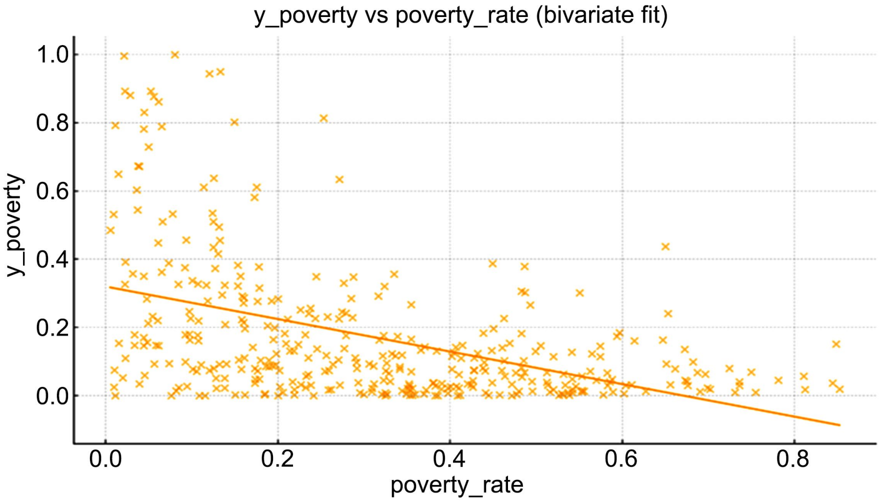

Chart 2. Playground access for ≤150% FPL residents vs. neighborhood poverty rate.

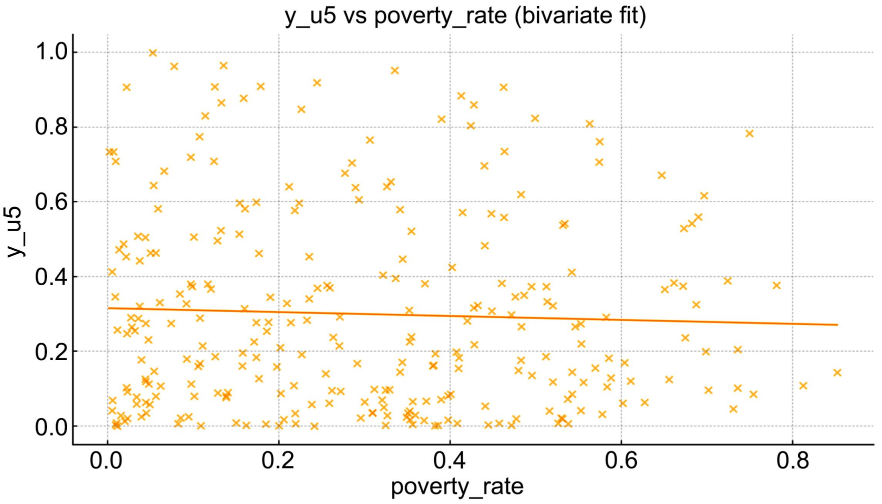

Chart 3. Playground access for children under age 5 vs. neighborhood poverty rate.

OLS (reported once; HC3 SEs): Because areal apportionment applies a common weight W_i to each subgroup, the three outcome proportions are identical wherever denominators are nonzero. We therefore estimate a single OLS model on the intersection sample (n = 523). By contrast, GLMs are fit separately per outcome with denominator (frequency) weights, so per-outcome samples can be larger (n = 529). Coefficients are small and not statistically significant: for poverty rate B ≈ 0.031, p ≈ 0.660, and for under-5 share B ≈ −0.044, p ≈ 0.873. These imply roughly +0.3 pp (pp = percentage points) in accessibility per +10 pp increase in poverty and a negligible association with under-5 share; model R^2 is near zero. Full OLS results are reported in Table 3.

Table 3. OLS (HC3)—Coefficients and Significance (n = 523).

