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Socioeconomic and racial disparities of sidewalk quality in a traditional rust belt city

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ABSTRACT:

Neighborhood walkability is key to promoting health, accessibility, and pedestrian safety. The Accessible, Connected Communities Encouraging Safe Sidewalks (ACCESS) project was developed to assess sidewalks throughout an urban community in Pontiac, Michigan. Data were collected from 2016 to 2018 along eighty miles of sidewalk for tripping hazards, cracking, vegetation, obstructions, overhead coverage, street lighting, buffers, and crosswalks. Data were mapped in ArcGIS with sociodemographic characteristics by U.S. Census block group. The majority of sidewalks had moderate (57.6%) or major (29.4%) sidewalk quality issues, especially maintenance-related impediments (68.6%) and inadequate street lighting or shade coverage (87.2%). The majority of crosswalks had a curb ramp to improve access for people with disabilities (84.4%), however over half lacked a detectable warning strip (55.8%). Degraded sidewalk quality was associated with lower neighborhood socioeconomic status and a higher proportion of Black and Latinx residents. Equity-centered pedestrian infrastructure improvement plans can address these disparities by increasing accessible, safe active transport options that promote physical activity and reduce health disparities. Evaluations like ACCESS can connect public health professionals with municipal planners to advance Complete Streets plans and promote healthy living.

1. Introduction

The built environment and pedestrian infrastructure are central to promoting physical activity, community cohesion, and environmental sustainability (Burden & Litman, 2011; Jun & Hur, 2015; Lovasi et al., 2009; Rundle et al., 2009). Globally, physical inactivity is estimated to lead to 13.4 million disability-adjusted life years from associated diseases such as heart disease, type 2 diabetes, stroke, breast cancer, and colon cancer (Ding et al., 2016). Yet only one-third of all US adults report walking in the past month, the most commonly reported physical activity (Dai et al., 2015). Access to walkable neighborhoods is therefore important for promoting physical activity and reducing mortality (Patel et al., 2018). The relative accessibility of walking (e.g., it does not require equipment, skills, or membership fees) makes it an important component of physical activity, particularly for low-income individuals. Walkability and sidewalk quality are often deficient in lower-income neighborhoods and neighborhoods of color, but the trends vary by community and attributes measured (Duncan et al., 2012; Kelly et al., 2007; Rigolon et al., 2018; Zhu & Lee, 2008). Accordingly, promoting environments that enable regular physical activity could alleviate health burdens and address long-standing economic and racial health disparities (Carlson et al., 2015; Ding et al., 2016).

Research on walkability has primarily focused on macroscale characteristics such as population density, proximity of desirable destinations or amenities, land use, greenspace, and/or active transportation infrastructure (Adu-Brimpong et al., 2017; Zhu & Lee, 2008; Rigolon et al., 2018; Jun & Hur, 2015). While macroscale assessments can be sufficient in evaluating walkability of neighborhoods and larger areas,

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there is a growing use of microscale characteristics to assess walkability on a block-by-block basis (Dannenberg et al., 2017). Microscale characteristics include sidewalk quality, street lighting, parks, bike paths, building heights and setbacks, intersection crossings, etc. Microscale assessments of walkability such as the Microscale Audit of Pedestrian Streetscapes (MAPS; Cain et al., 2012) and the Built Environment Assessment Tool (BE Tool; Centers for Disease Control and Prevention, 2015), focus on microscale pedestrian environments that promote walkability and accessibility, typically through assessments by neighborhood block or between intersections. Even smaller-scale, nanoscale, assessments of sidewalk segments within neighborhood blocks have not been examined to the authors' knowledge. Assessing nanoscale characteristics may help to explain disparities in walking practices that macro- and microscale surveys are unable to discern.

Previous microscale assessments have exposed racial and income disparities in access to walkable neighborhoods. Maintenance issues, tripping hazards, and sidewalk obstructions are found more frequently in majority non-white or Black neighborhoods (Rigolon et al., 2018; Kelly et al., 2007). Kelly et al. (2007) found that block groups that were majority Black were 15 times more likely to have sidewalk obstructions, while poverty was not associated with obstructions. Some researchers such as Zhu and Lee (2008) found poverty, not race, to be associated with worse sidewalk maintenance near elementary schools. Other researchers observe tandem relationships between race and poverty in relation to sidewalk quality (e.g., Rigolon et al., 2018).

Neighborhood walkability is important for promoting safety; inaccessible neighborhoods with low macroscale walkability reduce pedestrian and cyclist safety (Yin & Zhang, 2021). One-fifth of all motor vehicle crash fatalities are non-motorists, 85% of whom are pedestrians (National Highway Traffic Safety Administration, 2021). While fatalities involving motor vehicles have largely been decreasing since 1975 (National Highway Traffic Safety Administration, 2020), the proportion of fatal motor vehicle crashes involving non-motorists has increased since 2009 (National Highway Traffic Safety Administration, 2020). Ensuring individuals have access to sidewalks is imperative to providing safe, designated space for pedestrians.

