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Neighborhood Walkability, Socioeconomic Adversity, and Transportation Policy:
Insights into Health Equity from SOL CASAS and Policy Analysis in San Diego County, CA

A Dissertation submitted in partial satisfaction of the requirements
for the degree Doctor of Philosophy

in

Public Health (Health Behavior)

by

Jacob Robert Carson

Committee in charge:

University of California San Diego
Professor Britta Larsen Demartini, Chair
Professor Cheryl Anderson
Professor Lawrence Frank

San Diego State University
Professor Jerel Calzo
Professor Linda Gallo

2026

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Chair

University of California San Diego
San Diego State University

2026

DEDICATION

I would like to dedicate this to my community, of which I have learned to rely on over the last four years.

Thank you to my wonderful wife Kathryn, who continues to inspire me every day to pursue great achievements and remain true to my values through her own dedication and undying support. Thank you to my sister Danielle, for her bravery, perseverance, and leadership as the best big sister anyone could ask for. Thank you to my brother Brian for his never-ending curiosity and generosity which motivate me to be a kinder person. Thank you to my brother Mark for his creativity and ingenuity which makes me feel young and reminds me to stay ever vigilant. Thank you to my mother for being a constant source of love and admiration throughout times of familial hardship. Thank you to my father for instilling in me the values necessary to be independent and hard working.

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Thank you to my Parkour community, Daniel, Lonnie, Brittney, Michael, Dillon, James, Mark, Jacob, Zack, and so many more. It was through Parkour that I developed a lens through which to view the world that carried me to this dissertation. The lessons that I have learned from each member of the community have helped me to maintain and appreciate a balanced life.

EPIGRAPH

“The ultimate, hidden truth of the world is that it is something that we make, and could just as easily make differently.”

– David Graeber

"Alone we can do so little; together we can do so much."

– Helen Keller

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FIELD OF STUDY

Major Field: Public Health
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ABSTRACT OF THE DISSERTATION

Neighborhood Walkability, Socioeconomic Adversity, and Transportation Policy:
Insights into Health Equity from SOL CASAS and Policy Analysis in San Diego County, CA

by

Jacob Robert Carson

Doctor of Philosophy in Public Health (Health Behavior)

University of California San Diego, 2026
San Diego State University, 2026

Professor Britta Larsen Demartini, Chair

Background: Cardiovascular health (CVH) is shaped by upstream determinants, including socioeconomic adversity (adversity) and the built environment. Research on walkability has shown positive associations with CVH, but studies are largely cross-sectional and focus on macro-scale features such as density rather than micro-level pedestrian streetscape features such as sidewalk quality. Key gaps remain in how walkability is operationalized, how it interacts with adversity, and how it operates within Hispanic/Latino communities, a key US demographic. Despite decades of research, the political factors that shape walkability also remain understudied.

Objectives: This dissertation aimed to 1) describe the spatial and statistical distributions of adversity, walkability, and pedestrian streetscapes in San Diego, California, 2) estimate longitudinal relationships and effect modification between those variables on six year changes in CVH among Hispanic/Latino adults in San Diego, and 3) identify electoral, demographic, and environmental predictors of support for a public transportation focused sales tax initiative in San Diego (Measure G).

Methods: Chapters 1 and 2 used data from the Study of Latinos Community and Surrounding Areas Ancillary Study (SOL CASAS), which collected socioeconomic, environmental, and CVH data during Visit 2 with follow up CVH data six years later. Chapter 3 used a convergent parallel mixed methods design combining electoral, census, and walkability data with key informant interviews. Quantitative analyses were conducted in R and Python and accounted for the complex sampling design of SOL CASAS.

Results: Chapter 1 documents spatial inequities in physical infrastructure, with pedestrian supportive features concentrated in wealthier areas and some neighborhoods lacking health and economically supportive environments. Chapter 2 finds that higher adversity and lower walkability are associated with declines in CVH, while associations with pedestrian streetscapes vary by walkability. Chapter 3 shows that social and built environmental factors shape support for Measure G independent of partisanship, and that geographic and political fragmentation in San Diego undermines institutional legitimacy and policy advancement.

Conclusions: These findings highlight how socioeconomic conditions interact with multiple levels of physical infrastructure and demonstrate that improving walkability is a political process. This work underscores the need to integrate structural and political perspectives into future public health research and promotion.

Introduction

Historical Background

In 1961, Jane Jacobs published *The Death and Life of Great American Cities*, an insightful and critical take on the approach to urban planning that dominated the 1950s.¹ This work explicitly attacked the planning consensus which sought to promote suburbs and car-centric regions while deeming the urban core as slums in need of “renewal”. Through this novel, Jacobs highlights her alternative vision, one that places the sidewalk at the center of healthy urban design, focused on mixed use, dense designs. Jacobs’s insights into community-driven, “walkable” urban design have had a lasting impact on urban planning and the general public. In its simplest terms, walkability is defined as the accessibility of amenities by foot,² including designing spaces that are intended to not just maximize automobile throughput but accommodate a variety of users. Although Jacobs began to pioneer this field from an urban planning perspective with her seminal work in 1961, the remainder of the 20th century did not advance the concept of walkability as we conceptualize it today. Urban planners would occasionally explore walkability through the lens of livability, market success, urban development, but the literature did not explicitly focus on health.³ Rather, the exploration of mixed-use, dense urban forms in transportation research was focused on mode share, and only as the 20th century came to a close did researchers suspect that land use could induce active transportation.⁴

Also in the late 20th century, within the realm of psychology and public health, Bronfenbrenner’s 1979 social ecological model (SEM) helped to advance the integration of environmental considerations into conceptualizations of health, and the social determinants of health (SDOH) which are broadly used today.^{5,6} By the early 2000s, in the context of increasing concerns over air pollution and environmental toxins^{7,8} and the growth of interdisciplinary research,⁹ a new understanding of how urban design could impact population health was formed. This new approach not only included environmental exposures through the traditional framework of environmental health but explored how environments are associated with social inequity and chronic health behaviors and outcomes such as physical activity and obesity.^{10–12}

The work by Lawrence Frank, James Sallis, and others in the early 2000s launched a broad body of research that uses macro-environmental features of urban form, much aligned with Jacobs's original conceptualization, to predict health behaviors and outcomes across a variety of populations. This work has had consistent findings, that neighborhoods with higher density, more mixed-use zoning, and better street connectivity were associated with more physical activity, better social health, and improved cardiovascular health outcomes.^{11,13–15} As interest in walkability as an exposure increased, from perspectives of health and climate change,^{16,17} so did the quality of data. Moving up the causal inference ladder, longitudinal studies broadly support cross-sectional research and suggest direct links between walkability and cardiovascular health outcomes.¹⁸ Despite major advances, there are still remaining questions about walkability through the lenses of variable operationalization, the relationship between walkability and other SDOH, and the relevant policy and political approaches which the proposed dissertation aims to address.

Operationalization of Walkability

The majority of walkability literature using objective measurement operationalizes walkability at the macro-level. This is to say that walkability has been traditionally defined by broader land-use patterns at the spatial scale of census tracts or block groups. This methodology situates walkability well for analyses and questions related to differences between neighborhoods, cities, and regions. Additionally, this operationalization is relatively easily accessible through its use of geographic data that do not require surveying individuals or direct observation of environments but can use publicly available data that has become more accessible over time.¹⁹

Limitations of Walkability Alone

This approach has its limitations. Interpreting walkability only at this scale excludes individual level metrics such as perceived safety, tree canopy, and the presence or quality of pedestrian features like sidewalks, crosswalks, and streetlights which have been associated with walking in previous research.^{20–23} Additionally, the spatial resolution for which meaningful walkability values can be determined is coarse compared to any individual person's experience while walking. Rather than thinking about how dense

their census tract or block group (which may or may not coincide with their lived “neighborhood”), a pedestrian may experience their environment on their block, the route they walk to the store, or the path to the nearest park.^{24,25} These key limitations could lead to misclassification for an individual, a block, or even a dense, mixed-use neighborhood that has bad sidewalks, unsafe street crossings, and/or high crime. The opposite may also be true, that the typical American suburb may be perceived as more walkable than the macro-scale classification might imply due to high quality pedestrian features and/or pleasant aesthetics, particularly among children, older adults, women, or other populations that are more sensitive to community crime and safety concerns.^{26,27} Previous research relying solely on the macro-scale walkability metrics has found expected associations between proximity based land use metrics, connectivity based route directness metrics, and physical activity. However, these relationships could be examined more thoroughly with the inclusion of pedestrian streetscape metrics. Additionally, from a policy perspective, changing walkability calls for interventions that need to be done at the broader policy scale and includes far more controversial shifts like densification and introduction of commercial destinations. These changes are essential for creating a healthier, more sustainable urban form; but are slow processes that can take decades.²⁸ Identifying other factors that encourage walking/active transportation can lead to more specific targeted policies that could be applied at faster time scales.

Pedestrian Streetscapes

The existing literature suggests that examining these pedestrian environmental features or pedestrian streetscapes are worth examining in their own right.¹⁹ A 2014 paper across three metropolitan areas in the US found that multiple pedestrian features were significantly associated with active transportation behaviors across all age groups.²⁹ Another paper from New York City found that proportion of street windows, active street frontage, and the amount of street furniture were significantly associated with pedestrian counts.³⁰ However, as with other walkability research, the direct relationship with cardiovascular health outcomes, rather than physical activity as a mediator for health, is a less studied but growing field of research.¹⁸ Traditionally, the collection of robust walk audit data to quantify pedestrian streetscapes has been challenging, relying on the manual coding of block faces either through

in-person or virtual walks along a prescribed route.²⁹ However, recent advancements in machine learning and artificial intelligence have made the process less burdensome and allow for more thorough data coverage.³¹

The relationship between Walkability and Pedestrian Streetscapes

To date, few studies have explicitly explored the associations between these different ways of objectively measuring walkability. Adams et al. 2022 aimed to using machine learning to quantify the pedestrian environment and when compared to traditional macro-scale walkability measure found significant, modest to moderate correlations.³¹ Other research that has sought to compare these approaches has found disparities in micro-scale features that correlate with socioeconomic disadvantage or high percentages of racial/ethnic minorities.^{32,33} Despite similar findings overall, some research indicates that this pattern of socioeconomic disadvantage correlating with worse micro-scale features was not always consistent, suggesting the need for more context specific research.²⁶ Variation between walkability and pedestrian streetscapes at the contextual level may be a useful tool for understanding neighborhood inequities. A framework of neighborhood typologies through this multilevel lens may have important implications for equity and targeting interventions or policies to best address structural inequities that perpetuate harm.³⁴ This previous work suggests the need to explore the how health outcomes are associated with pedestrian streetscapes, the relationship between pedestrian streetscapes and walkability, and how the scale of operationalization relates to metrics of equity.

Walkability and Equity

Walkability as an Environmental Health Exposure

Numerous studies have explored the unequal burden of pollutant exposure and other environmental injustices on communities of color and low socioeconomic status compared to their White and/or wealthier counterparts.³⁵ These environmental exposures inequitably burden communities of color because of historical segregation, community divestment, and inequitable planning practices, such as the predominantly Hispanic San Diego neighborhood of Barrio Logan, which was split by highway

expansion and harmed through industrial zoning.^{36,37} This same framework may be useful in understanding other chronic environmental exposures like walkability.

Early evidence of the interactions between race and walkability are presented in the one of the first papers on walkability, physical activity, and obesity which did not find significant associations between BMI and walkability variables among Black participants that had been found in their White counterparts.¹⁰ While some of this could be explained by the other environmental features that were unmeasured (such as the food environment), the only significant associations between walkability variables and walking distance among Blacks were in women, suggesting that walkable urban form, as conceptualized there, was not associated with walking in Black men. This early example of walkability interacting with race has been repeated in subsequent literature, where communities of color or low socioeconomic status do not consistently benefit from walkability as their White and/or wealthier counterparts.^{38,39} Additionally, more racial and ethnic minorities historically lived in “walkable” urban centers but do not benefit from their own neighborhoods as their white counterparts do.^{38,40,41} Part of this discrepancy may be explained by the limitations of measuring walkability primarily at the macro-scale, and identifying other components of the pedestrian experience that interact with race and metrics of socioeconomic disadvantage is important for addressing health disparities.^{26,41}

Theoretical rationale for studying interactions with walkability

Disentangling the complexities of race, structural inequities, and health is complicated, given that these associations vary spatially, intertwining variables and masking causal pathways that could provide opportunities for intervention. Theoretically framing our understanding of these constructs through Bronfenbrenner’s original SEM is helpful.⁶ The outermost circle, the chronosystem, represents historical and temporal factors such as the compounding effects of slavery, disenfranchisement, historical redlining, and discrimination against communities of color. These historical and temporal factors influence modern societal structures and ideologies (macrosystem) such as systemic racism, structural racism, and environmental injustices. These forces act on the ecosystem of institutional and community contexts, resulting in communities with poor infrastructure, racial inequities in education, income, and political

power, and health disparities that manifest spatially. The effects of which are felt directly by individuals and families living in those environments. Materially, this manifests as white flight from urban centers followed by community divestment and communities of color being destroyed to create freeways aimed at benefitting wealthier suburbanites.^{42,43} Understanding how these factors convalesce and interact to create compounding systems of disadvantage across communities is crucial for addressing the upstream contributors to individual level disadvantage and poor health outcomes. Specifically, working to identify key environmental factors that moderate the relationship between concentrated disadvantage and poor health outcomes. Framing these associations in this way is an important step forward from describing the world towards working for its betterment. While much of the previous research on walkability has emphasized differences in walkability by race/ethnicity or socioeconomic status, less work has been done in understanding it as a moderator between other SDOH and health, thereby conceptualizing it as a modifiable physical manifestation of structural inequity.

Walkability as a moderator for SDOH

It is reasonable to suspect that walkability could moderate how disadvantage impacts health given the reduced tree canopy, lack of access to green space, and poorer economic markers of the built environment between neighborhoods segregated by race/ethnicity.^{44,45} Some literature has explicitly explored the role of walkability as a moderator between complex socioenvironmental constructs and downstream health behaviors. US studies have found that pedestrian-oriented zoning code reforms that change the built environment moderate the relationship between racialized economic segregation and poverty with active transportation.^{46,47} A study from Japan found that low walkability was only related to increased risk of cardiovascular disease in medium to high income neighborhoods, and high walkability was not protective in low-income neighborhoods.⁴⁸ A more common approach to these variables in previous research is to explore how walkability and cardiovascular health behaviors/outcomes are moderated by socioeconomic status.^{38,49} Interactions between pedestrian streetscapes specifically and markers of socioeconomic disadvantage are largely unknown. This gap in knowledge limits the evidence-based, contextually specific ways in which walkability and pedestrian streetscape interventions can be

applied. Given the complexities of these socioenvironmental constructs, additional research is warranted for distinct racial/ethnic groups with different historical backgrounds that may have shaped modern neighborhoods. This framing as a moderator may seem pedantic, but shifting the focus on walkability from an exposure to a tool cements it as a policy solution to the aforementioned social, environmental, and health inequities.

Walkability as Policy

While additional research is needed to optimize policy and infrastructure based solutions for particular communities, the existing body of literature provides ample justification for change. Previous research into global policies that support walkability found that, while many cities have explicit documented language that supports healthy and sustainable urban design, there is a lack of measurable policy targets that can translate into funding and action.²⁸ Improvements to walkability at the macro-scale, such as increasing density or access to mass transit, require overcoming contentious politics and long time-scales to implement before material changes are observable. Even pedestrian streetscape improvements, such as pedestrianizing streets, slowing traffic in urban areas, or adding protected cycling lanes can receive substantial political backlash.^{50,51} So, what is to be done? Once again, we turn to theory to approach the question of walkability as policy.

Kingdon's Multiple Streams Framework provides some insight into the conceptualization of the "policy window" to be achieved for successful policy.⁵² This broad framework provides the structure to organize thoughts around transportation and land use questions within specific contexts. Previous transportation researchers have argued that this framework may be useful instead of or in addition to traditional cost-benefit analyses when working to advance non-car focused transportation policy.⁵³ Kingdon argues that there are three "streams" that need to align for the policy window to open and a particular policy to succeed: the Problem, the Policy, and the Politics. To better contextualize this framework, the following discussion will be focused on San Diego County, as the social, political, and environmental context for this dissertation.

The Problem Stream (What is the issue and how is it framed?)

Broadly, the problem has already been described for the US overall, of which San Diego County is no exception. Estimates based on 2023 data indicate that San Diegans drive over 33,000 miles per household annually and have continued to experience increasing commuting times since the COVID-19 pandemic.^{54,55} In addition to traffic injuries and fatalities (952 and 207 collisions respectively), more driving means more time sitting in cars, increasing local air pollution and contributing to physical inactivity.^{10,56} This also has economic implications, not only for drivers burdened with the need to own, maintain, and operate a vehicle (averaging over \$12,000 per year in 2023), but for a region whose sprawling road system is increasingly in a state of disrepair.^{54,57} While San Diego has experienced a better return to transit ridership than other American cities post-pandemic, it still has not reached pre-pandemic levels, with transit ridership marred by infrequent service and poor access to much of the job market; issues that will only be exacerbated by funding shortfalls.^{54,58} Similarly, while there have been major improvements in the mileage and quality of cycling facilities over the last 15 years, San Diego still lacks any substantial cycling mode share (estimated at 0.5% of commuting) likely due in part to poor network connectivity.^{54,59} The culmination of these economic and health costs have a disparate burden on communities and individuals who already struggle to make ends meet and may not be able to maintain a car needed to access economic opportunities.⁶⁰ This creates a feedback loop, increasing demand for cars and thereby further reinforcing the land use decisions that exacerbate the disparities in the first place.^{61–63}

The Policy Stream (Development and promotion of policy solutions)

So, what are the potential policy solutions in San Diego County? Addressing the ills of car dependency requires providing and prioritizing other modes of transportation. Increasing access to public transportation is a tangible policy approach to provide alternatives to driving and positively impacts walking both directly and indirectly through land use patterns. Directly, the CDC explicitly recommends expanding access to public transportation as a mechanism for increasing active transportation, reducing traffic deaths, and improving air quality, consistent with research demonstrating the increased physical activity of transit users relative to non-users.^{64–67} A 2021 study in Southern California found that residential properties were more likely to be densified in current or planned transit-rich areas, and that

these effects (with the loosening of zoning restrictions) can induce changes in nearby areas.⁶⁸ This relationship is also bidirectional, with walkable land-use patterns supporting transit ridership.⁶⁹ “Transit-oriented development” supports an improved return on investment for transportation projects alongside the aforementioned benefits of dense, mixed-use zoning practices.⁷⁰ Improving public transportation could provide residents with the connections to pedestrian-oriented environments and encourage further development that addresses both walkability and pedestrian streetscapes.

However, funding for public transportation, such as the introduction of a new light rail line, can be very costly. Since the 1980s, local transportation sales tax measures have become increasingly popular as a funding mechanism for large projects, as opposed to the traditional “user fee” approaches that fund roadway maintenance.⁷¹ This change shifted decisions about major transportation projects into the public arena and has major implications for the development of transportation systems and the resulting land use patterns. Understanding what factors influence support of these measures is important for the field of healthy and sustainable urban environments, especially given the uncertainty of the current Trump administration’s support for public transit and walkability.⁷²

San Diego County has its own rich transportation funding history. In 1987 voters passed TransNet, a measure for an initial 20 year (totaling \$3.3B from 1988-2008) half-cent sales tax to fund SANDAG (the metropolitan planning organization) for transportation projects. This initial funding was split into equal thirds between highways, local roads, and transit projects. An additional \$1 million was specified for bike facilities and walkable community demonstration projects. In 2004, San Diego voters approved a 40 year extension (ending in 2048; expected to generate \$18.8B) of TransNet with an over two-thirds majority. In addition to naming more specific highway projects, additional funds were allocated to offset environmental impacts, five times the funding for bike facilities, and smart growth incentives all overseen by an independent citizen oversight committee.⁷³ This oversight committee is appointed by SANDAG and largely consists of technical experts as prescribed by their bylaws. Crucially, this board has four year unpaid terms and does not require any representation by community groups. The

selection committee is designed to represent the County at large but fails to discern unincorporated communities from the County more broadly, resulting in potential underrepresentation.

As a tangible infrastructure improvement, a proposed “Purple Line” trolley has been discussed by the metropolitan planning organization, SANDAG, as a tool to relieve congestion and improve transportation access particularly connecting the dense, predominantly Hispanic communities to the largest employment center in the County.⁷⁴ Recent cost estimates place this development at over \$20 billion, 10 times the cost of the “UCSD Blue Line” extension in 2021 which is by far the most popular service in the region and responsible for San Diego’s relative success in the return from the pandemic.^{54,75} In 2022, with the backdrop of a growing coalition around the 10 transit lifelines spearheaded by multiple environmental justice groups in San Diego and interest in the Purple Line,⁷⁶ the Let’s Go SD campaign made their first attempt at placing a ballot measure for a half-cent sales tax onto the ballot.⁷⁷ It failed to gather the required 116,000 valid signatures to establish the ballot measure, however the policy as written did succeed to be placed on the ballot in the November 2024 General Election as a half-cent sales tax measure. San Diego’s “Measure G” which specified the majority of its funding for public transportation, narrowly failed on the ballot box, despite only needing to beat the 50% threshold as a citizen-led initiative.⁷⁸

The Politics Stream (What are the political dynamics around a topic?)

Understanding the political dynamics behind public transportation and walkability broadly can provide insights into advancing healthy and sustainable cities. While the benefits to equity, health, and the environment from transitioning away from car dependency are clear, American society is deeply intertwined with the car. Historically, cars have meant freedom, status, and represent American cultural paradigms that in some ways, have limited our ability to imagine a different system.⁷⁹ This cultural hegemony is evident in behavior choices, where even in more walkable, transit-accessible environments, Americans still show a preference towards driving over other countries in similar (or less walkable) environments.⁸⁰ This disconnect between the broadly popular belief among climate, planning, and health experts for a transition away from car dominance and the perspectives of most car owners reinforces the

need for approaches that aim to increase the availability of alternative modes while minimizing the harm done by cars.⁸¹ While it is true that the land use patterns that make car use enjoyable/viable largely preclude more walkable environments, investment in robust public transportation systems can help to bridge that transition.^{80,82}

For local transportation sales tax measures, voter survey research suggests that transparency and oversight for spending, competing sales tax measures, tax expiration dates, and a desire for the benefits of reduced congestion and better air quality (rather than being able to ride transit) predict support.^{83,84} There is conflicting evidence on how income may be an additional predictor, with some studies reporting that lower income households/communities support transit less (potentially due to a higher tax burden) while others citing more support, due to political alignment (Democrats tend to be more supportive of funding transit) or that they will directly benefit given that they use public transit more.^{83,84} Another approach to studying the success of transportation sales tax measures is by using census data. Findings from this approach suggest that closer proximity to the planned project, higher income, and a more Democratic voting block predicted support for public transportation.⁸⁵ Conflicting findings in previous research suggest that the specific political context is crucial to the success or failure of a given measure.

The Policy Window (Temporal alignment of the multiple streams.)

The policy window has been described as the alignment of the multiple streams to create an opportunity for the enactment of new public policy. This concept is consistent with the idea of the chronosystem, wherein cyclical and time dependent patterns can give rise to moments of alignment that would have otherwise been untenable. As described earlier, the process of tax-funded transportation in San Diego County is storied and until recently has been successful in raising funds through TransNet. The shift in focus among community groups engaged in environment justice and health causes to more public and active transportation specifically in recent times climaxed with Measure G. Just as the relationships between walkability, health, and socioenvironmental factors are nuanced, so are the complexities of transitioning from car dependent communities to more sustainable, activity supporting designs from a policy perspective. Local funding measures are an increasingly important topic of

discussion in the current political climate with a federal government that has demonstrated hostility towards active transportation and mixed positions on public transportation funding.^{72,86–90} Alignment or misalignment of the three streams described above can help us to describe the policy landscape that may foster positive change, and to identify specific approaches for different local contexts that may increase support in the future. There is a need for more holistic research approaches that can leverage both publicly available voting data and gather the perspectives of key stakeholders who understand the context. In San Diego County, through the analysis of Measure G, there is a timely opportunity to learn how the region's ambitious climate, mode share, and transportation equity goals could be supported by future policies both in and out of the ballot box.

Synthesis and Statement of Work

As described in the preceding sections there are still remaining questions about walkability through the lenses of variable operationalization (i.e., the importance of pedestrian features), the relationship between walkability and other SDOH, and policy change. Approaching these questions through the lens of a single local context allows for tangible interpretation that can have real practical implications while still contributing to scientific knowledge more generally. San Diego County provides an interesting backdrop as the fifth most populous county in the US, with broad geographic diversity, a distinct racial/ethnic composition, and an evolving transportation policy landscape.

Hispanics/Latinos are the 2nd largest racial/ethnic group in the United States and are set to become 25% of the national population by 2045.⁹¹ Accordingly, more work needs to be done to understand the environmental contexts in which these communities live, and how their physical and social environment impacts their health. Research around walkability may be of particular importance for this demographic given the disproportionately high rates of physical inactivity.⁹² Hispanics/Latinos also face more socioeconomic disadvantage, potentially compounding the negative health effects of physical inactivity and interacting with other environmental factors like walkability to result.^{93,94} Walkability research has seldom focused exclusively on Hispanic/Latino communities despite these facts, and further longitudinal research is warranted to understand the environmental context that may support healthier lifestyles.^{95,96}

Among studies that have examined the role of walkability on Hispanic/Latino population health, walkability was positively associated with physical activity and lower BMI, even among those of lower socioeconomic status.^{95,97} One qualitative study found that while material conditions impacted perceptions of the built environment among a Hispanic/Latino sample, sociocultural factors related to social cohesion may contribute to more positive perceptions.⁹⁸ These unique factors underscore the importance of studying the built environment as it specifically relates to the Hispanic/Latino population.

With Hispanics/Latinos representing nearly 35% of all San Diego County residents, this region provides an optimal area to expand this line of inquiry.⁹⁹ Previous research in San Diego through the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) has provided great insights into cardiovascular and metabolic health, but there is more to be learned. The Community and Surrounding Areas Study (SOL CASAS), an HCHS/SOL ancillary study, gathered data related to the neighborhood environments in which participants reside, capturing socioeconomic adversity (an indicator of concentrated disadvantage), walkability, and pedestrian streetscape data.¹⁰⁰ Previous SOL CASAS analyses report the importance of socioeconomic adversity as predictor of health outcomes and an indicator that tracks well with other metrics of disadvantage, such as racial/ethnic segregation.¹⁰¹ The findings related to walkability in this sample are mixed yet suggest potential interactions between environmental variables.^{102,103} As a new wave of SOL CASAS outcome data has become available, there is ample opportunity to address existing questions about walkability and pedestrian streetscapes within a discrete context. From a policy perspective, the aforementioned Purple Line trolley, a planned light rail line that would have been largely funded by Measure G, is proposed to primarily serve South San Diego, a predominantly Hispanic/Latino region of San Diego and the area primarily sampled by SOL CASAS.⁷⁴ Additionally, a 2019 study on the economic impact of San Diego's Metropolitan Transit System (MTS) estimates that 40% of riders were Hispanic/Latino, and that about 20% of riders made less than \$15,000 annually.¹⁰⁴ These characteristics underscore the relevance of walkability, transit access/quality, and Measure G to Hispanic/Latino and low-income San Diegans in particular.

This dissertation aims to explore the relationships between socioeconomic equity, walkability indicators, health, and the policy climate that surrounds them within San Diego County, CA by using existing data from SOL CASAS and leveraging publicly-available voting data combined with key stakeholder interviews. The following three chapters will:

1. Describe the convergence and divergence of walkability and pedestrian streetscapes and their relationship to socioeconomic adversity within the predominantly Hispanic communities in the South Bay of San Diego County.
2. Quantify the longitudinal relationships and interactions between socioeconomic adversity, walkability, and pedestrian streetscapes on cardiovascular health using data from Visits 2 and 3 of the Hispanic Community Health Study/Study of Latinos (HCHS/SOL).
3. Identify the community-level predictors of electoral support for tax-funded public transportation in San Diego County (Measure G) and the policymaker/stakeholder perspectives surrounding the policy environment.

Scientific Contribution and Future Research

Together, these three manuscripts represent a practical lens for studying walkability and healthy urbanism as it relates to health equity. The dissertation aims to build on previous work to focus on how we can better leverage the different conceptualizations of walkability for application to interventions, and what the policy landscape looks like for enacting those changes. This proposal offers a robust approach to understanding the local context of walkability holistically so that findings can be used both locally and for future researchers. By the explicit integration of health equity, framed through socioeconomic adversity, and pedestrian streetscapes, this dissertation contributes to key gaps in the literature. A better understanding of walkability as a concept, its role in the health outcomes of specific communities, and the policies that can make material change are essential to moving the field towards action and a more equitable world.

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Introduction

Over the last three decades the concept of walkability and more broadly how our built environments impact our health has been the subject of much research. A growing body of cross-sectional and longitudinal research suggests that more walkable environments increase physical activity, social interaction, and downstream cardiovascular and metabolic health.¹⁻³ Walkability has historically been operationalized solely at the neighborhood-scale, with indices comprised of metrics such as street connectivity, land-use mix, and residential density typically available at the census block group or larger units.⁴ These components have the benefit of being readily available and objective at spatially large scales, allowing for research to include walkability with as little as a an address or even a ZIP code for research participants. However, this operationalization of walkability lacks the granularity and detail that represent the experience of pedestrians when navigating streetscapes in the real world. In particular, while neighborhood walkability provides the substrate for healthy urban design by providing more dense, mixed-use environments that do not require automobiles to navigate, it does not guarantee pedestrian-supportive features or designs that facilitate walking in a safe and accessible way.⁵

To address these gaps, prior studies have examined features of pedestrian streetscapes, such as well-defined crosswalks, buffered sidewalks, tree cover, or neighborhood aesthetics. Existing literature has found that pedestrian streetscape features such as neighborhood aesthetics and sidewalk presence or quality support physical activity.⁶⁻⁹ However, data collection of pedestrian streetscapes is typically more burdensome, with methods that have historically required auditors to physically or virtually collect data on each street segment of interest.^{6,10}

Recent advances in machine learning and artificial intelligence have allowed some researchers to assess pedestrian streetscape features at a larger scale more efficiently.^{5,11,12} However, while there have been technological advancements to assess pedestrian streetscapes, there remains a large gap in the literature as to their associations with other environmental variables.^{5,11,13} Additionally, studies are needed

to align these new approaches with the existing validated tools for providing detailed assessments of pedestrian environments.

