

Heat Exposure and Social Vulnerability: The Double-Edged Impact of Walkable Built Environments

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GEODESIGN +
PLANNING
for Sustainable and Resilient Communities

Overview

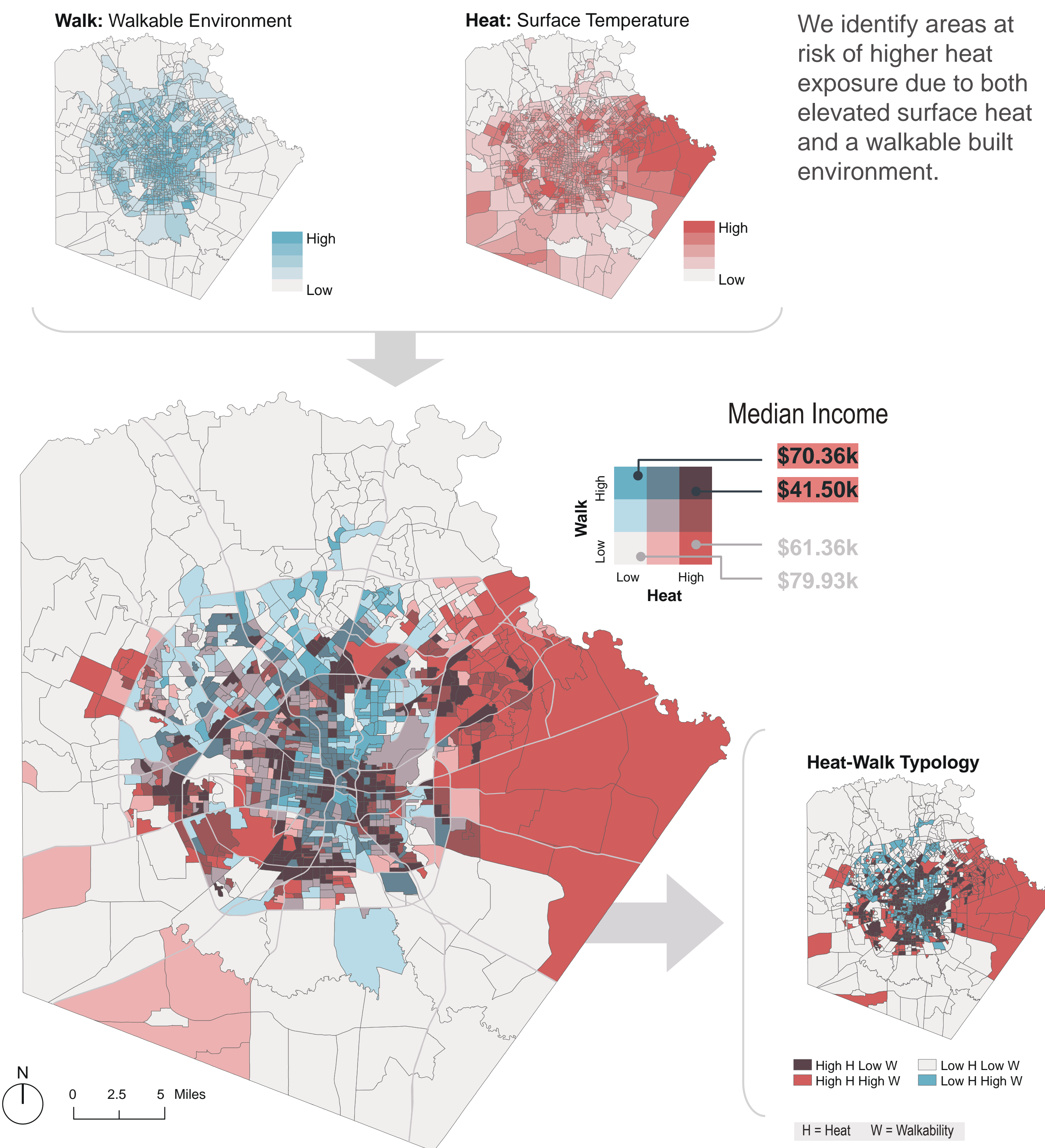
This study explores the complex interplay between urban walkability, heat exposure, and social vulnerability in the context of climate change and urban heat mitigation. Socially vulnerable communities are often more exposed to heat due to a lack of resources to avoid or mitigate high temperatures in summer. By its nature, walking increases exposure to the ambient environment compared to vehicle-based transportation or remaining indoors, yet increased exposure to the outdoor environment during hot seasons may raise health concerns. This study addresses the concerns of higher heat exposure in walkable communities by questioning whether socially vulnerable communities are at greater risk of heat exposure in walkable built environments.