The auto-centric urban community of Pontiac, located 30 miles north of Detroit, Michigan, was selected for this study in part because of pedestrian safety concerns. The proportion of fatal crashes involving pedestrians (45.8%) was almost three times the state's average (16.5%) from 2016 to 2018 (Michigan Office of Highway Safety Planning, 2020). Despite a greater safety risk, pedestrians opt to walk in the roadway when sidewalks are missing, in poor condition, or not plowed in winter (Smart Growth America, 2017). In a 2018 Pontiac Community Survey Report, 23.3% of respondents indicated that they used an alternative means of transportation (e.g. walking, transit, and biking) to get to work (Healthy Pontiac, We Can! Coalition, 2018), making non-motorized transportation options a necessity. Residents also ranked sidewalks and parks as the second most popular site to engage in physical activity, highlighting the importance of prioritizing sidewalk infrastructure to promote physical activity.

Pontiac is a diverse rust belt city of almost 60,000 characterized by the decline of the local automotive industry (US Census Bureau, 2021b). Its population grew rapidly after World War II with the growth of the automotive industry within and surrounding Pontiac, to a height of over 85,000 in 1970 (City of Pontiac, n.d.; Michigan Information Center, n.d.). The decline of the automotive industry devastated Pontiac, which lost tax revenue as automotive plants closed and residents left the city. The shrinking tax base led to financial crisis and a Governor-appointed emergency management government of austerity from 2009 through 2016 (State of Michigan, 2017). Residents of Pontiac are vulnerable to infrastructure divestment as a majority-Black city with one-third of residents living below the federal poverty level (US Census Bureau, 2021b). Pontiac, like many rust belt cities, has deferred maintenance on aging infrastructure including the built environment, resulting in many infrastructure projects being completed well after they have surpassed their designed service life. Many sidewalks in the city are not in compliance with the Americans with Disabilities Act (ADA) of 1990 since they predate ADA Standards.

A local coalition, Healthy Pontiac, We Can! facilitated a Complete Streets Plan for Pontiac, which outlined strategies to improve walking and biking infrastructure in order to increase physical activity in the daily lives of residents. The National Complete Streets Coalition uses a "Complete Streets" approach that includes multiple forms of transportation (walking, bicycling, rolling, driving, or public transit) to encourage a place- and people-based approach to planning, designing, constructing, operating, and maintaining transportation networks (Smart Growth America, 2021). Complete Streets initiatives can reduce pedestrian fatalities and injuries; and improve traffic congestion, air quality, quality of life, and social equity (Burden & Litman, 2011; Shu et al., 2014).

One of the recommendations of the Pontiac Complete Streets Plan was to conduct a sidewalk audit to help city officials prioritize sidewalk repair and installation due to limited resources. We formed the ACCESS (Accessible, Connected Communities Encouraging Safe Sidewalks) project to address residents' concerns expressed in public meetings on sidewalk gaps and poor pavement condition, a lack of crosswalks, overgrown vegetation, and people often walking in roadways (Greenway Collaborative Inc., 2017). Our primary objective was to provide the local municipality with highly detailed sidewalk quality data to help prioritize sidewalk and pedestrian environment upgrades that promote social equity in Pontiac. The corresponding research question was: How are sidewalk quality and other pedestrian environment factors associated with sociodemographic characteristics in Pontiac? To answer this question, we conducted a direct, observational sidewalk assessment and overlaid it with sociodemographic Census data.

While walkability research has predominantly focused on macroscale factors and recent research has explored microscale factors, our research through ACCESS examined nanoscale walkability factors (i.e., sidewalk infrastructure and pedestrian environments *within* one neighborhood block). There is evidence indicating the relationship between macro- and microscale pedestrian environments with sociodemographic characteristics, but the data are limited at nanoscales. Most research only focuses on race and poverty, without also examining education, rental status, and age of housing, which can contribute to pedestrian infrastructure quality. It is more feasible for municipalities like Pontiac to modify or update selected portions of sidewalk over broad macro- or microscale features, so nanoscale data is paramount to reducing built environment disparities. While the research was conducted in Pontiac, a relatively small urban community, it is comparable to other rust belt communities that similarly face limited financial resources, disinvestment, and diverse population concerns. Examining disparities in pedestrian environments is the first step in identifying and addressing upstream factors that contribute to health disparities.

2. Methods

2.1. *Sidewalk quality assessment*

A direct observational sidewalk quality assessment along major roads and neighborhood streets was conducted in Pontiac, Michigan, from June through October in 2016, 2017, and 2018. The ACCESS sidewalk quality assessment included questions from the CDC's Division of Community Health's Built Environment Assessment Tool (BE Tool), which was adapted from the Microscale Audit of Pedestrian Streetscapes (MAPS; Cain et al., 2012; Centers for Disease Control and Prevention, 2015). Due to a need for a finer-scale sidewalk assessment, ACCESS assessed 100-feet sidewalk segments utilizing a 23 question survey about sidewalk quality, maintenance, obstructions, crosswalks, ADA curb ramps, and street lighting, including 14 questions adapted from the BE Tool. A guide for the sidewalk assessment that included photographic examples of varying sidewalk quality conditions was developed based on the instructions in the CDC BE Tool and provided to all researchers. All student researchers were trained on the questions, response options, survey protocol, and survey instruments with county planning and research experts.

