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Association between racial residential segregation and walkability in 745 U.S. cities

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Abstract

Despite higher chronic disease prevalence, minoritized populations live in highly walkable neighborhoods in US cities more frequently than non-minoritized populations. We investigated whether city-level racial residential segregation (RRS) was associated with city-level walkability, stratified by population density, possibly explaining this counterintuitive association. RRS for Black-White and Latino-White segregation in large US cities was calculated using the Index of Dissimilarity (ID), and walkability was measured using WalkScore. Median walkability increased across increasing quartiles of population density, as expected. Higher ID was associated with higher walkability; associations varied in strength across strata of population density. RRS undergirds the observed association between walkability and minoritized populations, especially in higher population density cities.

Keywords

Walkability; Built Environment; Segregation; Cities; Population Density; Health Disparities

Introduction

A growing body of evidence has established that the built environment is an important determinant of health[1,2]. Studies have identified associations between higher neighborhood walkability (measuring features of the built environment that facilitate walking[3,4]), and lower prevalence of chronic disease[5–8]. Two recent studies reported a higher density of racial/ethnic minoritized individuals in more walkable areas of cities[4,9], despite typically higher prevalence of chronic diseases among these same minoritized populations

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that can in part be prevented by physical activity, including walking[10–12]. Important questions arise from these findings, including whether this observed association is evident in racially segregated cities only, in which racial/ethnic minoritized populations are differentially distributed[13]. We theorize that in segregated cities, high minoritized population neighborhoods have higher population density and higher density of amenities, increasing walkability in those neighborhoods and potentially in the city overall. Exploring this hypothesis will shed light on whether racial residential segregation (RRS) – an important contributor to both health and built environment disparities[13,14]– is related to this counterintuitive association between higher walkability and higher percent minoritized residents.

The present analysis examines whether city-level (RRS) is associated with city-level walkability. It also examines this potential association across strata of city-level population density. If racial residential segregation were associated with walkability only in high population density cities, it could be the case that population density- which is a core component of most walkability metrics and tends to be high in minority neighborhoods in segregated cities [15,16] – actually drives the hypothesized association.

We examine RRS among two US minoritized groups: non-Hispanic Blacks (Black) and Latinos. We examine these groups because they comprise a substantial minority of the total US population and experience RRS[17–19]. We hypothesize that city-level walkability will increase as city-level RRS increases, driven by highly walkable, high density minority neighborhoods within cities.

Methods

The sample of cities was selected in 2017 for the creation of the City Health Dashboard (‘the Dashboard’, www.cityhealthdashboard.com)[20]. The sample consisted of US Census incorporated places with population >50,000 in the 2017 American Community Survey (ACS), plus the largest city in Vermont (Burlington, 2017 population 42,445) and West Virginia (Charleston, 2017 population 48,017), to ensure all states were represented (n=756 cities). We removed cities with fewer than 10 census tracts to eliminate unstable estimates. Cities missing analytic variables were also excluded (final n=745).

City-level walkability was measured using 2019 WalkScore data. WalkScore is a validated walkability metric calculated based on density of amenities nearby a location of interest[3,21], on a scale of 0 to 100, 100 being most walkable. City-level WalkScore was measured as the population-density weighted average of WalkScore values for 500 square-foot city blocks in a given city[22]. WalkScore values were purchased from Redfin, the company that calculates WalkScore, and were not altered during analysis. WalkScore is well fit to test our hypothesis because it factors into its calculation the two primary drivers through which we theorize RRS and walkability are linked- population density and walkable neighborhood amenities. Other walkability measures typical include population density, but not distance to amenities[23], in their calculations.

City-level RRS was measured using the Index of Dissimilarity (ID)[24]. ID measures the percentage of a group's population that would have to relocate to a different neighborhood within a city in order to achieve an even distribution of that group's members across the city's neighborhoods[24]. A higher percentage indicates greater segregation. ID calculation methods are described elsewhere[24]. There are numerous potential ways to measure RRS, including measures of evenness, exposure, concentration, centralization, and clustering[25]. Evenness measures, like ID, produce high values in cities where there is substantially uneven distribution of two populations. Our hypothesis can be interpreted as hypothesizing that cities with highly uneven racial population distributions will have higher walkability. Given this, ID is the RRS measure best fit to test our hypothesis.