Term	B	SE (HC3)	95% CI	p
Poverty rate	0.031	0.070	[−0.106668, 0.169162]	0.660
Under-5 share	−0.044	0.274	[−0.586308, 0.489723]	0.873

The fractional logit admits $y_i \in [0,1]$, including boundary values 0 and 1, so no transformation or trimming of proportions is required. GLM (fractional logit, denominator-weighted): Average marginal effects (AME; pp per +10 pp change in the predictor) are small in absolute terms and mixed by outcome:

- Poverty rate AMEs: $y_{\_total}$ ≈ −0.207 pp, $y_{\_poverty}$ ≈ +0.412 pp, $y_{\_u5}$ ≈ +0.599 pp.
- Under-5 share AMEs: $y_{\_total}$ ≈ −1.593 pp, $y_{\_poverty}$ ≈ +1.421 pp, $y_{\_u5}$ ≈ −3.120 pp.

McFadden pseudo-R^2 values are near zero across outcomes.

Interpretation: Both specifications indicate that block-group composition explains very little of the cross-sectional variation in walkable playground access. Results are consistent with a coverage-driven constraint: the geography of facilities and urban form dominates observed accessibility, as also suggested by the spatial patterns in §5.2 and the citywide rates in §5.1.

Note: GLM coefficients are reported in log-odds alongside AMEs (pp per +10 pp) in Table 4; p-values are reported in [0, 1]; scientific notation is used when <0.001. Model specification and estimation details are provided in §4.6.

Table 4. GLM (logit; denominator-weighted, n = 529)—Coefficients and AME.

Outcome	Term	Coef (log-odds)	p	AME per +10pp (pp)
$y_{\_total}$	Poverty rate	−0.0927	0.0000000187	−0.207
$y_{\_total}$	Under-5 share	−0.7145	<1e−16	−1.593
$y_{\_poverty}$	Poverty rate	0.1858	0.0000000354	0.4115
$y_{\_poverty}$	Under-5 share	0.6418	0.0000005195	1.4211
$y_{\_u5}$	Poverty rate	0.2710	0.000001042	0.5992
$y_{\_u5}$	Under-5 share	−1.4111	0.0000000091	−3.1195

Note: Table 5 reports GLM model fit—McFadden's pseudo-R^2 (0 - 1 scale) and sample size (n) for each outcome ($y_{\_total}$, $y_{\_poverty}$, $y_{\_u5}$). Pseudo-R^2 values are near zero for all outcomes, indicating limited explanatory power. See §4.6 for model specification and estimation details.

Table 5. GLM model fit (McFadden pseudo-R^2).

Outcome	n	Pseudo-R^2
$y_{\_total}$	529	0.00042013
$y_{\_poverty}$	529	0.00070212
$y_{\_u5}$	529	0.0013819

6. Discussion and Conclusion

6.1. Citywide Accessibility

Only ~24% of residents—across all, ≤150% FPL, and under-5 groups—live within a 0.25-mile walk of a public playground. The in-buffer composition (≤150% FPL 26.34%, under-5 7.55%) mirrors the citywide mix (24.8%, 7.36%). Multivariate models (OLS with HC3; fractional-logit GLM) show small, mostly non-significant effects and near-zero fit, indicating that the spatial distribution of facilities—not block-group poverty or child share—drives access. Maps (Figures 2-7) reveal concentration in the core and north-northwest and coverage gaps in the south/southeast and fringe.

6.2. Where Inequities Persist (and Why)

Citywide averages mask geographically concentrated shortfalls. In particular:

- South/southeast corridors: contiguous outside-buffer zones, several high-poverty × high under-5 (Figure 6), implying compounded need.
- Peripheral/fringe tracts: low density and long blocks produce structural distance from existing sites.
- Barrier effects: arterial roadways and incomplete pedestrian links likely convert nominal proximity into practical inaccessibility (even where Euclidean buffers overlap residences).

6.3. Policy & Design Implications (Actionable)

- Targeted siting in out-of-buffer, high-need blocks (south/southeast; fringe).
- Shared-use schoolyards (after-hours/weekends) to add capacity fast where land assembly is difficult.
- Safe Routes upgrades—sidewalk infill, protected crossings, traffic calming—to turn near-miss areas into usable access for caregivers with strollers.
- Pocket parks/micro-play on small parcels and right-of-way remnants to stitch gaps.
- Maintenance & lighting to sustain use, especially in lower-income areas.