Study Objectives

This study addresses the concerns of higher heat exposure in walkable communities by questioning whether walkable environments are equitably accessible and thermally comfortable for socially vulnerable populations.

Walkable Environment + Heat Overlay

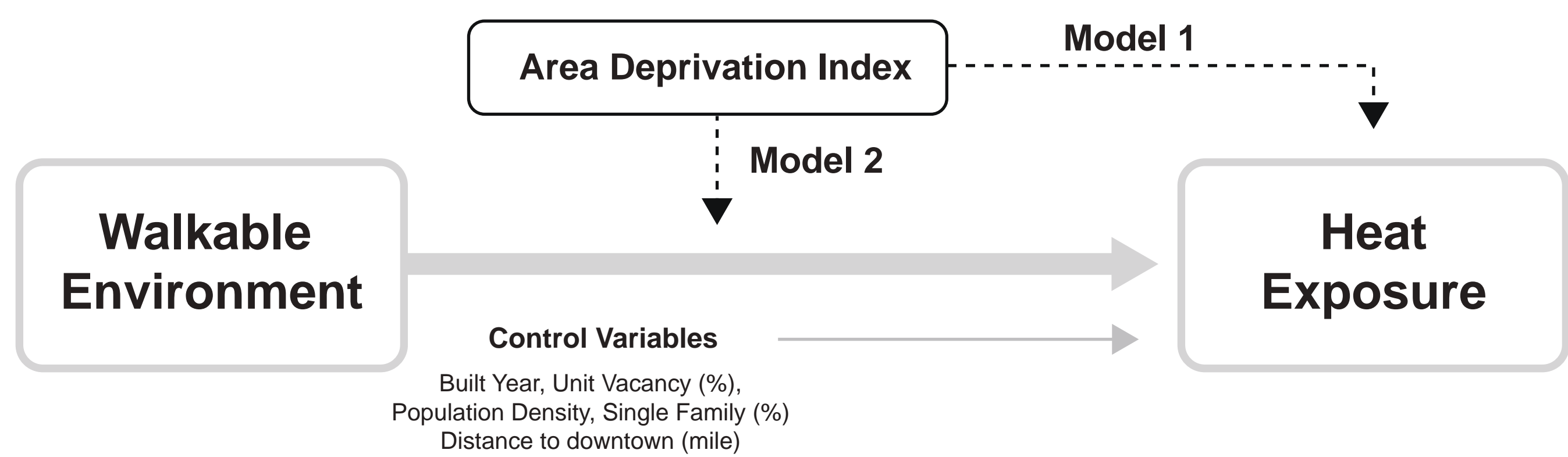
Identifying Heat Exposed and Walkable Areas



Walkability, Heat Exposure, and Social Vulnerability

- Walkable environments promote physical activity and better health outcomes (O'Brien et al., 2019), help reduce emissions through compact, sustainable development (Rafiemanzelat et al., 2019), and foster stronger social ties and community identity (Leyden, 2003)
- Extreme heat increases the risk of heat-related illnesses, particularly for vulnerable populations (Gauer & Meyers, 2019), and can worsen existing health conditions, including kidney and cardiovascular issues (Hifumi et al., 2018; Nerbass et al., 2017). It disproportionately affects low-income and minority communities due to limited access to green infrastructure (Locke et al., 2021; Grabowski et al., 2023).