Teams of student researchers conducted a direct evaluation per 100-feet segments of sidewalk (demarcated with a measuring wheel) and crosswalk characteristics. Since the focus was on sidewalk quality, only segments with at least partial sidewalks were included in the direct assessment. The teams included at least one person per road section where sidewalks were present. Segments shorter than 75-feet were indicated as a "partial segment." A sidewalk quality assessment for each segment was recorded electronically through a Qualtrics survey (Qualtrics, Provo, UT). All sidewalk assessments were conducted during the daytime (8:00–15:00), Monday through Friday. Latitude and longitude coordinates were recorded at the center of each sidewalk segment using a handheld global positioning system (GPS) unit (Garmin Oregon 650t device [Garmin Ltd., Olathe, KS]). The GPS data for each segment were matched with sidewalk data and collated into one dataset. The information collected for each sidewalk segment was mapped as point data using Esri ArcGIS software (Esri, Redlands, CA).

The sidewalk quality assessment included questions regarding sidewalk presence, width of sidewalk, buffer between the roadway and sidewalk, the prevalence of sidewalk cracking and tripping hazards, the severity of tripping hazards and vegetation growth on the sidewalks, overhead coverage (as a measure of shade availability), the presence of street light infrastructure, the overall perceived sidewalk quality, and obstructions that could impede or discourage travel on the sidewalk (e.g., overhanging branches, poles, improperly placed benches, litter, or graffiti). Questions on tripping hazards, vegetation growth, and cracking of the sidewalk were added to assist with municipal maintenance planning. A subset of questions was included to record crosswalk presence and safety characteristics (i.e., ADA curb ramps and detectable warning strips) for sidewalk segments that started or ended at a road intersection or commercial driveway (US Access Board, 2013). The full sidewalk quality assessment is available in Supplemental File A.

For some sidewalk features, such as the presence of sidewalk cracking, tripping hazards, and vegetation growth on the sidewalk, responses were categorized by the coverage of the segment with the characteristic (e.g., none or 0% of the segment, minor presence or ~25% of the segment, moderate presence or ~50% of the segment, and major presence or ~75% or more of the segment). These scales were set in accordance with scales used in the BE Tool for similar questions. The ~50% of the segment and ~75% of the segment or more options (moderate and major presence) were collapsed into one category of >50% of the segment/at least moderate presence. The presence of tripping hazards and their respective severity were evaluated separately and merged into one variable (i.e., tripping hazard severity). Because sidewalk data were collected during daylight hours, street lighting presence, not functionality, was recorded. Potential obstructions to pedestrians were recorded and stratified into three sub-categories: landscaping (shrubs/overhanging trees and vegetation growth reducing overall sidewalk width), non-landscaping removable (trash receptacles, parked vehicles, a-frame vendor signs) and permanent obstructions (water meter shut off valves, utility poles, fire hydrants, etc.).

Individual sidewalk features were calculated into composite scores by infrastructure (presence of buffer and width of sidewalk), easement (street light infrastructure, overhead coverage, permanent obstructions), conditions (severity of cracking and tripping hazards), and maintenance (severity of vegetation growth on the sidewalk, landscaping obstructions, and removable obstructions). Scoring for sidewalk quality was done in alignment with BE Tool scoring for individual sides of the sidewalk. Each composite score is a sum of the corresponding variables (with a one-to-one weighting for minor issues and two-to one weighting for moderate/major issues) and two-to-one weighting for obstructions. Infrastructure was met/not met for having a buffer and at least 3 feet wide sidewalks. An overall sidewalk quality score was calculated as a composite sum of infrastructure, easement, conditions, and maintenance scores. Infrastructure characteristics were categorized as present or inadequate. Easement characteristics were categorized as ample/some, some/slightly inadequate, or inadequate or permanent obstructions present. Sidewalk conditions and maintenance characteristics were categorized into no/none, moderate, or major issues. Overall sidewalk quality was categorized into no/minor, moderate, and major issues.

Google Maps "street view" was used to conduct aerial photograph interpretation to identify roadways with missing segments of sidewalks (Google LLC, Mountain View, CA). All street segments without a sidewalk present were recorded using two coordinate points (i.e., starting and ending point). These coordinates were used to create line data and were mapped using ArcGIS. Geographic information systems (GIS) municipal boundary and roadway data were obtained through Access Oakland, an open GIS county data portal (Access Oakland, n.d.).

2.2. Sociodemographic data

Sidewalk quality data were overlaid with U.S. Census data to analyze sidewalk conditions by neighborhood sociodemographic characteristics. Sociodemographic data were obtained through the U.S. Centers for Disease Control and Prevention, 2015 American Community Survey (ACS) Topologically Integrated Geographic Encoding and Referencing (TIGER) GIS data (US Census Bureau, 2017). The ACS GIS data were limited to Pontiac and delineated at the block group level (block groups contain between 600 and 3000 residents or between 240 and 1200 housing units, and are a composite of Census blocks; US Census Bureau, 2021a). For each block group, the percent of people by education level, racial and ethnic composition, below poverty ($11,880 for one person and $24,300 for a household of four in 2016; Assistant Secretary for Planning and Education, 2016), household income level below $40,000, disability status, and work commute mode; and the percent of housing units built before 1949, renter-occupied homes, and vacant housing; and the average number of housing units was calculated. The proportion of housing units built before 1949 was selected to capture the urban growth of the early 1900s but exclude the rapid suburban expansion of the 1950s and onward. Racial categories were used as one race alone or in combination with another race to allow for representation of people who are two or more races.

