Exploring Risk Factors to Disparities in Pedestrian and Bicyclist Fatalities and Serious Injuries





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FOREWORD

Traffic crashes are a leading cause of death in the United States, and the Federal Highway Administration (FHWA) is committed to reaching zero deaths. FHWA recognizes that some communities are disproportionately burdened by pedestrian and bicyclist fatalities and serious injuries. These disproportionate differences in road safety outcomes across sociodemographic categories are referred to as health disparities, or health inequities, and they are preventable. To reach zero deaths, the risk factors producing these inequities need to be identified and addressed.

Through a scoping review, this report identifies inequitable institutional decisionmaking and infrastructural risk factors that contribute to these disparities. Then, it highlights noteworthy practices implemented by State, regional and local transportation agencies and organizations across the country to address these disparities. Finally, it provides proven practices that agencies may implement to address inequities on the way to achieving the complimentary goals of zero deaths from traffic crashes and safe, reliable, and affordable transportation for all people.

This report may be a useful resource for transportation professionals and other stakeholders interested in road safety to learn how to identify and implement strategies and tools to address inequities in pedestrian and bicyclist safety and the expected benefits of these practices.

John A. Harding
Director, Office of Safety and Operations
Research and Development

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1,000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2,000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	2.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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LIST OF ABBREVIATIONS

AADT	annual average daily traffic
ACTT	Advocacy Council for Tribal Transportation
ADA	Americans with Disabilities Act
APS	accessible pedestrian signal
AT	active transportation
ATI	active transportation infrastructure
BCPHD	Buchanan County Public Health Department
BIPOC	Black, indigenous, and persons of color
BTS	Bureau of Transportation Statistics
CB	census block
CBG	census block group
CBO	community-based organizations
CBR	community-based research
CDC	Centers for Disease Control and Prevention
CT	census tract
DOT	department of transportation
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
JC	Jersey City
JCMAP	Jersey City Mural Arts Program
KSI	killed or seriously injured
LA	Los Angeles
LADOT	Los Angeles Department of Transportation
LPIs	leading pedestrian intervals
LRSP	local road safety plan
MEAL	monitoring, evaluation, accountability, and learning
MET Council	Metropolitan Council
MnDOT	Minnesota Department of Transportation
MUTCD	*Manual of Uniform Traffic Control Devices*
NDOT	Nashville Department of Transportation
NHTSA	National Highway Traffic Safety Administration
NJTPA	North Jersey Transportation Planning Authority
NYC	New York City
NYC DOT	New York City Department of Transportation
NYDT	Nashville Youth Design Team
OMB	Office of Management and Budget
Ph.D.	Doctor of Philosophy
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
PROWAG	Public Right-of-Way Accessibility Guidelines
RRFB	rectangular rapid flashing beacons
RSA	road safety audit
SDOH	social determinants of health
SES	socioeconomic status
SPFAs	senior pedestrian focus areas

SRTS	Safe Routes to School
SSA	Safe System Approach
SSFS	Safe Streets for Seniors
TAZs	traffic analysis zones
TDOT	Tennessee Department of Transportation
TNDL	Transportation Needs in Daily Life
TRID	Transportation Research International Documentation
UMN	University of Minnesota
USDOT	United States Department of Transportation
WOS	Web of Science
YoOS	Year of Open Space
YPAR	youth participatory action research

CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

Traffic crashes are a leading cause of death in the United States. An extensive body of traffic safety literature explores the roadway design and behavioral contributors to fatal and serious injury crashes. Within this literature, there has been a growing recognition that some populations are significantly more likely to be killed or seriously injured (KSI) in traffic crashes. In particular, various analyses have demonstrated stark overrepresentation of Black and indigenous people and people with low incomes (Glassbrenner et al. 2022). These differences in health and safety outcomes across sociodemographic categories are referred to as health disparities, or health inequities,[1] and they are preventable.

Through a scoping review of literature and case studies of innovative practices, this report identifies inequitable institutional and infrastructural risk factors that contribute to disparities in fatal and serious injury crashes across five sociodemographic categories: race and ethnicity, socioeconomic status (SES), age, disability, and sex and gender. The report also highlights seven case studies from State, regional, and local agencies and organizations across the United States. The findings inform the development of proven practices for practitioners at Federal, State, regional, and local agencies and their partners to address these inequitable institutional and infrastructural risk factors on the way to achieving the goals of zero deaths from traffic crashes and safe, reliable, and affordable transportation for all people.

1.2 HISTORICAL OVERVIEW

It is beyond the scope of this report to detail historical policies, practices, and processes that have contributed to inequities in traffic fatalities, as they are numerous, vary across localities and geographies, and have received extensive attention in scholarly and governmental research elsewhere. Instead, in this section, the researchers provide an overview of pertinent policies and institutional decisionmaking processes that have been identified to contribute to present-day inequities in transportation and road safety. The researchers reference resources for further reading.

A range of economic, transportation, and housing policies and practices harmfully impacted Black, indigenous, and persons of color (BIPOC) individuals and continue to contribute to present-day inequities, including disparities in fatal and serious injury crashes (Reft, de Lucas, and Retzlaff 2023; Rothstein 2017; Taylor et al. 2023). These policies and practices include residential racial segregation through redlining, blockbusting, and exclusionary zoning (Rothstein 2017); the construction and expansion of the interstate highway system through urban neighborhoods with Black and Brown communities (Reft, de Lucas, and Retzlaff 2023); and systemic disinvestment in public transit (Archer 2020). Studies have demonstrated that many of these policies were, in specific instances, intentionally implemented to segregate, disenfranchise, or dispossess BIPOC communities (Rothstein 2017; Archer 2020). Today, many of these policies and practices remain embedded in institutional decisionmaking processes and (re)produce unfair

[1]Disparities refer to preventable differences in health outcomes. Inequities refer to systematic, unjust, and unfair differences in the opportunities individuals and communities have to achieve the highest level of health.

treatment of, and disparate outcomes for, BIPOC individuals: these entrenched and persistent policies and practices have and continue to perpetuate structural racism, systemic racism, and institutional racism (Jones 2014, 2000; Braveman et al. 2022; Lett et al. 2022).

Additionally, for decades, policies and design of the transportation system in the United States have prioritized and subsidized infrastructure for cars and underinvested in infrastructure that supports walking, bicycling, using micromobility, and accessing safe, reliable, and affordable public transit (Agyeman and Doran 2021; Chiarenza et al. 2023). Some refer to the organizational culture that promotes projects for motor vehicle infrastructure as autonormativity (Agyeman and Doran 2021). As elaborated in the Federal Highway Administration's (FHWA) report on *Improving Pedestrian Safety on Urban Arterials: Learning from Australasia* (Chiarenza et al. 2023), the emphasis on motor vehicle mobility and access in the United States, at the expense of all other modes, causes negative outcomes, including vulnerable road user deaths and serious injuries, worsening air quality, inequitable access to opportunity, and low-density, sprawling development patterns (Chiarenza et al. 2023). Additionally, autonormativity creates a lack of affordable transportation options, imposing a high transportation cost burden on communities and a disproportionately high burden on people with low SES across urban, suburban, and rural areas (Bureau of Transportation Statistics (BTS) 2024). According to BTS (2024), households in the lowest income quintile spent 30 percent of their after-tax income on transportation in 2022, largely as a result of owning or leasing a vehicle, compared to 12 percent for households in the highest income quintile.

This structural history is incomplete without considering the work of activists and organizers who contested these systems and who offer alternatives to address the continuing harm of their legacies (Reft, de Lucas, and Retzlaff 2023). The civil rights movement, which eventually overturned many racially discriminatory policies and practices, was rooted in the emblematic protest of Rosa Parks, organizing of Jo Ann Robinson in the Montgomery Bus Boycott, and the work of many other leaders and individuals who led and participated in marches, bus boycotts, and *The Negro Motorist Green Book* (Green 1937). These efforts spurred the Federal Government to adopt civil rights statutes, including the Civil Rights Act of 1964 (Code of Federal Regulation 2023), the Voting Rights Act of 1965 (U.S. Commission on Civil Rights 1965), and the Fair Housing Act of 1968 (Title VIII of the Civil Rights Act 1968). They also inspired environmental rights, women's rights, and disability rights movements, which in turn led to the adoption of the National Environmental Policy Act in 1970 (National Environmental Policy Act 1970) and the landmark Americans With Disabilities Act (ADA) of 1990 (2014). These movements for fairness and justice provide a foundation for this scoping review and proven practices.

1.3 EQUITY AND THE SAFE SYSTEM APPROACH

Recently, the transportation safety field led a paradigm shift in its approach to address the crisis of roadway fatalities and serious injuries on the Nation's highways, roads, and streets. Agencies across the country, including the U. S. Department of Transportation (USDOT), adopted a bold goal of zero deaths (USDOT. n.d.b.). As of February 2024, the Vision Zero Network recognized 59 communities as committing to Vision Zero (FHWA 2024b), a clear goal of eliminating traffic fatalities and serious injuries (Vision Zero Network 2024). More than 160 organizations, including State and local transportation agencies, State safety offices, businesses, and nonprofits

committed as allies in action to support implementation of USDOT's National Roadway Safety Strategy (USDOT 2024). According to the National Complete Streets Coalition, more than 1,700 jurisdictions, including 35 States, Puerto Rico, and the District of Columbia, have adopted Complete Streets policies, which demonstrate commitments to safe, accessible, and healthy streets for all users (Smart Growth America 2024a).

To achieve the goals of zero deaths and safety for all users, agencies are implementing the Safe System Approach (SSA), a human-centered framework that refocuses transportation system design and operation on anticipating human mistakes and diminishing impact forces (i.e., kinetic energy transfer) to reduce crash severity for all road users (USDOT 2022). Its key tactics include separating users in space (e.g., sidewalks and separated bike lanes) and time (e.g., pedestrian hybrid beacons and leading pedestrian intervals (LPIs) with accessible pedestrian signals (APSs)), managing kinetic energy transfer (e.g., setting appropriate speed limits), and increasing attentiveness and awareness of road users (e.g., street lights and rumble strips) (Hopwood, Little, and Gaines 2022). Implementing the SSA also requires improving safety culture and increasing collaboration among many stakeholders.

Although the SSA was not initially founded with an embedded framework to address transportation inequities or racial injustice, equitable implementation approaches have been shown to reduce crash risk for all communities as the researchers demonstrate later in this report (see chapter 3). Achieving zero deaths requires transportation professionals to better understand all contributors to roadway fatalities and serious injuries. An equity-informed approach, which meaningfully identifies and addresses institutional and infrastructural risk factors that contribute to traffic fatalities and serious injuries, is essential for the effective implementation of SSA tactics to ultimately achieve the goal of zero deaths (Ederer et al. 2023).

For the purpose of this report, the researchers define equity as the consistent, systematic, fair, just, and impartial treatment of all individuals, including individuals who belong to underserved communities that have been denied such treatment, such as the following groups (White House 2021):

- Black persons.
- Latino persons.
- Indigenous and Native American persons.
- Asian Americans and Pacific Islanders persons.
- Other persons of color.
- Members of religious minorities.
- Lesbian, gay, bisexual, transgender, and queer persons.
- Persons with disabilities.
- Persons who live in rural areas.
- Persons otherwise adversely affected by persistent poverty or inequality.

In an equitable society, race, background, or identity do not predict an individual's quality of life. Achieving equity requires removing social, economic, contextual, institutional, systemic, and structural barriers and addressing the ongoing or pervasive impacts these barriers have caused, providing everyone what they need to thrive. Equity is not the same as equality

(figure 1). Equality assumes that everyone is at the same starting point and has faced the same circumstances and challenges. Instead, equity has three requirements: valuing all individuals and populations, recognizing and rectifying historical injustices, and providing resources according to need (Jones 2014). Equity-related efforts can and should be led by individuals, agencies, and institutions that have dominant power—particularly Government agencies and staff—to create and memorialize policies, practices, and processes that prevent or undo exclusion and harm (Coalition of Communities of Color 2024).

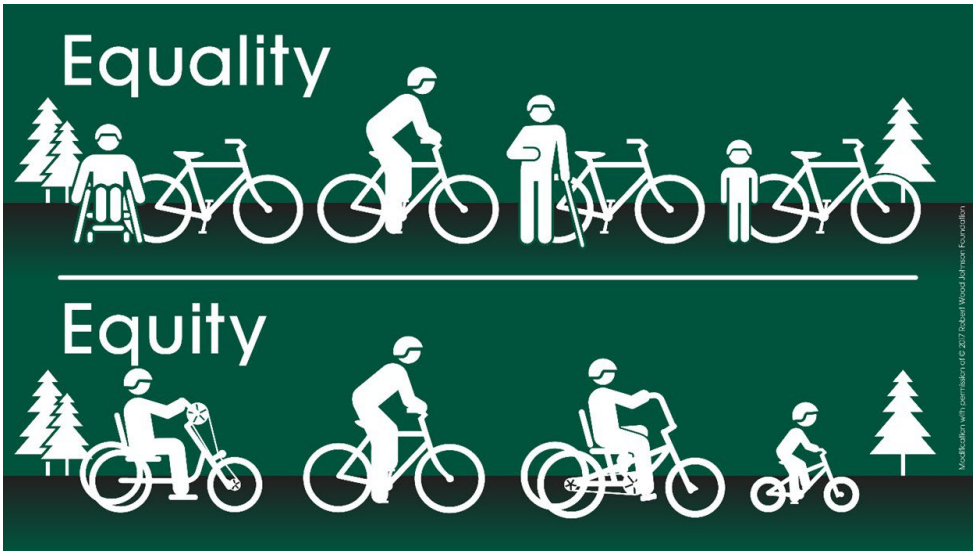

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Figure 1. Illustration. Equality versus equity.

Transportation equity (Krapp, Barajas, and Wennink 2021), in turn, is an outcome that provides all people safe, reliable, and affordable transportation through a process that accomplishes the following:

- Provides meaningful opportunities for underserved communities to participate in the transportation decisions that affect them.
- Allocates resources based on communities' needs and priorities, with the aim of addressing existing disparities and removing the effects of past and present-day discrimination.
- Fairly distributes benefits and burdens of transportation policies, plans, projects, and funding between individuals and groups that differ by race, SES, disability, age, gender, and other sociodemographic categories.
- Aims to protect and increase the benefits—with an emphasis on safe access—for underserved communities, especially Black and indigenous communities with low SES.

1.4 MULTIDISCIPLINARY APPROACH

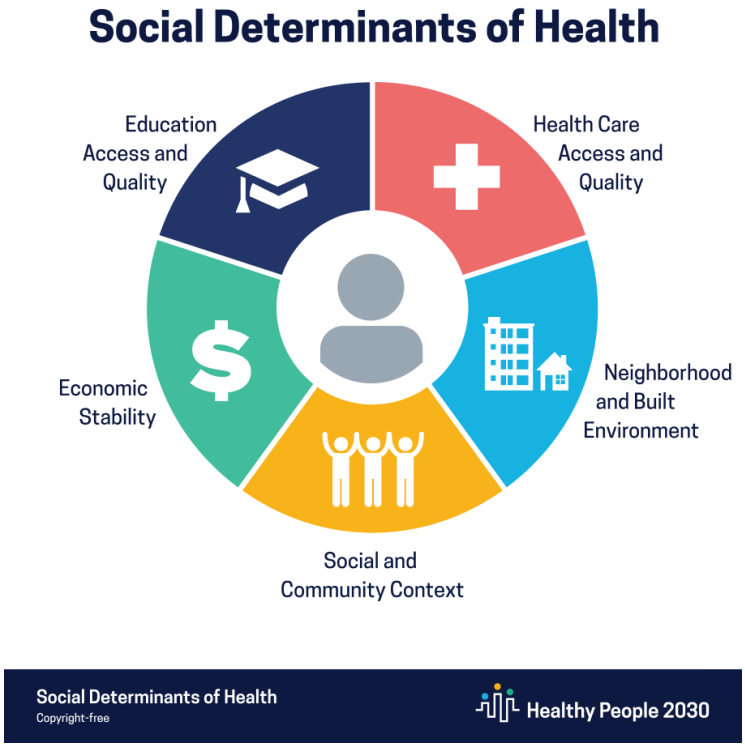
Both road safety and transportation equity are multidisciplinary fields that draw on a wealth of expertise to achieve their interconnected goals of zero deaths and safe, reliable, and affordable transportation for all people. This report draws on the knowledge and experience of experts in road safety, public health, and the social sciences. The frameworks applied across these fields build on each other and provide insights to comprehensively understand and address the risks and inequities contributing to the Nation's road safety crisis. They include the SSA, safe system pyramid, and key considerations from the social sciences to frame and understand findings.