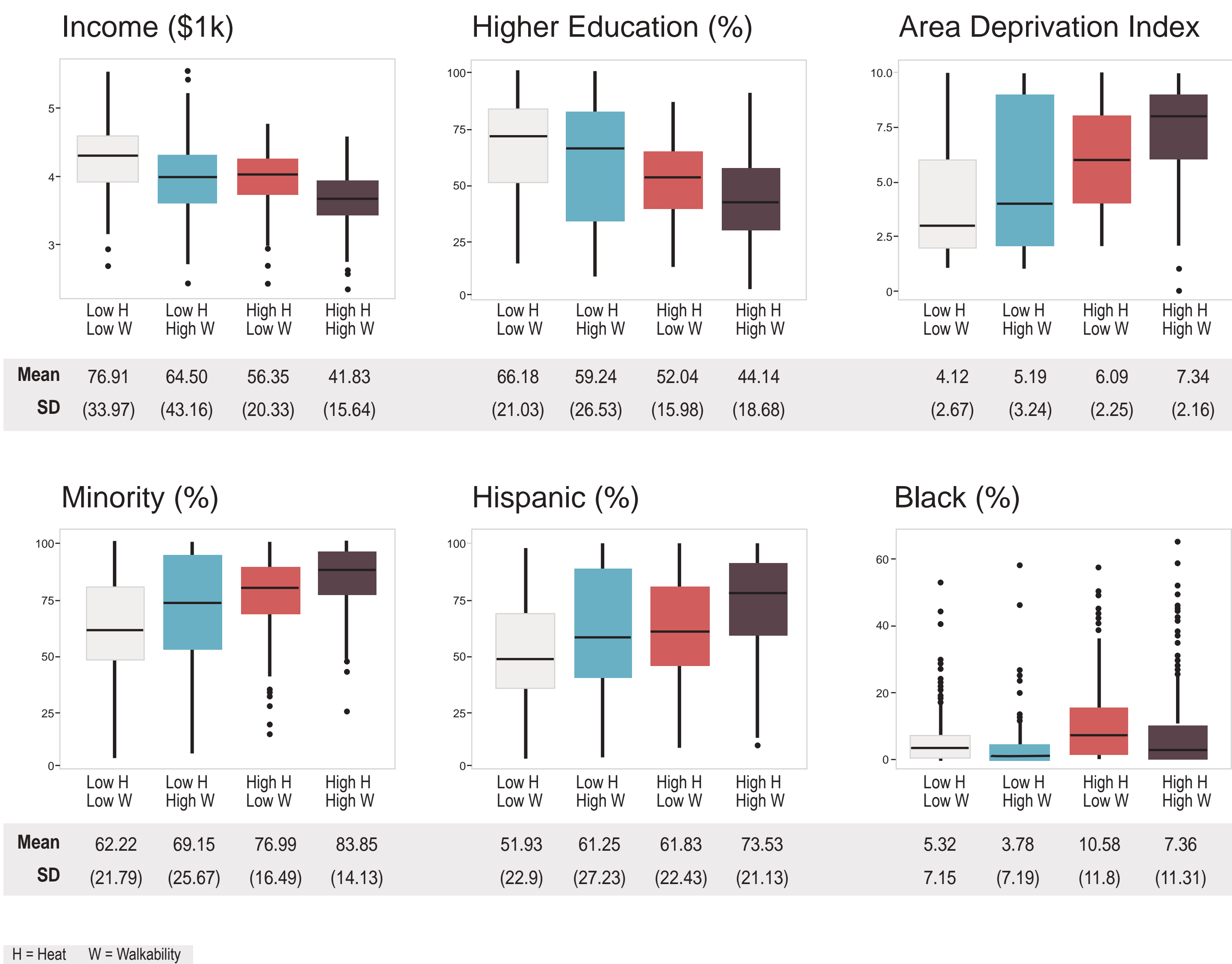
Study Design



Results

Average SES by Walkable Environment - Heat Relationship

- Areas with both high heat and high walkability exhibit the lowest average incomes and education levels, while cool, low-walkability neighborhoods have the highest.
- Socioeconomic deprivation, as measured by the Area Deprivation Index, increases steadily from Low-Heat/Low-Walk to High-Heat/High-Walk areas.
- The proportion of minority and Hispanic residents is also highest in hot, walkable neighborhoods and lowest in cool, car-dependent ones.