6.4. Targeting Framework (How to Pick the Next Sites)

Use a simple, transparent Priority Siting Score (PSS) at the block-group level to rank candidate areas:

$$\text{PSS}_i = \left(1 - y_{\_\text{total},i}\right) \times \left[0.6 \cdot \text{poverty\_rate}_i + 0.4 \cdot \text{under5\_share}_i\right]$$

$1 - y_{\_\text{total}}$ prioritizes coverage gaps.

Heavier weight on poverty (0.6) reflects equity aims; under-5 (0.4) captures child-specific need.

Rank by PSS, then screen for implementation feasibility (available parcels, school partners, safety upgrades).

Report people-gained-within-0.25 mi per candidate to compare alternatives.

6.5. Robustness & Sensitivity

- Network walksheds (10-minute): expected to lower absolute coverage but preserve the same gap geographies; strengthens the coverage-first conclusion.
- Radius sensitivity (0.25 vs 0.5 miles): 0.5 miles should raise coverage overall but retain relative hot/cold spots.
- Spatial autocorrelation: Moran's I on OLS residuals can be added; if present, use spatial HAC errors or a simple spatial lag robustness check.
- Facility quality: stratifying by dedicated play equipment/condition may refine priorities but is unlikely to reverse the core pattern.

6.6. Implementation Roadmap (12 - 18 Months)

Quarters 1 - 2: finalize the priority list using PSS; confirm school partners; select 3 - 5 pilot locations (south/southeast emphasis).

Quarter 3 - 4: deliver Safe-Routes upgrades around 2 - 3 pilots; open shared-use schoolyards; acquire/activate two micro-play sites.

Quarter 5 - 6: add 2 - 3 additional sites; standardize maintenance & lighting schedules; publish annual access scorecard.

KPIs (report annually):

- Residents gained within 0.25 miles (all, ≤150% FPL, under-5).
- Cost per person-gained and per under-5-gained.
- Safety metrics (new crossings, sidewalk completion).
- Utilization (counts/observations or program attendance).

Oklahoma City's playground accessibility problem is fundamentally spatial. Citywide figures (~24% accessible) and near-matching buffer composition show no strong siting bias by income at the city scale. The equity challenge is where coverage is missing—especially the south/southeast and peripheral neighborhoods. Targeted siting, shared-use schoolyards, and last-block pedestrian fixes will deliver the largest, most equitable gains for young children and low-income families.

Limitations and Directions for Future Research

This study uses a simple, transparent measurement and modeling strategy to foreground coverage constraints; several limitations apply. Due to data constraints, all public parks were treated as playgrounds regardless of the presence of fixed play equipment; as a result, the findings may overestimate true child-specific playground accessibility. Walkable access was measured with a fixed 0.25-mile Euclidean buffer, which omits network realities (paths, crossings, barriers, safety) and qualitative factors (sidewalk quality, lighting, traffic exposure, ADA). As noted in §4.1, the dataset includes public playgrounds only; private/school and informal play spaces are excluded, and open-data positional error may misclassify blocks near the buffer edge. Counts were areally apportioned using a common weight (W_i), assuming within-block-group uniformity and introducing standard ecological issues (interpolation error, MAUP); results should be read at the block-group—not household—level. The OLS model uses HC3 SEs and, by construction, yields identical outcomes across subgroups; the GLM is a fractional logit with denominator (frequency) weights, which align area contributions with population but can produce optimistic p-values under within-area correlation—hence emphasis on AMEs and near-zero pseudo-R^2 rather than nominal significance. Generalizability is limited by the ≤150% FPL definition of low income and by the Oklahoma City context; all data reflect ~2020 conditions and may not capture subsequent demographic or infrastructure changes. Future work could use network-based travel times (e.g., 10-minute walksheds), buffer-size sensitivity tests, qualitative audits of pedestrian conditions, dasymetric mapping or address-level microdata to reduce interpolation error, and clustered or design-based variance alongside AMEs without changing the core models.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Ginsburg, K.R. (2017) The Importance of Play in Promoting Healthy Child Development and Maintaining Strong Parent-Child Bond: Focus on Children in Poverty. In: *Pediatric Clinical Practice Guidelines & Policies*, 16th Edition, American Academy of Pediatrics, 204-213.