As with other environmental determinants of health, research on both walkability and supportive pedestrian streetscapes can help us identify the best strategies to promote community-level health equity. Even among the earliest literature examining walkability, findings suggested that race moderated the relationship between walkability and physical activity, with fewer activity benefits for non-white individuals.¹⁴ Later studies have produced inconsistent findings regarding these so-called “positive disparities” wherein walkable environments were more often found in historically disadvantaged communities, depending on the setting and the manner in which walkability was operationalized.^{15,16} Understanding these inequities in the relationship between walkability and health can inform interventions and policies. Examining how walkability has been and can be operationalized may provide a unique approach to disentangling our understanding of these phenomena.

Identifying mismatches between walkability and pedestrian streetscapes may provide information on the manifestation of environmental inequities that impact downstream health in diverse communities. For example, a recent analysis done in the City of Los Angeles (Ki and Chen 2023) found distinct associations between race and ethnicity and the types of walking supportive infrastructure present, with higher Hispanic/Latino population ratios positively associated with walkability but negatively associated with supportive pedestrian streetscapes, providing evidence that neighborhood-scale measures alone may overestimate the true “walkability” of neighborhoods with large racial and ethnic minority populations.⁵ While this novel analysis provided a first insight into the co-occurrence of walkability and pedestrian streetscapes, its reliance on a priori theory (i.e., wealthier neighborhoods will have better pedestrian features) limits detailed description and comparison of overlap and mismatch. An emphasis on understanding the importance of the specific pedestrian streetscape features in different environmental contexts may help to identify interventions that are less cost- and time-prohibitive than modifying the density or street connectivity features of neighborhoods.^{4,17}

Hispanic/Latino individuals are the largest racial or ethnic group in the US.¹⁸ Additional research is warranted to understand the community contexts that influence their health, specifically as it relates to long-range planning efforts at the local, state, and even national level. Hispanic/Latino adults are less likely to engage in sufficient physical activity compared to their White counterparts, underscoring the need to understand environmental factors that support active living among this population.¹⁹ Research in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL), the largest and most comprehensive longitudinal study of Hispanic/Latino health in the United States, has examined the cross-sectional relationships between environmental factors and physical activity. The work by Sallis et al. identified that within high socioeconomic adversity neighborhoods (a composite measure of concentrated social disadvantage), pedestrian streetscapes were significantly and positively associated physical activity after adjustment for walkability.⁴ This interaction suggests the need to further explore the relationships between these three environmental variables and their inequitable spatial distributions. Methodologies that seek to describe neighborhood typologies, classifications based on structural characteristics, can advance policy development and upstream interventions by improving our understanding of what is needed and where.

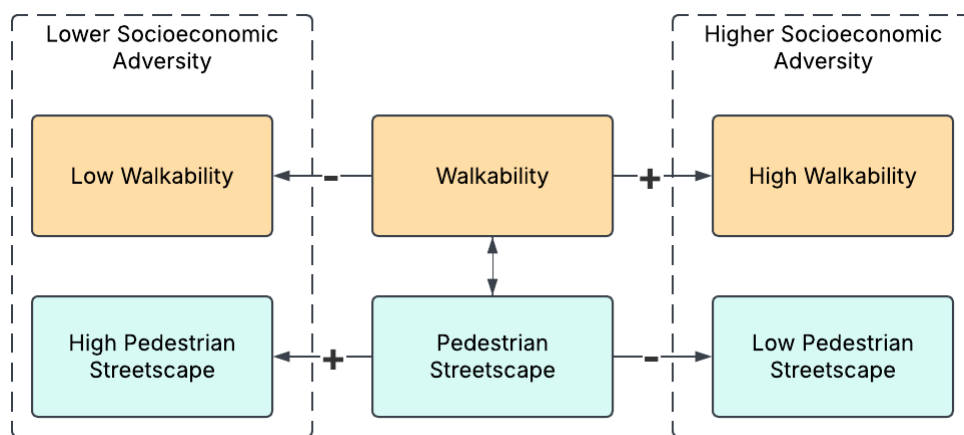


Figure 1.1: Conceptual Hypothesis

Therefore, the current study aimed to build on previous research by 1) evaluating the cross-sectional relationships between socioeconomic adversity, walkability, and pedestrian streetscapes, 2) comparing socioeconomic adversity across High-Low walkability/pedestrian streetscape typologies, and

3) describing the dominant neighborhood clusters defined by socioeconomic adversity, walkability, and pedestrian streetscapes, using data from the HCHS/SOL. Consistent with previous research, I hypothesized that typologies characterized by higher walkability and lower pedestrian streetscape scores (relative to other neighborhoods) will be of higher socioeconomic adversity than the opposite condition as depicted in Figure 1.1. This combination of theory- and data-derived typologizing can provide rich insights into the ways that key neighborhood characteristics manifest among Hispanic communities in a large US metro area.

Methods

Sample

The HCHS/SOL is a prospective cohort study of 16,415 Hispanic/Latino adults aged 18–74yrs at enrollment across four major US cities. HCHS/SOL conducted its baseline examination between 2008–2011 (V1), the second examination between 2014–2017 (V2), and the third examination between 2020–2024 (V3). More information on the parent study have been published previously.^{20–22} This study used data from the Community and Surrounding Areas Study (SOL CASAS), an ancillary study focused on the environmental exposures exclusively in San Diego, CA, that was aligned with V2. SOL CASAS included 3,758 participants from V2 across 346 census block groups.²³ The present analyses excluded participants without addresses that could be geocoded, those with addresses outside of San Diego County, and those with identical geocoded locations and environmental data to avoid overrepresenting shared households given that the aims of this study are to describe environmental features. A subset of participants had the same geocoded locations but different environmental variables due to the jittering of addresses (i.e., purposive displacement of addresses to protect privacy) and these observations were retained given that they represent unique environmental data.

Neighborhood Environment Features

To estimate environmental exposures, an egocentric-neighborhood approach using Geographic Information Systems (GIS) software was employed to construct 800-meter circular radial buffers around

each SOL CASAS participant's home address.²³ Built and social environment variables within that buffer were computed and geocoded to create the variables used in these and prior analyses. These methods are described in more detail in the protocol paper for this ancillary study.²³ Below, brief descriptions of the methods used to create the variables of interest from SOL CASAS are described. Potential scoring ranges, sample ranges, and sample means for this study are presented in Supplemental Table S1.4.

Socioeconomic Adversity

Socioeconomic adversity was operationalized as a composite variable using the non-rotated first component from a Principal Components Analysis of census variables. This variable is composed of Census/ACS 5-year estimates from 2013-2017 (aligned with V2) and included the percent of adults 25 years or older with no high school diploma, adults who are unemployed, households that are rented, crowded households (more than one person per room), households living below the poverty line, female headed households with dependent children, households on public assistance, and population on public health insurance. Higher values indicate greater socioeconomic adversity.

Walkability

Walkability was defined as an index of intersection density, residential density, and land-use mix around participants' homes (summed Z-score, consistent with Frank et al. 2004),¹⁴ utilizing data from 2016-2019 for V2. Intersection density, the number of intersections per 200x200m grid cell, was derived from 2019 SANDAG data. Residential density per 200x200m grid cell was derived from 2017 Census/ACS data. Land-use mix, represented as Mix of Park, Residential, Retail, Civic, and Other land use types, was derived from 2017 Census/ACS data and calculated using an entropy formula per 200x200m grid cell.

Pedestrian Streetscape

Pedestrian streetscape was evaluated using a series of systematic observational audits by trained raters along a 0.25 to 0.44-mile route from each participant's approximate home address toward the nearest commercial cluster to approximate likely walking routes. The Micro-scale Audit of Pedestrian Streetscapes Abbreviated Tool (MAPS-Abbreviated) via Google Street View and Google Earth was used,

which has shown good inter-rater reliability.¹⁰ MAPS-Abbreviated includes 60 items to assess features such as sidewalks, street crossings, bicycle facilities, landscaping, buildings, and lighting. The present analyses include the primary composite score alongside the four validated MAPS subscales that better represent a set of attributes associated with higher physical activity.⁴ The summary “Overall Micro-scale Positive” score (hereafter referred to as *pedestrian summary score*) represents a summation of each of the subscales below, with higher composite scores representing a more pedestrian-friendly environment for the summary score and all subscales.

- *Route overall aesthetics and social*: Designed to capture the visual aesthetics and perceived safety of a route. A composite score for seven items related to landscaping, maintenance, graffiti, presence of people walking, etc.
- *Overall positive street segment*: Designed to capture the quality of active transportation infrastructure for a given street segment. Includes the presence of buffers between the street and sidewalk, presence of a marked bicycle lane, tree coverage, building setback from sidewalk, building height (taller buildings receive higher scores), ratio of the building height to road width + setback (middle values receive higher scores than the extreme values), and the surveillance (i.e., street-level windows, street lights), and sidewalk (i.e., sidewalk quality, size) subscales.
- *Overall positive crossing characteristics*: Designed to capture features that facilitate safe street crossing features. Scored for the presence of crosswalk amenities (such as marked crosswalks), curb ramps, and crossing signals averaged across all crossing on the audit route.
- *Route positive streetscape elements*: Designed to quantify street amenities that complete the street for a more pleasant pedestrian or cyclist experience. Scored for the presence of transit stops, driveways, building overhangs, trash bins, benches, bicycle racks, and traffic calming features.

Analyses

All statistical analyses were conducted in Python Version 3.7.16 in Jupyter Lab.

Correlations and Descriptive Analyses

To address Aim 1, Spearman correlations were calculated between all variables given that many pedestrian subscales were non-normal or discrete in their distributions. Primary visualizations for variable distributions were depicted spatially as data points on plain base maps with 2010 census block group outlines to align with the original formatting of data collection using the *matplotlib* and *seaborn* packages. All maps were zoomed from the County-level extent to the bounds of 99% of the data given that the overwhelming majority of observations were located in the South part of San Diego County. An example map including all observations and an indicator for the 99% extent is provided in Supplemental Figure S1.7.

Theory-Derived Typologies and ANOVA

To address Aim 2, four distinct neighborhood typologies (visually represented in Figure 1.2) were created in line with the categorization used in Ki and Chen 2023 using the pedestrian summary score and each subscale;⁵ High walkability & High Pedestrian Score (HH – walking supportive environment), High walkability & Low Pedestrian Score (HL – walkable but unpleasant), Low walkability & High Pedestrian Score (LH – unwalkable but pleasant), and Low walkability & Low Pedestrian Score (LL – hostile walking environment).

	Low Walkability	High Walkability
Low Pedestrian Streetscape		
High Pedestrian Streetscape		

Figure 1.2: Walkability and Pedestrian Streetscape Typologies

All environmental variables were originally split by top and bottom tertiles to create the high and low values but given the discrete nature of some scales and non-normal distributions, alternative high vs low categorizations with the middle value dropped were used to optimize both observation retention and differentiation between categories. Supplemental Figure S1.8 depicts the distribution of all study variables with the split decision depicted in the accompanying Supplemental Table S1.5. Spatial distributions of these typologies were visualized consistent with the descriptive maps described above.

ANOVA was used to test for significant differences in mean values of socioeconomic adversity across each defined typology. Pairwise t-tests with Bonferroni adjustment for multiple testing were used to identify significant differences between individual typologies at the $\alpha=.05$ significance level (six total tests). Robust variance tests were used when unequal variances were identified. While the assumption of independence is violated by the spatial dependence of independent variables, ANOVA was purposively chosen to provide a descriptive analysis between typologies. Removing spatial dependence using a spatial lag or error term was not pursued given that the inherent spatial clustering is part of the descriptive goal, therefore ANOVA findings are intended to be interpreted descriptively and not inferentially.

Cluster Analysis

To address Aim 3, k-means clustering was performed on all included observations using the socioeconomic adversity, walkability, and the pedestrian summary scores that were robustly scaled as the input variables using the *math* and *sklearn* packages. A random seed of “1234” was used to generate replicable results given the stochastic nature of cluster analysis. The final number of clusters was chosen using a combination of the elbow method from visual inspection of the scree plot, maximization of the silhouette scores, and conceptual interpretability. Final cluster sizes of two through four were used to understand how interpretability changed within reasonable ranges. The final clusters were described by the mean values for three input variables relative to the sample mean. Mean values by cluster for the pedestrian subscales were used to understand differentiation across pedestrian features. As a sensitivity analysis, the above methods were repeated by replacing the pedestrian summary score with each of the four pedestrian subscales to verify comparable spatial patterning and consistent neighborhood descriptions. Spatial distributions of the emergent clusters were visualized consistent with the descriptive and typology maps described above.

Spatial Autocorrelation

Spatial autocorrelation was calculated as Moran’s I values for both the literature and theory derived typologies (Aim 2) and the data-driven cluster analysis (Aim 3). Spatial weights were based on distance band values of 800m to approximate a reasonable walking distance from each address. Spatial autocorrelation was used as a key diagnostic to understand if categorizations are spatially as well as statistically meaningful (i.e., are these typologies grounded in real neighborhoods or fragmented across the space?).

Results

Descriptive Analyses

Pairwise correlations (Figure 1.3) between primary variables were fair to moderate in magnitude and positive in direction, with walkability and socioeconomic adversity having the largest correlation

($r=0.48$), followed by walkability and the pedestrian summary score (0.35), and socioeconomic adversity and the pedestrian summary score (0.24). With the exception of overall aesthetics, all pedestrian streetscape subscales were moderately to strongly positively associated with the pedestrian summary score and weakly positively correlated with walkability. Of those subscales, only positive streetscape was meaningfully positively associated with socioeconomic adversity ($r=0.24$). With the exception of the correlations below 0.1, all correlations were statistically significant.

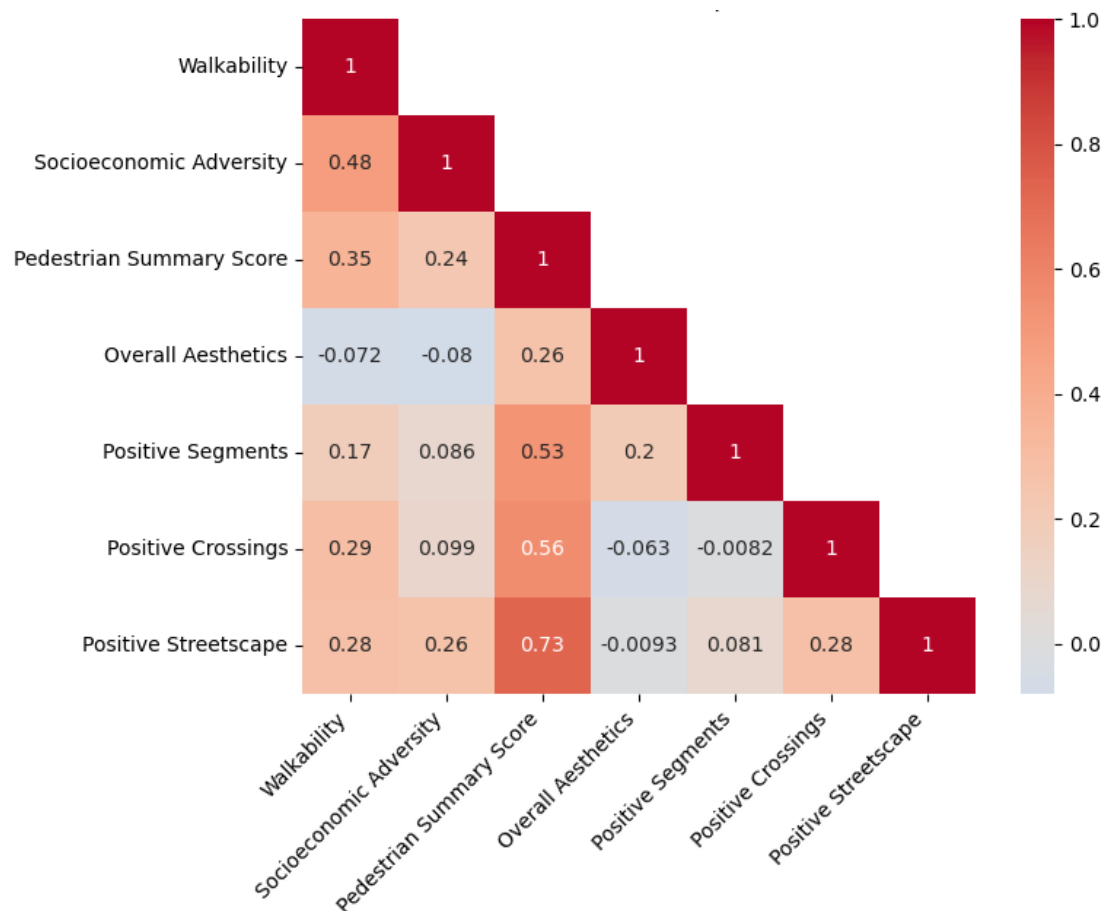


Figure 1.3: Spearman Correlation Matrix

The spatial distribution of the primary variables is depicted in Figure 1.4, with darker colors indicating higher values for each variable (maps of pedestrian subscales can be found in Supplemental Figure S1.9). Walkability values ranged from 0.17 to 13.90 (Mean = 6.37, SD = 1.94) with higher values visually concentrated in the core urban neighborhoods of South San Diego (such as Chula Vista and

Imperial Beach) and lower values in suburban communities in the east. Socioeconomic adversity values ranged from -0.84 to 2.17 (Mean = 0.87, SD = 0.68) with lower values visually concentrated in the suburban neighborhoods of South San Diego (such as Otay Ranch and Eastlake) and higher values concentrated in the urban core. Pedestrian summary score values ranged from 3.83-23.00 (Mean=13.87, SD=3.35) with values visually scattered and some high value spots in the urban cores. Additional descriptive information can be found in Supplemental Table S1.4.

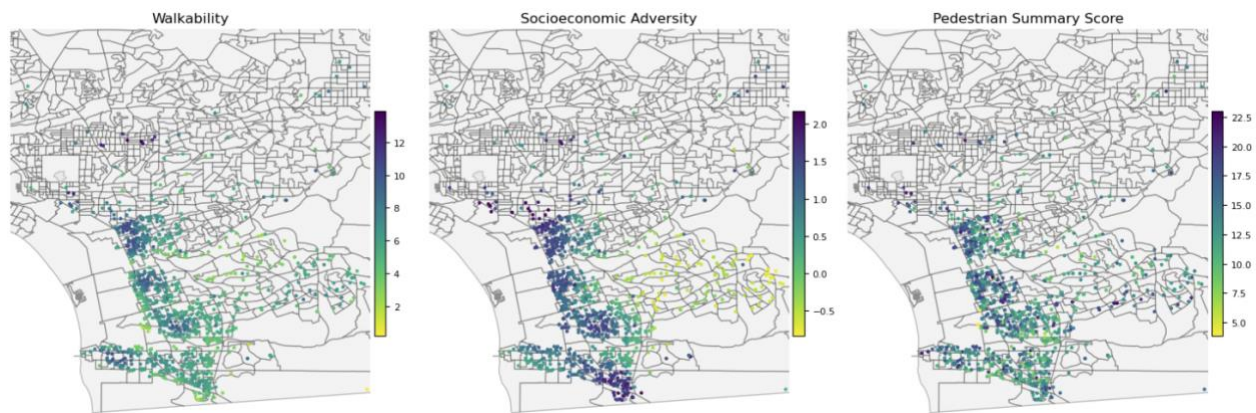


Figure 1.4: Spatial Distributions of Primary Study Variables

Theory-Derived Typologies and ANOVA

The relative representation of observations across the four walkable infrastructure types consistent with Ki and Chen 2023 are presented in Table 1.1. Approximately 50% of observations did not fit the criteria for any typology. Given the low representation of high walkability or pedestrian supportive environments, “High” typology values had means similar to the sample mean while low values were below the mean (See Supplemental Table S1.6 for distribution data). Overall aesthetics, positive crossing characteristics, and positive streetscape were the exceptions to this pattern, having low and high values both differential from the mean. Hostile walking environments (LL) were the most common type among the pedestrian summary score types. Among the overall aesthetics types, low aesthetic types (HL and LL) were about half as common as high aesthetic types whereas the opposite was true among the positive streetscape typologies. The unwalkable but pleasant (LH) type was most common in the positive segments and positive crossings typologies.

Table 1.1: Pedestrian Variable Distributions after Typologizing

Type	Pedestrian Summary	Overall Aesthetics	Positive Segments	Positive Crossings	Positive Streetscape
HH	145 (11.1%)	203 (15.7%)	152 (11.7%)	149 (11.5%)	128 (9.9%)
HL	152 (11.7%)	102 (7.9%)	159 (12.3%)	146 (11.3%)	210 (16.2%)
LH	136 (10.5%)	199 (15.4%)	108 (8.3%)	122 (9.4%)	85 (6.6%)
LL	210 (16.2%)	96 (7.4%)	189 (14.6%)	172 (13.3%)	254 (19.6%)
Uncategorized	653 (50.4%)	696 (53.7%)	688 (53.1%)	707 (54.6%)	619 (47.8%)

ANOVA Results

All ANOVA models were significant and pairwise comparison results are presented in Table 1.2. The hostile walking environment (LL) type had consistently lower socioeconomic adversity than both the walkable but unpleasant (HL) and the supportive walking environment (HH) types across all pedestrian scales. The unwalkable but pleasant (LH) type had lower socioeconomic adversity than the walkable but unpleasant (HL) and supportive walking environment (HH) types in all pedestrian scales except positive streetscapes. The hostile walking environment (LL) type had lower socioeconomic adversity than the unwalkable but pleasant (LH) type only in the positive streetscapes scale. Last, the walkable but unpleasant (HL) had higher socioeconomic adversity than the supportive walking environment (HH) type for overall aesthetics, but lower for positive streetscapes. All typologies across all pedestrian scale comparators were moderately significantly spatially autocorrelated, with Moran's I values ranging between 0.300 and 0.511. Key maps for this analysis are presented in Figure 1.5.

Table 1.2: Absolute Mean Difference in Socioeconomic Adversity by Walking Infrastructure Typology

Comparison ^{a b}	Pedestrian Scale				
	Pedestrian Summary	Overall Aesthetics	Positive Segments	Positive Crossings	Positive Streetscapes
LL - HL	-0.527 (0.068)**	-0.527 (0.087)**	-0.466 (0.066)**	-0.401 (0.074)**	-0.476 (0.062)**
LL - HH	-0.506 (0.068)**	-0.282 (0.081)**	-0.485 (0.069)**	-0.451 (0.069)**	-0.702 (0.062)**
LH - HL	-0.386 (0.084)**	-0.591 (0.080)**	-0.497 (0.082)**	-0.573 (0.084)**	0.044 (0.096)
LH - HH	-0.365 (0.085)**	-0.347 (0.073)**	-0.516 (0.085)**	-0.622 (0.079)**	-0.182 (0.096)
LL - LH	-0.141 (0.085)	0.065 (0.090)	0.032 (0.089)	0.172 (0.087)	-0.520 (0.097)**
HL - HH	0.021 (0.067)	0.245 (0.069)**	-0.019 (0.059)	-0.050 (0.065)	-0.227 (0.061)**

^aBonferroni adjustment for multiple testing used for pairwise comparisons

^bMean Difference (Standard Error of Difference); **p<.01 (adjusted)

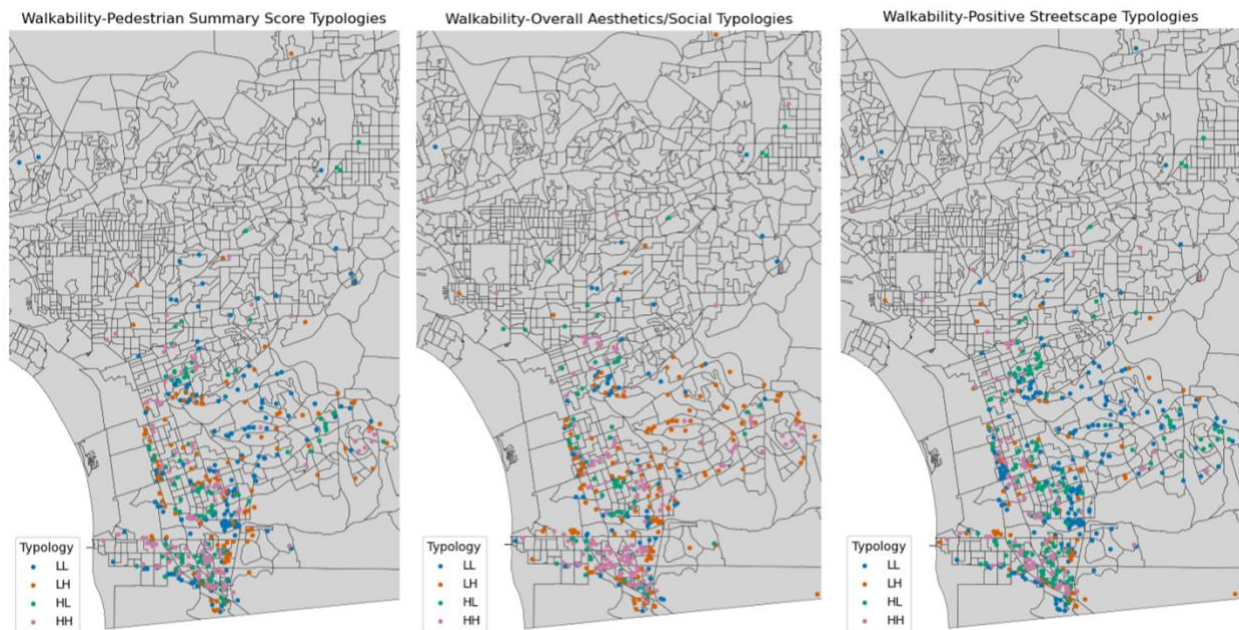


Figure 1.5: Maps of Key Walkable Infrastructure Typologies

Cluster Analysis Results

The combination of interpretive salience, silhouette score, and scree plot diagnostics suggested that $k=3$ clusters was the optimal number. Clusters were defined by their mean values relative to the overall sample mean and geographic placement (see Table 1.3 and Figure 1.6), with abbreviated acronyms ordered as walkability, pedestrian score, and then socioeconomic adversity. The three emergent typologies were suburb (LL-L), urban fringe (LL-H), and urban core (HH-H). For example, suburbs are LL-L because the mean walkability, adversity, and pedestrian summary scores are all lower than the sample mean. Among the pedestrian subscales, only overall aesthetics and positive segments differed from the pedestrian summary score relative values, with the suburb cluster having higher overall aesthetics and positive segments, while the urban core cluster having lower aesthetics. These results were consistent across alternative clusters defined by pedestrian subscales in sensitivity analyses. All clusters were significantly spatially autocorrelated, with Moran's I values between 0.639 and 0.709.

Table 1.3: Mean Values by K-means Cluster^a

Cluster	N	Walkability	Adversity	Ped Summary	Overall Aesthetics	Positive Segments	Positive Crossings	Positive Streetscape
<i>Overall Sample</i>	<i>1296</i>	<i>6.365</i> <i>(1.954)</i>	<i>0.857</i> <i>(0.682)</i>	<i>13.761</i> <i>(3.392)</i>	<i>1.073</i> <i>(1.066)</i>	<i>6.058</i> <i>(1.622)</i>	<i>2.183</i> <i>(1.537)</i>	<i>3.329</i> <i>(1.856)</i>
Suburb (LL-L)	350	4.793 (1.212)	-0.072 (0.412)	12.474 (3.140)	1.201 (0.959)	5.978 (1.790)	1.872 (1.378)	2.477 (1.671)
Urban Fringe (LL-H)	552	5.871 (1.155)	1.166 (0.355)	12.682 (2.899)	0.982 (1.138)	5.695 (1.487)	1.739 (1.416)	3.105 (1.766)
Urban Core (HH-H)	394	8.531 (1.443)	1.250 (0.386)	16.415 (2.684)	1.087 (1.044)	6.636 (1.484)	3.082 (1.454)	4.339 (1.660)

^aMean (SD)

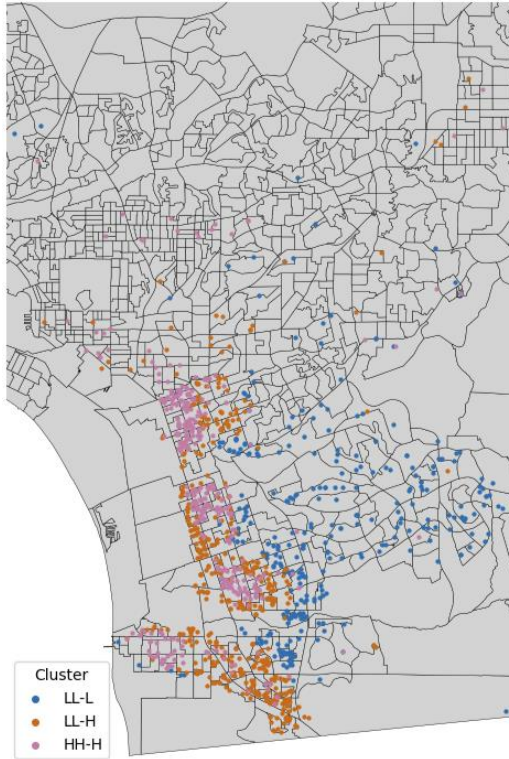


Figure 1.6: Cluster Derived Typologies

Discussion

This descriptive analysis of walkability, pedestrian streetscapes, and socioeconomic adversity in South San Diego revealed distinct neighborhood typologies that align with and extend previous research. In particular, correlations between primary variables and subscales indicate that overall aesthetic features are uncorrelated with both walkability and socioeconomic adversity and only weakly correlated with the pedestrian summary score. Pairwise comparisons of High/Low typologies are consistent with results of prior study (Ki and Chen 2023), wherein communities that were walkable but had poor pedestrian features were significantly more socioeconomically adverse than those that were low in walkability but had good pedestrian features. In the current study, these differences appear to be largely driven by walkability, not pedestrian streetscape, with the exception of the overall aesthetics and positive streetscapes subscales. Results of cluster analyses further supported these findings, with three emergent neighborhood types from the San Diego Hispanic/Latino community as represented in SOL CASAS; suburbs (unwalkable, poor pedestrian features, and low adversity), urban fringe (unwalkable, poor

pedestrian features, and high adversity), and the urban core (walkable, good pedestrian features, and high adversity). The suburb typology had scores greater than the mean for overall aesthetics and positive street segment features, highlighting the differences in the distribution of specific features by typology.