This report follows a multidisciplinary approach that bridges frameworks from engineering and human factors traffic professionals, public health experts, and social scientists to excavate the inequitable institutional and infrastructural risk factors that may contribute to disparities in pedestrian and bicyclist fatalities and serious injuries. By addressing these risk factors through a multidisciplinary approach, individuals and institutions can take intentional and meaningful action to redress disparities on their path to ultimately eliminate all roadway fatalities and serious injuries.

Road safety researchers and professionals attempt to identify risk factors that contribute to, and countermeasures that may mitigate or eliminate, traffic crashes. Often, these risk factors are defined as roadway design elements (infrastructure) or road user behaviors in relation to the transportation system (human factors). Traffic safety studies demonstrate that infrastructure and human factors contribute to the risk of fatal and serious injury crashes. Recently, traffic safety professionals adopted the SSA described in section 1.3. In practice, practitioners can implement the SSA by performing the following (USDOT 2022):

- Prioritizing safety in transportation policy and planning.
- Refocusing transportation system design and operation on anticipating human mistakes and lessening impact forces to reduce crash severity for all road users (e.g., remove severe conflicts and reduce vehicle speeds).
- Strengthening safety culture in agencies.
- Increasing collaboration among transportation and land use stakeholders.

Public health researchers and professionals adopt a social determinants of health (SDOH) approach to understand and address public health issues (figure 2). SDOH refer to nonmedical factors—like access to transportation options, housing, healthcare, high-quality green space, places for physical activity, and food—that affect health outcomes, including traffic fatalities and serious injuries (U.S. Department of Health and Human Services n.d.).



Source: U.S. Department of Health and Human Services.

Figure 2. Illustration. SDOH (U.S. Department of Health and Human Services n.d.).

Public health experts have also developed a conceptual model that links SDOH and health equity as depicted in figure 3. The root causes contributing to inequities, such as structural racism and ableism, manifest across social, political, and economic systems through structural tools, like laws and policies; organizational policies, practices, and budgets; collaborative governance; and data and research. These tools impact the distribution of the SDOH, which, in turn, produce differences in health and quality-of-life outcomes across communities (Porter et al. 2023). These preventable differences in health outcomes between communities are referred to as *health disparities*. Public health professionals work to locate and address the sources of health disparities, including the drivers of health inequity, to allow all people to reach the highest level of health possible.

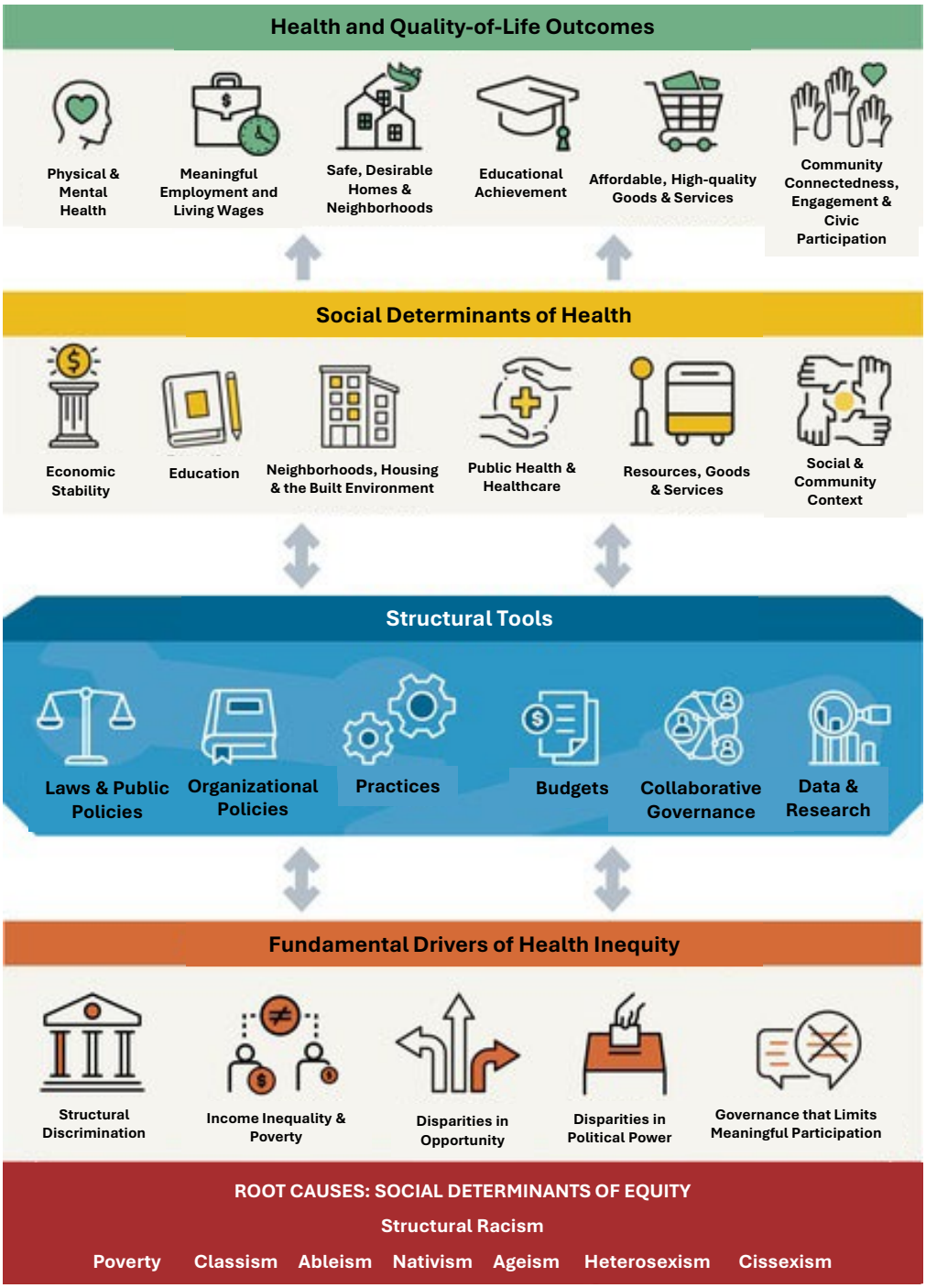


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Figure 3. Illustration. Framework linking SDOH and health equity (Porter et al. 2023).

Applying these models to road safety, public health experts developed the safe system pyramid (figure 4), which prioritizes transportation safety interventions that maximize the population health impact and minimize individual effort (Ederer et al. 2023). Consistent with the model in figure 3, the pyramid emphasizes that the most effective strategies address the drivers of health inequity. This report aims to excavate the socioeconomic factors at the base of this pyramid.

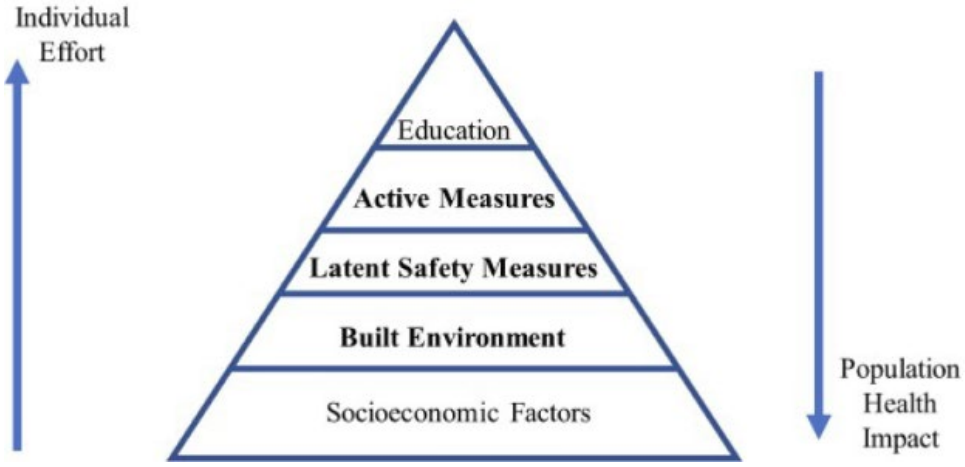

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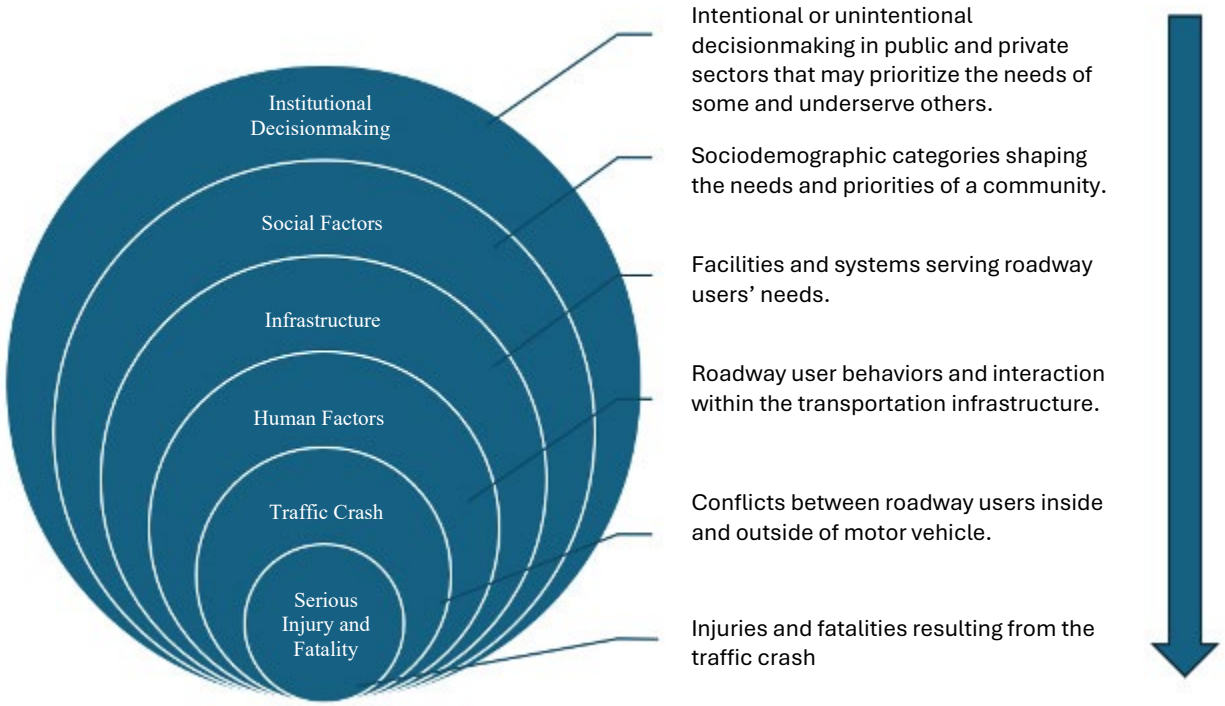
Figure 4. Illustration. Safe system pyramid (Ederer et al. 2023).

Social scientists investigate the complex relationships and interrelationships between the categorization of people into sociodemographic groups such as race and ethnicity, SES, etc., and social, economic, political, and health opportunities and outcomes (figure 5).

Social scientists provide three important frameworks to consider when investigating equity:

- Specificity: Individuals and communities experience risks in relation to the transportation system differently based on their community's history, individual abilities and needs, and access to resources:
    - As such, many risk factors—like car ownership—are *not universal* but are rather lived locally and require further examinations at community levels to better understand and address specific needs, relationships with the built environment, and contexts of specific communities and individuals (Fan 2023).
    - Additionally, risk factors are not *determinant*, meaning that being categorized into a specific social group should not be interpreted to essentialize an individual's needs: for example, individuals with low incomes may be less likely to have access to vehicles and rely on pedestrian and bicyclist infrastructure, but many individuals with low incomes may own vehicles, while some individuals with higher incomes may choose not to, or be unable to, own vehicles (Zivarts 2024).
    - Finally, risk factors are not comprehensive or *mutually exclusive*. For example, disparities in traffic fatalities based on income should not be explained by only one factor like vehicle ownership; instead, there are multiple factors that compound to contribute to these disparities.



Source: FHWA.

Figure 5. Illustration. Relationship between institutional decisionmaking, sociodemographic categories, and road safety.

- Intersectionality: Social scientists highlight that people experience multiple, overlapping, and compounding privileges or barriers based on their categorization in interconnecting social categories such as race and ethnicity, SES, age, disability, and sex and gender (Crenshaw 1989; Fan 2023). When applied to equity in roadway safety, intersectionality explains that people—particularly those in underserved communities who are characterized as having multiple marginalized identities—often experience overlapping and compounding barriers that affect their ability to move and access destinations safely.

  Examine, for example, two individuals who need to get groceries from a store located at an intersection that does not have sidewalks or safe pedestrian crossings. The first individual does not have access to a vehicle, and the second person does not have access to a vehicle and uses a wheelchair. Both individuals face the risk of having to navigate a roadway without safe pedestrian facilities, but the second individual faces a compounding risk of inaccessible facilities (figure 6). Intersectionality is a critical lens that not only frames the real barriers that individuals and communities face but also empowers decisionmakers to implement solutions that meaningfully consider and improve safe access for all users. Intersectionality requires understanding how people experience compounding barriers and addressing barriers systematically to achieve safe access for all road users.

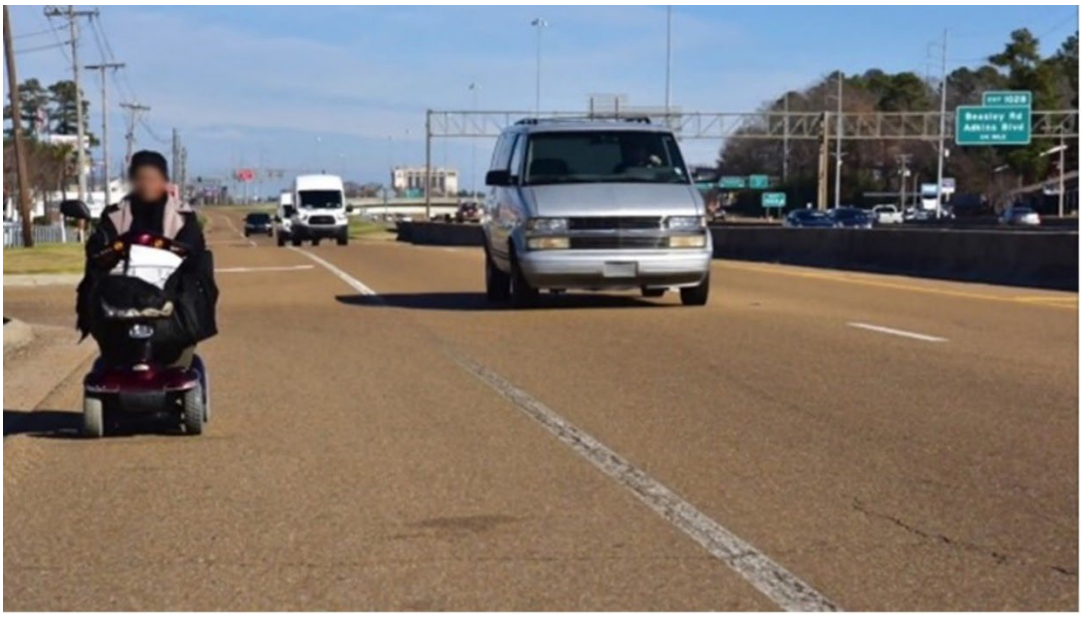


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Figure 6. Photo. Divided by design (Smart Growth America 202b).