2.3. Analyses

Maps were created by layering sidewalk and sociodemographic data of interest in ArcGIS. The number of sidewalk segments analyzed per block group was calculated to estimate the spatial distribution of the sidewalk assessments. The length of line data representing the total miles of streets missing sidewalks and the average sidewalk quality scores per bock group were calculated in ArcGIS. Sidewalk assessment data were intersected with the block group polygons of the ACS demographic data, so that each sidewalk segment was assigned corresponding demographic data of its host block group (e.g., if the segment was in a block group with 30% below poverty, then the 30% below poverty attribute was ascribed to the sidewalk segment point data).

All sidewalk assessment data were imported into SPSS (v.25) for statistical analysis, including descriptive statistics, bivariate correlations, and regressions. Census demographic data were not normally distributed and therefore non-parametric statistical tests such as Spearman's rho, Mann-Whitney U, and Kruskal-Wallis tests were utilized to analyze differences in ACS demographic characteristics and sidewalk quality variables. Sidewalk variables were analyzed through ordered logistic regressions with sociodemographic variables.

3. Results

There were 4488 sidewalk assessments of complete and partial sidewalk segments (3917 and 574 segments, respectively), encompassing approximately 80 miles of sidewalk (Fig. 1). A total of 1901 sidewalk segments were assessed in 2016, 1057 in 2017, and 1530 in 2018. Sidewalks were assessed in 57 (92%) of the city's 62 block groups. There was a mean of 72.4 sidewalk segments assessed per block group (SD: 78.7 segments, median: 36.5 segments, maximum: 316 segments). There were almost 71 miles of missing sidewalk within the city.

3.1. Sidewalk quality

Sidewalk characteristics are summarized in Table 1. There were few infrastructure issues (<5% without a buffer or with a sidewalk < 3 ft wide), but negative easement attributes, conditions, and maintenance issues were more common (13–26%). Over one-quarter of all sidewalk segments had major sidewalk quality issues. The majority of sidewalk segments (54%) had no covering or trees to provide shade and 41% had no street lighting infrastructure present around the segment. Overall, there were more obstructions pertaining to landscaping present within