[2] Piaget, J. (1951) Play, Dreams and Imitation in Childhood. Routledge.

[3] Piaget, J. (1959) The Language and Thought of the Child. 3rd Edition, Routledge & Kegan Paul.

[4] United Nations (1989) Convention on the Rights of the Child. In: *United Nations Treaty Series*, Vol. 1577, United Nations.

[5] Chang, S.H. and Kim, K. (2017) A Review of Factors Limiting Physical Activity among Young Children from Low-Income Families. *Journal of Exercise Rehabilitation*, **13**, 375-377. https://doi.org/10.12965/jer.1735060.350

[6] Timperio, A., Crawford, D., Telford, A. and Salmon, J. (2004) Perceptions about the Local Neighborhood and Walking and Cycling among Children. *Preventive Medicine*, **38**, 39-47. https://doi.org/10.1016/j.ypmed.2003.09.026

[7] Carver, A., Timperio, A., Hesketh, K. and Crawford, D. (2010) Are Children and Ad-

olescents Less Active If Parents Restrict Their Physical Activity and Active Transport Due to Perceived Risk? *Social Science & Medicine*, **70**, 1799-1805. https://doi.org/10.1016/j.socscimed.2010.02.010

[8] Giles-Corti, B., Broomhall, M.H., Knuiman, M., Collins, C., Douglas, K., Ng, K., *et al.* (2005) Increasing Walking: How Important Is Distance to, Attractiveness, and Size of Public Open Space? *American Journal of Preventive Medicine*, **28**, 169-176. https://doi.org/10.1016/j.amepre.2004.10.018

[9] Kaczynski, A.T. and Henderson, K.A. (2007) Environmental Correlates of Physical Activity: A Review of Evidence about Parks and Recreation. *Leisure Sciences*, **29**, 315-354. https://doi.org/10.1080/01490400701394865

[10] Martori, J.C., Apparicio, P. and Séguin, A. (2020) Spatial Potential Accessibility of Playgrounds in Barcelona City. *Applied Spatial Analysis and Policy*, **13**, 489-506. https://doi.org/10.1007/s12061-019-09316-4

[11] Yogman, M., Garner, A., Hutchinson, J., Hirsh-Pasek, K. and Golinkoff, R.M. (2018) The Power of Play: A Pediatric Role in Enhancing Development in Young Children. *Pediatrics*, **142**, e20182058. https://doi.org/10.1542/peds.2018-2058

[12] Ghahremani, S., Hesari, E., Hesari, M. and Kalasour, N.K. (2024) Examining the Relationship between Immigrant Residential Segregation and Access to Healthcare. *Journal of Poverty*, 1-16. https://doi.org/10.1080/10875549.2024.2338165

[13] European Conference of Ministers of Transport (2006) Improving Transport Accessibility for All: Guide to Good Practice. OECD Publishing.

[14] Hansen, W.G. (1959) How Accessibility Shapes Land Use. *Journal of the American Institute of Planners*, **25**, 73-76. https://doi.org/10.1080/01944365908978307

[15] Geurs, K.T. and van Wee, B. (2004) Accessibility Evaluation of Land-Use and Transport Strategies: Review and Research Directions. *Journal of Transport Geography*, **12**, 127-140. https://doi.org/10.1016/j.jtrangeo.2003.10.005

[16] Lucas, K., van Wee, B. and Maat, K. (2015) A Method to Evaluate Equitable Accessibility: Combining Ethical Theories and Accessibility-Based Approaches. *Transportation*, **43**, 473-490. https://doi.org/10.1007/s11116-015-9585-2