- Structure and agency: Agency is defined as the capacity for individuals and communities to impact their lives, and structure is defined as the set of institutions and organizations that empower or conscribe the agency of individuals. Social scientists demonstrate how institutions, like governments and private industry, make decisions about systems, like the transportation system, that may privilege the agency and needs of some while underserving the needs and disempowering the agency of others. Importantly, they emphasize that institutional decisions are agential; in other words, there are people in institutions and organizations that make, reproduce, or disrupt these decisions. These institutions include Federal, State, regional, and local Governments; private sector organizations, including design consultants, vehicle manufacturers, and insurance companies; and other organizations. Social scientists demonstrate that people in these institutions have historically made and may continue to reproduce decisions that intentionally or unintentionally privilege some communities, by prioritizing their needs through investments and meaningful representation, and disadvantage other communities, by disinvesting in their needs and underrepresenting or excluding them from decisionmaking.

  For example, governments (who distribute funding and provide design guidance) and private companies (who develop technologies and contribute to designing and constructing roads) make decisions about the transportation system (like whether there are curb ramps or not at a crossing) with or without community leadership or involvement that can enable or disable a person from being able to safely and independently move throughout their community. In short, social scientists attempt to excavate specific risk factors to enable decisionmakers in institutions to identify, mitigate, and eliminate barriers and shift power so all people have agency in the decisions that impact their lives.

In summary, this report uses a multidisciplinary approach to explore risk factors that variably impact individuals categorized across five sociodemographic categories, with an intersectional lens where possible: race and ethnicity, SES, age, disability, and gender. The report highlights findings from research that specifies how institutions can meaningfully integrate considerations based on these risk factors into their decisionmaking processes to address inequities contributing to disparities in pedestrian and bicyclist safety and make progress toward the goals of zero deaths and safe, reliable, and affordable transportation for all people.

1.5 REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Chapter 2. Scoping Review.
- Chapter 3. Noteworthy Case Studies.
- Chapter 4. Proven Practices and Future Research.
- Chapter 5. Conclusions.
- Appendix and References.

CHAPTER 2. SCOPING REVIEW

2.1 INTRODUCTION

In this chapter, the researchers first present the scoping review approach, which is divided into two phases. Then, the researchers present the findings to address the following research questions:

- Analysis methods: What methods are commonly used in studies to describe and explain disparities in roadway fatalities and serious injuries? Section 2.3.1 reviews how the sociodemographic categories of interest are variably defined and framed in the studies the researchers reviewed, and the researchers provide a critical perspective based on social science expertise. Section 2.3.2 presents geographies and spatial units, and section 2.3.3 provides overview of how safety performance measures are variably defined across studies. Section 2.3.4 presents three quantitative approaches used to address equity in highway safety and planning literature: model comparison, interaction term, and structural equation modeling. These methods are primarily applied when investigating SES and race and ethnicity. The researchers also highlight qualitative methods, including policy analysis, qualitative surveys, and interviews.

- Risk factors: What risk factors contribute to disparities in road safety outcomes? The researchers review available literature for five sociodemographic categories: race and ethnicity (section 2.3.5.1) , SES (section 2.3.5.2), age (section 2.3.5.3), disability (section 2.3.5.4), and sex and gender (section 2.3.5.5). Each section describes the results of studies that have investigated disparities across these respective categories and highlights relevant institutional and infrastructural risk factors investigated in the literature. Within the discussion for each section, the researchers highlight intersectional findings where they are available in the literature.

- Active transport investments: How do active transportation (AT) investments variably apply to and impact underserved communities? In section 2.3.6, the researchers briefly attend to this question by highlighting available research on variable implementation of AT investments in underserved communities; the multitude of safety, environmental, and health disparities identified; and a brief discussion of research on displacement and gentrification.

The chapter ends with a discussion of limitations and gaps found in the literature. The proven practices and future research topics are discussed in chapter 4.

2.2 LITERATURE SEARCH APPROACH

The scope and interdisciplinary nature of these questions presented significant methodological challenges, spurred discussions among the research team members and with two expert panels established to advise this effort, and required multiple pivots to meet the goals of the project. In section 2.2.1, the researchers provide a positionality statement on the researchers and expert panelists who contributed to this report to contextualize the findings.

The research team's focus was to identify a range of possible studies, across disciplines, that could elucidate risk factors contributing to disparities in roadway fatalities and serious injuries that practitioners and researchers across multiple fields can consider and address in their respective work. While initially intended to be a systematic literature review, the research team ultimately opted to conduct a scoping review. Unlike a systematic review, a scoping review allows the team to have a broader focus to identify and map what is currently known (Arksey and O'Malley 2005).

Through the scoping review, the researchers address the variance in the conceptualization across and within the sociodemographic categories that interest this study, different definitions of safety, and different methodological and disciplinary approaches in the literature. Additionally, the researchers are able to highlight a range of risk factors while contextualizing how the risks were identified through a narrative review of selected studies. In summary, this approach allows the team to address the questions listed in section 2.1, Introduction, including excavating infrastructural and institutional risk factors, understanding how these factors are variably defined and studied, and then, using a narrative approach, contextualizing the findings.

As such, the research team used an evolving review methodology to search, identify, and summarize the literature search results. The researchers divided the review into two phases. In phase I, the research team used the systematic review approach process proposed by Xiao and Watson (2019) to search, identify, and summarize the review findings. In this phase, the research team used literature from various areas including highway safety, engineering, planning, and public health. After assessing the identified literature, the research team identified significant differences and gaps across the literature. For example, there were significant methodological differences within and between studies addressing risks across the five sociodemographic categories of interest, requiring the team to contextualize how these sociodemographic categories are variably defined and investigated and how that may impact findings. Additionally, given that this topic was an emerging priority with great interest in the research community, relevant studies were consistently being identified by the team through conferences, references, and suggestions by expert panel members. Since the goal of the study is to provide a timely, comprehensive, and reliable overview of risk factors for practitioners and researchers to consider, the research team decided to supplement phase I with a phase II that expands the search by scoping and integrating additional relevant research. The researchers clearly document how studies were identified to ensure transparency.

2.2.1 Positionality

To effectively present the results, the researchers begin with a positionality statement to contextualize their findings. According to Daly et al. (2023):

> Positionality is the reflective process of understanding our own social position and identity relative to others and the work we engage in (for example, research, technical assistance, nonprofit programs). Social constructions like gender, race, and class, and the way these all intersect with each other, determine individuals' social positions, which significantly shape our experiences, power, privileges, and even expertise. All of these factors, in turn, shape the thinking, approach, and process of our work in overt and subtle ways.

As researchers or professionals, one might relate to the positions of the communities they are researching/working with in different ways that could impact both how the researcher/professional views the communities and how the communities, in turn, view the researcher/professional. This relationship between the researcher/professional and community members might influence the types of questions a researcher/professional decides to ask, the ways that community members decide to answer the researchers'/professionals' questions, what data are chosen to be included or not included in a study/plan/project, and how the researcher/professional analyzes data, whether qualitative or quantitative. Often, researchers strive for objectivity when studying or implementing a project, but many social scientists and public health professionals believe that true objectivity is impossible because people simply cannot leave behind their own backgrounds and the thoughts and ideas, many subconscious, they bring with them. For this reason, social scientists often include "positionality statements" in their work. If true objectivity is impossible, the next best thing is to recognize and acknowledge the backgrounds and starting points of the researchers/professionals and keep these social constructions in mind while reviewing and considering their work.

In that spirit, the authors who contributed to this report represent a diverse array of lived experiences and professional expertise. The contributors included Federal employees, faculty, and graduate students. The authors' perspectives were further fortified by a diverse expert panel representing a range of Federal agencies, nonprofit organizations, and university researchers. Personally, some authors and panelists choose or are reliant on walking and biking, and some have been impacted by traffic crashes. Professionally, multiple disciplines were represented, including highway safety planners and engineers, sociologists, anthropologists, and public health professionals. However, the project lacks representation from indigenous communities, people who use wheelchairs, people who have cognitive or intellectual disabilities, children, and people experiencing homelessness. These gaps in lived experience may have shaped the questions, research methods and interpretation of findings included in this report.

2.2.2 Phase I—Systematic Review

Using recommendations from the process proposed by Xiao and Watson (2019), the researchers use the eight-step process to plan, conduct, and report the review:

1. Formulate the problem and write specific research questions.
2. Develop and validate the review protocol and eligibility criteria.
3. Search the literature via title and abstract review.
4. Screen for inclusion based on the inclusion criteria.
5. Assess the quality.
6. Extract the data.
7. Analyze and synthesize the data.
8. Report the findings.

The literature review tried to address the following three research questions:

- What methods are commonly used in studies to describe and explain disparities in roadway fatalities and serious injuries?

- What risk factors contribute to disparities in road safety outcomes?
- How do AT investments variably apply to and impact underserved communities?

After defining the research questions, a list of search terms was identified. The search terms were divided into nine areas: safety; road user; equity; socioeconomic and demographic categories; roadway infrastructure; active transportation infrastructure (ATI); displacement and land use; homelessness and housing insecurity; and transportation professionals. .

Table 1 shows the list of search terms per area.

Table 1. List of areas and search terms.

Area	Search Terms
1. Safety	Safety Crash Accident* Fatal* Injur* Death Collision Casualty Perceived safety Perception of safety Security Public safety (policing) Community violence Surrogate safety
2. Road use/users	Walk* Bik* Bicycl* Cycl* Pedestrian Active travel Bikeshare/bike share/bike sharing E-scooter Electric scooter Micromobility Vulnerable road users Nonmotor*

Area	Search Terms
3. Equity	Disparit* Equit* Equalit* Fairness Exclusion Justice Injustice Vulnerability Structural racism*
4. Socioeconomic and demographic categories at the community level	Demographic* Economic* Income Poverty Ethnic* Minorit* Race Racial Disab* Trib* Indigenous Immigra* Undocumented immigra* Underserved Underrepresented Disadvantaged
5. ATI	Sidewalk Shared used path Bicycl* infrastructure/cycl* infrastructure Bike lanes Bicycl*/cycl* facilities
6. Displacement and land use	Gentrif* Environmental gentrify* Green gentrify* Displace* Segregat* Environment justice Suburbanization
7. Homeless and housing insecurity	Homeless* Houseless* Housing insecure* Shelter* Unshelter* Unhoused

Area	Search Terms
8. Transportation professionals	Fund* Plan* Design* Construct* Invest* Capital
9. Roadway infrastructure	Road infrastructure Street infrastructure Road/street environment Road/street characteristic* Road/street design Road/street condition Quality Maintenance

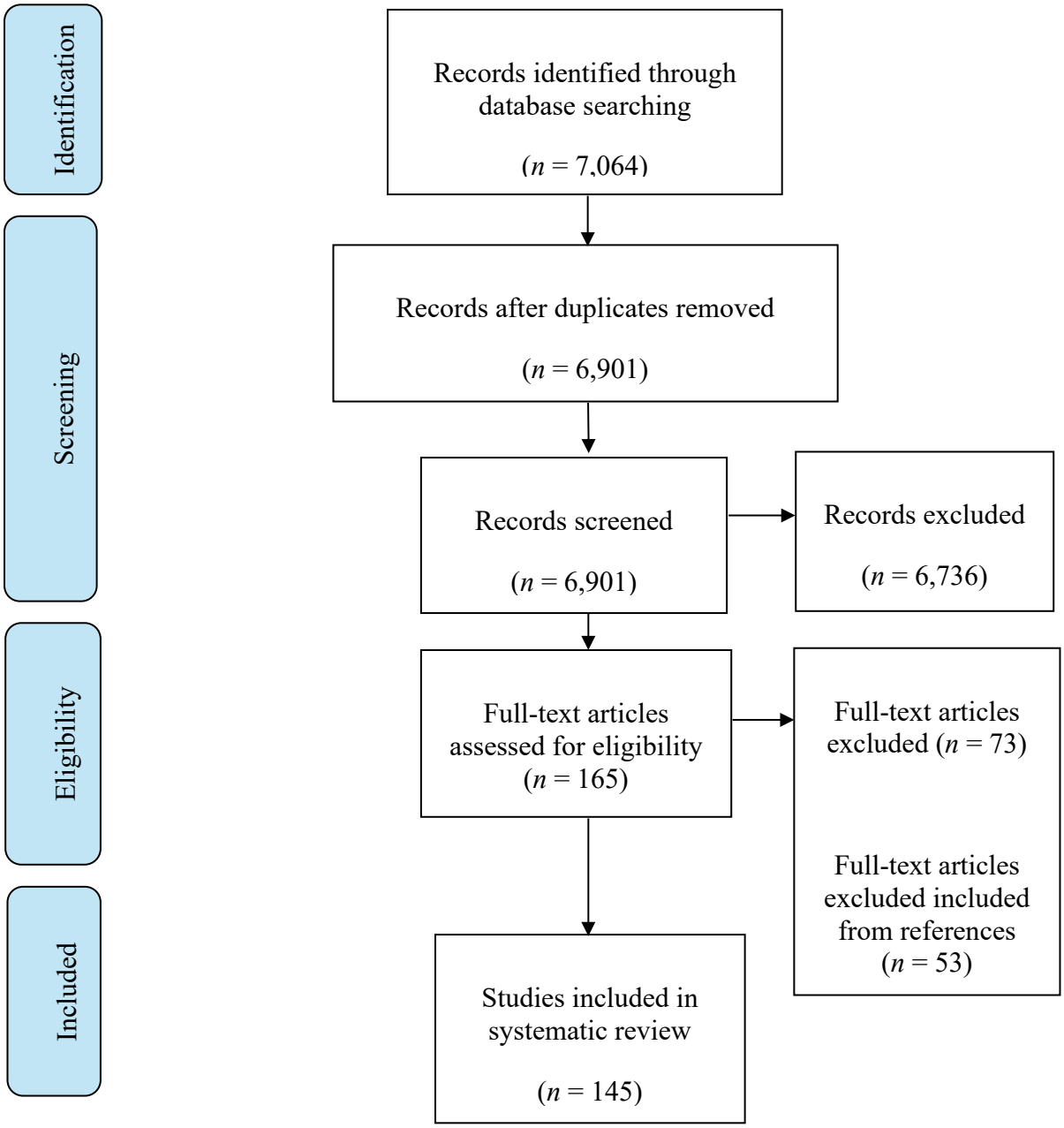
*Wildcard character.

After developing the list of search terms, the librarian conducted a search of computerized databases such as Transportation Research International Documentation (TRID) (National Academies of Sciences, Engineering, and Medicine 2024), Web of Science (WOS) (Clarivate 2024), and Google® Scholar™ (Google 2024) based on the following eligibility criteria:

- Year: 2000–present.
- Language: English.
- Location: All.
- Study design: Qualitative and quantitative.
- Balance between peer-reviewed, empirical studies, and gray literature.

The initial search of literature yielded 7,064 studies. Two researchers then completed the screening and selection of literature based on the relevance of studies to the research objective using the Covidence (n.d.) software. The research team conducted a systematic review of the literature to address research questions 1 and 2 following the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines (Page et al. 2021). As the systematic search of the literature did not yield many results related to safety concerns among people experiencing homelessness, the research team conducted another search based on a snowballing method from the systematic literature review results and search engines such as Google to identify the relevant gray literature, which includes agency reports and news media, on this topic. The team ultimately decided to cover this topic more comprehensively in a separate FHWA Case Study Report entitled *Promising Practices for Transportation Agencies to Address Road Safety among People Experiencing Homelessness: Case Studies in Current Practice* to address the significant gaps identified (FHWA 2024b). Similarly, due to the lack of relevant studies on active transport investments, the research team turned to the expert panel to address research question 3.