While the theoretical underpinnings of the present analyses were derived from Ki and Chen 2023, the multi-method approach to typologizing and describing neighborhood characteristics here advances this area of inquiry. Specifically, the a priori neighborhood typology method, while useful for understanding the concept of mismatch, is weakened by its relevance to the geography under examination. Diverse policies, land-use patterns, and public improvement programs across unique cities will generate diverse inconsistencies across the scales of walking infrastructure that may not fit into theoretical frames. In Ki and Chen 2023, only 436 of 2,430 block groups (approximately 18%) fit the mismatch criteria, similar to our approach where over 50% of observations were dropped before pairwise comparisons. These dropped observations, in the lens of this discussion, reduce our ability to fully interpret the ways that inequitable environments are most likely manifesting. The cluster driven approach applied here, while somewhat consistent with the a priori theory, generated unique findings that allow for a richer description and appraisal of the specific environmental features. While Ki and Chen 2023 complemented their mismatched typologies with spatial regression to describe the linear relationship between pedestrian features or walkability with demographic characteristics (thereby retaining block groups dropped), this approach reduces the spatial description available through cluster analysis or similar machine learning methods.

These results are largely consistent with previous research that links higher walkability to more socioeconomically disadvantaged communities.²⁴ Historically this patterning is often attributed to “white flight”, a phenomena connected to the suburbanization of major US cities wherein wealthier, often White households left the neighborhoods in the urban cores for larger single family households available in the newly developed suburbs.²⁵ In recent years however, scholars have noted an increase in the “suburbanization of poverty”— households that lack both material and transportation resources which further exacerbates health and social inequities.^{26,27} Both of these distinct typologies were identified in our

cluster analysis, with households that have poor walking infrastructure resources being split by their socioeconomic status. As with previous research examining the intersection between socioeconomic adversity and urban form, we find that traditional measures of walkability alone would be insufficient to describe the walking propensities of diverse communities, and our inclusion of pedestrian streetscape features indicates some potential rationale for the disparate impact of walkability across socioeconomic groups. Our mismatched walking infrastructure typology findings aligns with those from Ki and Chen 2023, but the unique findings when walkability is held constant (i.e., differences in socioeconomic adversity between walkable neighborhoods with good or poor pedestrian features) warrant further explanation.

One potential rationale for the observable differences is that the pedestrian streetscape subscales may be a signal for walkability in this sample given the low variability of walkability in South San Diego more generally. For example, the overall aesthetics subscale is primarily representative of good landscaping and a low propensity of negative visual features like billboards. These factors were generally high in the examined neighborhoods, but were over-represented in the suburban typology, potentially acting as a signal for unwalkable built environments such as landscaped business parks. Similarly, the positive streetscape subscale includes transit stops, which other walkability indices, such as the EPA Smart Location National Walkability Index, purposively include as a metric of walkability given the association between transit and active transportation behaviors.²⁸ The inclusion of transit stops in the positive streetscape subscale may once again indicate this measure a potential proxy for urban spaces, thus signaling walkability (and conflation between constructs). Alongside the lower number of neighborhoods which had mismatched walkability and positive streetscape typologies, the positive streetscape score may be a proxy for walkability in these High/Low categorizations.

Another complementary explanation would be that the infrastructure investments differ across communities that vary by socioeconomic adversity. More socioeconomically disadvantaged, walkable communities are more likely to have positive streetscape features (such as transit stops, benches, trash cans, and bike racks) while the less disadvantaged suburbs tend to have better overall aesthetics and

positive street segments (such as bike lanes, tree coverage, and sidewalk buffers) than would be expected based on their other infrastructure. This explanation is aligned with previous research where overall aesthetics (as measured by the MAPS-Abbreviated scale) was negatively associated with physical activity as opposed to the positive association found for the other MAPS subscales.⁶ Additionally, previous research has identified that low income neighborhoods have poorer aesthetics and walking infrastructure measured at the pedestrian scale compared to their higher income counterparts.²⁹ As extended further in this dissertation, additional work is needed to be done to identify the contexts in which specific pedestrian streetscape factors positively impact health behaviors and outcomes. Without a complete understanding of what pedestrian streetscape features matter for improving health outcomes and in which community contexts (both in relation to socioeconomic and pre-existing infrastructure) policymakers and interventionists risk exacerbating health inequities or wasting resources, therefore undermining trust in public investment.

An additional important finding from the present analysis was the emergence of the “urban fringe” neighborhood typology, defined by poor walking infrastructure in addition to high socioeconomic adversity, both of which are associated with poor health outcomes.^{2,30–32} The emergence of this neighborhood type highlights a potential area for intervention as additional research is done to understand the most cost effective infrastructure within its context (e.g., does the proximity of this type to walkable urban cores suggest that urban densification is a potential strategy or should pedestrian improvements precede them?). These doubly disadvantaged communities are not unique to this sample; as previously mentioned; other researchers have described the rise of suburban poverty, marked by transportation insecurity as a result of the high costs of owning and operating a motor vehicle and the dearth of transportation choices available.^{26,27,33} It is estimated that one in four US adults experience transportation insecurity (the inability to move from place to place in a safe and timely fashion), with those who are non-white and live in high poverty urban areas being overrepresented.³³ Transportation insecurity intersects with other forms of material hardship, such as poor access to nutritious food and quality healthcare, which can exacerbate health disparities.³⁴ While much of the literature around walkability and pedestrian

infrastructure in Public Health is focused on the benefits to physical activity and social health, the broader health implications of inequities in walkability should be examined holistically.

Strengths and Limitations

The current study is among the first to describe walking infrastructure resources as they relate to socioeconomic adversity both generally and specifically among Hispanic/Latino communities. This study is also strengthened by the multiple approaches to typologizing neighborhoods to triangulate our findings. Additionally, the use of the MAPS-Abbreviated tool, through both the summary and validated subscales, provided a useful framework to examine the different dimensions of pedestrian streetscapes and allows for direct comparison with prior literature in this space. This unique approach to typologizing egocentric neighborhood data also allowed for the evaluations of different types by their spatial autocorrelations, validating the findings by grounding them in real community spaces.

This study is not without its limitations. First, the restriction to a single region (primarily in the South Bay of San Diego) and timepoint limit generalizability and preclude consideration of how environmental changes manifest over time. The relatively low variability of walkability and pedestrian streetscape values in this sample is a limitation that has been noted in prior reports and may mask distinct walking infrastructure typologies.⁴ Additionally, the pedestrian streetscape features in this analysis were limited in their spatial coverage. While the approach used to gather pedestrian streetscape data has been previously validated,⁶ there is the risk of misclassification given that it uses a single quarter-mile route rather than an exhaustive evaluation of all features within an 800m buffer. Compared to the analysis performed by Ki and Chen 2023, which leveraged semantic segmentation of Google Street View images to achieve full coverage and compare census block groups,⁵ our approach is limited to comparing point data that represents egocentric neighborhoods. However, the strength of this approach is the ability to identify spatial clusters and typologies that are not bound by census tract structures which are often arbitrarily drawn.³⁵

Future Directions

Future research should continue to employ the approaches used here and advances in data collection that allow for a more holistic accounting of walking infrastructure when studying the concept of “walkability” and its related health impacts. In particular, the use of machine learning and artificial intelligence to evaluate pedestrian streetscape features that are consistent with existing measurement tools, such as the MAPS-Abbreviated, would support more thorough evaluations and comparisons with prior research. These measures can and should still be complemented by assessing the perceived built environment, particularly when community perceptions do not align with objective measures to inform multi-level intervention strategies.³⁶ Traditional approaches that statistically isolate neighborhood features to understand their independent effects on health could be complemented with a thorough accounting of the types of environments that exist in our communities. By exclusively using a reductionist statistical approach to evaluating the health impacts of our built environments, we may miss synergistic or interference effects that can help us to better plan, invest, and intervene to advance health equity in context.

Conclusion

Neighborhood walkability in the predominantly Hispanic/Latino South Bay of San Diego is not evenly distributed across space and is largely spatially consistent with socioeconomic adversity. Pedestrian streetscape features are less spatially consistent, with suburban neighborhoods having better aesthetics and active transportation features relative to the other typologies and overall sample. These patterns suggest that streetscape quality may reflect localized investment that could be prioritizing already advantaged neighborhoods. The findings here suggest the need for future research and share transferable methodologies and approaches that would benefit the field. Blending policy, health outcome, and typology research together could provide rich insights into the ways we can effectively address health inequities and avoid potentially negative consequences from environmental change projects.

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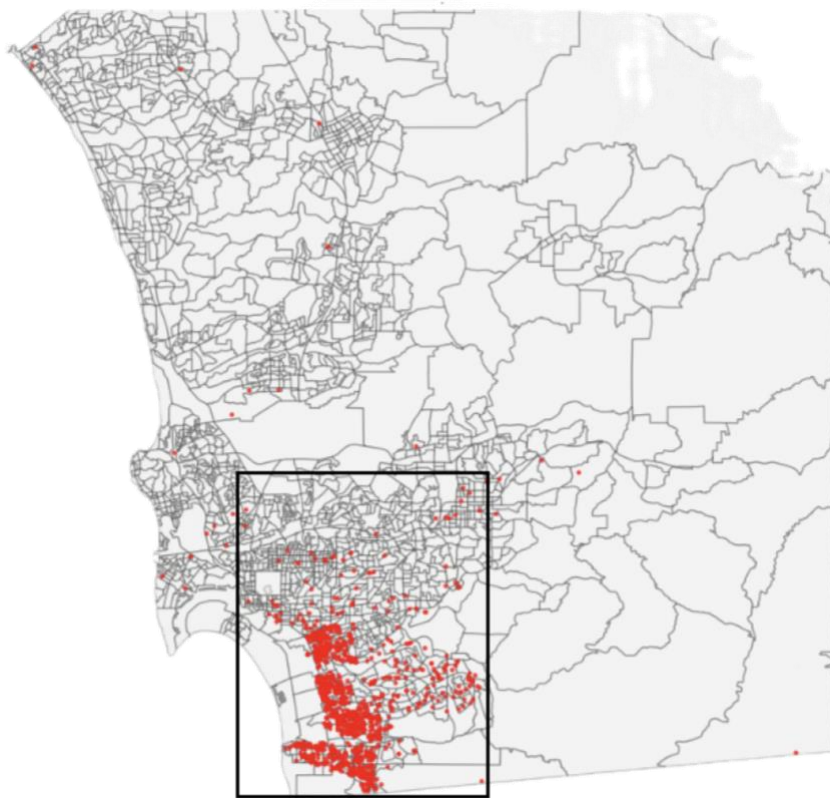
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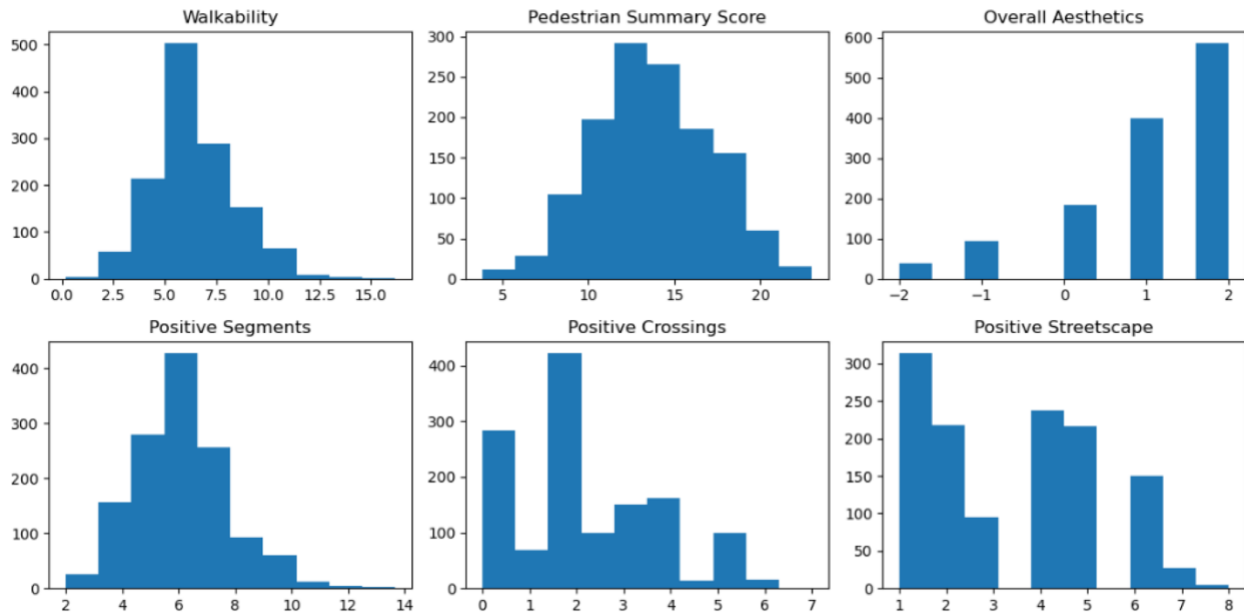
Supplemental Materials

Supplemental Table S1.4: SOL CASAS and Sample Variable Distributions

Variable	Scoring Range	Sample Range	Sample Mean (SD)
Socioeconomic Adversity	-1.6-4.16	-0.84-2.17	0.87 (0.68)
Walkability	-1.01-32.87	0.17-13.90	6.37 (1.94)
Pedestrian Summary Score	0-48	3.83-23	13.87 (3.35)
Overall Aesthetics	-5-3	-2-2	1.07 (1.07)
Positive Segments	0-25	2-12.5	6.05 (1.57)
Positive Crossings	0-11	0-7	2.16 (1.53)
Positive Streetscape	0-9	1-8	3.33 (1.86)



Supplemental Figure S1.7: Spatial Extent of Sample Data and Focus Area



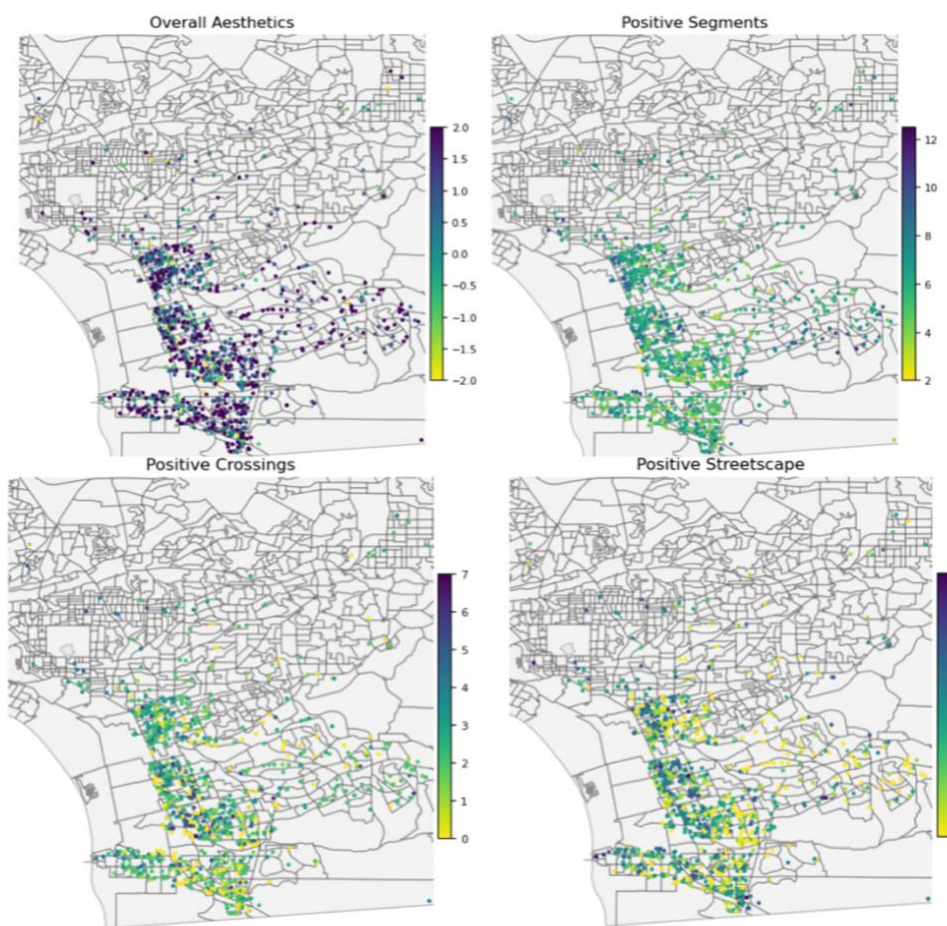
Supplemental Figure S1.8: Raw Variable Distributions

Supplemental Table S1.5: Typology Splits

Variable	Split
Walkability	Top and Bottom Tertile
Pedestrian Summary Score	Top and Bottom Tertile
Overall Aesthetics	<1 and >1
Positive Segments	Top and Bottom Tertile
Positive Crossing	< 2 and >2
Positive Streetscape	< 4 and >4

Supplemental Table S1.6: Variable Means by Typology

Variable	Sample Mean	Low Value Means	High Value Means
Walkability	6.37	4.257 to 4.535	6.117 to 6.328
Pedestrian Summary Score	13.87	9.827 to 10.159	13.453 to 13.698
Overall Aesthetics	1.07	-0.520 to -0.594	2.000
Positive Segments	6.05	4.359 to 4.373	5.978 to 6.032
Positive Crossing Characteristics	2.16	0.330 to 0.412	3.556 to 3.594
Positive Streetscapes	3.33	1.539 to 1.657	5.508 to 5.529



Supplemental Figure S1.9: Map of Pedestrian Subscale Distributions

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Chapter 2 Longitudinal and Moderating Relationships of Adversity and Walkability Indicators on Cardiovascular Health from the HCHS/SOL CASAS Ancillary Study

Introduction

Heart disease is the leading cause of death in the United States, attributed to one in every five deaths.¹ While Hispanic/Latino populations have historically had a lower burden of cardiovascular disease relative to other racial or ethnic groups, it remains the leading cause of death among Hispanic/Latino males and is only second to cancer among Hispanic/Latino females.^{1,2} Additionally, Hispanic/Latino adults are less physically active and have higher rates of diabetes than their non-Hispanic white counterparts, suggesting the need for solutions to improve health equity.^{3,4} While individual-level determinants and interventions may be effective in altering the health behaviors that impact cardiovascular health (CVH), upstream environmental and neighborhood-level determinants of health are essential for creating broader reach and addressing the underlying causes of health disparities.⁵

Socioeconomic adversity (adversity) is one way to operationalize the socioeconomic conditions of a given geographic region.⁶ Adversity can include different neighborhood-level components, such as levels of education, unemployment, and poverty among residents, as well as percent renting, living in crowded households, and receiving public assistance. This construct is powerful in that it provides a more holistic view of socioeconomic disadvantage than more simple approaches such as examining race, ethnicity or household income alone. This measure also helps to avoid overt “disparity framing”, which ascribes negative values to communities of color without an appraisal of the assets that also exist.⁷ Previous literature has established multiple adverse health behaviors and outcomes with measures of adversity, including hypertension, weight gain, obesity, metabolic syndrome, and cardiovascular disease mortality.^{8–12} Specifically among Hispanic/Latino adults, previous research in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) San Diego cohort has found that neighborhood adversity was longitudinally associated with adverse changes in body mass index (BMI), diabetes status, and blood pressure.^{13,14}

At the policy and environmental level, increasing access to physical activity opportunities is a potential intervention for improving CVH. The role of neighborhood walkability as a facilitator for healthier lifestyles is well-established, with cross-sectional and longitudinal evidence of its association with physical activity, obesity, type 2 diabetes, and hypertension.¹⁵ However, this body of evidence is largely built on macro-scale walkability features, such as land-use mix, residential density, and street connectivity, as opposed to the micro-scale, pedestrian streetscape features such as sidewalk quality and neighborhood aesthetics. Given the more burdensome nature of data collection, pedestrian streetscape features are less well studied, however, findings thus far support benefits to physical activity through features such as neighborhood aesthetics and sidewalk presence/quality.^{16–19} Specifically in HCHS/SOL, macro-scale walkability has been found to be cross-sectionally associated with physical activity but not with changes to activity over time.²⁰ However, other HCHS/SOL analyses have not revealed significant associations between either walkability or pedestrian streetscape and CVH outcomes and behaviors among the San Diego Hispanic/Latino population.^{13,14,21} Additionally, there is a paucity of research that has explored how walkability and the pedestrian streetscape interact to support physical activity or CVH more directly. This evidence is needed given that the implementation of pedestrian streetscape interventions is less costly and burdensome than making changes to the urban form at large. Understanding the interaction between these types of pedestrian infrastructure can help better target funding and intervention strategies.

To reframe environmental change projects as health behavior interventions, it is important to understand how high-quality pedestrian features or dense urban form may attenuate the negative consequences of other neighborhood factors, including adversity. This is particularly relevant given that walkability researchers have described so-called “positive disparities” wherein low-socioeconomic status neighborhoods often have higher walkability scores which do not confer the same benefits as in high-socioeconomic status neighborhoods.^{22,23} Previous studies have identified that racial segregation attenuates the positive relationship between walkability and CVH.²⁴ Additionally, there is evidence that walkability changes (in the form of zoning code reform) may alleviate the negative impacts of adversity

on active transportation to work.^{25,26} Specifically, in HCHS/SOL, Sallis et al. 2022²¹ found a significant cross-sectional interaction between adversity and pedestrian streetscapes with objectively measured physical activity.²¹ In high-adversity neighborhoods, overall positive pedestrian streetscape was positively associated with physical activity, with an inverse association noted in low-adversity neighborhoods suggesting the need for additional research into these interactions. Still, there is limited research on the potential role of walkability indicators as moderators, particularly micro-scale pedestrian streetscape features of walkability which are less studied than their macro-scale counterpart. These inconsistent findings warrant future analyses into the interactions between these three distinct neighborhood features on CVH outcomes.²⁷

The HCHS/SOL Community and Surrounding Areas Study (CASAS) Ancillary study provides a unique opportunity to examine these relationships and interactions using longitudinal data. The current study explored the longitudinal associations between socioeconomic adversity, walkability, and pedestrian streetscapes (both independently and as moderators) with CVH metrics 6 years later. As depicted in Figure 2.1, this study has several aims. Aim 1 was to assess the longitudinal relationships between socioeconomic adversity, walkability, and the pedestrian streetscape with six-year changes in CVH among a sample of Hispanic/Latino adults from San Diego, California. Aims 2-4 were to explore the potential moderating effects of walkability on the relationship between adversity and CVH, pedestrian streetscape on the relationship between adversity and CVH, and walkability on the relationship between pedestrian streetscape and CVH respectively.

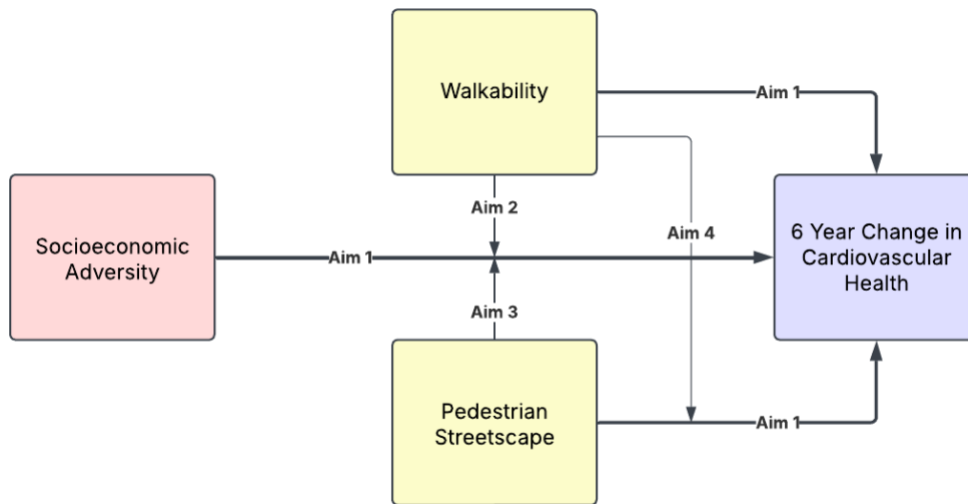


Figure 2.1: Study Aims and Conceptual Model

Methods

Study Population

The HCHS/SOL is a prospective cohort study of 16,415 self-identified Hispanic/Latino adults aged 18–74 years at enrollment residing in four major cities across the U.S. HCHS/SOL conducted its baseline examination in 2008–2011 (visit 1/V1), a second examination in 2014–2017 (visit 2/V2), and a third examination between 2020–2024 (visit 3/V3). More information on the parent study and complex sampling design have been published previously.^{28–30} This study used data from SOL CASAS, an ancillary study focused on social and environmental exposures exclusively at the San Diego, CA field center. SOL CASAS included 4086 participants from V1 across 158 census block groups, with follow up micro- and macro-scale neighborhood measures at V2 for 1,776 participants.³¹ The present analyses included all participants with complete data at V2 for 1) socioeconomic adversity, 2) walkability, 3) and pedestrian streetscape, and 4) relevant clinical information to calculate a CVH score at both V2 and V3.

Measures

Independent Variables: Neighborhood Environment Features

To estimate environmental exposures, 800-meter and 1600-meter circular radial buffers around each CASAS participant’s home address were constructed using GIS software, to reflect reasonable

exposure distances around the home.³¹ Built and social environment characteristics within that buffer were computed and geocoded to create the variables used in these analyses. These methods are described in more detail in the protocol paper for this ancillary study.³¹

Socioeconomic Adversity

A composite variable was created to quantify adversity using the non-rotated first component from a Principal Components Analysis of census variables with higher values indicating greater adversity. This variable is composed of Census/American Community Survey (ACS) 5-year estimates from 2013-2017 (aligned with V2) including the percent of: adults within the buffer who were 25 years or older with no high school diploma, adults who were unemployed, households that were rented, crowded households (more than one person per room), households living below the poverty line, female headed households with dependent children, households on public assistance, and population on public health insurance using the 800m buffer.

Walkability

An index of intersection density, residential density, and land-use mix within an 800m circular buffer from participants' homes (summed Z-score) was calculated, utilizing data from 2016-2019 for V2 values similar to the method devised in Frank 2004.³² Intersection density was derived from 2019 SANDAG data, represented as the number of intersections per 200x200m grid cell. Residential density is derived from 2017 Census/ACS data, represented as residential density per 200x200m grid cell. Land-use mix is derived from 2017 Census/ACS data, represented as Mix of Park, Residential, Retail, Civic, and Other land use. It was calculated using an entropy formula for those land use classifications per 200x200m grid cell.

Pedestrian Streetscape

A series of systematic observational audits of the streetscape by trained raters along a 0.25 to 0.44-mile route from each participant's approximate home address toward the nearest commercial cluster were conducted to approximate likely walking routes and were used to evaluate the pedestrian streetscape. This procedure was done using the Micro-scale Audit of Pedestrian Streetscapes Abbreviated

Tool (MAPS-Abbreviated) via Google Street View and Google Earth, which has shown good inter-rater reliability.³³ MAPS-Abbreviated includes 60 items to assess features such as sidewalks, street crossings, bicycle facilities, landscaping, buildings, and lighting. The overall micro-scale positive score used in the present analyses represents a summation of individual items, with higher scores representing a more pedestrian-friendly environment. The subscales that compose this summary score were also used in sensitivity analyses including positive crossing characteristics, positive street segments, positive streetscapes, and overall aesthetics/social.

Dependent Variable: Change in Cardiovascular Health

The cardiovascular health (CVH) score was based on the Life's Essential 8 (LE8) metrics for promoting and maintaining optimal CVH.³⁴ Specifically, I examined the four LE8 clinical health factors: body mass index (BMI), blood glucose HbA_{1c}, blood lipid levels, and blood pressure.³⁴ For present analyses, the composite CVH score was calculated as the mean values of the scores for the four clinical components. Each component was individually scored from 0 to 100 (higher scores representing better health), for blood lipids, HbA_{1c}, and blood pressure 20 points were deducted from total points for medication use. The definitions, levels of each component, and a tabular depiction of this scoring method is presented in Supplemental Table S2.4.

- BMI was calculated as weight in kilograms divided by squared of height in meters. Standing height was measured with a wall-mounted stadiometer. Body weight was measured with a Tanita Body Composition Analyzer (Model TBF-300A, Tanita Corporation of America, Inc, Arlington Heights, IL 60005, USA).
- Blood lipids were presented as non-HDL cholesterol, the difference between HDL cholesterol levels and total cholesterol levels. Blood lipids were obtained from venous blood samples and measured using the magnesium/dextran sulfate method.
- A Tosoh G7 Automated High Pressure Liquid Chromatography Analyzer (Tosoh Bioscience) was used to measure HbA_{1c}, a measurement of blood glucose regulation in the past 2-3 months.