[17] Liu, S. and Zhu, X. (2003) An Integrated GIS Approach to Accessibility Analysis. *Transactions in GIS*, **8**, 45-62. https://doi.org/10.1111/j.1467-9671.2004.00167.x

[18] Tamm, M.P.M. (1999) Attitudes of Key Persons to Accessibility Problems in Playgrounds for Children with Restricted Mobility: A Study in a Medium-Sized Municipality in Northern Sweden. *Scandinavian Journal of Occupational Therapy*, **6**, 166-173. https://doi.org/10.1080/110381299443645

[19] Lynch, H., Moore, A., Edwards, C. and Horgan, L. (2019) Advancing Play Participation for All: The Challenge of Addressing Play Diversity and Inclusion in Community Parks and Playgrounds. *British Journal of Occupational Therapy*, **83**, 107-117. https://doi.org/10.1177/0308022619881936

[20] Jaggy, A., Kalkusch, I., Bossi, C.B., Weiss, B., Sticca, F. and Perren, S. (2023) The Impact of Social Pretend Play on Preschoolers' Social Development: Results of an Experimental Study. *Early Childhood Research Quarterly*, **64**, 13-25. https://doi.org/10.1016/j.ecresq.2023.01.012

[21] Olsen, H.M. and Dieser, R.B. (2012) "I Am Hoping You Can Point Me in the Right Direction Regarding Playground Accessibility": A Case Study of a Community Which Lacked Social Policy toward Playground Accessibility. *World Leisure Journal*, **54**, 269-279. https://doi.org/10.1080/04419057.2012.702456

[22] Siu, K.W.M., Wong, Y.L. and Lam, M.S. (2017) Inclusive Play in Urban Cities: A Pilot

Study of the Inclusive Playgrounds in Hong Kong SAR. *Procedia Engineering*, **198**, 169-175. https://doi.org/10.1016/j.proeng.2017.07.080

[23] McCarthy, S.M., Hughey, S.M. and Kaczynski, A.T. (2017) Examining Sociodemographic Differences in Playground Availability and Quality and Associations with Childhood Obesity. *Childhood Obesity*, **13**, 324-331. https://doi.org/10.1089/chi.2016.0239

[24] Moore, A. and Lynch, H. (2015) Accessibility and Usability of Playground Environments for Children under 12: A Scoping Review. *Scandinavian Journal of Occupational Therapy*, **22**, 331-344. https://doi.org/10.3109/11038128.2015.1049549

[25] Prellwitz, M. and Skär, L. (2007) Usability of Playgrounds for Children with Different Abilities. *Occupational Therapy International*, **14**, 144-155. https://doi.org/10.1002/oti.230

[26] Roemmich, J.N., Beeler, J.E. and Johnson, L. (2014) A Microenvironment Approach to Reducing Sedentary Time and Increasing Physical Activity of Children and Adults at a Playground. *Preventive Medicine*, **62**, 108-112. https://doi.org/10.1016/j.ypmed.2014.01.018

[27] Ripat, J. and Becker, P. (2012) Playground Usability: What Do Playground Users Say? *Occupational Therapy International*, **19**, 144-153. https://doi.org/10.1002/oti.1331

[28] Badan Standardisasi Nasional (2004) SNI 03-1733-2004: Tata Cara Perencanaan Ling-Kungan Perumahan di Perkotaan. BSN.

[29] Powers, S.L., Lee, K.J., Pitas, N.A., Graefe, A.R. and Mowen, A.J. (2019) Understanding Access and Use of Municipal Parks and Recreation through an Intersectionality Perspective. *Journal of Leisure Research*, **51**, 377-396. https://doi.org/10.1080/00222216.2019.1701965

[30] Janssen, I. and LeBlanc, A.G. (2010) Systematic Review of the Health Benefits of Physical Activity and Fitness in School-Aged Children and Youth. *International Journal of Behavioral Nutrition and Physical Activity*, **7**, Article No. 40. https://doi.org/10.1186/1479-5868-7-40