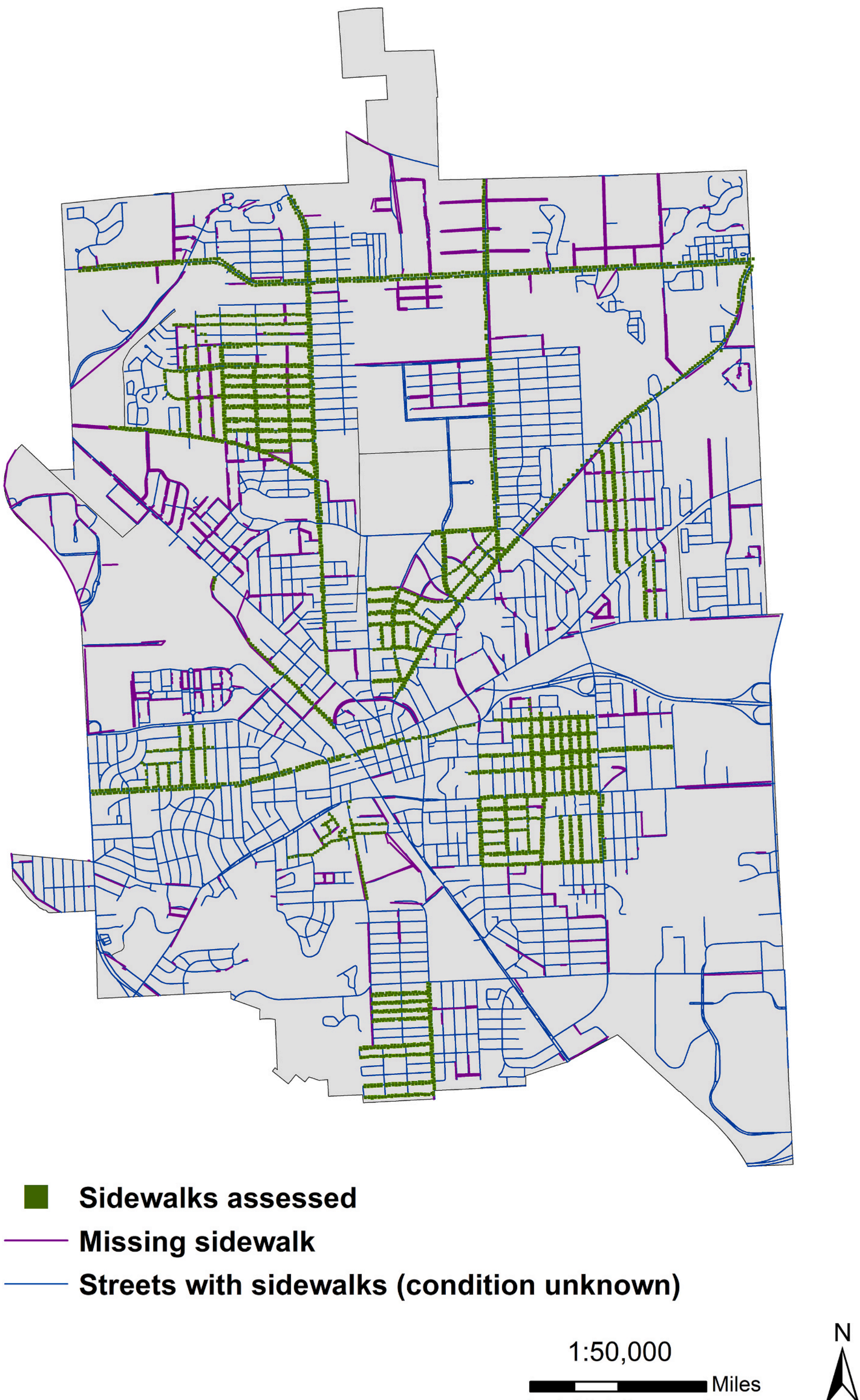

Fig. 1. Sidewalks assessed through ACCESS in 2016–2018, including areas with missing sidewalks and streets with sidewalks that were not assessed. Map produced from data provided through Access Oakland's Oakland County and Pontiac, Michigan, data.
[Alternative text: Map of the City of Pontiac with point data for each sidewalk segment assessed throughout the city, lines for areas missing sidewalks, and lines for streets with sidewalks but the condition is unknown. Sidewalks were spatially assessed throughout the city.].

Table 1
Frequencies of sidewalk and crosswalk characteristics.

Variables	Categories	Frequency (n)	Percent (%)
Sidewalk segments (*n*)	All	4488	100.0
	Complete (~100 ft)	3917	87.2
	Partial (<75 ft)	574	12.8
Infrastructure characteristics	Buffer present and/or sidewalk > 3 ft wide	4280	95.4
	No buffer present and/or sidewalk < 3 ft wide	208	4.6
Easement characteristics	Ample or some lighting and overhead coverage, no permanent obstructions	576	12.8
	Some or no lighting and/or overhead coverage; no permanent obstructions	2746	61.2
	No lighting or covering, and/or at least one permanent obstruction	1166	26
Sidewalk condition [a]	No sidewalk cracking or tripping hazard issues	1436	32
	Moderate sidewalk cracking or tripping hazard issues	2460	54.9
	Major sidewalk cracking or tripping hazard issues	586	13.1
Maintenance quality	No sidewalk vegetation growth or landscaping/removable obstructions	1410	31.4
	Some sidewalk vegetation growth and/or 1–2 landscaping/removable obstructions	2311	51.5
	Sidewalk vegetation growth and/or 1–3 landscaping/removable obstructions	767	17.1
Sidewalk quality composite score [a]	Minor or no sidewalk quality issues	583	13
	Moderate sidewalk quality issues	2580	57.6
	Major sidewalk quality issues	1319	29.4
Crosswalks	At intersections	1304	89.6
	At driveways	152	10.4
ADA curb ramps at intersections or driveways	Curb ramp present	1256	86.4
	No curb ramp	197	13.6
Detectable warning strips at intersections	Warning strip present	608	44.2
	No warning strip	767	55.8

[a] $n = 4482$; 6 responses missing due to a discrepancy in responses (i.e. "25% of segment had tripping hazards" and "no tripping hazard severity").

sidewalk segments than there were removable or permanent obstructions. Only 261 segments (5.8%) had litter present, 17 sidewalk segments (0.4%) had benches, four sidewalk segments (0.1%) had graffiti on buildings or structures around them, and 10 segments (0.2%) had other miscellaneous characteristics. Almost one-third of assessed segments had a crosswalk at road intersections or large driveway ramps. Table 1 displays the frequencies of ADA curb ramps (86.4%) and detectable warning strips (44.2%) at crosswalks. Six percent (n = 82) of all detectable warning strips present were incorrectly placed.

3.2. Sociodemographic characteristics

The average sociodemographic characteristics assigned to sidewalk segments by their host block group are summarized in Table 2. The majority of residents were Black, held a high school diploma or lower, and had household incomes below $40,000; and two-fifths of all homes were built before 1949. Although most residents drove a vehicle alone to work (74%), others carpooled (18%), walked (3.4%), took public transit (1.2%), bicycled (0.2%) or took a cab (0.2%) to work. The average

Table 2
American Community Survey (ACS) Census block group data of sociodemographic variables at assessed sidewalk segments (n = 4488) and the Spearman's rho correlation coefficients of the length of streets without sidewalks and average overall sidewalk quality score per block group (n = 62).