- Systolic and diastolic blood pressure (SBP and DBP respectively) were measured using an automatic sphygmomanometer (Omron model HEM-907 XL, Omron Healthcare Inc., Bannockburn, IL). Before measuring their blood pressure, participants rested for 5 minutes, after which, while in a seated position, their blood pressure was captured three times at 1-minute intervals. The average of these three time points be used for SBP and DBP.

The unweighted average of the four health variable scores was then calculated, to determine the overall CVH score, which also ranged from 0 to 100 for all participants, at both V2 and at V3. A residualized change in the CVH scores between timepoints was calculated to account for expected differences in the variable between visits by regressing the CVH scores ($V3\ CVH \sim V2\ CVH$) and extracting the residuals.

Covariates

Analyses included multiple covariates including time between visits, age (calculated from self-reported date of birth), sex (male or female), Hispanic/Latino background (recoded as Mexican or other for present analyses given >90% of San Diego cohort members reported having a Mexican background), education (below high school, high school diploma equivalent, or greater than high school), annual household income ($\geq \$30\ K$ or $< \$30\ K$), nativity (born in US 50 states/DC, and foreign born with <10yrs >10yrs in the US, or <20yrs in the US), smoking status (non-smoker, smoker, or change in status across V2 and V3), health insurance status at V2 (yes/no), and a walkable neighborhood preference questionnaire consistent with the approach used in the Neighborhood Quality of Life Study (range from 0-5, with higher values indicating a greater preference for walkable communities).³⁵

Statistical Analyses

Unweighted and weighted descriptive statistics were calculated, and all regression analyses were conducted in RStudio (Version 2025.09.2+418), accounting for the complex sampling design (stratification, clustering) and sampling weights. Weights were trimmed and calibrated to the 2010 U.S. Census according to age, sex, and Hispanic/Latino background to support generalization of the results to

the underlying population in the target area (census tracts from which participants were recruited).²⁸

Statistical significance was set at the $\alpha=.05$ significance level. All results are presented as standardized β estimates for both exposures and outcomes for comparability across independent variables and models.

All independent variables of interest were scaled using z-scores to improve model stability and comparability between variables. Pearson correlations and variance inflation factors were calculated to verify that collinearity would not be an issue. The *svyglm()* package in R was used to run regression models in a stepwise adjustment fashion including 1) unadjusted models for each independent variable, 2) minimally adjusted for age, sex, Hispanic/Latino background, nativity/time in the US, and years between visits, 3) additionally adjusted for education, income, health insurance status, and smoking status, 4) fully adjusted for walkable neighborhood preference, and the other neighborhood variables. Only the minimally adjusted and fully adjusted models are presented here.

Formal interactions between each of the three independent variables were tested in a similar stepwise adjusted series of models. Comparisons also included fully adjusted models stratified by tertiles of walkability (and tertiles of pedestrian streetscapes in the analyses looking at the interaction between socioeconomic adversity and pedestrian streetscape). Significant interactions were plotted by tertile and using Johnson-Neyman plots to identify the inflection point in statistical significance.

Complete Case Analysis

Pedestrian streetscape measures were missing for a subset of participants with all clinical information across both V2 and V3 (n=672). Because these exposures represent objectively measured contextual characteristics rather than participant-reported variables, multiple imputation of microscale environmental values was not performed. Primary analyses were conducted among participants with complete pedestrian streetscape exposure data. To assess whether exclusion of participants with missing pedestrian streetscape measures materially influenced results, I conducted sensitivity analyses using the missing-indicator method (MIM). Participants missing pedestrian streetscape data were assigned the mean value of observed data as a constant, and then a binary missingness indicator was added to the fully

adjusted model to test for significant differences between those groups and if the main results differed.

Sensitivity Analyses

Additional exploratory sensitivity analyses were conducted using models that examined individual components of the clinical LE8 CVH score. The CVH components were analyzed as the residualized change between their scored values, where positive changes indicate better health. Similarly, additional analyses were conducted using the pedestrian streetscape subscales that compose the overall summary score used in the main analysis. Both approaches were undertaken using fully adjusted models and were performed to aid in the interpretation of potential pathways and contextualize the main findings.

Results

Descriptive Findings

After exclusion for missing pedestrian streetscape data, the final analytical sample was N=1,124. Supplemental Table S2.5 summarizes the differences between the CCA sample and those excluded in the sample weighted data. Those excluded from the present analyses were on average younger, more educated, had slightly longer time between visits, and had higher cardiovascular health scores than those with complete data. They did not significantly differ by walkability, socioeconomic adversity, or residualized change in CVH score. Descriptive statistics for the unweighted and weighted CCA sample can be found in Table 2.1. Nearly 85% of participants were 44+ years old, nearly 70% were female, and 94% were of Mexican heritage. Less than 18% of the sample was US born, with 57.6% having immigrated to the US over 20 years ago. Just over half (52%) of the sample had an annual household income of less than \$30,000, 44% of participants had greater than a high school education, and 19% of participants had no health insurance coverage. Nearly 88% of the sample were non-smokers, with 4% having quit smoking between V2 and V3. The median time between V2 and V3 was 6.36 years. The median score for the walkable neighborhood preference question was 3.67 (range 1 to 5), suggesting a preference for walkable neighborhoods in the sample.

Table 2.1: Analytic Sample Descriptive Statistics

	Unweighted (N=1,124)		Weighted ^a (N=942)	
Characteristic	n (%)	Median (Q1, Q3)	n (%)	Median (Q1, Q3)
Age group, years				
18-43 Years Old	170 (15.1)		340 (36.1)	
44+ Years Old	954 (84.9)		602 (63.9)	
Sex				
Male	340 (30.2)		447 (47.5)	
Female	784 (69.8)		495 (52.5)	
Hispanic/Latino background				
Non-Mexican	67 (6.0)		60 (6.4)	
Mexican	1,056 (94.0)		881 (93.6)	
Unknown	1 (0.1)		0 (0.0)	
V2 Annual Household Income				
Less than \$30,000	589 (52.4)		416 (44.2)	
More than \$30,000	535 (47.6)		525 (55.8)	
Education Level Completed				
No high school diploma or GED	379 (33.7)		249 (26.4)	
At most a High school diploma or GED	244 (21.7)		227 (24.1)	
Greater than high school (or GED) education	501 (44.6)		466 (49.4)	
Health Insurance Status V2				
No Health Insurance	216 (19.2)		217 (23.1)	
Yes Health Insurance	908 (80.8)		724 (76.9)	
Nativity/Immigration Status				
Immigrated < 10yrs ago	67 (6.0)		71 (7.6)	
Immigrated 10-20yrs ago	213 (19.0)		192 (20.3)	
Immigrated > 20yrs ago	647 (57.6)		425 (45.1)	
Born in US 50 States/DC	197 (17.5)		254 (27.0)	
Smoking Status				
Non-Smoker	987 (87.8)		813 (86.4)	
Quit Smoking	47 (4.2)		57 (6.1)	
New Smoker	15 (1.3)		11 (1.2)	
Continuous Smoker	75 (6.7)		60 (6.4)	
Walkable Neighborhood Preference		3.67 (2.67, 4.67)		3.67 (2.67, 4.33)
Years between V2 & V3		6.36 (6.08, 6.74)		6.33 (6.06, 6.76)
Socioeconomic Adversity		1.05 (0.39, 1.38)		1.00 (0.24, 1.32)
Neighborhood Walkability		6.12 (5.16, 7.49)		6.28 (5.14, 7.49)
Pedestrian Streetscape		13.67 (11.25, 16.00)		13.67 (11.25, 16.50)
LE8 Clinical Score (Visit 2)		61.25 (48.75, 75.00)		66.25 (52.50, 82.50)
LE8 Clinical Score (Visit 3)		60.00 (47.50, 72.50)		65.00 (50.00, 77.50)
LE8 Residualized Change (V3~V2)		0.46 (-8.61, 9.32)		1.88 (-8.12, 10.35)

^aEffective sample size after weighting

The median socioeconomic adversity score was 1.05 (interquartile range (IQR) from -0.74 to 2.02). The median walkability was 6.12 (IQR 0.17 to 16.18). The median pedestrian streetscape score was 13.67 (IQR 3.83 to 23). The median LE8 clinical scores were 61.25/100 and 60/100 at V2 and V3 respectively, with a median residualized change score of 0.46 (IQR -40.75 to 40.38).

Prospective Associations

Table 2.2 presents the longitudinal associations for each of the independent variables in both the minimally adjusted and fully adjusted models. Neighborhood socioeconomic adversity was significantly negatively associated with changes in CVH in the minimally adjusted ($\beta=-0.127$, $SE=0.038$, $p=.001$) and fully adjusted model ($\beta=-0.130$, $SE=0.060$, $p=.031$). Each standard deviation (SD) increase in socioeconomic adversity was associated with a .13 SD decline in the clinical LE8 CVH score from V2 to V3. Walkability was not associated with changes in CVH in the minimally adjusted model but was significantly positively associated after full adjustment ($\beta=0.140$, $SE=0.063$, $p=.028$). A 1 SD increase in walkability is associated with a 0.14 SD increase in the clinical LE8 CVH score from V2 to V3. Pedestrian streetscape was not significantly associated with changes in CVH in either the minimally or fully adjusted models.

Table 2.2: Prospective Associations between V2 Neighborhood Variables and V3 CVH Score

	Residualized Change in CVH Score from V2 to V3					
	Model 1 ^a			Model 2 ^b		
	Estimate (β)	SE	p-value	Estimate (β)	SE	p-value
Socioeconomic Adversity	-0.127	0.038	.001**	-0.130	0.060	.031*
Walkability	-0.003	0.040	.939	0.140	0.063	.028*
Pedestrian Streetscape	-0.032	0.040	.416	-0.053	0.046	.256

Note. * $p < .05$; ** $p < .01$

^aAdjusted for Age, sex, Hispanic/Latino background, place of birth and years lived in the US 50 states/DC.

^bAdjusted additionally for time between visits, smoking status, health insurance, income, education, neighborhood preference, and other neighborhood variables.

Statistical Interactions

Table 2.3 presents the statistical interactions between each of the three independent variables and the comparison between the estimates for the top and bottom tertiles of walkability (pedestrian streetscape in the interaction with socioeconomic adversity). There was no significant interaction between socioeconomic adversity and walkability ($\beta=-0.048$, $SE=0.054$, $p=.377$) or adversity and pedestrian streetscape ($\beta=-0.021$, $SE=0.095$, $p=.830$).

The interaction between walkability and pedestrian streetscape was significant and positive ($\beta=0.091$, $SE=0.043$, $p=.038$), with pedestrian streetscape being negatively associated with changes in CVH (harmful) in the lowest tertile of walkability ($\beta=-0.234$, $SE=0.080$, $p=.004$) but no association in the highest tertile ($\beta=0.090$, $SE=0.074$, $p=.229$). Figure 2.2 presents the linear associations between pedestrian streetscape and changes in CVH at the different tertiles of walkability. In the lowest tertile of walkability, a 1 SD change in pedestrian streetscape is associated with a .23 SD decline in the clinical LE8 CVH score from V2 to V3. The Johnson-Neyman plot presented in Figure 2.3 depicts the inflection point at which the interaction becomes significant.

Table 2.3: Moderation by Walkability Variables on Associations with Cardiovascular Health

	Residualized Change in CVH Score from V2 to V3 ^a					
	Stratified Analyses				Interaction Test	
	Bottom Tertile		Top Tertile			
	β (SE)	p-value	β (SE)	p-value	β (SE)	p-value
Socioeconomic Adversity X Walkability^b	-0.048 (0.054)	.377	-0.060 (0.141)	.671	0.047 (0.053)	.377
Socioeconomic Adversity X Pedestrian Streetscape^c	-0.021 (0.095)	.830	-0.159 (0.085)	.065	-0.043 (0.048)	.372
Pedestrian Streetscape X Walkability^b	-0.234 (0.080)	.004**	0.090 (0.074)	.229	0.091 (0.043)	.038*

Note. * $p < .05$; ** $p < .01$

^aAll models fully adjusted for all covariates

^b Stratified by bottom and top tertiles of walkability

^cStratified by bottom and top tertiles of pedestrian streetscape

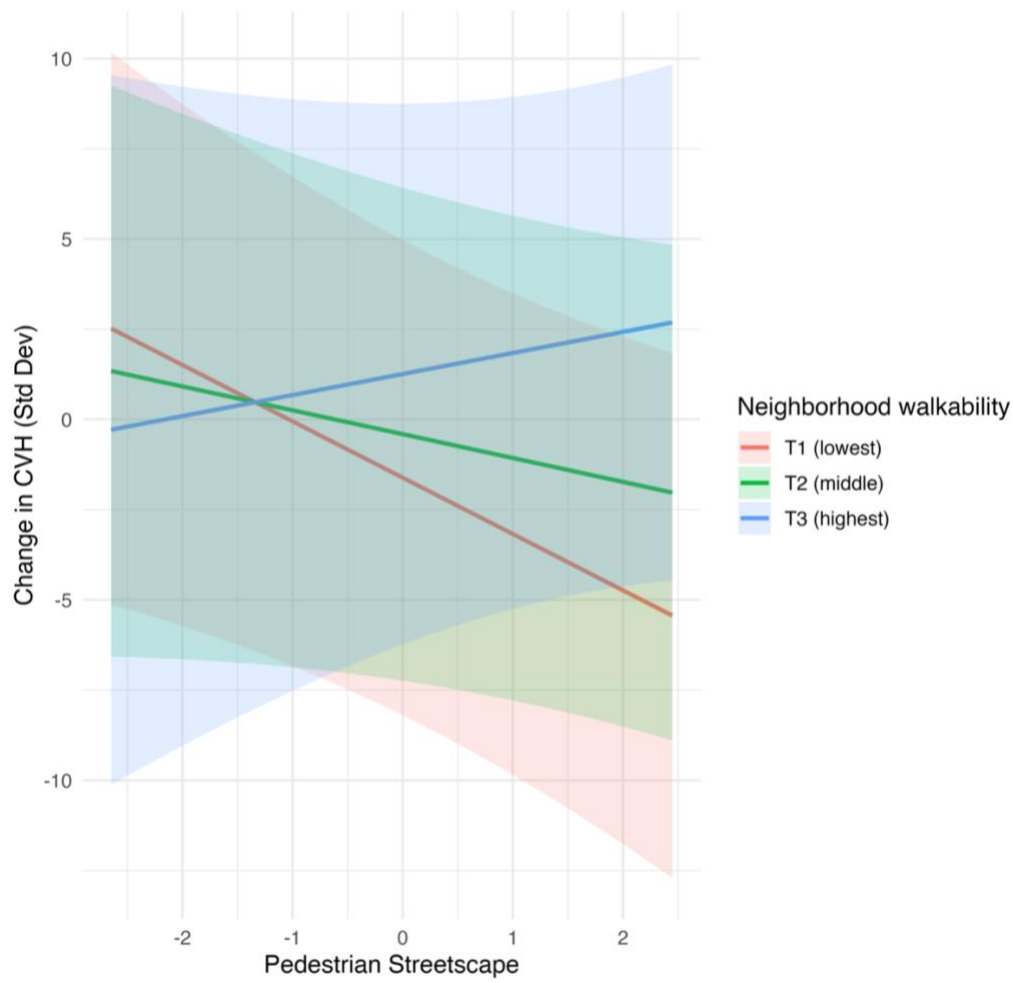


Figure 2.2: Pedestrian Streetscape x Walkability Interaction on CVH

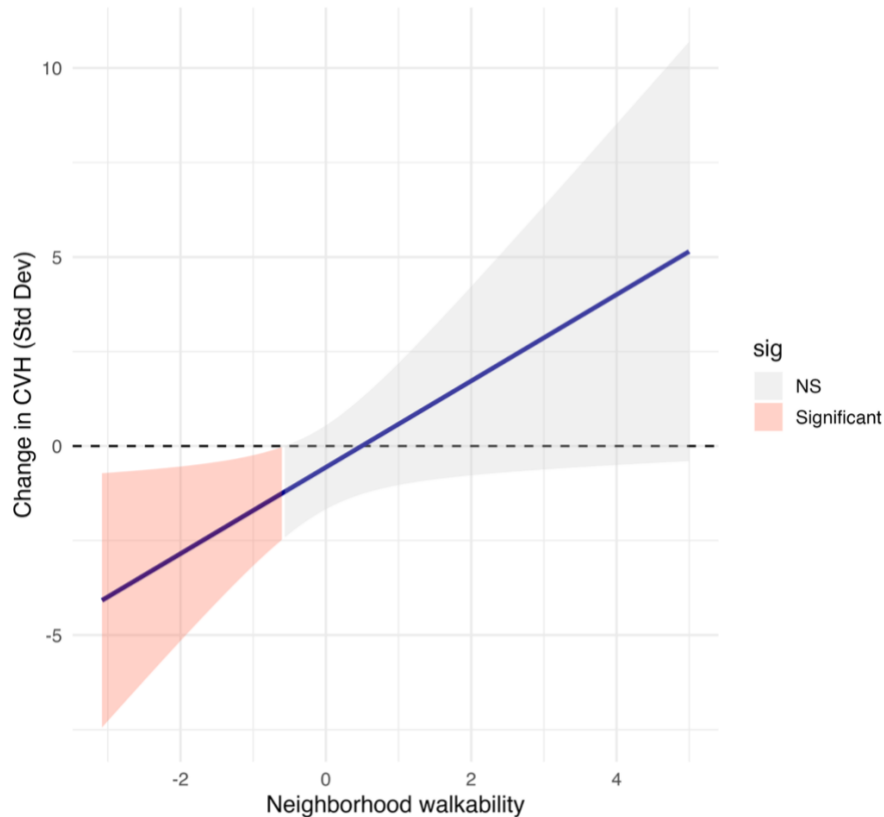


Figure 2.3: Johnson-Neyman Plot – Slope of Pedestrian Streetscape on CVH Across Std Devs of Walkability

Missing Indicator Method

Results from the MIM approach as a sensitivity analysis to the CCA were consistent in result and magnitude to the primary results described above. The missingness indicator for microscale exposure was not independently associated with CVH change after covariate adjustment. Supplemental Table S2.6 displays the side-by-side comparison of the results between these fully adjusted models.

Sensitivity Analyses

In the decomposed CVH outcome analyses (Supplemental Table S2.7), higher socioeconomic adversity was associated with more adverse changes in BMI score ($\beta=-0.168$, $SE=0.045$, $p<.001$; higher BMI) and walkability was associated with more favorable changes in BMI score ($\beta=0.085$, $SE=0.039$, $p=.032$; lower BMI) with no significant interactions. Related to HbA₁C, there was a marginally significant positive interaction score between walkability and pedestrian streetscape ($\beta=0.084$, $SE=0.054$,

p=.059), but no difference in models stratified by highest and lowest tertile. Inspection of the associated Johnson-Neyman plot (Supplemental Figure S2.4) showed that pedestrian streetscape reaches significance 0.734 SD above the mean, meaning that greater pedestrian streetscape values are associated with more favorable HbA_{1c} at the highest levels of walkability. Walkability at V2 was associated with improvements in the blood pressure score ($\beta=0.080$, $SE=0.064$, $p=.014$). In addition, there was a significant positive interaction between pedestrian streetscape and walkability. Pedestrian streetscape was significantly negatively associated with changes in the blood pressure score in the lowest tertile of walkability ($\beta=-0.197$, $SE=0.075$, $p=.010$; worse blood pressure) but not in the highest tertile ($\beta=0.054$, $SE=0.065$, $p=.408$). The Johnson-Neyman Plot (Supplemental Figure S2.5) depicts how the in very highest walkability areas (3.738 SD above the mean), pedestrian streetscape reaches significance again.

In the alternative pedestrian streetscape subscale models (Supplemental Table S2.8), only the Overall Aesthetics/Social subscale (in which greater scores indicating better aesthetics, measuring landscaping, graffiti, billboards, etc.) had significant findings, being negatively associated with changes in CVH ($\beta=-0.115$, $SE=0.043$, $p=.009$).

Discussion

In this study of Hispanic/Latino adults in San Diego County, both socioeconomic adversity and walkability were significantly associated with changes in CVH, with greater adversity associated with worse CVH while greater walkability was associated with better CVH over a six-year period. Sensitivity analyses suggest that these associations are driven by BMI and blood pressure components of the clinical LE8 score. The association of socioeconomic adversity with CVH did not vary by walkability or pedestrian streetscape level. This is not surprising since a prior analysis found significant correlation and spatial coincidence between adversity and walkability in this sample (see Chapter 1). This point underscores the necessity of adequate environmental variability to demonstrate effects of these exposures,³⁶ the lack of which has been described as a limitation of this dataset in prior analyses.²¹

These findings are largely consistent with prior literature linking neighborhood factors to CVH. Socioeconomic adversity has been both directly linked to cardiovascular disease and increased cardiovascular risk through increased stress, poor metabolic markers, and hypertension.^{8–10,37} Most consistent with our sensitivity findings here, prior literature has also linked adversity with obesity and weight gain.^{11,12} There is ample evidence that better walkability is associated with lower risks of hypertension and reduced BMI, the pathways evident from our present analyses.^{15,38,39} More recently, research has linked walkability directly to cardiovascular disease risk.^{40,41}

Pedestrian streetscape was not significantly associated with CVH in this population, which could be due to the significant interaction found between streetscape and walkability. In the lowest tertile of walkability, higher pedestrian streetscape values were associated with worse CVH, but this was not seen in the highest tertile. The decomposed pedestrian streetscape sensitivity analyses provide some insight into the unexpected negative association in the lowest tertile of walkability, which appears to be primarily driven by the “Overall Aesthetics/Social” subscale. This subscale captures positive visual features such as landscaping and maintained hardscape, while penalizing indicators of physical disorder. In low-walkability contexts, higher scores on this subscale may reflect well-maintained but car-dependent environments (e.g., landscaped arterials) that are not conducive to physical activity or may induce stress due to traffic exposure. In combination with the findings presented in prior analyses (Chapter 1), aesthetics may be a marker for suburban development in this sample specifically. Future studies within different walkability and pedestrian streetscape contexts, including highly walkable environments, are needed. Additionally, this finding may imply that aesthetic quality and improvements alone may not confer benefits to CVH in the absence of a walkable urban form. This finding highlights the importance of investing in changes to the broader built environment to facilitate cardiovascular health. While existing literature linking pedestrian features to increased walking is prominent, there is a scarcity of evidence linking pedestrian streetscape features directly to CVH metrics.^{23,42,43}

Notably, the negative association between pedestrian aesthetics and CVH here is contrary to prior evidence supporting the role of neighborhood aesthetics for increasing physical activity.^{16,44} This pedestrian streetscape subscale is uniquely divergent from the summary score and interaction results. The interaction between overall pedestrian streetscape and walkability is consistent with the “synergy” argument made by Adhikari et al. (2025), one of the few other studies to explore interactions between these two neighborhood variables.⁴⁵ The positive interactions found in that paper may be more specific to older adults, consistent with prior research in that population.^{46,47} Our inability to identify a significant positive association of pedestrian streetscape in more walkable neighborhoods may be an artifact of relatively low walkability levels in the neighborhoods I examined.²¹ Similarly, and contrary to our hypothesis, the negative association of socioeconomic adversity with CVH was not attenuated with inclusion of walkability or pedestrian streetscape. While the lack of an interaction could also be attributable to the low variability of walkability, given the close association of higher walkability with higher socioeconomic adversity in this population, this shared spatial patterning is also largely consistent with a broader cross-sectional study correlating walkability and adversity.⁴⁸ Adversity and walkability indicators may be impacting CVH through different pathways, suggesting that, while walkability is beneficial regardless of adversity, its presence does not necessarily address the deleterious impact of concentrated poverty and disadvantage. Further investigation is warranted into the idea that improvements to the pedestrian streetscape alone will improve health behaviors and downstream outcomes across contexts.

Given the operationalization of the clinical LE8 CVH score as the residualized change between visits two and three, point changes can be interpreted as greater than expected differences (i.e., the residuals between the observed V3 values and those predicted based on V2 values). These findings amount to modest effect sizes of 1.65pts decrease and 1.78pts increase for adversity and walkability respectively, comparable to previous research linking socioeconomic variables to LE8 scores.⁴⁹ Previous research has established that a 10-point increase in the clinical LE8 score was associated with a

significant reduction in all-cause and cardiovascular mortality,^{50,51} grounding the effect sizes found here. Although the observed differences in LE8 points over six years were modest in magnitude, sustained trajectories may accumulate over longer time periods and contribute to meaningful differences in cardiovascular risk. Additionally, given that the aim of these analyses was to estimate the total, rather than direct association of these environmental factors with CVH, physical activity and diet were not included in the analyses either as mediators or as factors in the clinical LE8 score. This choice leads us to believe that the estimates here are conservative given that physical activity and diet are more proximal outcomes related to environmental factors.^{52,53} Therefore their inclusion in the LE8 score would likely result in larger changes than observed here.

Strengths and Limitations

This study has multiple strengths. First, the complex survey design of HCHS/SOL, along with sample weights applied, makes the inferences here representative of the Hispanic/Latino population in the target recruitment communities. This study leveraged the unique data offered in SOL CASAS to explore longitudinal associations and interactions with pedestrian streetscape features that had previously been unexplored. Rigor is also bolstered by the use of a well-established measure for pedestrian streetscape features that has been widely validated. The range of interactions explored, and sensitivity analyses provide cohesive explanatory pathways that set the ground for future research into the contextual neighborhood factors that contribute to CVH. The use of the clinical LE8 scoring system also makes these findings comparable to a larger body of research.

Limitations of the present analyses include the use of multiple composite measures, which partially obscure interpretations of specific effects. This is partly addressed by the decomposition of the pedestrian streetscape and clinical LE8 score in the sensitivity analyses, but the intentionally abstracted nature of socioeconomic adversity makes specific policy recommendations more challenging. As mentioned throughout this discussion, the relatively low variability in walkability features may limit our ability to detect both main effects and interactions. Given that our pedestrian streetscape features were

assessed using Google Street View imaging, there is the potential for a temporal mismatch in this exposure, although recent research within the HCHS/SOL cohort more broadly suggests that the risk of bias from this is limited due to the slow rate at which changes in the built environment occur.⁵⁴ While I feel that the complete case analysis is the appropriate approach given the research question on hand, this approach does potentially introduce selection bias that cannot be completely accounted for through the missing indicator method. That being said, the estimates provided here represent all available pedestrian streetscape data that can be linked to changes in CVH, consistent with our aims. Finally, while the longitudinal evidence strengthens causal inference over previous cross-sectional research, the study is not free from residual confounding due to the inability to randomize limiting statements of causality.

Future Directions

Future research should continue to explore the interactions between adversity, walkability, and pedestrian streetscapes over longer time scales and in larger samples with more diverse neighborhood characteristics. The recent advances in machine learning and artificial intelligence techniques such as semantic segmentation AI audits should increase the availability of objective pedestrian streetscape data that can improve the operationalization of what makes a neighborhood “walkable”.^{55,56} More research is needed to identify the efficacy of specific environmental changes in context to make interventions cost-effective and acceptable.

Conclusion

This study contributes additional longitudinal evidence supporting the connection between socioeconomic adversity and walkability to CVH among Hispanic/Latino populations. As the proportion of Hispanic/Latino persons in the US continues to grow, it is important to understand impacts of neighborhood factors on their leading causes of morbidity and mortality. The significant interaction between pedestrian streetscapes and walkability suggests the importance of addressing the concept of walkability through macro-level changes and warrants future research into the specific pedestrian features that matter and in what context.

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Supplemental Materials

Supplemental Table S2.4: Definitions and levels of each of Life's Essential 8 clinical health factor components

Non-HDL Cholesterol	Points	Body Mass Index	Points	Blood Glucose Glycosylated Hemoglobin A ₁ C	Points	Blood Pressure	Points
<130 mg/dL	100	<25.0 kg/m ²	100	HbA ₁ C <5.7 gm% with no history of diabetes mellitus	100	SBP <120 mmHg & DBP <80 mmHg	100
130-159 mg/dL	60	25-29.9 kg/m ²	70	HbA ₁ C 5.7-6.5 gm% with no history of diabetes mellitus	60	SBP 120-129 mmHg & DBP <80 mmHg	75
160-189 mg/dL	40	30-34.9 kg/m ²	30	HbA ₁ C <7.0 gm% with diabetes	40	SBP 130-139 mmHg or DBP 80-89 mmHg	50
190-219 mg/dL	20	35-39.9 kg/m ²	15	HbA ₁ C 7.0-7.9 gm%	30	SBP 140-159 mmHg or DBP 90-99 mmHg	25
≥220 mg/dL	0	≥40 kg/m ²	0	HbA ₁ C 8.0-8.9 gm%	20	SBP ≥160 mmHg or DBP ≥100 mmHg	0
				HbA ₁ C 9.0-9.9 gm%	10		
				HbA ₁ C ≥10.0 gm%	0		

Abbreviations: DBP: diastolic blood pressure, HbA₁C: glycosylated hemoglobin A₁C, kg/m²: kilograms per meter squared, mmHg: millimeters of mercury, SBP: systolic blood pressure, mg/dL: milligram per deciliter.