Conversely, measures of exposure focus on potential for interactions between members of different groups; interpersonal interactions are most relevant for health drivers related to social interactions, like finding job and educational opportunities, social cohesion, and others. They are not as well suited for the study of environmental drivers like walkability. Measures of centralization capture how close minority populations live to a hypothetical central business district, which may not exist in many cities. Measures of clustering and concentration factor in the geographic size of smaller areal units, in this case census tracts, and therefore are not comparable across the study sample; there is substantial variation in population density across the study sample, and census tract size is roughly inversely proportionate to population density[26].

We calculated city-level ID for Black-White segregation and Latino-White segregation using census tracts to proxy neighborhoods (data source: 2019 ACS population estimates). Black is defined as 'Black or African American alone, Not Hispanic or Latino', White is defined as 'White alone, Not Hispanic or Latino', and Latino is defined as 'Hispanic or Latino'.

City-level linear regression models assessed associations between ID and walkability. Models controlled for percentage of adults with at least a high school diploma, percentage of families living below the poverty level, and US Census region (South, Northeast, Midwest, and West), defined using 2019 ACS data. We controlled for these variables because each has been related to both RRS and walkability in previous literature[13,27]. Analyses were stratified by quartile of city population density and by quartile of city population percentage Black or Latino to examine whether observed associations could be explained by either population density (calculated as mean population count per square mile excluding water area, using 2019 ACS data) or percentage minoritized population. We also examined tract-level correlations between percentage Black/Latino and walkability to explore whether potential associations between RRS and walkability were driven by higher walkability in high minoritized population neighborhoods. Model fit was assessed by examining plots of residuals. All analyses were conducted using SAS version 9.4.

Results

Median walkability was 38.1 (IQR: 31.1–49.4), median Black-White ID was 39.5 (IQR: 32.6–47.4), and median Latino-White ID was 32.0 (IQR: 25.2–39.4). As expected based on the measure, median walkability increased with increasing city population density, from

29.3 (IQR: 23.3–34.7) for low density cities to 62.6 (IQR: 53.1–70.7) for high density cities. Census tract-level percent Black and Latino were significantly, albeit weakly, correlated with walkability (r=0.10 and 0.18, respectively; p<.001 for both).

When controlling for region and socioeconomic factors, a one-unit increase in Black-White ID was associated with a 0.35-unit increase in walkability, and a one-unit increase in Latino-White ID was associated with a 0.22-unit increase in walkability (Table 1). The strength of association between ID and walkability varied when stratified by population density. For Black-White ID, the strongest association was observed in high density cities (β=0.34, p<0.001). The association between Latino-White ID was strongest in mid density cities (β=0.32, p<0.001). Broadly, the association between RRS and walkability increased with population density.

ID and walkability also varied when stratified by city percentage minoritized population, as expected. There was no association between Black-White ID and walkability in cities with low percentage (<2.7%) Black residents (β=0.02, p=0.83). Similarly, there was no association between Latino-White ID and walkability among cities with low (<7.7%) or low-mid percentage (1.7-<16.4%) Latino residents. In other strata, for both groups, coefficients were between 0.21 – 0.50 and statistically significant.

Discussion

The present research explored possible associations between city-level RRS and walkability. Though this is not the first time investigators have explored an association between race and walkability, RRS is rarely examined, and this potential association has not been examined among a sample of cities as large as that examined here.

We observed a positive association between RRS and walkability. Median Black-White and Latino-White ID scores were similar, as were full sample regression coefficients. Observed associations persisted across population density strata. Our findings suggest ID is associated with walkability across strata of population density for both minoritized groups examined. This indicates the association between ID and walkability cannot be fully explained by population density. Our primary hypothesis – that RRS would be associated with walkability- appears to be accurate.

Given population density is a part of the WalkScore calculation, we sought to explore how the observed association changed across population density strata. The association persisted across most strata of population density, but the estimate was attenuated in most strata compared to non-stratified effect size estimates. This suggests that population density plays an important role in the association between RRS and walkability, but does not fully explain the association.

For both Black-White and Latino-White ID, associations were weakest or non-significant in cities with low and low-mid percentage minoritized populations. However, significant associations were observed in mid (Black and Latino) and high (Black only) percentage minoritized residents cities, suggesting city-level percentage minoritized partially, but does not fully, explain the association between ID and walkability.