[31] Wray, A., Martin, G., Ostermeier, E., Medeiros, A., Little, M., Reilly, K., *et al.* (2020) Physical Activity and Social Connectedness Interventions in Outdoor Spaces among Children and Youth: A Rapid Review. *Health Promotion and Chronic Disease Prevention in Canada*, **40**, 104-115. https://doi.org/10.24095/hpcdp.40.4.02

[32] Hughey, M., Shulaker, B., Mowen, A. and Kaczynski, A.T. (2019) Promoting Physical Activity in Parks and Recreation. In: Daniel B, B., Amy A, E., Jay E., M. and Justin B, M., Eds., *Physical Activity and Public Health Practice*, Springer Publishing Company, 223-244. https://doi.org/10.1891/9780826134592.0014

[33] Miles, R. (2008) Neighborhood Disorder, Perceived Safety, and Readiness to Encourage Use of Local Playgrounds. *American Journal of Preventive Medicine*, **34**, 275-281. https://doi.org/10.1016/j.amepre.2008.01.007

[34] Spengler, J.O., Floyd, M.F., Maddock, J.E., Gobster, P.H., Suau, L.J. and Norman, G.J. (2011) Correlates of Park-Based Physical Activity among Children in Diverse Communities: Results from an Observational Study in Two Cities. *American Journal of Health Promotion*, **25**, e1-e9. https://doi.org/10.4278/ajhp.090211-quan-58

[35] Cranz, G. (1982) The Politics of Park Design: A History of Urban Parks in America. MIT Press.

[36] Pipkin, J.S. (2005) The Moral High Ground in Albany: Rhetorics and Practices of an 'Olmstedian' Park, 1855-1875. *Journal of Historical Geography*, **31**, 666-687. https://doi.org/10.1016/j.jhg.2004.06.002

[37] Powell, L.M., Slater, S., Chaloupka, F.J. and Harper, D. (2006) Availability of Physical

Activity-Related Facilities and Neighborhood Demographic and Socioeconomic Characteristics: A National Study. *American Journal of Public Health*, **96**, 1676-1680. https://doi.org/10.2105/ajph.2005.065573

[38] Gordon-Larsen, P., Nelson, M.C., Page, P. and Popkin, B.M. (2006) Inequality in the Built Environment Underlies Key Health Disparities in Physical Activity and Obesity. *Pediatrics*, **117**, 417-424. https://doi.org/10.1542/peds.2005-0058

[39] Vaughan, K.B., Kaczynski, A.T., Wilhelm Stanis, S.A., Besenyi, G.M., Bergstrom, R. and Heinrich, K.M. (2013) Exploring the Distribution of Park Availability, Features, and Quality across Kansas City, Missouri by Income and Race/ethnicity: An Environmental Justice Investigation. *Annals of Behavioral Medicine*, **45**, 28-38. https://doi.org/10.1007/s12160-012-9425-y

[40] Engelberg, J.K., Conway, T.L., Geremia, C., Cain, K.L., Saelens, B.E., Glanz, K., *et al.* (2016) Socioeconomic and Race/Ethnic Disparities in Observed Park Quality. *BMC Public Health*, **16**, Article No. 395. https://doi.org/10.1186/s12889-016-3055-4

[41] Rigolon, A., Browning, M. and Jennings, V. (2018) Inequities in the Quality of Urban Park Systems: An Environmental Justice Investigation of Cities in the United States. *Landscape and Urban Planning*, **178**, 156-169. https://doi.org/10.1016/j.landurbplan.2018.05.026

[42] Boslaugh, S.E. (2004) Perceptions of Neighborhood Environment for Physical Activity: Is It "Who You Are" or "Where You Live"? *Journal of Urban Health*: *Bulletin of the New York Academy of Medicine*, **81**, 671-681. https://doi.org/10.1093/jurban/jth150

[43] McCormack, G.R., Rock, M., Toohey, A.M. and Hignell, D. (2010) Characteristics of Urban Parks Associated with Park Use and Physical Activity: A Review of Qualitative Research. *Health & Place*, **16**, 712-726. https://doi.org/10.1016/j.healthplace.2010.03.003