Supplemental Table S2.5: Missing Data Sample Differences^a

Characteristic	Observed Microscale n = 1,017	Missing Microscale n = 767	p-value ^b
<i>n (%)</i>			
Age group, years			.016
18-43 Years Old	372 (36.5%)	383 (49.9%)	
44+ Years Old	646 (63.5%)	384 (50.1%)	
Sex			>.9
Male	474 (46.6%)	355 (46.3%)	
Female	544 (53.4%)	412 (53.7%)	
Hispanic/Latino background			.5
Non-Mexican	74 (7.3%)	69 (9.0%)	
Mexican	943 (92.7%)	694 (91.0%)	
Unknown	0 (0.0%)	0 (0.0%)	
Annual Household Income at Visit 2			.1
Less than \$30,000	431 (43.5%)	269 (37.0%)	
More than \$30,000	560 (56.5%)	458 (63.0%)	
Education Level Completed			.041
No high school diploma or GED	263 (26.3%)	150 (20.2%)	
At most a High school diploma or GED	253 (25.2%)	159 (21.5%)	
Greater than high school (or GED) education	485 (48.5%)	431 (58.3%)	
Health Insurance Status Visit 2			.4
No Health Insurance	231 (22.7%)	193 (25.3%)	
Yes Health Insurance	786 (77.3%)	571 (74.7%)	
Nativity/Immigration Status			.072
Immigrated < 10yrs ago	76 (7.5%)	71 (9.3%)	
Immigrated 10-20yrs ago	208 (20.5%)	183 (24.0%)	
Immigrated > 20yrs ago	462 (45.4%)	269 (35.3%)	
Born in US 50 States/DC	271 (26.7%)	240 (31.4%)	
Smoking Status			.8
Non-Smoker	875 (86.2%)	647 (84.4%)	
Quit Smoking	59 (5.8%)	43 (5.5%)	
New Smoker	17 (1.7%)	14 (1.8%)	
Continuous Smoker	64 (6.3%)	64 (8.3%)	
<i>Median (Q1, Q3)</i>			
Years between Visit 2 & 3	6.46 (0.61)	6.72 (0.83)	<.001
Socioeconomic Adversity (800m)	0.75 (0.74)	0.68 (0.79)	.3
Neighborhood Walkability (800m)	6.36 (1.97)	6.16 (1.99)	.13
LE8 Clinical Score (Visit 2)	66.33 (19.34)	70.04 (18.31)	.025
LE8 Clinical Score (Visit 3)	64.04 (18.99)	66.63 (18.21)	.071
LE8 Clinical Score Residualized Change (V3~V2)	0.67 (12.66)	0.60 (12.60)	.6

^aWeighted Data^bPearson's χ^2 : Rao & Scott adjustment; Design-based Kruskal Wallis test

Supplemental Table S2.6: Comparison between Missing Indicator Method and Complete Case Analyses^{a,b}

	MIM Model			CCA Model		
	β	SE	p-value	β	SE	p-value
Socioeconomic Adversity	-0.153	0.052	.004**	-0.130	0.060	.031*
Walkability	0.148	0.052	.005**	0.140	0.063	.028*
Pedestrian Streetscape	-0.049	0.041	.234	-0.053	0.046	.256
SES X WALK	0.003	0.030	.909	0.047	0.053	.377
SES X STREET	-0.015	0.016	.363	-0.043	0.048	.372
WALK X STREET	0.042	0.017	.015*	0.091	0.043	.038*

Note. * $p < .05$; ** $p < .01$

^aAll estimates are fully standardized, with positive values indicating better CVH

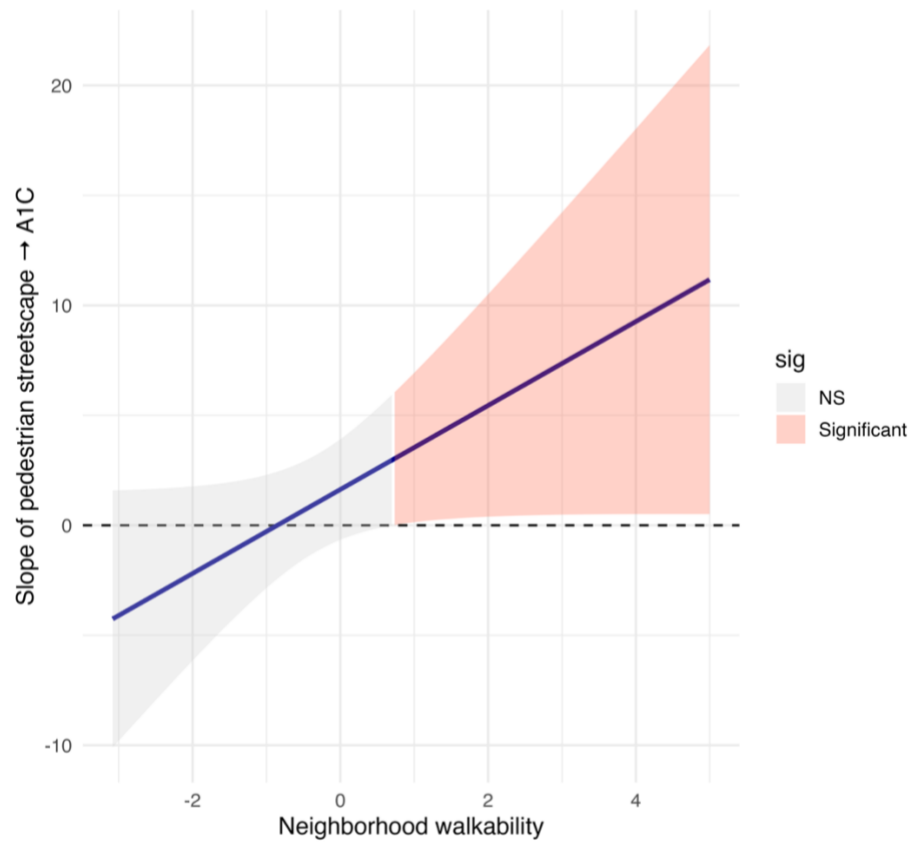
^bAdjusted additionally for time between visits, smoking status, health insurance, income, education, and environmental factors.

Supplemental Table S2.7: CVH Component Sensitivity Findings^{a,b}

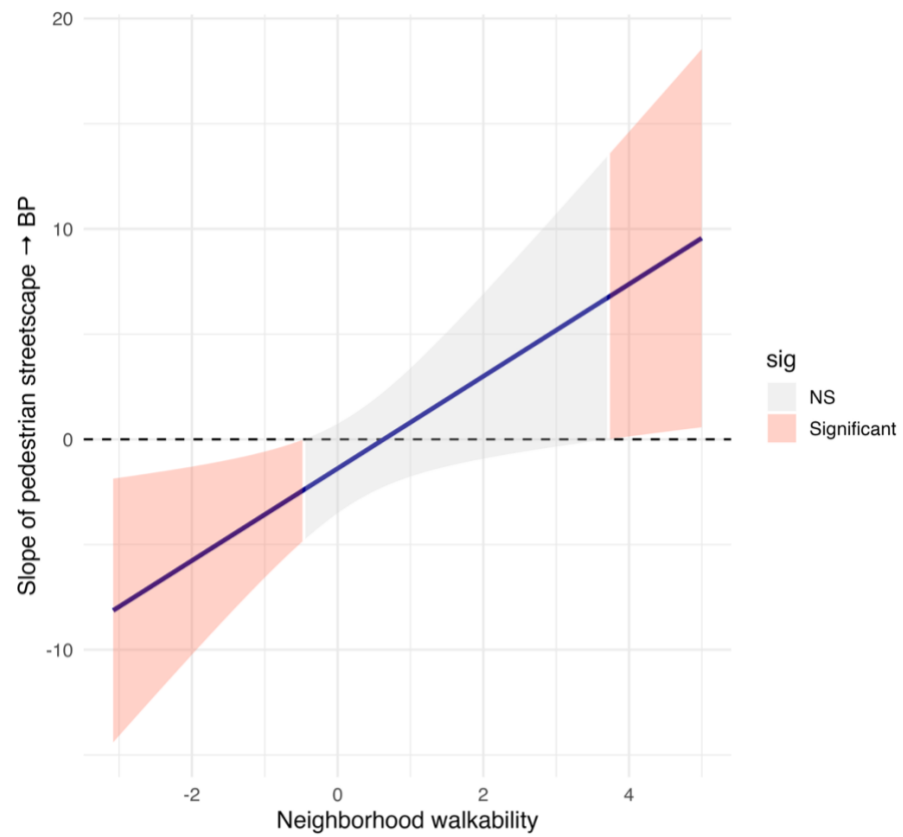
	Non-HDL Cholesterol		Body Mass Index		HbA ₁ C		Blood Pressure	
	β (SE)	p-value	β (SE)	p-value	β (SE)	p-value	β (SE)	p-value
SE Adversity	0.015 (0.066)	.820	-0.168 (0.045)	<.001**	-0.049 (0.068)	0.469	-0.081 (0.046)	.080 ⁺
Walkability	0.010 (0.066)	.875	0.085 (0.039)	.032*	0.080 (0.064)	0.218	0.112 (0.045)	.014*
Pedestrian Streetscape	-0.034 (0.054)	.532	-0.076 (0.052)	.148	0.064 (0.051)	0.216	-0.061 (0.043)	.157
SES X WALK	0.025 (0.059)	.670	-0.048 (0.043)	0.263	0.060 (0.052)	0.248	0.038 (0.034)	.257
SES X STREET	-0.086 (0.050)	.086 ⁺	-0.034 (0.047)	0.477	0.005 (0.047)	0.910	0.040 (0.037)	.286
WALK X STREET	0.019 (0.046)	.680	0.001 (0.041)	0.974	0.084 (0.044)	0.059 ⁺	0.085 (0.036)	.019*

^aAll models are fully adjusted, and positive coefficients represent a better score on the CVH Component

^b<.10, * <.05, ** <.01



Supplemental Figure S2.4: Johnson-Neyman Plot – Slope of Pedestrian Streetscape on A1C Across Std Devs of Walkability



Supplemental Figure S2.5: Johnson-Neyman Plot – Slope of Pedestrian Streetscape on BP Across Std Devs of Walkability

Supplemental Table S2.8: Microscale Subscale Findings^a

	Pearson Correlation with Walkability	Independent Associations		Stratified Analyses ^b			Interaction with Walkability	
		β (SE)	<i>p</i> - <i>value</i>	Low Walkability	High Walkability		β (SE)	<i>p</i> - <i>value</i>
Overall Microscale Positive	0.354	-0.053 (0.046)	.256	-0.234 (0.080)	0.090 (0.074)	.229	0.091 (0.043)	.038*
Positive Crossing Characteristics	0.263	-0.014 (0.039)	.718	-0.082 (0.071)	0.054 (0.071)	.451	0.061 (0.052)	.241
Positive Street Segments	0.208	0.023 (0.047)	.629	-0.098 (0.072)	0.009 (0.085)	.920	0.014 (0.024)	.560
Positive Streetscape	0.260	-0.019 (0.048)	.701	-0.129 (0.095)	0.087 (0.085)	.310	0.061 (0.051)	.234
Overall Aesthetics/Social	0.316	-0.115 (0.043)	.009**	-0.184 (0.065)	-0.066 (0.070)	.348	0.060 (0.039)	.124

^aAll models are fully adjusted and standardized^bAnalyses stratified by the bottom and top tertiles of walkability

+ <.10, * <.05, ** <.01

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Chapter 3 Demographic, Electoral, and Environmental Predictors of Support for a Public Transportation Sales Tax: A Mixed-Methods Analysis of San Diego County Measure G

Introduction

Driving alone to work is the most common commuting mode nationally, with the US census estimating that 75.9% of workers drove alone in 2019 (the largest share globally), dropping to 68.7% by 2022 largely due to increases in working from home.¹ Despite the personal benefits that car ownership is associated with, such as increased access to opportunities and upward economic mobility,² the burdens of car-dependent infrastructure are undeniable. One literature review estimates that 1 in every 34 deaths is attributable to cars, citing traffic fatalities, air pollution, and physical inactivity as immediate consequences, with poor land use patterns and continued environmental degradation and injustice as downstream outcomes.³ The pervasiveness of automobiles in the US is a direct result of urban planning that optimizes car-based travel and in doing so, stifles alternative modes of transportation. Policies that work to undo the harm of car dependent infrastructure are necessary to move towards a more equitable and sustainable transportation system and built environment generally.

Multimodal planning centered around public transit offers an alternative that produces fewer emissions, less economic burden on users, encourages healthy behaviors, and supports sustainable development when compared to automobile-centric designs.⁴ The CDC recommends expanding public transportation options in order to improve health through increased active transportation (primarily walking), improved air quality, reduced car related injuries/deaths, and increased transportation equity (i.e., equitable access to timely, safe, and affordable transportation options).⁵⁻⁹ More broadly, transit oriented development encourages a more compact urban form including increased density, street connectivity, and mixed use areas.¹⁰ The factors of compact urban form represent neighborhood walkability, intrinsically tying intentional public transportation development to health promoting urban design.¹¹

Unfortunately, decades of car-centric planning have created social and cultural norms in the US that are pervasive even when alternatives are available. Germans, with a comparable number of cars per

capita to the US, drive 25% less than their US counterparts and have a four times higher share of non-car transportation modes.¹² Even for Americans living in dense, mixed-use, and transit accessible places, car use is still more common than among Germans living in less walkable environments.¹² These findings empirically highlight the cultural component of car-dependency that makes changes to the US transport system particularly challenging when entering the political sphere. Despite these barriers, the movement for healthy urbanism has been growing in the US, as more communities become concerned with the harms and inequities that car-dependency have wrought.¹³

For growing support to transfer into material change, legislation and funding for public transit and transit-oriented development are necessary. Despite the relative economic gains provided by investing in public transit in the long run,^{14,15} local costs can be daunting for policymakers and taxpayers. One common approach to funding public transit includes local transportation sales tax measures (LTSTs). While these measures have been critiqued for their inherent regressivity or for “ballot-box budgeting”, this approach has been relatively common in the US since the 1980s as a tool to democratize the taxes being levied on citizens.¹⁶

Understanding the success or failure of LTSTs that aim to fund public transit is important from a policy perspective if we want to advance healthy urbanism (i.e., the integration of human health into urban design). While some public opinion based surveys suggest that fiscal conservatism and mistrust of public officials are significant factors in the failures of LTSTs,¹⁷ others have found that wealthier groups who do not ride transit are more likely to vote in support due to the perceived collective benefits (e.g., reduced traffic).¹⁸ More broadly than mistrust of government officials, the perceived legitimacy of governing bodies is another, less well studied aspect of support for LTSTs. Previous policy-focused research has suggested the importance of understanding the interplay between politics and transportation policy through this lens of institutional legitimacy.¹⁹ Furthermore, the presence of other sales tax measures and lack of definitive sales tax termination may also predict voting outcomes.²⁰ While surveying constituents can provide useful insights into the personal motivating factors for voting, community-wide predictors may also be important. Previous research has found utility in examining how demographic

characteristics predict local transportation sales tax measure outcomes. A 2007 paper found that proximity to transportation projects, income, and political leanings were all associated with ballot outcomes.¹⁶

The present study aims to understand the failure of an LTST by exploring the associations between voting outcomes and census demographics, environmental predictors, and other voting behaviors in addition to qualitative interviews with key community stakeholders. These analyses build off previous work by improving the spatial interpolation method used to join data sources, examining environmental variables in addition to census data, and using a mixed-methods approach. This study is focused on a single US region, San Diego County, CA, the fifth most populous county in the US with over 3.2 million residents across 4,206.63 mi².²¹ In the November 2024 General Election for San Diego County, Measure G proposed a half cent sales tax increase countywide to fund the work of SANDAG, the regional transportation planning agency. The language of the measure specified the following funding split of the estimated \$350 million generated annually: 50% to transit, 27% to road and highway projects, 12% for transit operations and maintenance, 7% for local roads and streets, 2% for repair & maintenance of rail transit equipment, and 2% to administrative costs.²² Measure G required a simple majority (over 50%) to pass but, despite citizen-led efforts, failed by a slim margin of 12,717 votes (688,922 in favor vs 701,639 in opposition). This sales tax would have been the first transportation measure approved since the existing TransNet tax was renewed by voters in 2004 (originally passed in 1987 and set to expire in 2044).

The census and environmental variables for the quantitative analyses were chosen through the lens of health equity with additional voting predictors based on prior literature. This lens was adopted to better understand the current beneficiaries of San Diego County's transportation system, and whether voting behaviors at the precinct-level represent the perpetuation of socioeconomic inequity. The present analysis focused on six potential predictors of support for Measure G. 1) Socioeconomic adversity (adversity): Communities of lower socioeconomic status are poised to benefit the most from improved public transportation access and reduced car dependency given the current inequitable burden of car-related expenditures.²³ If precincts with higher adversity voted more favorably for Measure G, it may signal that sales tax regressivity is less important and that more affluent precincts may be perpetuating

inequity by voting against funding for transit. 2) Neighborhood walkability: More walkable areas may see the benefits of public transit and transit oriented development and wish to continue funding them. This may suggest a sort of inertia that has implications for potential snowballing that could occur once transit is funded, or the inverse where transit services need to be cut, and public transit loses perceived value. 3) Commute time: The importance of transportation improvements to voters may be related to how successful they view the current transportation system in the County. Census estimates of commuting times provides some sense of that, with individuals who have longer commutes reporting a lower quality of life.²⁴ As commute times increase, the alternatives to driving can become more attractive, or in the case of voters, funding alternatives that can relieve congestion can become more popular.¹⁸ 4) Partisanship: Previous research has found that political conservatives are less likely to endorse sales tax measures and public transportation generally.^{16,17} Understanding political party preferences may help better tailor messaging for successful policies, and accounting for party preference could help provide that context. 5) Support for competing tax measures: Economic concerns have been cited as the most important factor for voters in the 2024 general election,²⁵ so there is reason to believe that opposition to sales tax measures generally could predict endorsement of Measure G. This approach is consistent with previous research that suggests the negative impact of concurrent sales tax measures. Understanding how sales tax measures fared in the same election could indicate the need to identify different funding mechanisms for public transportation during challenging election cycles.²⁰ 6) Voter Turnout: Additional local and national commentary regarding the importance of partisan differences and overall voter turnout in the 2024 election also warrants its inclusion in the statistical models.²⁶

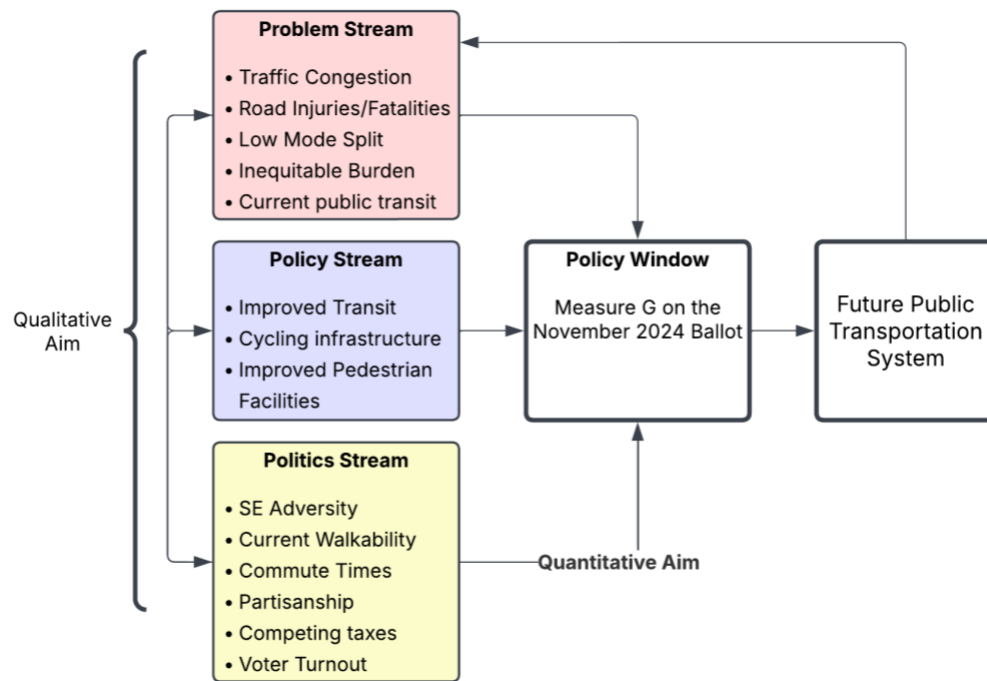


Figure 3.1: Applied Kingdon's Multiple Stream Conceptual Model

Combining these data with stakeholder interviews retroactively framed through the lens of Kingdon's Multiple Streams Framework, a theoretical tool typically used to analyze policy development,²⁷ (See Figure 3.1) allows for contextually rich findings that will fit within the larger body of policy research. Qualitative data provides not only additional context to the quantitative approach but also uncovers other predictors and factors that are more challenging or impossible to capture using quantitative methods alone.

Aim 1: Explore the cross-sectional associations of precinct-level voting outcomes on San Diego County Measure G in the 2024 General Election and a) socioeconomic adversity, b) national walkability index, c) commuting time, d) partisanship, e) support for competing tax measures, and f) voter turnout.

I hypothesize that socioeconomic adversity, walkability, mean commute time, and support for competing tax measures will be positively associated with support for Measure G while percent Republican (partisanship) will be negatively associated with support for Measure G.

Aim 2: Understand the perspectives of key stakeholders, from diverse community groups that both supported and opposed Measure G and the broader policy landscape through the lens of Kingdon's Multiple Streams Framework.

Methods

Quantitative and qualitative approaches were mixed using a convergent parallel design consistent with a pragmatism approach as described by Creswell and Clark.²⁸ This approach was chosen based both on the timing of data collection and the focus on using multiple methods to compare and contrast findings rather than an exclusively exploratory or explanatory approach. Both methodologies described below were conducted simultaneously and independently although they share the same conceptual framework of Kingdon's Multiple Streams. Findings are presented in a comparative and integrated manner to emphasize the overlap between and divergence of these methods.

Quantitative Approach

Data Sources:

The quantitative analyses used data from the San Diego County Registrar's office from the November 2024 General Election, the 2020 US Census/American Community Survey, and the EPA National Walkability Index.

Variables:

The primary outcome variable was operationalized as the percentage of "Yes" votes for Measure G of all the votes cast for Measure G in a given precinct per County of San Diego Registrar data.²⁹ There were six independent variables of interest. Socioeconomic adversity, neighborhood walkability, and travel time were all interpolated in 2024 voting precincts as intensive variables to align geographies.

1) Socioeconomic Adversity: This composite variable was calculated following the approach from the HCHS/SOL CASAS Ancillary Study to align with other chapters in this dissertation research.³⁰ Adversity was quantified using the non-rotated first component from a Principal Components Analysis of Census/ACS 5-year estimates from 2020 based on the voting precinct centroids (original census variables

was interpolated as intensive variables). Positive values for this variable indicate greater adversity while negative values indicate less adversity. Census/ACS tract level variables included in the PCA were the percent of adults 25 years or older with no high school diploma, adults who are unemployed, households that are rented, households that are defined as crowded (more than one person per room), households living below the poverty line, female-headed households with dependent children, households on public assistance, population on public health insurance.

2) Neighborhood Walkability: Neighborhood walkability was determined for all census block groups using the National Walkability Index, a nationwide geographic data resource that ranks 2019 block groups based on their relative walkability provided by EPA Smart Location Mapping.³¹ This walkability index is based on intersection density, proximity to transit stops, and employment and household mix.

3) Travel Time: 2023 ACS 5-year estimates from the US Census for Travel Time to Work at the census tract level were used to represent commuting time. ACS estimates provided the mean commute time in minutes for each census tract.

4) Partisanship: Partisanship was proxy measured by using the percent of all Presidential Candidate votes that voted Republican for each precinct, as previous research has indicated that Republicans are less likely to endorse transit sales tax measures. As a sensitivity analysis this variable was also operationalized using the US Senator race given that presidential choice alone may not adequately represent a preference for a particular political party. These sensitivity analyses resulted in no meaningful differences (Pearson's Correlation $r=0.95$).

5) Support for Competing Tax Measures: Support for competing tax measures in the November 2024 General Election was available for ten incorporated cities within San Diego County, representing 1169 total precincts (61.88% of the 1889 precincts that exist spatially). These precincts account for 990,044 votes on Measure G (71.21% of the 1,390,346 votes from all precincts). While incorporated regions bias towards more urban and therefore more likely to benefit from transportation funding, this subsample provides insight into how competing tax measures interacted in this election.

6) Voter Turnout: Voter turnout (as a percentage) was gathered from the San Diego County Registrar of Voters at the precinct level.

Statistical Analyses:

All quantitative analyses were conducted in R Version 2025.09.2+418 (PCA for socioeconomic adversity only) and Python using the PySal suite.

Spatial Interpolation

Spatial interpolation was necessary to align census/ACS, walkability, and voting data given that they are provided at different geographic scales. The *tobler* package from the PySal suite was used to interpolate census and walkability data at the census block group level (2057 total block groups) into the 1889 voting precincts in San Diego County. Dasymetric interpolation was done using raster data from the National Land Cover Database alongside road network data and population density from SanGIS to mask out uninhabited land and properly weight interpolated data. Multiple interpolation techniques were used to verify consistency in the new values, including basic areal, land cover, and road network. Binary Dasymetric interpolation using both land cover and road network produced similar results, with previous research suggesting that road network data with a ~100m buffer provides accurate results for census variables (the focus of our analyses) while balancing model complexity.^{32,33} Comparisons between these methods and the association between polygon intersection and support for Measure G were explored for sensitivity and relevant plots can be found in the supplemental materials (see S3.11 through S3.13).

Regression Models

To understand spatial patterning in the data, Global Moran's I and Local Indicators of Spatial Autocorrelation (LISA) were calculated for all variables. Significant Moran's I for all variables indicated that spatial terms were necessary in the regression models to avoid violating the independence assumption of ordinary least squares regression.

Spatial lag (SLM) and spatial error models (SEM) from the *spreg* package from PySal were used in addition to standard ordinary least squares regression (OLS) pending the LaGrange Multiplier (LM) and Robust LM findings. Collinearity was assessed using the multicollinearity number and variance

inflation factors for all independent variables. All three regression models are presented in the results to show differences in fit and consistency across the modelling approaches. A Geographically Weighted Regression (GWR) was used to examine differential associations between our independent and dependent variables given the geographic diversity of San Diego County. The mean and range of estimates for each variable are presented numerically while mapped depictions of the estimates are provided for a narrative interpretation of how these estimates relate to the spatial distributions of the independent variables. Given that precincts are of unequal size, an additional binomial generalized linear model (GLM) was used as a sensitivity analysis to understand if weighting the precinct values by the total number of voters significantly changes the findings in the OLS models (see Supplemental Table S3.3). Findings for these models were consistent with the OLS approach and are detailed in the supplemental materials and presented as the odds of a precinct supporting Measure G after weighting.

Qualitative Approach

The qualitative sample included 12 semi-structured interviews with representatives from the key stakeholders in the San Diego Community who both supported and opposed Measure G. These hour-long qualitative interviews were conducted via Zoom to accommodate interviewee schedules. All interviews were conducted by the lead author. Interviewees from a variety of community organizations and political groups, focusing on representatives that were directly involved in the formation, implementation, advocacy, and/or marketing of policies both for and against Measure G. Participants were primarily recruited via email using publicly available contact information as well as snowball sampling from prior interviewees. Interviewees represented both policymakers/implementors and community organizations, and while there is some overlap between these groups given that Measure G was a citizen's initiative, this approach provided a balance of policy knowledge and community perspective through which to explore the multiple streams. The semi-structured interview guide was based on Kingdon's Multiple Streams Framework in alignment with the conceptual model (Figure 3.1) and to generate complementary data across quantitative and qualitative results. In addition to questions based on understanding the defeat of Measure G at the ballot box, interviewees were also explicitly asked about future directions for advancing

public transportation funding in the region. The interview guide can be found in the supplemental materials for this chapter. The qualitative sample size was based on saturation from the interviews across both support and opposition perspectives as determined through the interviewing and complementary post-interview reflection notes. Audio only recordings were used to capture interview data and that were then professionally transcribed verbatim by Landmark Transcription services.³⁴ Transcripts were then redacted of personally identifiable information before analyses.

All qualitative analyses were conducted using NVivo 15.³⁵ Analyses of the interview data were conducted by two coders using a consensus approach wherein coders would independently code transcripts and resolve disagreements during regular meetings. I employed a constant comparison analysis strategy, moving from the open coding of raw transcripts through an iterative coding process to express interview themes.³⁶ In practice this involved an initial coding of four transcripts without the use of a thematic codebook, only using codes based on the interview guide questions to understand alignment and coverage of the Multiple Streams Framework. After initial codes were generated inductively, a subset of codes were selected based on frequency, coverage, and overlap for the primary thematic codebook that was then applied to all 12 transcripts. Once all transcripts were coded and consensus was reached, themes were generated by consolidating codes based on overlap, coverage, and conceptual salience. These final themes were used to generate a conceptual map of the findings and select relevant quotes from interviewees. Support and opposition interviewees were defined as cases in NVivo to allow for basic comparisons between the two groups. UCSD IRB exempt approval was secured before the initiation of outreach and data collection.

Procedures for Mixing

Consistent with a Convergent Parallel Design as described by Creswell and Clark, all quantitative and qualitative analyses were conducted separately and prioritized equally before the mixing of the results in the interpretation phase of this research.^{28,37} Both strands of data (quant and qual) used the shared theoretical framing of Kingdon's Multiple Streams Model to inform variable selection and the design of the interview guide. Mixing of results was achieved through two mechanisms: 1) the creation of a joint

display thematic map and 2) integrated narrative description and comparison of findings. The thematic map was created by generating nodes to represent the key qualitative themes connected based on thematic overlap across coded transcripts. Quantitative findings were then positioned alongside relevant thematic domains to facilitate systematic comparison. This structure enabled identification of areas of convergence, complementarity, and divergence across methods. In addition, qualitative quotations were selected to illustrate, contextualize, and contrast quantitative patterns. These quotations were not used to modify quantitative analyses but to support integrated interpretation of findings across and within strands.

Positionality & Reflexivity

The lead author identifies as a white cisgender male from a low socioeconomic background and, during the study design, data collection, analysis, and manuscript preparation, lived without access to a personal automobile. These lived experiences inform the author's understanding of transportation systems and community mobility. The author also brings an explicit normative commitment to reducing car dependency and promoting less car-dependent community design.