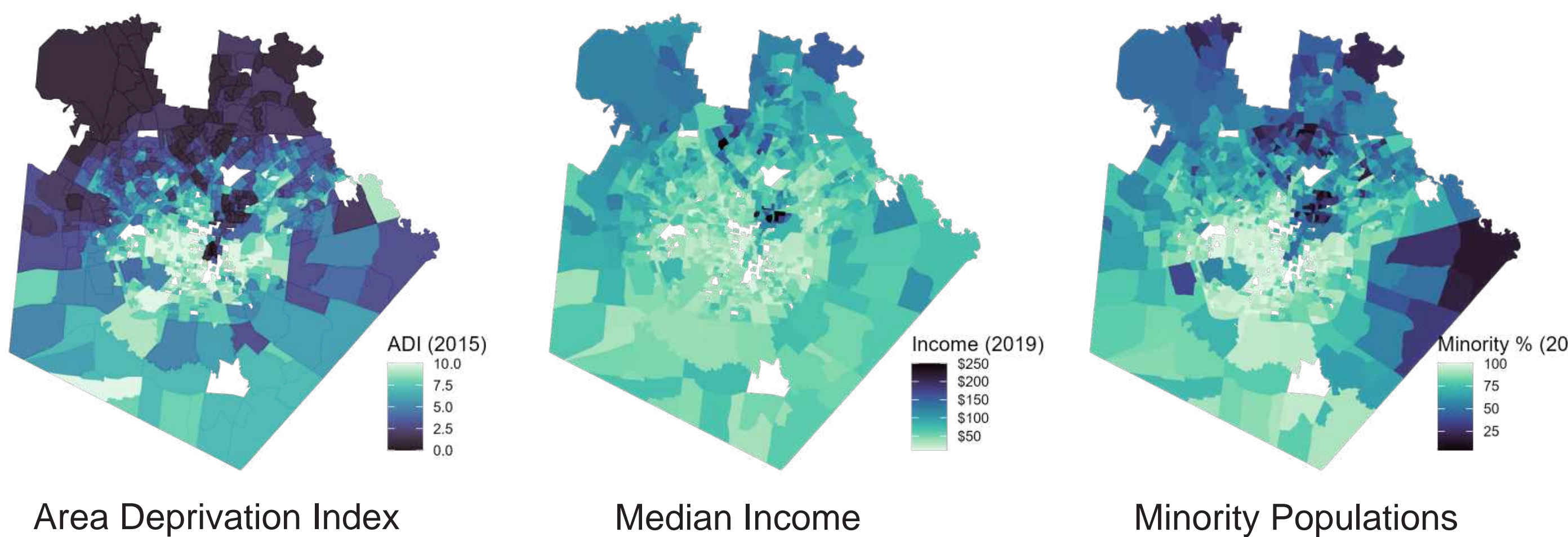


Data Collection

Walkable Environment	EPA's National Walkability Index (1–20), based on intersection density, land use mix, transit access, and employment mix.
Heat Exposure	Land surface temperature: Landsat 8 remote sensing data from August 2019 and August 2020
Socioeconomic Characteristics	2019 ACS; includes income, race (White, Black, Hispanic), education, Area Deprivation Index (1 = least deprived, 10 = most deprived).
Physical Characteristics	Median year built, unit vacancy (%), density, single family home (%), and distance to downtown (ft).