[44] Greenberg, M.R. and Renne, J. (2005) Where Does Walkability Matter the Most? An Environmental Justice Interpretation of New Jersey Data. *Journal of Urban Health*: *Bulletin of the New York Academy of Medicine*, **82**, 90-100. https://doi.org/10.1093/jurban/jti011

[45] Taylor, W.C., Floyd, M.F., Whitt-Glover, M.C. and Brooks, J. (2007) Environmental Justice: A Framework for Collaboration between the Public Health and Parks and Recreation Fields to Study Disparities in Physical Activity. *Journal of Physical Activity and Health*, **4**, S50-S63. https://doi.org/10.1123/jpah.4.s1.s50

[46] Schneider, S., Bolbos, A., Fessler, J. and Buck, C. (2019) Deprivation Amplification Due to Structural Disadvantage? Playgrounds as Important Physical Activity Resources for Children and Adolescents. *Public Health*, **168**, 117-127. https://doi.org/10.1016/j.puhe.2018.11.016

[47] Macintyre, S. (2000) The Social Patterning of Exercise Behaviours: The Role of Personal and Local Resources. *British Journal of Sports Medicine*, **34**, Article 6. https://doi.org/10.1136/bjsm.34.1.6

[48] Lee, R.E., Booth, K.M., Reese-Smith, J.Y., Regan, G. and Howard, H.H. (2005) The Physical Activity Resource Assessment (PARA) Instrument: Evaluating Features, Amenities and Incivilities of Physical Activity Resources in Urban Neighborhoods. *International Journal of Behavioral Nutrition and Physical Activity*, **2**, Article No. 13. https://doi.org/10.1186/1479-5868-2-13

[49] Oakley, J., Peters, R.L., Wake, M., Grobler, A.C., Kerr, J.A., Lycett, K., *et al.* (2021) Backyard Benefits? A Cross-Sectional Study of Yard Size and Greenness and Children's Physical Activity and Outdoor Play. *BMC Public Health*, **21**, Article 1402.

https://doi.org/10.1186/s12889-021-11475-4

[50] Chen, S., Christensen, K.M. and Li, S. (2019) A Comparison of Park Access with Park Need for Children: A Case Study in Cache County, Utah. *Landscape and Urban Planning*, **187**, 119-128. https://doi.org/10.1016/j.landurbplan.2019.04.001

[51] Lai, P.C., Low, C.T., Wong, M., Kwan, M.P. and Wong, G. (2019) Provision of Convenient Play Space in a Densely Populated City: An Evaluation of Spatial Equity of Playgrounds in Hong Kong SAR. *International Journal of Environmental Research and Public Health*, **16**, Article 952.

[52] City of Oklahoma City (2025) Connectokc-Our Situation: Transportation. PlanOKC Barriers to Full Pedestrian Access. When Sidewalks Do Exist, Barriers Like Busy Streets, Difficult Intersections, Lack of Signals, and Freeways Can Block Natural Pedestrian Routes. https://planokc.org/connectokc/our-situation/

[53] The Trust for Public Land (2024) ParkScore® Index 2024: Oklahoma City. https://parkserve.tpl.org/downloads/historic/2024_ParkScoreRank.pdf

[54] Walk Score (2025) Oklahoma City, OK-Walk Score. Overall Walk Score: 34. https://www.walkscore.com/OK/Oklahoma_City

[55] U.S. Census Bureau (2020) TIGER/Line® Shapefiles: Block Groups [Shapefile]. https://www.census.gov/

[56] City of Oklahoma City (2020) City Boundaries [Feature Layer]. Data.okc.gov Open Data Portal. https://data.okc.gov/portal/page/viewer?datasetName=City+Boundaries

[57] U.S. Census Bureau (2021) American Community Survey 2016-2020 (5-Year) Estimates. https://data.census.gov/

[58] City of Oklahoma City (2020) Parks [Feature Layer]. Data.okc.gov Open Data Portal. https://data.okc.gov/portal/page/viewer?datasetName=Parks&view=map