Given that the study evaluates public support for a public transit ballot measure, these positionalities may shape how transportation policy debates are interpreted and framed. To mitigate the influence of personal advocacy perspectives, the author engaged in ongoing reflexive practice throughout the research process, including careful documentation of analytic decisions, explicit attention to disconfirming evidence, and structured coding procedures.

To further strengthen analytic rigor, a research assistant who does not share the lead author's transportation advocacy perspective served as a secondary qualitative coder. Differences in interpretation were discussed and resolved through iterative comparison, helping to ensure that findings reflect the data rather than a single interpretive lens.

Results

Descriptive Results

Spatial distributions of all study variables, including interpolated socioeconomic adversity, walkability, and mean commute time, can be seen in Figure 3.2. As expected, support for Measure G was largely concentrated in the coastal and urban regions of the county. Basic Pearson correlations revealed moderate ($r=|0.299$ to $0.645|$) relationships between each of the independent variables and support for Measure G. Despite visual spatial overlap and statistical correlations, the variance inflation factors ranged between 1.41 and 1.71, suggesting minimal risk of collinearity in regression models. Moran's I and LISA results suggested significant ($p<.001$) spatial autocorrelation for all study variables, underlying the importance of accounting for that in the modeling process.

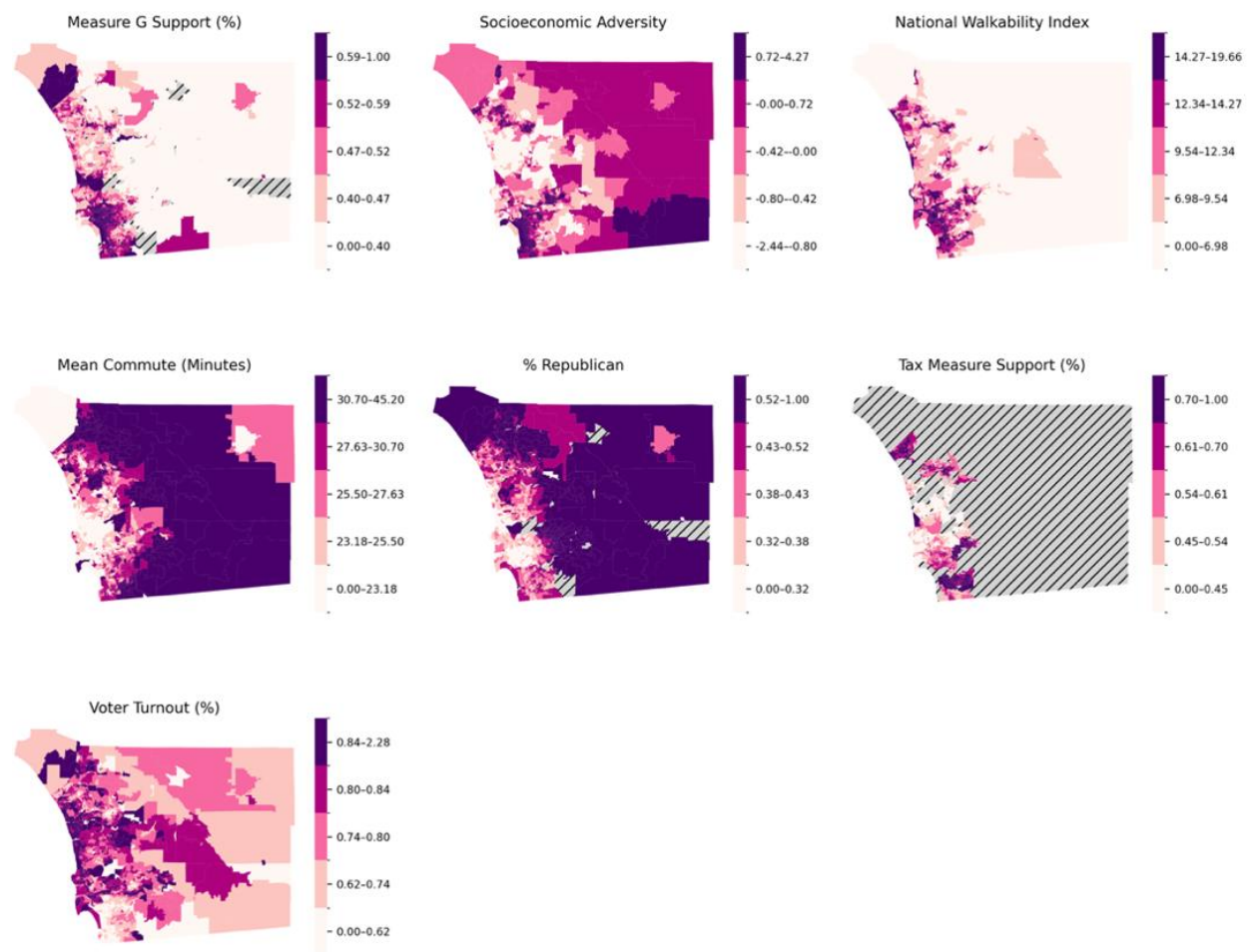


Figure 3.2: Distributions of Study Variables by Precinct (Quantile-Binned)

The qualitative sample consisted of a total of 12 interviews, ranging from 36-57min in length with seven of the twelve being supporters of Measure G while the other five represented the opposition. From all Kingdon's Multiple Streams coded references (initial codes), the opposition interviewees had nine percent more content focused on the problem stream than the supporter interviewees. Final thematic coding resulted in six core themes that are defined in more detail in Table 3.1 below. Themes were defined broadly to reflect the complex ways the concepts interacted in interview data and aid in the integration of quantitative results.

Table 3.1: Emergent Qualitative Themes and Definitions

Qualitative Theme	Definition	Example Quotation	Dominant Streams
Political Pessimism	Comprised of anti-government sentiments, anti-tax sentiments, and negative perspectives on the electorate that manifest as hopelessness in solving a problem or good governance in general.	Now, it's this positive feedback loop of like, "Government doesn't work for me. Let's not fund it." Government is then underfunded, and so then it doesn't work for you. – Support, Community Org.	Politics
Issue Hierarchy	The ways in which voters prioritize political issues in discourse and voting patterns, inclusive of specific Measure G funding allocations and concerns about the temporality of issues.	spending money on infrastructure, on public infrastructure, while it's important, it just seems like—and this is just how it looks to me—there's other things that we need to be focusing on. – Opposition, Local Gov.	Problem & Politics
Geographical Differences	A broad theme to encompass the ways in which needs, perspectives, and politics manifest differentially across San Diego County.	Making this a county-wide initiative, which is the right play, I think, did also set it up for failure. Because I actually just pulled up the results by precinct, and it is—everywhere you would think it's red, it's red. Everywhere you would think it's blue is blue – Support, Community Org.	Problem & Politics

Table 3.1: Emergent Qualitative Themes and Definitions (Continued)

Qualitative Theme	Definition	Example Quotation	Dominant Streams
Campaign Dynamics	A specific theme defining the ways in which internal campaign discussions, tactics, and coalitions influenced the outcome of Measure G.	I would say by the time [Measure G] had actually started happening, all of the grassroots orgs, all of the people who were working on this had coalesced around this issue and the issue was coming from other people from the outside and there we had answers, but certainly this was not perfect for anyone, I think. – Support, Community Org.	Politics
Infrastructure Environment	Perspectives on the costs, benefits, and importance of existing and future transportation infrastructure.	I think broadly that anyone that looks at their phone and says, "I wanna get from point A to point B and I'm gonna look at Google Maps and see how long it takes me to do it in my car versus to do it in mass transit." Always, it is four times longer to do it by mass transit. That's just not the way it should be. – Support, Campaign Leader	Problem
Rebuilding Trust	Call to action described by interviewees with specific regard to San Diego transportation planning.	I know SANDAG had this other measure 20 years ago, and they didn't stick to it, but of course, things change. Leadership looks different now than it did back in the early 2000s. That is one thing that we have planned is just getting the public to trust these agencies once again. – Support, Campaign Leader	Policy Window

On average, supporters had more content on Campaign Dynamics and Issue Hierarchy while the opposition had more content on each of the other core themes.

Integrated Analytic Results

To best combine and describe the quantitative and qualitative findings related to the outcome of Measure G, results are presented in the section following the structure of the thematic map depicted in Figure 3.3.

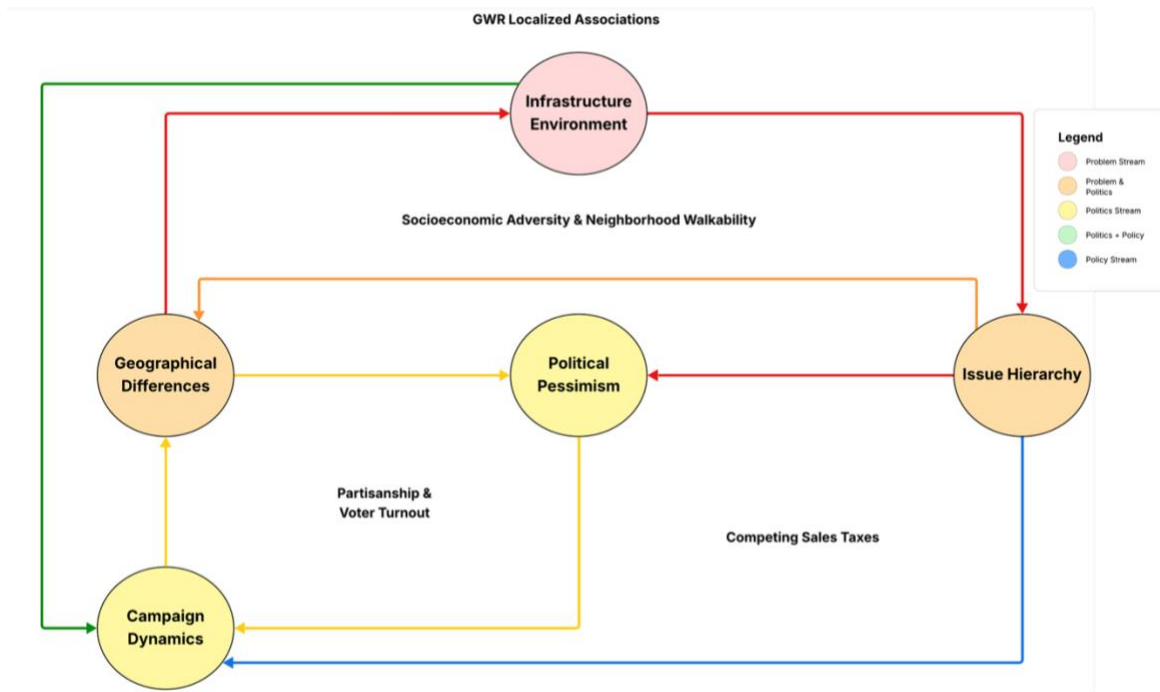


Figure 3.3: Thematic Map of Key Findings

This thematic map comprises the core qualitative themes as the primary nodes, with the connection between themes denoted by arrows. The color of the object denotes their alignment with Kingdon’s Multiple Streams based on the overlap between the themes and the stream from the qualitative interviews. Higher order quantitative results are represented inside of the relevant thematic “loops”. For example, quantitative results related to Socioeconomic Adversity and Neighborhood Walkability are connected due to mixing and describe the thematic loop containing Infrastructure Environment, Issue Hierarchy, and Geographical Differences. Of note, the localized associations identified from the GWR encompass the entire model as the quantitative associations for all variables varied by location, and therefore those results are integrated across all three loops (see Supplemental Figure S3.14 for GWR summary results). Each loop is named for the quantitative theme at its center, and the convergence/divergence of themes and quantitative results are described in order below. **Qualitative themes are bolded in the text as they are described narratively.** Results from the qualitative inquiry

explicitly aimed at understanding future steps for advancing public transportation funding in the future are described at the end of the results section.

Socioeconomic Adversity & Neighborhood Walkability Loop

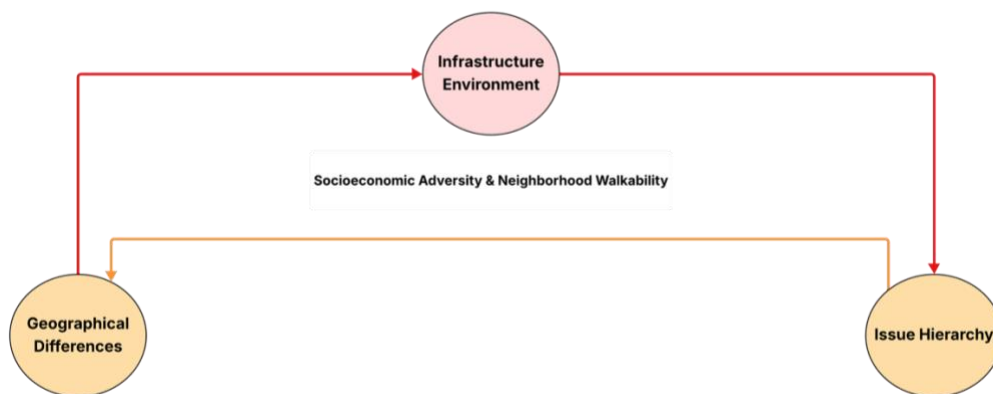


Figure 3.4: Socioeconomic Adversity & Neighborhood Walkability Loop

Across all regression models, both socioeconomic adversity and neighborhood walkability were consistently significantly associated with greater support for Measure G after adjustment for all other variables. Table 3.2 shows the results for OLS, SLM, and SEM across the entire sample with data for Measure G (1756 precincts of 1889 in San Diego County). Given the lower AIC, non-significant Anselin-Kelejian test, and highest explained variance, coefficient interpretations are based on the SLM. In terms of changes in support for Measure G, a one standard deviation increase in adversity is associated with a 2.7% greater support for Measure G while a one quartile increase in walkability (the move from unwalkable to somewhat walkable per EPA Smart Location categories) is associated with 1.5% greater support. Based on the scaled estimates of the variables, the strength of the association of adversity was 2.45 times that of walkability.

Table 3.2: Regression Results without Tax Support (n=1756)

	OLS Regression (AIC = -3666.347) ($R^2 = 0.5759$)			Spatial Lag (AIC = -3762.37) ($R^2 = 0.6035$)			Spatial Error (AIC = -3743.83) ($R^2 = 0.5766$)		
	Estimate (SE)	t-statistic	p-value	Estimate (SE)	z-statistic	p-value	Estimate (SE)	z-statistic	p-value
Constant	0.491 (0.002)	242.05	<.001	0.373 (0.044)	8.436	<.001	0.491 (0.003)	152.629	<.001
Socioeconomic Adversity	0.032 (0.003)	12.285	<.001	0.027 (0.006)	4.491	<.001	0.033 (0.006)	5.631	<.001
National Walkability Index	0.017 (0.003)	6.384	<.001	0.011 (0.002)	4.406	<.001	0.015 (0.003)	4.402	<.001
Mean Commute	-0.003 (0.002)	-1.117	.264	-0.000 (0.004)	-0.128	.898	-0.005 (0.005)	-1.126	.260
Percent Republican	-0.072 (0.002)	-30.038	<.001	-0.062 (0.010)	-6.092	<.001	-0.067 (0.009)	-7.748	<.001
Voter Turnout	-0.017 (0.002)	-6.709	<.001	-0.014 (0.010)	-1.364	.173	-0.014 (0.011)	-1.272	.204
Spatial Weight	-	-		0.239 (0.090)	2.673	.008	-	-	-
Lambda	-	-	-	-	-	-	0.395 (0.047)	8.328	<.001

The importance of the **Infrastructure Environment** was echoed in the qualitative interviews, with active transportation advocates describing how the confluence of socioeconomic disadvantage and transit dependency relate to greater support for a sales tax increase for public transportation.

...there's a geographic concentration in injuries and deaths, and they're disproportionately experienced in lower-income communities, and older communities, and communities with higher preponderance of pedestrian activity... Some of those communities that I just described tend to have more transit access than other communities, but these are also communities that have a greater need for transit and are not sufficiently served by transit.
– Support, Community Organization

Insufficient public transit and related infrastructure was a complaint shared by opposition interviewees, their discussions of transportation convenience centered around the relative lack of options in unincorporated communities that comprise approximately 550,000 people (over 16% of the population).

If you live in the more metro area, you can get around with Uber, Lyft, and not the best bus frequency service, but there's something there. If you live in the unincorporated area, there's nothing, so we have lots of youth up here that are also trending and don't want to drive yet or at all, but then that geographically isolates them, what do they do? –
Opposition, Local Government

These **Geographical Differences** in infrastructure dovetail with partisanship across space (see Figure 3.2, % Republican), to generate distinct **Issue Hierarchies** for the different electorates. While advocates were focused on climate and equity goals and centering public transit as a solution, some unincorporated community members described public infrastructure as non-pressing.

If we don't address transportation, we're wasting money and very valuable resources and capacity and time. We're in a fight against time. I would say Measure G addressed one of the highest priorities for the region. – Support, Campaign Leader

They're [Unincorporated voters] more focused on California's government, what's happening in California's government, regardless of where you sit politically, but and then saying—spending money on infrastructure, on public infrastructure, while it's important, it just seems like—and this is just how it looks to me—there's other things that we need to be focusing on. – Opposition, Local Government

These differences in what matters where do not just differ in their temporal priority (longer timescale of climate change vs the shorter one of contemporary California politics), but also specifically regarding their **Infrastructure Environments**. Convergent with the independent significance of

walkability and adversity in quantitative models, dense, poor urban communities expressed the negative externalities of car dependency while rural communities still need basic human-scale infrastructure.

When you look at communities that are impoverished or have less wealth, if you will, generally speaking, they have a higher propensity of being located next to freeways and widened freeways which increases air pollution for them. Then there's also kind of [getting places] without going broke and without having to buy a car. – Support, Campaign Leader

Why do I care if I live out there [Alpine] and my kid can't walk to school because there's no sidewalks, but I'm gonna fund a people mover to San Diego Airport. – Opposition, Local Government

To summarize, these themes elucidated distinct **Geographical Differences** and inequitably distributed resources across the county. The ways in which these differences in the environment manifest into differential associations is partially depicted in Figure 3.5 below, where the positive association between adversity and support for Measure G was stronger in more walkable communities, but more negative in the rural/semi-rural unincorporated communities.

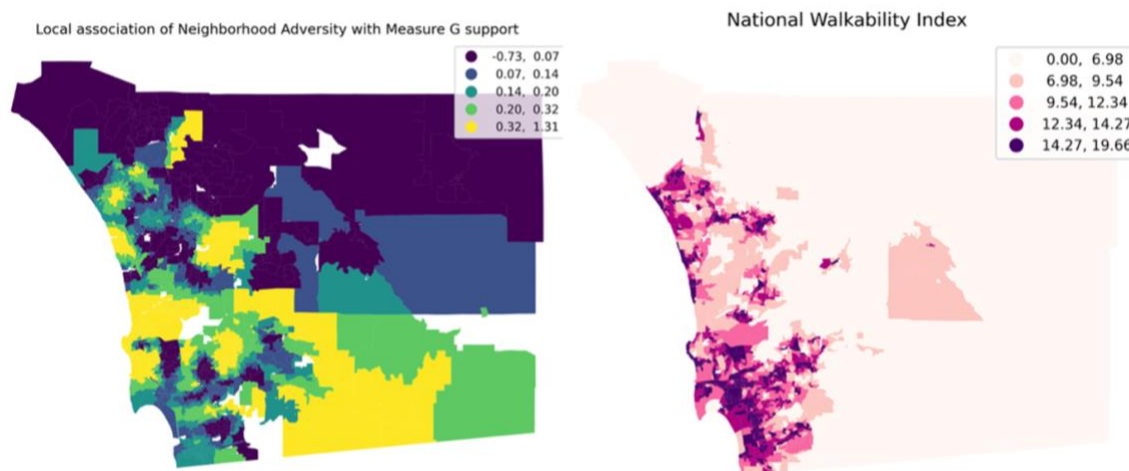


Figure 3.5: Local Associations of Socioeconomic Adversity with Measure G and Walkability

Similarly, while mean commute was not significantly associated with support for Measure G overall, localized associations are patterned with walkability aligning with the **Geographical Differences** expressed the qualitative interviews (see S3.15). The associations with the **Infrastructure Environment**

and the neighborhood context described in this section also interact with the political contexts described in the next section.

Partisanship & Voter Turnout Loop

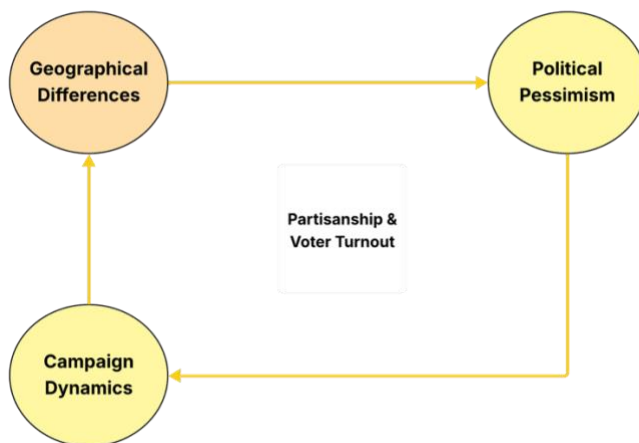


Figure 3.6: Partisanship & Voter Turnout Loop

With the exception of tax support in the subsample (described in the next section), percent Republican was consistently the strongest predictor analyzed, with a 10% increase in endorsement of the Republican candidate for President associated with a 4.3% reduction in support for Measure G (Table 3.2). From scaled estimates, the strength of the association of percent Republican was 2.30 times that of adversity and 5.64 times that of walkability. Campaign leadership expected this outcome as part of the endorsements behind Measure G and preexisting expectations about Republican tax preferences.

We picked up almost every single endorsement possible with the exception of the Republican Party, that it's a tax increase, they're gonna be opposed,... - Support, Campaign Leader

Preexisting partisan preferences aside, qualitative interviews revealed key rationales for opposition to Measure G that aligned with the broader climate of **Political Pessimism**. Regardless of their position on Measure G, the negative influence of SANDAG was clear given previous complaints from unincorporated communities and recent scandals that have reduced public trust across various

constituencies.³⁸ While the **Campaign Dynamics** described by insiders actively aimed to distance themselves from SANDAG, emphasize their status as a citizen’s led initiative, and highlight the role of the independent oversight committee written into the ballot measure, convincing the broader electorate proved challenging. In particular, the slogan “Broken Promises” was a focal point of opposition advertisements that played on sentiments in the primarily unincorporated areas that felt they did not receive the road improvements promised by TransNet.

Something that the opposition wasn't really saying is that this was a citizens' initiative. SANDAG had nothing to do with it. It was a citizen's initiative. Had it been SANDAG, of course, the threshold would've been different. – Support, Community Organization

It doesn't matter that it said it was a citizen's initiative, it's still a tax and where we've already been paying taxes for improved safe roads, and the evidence shows we don't have improved safe roads. – Opposition, Local Government

The link between these **Geographical Differences** and the **Political Pessimism** in unincorporated communities stem not only from this idea of “broken promises”, but a lack of political representation within SANDAG.

There's 550,000 of us on the unincorporated area, we are second in size only to the city of San Diego, and as an area we have no vote on the [SANDAG] board... If you live in the unincorporated area, you have only the county overlay, and that person may or may not live in the incorporated area, so it's very distancing from what we need. – Opposition, Local Government

These grievances align with low levels of support in unincorporated communities of East and North County (see Figure 3.2 Measure G Support (%)) and with general concerns about the cost of living and low levels of government trust. Our primary regression models found no significant association between voter turnout and support for Measure G after adjustment for spatial autocorrelation, but the GWR results (Figure 3.7) thematically converge with **Political Pessimism** manifesting as lower turnout in expected Measure G strongholds.

[Turnout] was really low in the areas where we expected support to be highest and where polling suggested it was highest. For example, in the South Bay, the turnout was lower than in North County and that was surprising. – Support, Community Organizer

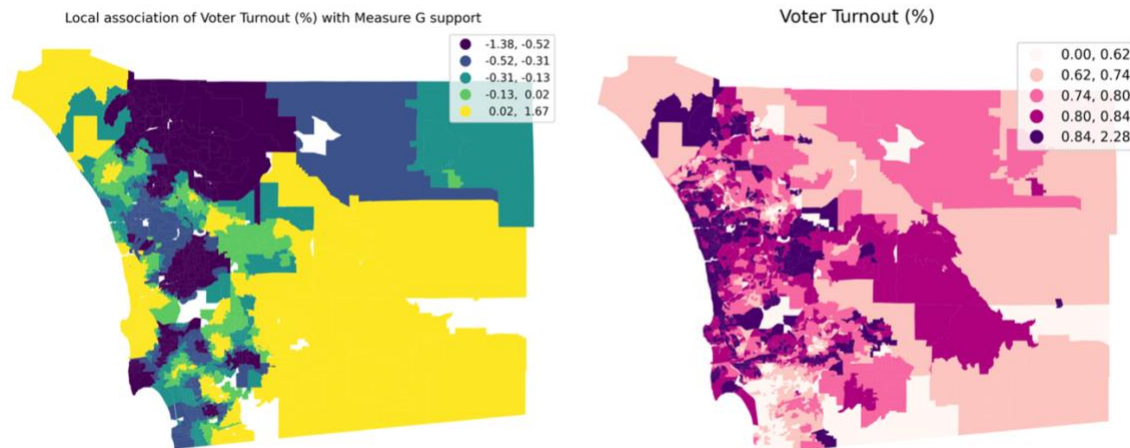


Figure 3.7: Local Associations of Turnout with Measure G

This backdrop culminated in the campaign fighting an uphill battle, with support and opposition alike having trouble describing a formalized opposition to Measure G.

There was no coalition. These things were defeated and at less than 50 percent with not a lot of resources. I don't know how much the support coalition put into it. I wouldn't be surprised if the ratio is like 30 to one... There was no coalition. This is how the people felt. – Opposition, Policy Expert

The cost of this campaign was cited by leaders as a significant hurdle to overcome, and the role of labor unions became a key part of getting the measure on the ballot. This effort was largely funded and supported by construction unions, which contributed both to the proposed funding allocation (primarily for capital vs operational costs) and the core campaign message: “Traffic Relief. Transit. Jobs.”. Interviewees also highlighted how the core of Measure G’s **Campaign Dynamics** were centered around the community organizations that reside in urban communities of color such as City Heights and the South Bay, which represent some of the highest Hispanic proportions in the County.

I think this is a really good example where labor has the funding mechanisms to advance initiatives like this. I think the reason why—even though the measure did not pass, I would say that it was successful in a lot of different ways if we don't just measure it by passage of the measure. The reason why it was successful was because it was a joint coalition between labor and community groups and other partners that are pretty much articulating a very broad agenda of what needs to happen in their region in terms of transit or mobility access. – Support, Community Organizer

However, not all endorsees believed that the coalition was broad enough or represented the necessary portion of the electorate, failing to capture the **Geographical Differences** in priorities across

the county. Concerns about the progressiveness of the campaign (focuses on climate, equity, and union labor) were noted and echoed in some partisan rhetoric shared by opposition respondents. Intra-campaign disagreements on the types of issues at focus were shared, particularly in reference to how broad “the tent” needed to be given the lower passing threshold of 50% +1 compared to government-led ballot measures.

...it really might be that when there was the incentive to get a super majority, the advocates were forced to think more broadly about building a coalition. I think there might've been some relaxation on that because we don't have to get a super majority. We can just go with our crew, and it'll happen. – Support, Community Organization

Despite the strong negative association between % Republican and Measure G, GWR provides some insight into the ways in which this association can vary at smaller scales, with the areas where % Republican was positively (or least negatively) associated with Measure G being aligned with the strongest positive associations for walkability (Northeast Oceanside, Clairemont, and National City, bright yellow spots in Figure 3.8).

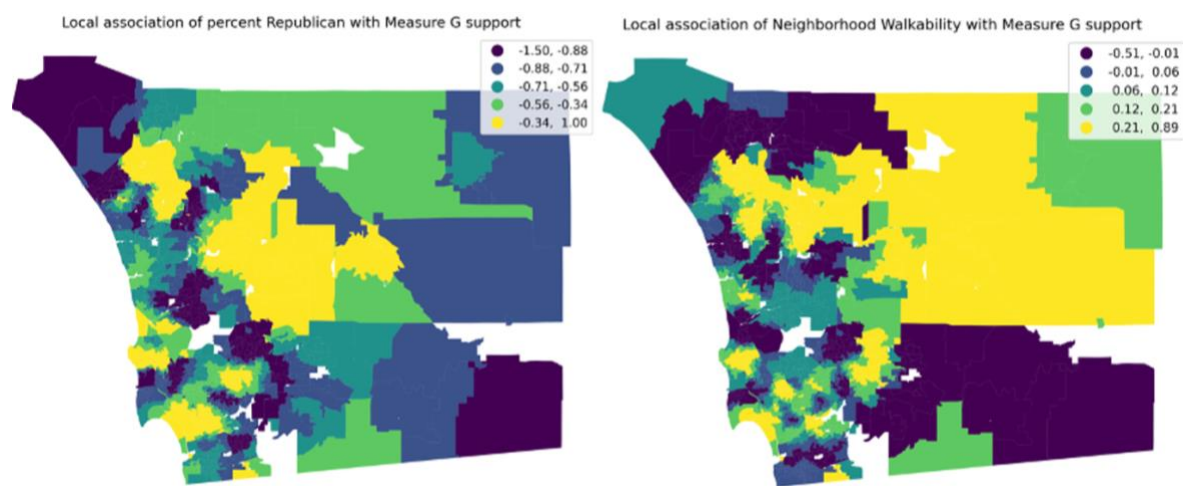


Figure 3.8: Local Associations of Republicanism with Measure G and Neighborhood Walkability

As described by a policy expert who opposed Measure G, while convincing the electorate to pay more in taxes is a challenge, it is not an immutable fact even in more Republican communities. Of the ten

municipalities that had their own sales tax measure during the election, seven succeeded in passing them, including the traditionally more conservative cities of El Cajon, Escondido, and San Marcos.