Study Area: Bexar County, Texas

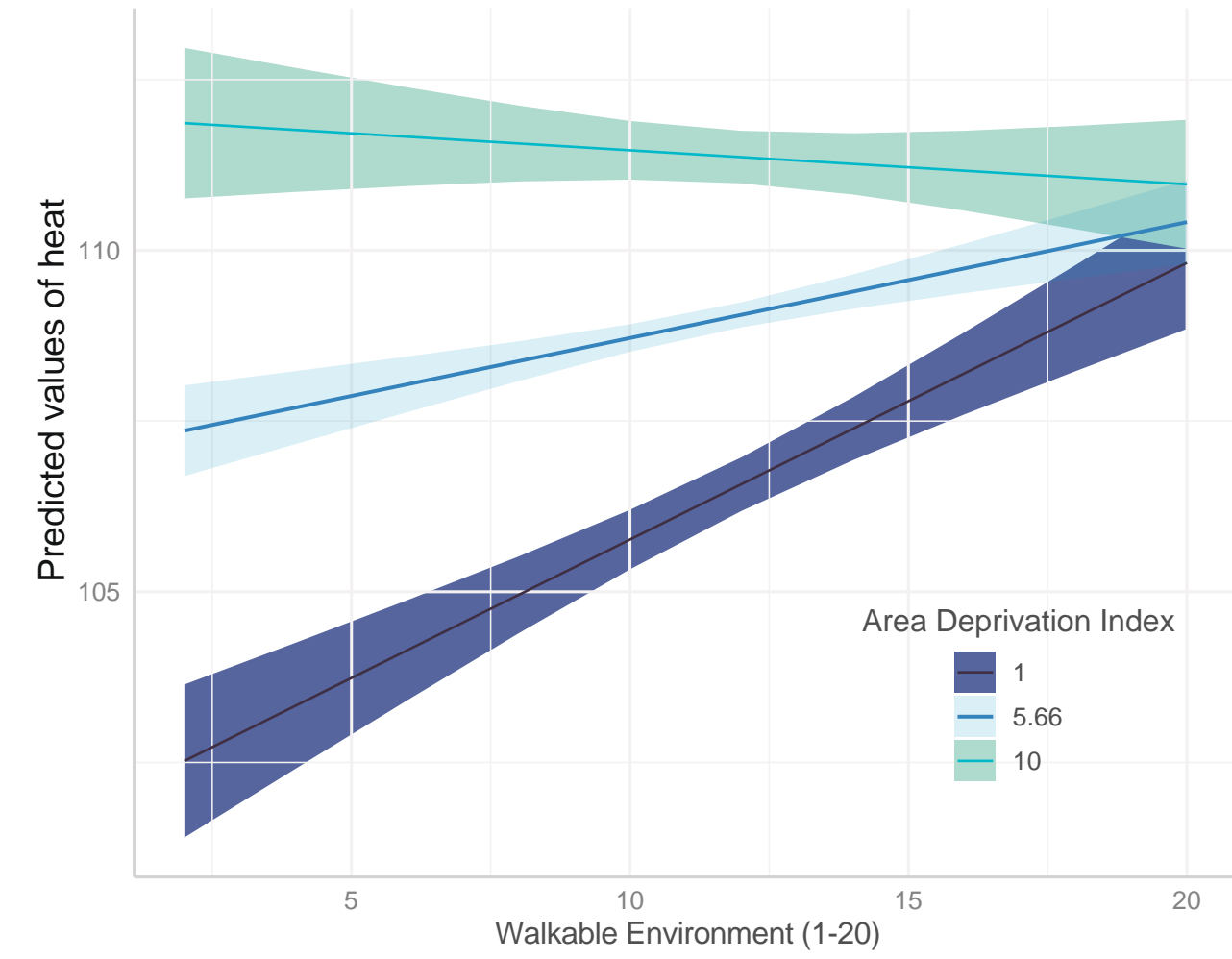
Census block groups (n = 1,084) as the unit of analysis.



Moderating effects of SES on walk-heat relationship

- Areas with higher walkability and deprivation scores significantly increase surface heat.
- In more deprived neighborhoods, greater walkability does not necessarily increase surface temperatures; however, these areas already experience elevated baseline heat exposure.
- More recently constructed, high-density, and single-family dominated neighborhoods exhibit significant associations with elevated surface heat, reinforcing the role of urban form and land use in shaping thermal exposure.

DL: Land Surface Heat	Coef.	S.E	Coef.	S.E
Walkability (1-20)	0.174	0.035 ***	0.456	0.062 ***
Area Deprivation Index (ADI)	0.529	0.039 ***	1.139	0.118 ***
Walkability X ADI			-0.051	0.009 ***
Built Year	0.029	0.008 ***	0.032	0.008 ***
Unit Vacancy (%)	0.020	0.012	0.023	0.012 +
Pop. Density (pop/mi2)	0.163	0.028 ***	0.168	0.028 ***
Single Family (%)	0.006	0.004 +	0.010	0.004 **
Distance to Downtown (mi)	0.004	0.040	0.024	0.039
Intercept	45.975	16.061 **	36.062	15.936 *
N	999		999	
R2	0.285		0.306	



Discussion and Conclusion

- The findings suggest that walkability alone does not ensure thermal comfort, especially in deprived neighborhoods that already endure higher baseline heat.
- Socially disadvantaged neighborhoods are disproportionately represented in high heat, walkable areas, exposing residents to greater environmental and health risks, underscoring environmental justice challenges. Equity-focused urban planning must go beyond infrastructure by addressing urban heat through design interventions such as shade structures, tree canopy expansion, and cool pavements, targeting investments and heat mitigation strategies in walkable but overheated areas.
- Planners and policymakers must ensure that walkable design is also livable, particularly for the populations most dependent on walking and public transit.

References:
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