	Assessed sidewalk segments	Correlation coefficients	
		Streets without sidewalks	Sidewalk quality composite
	Mean (SD)	rho (p-value)	rho (p-value)
Education			
Less than high school or GED	24.6 (9.4)**	0.20 (.875)	-.105 (.435)
High school diploma or GED	37.3 (9.2)**	-.263 (.039)*	.500 (<.001)**
Some college or associate's degree	30.2 (9.4)	.309 (.015)*	-.144 (.284)
Bachelor's degree or higher	7.9 (6.9)**	.108 (.402)	-.291 (.028)*
Racial and ethnic composition [a]			
White race	47.1 (23.9)	-.113 (.381)	-.020 (.880)
Black race	52.1 (25.1)**	.229 (.073)	.069 (.609)
Asian, NHOPI, AIAN, and/or other race	8.8 (9.2)	-.027 (.833)	-.108 (.426)
Latinx or Hispanic ethnicity	18.8 (13.7)*	-.185 (.150)	.157 (.243)
Below poverty level	35.5 (14.1)**	.164 (.204)	.308 (.020)*
Household income < $40,000	66.2 (16.3)**	-.004 (.975)	.232 (.082)
Disability in household	36.0 (12.3)**	-.193 (.132)	.119 (.380)
Vacant housing	15.9 (11.9)**	-.240 (.060)	.218 (.104)
Renter occupied housing units	49.9 (17.7)	.095 (.464)	.068 (.614)
Homes built before 1949	40.0 (20.8)**	-.457 (<.001)**	.360 (.006)*
Number of housing units in block group	442.4 (195.6)**	.401 (.001)**	-.390 (.003)**

*p < .05 for Kruskal-Wallis tests of the overall sidewalk quality composite score by ACS variable; or Spearman's rho of the street length without sidewalks and the average overall sidewalk quality composite score per block group by ACS variable.
**p < .005 for Kruskal-Wallis tests of the overall sidewalk quality composite score by ACS variable; or Spearman's rho of the street length without sidewalks and the average overall sidewalk quality composite score per block group by ACS variable.
[a] All racial data is by race alone or in combination with another race. NHOPI refers to Native Hawaiian and other Pacific Islander and AIAN refers to American Indian and Alaska Native.

sociodemographic characteristics attributed to sidewalk segments by their host block group were similar to average levels in the city.

3.3. Sidewalk quality and sociodemographic factors

Bivariate Spearman correlations of block group data indicated that the average length of streets without sidewalks was inversely correlated to the percent with a high school diploma or GED (p = .039) and the number of homes built before 1949 (p<.001), and positively correlated to the percent with some college or higher (p = .015) and the number of housing units (p = .001). Kruskal-Wallis tests of sociodemographic data revealed significant differences by overall sidewalk quality scores (Table 2). Segments with major sidewalk quality issues had a higher percent Black race, Latinx/Hispanic ethnicity, HS diploma or GED, below the poverty level or with a household income <$40,000, disability, vacant housing, and housing built before 1949; and lower percent with less than a high school degree or a bachelor's degree or higher and fewer housing units.

Mann-Whitney U tests of ADA curb ramps showed areas without curb ramps had significantly higher levels of percent Latinx/Hispanic, race other than White or Black, with a high school diploma or GED, below the poverty level, household income <$40,000, and homes built before

1949; and fewer renters, residents with a bachelor's degree or higher, and number of housing units. Mann-Whitney U tests of detectable warning strips showed areas without detectable warning strips had significantly higher levels of percent Black, with a high school diploma or GED, holders of some college or associate's degree, below the poverty level, and household income <$40,000, and homes built before 1949; lower levels of percent White, with less than a high school degree, with a bachelor's degree or higher; and fewer number of housing units.

In ordered logistic regression models adjusting for the number of housing units, vacant housing, renters, older homes, education, poverty, race, and ethnicity (Table 3), the odds of having worse overall sidewalk quality significantly increased for block groups with a higher proportion of people living below the poverty level, older homes, and Black and Latinx/Hispanic residents. Block groups with a greater number of housing units, proportion of renters, and residents with less than a high school degree were associated with a decreased odds of worse sidewalk quality. In adjusted binary logistic models for the presence of ADA curb ramps and detectable warning strips at crosswalks (Table 3), the odds of not having a detectable warning strip at a crosswalk significantly increased for block groups with a higher proportion of homes built before 1949 and Black and Latinx residents. The proportion of renters in a block group was associated with greater odds that warning strips and ADA curb ramps were present at crosswalks.

4. Discussion

ACCESS builds on prior research examining the connections of race and income with microscale pedestrian environments (Duncan et al., 2012; Kelly et al., 2007; Rigolon et al., 2018). By also examining education, disability, and housing characteristics, ACCESS offers a more holistic equity assessment. The nanoscale assessment showcases a novel approach to studying pedestrian environments and sidewalk quality that can be used for equitable municipal planning, capital improvement programs, and priority setting.

Table 3
The odds of sociodemographic characteristics of host block groups by sidewalk quality score, ADA curb ramps, and detectable warning strips.