These are folks in East County who do not want to say yes to things. If they can be persuaded that there's decent managerial acumen, there's plans and that they can trust, I think they're willing to do it, so that then they can have better paved roads or the cops show up quickly or what have you. – Opposition, Policy Expert

Competing Sales Taxes Loop

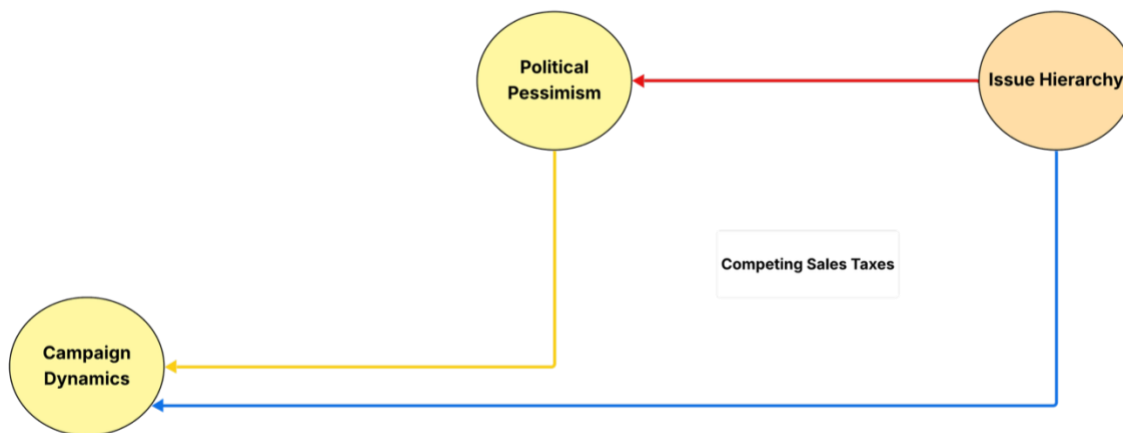


Figure 3.9: Competing Sales Taxes Loop

Qualitative interviewees consistently described the negative impact of the ten competing sales tax measures for the various incorporated communities throughout the county with a particular emphasis on the late-announced City of San Diego sales tax. This negative impact was framed through the theme of **Issue Hierarchy**, with competing sales taxes either deprioritizing or cannibalizing support for Measure G.

In San Diego County sales tax increases themselves, and so you saw City of San Diego pursue their own, really, late in the game. Then we were well established with the campaign infrastructure dollars, et cetera. Then they joined late of like, "We're gonna do it too." Then whenever you have on the ballot, [NAME], anything that's asking you to increase your taxes, not once but twice, if possibly three times, if you also have a bond measure in there too, people start to say no. – Support, Campaign Leader

Results from the regression model restricted to the subsample with a competing sales tax (n=1169) showed a significant positive association between endorsement of a competing sales tax and support for Measure G (see S3.4). The association of tax support with support for Measure G was the

largest of the independent variables, 1.16 times that of percent Republican. A 10% increase in endorsement of another sales tax measure resulted in 5% greater support for Measure G. Interpreted through the lens of the qualitative interviews alongside a non-significant association between presence of a competing sales tax and Support for Measure G, this suggests a “tale of two precincts”, those who endorsed increased taxes and those who did not. The apparent divergence between qualitative and quantitative findings here is attenuated by the localized associations depicted in Figure 3.10, where support for a competing sales tax in the South Bay was weakly and potentially negatively associated with support for Measure G.

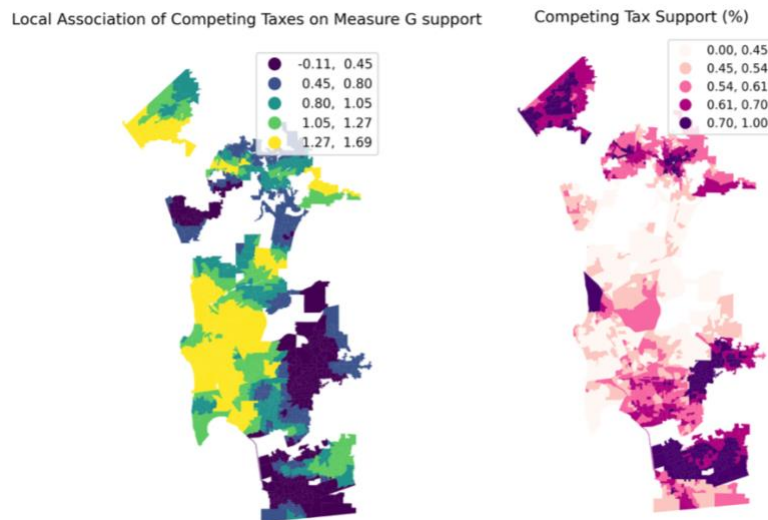


Figure 3.10: Localized Associations for Competing Sales Taxes

While the idea that competing sales taxes were a significant issue was shared by many of the respondents (both support and opposition), others viewed it as a further signal of the **Political Pessimism** in SANDAG and the institutional legitimacy of regional transportation planning more generally. In other words, if other sales taxes passed in this environment, why couldn’t Measure G?

In the great city of La Mesa, we adopted an extension of a half-cent sales tax. In about half the jurisdictions in the region, we put them up, they passed. I just don't think that's a real explanation for what's going on here. – Support, Community Organization

While interviewees do highlight the competing ballot measures, responses consistently came back to the distrust of SANDAG due to their perceived failure to address issues that mattered in all

communities, but road safety in unincorporated communities in particular. The perspective on this shift in SANDAG policy is vastly different between support and opposition representatives, highlighting the different **Issue Hierarchies** they hold.

Then lo and behold, as TransNet, this is decades ago, policy and priorities changed over the years. It became known that you couldn't fulfill all of those projects while also meeting California's climate goals. So many of those projects that were promised under TransNet, included freeway and highway widening, which contributes to more air pollution. – Support, Campaign Leader

They'll [SANDAG] say they're doing something, but show us where's the safe routes? They're not there. People don't wanna give any more money, if it's not going to improve their safety and at this point their children and their grandchildren's safety, because this is a long period of time we're talking about. – Opposition, Local Government

The Measure G **Campaign Dynamics** aimed to address these different **Issue Hierarchies** by including funding for fire evacuation and highway improvements into Measure G. However, the consistent response was along the lines of “*They'll say they're doing something, but show us where's the safe routes? They're not there.*”, highlighting the dominance of **Political Pessimism**. This emphasis on trust was the recurring theme when participants were asked about the potential path forward for the region.

Rebuilding Trust and the Relevance of Public Health

Excluded from the thematic map is the concept of *Rebuilding Trust* which was the recurring theme when interviewees were posed the question “In light of the failure of Measure G, how might future efforts for transportation funding be better positioned for success?”. This response was consistent for support and opposition alike and is the response to **Political Pessimism** as the central issue in not just local transportation policy, but evidently San Diego County politics in general.

I wanna really emphasize the building back of trust. A lot of trust I do think has been broken, if only because there's just a lot of things have been happening at SANDAG, but also just people go on the trolley and they feel unsafe or they feel like it's not clean or they can't understand where the money is going to when there're still potholes on the ground – Support, Community Organizer

Despite the convalescence on rebuilding trust as the goal for the region, recommendations for how to achieve this goal were sparse and differed across interviewees. The temporality of potential solutions was a core consideration from interviewees, drawing the contrast between what can be done today versus the longer time-scale expected to be necessary in rebuilding trust. Many supporters highlighted that the work to rebuild trust was constant in their communities, through engagement and education that predate asking for people to accept new taxes.

Trying to go into a community before we're actually asking for something and talking to them about why this is important, why these things benefit you, really talking up the air pollution aspect of all this and also reminding people like, "Parking is really bad in certain areas. You do not like parking..." - Support, Community Organizer

These comments often referenced the problem stream, with a focus on how the current **Infrastructure Environment** is insufficient. Opposition interviewees also offered solutions grounded in tangible transportation desires for their communities.

If you want...a decreased margin of defeat in East County, which is where I'm more familiar with at this point, they need sidewalks. They need less dirt roads or they need the roads paved more, so they need a little bit more attention. – Opposition, Local Government

The most passionate discussion of what transportation work needs to be done in unincorporated communities was focused on public health issues related to fire evacuations, road safety, and access to active transportation resources. The unincorporated areas of San Diego consistently have the highest traffic fatality and injury rates in the county,³⁹ and this fact is reflected in the ways these regional advocates frame their perception of SANDAG's failures.

Each individual life matters and there's a lot of one and two deaths, one and two, one and two, and you get numb to it, and you shouldn't be numb to it, but it doesn't get the attention that wildfires get, or a big accident where eight people die within 10 days. It just doesn't get that to—it has to be something unfortunately really big, but it shouldn't happen in the first place. – Opposition, Local Government

You would never get on a bike or walk on that highway, and even my 19-year-old son, I still will not let him walk down the highway to the little market, which is less than a quarter of a mile because it is so dangerous. There's nowhere to walk, there's nowhere to ride safe... That would be negligent, so there's these real realities out there that a bike path, a bike lane won't do it. – Opposition, Local Government

Public health concerns regarding pedestrian safety were shared by community organization representatives from low-income urban communities in addition to concerns about air pollution and access to healthcare.

Here in City Heights, we have University Avenue, which is a major corridor, and walking is—it feels unsafe sometimes, and it's mostly because of drivers who don't obey any of the traffic signals. Sometimes it would be your turn to cross the street, but of course, they don't yield to pedestrians. – Support, Community Organizer

These overlapping interests represent common ground in the problem definition and could answer previous calls for a broader coalition that addresses common needs and the difficulty in doing so.

How do we integrate rural community priorities within urban core needs? How do you articulate policy that both addresses the needs of the urban core with rural? – Support, Community Organizer

Discussion

Overview of Key Findings

Through quantitative analyses, consistent significant associations with support for Measure G included support for competing sales taxes, percent Republican, socioeconomic adversity, and neighborhood walkability. Inconsistent associations for mean commute and voter turnout are interpretable through the localized associations from the GWR, as well as the ways all quantitative relationships differed across San Diego County. Combined with the emergent qualitative themes, these results provide rich insights into the policy streams that resulted in Measure G's defeat and potential paths forward. Both socioeconomic adversity and walkability were significantly positively associated with support for Measure G, which alongside qualitative themes is consistent with our hypotheses that precincts who are more reliant or already benefit from public transportation are more likely to support it. In the full sample, the strongest association was the negative relationship between Republicanism and support for Measure G, consistent with previous research linking LTST support to partisanship.^{16,17} The qualitative interviews suggest key geographic and political disparities that contribute to this stark partisan difference, beyond traditionally attributed anti-tax sentiment. Quantitative and qualitative results diverged with respect to

competing sales taxes, where both support for and presence of a competing sales tax were not associated with reduced support for Measure G. These findings are consistent with our hypothesis but run counter to previous literature suggesting that competing sales tax measure may “crowd out” transportation sales taxes.²⁰

Context of the Multiple Streams

As represented by the coloring in the thematic map, the problem stream was well represented in the data, both quantitatively and qualitatively. The statistical significance of both adversity and walkability across models combined with participant responses regarding inequitable, insufficient, and unsafe transportation infrastructure seem to satisfy the notion the problem Measure G purported to solve was relevant. Although as described previously this was not uniform across geographic or political constituencies. Surprisingly, the policy stream was largely unrepresented in the results, only serving to connect the major themes of Issue Hierarchy, Campaign Dynamics, and Infrastructure Environment through the lens of policy development during the coalition building phase. While participants did refer to the funding split as a potential point of contention, these issues were primarily relegated intra-campaign discussions with concerns from non-campaign groups presented more politically. This is not to say that participants were unconcerned with the content of Measure G, but that political issues regarding SANDAG, the political representation of unincorporated areas, and the equity of resource allocation overshadowed policy-specific concerns. In other words, any policy that provided additional funding to SANDAG was a virtual non-starter.

The long-range organization required by the Measure G coalition to create a citizen’s led initiative is concordant with previous Multiple Streams Framework research which identifies this type of interest group driven change.^{40,41} The so-called “Political Window” here was defined by conflicting events which cemented the dominance of the politics stream; the relative momentum in the Measure G campaign for effort for equitable transportation in San Diego conflicting with the increase in government distrust and recent SANDAG scandals. This dominance of the politics stream aligns with the importance of rebuilding trust to advance future actions.

Rebuilding Trust and Legitimacy

I have presented multiple key findings and a thematic map through which they can be understood, however additional framing will improve their interpretability, transferability, and actionability with respect to the idea of rebuilding trust. Suchman's taxonomy of institutional legitimacies provides a helpful orientation.⁴² Suchman defines legitimacy as the perception that an entity's actions are "desirable, proper, or appropriate" within some set of social norms, values, or beliefs and is broken into pragmatic (support if this benefits us), cognitive (this is the natural order), and moral (this is the right thing to do) legitimacies. Within moral legitimacy, subdivisions of consequential (ends justify the means), procedural (correct mechanisms), structural (correct type of organization), and personal (correct entity) exist. I will refer to these terms as I interpret the key findings alongside previous literature in the following paragraphs.

Pragmatic legitimacy is readily apparent in the voting patterns alignment with socioeconomic adversity and walkability, wherein support for Measure G was higher where the benefits of the sales tax were more salient with voters. With respect to walkability specifically, our findings suggest the potential for synergy in pragmatic legitimacy from the built environment, where voters who benefit from walkable neighborhoods are more likely to support public transit initiatives. Likewise, the lack of pragmatic legitimacy for unincorporated communities was explicitly stated as a rationale for not supporting the measure. Further research is warranted to understand the potential reinforcing role of environmental changes on support for further improvements (i.e., synergy). The idea of pragmatic legitimacy is present in previous research on LTSTs specifically, where proximity to funded projects, and use of public transportation infrastructure are associated with increased support.^{16,43} This pragmatism did not present itself quantitatively regarding commute times (or the campaign slogan of "Traffic Relief"). The GWR results depict some spatial patterning where urban residents may have agreed with this framing, but qualitative interviews underscore how the believability of traffic relief as a tangible benefit was tenuous, at least in a meaningful timeframe. Our framing of personal pragmatic driven support runs counter to the findings from Manville & Cummins 2015 which suggest that perceived communal benefits are a greater

predictor of support.¹⁸ This departure could be partially attributed to our use of precinct-level as opposed to individual data. However, the stronger support in regions most likely to benefit from Measure G based on socioeconomic adversity and transit reliance are consistent with this frame and literature on tax support more generally.⁴⁴ The local impacts of robust community organizations that endorsed and campaigned for the measure in these communities (and the fact that this was a citizen's initiative) could explain these different findings. The support of key community organizations represents both ideas of pragmatic and moral consequential legitimacy, with a clear focus on the climate and equity benefits in interviews with these organizations.

Republican and unincorporated community opposition can also partially be explained through the lens of cognitive legitimacy regarding the perceived natural state of car-dependency in those communities and San Diego County at large. This is in sharp contrast to the opinions of key campaigners, which explicitly state the goal of undermining "auto-normativity". Moral legitimacy dominates the arguments presented by the opposition to Measure G, particularly the personal legitimacy that SANDAG lacks (an opinion often shared by Measure G proponents). This failure of personal legitimacy is compounded by procedural (why does SANDAG need more money to do what they should have already done?) and structural (bloated bureaucracy) arguments. The lack of SANDAG's personal legitimacy as the executing agency for Measure G is further evidenced by the fact that seven of the ten competing sales taxes passed in their respective municipalities implying that external economic forces were not so dominant as to forego all tax increases/renewals. These findings are consistent with the large body of evidence linking trust to attitudes for local taxes.⁴⁴ The dominance of both pragmatic and moral legitimacy in the findings is also reflected by which Kingdon's Streams were most represented in interviewee responses. The Politics Stream was coded in more than double the instances than the Policy Stream, emphasizing how the content Measure G (while a point of intra-campaign discussion) was not as pertinent to its defeat as the political factors described here through the lens of legitimacy. The various ways through which the concept of legitimacy aligns with the quantitative and qualitative findings supports the conclusion that rebuilding trust is the primary goal moving forward.

Future Recommendations

The findings described suggest recommendations that are relevant for the San Diego region specifically but have transferability to other regions that struggle from similar issues regarding partisan and geographic polarization, infrastructure deficits, and economic inequity that all interact with governance institutions that struggle to maintain legitimacy. First, the near success of the measure in a less than favorable political environment should not be understated. This was achieved through the high level of coalition building that took place over decades, and by creating this as a citizen's initiative the passing threshold became much more attainable. Future research should expand on this idea by exploring the role of bottom-up organizing in stimulating environmental changes by directly (i.e., placemaking, tactical urbanism, etc.) as well as electorally. Based on the present findings, expanding the coalition to non-urban San Diego County residents who share common concerns related to the problem definition could be advance broader pragmatic legitimacy. I found commonalities in areas related to public health, particularly transportation safety, that were shared across key communities. This is not to undermine the approach taken by the campaign which worked within budgetary and political constraints to get this measure on the ballot, but to acknowledge that there is still common ground to be found when defining the problem across diverse groups. Further work on bridging the partisan gap regarding public funding for active transportation is warranted, with peer cities that are more homogenously Democratic (like Los Angeles) succeeding in their efforts where San Diego fell short.⁴⁵ This discussion is increasingly important in a more polarized political climate where issues that were previously seen as non-political can be swept into partisan divisions.⁴⁶ As public health professionals and academics, the findings here reinforce the ideas of "health in all policies",⁴⁷ as a pragmatically legitimate framing for advancing health equity in a politically polarized climate. As such, public health can and should be more engaged in the political arena (e.g., health in all politics) to understand how robust evidence can support local political efforts to impact the social determinants of health.

Strengths and Limitations

This research is limited by its cross-sectional nature and reliance on precinct-level rather than voter polling data. It is possible that precinct-level outcomes are inconsistent with the individual-level associations between neighborhood walkability, income, commuting times and endorsement of Measure G. Alternatively, there is value in the use of precinct level outcomes for understanding broader community sentiments that are actionable at higher levels of organization. Additionally, the limited number of precincts with a competing sales tax measure reduced our sample size, limiting the geographic scope of that specific research question. I also experienced a slight underrepresentation of opposition interviewees in our qualitative sample given non-response from this group. However, saturation was still reached, and I do not expect this to bias the findings.

Despite these limitations, the convergent mixed-methods approach bolsters the findings by triangulating the quantitative findings and providing key context regarding the campaign approach and community perspectives. This approach was also resource efficient by leveraging publicly available data and key stakeholder interviews to generate rich findings. Compared to prior research on LTSTs, our approach is strengthened by the robust interpolation methodology and improved accountancy of spatial factors including weighting and dependence. The consistency in findings across multiple regression models and alignment within our qualitative framework also increases the confidence in our results. This study also has a strong theoretical foundation that allows for comparability to previous and future work in this arena. The theory-building aspect of this analysis should not be discounted, for the formal thematic map and key findings offer lenses of analysis and insights that are transferrable to other US cities that face similar geographic and partisan divides.

Conclusion

The goal of this research was to reinforce the importance of understanding the complex systems of politics, policies, and funding mechanisms that shape our built environment, and therefore our health. Overall, this research provides a novel mixed-methods approach to understanding the predictors and

policy environment surrounding an LTST intended to primarily fund public transportation. The results highlight the notion that more walkable, transit accessible neighborhoods warrant support for these policies from constituents, a sort of “if you build it they will fund” approach that is consistent with previous research on the “death spiral” of local public transportation system finances.⁴⁸ The findings underscore that just as our policies shape our environment, our environment may also shape our policy preferences and political environments.

Our findings also counter the narrative that the inherent regressivity of sales taxes are a non-starter for socioeconomically disadvantaged communities for public transportation funding, although alternative tax systems including land value taxation and wealth taxes should be considered. While political affiliation is the strongest throughline, the local estimates and qualitative interviews suggest that it is not an insurmountable barrier to securing tax-based funding for local transportation projects. The need to build and rebuild legitimacy in the political and governmental institutions that advance or undermine health equity is a key takeaway. This work requires engagement by public health professionals/academics in the political processes that shape our environments to leverage the shared interest in safe, health-supportive communities.

This research is also timely; local funding measures are an important topic of discussion in the current US political climate with a federal government that is actively opposed to non-car transportation improvements and local dollars make up an increasingly larger share of both capital and operating expenses.^{49–51} It is worth noting that largest public transportation agency in San Diego County, MTS is now facing a \$120 million budget shortfall (about 25% of the operating budget) which may result in increased fares and reduced service if additional funding is not secured.⁵² I hope that the insights from these analyses can help the region move forward while promoting health equity in our built environment. Additionally, the conceptual framework provides transferrable insights into understanding diverse contexts and uses replicable methodology that can benefit future research.

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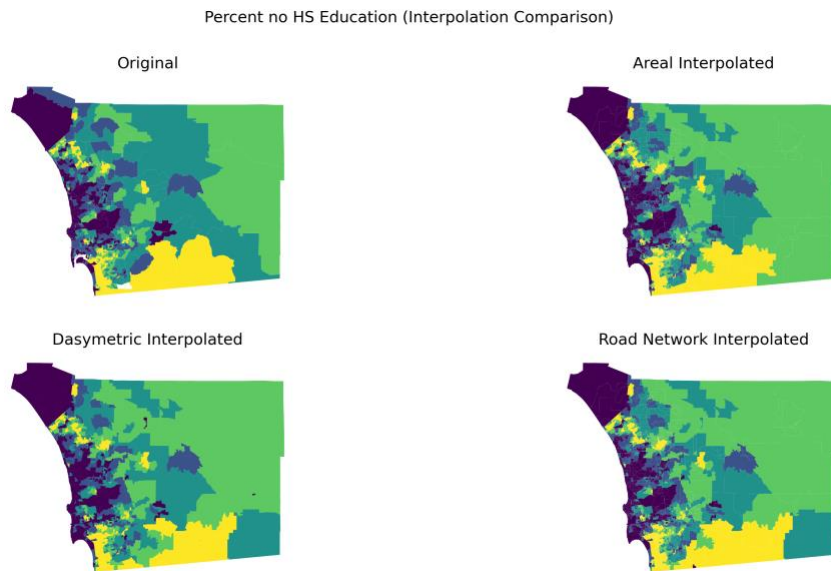
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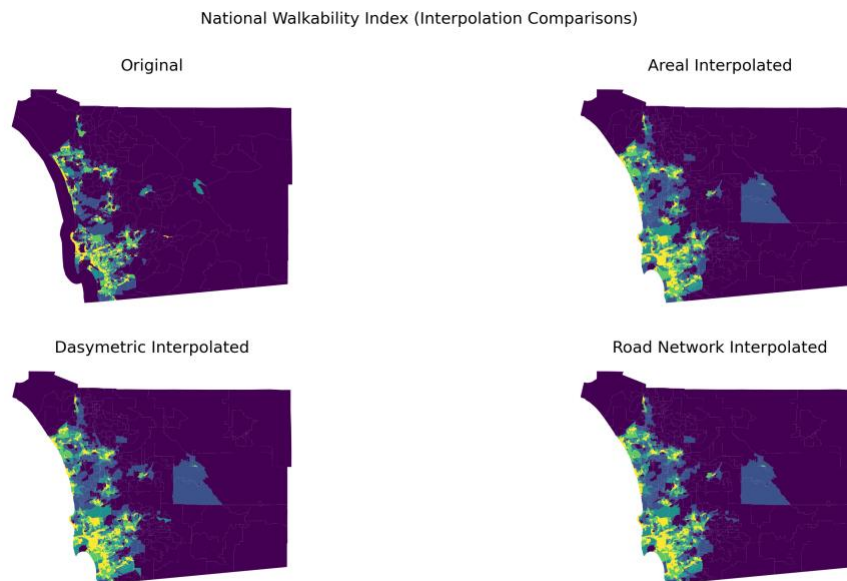
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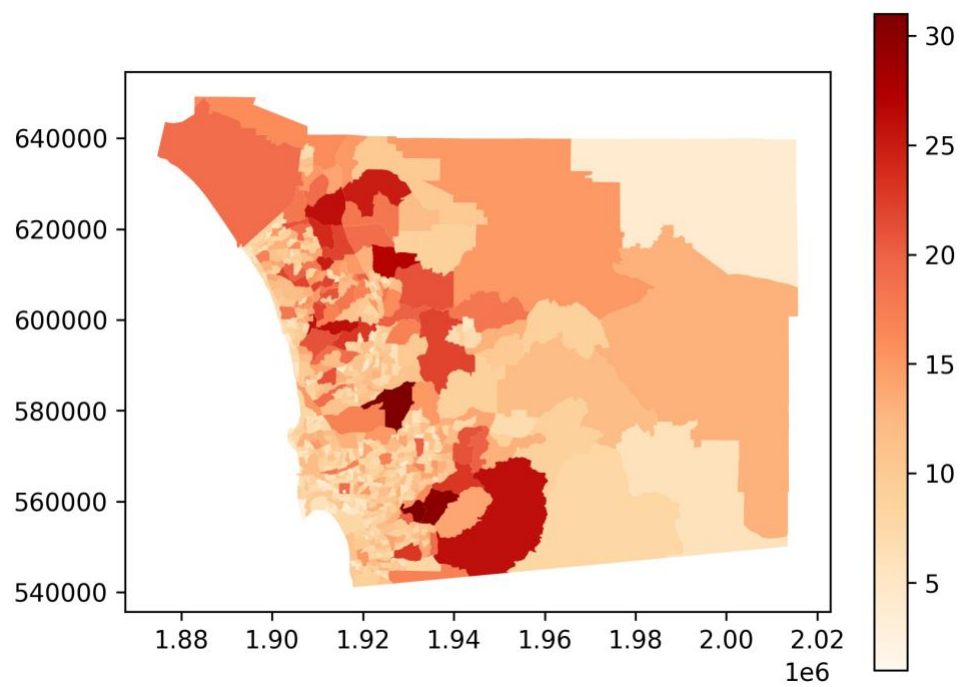
Supplemental Materials



Supplemental Figure S3.11: Example of Tract Level Interpolation Comparison



Supplemental Figure S3.12: Sample Block Group Level Interpolation Comparison



Supplemental Figure S3.13: Correlation between Support for Measure G and Geometry Intersection (Tracts)

INTERVIEW GUIDE

Thank you so much for taking the time for me to interview you today. As a reminder, this research project is focused on understanding the policy landscape surrounding Measure G, which proposed as a countywide half cent sales tax to fund transportation in the region. As this is a research project, your name will be kept anonymous throughout the write-up, and you can opt out of recording at any time during or after the interview.

INTRODUCTION QUESTIONS

- Can you start by telling me about your work?
- How did you get involved with Measure G? **OR** What do you know about Measure G?

When answering the following questions, I would like for you to try to think about the time preceding November 2024 when Measure G was on the ballot.

PROBLEM STREAM (How the issue was recognized and framed as a problem in need of action)

Problem Identification:

1. What do you think are the major transportation issues in San Diego County?
 - a. **PROBE:** Of the issues mentioned, what would you describe as the most urgent?
 - b. **PROBE:** Which communities are most affected by these issues?
2. How would you describe the public's perception of public transportation in San Diego generally?
 - a. **PROBE:** Do you feel that differs across different communities? If so, how?

POLICY STREAM (How potential solutions were developed and promoted)

3. Generally, what do you think about the role of transportation policy for addressing social challenges?
 - a. For Example: health, economic inequality, poverty, etc.,

More specifically for Measure G...

Policy Alternatives:

ONLY FOR POLICY DEVELOPERS (Were you involved in the drafting of Measure G?):

4. How were the specifics of Measure G chosen (such as the funding split)?
 - a. **PROBE:** Why specific allocation or "ballot box budgeting"?
 - b. **PROBE:** How was the community involved in its development?

Technical Feasibility:

5. What concerns did stakeholders express about the practicality of Measure G as a ballot initiative?
 - a. **PROBE:** For example, the fiscal accountability of the SANDAG or other implementing agencies
 - b. **PROBE:** Did the establishment of an external review board ease those concerns? Why or why not?

Alignment with Public Preferences:

6. From your perspective, how did Measure G frame the cost-benefit trade off to the public?
 - a. **PROBE FOR POLICY DEVELOPERS:** Can you say more about the "traffic relief, transit, and jobs" framing?
 - b. **MAYBE PROBE:** Was equity or health considered in the framing? Why or why not?
-

POLITICS STREAM (How political dynamics influenced the proposal)

Political Support and Opposition:

1. Which political leaders or groups supported the Measure G, and which opposed it?
 - a. **PROBE:** Was this support or opposition explicit?

Public Engagement and Advocacy:

2. How was public engagement handled during the campaign?
 - a. **PROBE:** Were there grassroots efforts to build support?
 - b. **PROBE:** How was outreach changed based on the community?

Timing and Political Climate:

3. How did the timing of the Measure G align with the broader political climate (e.g., economic conditions, election cycles)?
 - a. **PROBE:** How do you think that competing sales tax measures affect this outcome?
 - b. **PROBE:** Would a midterm election have been more successful?

POLICY WINDOW (Opportunities for coupling the streams)

4. From your perspective, how did Measure G align with the high priority issues for voters?
 - a. **PROBE:** Where did it align well? Where did it fall short?

GENERAL REFLECTIONS

5. In light of the failure of Measure G, how might future efforts for transportation funding be better positioned for success?
 - a. **PROBE:** Do you feel that potential ballot measure in 2026 will employ these changes?

That is the end of my questions, do you have anything else that you would like to share on this topic that we didn't get to?

As I would like to continue conducting interviews with people who you think would have unique perspectives or insights Measure G, are there any folks that you would recommend I reach out to?

Thank you again and please feel free to reach out to me with any questions!