The researchers identified 7,064 records, including journal articles, conference papers, and research reports from WOS and TRID. After the initial screening of the paper by title and abstract, the researchers identified 165 records for full-text review. After additional assessment and exclusion, a total of 145 articles were reviewed in phase I (figure 7).



Source: FHWA.
n = number.

Figure 7. Flowchart. Systematic review process.

The full-text review examined whether the article aligns with the research questions and extracted structural information based on the research questions. Most of the literature identified during the systematic search is from the United States; however, there are also some international studies. For the final narrative review for question 2, the research team primarily included the U.S.-based studies.

2.2.3 Phase II—Scoping Review

After the phase I literature review, the research team performed a broader scoping review of the literature. As these questions are actively being investigated and new research is consistently published, the research team determined that to meet the goal of excavating risk factors that contribute to disparities in road safety across the sociodemographic categories of interest, the study would benefit from including additional literature. In this phase, the research team added new publications to the literature review as they became available through new academic publications, conferences, and targeted searches as well as suggestions from the expert panel. The new collected studies provided public health, sociological and policy discussion on topics not typically included in traditional transportation safety studies. Specifically, they added new interdisciplinary methodological approaches to research and investigate disparities in pedestrian and bicyclist fatalities and serious injuries, a deeper understanding of institutional risk factors contributing to disparities in road safety, and critical frameworks for framing and contextualizing findings. Overall, 171 studies are elaborated in the scoping review in section 2.3, including 118 from the scoping review process (phase II) and 53 that had been identified and reviewed during the systematic review process (phase I). Some of the phase I studies were removed in phase II if their findings did not elaborate specific institutional and infrastructural risk factors that contribute to disparities in pedestrian and bicyclist fatalities and serious injuries.

2.3 SCOPING REVIEW FINDINGS

In this section, the researchers present the findings from the scoping review. First, the researchers highlight how the studies variably define or frame the five sociodemographic categories, geographies and spatial units, and safety outcome metrics. The researchers supplement the review of how studies have defined or framed the sociodemographic categories with critical perspectives based on expertise from the social scientists on the team and feedback from expert panelists. Then, the researchers highlight common quantitative and qualitative methodologies used to conduct analyses. Lastly, the researchers provide a narrative review of selected studies and summary tables to highlight identified risk factors.

A summary of socioeconomic factors used in quantitative studies is presented in table 8 in the appendix and is discussed in following subsections in more detail.

2.3.1 Framing Sociodemographic Categories

The studies in the literature review explored multiple sociodemographic categories, and they used different definitions, data sources, and aggregation methodologies to represent their population of interest. In the following subsections, the researchers summarize how the five sociodemographic characteristics were defined across studies in the review and supplement this summary with critical perspectives.

2.3.1.1 Race and Ethnicity

Few of the studies defined, framed, or contextualized their interpretation of race and ethnicity. Almost all studies used the U.S. Census Bureau's variables for race and ethnicity, which are based on the demographic categories established by the Office of Management and Budget (OMB) (Office of the Federal Register 1997). Since 1997, OMB has defined ethnicity as a binary choice—Hispanic/Latino or not Hispanic/Latino—and race as five minimum categories—American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, and White.

Note that while race and ethnicity have been reported separately in the U.S. Census, most studies combine them into the following categories: Hispanic, non-Hispanic White, non-Hispanic Black or African American, etc. Many studies aggregate all non-White race and ethnicity groups into categories including "minority populations"[1] and "persons of color," in part because aggregation may be the best option available because of sample size. This aggregation is common in safety planning and environmental justice studies, where potential impacts on "minority populations" in a specific geographical unit (like census tracts (CTs)) are compared to a regional or statewide average to determine if there are disproportionate impacts on these communities. This methodology is criticized as data aggregation and comparison to an average threshold can erase impacts on specific groups (Kauh, Read, and Scheitler 2021). For example, aggregating Hispanic, Black and Asian race and ethnicity categories may erase disparities experienced specifically by Black individuals in a community. Even some of the race categories themselves are aggregates that may mask differences and potential disparities; for example, the race category of Asian masks potentially meaningful differences across a diverse population representing Chinese, Bangladeshi, Vietnamese, Japanese, and people from many other national origins. Title VI analysis requires disaggregation based on available race, color, and national origin data to ensure that there are not disparate impacts on these specific communities (U.S. Congress 2008; Code of Federal Regulations 2023).

Similarly, most studies that addressed indigenous communities use OMB's race category of American Indian or Alaska Native, which refers to "a person having origins in any of the original peoples of North and South America (including Central America), and who maintains Tribal affiliation or community attachment" (Office of the Federal Register 1997).[2] Most studies refer to the race category of American Indian or Alaska Native as "Native American." Though many indigenous communities have been subjected to dispossession and discrimination by the Federal and State Governments, they have specific histories, cultures, natural environments, and systems of governance and sovereignty. Quick, Larsen, and Narváez (2019) distinguish between studies that examine population level disparities using the race and ethnicity category of American Indian or Alaska Native and geographic studies that contextualize road safety risks on mostly

[1]The research team uses the term "minority" only for the purpose of accurately representing the phrasing used in the studies. The team recognizes that "minority" is a term that is antiquated in scholarship and does not adequately reflect the identities or experiences of people in communities of color.

[2]The revised standards, as of March 2024, have updated the definition of American Indian or Alaska Native to to "individuals with origins in any of the original peoples of North, Central, and South America, including, for example, Navajo Nation, Blackfeet Tribe of the Blackfeet Indian Reservation of Montana, Native Village of Barrow Inupiat Traditional Government, Nome Eskimo Community, Aztec, and Maya" (Office of the Federal Register 2024).

rural American Indian lands. They elaborate the difference between the terminology of "Tribal lands," "Indian Country," and "reservation," which are all variably defined in various Federal statutes but are often used interchangeably in the literature. "Tribal lands" is defined by Federal laws and often refers to any land in the ownership of the 574 federally recognized tribes, which is a larger area than "reservations" since only 326 tribes have a formal reservation. "Tribal lands" in turn exclude many geographies where American Indians live that are included in the broader definition of "Indian Country," which includes Oklahoma Tribal statistical areas, lands established under the Alaska Native Claims Settlement Act of 1971 (2019), and lands of native Hawaiians or tribes that are not federally recognized.[3] The researchers use the term indigenous communities throughout the report.

To social scientists, race and ethnicity refer to the social categorization and racialization of people based on their physical appearance, national origin, and cultural expression. Demographic categories for race and ethnicity are not fixed biological categories; they are socially defined and fluid, i.e., they change over space and time.[4] In fact, in 2023, OMB released new guidance that updates standards for collecting and reporting race and ethnicity data for the 2030 Census (Office of the Federal Register 2024, U.S. Census Bureau 2024). The update combines race and ethnicity into one question that includes at least seven categories: American Indian or Alaska Native, Asian, Black or African American, Hispanic or Latino, Middle Eastern or North African, Native Hawaiian or Pacific Islander, and White. Individuals will be able to select multiple categories.

When studies do not specify how they are conceptualizing, defining, or using race and ethnicity data, they may unintentionally reinforce the harmful and inaccurate frameworks of biological essentialism or cultural inferiority, which reproduce historically racist narratives that naturalize inequitable differences in health outcomes as resulting from an assumed biological, behavioral, intellectual, moral, or cultural inferiority of BIPOC communities. To contest these harmful narratives, Lett et al. (2022) underscore that research on racial disparities should intentionally connect, contextualize, and interpret race and ethnicity data as proxies of exposure to systemic racism. Under this framework, racial disparities should be understood in relation to the structural decisionmaking mechanisms that produce and reproduce them.

2.3.1.2 SES

Income, poverty rate, and vehicle ownership are commonly used to assess the SES of a community in pedestrian and bicyclist safety studies. Studies typically define "economically disadvantaged communities" as geographic communities with lower incomes or higher poverty rates than a regional, statewide or national average. These data are commonly derived from the American Community Survey (ACS) (U.S. Census Bureau 2024).

Social scientists refer to SES in relation to economic, social, and cultural capital (Pinxten and Lievens 2014). Economic capital refers to material resources like income, car ownership, poverty status, and wealth. Social capital includes connection to decisionmakers, like elected officials, agency staff, or consultants in private organizations. Cultural capital refers to the ability of

[3]For additional information on methods to study road safety in Tribal jurisdictions, refer to appendix A of the *Tribal Transportation Strategic Safety Plan* (https://www.tribalsafety.org/reports).

[4]The American Medical Association published updated guidance on reporting race and ethnicity that provides a useful reference for discussing race and ethnicity: https://jamanetwork.com/journals/jama/fullarticle/2783090.

individuals to navigate decisionmaking processes and their ability to articulate and make legible their needs and priorities to decisionmakers; examples include education level, English proficiency, style of speech and dress, and the representation and inclusivity of individuals in decisionmaking spaces. Social scientists may also use a class-based approach (Wodtke 2016), which groups people with similar economic, social, and cultural capital into specific social classes; and highlights the specific and potentially conflicting interests of different classes. For example, a class-based approach may investigate how the transportation needs of wage laborers who work nontraditional hours may differ from salaried workers who work 9-to-5 jobs.

2.3.1.3 Age

For age, the two most common subpopulations used in pedestrian and bicyclist safety studies are children, who are mostly defined as individuals between the ages of 0 and 15 yr, and older adults, who are mostly defined as individuals who are 65 yr or older. However, the researchers found no standard definition across studies, which use a variety of cutoff points to define children and older adults. In the narrative review, the researchers specify how studies define their age groups. Most studies derive their age data from the ACS.

Social scientists define age in relation to life course, as people at different stages experience the transportation system differently (Jones et al. 2019). Often, people are categorized as infants (0–5 yr), children (5–15 yr), young adults (16–35 yr), adults (35–65 yr) and older adults (65+ yr). Age affects how and where people move. Children and older adults often have their mobility proscribed as they are less likely to access vehicles and may require accommodations to move safely and independently as pedestrians, bicyclists, micromobility users, and public transit riders.

2.3.1.5 Disability

Most studies in the review of safety studies frame disability in terms of the medical model, which defines disability in relation to medical conditions or biological impairments, including mobility impairments (e.g., people who use wheelchairs or other mobility device users), sensory impairments (e.g., people with low vision and hearing impairments), or cognitive impairments (e.g., people on the autism spectrum); use of assistive device; clinician diagnoses; or access to disability services (Schwartz et al. 2022a).

Like race, social scientists refer to disability as a social relationship between an individual and their environment and society (Jones 2014). While the medical model of disability aims to diagnose individuals with impairments for the purpose of treatment, the social model of disability emphasizes that people have a wide array of permanent or temporary differences in physical and cognitive abilities and that society should accommodate these differences to promote independence for all people (Oliver 1996, 2013). In this framework, the environment becomes disabling to a person, and transforming the environment can enable a person to live independently. In transportation, the social model of disability empowers professionals and decisionmakers to take actions that make the built environment accessible to all people through design and policies.

2.3.1.6 Sex and/or Gender

Many traditional transportation safety studies define sex and/or gender as male and female (McAndrews et al. 2021). They mostly derive these data from crash reports.

Social scientists refer to gender as a relational identity that plays a significant role in shaping mobility patterns, motivations, and behaviors (McAndrews et al. 2021; Hanson 2010). Sex refers to people who are male, female, and intersex; gender refers to cisgender (people whose gender identity matches the sex they were assigned at birth) and transgender (people whose gender identity differs from the sex they were assigned at birth) women and men, nonbinary persons, and people with other gender identities. An individual's experiences relating to their gender are shaped by the norms of their society and the culture in which they live, and the lived experiences of people of all gender identities differ based on their cultural and societal environment. An individual's gender identity often impacts how and why they make trips (Golan et al. 2019; McAndrews et al. 2021).

2.3.2 Defining Geographies and Spatial Units

There are many geographic units used for demographic analysis that follow physical, political or administrative areas, summarized as follows:

- The U.S. Census Bureau defines its smallest geographic unit as a census block (CB), which is delineated by an automated computer process every 10 yr according to visible features, such as roads, and nonvisible features, such as city limits. CB is the smallest geographic unit for which basic demographic information like age, sex, and race is available to the public. CBs lack other sociodemographic information and a time dimension. CB is rarely used in roadway safety research.

- Census block group (CBG) consists of a group of CBs and is generally defined to contain a population between 600 to 3,000 individuals. A CBG usually covers a contiguous area and never crosses State or county borders.

- CT is made up of one or more CBG and is a relatively permanent statistical subdivision in geopolitical entities like counties. CT generally covers 1,200 to 8,000 people, with an optimum size of 4,000 people. CT is commonly used in roadway safety research.

- Administrative or service zones are defined by government agencies or the private sector to represent specific public management and service purposes. The most common administrative zones in transportation are ZIP Codes and traffic analysis zones (TAZs). TAZs are administrative areas delineated by State or local transportation officials to tabulate traffic-related data, particularly journey-to-work and place-of-work statistics (Siddiqui, Abdel-Aty, and Choi 2012). TAZs usually consist of CBs, block groups, or CTs.

Understanding how studies define geographies and spatial units is important because different methods may explain discrepancies in results. The modifiable areal unit problem refers to how differences in how space is partitioned in a study may affect the results (Mitra and Builiung 2012).

2.3.3 Defining Safety Outcome Measures

Studies define different safety performance measures. Many studies use total crashes that contain crashes of all severity levels. Some studies disaggregate crash data by severity (e.g., fatal crashes, serious injury crashes, and property damage only crashes) and user type (e.g., driver, pedestrian, and bicyclists). Most of these crash data are derived from the Fatality Analysis Reporting System (FARS) (USDOT n.d.a.) or State reporting databases. These databases include data from police crash reports and death certificates, for some variables like race and ethnicity of individuals killed in traffic crashes. Other safety outcome measures reported in studies include perceived safety measures that are collected through surveys and questionnaires.

2.3.4 Analysis Methods

Most commonly, the studies the researchers reviewed examined whether communities with a higher proportion of a specific sociodemographic group have a higher risk of pedestrian and bicyclist crashes. These findings provided descriptive evidence of disparities across sociodemographic categories in both crash prevalence and severity. However, many of these studies did not analyze how inequitable institutional and infrastructural risk factors contribute to these disparities.

Some studies the researchers reviewed attempted to explain the contributors to the disparities by conducting more rigorous statistical modeling—including model comparison, interaction term, and structural equation modeling—and using qualitative methodologies.

In model comparison, the study divides communities into different categories based on sociodemographic categories and then uses the same statistical methods to compare variables like road, intersection, and land use factors across the different categories. Income and proportion of minority population are the major sociodemographic categories used to categorize the communities. For example, the communities were divided into high- and low-income communities (Dumbaugh et al. 2022), minority and majority communities (Haddad et al. 2023), or environmental justice and nonenvironmental justice communities that aggregated income, race, and ethnicity data (Cottrill and Thakuriah 2010; Siddiqui, Abdel-Aty, and Choi 2014). The effects of crash-related factors across categories of communities are further examined by comparing their coefficients under the same model configurations. For example, Dumbaugh et al. (2022) stratified the CBGs in Orange County, FL, by median household income into lower income CBGs with median household income less than $40,000 and higher income CBGs with median household income higher than $65,000. They compared the impact of crash-related factors including proportion of Black individuals, annual average daily traffic (AADT), length of urban arterials, number of intersections, number of commercial use parcels, proportion of streets with a sidewalk, and proportion of sidewalks with a buffer on pedestrian crashes. Their results show that AADT and miles of urban arterials have a significant positive association with pedestrian crashes in lower income communities while less significant in higher income

communities. This finding suggests that while urban arterials and AADT pose a risk factor across all communities, their detrimental impact on safety is significantly more pronounced in lower income communities than higher income ones.