	Model[a]					
	Overall sidewalk quality		Missing ADA curb ramps		Missing detectable warning strips	
	OR	95% CI	OR	95% CI	OR	95% CI
Number of housing units	0.999	(0.999, 0.9995)	0.999	(0.998, 1.000)	1.001	(1.0002, 1.002)
Renters	0.994	(0.991, 0.998)	0.980	(0.969, 0.990)	0.988	(0.981, 0.995)
Vacant housing	1.005	(0.999, 1.011)	0.994	(0.978, 1.010)	0.986	(0.975, 0.998)
Homes built before 1949	1.005	(1.002, 1.009)	1.011	(1.001, 1.021)	1.020	(1.013, 1.026)
Black race	1.004	(1.001, 1.008)	1.017	(1.006, 1.029)	1.011	(1.004, 1.017)
Latinx/ Hispanic ethnicity	1.006	(1.001, 1.012)	1.043	(1.026, 1.060)	1.013	(1.002, 1.024)
Below poverty	1.010	(1.006,1.015)	1.030	(1.015, 1.045)	1.003	(0.994, 1.012)
Holds less than high school degree	0.986	(0.979, 0.993)	0.986	(0.966, 1.007)	0.980	(0.967, 0.994)

[a] Models show the odds ratios (ORs) and 95% confidence intervals (CIs) for each sociodemographic variable from ordered logistic regression for the overall sidewalk quality score and binary logistic regression for ADA curb ramps and detectable warning strips.

Block groups with lower SES indicators (i.e., poverty, household income, older homes, vacant housing) and a greater proportion of racial and ethnic minorities generally had significantly worse overall sidewalk quality. This aligns with research findings by Kelly et al. (2007) and Rigolon et al. (2018) that there were more tripping hazards in majority Black block groups and worse maintenance in majority non-White and low SES block groups. Research on walkability trends by Latinx/Hispanic ethnicity is limited and has largely observed better macro-scale walkability characteristics with a greater proportion of Latinx/Hispanic residents (Duncan et al., 2012; Zhu & Lee, 2008). ACCESS, however, observed significantly worse sidewalk quality and accessibility features by Latinx/Hispanic ethnicity, which may be due to differences in scale. Areas with higher poverty were correlated with worse street lighting and overhead coverage, which aligns with research finding more mature street trees in wealthier neighborhoods (Schwarz et al., 2015). Contrary to the association of poor sidewalk quality with low SES indicators, sidewalk quality was better in block groups containing a higher proportion of renters, fewer high school graduates, and a greater number of housing units. While this study did not examine housing type (e.g., multifamily apartments, single family, etc.), renters and holders of less than a high school degree may live in areas with more multifamily housing complexes that have better sidewalk conditions, easement characteristics, and maintenance.

Sidewalk quality characteristics that are partially determined by residential maintenance, such as vegetation growth on the sidewalk, overgrown branches, or removable obstructions, were significantly associated with older homes, poverty, and race of the block group. Neighborhoods with older homes are more likely to have sidewalks but often have correspondingly older sidewalks with more sidewalk quality issues, including cracking and tripping hazard conditions, narrow or missing buffers or sidewalk infrastructure, and more landscaping-related maintenance issues (Thornton et al., 2016). Disinvestment in aging sidewalk infrastructure and a lack of code enforcement to replace sidewalks in need of repair contribute to worse sidewalk quality in older neighborhoods. Residential sidewalk maintenance costs are borne at least partially on property owners, which likely contributes to SES disparities in sidewalk quality. People who are lower income are often burdened with financial poverty and time poverty, which limits resources dedicated to residential yard and sidewalk maintenance (Cook et al., 2012; Krishnaswami & Merton, 2015). Higher poverty rates in Pontiac likely contribute to a greater number of maintenance and landscaping-related issues (e.g., 31% in Pontiac vs 11% live below the poverty level in Michigan; US Census Bureau, 2021b).

The relationships between SES, race, and sidewalk quality may be partially driven by residential sorting, where lower SES residents systematically move to more affordable areas that have correspondingly worse sidewalk quality. While this study did not examine temporality or causality, it is likely that residential sorting and maintenance disparities contribute to sociodemographic disparities in overall sidewalk quality. Chetty et al. (2016) noted that growing up in a low-income neighborhood significantly impacts long-term economic outcomes. Although they did not examine the causes for these economic disparities, factors such as education, job opportunities, social networks, pollution exposures, greenspace, safety, and even walkability and sidewalk quality likely contribute to this outcome. Because people who are low SES may have limited access to a personal vehicle, walkability can be integral for economic opportunities. Future research is needed to examine these relationships.

The presence of sidewalks, ADA curb ramps, and detectable warning strips are key indicators of sidewalk accessibility. Many sidewalks in Pontiac pre-date ADA Standards and require retrofits to comply. There was no correlation of ADA curb ramps or detectable warning strips with the percent of households with someone with a disability, however given over one-third of households have at least one member with a disability, the need for these improvements are widespread throughout the city. Pontiac has a higher rate of individuals with disabilities

(16.8%) than the state of Michigan (10.2%) and nationally (8.6%; US Census Bureau, 2021b), underscoring the importance of these amenities. Higher disability rates for racial minorities, those living in poverty, and those with lower educational attainment (Taylor, 2018) partially explain the higher disability rates in Pontiac.