Results from Voter Weighted Binomial GLM

To account for the fact that precincts vary in the number of voters they represent, a binomial GLM was conducted, weighted by the total number of voters for a given precinct, these results are shown in Supplemental Table S3.3.

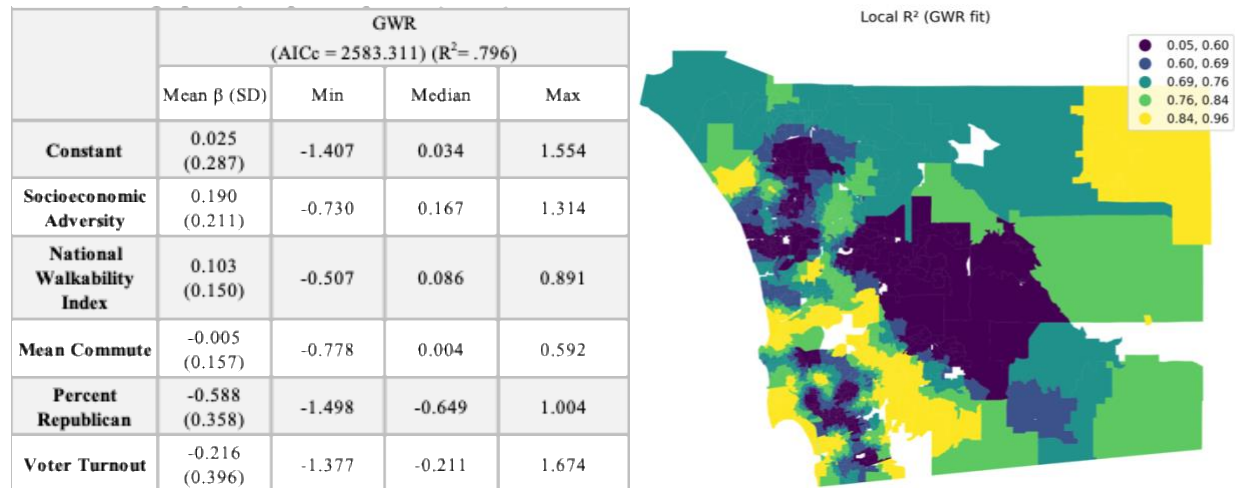
Supplemental Table S3.3: Voter Weighted Binomial GLM (N=1756)

	Binomial GLM (AIC = 1299894.063) (Deviance = 11434.034) ^a			
	Coef (SE)	z-statistic	p-value	OR (95% CI)
Constant	-0.050 (0.002)	-28.804	<.001	0.952 (0.949, 0.955)
Socioeconomic Adversity	0.149 (0.002)	62.552	<.001	1.161 (1.155, 1.166)
National Walkability Index	0.046 (0.002)	20.566	<.001	1.047 (1.042, 1.052)
Mean Commute	0.021 (0.002)	9.878	<.001	1.021 (1.017, 1.025)
Percent Republican	-0.392 (0.003)	-145.350	<.001	0.676 (0.672, 0.679)
Voter Turnout	-0.058 (0.003)	-22.379	<.001	0.944 (0.939, 0.949)

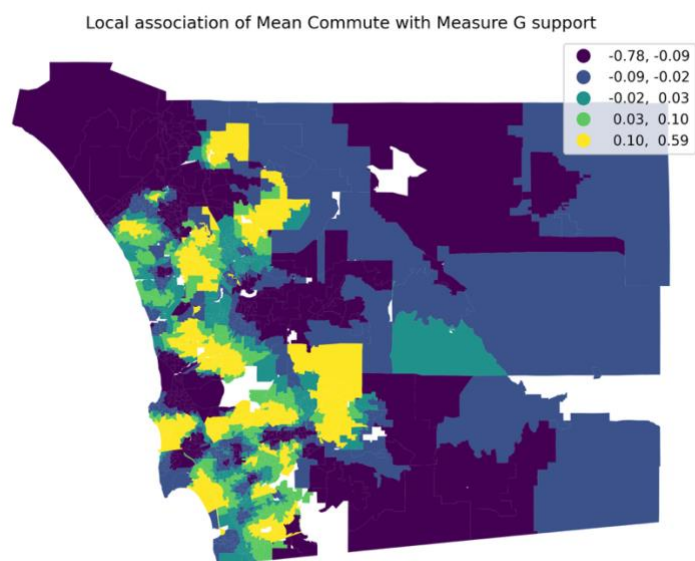
^aR² is inflated by voter-weighting and therefor AIC and Deviance are a better representation of model fit

These findings are largely consistent with the previous modeling approaches, however both mean commute and voter turnout are statistically significant in this approach. Per this model, a one standard deviation greater:

- Socioeconomic adversity is associated with a 16.1% higher odds of supporting Measure G
- Walkability is associated with a 4.7% higher odds of supporting Measure G
- Mean commute is associated with a 2.1% higher odds of supporting Measure G
- Percent Republican is associated with a 32.4% lower odds of supporting Measure G
- Voter turnout is associated with a 5.6% lower odds of supporting Measure G.



Supplemental Figure S3.14: Overall Geographically Weighted Regression Results



Supplemental Figure S3.15: Localized Associations between Mean Commute and Measure G Support

Results from Competing Sales Tax Subsample

Standardized regression results for each of the models used in the subsample of 1169 precincts can be seen in Supplemental Table S3.4. Overall results indicate consistent significant associations between all independent variables and support for Measure G, with the exception of voter turnout, which was only significant in the standard OLS regression and marginal significance for mean commute in the SLM. Both the spatial weight and lambda were significant in the SLM and SEM respectively, suggesting significant relationships across neighboring precincts and that there were unmeasured spatial dependencies in the model. A statistically significant Anselin-Kelejian test in the SLM, alongside the lower AIC in the SEM suggest that it is the most appropriate model choice despite the lower R^2 value. Therefore, coefficient interpretations for this subsample will be focused on the SEM results.

Based on the scaled versions of the variables, the effect of tax support on support for measure G was the largest of the independent variables, 1.16 times the effect of percent Republican, 2.63 times the effect of socioeconomic deprivation and 6.25 times the effect of walkability and mean commute.

Interpreting the beta coefficients from the SEM in meaningful contexts:

- A 10% increase in endorsement of another sales tax measure results in a 5% increase in support for Measure G in a given precinct independent of the other factors in the model.
- A 10% increase in endorsement of the Republican candidate for President results in a 4.3% reduction in support for Measure G in a given precinct independent of the other factors in the model.
- A one standard deviation increase in Socioeconomic Adversity is associated with a 1.8% increase in support for Measure G in a given precinct independent of the other factors in the model.
- A one quartile increase in walkability for a precinct would result in approximately a 1.3% increase in support for Measure G independent of the other factors in the model.
- A five minute increase in mean commute for a given precinct is associated with 0.97% increase in support for Measure G independent of the other factors in the model.

Supplemental Table S3.4: Regression Results with Tax Support (n=1169)

	OLS Regression			Spatial Lag			Spatial Error		
	(AIC = -3244.939) ($R^2 = 0.6784$)			(AIC = -3391.17) ($R^2 = 0.7180$)			(AIC = -3523.78) ($R^2 = 0.6502$)		
	Estimate (SE)	t-statistic	p-value	Estimate (SE)	z-statistic	p-value	Estimate (SE)	z-statistic	p-value
Constant	0.526 (0.002)	298.696	<.001	0.394 (0.062)	6.343	<.001	0.525 (0.005)	98.522	<.001
Socioeconomic Adversity	0.024 (0.003)	9.280	<.001	0.017 (0.005)	3.175	<.002	0.019 (0.004)	4.420	<.001
National Walkability Index	0.009 (0.002)	4.145	<.001	0.006 (0.002)	2.325	.020	0.008 (0.003)	3.192	.001
Mean Commute	-0.006 (0.002)	-2.697	.007	-0.006 (0.003)	-1.957	.050	-0.008 (0.003)	-2.911	.004
Percent Republican	-0.057 (0.002)	-28.419	<.001	-0.046 (0.009)	-5.011	<.001	-0.043 (0.011)	-4.016	<.001
Tax Support	0.034 (0.002)	15.457	<.001	0.032 (0.006)	5.548	<.001	0.050 (0.011)	4.393	<.001
Voter Turnout	-0.014 (0.002)	-6.152	<.001	-0.012 (0.007)	-1.596	.110	-0.011 (0.008)	-1.332	.183
Spatial Weight	-	-	-	0.251 (0.116)	2.157	.031	-	-	-
Lambda	-	-	-	-	-	-	0.712 (0.038)	18.527	<.001

Acknowledgements

Chapter 3, in full, has not yet been submitted for publication. The dissertation author was the primary researcher and author of this paper. I would like to acknowledge and thank my coauthors and collaborators: Madeline Roke, Britta Larsen Demartini, Cheryl Anderson, Jerel Calzo, Lawrence D Frank, Linda C Gallo.

Integrated Discussion

Summary of Results

Our analyses in Chapter 1 described that walking supportive infrastructure is not equally distributed across geographic or social space in the predominantly Hispanic/Latino neighborhoods of South San Diego. Consistent with previous research, pedestrian streetscape features that have been associated with increased physical activity are disproportionately present in less socioeconomically adverse areas, however this is not consistent across all types of pedestrian infrastructure. Similarly, while more disadvantaged neighborhoods tended to have higher walkability scores, there is a distinct typology on the urban fringe that is doubly disadvantaged in terms of socioeconomic factors and walking infrastructure.

Regarding the public health implications in question in Chapter 2, socioeconomic adversity was significantly negatively associated with changes in clinical CVH factors over six years in fully adjusted models, while walkability was associated with better CVH. Pedestrian streetscape features were unassociated with CVH independently but positively interacted with walkability and showing significant negative associations in the bottom tertile of walkability in stratified models. Sensitivity analyses suggest that these associations were driven by overall aesthetics (potentially as a signal of suburban infrastructure consistent with the findings in Chapter 1) and acting through BMI and Blood Pressure.

In Chapter 3, the mixed-methods approach to understanding the outcome of Measure G in the November 2024 election suggested multiple findings consistent with transportation public policy theories and with implications for public health practice. First, independent of other variables in the model, walkability and socioeconomic adversity were both significantly positively associated with support for Measure G while the strongest factor in complete precinct models was the negative association between percent Republican and support for Measure G. These quantitative findings dovetail with insights from the qualitative interviews where the emergent themes of the roles of the infrastructure environment, geographical disparities, issue hierarchies, and campaign dynamics converge into political pessimism and

serve to undermine the institutional legitimacy needed by San Diego governments to validate additional tax funding. The paucity of interest in the policy stream, as described by Kingdon, underscores the importance of politics in the promotion of public health through upstream determinants. These factors interact to form positive feedback loops that serve to reinforce the status quo and in doing so may exacerbate health inequities across diverse groups and geographies.

Together, this in-depth analysis of socioeconomic adversity and walking infrastructure in San Diego County paints a significant story about the inequities in health supportive environments and the ways in which they are reinforced by electoral politics for which public health expert voices are largely absent.

Collective Significance

The Contextual Importance of Pedestrian Streetscapes

While previous research has identified the potential role of pedestrian streetscapes for promoting health behaviors,¹⁻⁴ this novel analysis on the longitudinal associations with facets of CVH suggest more complex patterns may be at play. A key takeaway from our findings is the importance of walkability features that are, unfortunately, more difficult to change. The role of walkability at the macro-level as the substrate for other positive pedestrian features suggests the importance of more challenging policy approaches, such as Measure G, particularly in conjunction with initiatives that combine densification with the establishment of public transportation. This is not to say that public investment in pedestrian streetscape features like greenery, sidewalks, or bike lanes are unimportant, but that understanding the context in which these approaches are used to complement infrastructure is necessary for their successful implementation. Ill placed or fragmented streetscape infrastructure may prove to have an insignificant impact or even negative consequences on health and safety, particularly in high stress traffic environments or those without destinations worth walking or cycling to. This reality is evident from a recent paper by Garber et al. which described the prevalence of unprotected bike infrastructure on high

traffic streets across the US, ranking San Diego as having the fifth highest proportion of high stress unprotected cycling infrastructure among the 20 most populous US cities.⁵ With the advent of machine learning techniques to allow for a more holistic and systematic evaluation of pedestrian streetscape features,⁶ more work is needed to best inform planners, policymakers, and community advocates. More careful and comprehensive implementation of active transportation infrastructure (including public transportation) may also prove to be more politically viable and stave off the reactive removal of new bike infrastructure which has become increasingly common in San Diego County^{7,8} and in the US writ large.

Environmental and Political Inequities

Some of the qualitative interviews in this dissertation echo those news stories of bike lane removal, with residents of the unincorporated communities in San Diego County expressing their frustration with new bike infrastructure featuring public art in the wealthy urban communities while unsafe driving conditions and car-dependency in the semi-rural areas result in the deaths of their friends and family. These concerns, amplified by distrust of the leading government agencies, validated their opposition to transportation funding desired by the largely disadvantaged, Hispanic/Latino community groups who seek to improve health and economic outcomes in the South Bay. Yet, at the same time, the failure to fund public infrastructure all but ensures that rural highways and transit corridors alike will continue to degrade and negatively contribute to downstream health consequences. The fraying of government trust in San Diego County is related to the value that the government provides, as evidenced by the association between walkability and support for Measure G independent of partisanship and consistent with previous research linking transportation satisfaction with support for local democracy.⁹ Likewise, unincorporated communities feel neglected both through the lack of physical infrastructure and political representation, reinforcing geographic rifts. The South Bay communities are similarly disillusioned with government for its seemingly lackluster approaches to addressing environmental injustice or climate change issues. While other researchers have called for the integration of climate change and other public health agendas (like those argued by Measure G proponents),^{10,11} the findings

here echo concerns regarding the potential pitfalls of political failures to damage multiple agendas or narrow the base of support.¹²

While the findings here can be interpreted pessimistically, they also provide a vision for how to move forward. Despite the geographic differences across San Diego County, respondents consistently prioritize transportation safety, convenience, and enjoy access to active transportation (or leisure) infrastructure. Due to data limitations, the present analyses were unable to link pedestrian streetscape features with support for Measure G, but interviewees consistently highlighted the desire to see such improvements in their own communities (an expression of pragmatic legitimacy as defined by Suchman).¹³ The inherently political nature of public health, particularly at the intersection of urban planning and transportation is emphasized here. This research collectively highlights the importance of understanding the reinforcing nature of policies, the physical/social environment, and community support in generating broader changes. The promotion of walkability as a larger system, one where community members attitudinal disposition shapes the environment through politics and then is in turn shaped by the environment in which they live, is a wicked problem that warrants additional effort.

The Built Environment, Poverty, and the Role of Public Health

Contrary to our hypothesis in Chapter 2, neither walkability nor pedestrian streetscape features moderated the relationship between adversity and CVH. Additionally, while pedestrian features did vary across the dominant a priori and data driven neighborhood typologies in Chapter 1, differences across neighborhoods were dominated by variation in adversity and walkability. While our findings indicate that pedestrian features may be beneficial in specific contexts, together, the distinct spatial clustering and consistent association between both adversity and walkability with CVH imply that acting to address broader land use patterns and economic policy together should be a priority. This takeaway is unsurprising and consistent with a wider body of prior research reinforcing the importance of upstream factors on the promotion of public health.¹⁴ However, the inclusion of pedestrian streetscape features in these analyses, and their interaction with walkability, provides additional evidence that the larger and

more difficult changes take precedence. This distinction bolsters the relevance of exploring policy approaches that seek to change the physical landscape of our cities.

While not the focus of this dissertation, a discussion of the role of housing policy is warranted here and deeply intertwined with the transportation policy. In 2024, the US Bureau of Labor Statistics reported that housing and transportation were the leading household expenses, coming in at 33.4% and 17% of total household spending respectively.¹⁵ Previous urban planning and public policy researchers have noted the interconnection between these factors, wherein increased housing stock in the form of infill/densification combined with robust transportation options (e.g., transit-oriented development) have a synergistic role in decreasing household expenditures particularly when there is sufficient, economically diverse housing stock.^{16–19} Through this lens, a policy approach like Measure G, which, through primarily funding public transit and in alignment with recent changes in California state law requiring upzoning around public transit stations (CA SB 79),²⁰ had substantial potential to change the macro-level environment of South San Diego and San Diego more broadly. Prior countervailing research has suggested that increased housing costs in desirable Transit Oriented Developments (TODs) can overwhelm transportation cost savings, and therefore, the promotion of public and low income housing in TODs is a recommended strategy.^{21,22} These recommendations dovetail with other important considerations such as gentrification which, although beyond the scope of this dissertation, warrants inclusion in future analyses and in policy implementation efforts to avoid exacerbating health inequities through economic displacement.²³ Specifically related to Hispanic/Latino communities, prior research from the HCHS/SOL cohort did not link gentrification to health outcomes but the unique sociocultural factors that describe Hispanic/Latino communities warrant continued research in this area, particularly in conversation with other facets of neighborhood change (like densification).^{24,25}

Previous public health research has identified the role of city planning policies on health,²⁶ including specific calls to action for the advancement of physical activity as policy.²⁷ However, there has been markedly less discussion about the role of politics. The focus on and emergence of the political domain as an important factor related to Measure G in Chapter 3 suggests that greater research

consideration should be applied to electoral politics. Those involved in safe streets and healthy urbanism activism are intimately familiar with the importance of politics in shaping the physical environment, often confronting so-called NIMBYs (“Not in my backyard”) at local government meetings to advocate from housing or bike infrastructure projects.²⁸ In our analysis of Measure G, competing interests across San Diego highlighted geographic differences in priorities, perceived benefits, and politics that were further obfuscated by local government scandals. The significantly greater support for Measure G in more walkable and socioeconomically adverse communities, even after adjusting for partisanship, alongside the aforementioned political backlashes to bike infrastructure in San Diego County, paint a picture of the circular relationship between the physical environment and related politics. The current political situation in San Diego County, as it relates to transportation, is failing not only the largely Hispanic/Latino transit reliant communities of the South Bay, but evidently the semi-rural communities that are plagued by automobile collisions and fire evacuation concerns. When taken all together, the findings of this dissertation, which link spatial inequities in neighborhood resources to CVH and provide an example of how these material conditions are reinforced politically, and the argument for understanding politics and institutional legitimacy for the promotion of public health becomes more salient.

Alignment with the Future of Physical Activity

As a health behavior researcher, the future of physical activity as a field provides a useful lens to contextualize both the rationale underscoring my research approach and the findings therein. While the present analyses did not include the measurement of physical activity explicitly, the connection between walkability and CVH highlighted in Chapter 2 implicitly assumes physical activity as a (if not the) mechanism of this association. The field of physical activity has been increasingly focused on upstream determinants, including global policy approaches as evidenced by the Global Observatory of Healthy and Sustainable Cities.²⁹ This dissertation, and the key combined findings described above align with this shift in focus among physical activity researchers. Therefore, this section will describe the alignment with the *Global physical activity for health collection* in Nature published in March 2026 given its goal of orienting physical activity research priorities for the 21st century.³⁰

In the *Global physical activity for health collection*, the authors emphasize the importance of different types of physical activity. In no countries or income categories does the amount of leisure time physical activity satisfy the WHO recommendations, and the promotion of active transportation (mediated through physical and social contexts) will be necessary to increase non-coercive types of physical activity.³¹ This emphasis on non-coercive physical activity by Salvo et al., relates to our discussion of infrastructural car-dependency and socioeconomic adversity as potential examples of unsafe, non-choice based active transportation behaviors. The authors' recommendations regarding the promotion of social justice and equity within physical activity policy and interventions is consistent with the argument regarding the intrinsic link between walkability features and neighborhood socioeconomic conditions. This lens provides a useful framework for understanding the positive disparities uncovered in prior walkability research and warrants future investigations into the holistic physical and social contexts that relate to physical activity behaviors.

The emphasis on policy adoption, implementation, and integration across multiple domains in the *Global physical activity for health collection* is also aligned with the analysis of Measure G provided here. Notably, Measure G and the qualitative interviews conducted to better understand its failure at the ballot box, were not focused on physical activity. Air pollution and climate change were central to the Yes on Measure G campaign, and both supporters and opposition described concerns related to traffic safety highlighting that public health concerns regarding transportation policy were present. This is consistent with the key findings from Ramírez Varela et al. 2026,²⁷ where, despite its relevance to physical activity, the low political priority of physical activity in Measure G and San Diego politics more broadly may contribute to the inability to advance meaningful policy change. Specifically, in the context of the argument of institutional legitimacy, the exclusion of physical activity, its advocates, and its downstream benefits from discussion in transportation policy may undermine broader coalition support and its perceived utility for contributing to social goods (including health outcomes).²⁷ Arguments presented both in the *Global physical activity for health collection* and this dissertation suggest the importance of building a transdisciplinary political approach that can argue the co-benefits of policies.

The most prominent co-benefit discussed in the recent literature is through the intersection between climate change and physical activity, often through the promotion of active transportation as an alternative to personal automobiles.^{10,32} The call to action for a better understanding of public support for policies that have climate and physical activity co-benefits is addressed at a local level in Chapter 3 of this dissertation. As mentioned, the discussion of physical activity and its benefits was largely absent from qualitative interviews, reinforcing the arguments made in the Nature series regarding the advancement of physical activity as a priority. However, much of the effort to get Measure G on the ballot and advocate for its passage was led by prominent climate action community groups in San Diego, suggesting potential community-oriented pathways for synergizing these public health efforts. Much like the findings in Chapter 1 and 2 of this dissertation, climate researchers have noted the relative importance of addressing the macro-scale environmental features, such as land-use patterns, over pedestrian streetscape improvements.³² This agreement is promising for generating both a shared problem definition and policy solutions, yet, as previously mentioned, concerns about the potential downsides of co-benefit framings need to be better understood.

While this dissertation shares many key findings and implications with the *Global physical activity for health collection*, there are distinct contributions that go beyond the recommendations shared there which deserve attention. First and foremost, the findings presented here suggest that additional efforts should be made by physical activity researchers, and public health experts more generally, to understand the political (rather than just policy) determinants and contexts in their research. This is consistent with previous calls to action by numerous public health researchers, most notably Daniel Dawes,³³ however his description of the political determinants of health was still largely relegated to those concerning healthcare as opposed to transportation policy or factors that are not traditionally under the purview of health. Additionally, the exploration of interactions between adversity, walkability, and pedestrian streetscape features both spatially and as they relate to longitudinal changes in CVH, particularly through the examination of the MAPS-Abbreviated subscales, provide a first look at how different built and social environments relate. More in-depth explorations into the operationalization of

“walkability” can help us to better understand not only physical activity paradoxes but also optimize policies and programs for acceptability and impact.

Strengths and Limitations

Collectively this dissertation is strong in its multilevel, multimethod approach to understanding the role of the environment in the promotion of public health, leveraging individual, community, and political data to provide a rich and holistic description of a major US metropolitan area. This dissertation is among the first to examine the interactions between walkability and pedestrian streetscape features both descriptively and as they relate to health outcomes. This type of work is foundational as we approach the next stage of walkability research wherein machine learning allows for a more holistic accounting of pedestrian features. The rigorous mixed-methods analysis of support for a local transportation sales tax is a novel lens to view the role of public health research and to understand how public health professionals can better advance evidence-based policies. This research is also forward thinking in its framing of understanding public support for policies that have the ability to promote physical activity (although not explicit in the messaging for Measure G) as called for in the *Global physical activity for health collection*.³²

This dissertation is of course not without its limitations. The generalizability of these findings should not be overstated. Despite the intentional approach to focus on a single metropolitan area, many of the findings here cannot be reasonably extrapolated to other localities with diverse urban forms, demographic characteristics, and political environments. The findings here are intended to contribute to the broader literature through their methodological transferability and the theoretical frameworks employed to more holistically investigate these questions of community health. This is also true for the extension of these findings to other demographic groups outside of Mexican-heritage Hispanic/Latino communities, given the restriction of these analysis to a single HCHS/SOL site. Given the order in which the analyses were conducted and the use limitations of identifiable participant characteristics (namely home location data), congruence between the typologies identified in Chapter 1 and the longitudinal

health effects in Chapter 2 is limited. Future research can and should use data-derived clustering to understand how health differs by neighborhood typology in addition to the individual factors. This dissertation is also limited by its timing, both in the use of HCHS/SOL visit 2 environmental data for Chapter 1 (which is constrained to data from 2014-2017) and the lack of data preceding the November 2024 election described in Chapter 3. On the first point, this approach was chosen given the limitations of the pedestrian streetscape data collected and to maintain congruence between chapters. Regarding Measure G, the socioeconomic adversity and walkability indices are not temporally aligned with the other chapters with the aim of providing more accurate predictors of precinct-level support, therefore a “one-to-one” comparison between the chapter findings should be approached with caution. In the context of recent calls to action for physical activity research, this dissertation is rather narrowly focused on the well-established pathways to CVH as opposed to including the connections with mental health, immune response, and cancer.³¹

Future Research Directions

This dissertation provides initial groundwork for a personal research agenda and this line of research more broadly. Expanding the methodologies used here to typologize neighborhoods by macro-scale walkability, pedestrian streetscape features, and socioeconomic factors is a key step for future research that can be used by policymakers at all levels of government. This work should be done in conjunction with an evaluation of the historical, contemporary, and proposed policies alongside the political contexts that reinforce or transform physical/social spaces.

Technological advances are not only limited to machine learning and AI, but also to the activity measurement tools that we have access to. Evaluating the impacts of specific built environment features on CVH more holistically, specifically with the use of 24hr activity cycles to capture the complex trade-offs between sleep, sedentary time, light physical activity, and moderate-vigorous activity will provide more rich information about the types of activities that are informed by physical space. In conjunction

with GPS, these developments will help us remove some of the “black boxes” behind the mechanisms that link the environment and health.

In conjunction with the recommendations from the *Global physical activity for health collection*, research on 24hr activity cycles should be combined with the study of non-coercive physical activity and the different health benefits that active transportation may confer among those who have no other choice or concurrent stressors. This is particularly important in the context of a changing climate wherein greater severe weather events will disproportionately impact those who are transportation insecure.³² The discussion of non-coercive physical activity and the physical activity paradox (i.e., the null or negative health effects of occupational physical activity) has been primarily focused on comparisons between occupational and leisure-time activity. The addition of more objective pedestrian streetscape measures of the environment allows for the more analyses on how unfavorable environmental conditions may modify the positive health benefits of active transportation as well. Research along this avenue could provide important data that justifies certain policies and programs in the form of specific active transportation infrastructure.

Among Hispanic/Latino populations, previous research has been dedicated to understanding the so-called “Hispanic Paradox” wherein Hispanic/Latino immigrants maintain better health outcomes than their acculturated peers.³⁴ This field of research has been largely focused on dietary changes between traditional foodways and the US, but future research should expand on the environmental exposures analyzed here to understand how changes in commuting patterns pre- and post-immigration and generationally are impacted by environmental factors. This field of inquiry serves to benefit both Hispanic/Latino communities and isolate the ways in which the unique environmental and cultural factors of transportation in the US impact the health of all our community members.

Call to Action

This dissertation is in many ways the culmination of my admiration for and frustration with the field of public health as a whole. Many academic fields such as sociology or economics (like the basic sciences) are principally and rightfully focused on the scientific method and answering scientific questions. The implications and application of these findings, no matter how political, is often left to policymakers, entrepreneurs, and other actors because (in part), as described by David Hume, the “is” does not infer the “ought”. However, public health’s explicit goal of “promoting health through organized community effort”³⁵ does imply the “ought”, that as we learn new evidence we are obligated to apply it to the real world. This is evident in the coursework we take on health policy and implementation science, and the emphasis of health behavior programs on interventions that are designed to improve population health. However, as the scope of public health has rightfully expanded from being largely biomedical and focused on the individual determinants of health to the modern conception of the social, political, and commercial determinants, the types of interventions and policy influence ascribed to public health professionals have become harder to define. Willingness to address the wicked problems of car-dependency (consistent with the call to action from Garber and Rojas-Rueda),³⁶ climate change, and most-crucially, socioeconomic inequity as key issues challenging public health in the coming decades, is more lackluster than warranted by scientific evidence. The practice of statistically adjusting away the role of income, education, and environmental factors to identify behaviors or easily modifiable material conditions undercuts our ability to argue for policies that, while not explicitly health focused, nonetheless have significant health impacts.

Accordingly, my call to action is that we should consider all of these issues to be public health issues that are worthy not only of research and education, but of public health political advocacy. Public health is uniquely positioned to connect policy choices with tangible health (and downstream economic) outcomes and therefore public health professionals and researchers have an obligation to advocate for policies that seek to reduce economic inequities and create the types of vibrant communities that promote

healthy lifestyles. This work has become increasingly more important as US domestic and foreign policy threaten public health and scientific infrastructure through a barrage of misinformation, disinformation, and defunding.³⁷ The greatest mistake that we can make at this time is not “becoming political” but pretending that politics is separate from the work of public health therefore failing to provide tangible benefits for our communities.³⁸

Conclusion

In conclusion, this dissertation demonstrates the complex and reinforcing interactions between the political, social, and different levels of physical environmental factors in reinforcing health inequities among the predominantly Hispanic/Latino communities of San Diego County, CA. While the findings presented here are not entirely generalizable, the transferability of methodological approaches and transdisciplinary theory-building contribute to the field in important ways. The findings align with a growing effort among physical activity researchers focused on the upstream processes that impede our ability to address some of the largest health challenges of the 21st century. The more holistic approaches to understanding walkability contexts at pedestrian, neighborhood, and political scales employed here can contribute to more discrete and defensible policies to improve health equity.

Efforts to change the entrenched political, cultural, and physical contexts discussed in this dissertation are challenging. Progress cannot and should not be expected overnight. Just as the invention of the automobile in 1885 did not immediately transform our physical and social environment, the work to reshape our communities may also take many generations. However, systems thinking, patience, and the courage to use scientific knowledge for the advancement of health equity are necessary to make progress that we owe not only to ourselves, but future generations.

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