Some studies incorporate an interaction term, which allows researchers to examine the relationships between two or more variables on the outcome variable beyond their individual effect. For example, Benediktsson (2017) used an interaction term to assess the relationship between sprawl (*X1*) and car ownership (*X2*) on pedestrian fatality rates (*Y*). He finds that, in areas with higher sprawl, each unit increase in the proportion of the population that lacks access to a car significantly increases the pedestrian fatality rate.

Additionally, some studies developed structural equation models, which are statistical modeling techniques used to analyze complex relationships between observed and latent (unobserved) variables. Structural equation modeling is a combination of factor analysis and regression analysis, allowing researchers to examine both the direct and indirect effects of variables on an outcome. For example, the categorization of SES of a community is a composite metric comprising various indicators, such as income and education level. The crash risk for communities categorized as lower SES might be mediated by other variables, like traffic exposure. Al-Mahameed et al. (2019) applied a structural equation model to investigate how the pedestrian and bicyclist crash risk for communities categorized as low-SES is mediated by traffic exposure. They created a latent variable they termed "low social status," which is an index of education attainment, vehicle ownership, low-wage rates, and poverty rates, and found that communities categorized as "low social status" have higher traffic exposure and crash risk.

Finally, some studies and agency plans used a variety of qualitative methodologies, such as policy reviews, surveys (Quick, Larsen, and Narváez 2019), interviews, and focus groups. See the discussion of Community Based Participatory Research in the following Case Studies presented in chapter 3: Design Your Neighborhood Program—Nashville Civic Center, Vanderbilt University and Tennessee (TDOT) and Nashville Departments of Transportation (NDOT) (section 3.2.3), Changing Lanes on Gender Equity and Transportation—Los Angeles Department of Transportation (LADOT) (section 3.2.6), and Transportation Needs in Daily Life (TNDL) in the Twin Cities—Metropolitan Council (MET Council) (section 3.2.7).

2.3.5 Risk Factors to Disparities in Pedestrian and Bicyclist Fatalities and Serious Injuries

In this section, the researchers review the studies to identify disparities in pedestrian and bicyclist fatalities and serious injuries by the following sociodemographic categories: race and ethnicity, SES, age, disability, and sex and gender; and elaborate the specific risk factors that may underlie these disparities across these sociodemographic categories.

2.3.5.1 Race and Ethnicity

In this subsection, the researchers examine studies that explored risk factors that may contribute to racial inequities in pedestrian and bicyclist fatalities and serious injuries and highlight disaggregated findings for specific groups where available. The researchers elaborate findings for indigenous communities (American Indian or Alaska Native) separately to specify the unique status of Tribal governments.

BIPOC communities

BIPOC are more likely to be killed or seriously injured in pedestrian and bicyclist crashes (Barajas 2018; Chimba, Musinguzi, and Kidando 2018; Kravetz and Noland 2012; Karas 2015; National Highway Traffic Safety Administration (NHTSA) 2023; Reft, de Lucas, and Retzlaff 2021; Roll and McNeal 2022; Taylor et al. 2023). Spatially, studies find a higher pedestrian and bicyclist crash risk for areas with a higher proportion of Black individuals (Apardian and Monwar Alam 2020; Chimba et al. 2014; Kravetz and Noland 2012; Lee, Abdel-Aty, and Jiang 2014, 2015; Guerra, Dong, and Kondo 2022) and Hispanic population (Chimba, Musinguzi, and Kidando 2018; Dadashova et al. 2022; Kravetz and Noland 2012; Lee, Abdel-Aty, and Jiang 2014). Dumbaugh et al. (2022) find that areas with concentrations of Black residents are at increased risk, even after accounting for differences in income, in Orange County, FL. Roadway design (Barajas 2018; Dumbaugh et al. 2022; Haddad et al. 2023), systemic racism (Taylor et al. 2023), and discrimination in enforcement of traffic laws (Barajas 2021; Brown, Rose, and Kling 2023) are potential risk factors that contribute to disparities in pedestrian and bicyclist fatalities and serious injuries and lack of access to safe, reliable, and affordable transportation options.

Using national data, Sanders and Schneider (2022) find that Black (23.9 pedestrian fatalities per million population) and Native American (54.4) pedestrians were significantly overrepresented in pedestrian fatalities per capita, compared to White pedestrians (12.6), and they investigate dynamics underlying these racial disparities in pedestrian fatalities. Disaggregating by age, the authors find that Black and Hispanic pedestrians under the age of 16 yr were over two times as likely to be killed as their White counterparts, and Asian pedestrians age 65 yr or older were 1.7 times as likely to be killed than their White counterparts. They also find that Black and Native American pedestrians were significantly more likely to be killed in darkness. They hypothesized that the underlying causes may be a disproportionate lack of adequate street lighting, higher speeds on adjacent roadways, and/or labor and travel patterns that increase exposure at night for these communities. Additionally, they find that certain roadway design and operational factors were disproportionately associated with race and ethnicity groups, particularly roadway classification. The authors note that these findings align with previous studies that found that arterials are disproportionately located in Black neighborhoods, citing Roll and McNeal (2022), and that pedestrian hot spots are disproportionately located along higher speed, higher volume arterials in Black and Hispanic neighborhoods, citing Schneider et al. (2021). They emphasize that many of the factors that disproportionately impact Black, Hispanic, and Native American pedestrians—darkness and roadways with four or more lanes—are causally linked to pedestrian fatalities for all people. They also highlight that underlying these findings is a context of transportation and housing policy that have created increase exposure to more dangerous built environments for Black, Hispanic, and Native American communities.

Barajas (2018) explored the potential causes of difference in bicycle crash risk for White, Black, Hispanic, Asian, and all other populations in the San Francisco Bay Area. He finds that, in absolute numbers, bicyclist crashes were more likely to involve White victims, Black bicyclists faced the greatest chance of being in a crash both per population and per distance traveled, and Hispanic cyclists faced greater risk per distance traveled. He finds that CTs with bicyclist infrastructure had more White residents and less residents of color, people in poverty, and people with limited English proficiency. Conversely, CTs with freeways had higher proportions of

Black and Hispanic residents. His primary finding is that not all variables have equal explanatory power of crashes across racial and ethnic groups. Notably, he finds that arterial roadways, which represent higher traffic volumes, are associated with more pedestrian crashes for all racial groups, but bicyclist crashes for Black and Hispanic cyclists are more pronounced on these arterial roadways. He reports: "An increase of 1 km of principal arterials in equivalently sized census tracts yielded crash incidence rates over three times greater for Black cyclists and nearly twice as great for Hispanic cyclists compared to White cyclists." Additionally, he notes that bicycling infrastructure was not associated with crash frequency for Hispanic cyclists, which may indicate potential differences in how Hispanic cyclists use bicycling infrastructure out of necessity or habit.

Braun, Rodriguez, and Gordon-Larsen (2019) examine variance in the presence and access to bike lanes between multiple sociodemographic categories at the block group level for 22 large cities in the United States. They note that there was significant variability between the 22 cities examined, irrespective of sociodemographic categories. Generally, the models showed that:

> … Block groups with higher proportions of Black and Hispanic residents and those with lower SES (i.e., lower income and educational attainment, higher poverty levels, lower composite SES) were less likely to contain bike lanes, tended to be further from the nearest bike lane, and, with some exceptions, tended to have lower bike lane coverage and reach.

The authors emphasize that the needs of Hispanic communities may not be met given the inverse relationship between bike lane access and high rates of bicycling in this community. They also highlight that communities with greater SES may have more influence in the planning process and in advocacy organizations. Finally, they encourage professionals to be aware that different communities may assign different cultural meanings to bicycling and not equally prioritize cycling infrastructure as a community investment.[5]

Lowe (2016) assessed sidewalk continuity near bus stops in New Orleans, LA, by race and income. Using an extensive audit of bus stops conducted by the New Orleans Regional Transit Authority, which included observations about sidewalk continuity to the nearest intersection at over 2,000 bus stops, the author assessed whether current disparities exist in access to, and quality of, sidewalks between nonminority versus minority (i.e., non-White, non-Latino) categories and population above versus below the poverty level. She determined that there was a significant association between higher minority populations and less sidewalk continuity. The association between poverty and sidewalk continuity was not significant.[6]

Finally, studies demonstrate that traffic enforcement is often disproportionately and discriminatorily applied to Black and Hispanic pedestrians, bicyclists, drivers, and transit riders, which limits their ability to move safely in public spaces (Agyeman and Doran 2021; Brown,

[5]This study did not examine the impact of race/income and bicycle lane access on bicyclist crashes; however, given extensive evidence of the effectiveness of separated bicycle facilities on reducing crash risk and severity, the authors determined the study to be relevant for this scoping review.

[6]This study did not examine the impact of race/income and sidewalk connectivity on pedestrian crashes; however, given extensive evidence of the effectiveness of sidewalks on reducing crash risk and severity, the authors determined the study to be relevant for this scoping review.

Rose, and Kling 2023; Dragan and Glied 2024; Mitchell and Ridgeway 2018; Prochnow 2021). Some studies are connecting transportation planning and infrastructure to disproportionate policing. Barajas (2021) investigated the connection between bicycling infrastructure and bicycle citations in Chicago, IL, and found that a lack of bike facilities may contribute to disproportionate citations for bicyclists in Black and Hispanic neighborhoods.

Table 2 presents the summary of risk factors contributing to crash disparities for BIPOC communities.

Table 2. Summary of risk factors that may contribute to crash disparities for BIPOC communities.

Risk Factor	Mechanisms
Visibility	• Lack of adequate street lighting in BIPOC communities. • Labor and travel patterns that may increase exposure at night for BIPOC communities.
Arterials	• Roadways with four or more lanes, higher speeds, and higher volumes disproportionately located in BIPOC neighborhoods.
Quality of pedestrian and bicycling infrastructure	• Less sidewalk continuity in BIPOC communities. • Lower presence, proximity to, and coverage of bike lanes in BIPOC neighborhoods. • Higher rates of bicycling but lower bicycle lane access in Hispanic communities.

Indigenous Communities

The NHTSA reported that American Indian and Alaska Native people (using OMB's race category classification) experience the highest rates of motor vehicle crash fatalities and injuries compared to other ethnic or racial groups in the United States (Glassbrenner et al. 2022). Using FARS data, which is recognized as having significant gaps that lead to underreporting and undercounting traffic fatalities in Tribal areas, they elaborate that "American Indian and Alaska Native people have by far the highest traffic fatality rates per mile and per population. They were five times more likely to die walking than White people and close to three times as likely to die in passenger vehicles, on a per-mile basis."

Emerging research is integrating qualitative approaches to supplement documented data limitations from crash reporting in Tribal communities and provide deeper understanding of organizational processes and practices that contribute to road safety (Quick and Narváez 2018; Quick, Larsen, and Narváez 2019). Quick, Larsen, and Narváez (2019) used responses to the 2016 Tribal Transportation Data Survey (Larsen and Piland 2017) to determine areas of priority for road safety among Tribal governments. The most frequently cited top priorities were road infrastructure, including curves, ditches, surface conditions, and lighting; and driver behavior,

including speeding or reckless driving, impaired driving, or distracted driving.[7] Other frequent priorities included road maintenance problems, seatbelt use, child seats not properly used, and inadequate pedestrian facilities. Furthermore, they reference the 2017 *Tribal Transportation Strategic Safety Plan,* which establishes seven similar priority topics for transportation safety in Tribal areas: pedestrians, roadway departure, impaired driving, seat belts and child safety seats, availability of safety services, safety plans and safety data (Tribal Transportation Safety Management System Steering Committee 2017).

Since indigenous communities are often located in rural areas, many Tribal transportation safety problems resemble rural safety challenges, particularly rural roadway departure crashes, which contributed to 63 percent of crash fatalities from 2010 to 2014 (Transportation Safety for Tribes n.d.b.). However, there are two important distinctions from rural safety challenges: pedestrian safety and coordination challenges between Tribal governments and other jurisdictions (Quick and Narváez 2018; Quick, Larsen, and Narváez 2019). Specifically, many residents on reservations, including indigenous people, rely on or choose to walk or bike. However, the lack of pedestrian infrastructure, the tendency of pedestrians to walk long distances along roadways on Tribal reservations and concerns that drivers who do not reside on reservations may not expect to encounter any pedestrians and bicyclists and drive at fast speeds through these areas contribute to the increased risk of crash severity for pedestrians on reservations (Quick and Narváez 2018). As such, they conclude that pedestrian safety is a critical, yet underrecognized, issue on reservations that often differentiates Tribal areas from rural areas in general.

Additionally, studies elaborate multiple roadway design limitations, including narrow road shoulders, lack of crosswalk and pedestrian refuge islands, inadequate lighting, poor road surface condition, insufficient traffic control devices, vegetation obstructing visibility, the presence of animals on roads, and inadequate ice or snow removal (Grossman et al. 1997; LaValley et al. 2003; Raynault, Crowe, and Ngo 2010).

Quick, Larsen, and Narváez (2019) further elaborate on inter-jurisdictional collaboration issues and review a variety of institutional challenges for State DOTs to collaborate with sovereign Tribal Nations. The authors note that State DOTs tend to passively address safety concerns on Tribal lands, not systemically or proactively coordinating to address road safety challenges. Some State DOTs may not recognize Tribes' special status and equate them with local governments, including making Tribes compete with locals for State and State-managed Federal safety funds. Also, there are communication and capacity challenges to Tribe–State data sharing and quality.

Table 3 presents the summary of risk factors contributing to pedestrian crash disparities for indigenous communities. FHWA is currently conducting research on pedestrian crashes in Tribal areas. The report will include risk-based safety evaluation tools that tribal transportation departments can use to assess risk following the concepts of the systemic safety analysis method (Transportation Safety for Tribes n.d.a.).

[7]In interviews with Tribes in Minnesota, Quick elaborated that alcohol- or drug-impaired driving results in mixed statements, as some Tribal transportation leaders do not consider alcohol- or drug-impaired driving of particular concern, while others consider alcohol- or drug-impaired driving a concern but highlight that there is not a significant different between on- and off-reservation behavior (Quick and Narváez 2018).

Table 3. Summary of risk factors that may contribute to crash disparities for indigenous communities.

Risk Factor	Mechanisms
Roadway design	• Narrow road shoulders and absence of continuous sidewalks or separated pedestrian facilities. • Lack of crosswalk and pedestrian refuge islands. • Inadequate lighting. • Insufficient presence of traffic control devices.
Road maintenance	• Vegetation obstructing visibility. • Inadequate ice or snow removal. • Poor road surface conditions. • Quality of signs and markings.
Interjurisdictional collaboration issues	• State DOTs equating Tribes with local governments. • State DOTs passively addressing road safety concerns on Tribal lands. • Tribe–State data sharing and quality.
Inadequate infrastructure for travel patterns	• People living on reservations rely on or choose to walk or bike long distances. • Drivers may not expect to encounter pedestrians or bicyclists on high-speed roadways.

2.3.5.2 SES

Studies consistently show that areas with concentrations of economically disadvantaged communities experience a greater share of traffic related crashes, injuries, and deaths. Communities with lower incomes are more likely to experience more pedestrian crashes (Dumbaugh et al. 2022; Kravetz and Noland 2012; Roll and McNeil 2022; Roll and McNeil 2022; Siddiqui, Abdel-Aty, and Choi 2012; Younes et al. 2023) and bicyclist crashes (Chimba and Musinguzi 2016; Dumbaugh, Li, and Joh 2012). Areas with a higher concentration of people living below the poverty line are positively associated with pedestrian crash frequency (Guerra, Dong, and Kondo 2022; Lee, Abdel-Aty, and Jiang 2014, 2015; Wier et al. 2009) and bicyclist crash frequency (Barajas 2018). Vehicle ownership is another commonly investigated indicator of socioeconomic disadvantage. Several studies find that communities with more households without vehicles are associated with more pedestrian crashes (Amoh-Gyimah, Saberi, and Sarvi 2016; Cottrill and Thakuriah 2010; Dumbaugh, Li, and Joh 2012; Guo et al. 2020; Lee, Abdel-Aty, and Jiang 2014, 2015; Nashad et al. 2016; Roll and McNeil 2022; Sener et al. 2021) and more bicyclist crashes (Amoh-Gyimah, Saberi, and Sarvi 2016; Lee and Abdel-Aty 2018; Nashad et al. 2016; Saha et al. 2018; Sener et al. 2021).