4.1. Limitations

Because research on walkability has primarily focused on macro- and microscale features, there is no standardized or widely accepted protocol for assessing nanoscale sidewalk environments. The ACCESS assessment and scoring was based on validated survey tools (i.e., BE Tool and MAPS) to address this gap. Additional assessments are needed to evaluate this methodology. The ACCESS sidewalk assessment primarily utilized in-person observations of sidewalk quality, which was time and resource intensive. Other researchers have explored the use of virtual assessments of walking infrastructure such as Google Street View and found relatively high concordance with in-person observational assessments (Mooney et al., 2014; Phillips et al., 2017) but similar time requirements (Steinmetz-Wood et al., 2019). An advantage of direct assessments is that they allow for real-time measures of maintenance issues. Secondary GIS-based walkability data or self-reported perceptions can also be used to assess the built environment (Brownson et al., 2009), although they may be limited by larger spatial scales and temporal variations. Assessments during daytime hours were necessary for student safety, but meant that street lighting capability could not be evaluated. Given resource limitations and data needs of the city, our assessment was focused on areas with existing sidewalks. Street blocks that lacked sidewalks were not included as part of the direct assessment, although SES trends may be even more pronounced in these areas.

Teams of student researchers conducted the sidewalk assessments over three years, which introduces greater variability. As part of their training, pairs of students independently evaluated sidewalk quality and discussed assessments with planning experts to ensure they comparably assessed sidewalks. Some students remained with the project for all assessment years, which reduced variability.

Our analyses used Census block groups for sociodemographic data, which applies an average to the entire block group area that may not appropriately represent the sociodemographics of residents at the specific assessed sidewalks (e.g., there may be significant variation within the block group). Using block groups instead of Census tracts, though, provides a more accurate representation of local demographics (Chakraborty et al., 2011). While efforts were made to uniformly target the city, some areas were not assessed. Neighborhoods were assessed as a whole instead of in part, which created clusters of assessed areas that over-sampled in some block groups. Additionally, areas with recent violence were not sampled to ensure student researcher safety. Biases in sampling locations could influence statistical analyses, although analyses by block groups show similar results as by sidewalk segments and suggest limited bias.

This analysis focused on the nanoscale sidewalk pedestrian environment, however other factors such as connectivity, density, perceived traffic safety and crime, desirable destinations, and other infrastructure are also important for promoting walkability (Zuniga-Teran et al., 2017). While there are various methods and approaches for assessing fine-scale pedestrian streetscapes, sidewalks, and neighborhood walkability, our tailored survey from the BE Tool suited community desires to assess sidewalks and provide useable data for priority setting.

5. Conclusions

Despite the disconnect between public health planning and municipal urban planning, local municipal governments can play a role in addressing health inequities through targeted infrastructure improvements. Rust belt communities face specific challenges of limited financial resources and economically depressed residents, which require novel approaches to address infrastructure deficiencies and inequity. Dedicating resources to achieve walkable neighborhoods can rectify decades of infrastructure disinvestment to improve sidewalk quality, resident health, and livability. ACCESS exposes the economic, racial, and ethnic disparities that exist in pedestrian sidewalk infrastructure in Pontiac, Michigan, that may exist in similar rust belt communities. Incorporating equity in these improvements increases accessibility for people with disabilities and low socioeconomic or racial/ethnic minorities who may have limited automotive transportation options. Complete Street improvements can help reduce the comprehensive costs of pedestrian crashes, which was estimated to be about $20 million annually in Pontiac (National Highway Traffic Safety Administration, 2016). Student researchers conducted the ACCESS assessment; however, similar initiatives should consider the use of community citizen scientists to assist with pedestrian walking environment assessments (Winter et al., 2016). The community's insight would shed light on areas of need pertaining to walkability and accessibility.

Pontiac faces a number of challenges to increasing walking and biking accessibility and comfort, particularly in transforming the streets to be less auto-centric and addressing the deferred maintenance of aging infrastructure. The sidewalk quality maps created through ACCESS will be utilized in strategic planning to maximize limited funding and to prioritize areas that would benefit the most from existing sidewalk infrastructure improvements. While resource and personnel-intensive, the data showcase how these nanoscale assessments can be used in urban planning to create more vibrant, equitable neighborhoods that encourage physical activity and active modes of transport.

Author statement

Mozhgon Rajaee: Conceptualization, methodology, validation, formal analysis, data curation, writing – original draft, review, & editing, visualization, supervision. **Brenda Echeverri**: Methodology, validation, formal analysis, investigation, data curation, writing – original draft, review, & editing, visualization, supervision. **Zachary Zuchowicz**: Conceptualization, methodology, validation, investigation, data curation, writing review & editing, supervision. **Kristen Wiltfang**: Methodology, validation, writing review & editing. **Jennifer F. Lucarelli**: Conceptualization, methodology, validation, resources, writing review & editing, supervision, project administration, funding acquisition.

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Declaration of competing interest

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Appendix A. Supplementary data

Supplementary assessment data to this article can be found online at https://doi.org/10.1016/j.ssmph.2021.100975.

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