There was not a strong tract-level correlation between percentage Black or Latino residents and walkability. Though this simple correlation cannot conclusively disprove our secondary hypothesis – that city-level associations between RRS and walkability are driven by dense, highly walkable, high minoritized population neighborhoods- the correlation results do not necessarily support our secondary hypothesis either.

Though the secondary hypothesis concerns tract-level drivers of city-level associations, and other investigators have used tract-level RRS measures[28], tract-level RRS would be inappropriate to test the present hypothesis because census tract boundaries are likely too small to capture RRS at the scale at which we are interested[26,29]. Tract boundaries are drawn to encompass approximately 4,000 individuals[30], which may be only a few city blocks in densely populated cities. Also, ID is calculated based on the demographic composition of smaller geographic units nested within a larger unit of interest, e.g. census tracts nested within cities. Calculating tract-level ID would require the use of census blocks, which may be only one city block in size in dense areas, or census block groups; there can be a maximum of nine block groups in a tract. The small size of these geographic units, and the small number of these units located in each tract, may result in insufficient heterogeneity within each tract to produce meaningful ID values. We believe measuring the association between walkability and RRS is best at the city-level, an approach also employed by other investigators[31].

These results do not provide a straightforward explanation for the observed association between RRS and walkability. A better understanding of what factors drive higher city- and neighborhood-level walkability, including what drives the observed association between RRS and walkability- can guide planning of walkable urban environments, which could in turn encourage more physical activity. Additional research should more thoroughly examine the role population density plays in this association, as well as other potential drivers, like higher total retail demand in high minoritized population neighborhoods, and other built environment factors like block length and intersection density[23].

Our study has limitations. Although higher WalkScore is generally associated with more walking, it does not include subjective measures of the walking environment that may affect walking behavior, like residents' opinions on neighborhood safety or quality of sidewalks, which may be lower in impoverished or high minoritized population neighborhoods[32]. Furthermore, other environmental health hazards may be driving higher disease prevalence in high minoritized neighborhoods despite high walkability, including for example poor air quality[33], low healthcare access[34,35], social stressors[36], and others.

Conclusions

This research surfaces important new questions about the relationship between RRS, walkability and physical activity. Studies directly observing walking behaviors in diverse urban settings may provide further insight into whether and how neighborhood walkability attributes induce walking behavior in more and less racially segregated cities. This knowledge could then be leveraged to further inform urban design interventions to increase physical activity, particularly in segregated cities.[37]

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- Minoritized populations live in highly walkable US cities and neighborhoods
- Despite this, minoritized populations also suffer high prevalence of chronic disease
- Racial residential segregation and population density are associated with walkability
- However, these factors could not fully explain this counterintuitive association
- Racial residential segregation may proxy walkability-related city characteristics

Table 1.

City-level associations between segregation and walkability stratified by population density and percent Black or Latino

Model*	N	B†	SE†	p-value
Black-White ID †				
Full Sample	745	0.35	0.04	<0.001
Population Density Quartile				
Low Density (<2027)	186	0.29	0.05	<0.001
Low-Mid Density (2027-<3048)	186	0.14	0.05	<0.001
Mid Density (3048-<4758)	186	0.26	0.06	<0.001
High Density (≥4758)	187	0.34	0.07	<0.001
Percentage Black Quartile				
Low (<2.7%)	186	0.02	0.10	0.83
Low-Mid (2.7-<6.8%)	186	0.30	0.11	0.008
Mid (6.8-<17.2%)	187	0.50	0.09	<0.001
High (≥17.2%)	186	0.49	0.06	<0.001
White-Latino ID				
Full Sample	745	0.22	0.05	<.001
Population Density Quartile				
Low Density (<2027)	186	0.24	0.06	<.001
Low-Mid Density (2027-<3048)	186	0.16	0.06	0.008
Mid Density (3048-<4758)	186	0.32	0.06	<.001
High Density (≥4758)	187	0.16	0.08	0.044
Percentage Latino Quartile				
Low (<7.7%)	186	0.13	0.09	0.180
Low-Mid (7.7-<16.4%)	186	0.19	0.11	0.092
Mid (16.4-<32.6%)	187	0.37	0.09	<0.001
High (≥32.6%)	186	0.21	0.09	0.026

*All linear regression models control for region, poverty, and high school graduation.

†ID = Index of Dissimilarity, B = Beta coefficient, SE = Standard Error