Studies posit that communities with greater socioeconomic disadvantage are less likely to own cars, more likely to share cars with others, and more likely to drive older cars with fewer safety technologies (Hyun et al. 2021; Metzger et al. 2020).

Emerging studies are beginning to further explore policy and infrastructure mechanisms underlying socioeconomic disparities in pedestrian and bicyclist crash fatalities.

First, Kravetz and Noland (2012) find a higher occurrence of pedestrian crashes in lower income areas in three counties of northern New Jersey. The authors observed differences in roadway infrastructure, such as sidewalk buffers, medians, and pedestrian control buttons by manually inspecting street view images in those communities. Their findings suggest there are more sidewalk buffers in wealthier communities and that lower income communities have a higher prevalence of aging sidewalks. This finding demonstrates differences in the quality of pedestrian infrastructure between communities with lower and higher incomes.[8] However, as a result of the limited dataset obtained from street view images, the researchers were unable to identify a significant correlation that directly links these differences in sidewalk infrastructure to socioeconomic disparities in pedestrian crashes.

Yu, Zhu, and Lee (2018) divided communities into lower and higher income communities based on poverty rate in Austin, TX, and compared the differences in total crash, fatal crash, injury crash, and no-injury crash pedestrian crashes between these two groups. They found that communities with higher poverty rates experienced more total, fatal, and injurious pedestrian crashes. The results also indicated arterial roads and proportion of commercial land use are associated with more pedestrian crashes in both lower and higher income communities. There were no significant differences found in the safety effect of arterial roads and proportion of commercial land use between lower and higher income areas. Yu and Woo (2022) further explored how pedestrian safety around parks varied between high- and low-income areas in Orlando, FL, using negative binomial models. They found that in both high- and low-income areas, commercial parcels and transit stops at the street level were associated with more pedestrian crashes around parks while single- and multifamily residential uses along street segments were related to fewer pedestrian crashes. Notably, sidewalk coverage had a negative association with pedestrian-vehicle crashes in low-income areas but not high-income areas.

Dumbaugh, Mitsova, and Saha (2020) examined risk factors that contribute to pedestrian and bicyclist crashes in lower income areas in Broward and Palm Beach County, FL. They group their findings into six patterns of pedestrian and bicyclist risks based on age and time in lower income areas using negative binomial regression models:

- Pedestrian crashes for people aged 14 yr and under are concentrated between 6 to 9 a.m. and 3 to 9 p.m. on weekdays, indicating that they are related to school trips.

- Pedestrian crashes for people aged 20 yr and older were concentrated between the times of 6 and 9 p.m., indicating they were conducting evening errands.

- Pedestrian crashes for people aged 70 yr and over were distributed between 9 a.m. and 9 p.m., indicating active older adults throughout the day.

- Pedestrian crashes for people aged 25–34 yr were concentrated between 6 p.m. and midnight.

[8]Terminology used is specific to this study (Kravetz and Noland 2012).

- Bicyclist crashes for people aged 20–64 yr were concentrated between 6 a.m. and 9 p.m. indicating adult utilitarian bicycling.

- Bicyclist crashes for people aged 12 yr and under were concentrated between 3 to 6 p.m. on weekdays, indicating afterschool activities.

Across all categories, 80 percent of cyclists involved in serious crashes were male individuals. Neither the pedestrian nor the bicyclist models showed association with alcohol or drug use. Across all six groups, they found that the risk for individuals in low-income areas increased in the presence of restaurants, shopping centers, and five or more lane streets, and decreased in the presence of raised medians and the higher levels of intersection density. They conclude that disparities in pedestrian and bicyclist fatalities in lower income areas appear to be "principally the result of normal travel activities undertaken in environments that are poorly adapted to high levels of walking and bicycling," not solely due to the design of transportation infrastructure but the inconsistencies between the design and operation of transportation infrastructure and land development policies.

Dumbaugh et al. (2022) investigated the pedestrian crashes in Orange County, FL, and found lower income areas are exposed to higher risks of traffic crashes, injuries, and death than higher income areas. Notably, the authors find that environmental features have variable effects on lower income and higher income areas. They show that each mile of urban arterial in a low-income community is associated with a threefold increase in the number of total, injury, and fatal crashes compared to higher income areas. The study finds little difference in the overall design of arterials, specifically the use of raised medians to remove conflicts associated with commercial driveways. But they find that the geographies of lower income areas, compared to higher income areas, may explain this difference. Lower income areas are clustered just outside the urban core. The authors hypothesize that a significant portion of the traffic on arterial roads in these areas is made up of individuals who live elsewhere passing through to reach the urban core. They note that the findings for AADT support this finding as areas with lower incomes, which have fewer total miles of arterials than their higher income counterparts, report twice the total AADT. They conclude that regional development patterns may be a significant contributor to pedestrian and bicyclist disparities. Similarly, they find that the relationship between urban arterials and pedestrian crashes was significant, with each additional mile of urban arterials associated with a 15-percent increase in pedestrian crashes. They argue that these differences are most likely explained by trip purpose, with lower income households traveling for utilitarian purposes, such as to access work or school, regardless of the quality of the built environment. Meanwhile, higher income households may travel recreationally, avoiding unpleasant or unsafe environments.

Sanchez, Rodriguez, and Ferenchak (2024) support these findings and conclude that pedestrian fatalities are moving away from downtown areas (with a 63.0-percent decrease in study cities' downtowns) and are now happening more in suburbs (a 32.1-percent increase outside downtowns). The authors examined longitudinal patterns in the characteristics of the locations of pedestrian fatalities in nine major U.S. cities between the study periods of 1999–2002 and 2017–2020. They find that pedestrians are now being killed in places with less public transit access and lower pedestrian commute mode shares compared to the earlier study period, which further supports the finding that pedestrian fatalities are increasingly occurring in less dense,

suburban neighborhoods with less public transportation services and pedestrian infrastructure. They also found that while neighborhoods with hot spots for pedestrian crashes had elevated poverty rates in both study period, these neighborhoods accounted for 82.8 percent of the increase in pedestrian fatalities between the study periods. While national poverty levels decreased significantly from 2015 to 2019, pedestrians continued to be killed in areas with high levels of poverty during this time. These results are based on a longitudinal study that examined pedestrian fatality hot spots in nine of the largest, fastest growing, and fastest shrinking U.S. cities over the last 20 yr. They examined the spatial relationships between multiple explanatory variables (including average population density, proportion of population in poverty, and age of facilities) and spatial clustering of pedestrian fatalities with 3-yr rolling averages.

Benediktsson (2017) reinforces this finding, proposing that the main mechanism for increasing pedestrian fatalities is the material mismatch between automobile-oriented development decisionmaking for the built environment in suburban areas and the real needs and resources, including access to cars, of everyday users, particularly working class people. Using an interaction term to assess this relationship, he finds that, in areas with higher sprawl, each unit increase in the proportion of the population that lacks access to a car significantly increases the pedestrian fatality rate. He extends this quantitative ecological analysis with a qualitative investigation of two roads that account for 47 fatal pedestrian crashes in New Jersey using logbooks from law enforcement, autopsy reports from the medical examiners' offices, photographs and field notes from site visits, and local newspaper articles. This qualitative investigation highlights the following roadway design risk factors underlying material mismatch: four-lane, nonaccess controlled arterials originally designed for and still serving high-speed (45–55 mph) motor vehicle movement are currently lined with retail locations that workers and customers access with nonmotorized transportation. Consistent with the suburbanization of poverty theory, the author notes that over 17 yr (1990–2007), the two CTs surrounding these roads have had threefold and fivefold increases in poverty rates, respectively, and spurred changes in transportation patterns as people increasingly rely on walking and transit. For example, he highlights that the service workers—construction workers (who were not working) for men, and casino workers, waitresses, department store cashiers, nursing students, and post office clerks for women—were heavily represented in pedestrian fatalities on these roadways. He notes that efforts by the State DOT to block access, through a 3-ft cement barrier and 6-ft fence, were ineffective as people continued to regularly cross, given the significant time burden imposed by walking one-half a mile to the nearest crosswalk. He highlights the need for design-oriented countermeasures that move away from reinforcing the original design, through barriers, and provide meaningful safe access to impoverished communities outside of urban areas, through the installation of sidewalks and other pedestrian infrastructure.

Table 4 presents the summary of risk factors contributing to crash disparities for socioeconomically disadvantaged communities.

Table 4. Summary of risk factors that may contribute to crash disparities by socioeconomic status.

Potential Mechanisms	Mechanisms
Roadway Infrastructure	• Lower presence or quality of pedestrian infrastructure, including sidewalk buffers, medians, and pedestrian control buttons. • Five or more lane roadways increase risk. Raised medians and higher levels of intersection density decrease risk.
Regional development patterns	• Fewer total miles of arterials but twice the AADT in areas with lower incomes. • Lower income areas clustered just outside the urban core, with individuals who live elsewhere passing through to reach the urban core. • Pedestrian fatalities increasingly occurring in less dense, suburban neighborhoods with less public transportation services and pedestrian infrastructure.
Material mismatch: relationship between roadway infrastructure and trip purpose	• Unregulated development that leads to an absence of safe AT facilities to essential destinations on arterials in underserved communities where individuals may rely on walking, biking or accessing transit. • Individuals and households with lower incomes traveling for utilitarian purposes, such as to access work or school, regardless of the quality of the built environment. • Individuals and households with higher incomes traveling recreationally, avoiding unpleasant or unsafe environments. • Stroads, which are high-speed nonaccess controlled arterials lined with adjacent destinations that people need to access, including restaurants and shopping centers.

2.3.5.3 Age

Research on pedestrian and bicyclist safety and age can be divided into two categories:

- How differences in the proportional age makeup of a community influence risk of pedestrian and bicyclist crashes. These studies include age composition as a control variable in statistical models and provide trends or potential reasons for how age composition may contribute to crash risk or severity.

- How biological, SES, and built environment factors influence crash risk for children and older adults. These studies investigate sources for the disparities in crash risk for children and older adults and provide policy recommendations accordingly.

Impact of Age Composition

The age composition of a community is typically measured by the proportion of children and older people making up a community. Studies find that communities with a greater proportion of children have a higher pedestrian and bicyclist crash risk in Orange County, CA (Chakravarthy

et al. 2010) and San Antonio-Bexar County, TX (Dumbaugh, Li, and Joh 2012) and a lower crash risk in Tennessee (Chimba and Musinguzi 2016). These differences may result from heterogeneity in the study site and the fact that age is used as a control variable, rather than the core focus of the study.

Communities with a greater proportion of older adults show increased risk in bicyclist crashes in San Antonio-Bexar County, TX (Dumbaugh, Li, and Joh 2012) and Broward and Palm Beach County, FL (Guo et al. 2020). Stoker et al. (2015) found similar trends in a systematic review of pedestrian risk factors and found that those ages 65+ yr are positively associated with pedestrian crashes in several States and have some of the highest risk of mortality.

Sanchez, Rodriguez, and Ferenchak (2024) add that the average age of the U.S. population is increasing nationally, and the population in areas where pedestrians are being killed is also increasing. However, the areas where pedestrians are being killed have younger residents than the national average. They conclude that additional research is needed to examine the purpose of the pedestrian activity, the context of the walking, and the riskiness of the exposure. They note that younger pedestrians may have higher risk tolerances and older pedestrians may be more susceptible to physical injury.

Children

Most studies that investigate disparate crash impacts for children focus on school areas (Chakravarthy et al. 2012; Koopmans et al. 2015; McArthur, Savolainen, and Gates 2014; Rothman et al. 2020a, 2020b; Schwartz et al. 2022b) and provide policy recommendations to improve road safety around schools for children (Hwang, Joh, and Woo et al. 2017; McArthur, Savolainen, and Gates 2014; Rothman et al. 2017).

Studies consistently find an intersectional relationship between children and SES and traffic crashes. Children from low socioeconomic backgrounds or those living in neighborhoods with low SES are more likely to be struck and killed by motor vehicles while walking (Chakravarthy et al. 2012; Rothman et al. 2020a). Additionally, variables associated with low SES, such as proportion of population with limited English proficiency, proportion of population that did not graduate from high school, single-parent families, and residential instability, have also been linked to a higher risk of child pedestrian crashes (Chakravarthy et al. 2012; Silverman, Hutchison, and Cusimano 2013). Studies note that higher speed roads, reduced visibility, and heavy traffic volumes are more prevalent in disadvantaged socioeconomic areas, creating heightened risks for child pedestrians and bicyclists (Agran et al. 1996; Cloutier et al. 2021; Rothman et al. 2014). A study conducted in California revealed that schools with a higher concentration of Hispanic or Black populations and low SES were more likely to be located near major roads with higher speeds and traffic volumes (Green et al. 2004). Using a novel proactive methodology, Ferenchak and Marshall (2019) find that reactive methodologies that investigate crashes may underestimate the inequitable distribution of traffic safety issues on roadways

around schools in communities with high-Black, high-Hispanic, low-median income, and low-educational attainment communities in Denver, CO.[9]

Rothman et al. (2014) conducted a literature review to identify what can create more walkable and safer (i.e., less injuries) environments for children. They combine findings from studies that examine built environment and social features that contribute to greater physical activity for children (i.e., walking to school) and improve road safety (i.e., decreasing injuries from traffic crashes). They find that traffic calming and the presence of playgrounds are the only factors consistently associated with both more walking and less injury. Lights are protective against injury but have inconsistent results with walking. Meanwhile, multiple design, density, and land-use features are associated with more walking and less safety (or more injury), including higher pedestrian volume, population and road density, schools, urban location, land use mix, proximity to services/facilities, and crosswalks. However, they note that these factors may simply be confounders related to greater exposure to high-speed traffic. In this vein, they conclude that high speed traffic would be the primary risk for injury on these roadways, hence the importance of traffic calming measures. Followup studies demonstrated that implementing traffic calming measures such as reduced speed limits and speed humps reduce the risk of crashes involving children (Cloutier et al. 2021; Rothman et al. 2014). However, lower income neighborhoods have significantly fewer speed humps and lower speed local roads (Rothman et al. 2020b).

McArthur, Savolainen, and Gates (2014) investigated the risk factors in a 1-mi buffer zone of K–12 public schools for the crashes of school-aged children in Michigan to inform the selection of schools for the Safe Routes to School (SRTS) program. They find that schools situated on lower volume local roads have a higher occurrence of crashes compared to those located on roads with higher functional classes. This suggests that these findings may be attributed to certain behavioral factors, including erratic parent behavior during dropoffs and children darting in and out of traffic. But primarily, they noted that there may be significantly higher exposure on these roads, as the proportion of children walking or biking to or from school may be higher than along a major roadway.[10] Additionally, the authors find that greater family size and a lower number of parents per household contributed to crash risk, noting that these families may have a limited number of cars.

Hwang, Joh, and Woo (2017) investigated built environment factors, such as sidewalk coverage, crosswalk, and land use, for child pedestrian crashes near public schools in Austin, TX. They selected 124 public schools across all grade levels and used 1/4-mi street network buffer zones around school parcel boundaries to measure physical infrastructure and risk exposure at the street level. Specifically, they analyzed sidewalk coverage, crosswalk density, bus stops, intersections, and land use mixture and their effects on child pedestrian crashes. Their findings suggest that the

[9]To proactively assess traffic safety, authors surveyed parents on which streets—with variable vehicle speed, vehicle volumes, roadway width, and the presence of active transportation facilities—they would or would not allow their elementary-to-middle-school-aged child to walk or bike on. They mapped streets that parents consider unsafe across the city and overlayed these data with demographic data to determine whether children in specific communities disproportionately interact with roads that are perceived to be unsafe. They compared these data to a regressive traffic safety analysis that uses traditional crash data to uncover discrepancies.

[10]This study did not examine fatal or serious injury crashes, but all crashes, indicating that while more crashes may happen on local roads, more severe crashes may happen on arterial roads, as demonstrated by the other studies.

absence of sidewalks, denser crosswalks, and more commercial land use are associated with increased child pedestrian crash risk. Missing sidewalks and crosswalk density were notably significant for high-Hispanic school neighborhoods and low-income school neighborhoods. The results also show that commercial land use increases risk, possibly due to higher volumes of traffic.

Finally, Ganzar et al. (2022) evaluated the significant investment in SRTS infrastructure projects of Austin, TX, and provided key takeaways related to equitable funding and project prioritization processes to address inequities in safe, connected pedestrian and bicyclist facilities to schools. They note that in 2016, the citizens of Austin, TX, approved a $27.5 million mobility bond dedicated to SRTS, but this money was allocated equally across the 10 council districts, despite more schools and greater need in some districts compared to others. They also note that schools exhibited different types of need due to existing inequities, with some needing sidewalks, while others with existing sidewalk networks considered bike lanes and pedestrian hybrid beacons. Despite the equal yet inequitable distribution of funding, planners attempted to prioritize projects based on four factors: demand, safety, equity, and stakeholder engagement. Additionally, they determined that despite the significant investment by the city, overall need was far greater, totaling an estimated $825 million based on walk audits for 137 elementary and middle schools that assessed ATI needs within a 1/2-mi radius for walking infrastructure and 2-mi radius for bicycling infrastructure. Again, schools with a greater disadvantage, measured by poverty rate and free and reduced lunch rate, had greater need. The authors highlight that the city of Austin approved another mobility bond in 2020 for an additional $20 million for high-priority SRTS projects citywide, and this funding is not dependent on equal allocation among the council districts, which may increase equitable distribution of funding. Additionally, they highlight the importance of equitable planning to achieve safety as new schools are built, particularly in growing cities.[11]

Table 5 presents the summary of risk factors contributing to crash disparities for children.

Table 5. Summary of risk factor that may contribute to crash disparities for children.

Risk Factors	Mechanisms
Arterials	• Higher speed roads, heavy traffic volumes, and reduced visibility.
Roadway design	• Notably significant missing sidewalks and crosswalk density for high-Hispanic school neighborhoods and low-income school neighborhoods.
Land use	• Commercial land use, possibly due to higher volume of traffic. • Presence of playgrounds associated with more walking and less injury.
Funding	• Insufficient funding to SRTS and AT projects that serve children. • Funding criteria or restrictions that prevent equitable implementation of projects to address the inequitable infrastructure.

[11]This study did not examine pedestrian or bicyclist crashes; however, given the report's focus on decisionmaking and the relationship between funding and safety infrastructure, the authors determined the study to be relevant for this scoping review.

Older Adults

By 2050, one out of every five persons in the United States will be over the age of 65 (Vespa, Medina, and Armstrong 2020). Many studies find that older pedestrians and bicyclists are more likely to be severely or fatally injured in pedestrian crashes (Centers for Disease Control and Prevention (CDC) 2013; Clifton, Burnier, and Akar 2009; Dai and Dashova 2021; Lee and Abdel-Aty 2005; Moudon et al. 2011; Siddiqui, Abdel-Aty, and Choi 2014). Despite the United States' aging population and severe crash outcomes involving older adults, only a few studies try to investigate the risk factors for pedestrian and bicyclist crashes among adults 65 yr and older (Dumbaugh and Zhang 2013; Das et al. 2019). To fill this gap, Florida DOT developed a report to identify and prioritize regions for public involvement to improve road safety and mobility for an aging population, since Florida leads the nation in population of people 65 yr and older and this population is expected to grow (Alluri and Kodi 2021). They used a GIS-based approach with crash data involving older road users, sociodemographic data, roadway geometry data, and infrastructure-related data including transit stops to identify and prioritize regions to conduct outreach activities and recommend outreach activities at identified rural and urban areas.

Dumbaugh, Zhang, and Li (2012) and Dumbaugh and Zhang (2013) find that in San Antonio, TX, arterial thoroughfares and big-box stores are risk factors for pedestrians aged 75 yr and older. Using negative binomial models, they analyzed the relationship between urban form (i.e., build environment) and KSI pedestrian crashes for this population. They explored three land use variables: arterials, commercial land strip, and big-box stores. They find that big-box stores are significantly related to crashes for older pedestrians and cyclists, with an 8.6 percent increase in KSI crashes per store. Additionally, each mile of arterial thoroughfare is associated with a 28-percent increase in both total and KSI crashes. The authors note that these characteristics of land use are typical features of a suburban neighborhood. Conversely, the presence of a dense network of lower speed streets is associated with significant reductions in KSI pedestrian and cyclist crashes, and near-significant reductions into total crashes. Whelan et al. similarly (2006) note that a reduction of roadway speed and longer crossing intervals can reduce risks for pedestrians who are aged 65 yr and older.

Das et al. (2019) analyzed nationwide bicyclist fatalities among older adults from 2014 to 2016 using FARS data and find multiple risk factors related to fatal bicyclist crashes for older adults. They find that "motorists overtaking the bicyclists"-related crashes are associated with roadways with 50- to 55-mph posted speed limits. They also find a greater risk of fatal bicyclist crashes for people age 65 yr and older on roads with bicycle lanes, shoulders, and parking lanes in dark conditions without adequate lighting. Additionally, for two-way undivided roadways with bicyclists on the travel lane, they find an association with turn-related bicyclist fatal crashes; for multilane divided roadways, they find motorist left turning to be associated with "failure to yield"-related bicyclist crashes. They suggest multiple countermeasures to address these risks, including lowering speed limits and providing separated bicycle lanes, lighting, speed calming, sign messages, Barnes Dance intersections, hybrid beacons, high-visibility crosswalks, and bicycle intersection markings.

Table 6 presents the summary of risk factors contributing to crash disparities for older adults.

Table 6. Summary of risk factors that may contribute to crash disparities for older adults.

Risk Factors	Mechanisms
Arterials	• Higher speed roads, heavy traffic volumes, short crossing intervals, and reduced visibility.
Roadway design	• Lack of separated bike lanes and safe intersection designs on two-lane undivided and multilane divided roadways.
Land use	• Suburban neighborhoods, with arterials and big-box stores.

2.3.5.4 People with Disabilities

Available studies demonstrate elevated risk of fatal crash risk, hospitalizations, and collisions for people with disabilities (Schwartz et al. 2022a). Studies reviewed by Schwartz et al. (2022a) demonstrate elevated pedestrian fatality risk for people with "any disability," and some specifically explored risk for people diagnosed with visual and hearing impairments, cognitive impairments, developmental disabilities, and epilepsy. Kraemer and Benton (2015) notably examined differences in pedestrian mortality rates between people who use wheelchairs and the overall population in the United States from 2006 to 2012 using two databases, FARS data (USDOT n.d.a.) and news reports. They find that pedestrians who are wheelchair users have a 36-percent higher rate of fatalities compared to the general pedestrian population. Additionally, older (50–64 yr) men who use wheelchairs are 75 percent more likely to be involved in crashes compared to all men in the same age group. They find that almost half of fatal pedestrian crashes involving pedestrians who use wheelchairs occurred at intersections, many of which lacked traffic control devices (47.6 percent) and crosswalks (18.3 percent).

Evaluating the presence and implementation of policy, Eisenberg et al. (2022) used aerial imagery to explore whether having an ADA transition plan is associated with more accessible pedestrian infrastructure for 24 matched community pairs, and they find that communities with transition plans had more accessible pedestrian infrastructure near their city hall and along pathways to and from public transportation compared to communities without transition plans.[12] The find that the biggest difference is for sidewalks and curb ramps.

Some studies further elaborate infrastructure risk factors that contribute to the higher crash fatality risk for people with disabilities. Many of these risk factors are the same for people without disabilities; like high-speed roads, multiple lanes, and high vehicle volumes. Some may pose unique risks that require additional considerations; like roundabouts, channelized turn lanes, lack of curb ramps and sidewalks, and intersections lacking APSs (Lin et al. 2013; Pecchini and Giuliani 2015; Schwartz et al. 2022a; Stavrinos et al. 2011). Studies have elaborated on opportunities to create safer access for pedestrians with disabilities: installing sidewalks and curb ramps, considering whether on-street parking and signage may obscure the visibility of pedestrians using wheelchairs, installing APSs and midblock crossing islands, providing more visible walk signs, and slowing traffic (Pecchini and Giuliani 2015; Schwartz et al. 2022a).

[12]This study did not directly examine the impact of ADA transition plan, sidewalks, or curb ramps on pedestrian and bicyclist crashes for people with disabilities; however, given extensive evidence of the effectiveness of accessible ATI on reducing crash risk and severity, the authors determined the study to be relevant for this scoping review.

The U.S. Access Board, a Federal agency with the mission of advancing full access and inclusion for all, elaborates that: “Despite on-going efforts to improve access, pedestrians with disabilities throughout the United States continue to face major challenges in public rights-of-way because many sidewalks, crosswalks, and other pedestrian facilities are inaccessible. Equal access to pedestrian facilities is of particular importance because pedestrian travel is the principal means of independent transportation for many persons with disabilities” (Office of the Federal Register 2023).

In August 2023, the U.S. Access Board issued a final rule on Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG) (U.S. Access Board n.d.b.). Based on available research and engagement with numerous stakeholders, including State and local DOTs, engineering firms, and disability advocacy groups, these guidelines aim to “ensure that pedestrian facilities located in the public right-of-way are readily accessible to and usable by pedestrians with disabilities.” PROWAG (U.S. Access Board n.d.b.), provides minimum guidelines for creating accessible pedestrian routes and crossings, including alternate pedestrian routes when a pedestrian access route is closed for construction, APSs, curb ramps and detectable warning surfaces, boarding and alighting areas and shelters at transit stops, designated accessible parking spaces, and other considerations. The General Services Administration adopted PROWAG under the Architectural Barriers Act Accessibility Standards (U.S. Access Board n.d.a.), making compliance with these guidelines mandatory on federally constructed or leased facilities. PROWAG will become mandatory on State and local facilities once they are adopted, with or without modifications, as accessibility standards in regulations issues by the Department of Justice and USDOT, under the ADA (Americans with Disabilities Act of 1990 2014), Section 504 of the Rehabilitation Act (Office of the Federal Register 2002), and the Architectural Barriers Act (Office of the Federal Register 2023).

While technical requirements in PROWAG, such as accessible pedestrian signals (APS) and curb ramps, increase access for pedestrians with disabilities, there are barriers in the public right-of-way unique to pedestrians with cognitive, developmental, intellectual, or degenerative disabilities that are not fully addressed by PROWAG. These disabilities include autism spectrum disorder, attention-deficit/hyperactivity disorder, epilepsy, Alzheimer’s disease, Down syndrome, etc.

Some studies examine the needs of individuals living with intellectual and cognitive disabilities in naturalistic or simulated studies, which emphasize behaviors or reactions in a controlled or laboratory settings. For example, Earl et al. (2019) use eye-tracking technology to assess how people with intellectual disabilities navigate shared zones compared to a traditional marked crossing, and they find that individuals both with and without intellectual disabilities are more likely to look at traffic-relevant objects (e.g., motor vehicles, pedestrians, and traffic signage) on or at a zebra crossing, and that individuals with intellectual disabilities are less likely to look at traffic-relevant objects compared to people without intellectual disabilities in a shared zone. They hypothesize that shared zones may increase potential risk of injury for pedestrians, particularly those with intellectual disabilities, and suggest considering implementing shared zones, which may have many benefits, on a case-by-case basis, depending on the context, and considering providing a zebra crossing on the periphery of shared zones. These methods were similarly applied with visually impaired pedestrians, who were observed to encounter more challenges in accurately assessing safe crossing gaps compared to pedestrians without visual

impairments at roundabouts (Guth et al. 2005) and at channelized turn lanes (Schroeder et al. 2006). To address this gap, *NCHRP Report 674* detailed barriers and treatments at roundabouts and channelized turn lanes for pedestrians with vision disabilities (Transportation Research Board of the National Academies 2011) and PROWAG provides minimum guidelines for roundabouts in R306.4 and channelized turn lanes in R306.5 (U.S. Access Board n.d.b.).

Schwartz et al. (2022a) note that these studies often attribute risk factors, like risky crossing decisions and walking speeds, to "limitations" in the body of the disabled person. They note that, while there may be differences in the body's abilities, "these differences should not put individuals at greater risk of injury or death." Instead, they recommend that future studies focus on how road environments can be "disabling," or create conditions that are unsafe for people with varying abilities and disabilities.

Table 7 presents the summary of risk factors contributing to crash disparities for people with disabilities.

Table 7. Summary of risk factor that may contribute to crash disparities for people with disabilities.

Risk Factors	Mechanisms
Lack of ADA Transition plans	• Required commitment by public agencies to remove legacy barriers in their policies, programs, and facilities that prevent access by people with disabilities.
Arterials	• Higher speed roads, heavy traffic volumes, multiple lanes, and long crossing distances.
Roadway design	• Lack of traffic control devices, detectable warning surfaces, and marked crosswalks at intersections. • Lack of curb ramps, missing sidewalks, signalized intersections lacking APSs, inaccessible crosswalks including at roundabouts and channelized turn lanes, and other barriers and treatments elaborated in PROWAG. • Insufficient nonvisual cues about where to cross roadways and aligning to cross.

2.3.5.5 Sex and Gender

Studies find that male individuals are consistently disproportionately represented in overall traffic fatalities: Male pedestrians are 2.3 times more likely to be fatally injured and are consistently overrepresented as 70 percent of all crash fatalities (Zhu et al 2011; Insurance Institute for Highway Safety 2023). In 2017, 89 percent of bicyclists killed were male (Dai and Dadashova 2021). Additionally, male pedestrians with low incomes, lower household income, and less education are disproportionately fatally injured (Pirdavani et al. 2017). None of the reviewed studies examined how policies, infrastructure, and land use decisions increase risk for male pedestrians. While female pedestrians are less likely to die in traffic crashes, one study showed that they may experience higher rates of serious injury from crashes compared to male pedestrians (Lee and Abdel-Aty 2005).

Gender-informed literature to road safety provides two significant contributions: studies intricately link road safety to personal security for a more comprehensive understanding of safety, and they emphasize that transportation networks need to serve people doing care work.[13]

First, multiple studies highlight that fear and anxiety about traffic safety and personal security limit the mobility of people who identify as women, transgender, and nonbinary, including when (i.e., daytime or nighttime), where (i.e., routes), and how (i.e., walking, driving, taking transit) they travel. In their review of existing literature, McAndrews et al. (2021) demonstrate that women may be more sensitive to traffic safety concerns, highlighting that women bike at equal rates with men in countries with high-quality bicycling infrastructure but are far less likely to bike in countries without this infrastructure. They indicate a need for protected infrastructure for pedestrians and bicyclists to address gender equity in AT. Additionally, they note that multiple studies examine how women and transgender and nonbinary persons experience and are impacted by harassment and gender violence on roads and streets. They note institutional-level design and policy interventions to prevent or mitigate gender violence. For example, lighting impacts women's decisions to walk and bicycle, as women are more likely to consider lighting an important aspect of a safe bicycle route (Golan et al. 2019; Agyeman and Doran 2021). Similarly, Lubitow et al. (2017) interviewed transgender persons in Portland, OR, and elaborate on the harassment and discrimination that transgender persons experience and how this violence shapes, and often limits, their decisions to walk and use public transit. Finally, Agyeman and Doran (2021) elevate four key personal safety concerns and structural barriers specifically related to cycling: fear of theft, lack of bike parking and storage, cost (which particularly impacts people with low incomes and has spurred organizations that provide resources including workspaces, tools, and skill-building classes to community members), and shared mobility services (which they note, in many cases, tend to reinforce transportation inequities if they require credit card or bank accounts to pay for the service and a lack of bike-share stations in underserved neighborhoods).

Additionally, McAndrews et al. (2021) show that women are more likely to be caretakers and spend more of their travel time accompanying other people, particularly young children and older adults with limited mobilities. They demonstrate that historic and present-day transportation policy has prioritized travel for paid work over reproductive or care work, which is disproportionately done by women. They highlight that performance measures and design considerations often factor in travel time to work but do not consider multimodal access to healthcare facilities, grocery stores, and other essential services to conduct care work.

2.3.6 AT Investments

Various studies demonstrate the historically inequitable distribution of ATI investment, which contributes to enduring disparities in access to ATI. Despite growing interest and investment in AT, equity consideration for AT investments are not yet clearly defined, measured, or implemented in practice.

[13]While these studies do not directly examine disparate impacts of pedestrian and bicyclist crashes for women and gender minorities, the authors determined the studies to be relevant for this scoping review to provide a more comprehensive understanding of how road safety is experienced and perceived by everyday users for practitioners and researchers.

Aytur et al. (2008) reviewed 67 land use plans across North Carolina and found that plans in jurisdictions with low incomes and higher proportion of non-White residents are less likely to contain policies and strategies that support physical activity, such as nonautomobile transportation improvements and mixed land uses. Cradock et al. (2009) examined patterns of transportation spending in 3,140 counties across the United States and find that counties with high poverty rates and low educational attainment are less likely than their wealthier, more educated counterparts to implement pedestrian and bicycle projects between 1992 and 2004. Andersen and Hall (2015) interviewed activists and planners in communities of color who work on and build inclusive bicycle networks. They find that bicycling infrastructure is invested in those communities that have the time and the political resources to ask for and demand the goods from the Government, while leaving under-resourced communities underserved. Lee, Sener, and Jones (2017) examined the pedestrian and bicycle master plans from 13 major U.S. cities to assess how municipalities and planners understand and address AT equities. They find that equity in AT is inconsistently applied in practice, and that the plans vary significantly in the understanding, integration, and prioritization of equity in AT planning. Braun, Rodriguez, and Gordon-Larsen (2019) examined the spatial distribution of bicycling infrastructure in 22 U.S. cities and reveal that CBGs with lower education attainment and a high proportion of Hispanic peoples have lower access to bike lanes.

2.3.6.1 ATI Investment and Property/Land Use Value

Some studies have examined the relationship between the ATI investment and property values (Krizek 2006; Leinberger and Alfonzo 2012). These studies usually focus on two main characteristics of ATI: neighborhoods' walkability and proximity to ATI.

The impacts of proximity of ATI on property values varies across space. Racca and Dhanju (2006) find that proximity to a bike facility could increase housing prices by 4 percent. Krizek (2006) used a hedonic model to analyze the heterogeneous impact of bike facilities on housing prices and finds that proximity to both open space and some bike facilities are valued by urban residents. However, for suburban locations, he finds that bike facilities on roadways lowered home values. Cortright (2009) and Leinberger (2013) report that residential, office, and retail property values are higher in walkable areas. Connolly et al. (2019) examined the impact of connections between local amenities and ATI on the sales price of single-family homes in Franklin, OH. They find that bike facility capitalization is heterogeneous, depending on the types of local amenities and infrastructure links. For example, on-road facility connections with bus stops decrease house values, while on-road facilities linked with open space increase house values.

2.3.6.2 ATI Investment, Gentrification, and Displacement

Within the past decade, the linkage between AT investment and displacement has gained interest within transportation-related public discourse and scholarship. Briefly, gentrification today refers to a complex process in which underserved areas receive economic investment that spurs the in migration of new residents and may or may not displace old residents. Displacement refers to forced removal of residential households, commercial businesses, and/or cultural assets when continued occupancy is made impossible, hazardous, or unaffordable. Further discussion of gentrification and displacement can be found in the CDC's "Healthy Community Design,

Anti-displacement, and Equity Strategies in the USA: A Scoping Review" (Serrano et al. 2023). Beyond AT-induced gentrification, Agyeman and Doran (2021) note that gentrification, in part, is contributing to the displacement of underserved communities to the urban periphery and suburban areas, which impacts their safe access to essential services.

Davis (2011) and Schmitt (2011) published blog articles to highlight how mainstream bicycling is often perceived as an activity predominantly enjoyed by affluent White individuals. These articles describe how low-income and minority communities view bicycling culture as part of the gentrification process. Agyeman and Doran (2021), Hoffman and Lugo (2014), Lubitow and Miller (2013), and Stehlin (2015) discussed the underlying sociopolitical factors associated with bicycling-induced gentrification. These factors include "White" bicycling culture, disparities in the benefits of bicycling investments, which tend to follow people categorized as White and with higher incomes, and ongoing inequities in urban transportation networks and decisionmaking processes. Multiple organizations that promote bicycling for Black men and women, ranging from Grown Men on Bikes in Detroit, MI, to Black Girls Who Bike internationally, contest these cultural narratives in practice to create safe and inviting spaces for individuals who are categorized as Black.

Additionally, empirical studies that establish a causal relationship between bicycling infrastructure investment and gentrification are limited. Flanagan et al. (2016) empirically examined the relationships between the distribution of bicycling infrastructure investment and neighborhood demographic changes from 1990 to 2010 in Chicago, IL, and Portland, OR. This study verifies that bicycling infrastructure investment was prioritized in areas of existing or increasing privilege, and disadvantaged communities are less likely to have bicycling infrastructure investment (Flanagan et al. 2016). Ferenchak and Marshall (2021) longitudinally assessed 11,010 mi of bicycling facilities of various types over 10 yr (2010–2019) in 11,293 block groups across 29 U.S. cities. They find that communities with concentrations of people of color had low bicycling facility investment, while lower income communities had higher levels of investment (regardless of their racial/ethnic composition). They did not find significant causal relationships between bicycling facilities and neighborhood socioeconomic changes, and bicycling facilities were not associated with displacement. Additionally, Dsouza et al. (2022) find that "low-income, racial, or ethnic minority populations support environmental changes to improve active living despite cost-of-living concerns associated with community revitalization."

The CDC (Serrano et al. 2023) recognizes the well-established need for ATI to create connected, safe, and healthy communities for all people. They note that while no robust assessment documents the impact of AT investment on gentrification or displacement, the concerns of communities are valid and require proactive efforts to prevent displacement or mitigate its harms. Specifically, they recognize concerns that AT investments may increase property values, which may displace people with low incomes and people from BIPOC communities from their homes and businesses. To address these concerns, the CDC published a scoping review that identifies 141 mitigation and prevention strategies for displacement for a variety of practitioners to implement to ensure that the benefits of AT investments and projects are experienced by the communities residing in those areas (Serrano et al. 2023).

2.4 LIMITATIONS AND BIASES

The researchers identified several methodological limitations in the studies, including aggregation bias, concerns about data quality, and heterogeneity in methodologies.

Aggregation bias can happen when the researcher aggregates crashes to a spatial unit or aggregates demographic groups. When traffic crashes are assigned to specific CTs, for example, there is a potential for bias due to the use of road segments as boundaries for CTs. Crashes that happen near the boundary of two census units are usually assigned to only one unit, even though they could have occurred in either of the adjacent units. Second, certain studies have grouped together several race and ethnicity and income categories into aggregate measures like "minority," "environmental justice," or "non-White groups," which fail to distinguish potential differences between the demographic groups. Third, criteria to divide the communities into different groups for comparison can be arbitrary, such as the threshold to determine if a community is low/high income or minority/majority community. Unreasonable categorization leads to ineffective model comparison.

Current crash and roadway infrastructure data are limited. Pedestrian and bicyclist crash data from police crash reports or medical records were usually underreported and lack detailed information on the crashes and the people involved in the crashes, which has been commonly acknowledged in the literature (Barajas 2018; Steinbach et al. 2016; Yu, Zhu, and Lee 2018). Unavailability of information on pedestrian and bicycle exposure also forces researchers to use surrogate measurements by community characteristics, which would be problematic for its lack of consideration of individual traveling behaviors (Sze, Su, and Bai 2019; Zhang et al. 2015). The lack of exposure data is also noted as a potential confounding factor in multiple studies (Hwang, Joh, and Woo 2017; McArthur, Savolainen, and Gates 2014; Rothman et al. 2014; Sanders and Schneider 2022). Furthermore, the limitation of data for roadway infrastructure, especially the data of AT facilities and their quality, comfort, and maintenance, might lead to an insufficient investigation of their effect on crash risks (Guo, Osama, and Sayed 2018; Yu 2014).

Finally, most studies are cases of one city or region, whose results may not be generalizable. When looking at the effects of factors across different cities or regions, heterogeneity emerges in some studies. Local studies between cities and regions are needed to investigate if or what types of disparity in pedestrian and bicyclist crashes are consistent across different locations. Comparing local studies is important to understanding the specific barriers and needs within each community, which may not necessarily translate to others. If the disparity is context dependent, one can investigate what specific localized mechanism shapes the disparity (Barajas 2018).

As noted in the multidisciplinary approach (section 1.4) and methodology (section 2.2) sections, the purpose of this scoping review is to elucidate risk factors that could be investigated by practitioners and researchers as potential contributors to disparities in pedestrian and bicyclist fatalities and serious injuries. As such, these risks could be used to investigate potential disparities in specific contexts but should not be interpreted as universal, determinant, comprehensive, or mutually exclusive.

CHAPTER 3. NOTEWORTHY CASE STUDIES

3.1 CASE STUDY SELECTION AND DEVELOPMENT

To effectively identify and summarize the noteworthy case studies, the research team conducted outreach and developed evaluation metrics to rank and select noteworthy cases.

3.1.1 Selection

The team searched for case study recommendations through several channels:

- A questionnaire disseminated by the research team.
- Expert panel recommendations.
- Professional experience of research team.
- FHWA webinars on equity in roadway safety.

A total of 26 case studies were identified: 3 in Maryland, 3 in Texas, 2 in Minnesota, 2 in Florida, 2 in New Jersey, 2 in California, and 1 in each of the following States: Georgia, Iowa, Nevada, New York, North Carolina, Oregon, Tennessee, Washington, and Wisconsin. In addition, the researchers received one response on an international case study from Sudan, and the expert panel identified two case studies from Colombia. Seven case studies were selected based on evaluation metrics and availability of agency and organization staff.

3.1.2 Interviews

After selecting the seven case studies, the research team reviewed relevant city and organizational documents and conducted followup interviews. Each interview lasted approximately 1–2 hr. Interviews were semistructured around key themes, including equity in roadway safety, organizational structure and collaboration, meaningful public involvement and data analysis, and roadway safety interventions.

3.2 CASE STUDIES

In this section, the research team presents the seven noteworthy case studies, which highlight strategies the agencies and organizations implemented and promising practices that other agencies may implement:

- Safe Streets for Seniors (SSFS) Program—New York City (NYC) (NYC DOT 2022b).[1]
- Vision Zero Action Plan—Jersey City (JC) (Jersey City 2024).[2]

[1]Anthony Boutros, Melissa Chiovenda, and Teresa Haslauer (FHWA) and Rachael Thompson and Jessica Schoner (Safe Streets Research and Consulting) interviewed Rob Viola and Chris Brunson (NYC DOT).

[2]Anthony Boutros and Melissa Chiovenda (FHWA) interviewed Michael Manzella, Lyndsey Scofield, and Elias Guseman (Vision Zero).

- Design Your Neighborhood Program—Nashville Civic Center, Vanderbilt University, TDOT, and NDOT (Civic Design Center Youth 2024).[3]

- Roadway Safety Audits in Amish Communities—Buchanan County, IA.[4]

- Pedestrian Crossings and Safety on Four Anishinaabe Reservations—Minnesota (Lindsey et al. 2020).[5]

- Changing Lanes on Gender Equity and Transportation—LADOT (2021).[6]

- Transportation Needs in Daily Life—MET Council (Metropolitan Council Team 2023).[7]

3.2.1 SSFS Program—NYC

The followup interview with the New York City Department of Transportation (NYC DOT) was conducted on October 30, 2023, with NYC DOT staff by FHWA staff and members of the research team. Findings from the interview and review of related documents are summarized in the following subsections.

3.2.1.1 Background

SSFS is a pedestrian safety initiative designed to improve safety for older New Yorkers. NYC DOT launched SSFS in 2008 in response to the disproportionately high rate of senior fatalities on NYC streets, and SSFS became a part of the city's Vision Zero strategy when Vision Zero became policy in 2014. SSFS has improved safety outcomes for pedestrians and other road users by identifying and implementing effective policy and infrastructure investments (NYC DOT 2022a, 2022b). Several strategies characterize the SSFS initiative, including Vision Zero principles, educational and enforcement responses, and safety treatment evaluation.

Transportation agencies can learn from SSFS' successes using data to identify and elevate safety needs for seniors and leveraging momentum from those projects for broader safety and Vision Zero goals.

[3]Melissa Chiovenda and Anthony Boutros (FHWA) and Rebecca Sanders (Safe Streets Research and Consulting) interviewed Melody Gibson and Cydney Thompson (Youth Design Team) and Kayla Anderson and Eric Hoke (Civic Design Center).

[4]Anthony Boutros, Melissa Chiovenda, and Rosemarie Anderson (FHWA) and Rachael Thompson Panik (Safe Streets Research and Consulting) interviewed Brian Keierleber (Iowa).

[5]Anthony Boutros, Melissa Chiovenda, and Kristi Sebastian (FHWA) and Jessica Schoner (Safe Streets Research and Consulting) interviewed Adrien Carretero, Michael Petesch, and Greg Lindsey (MnDOT).

[6]Jessica Schoner (Safe Streets Research and Consulting) coordinated with Clare Eberly (LADOT).

[7]Jessica Schoner (Safe Streets Research and Consulting) coordinated with Jonathan Ehrlick (MET Council) by email correspondence.

3.2.1.2 Strategies

Strategy 1: Let Well-Framed Data Direct Organizational Focus and Action

NYC DOT started their focus on senior safety (figure 8) because data showed a significant need. The data showed the kinds of situations in which seniors are most vulnerable, for example, in conflicts involving motorists turning left. Through this study (NYC DOT 2022b), NYC DOT updated its senior pedestrian zones throughout the city. Planners used these data and evidence to secure buy-in up the chain. SSFS was a bottom-up effort within city staff supported by data.

Data are necessary, but data alone may not be sufficient for whole-system transformation. Nationally, roadway crash data show that arterial street design harms pedestrians—and many motorists, too—but communities have not bought into necessary interventions like slowing down drivers. In NYC DOT's case, engineers and planners framed the safety data through the lens of risk for seniors, which helped the agency get uncontroversial support for safety projects and ultimately triggered a cascade of systemic interventions, high-quality data and evidence validating them, and broader public and professional acceptance.

Promising Practice: Agencies can leverage safety data and frame the safety problem in a way that will get the most support from communities and decisionmakers.

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Figure 8. Photo. Senior pedestrians crossing Tinton Avenue (Bronx).

Strategy 2: A Narrow Focus and Small Steps, Backed by Data, Builds Momentum for Systemwide Change

With data as the catalyst, NYC DOT staff chose strategic safety investments: they prioritized a specific population (i.e., seniors) in specific locations (i.e., senior pedestrian focus areas (SPFAs)). Planners identified SPFAs through spatial concentration of senior-involved crashes, as well as concentrations of senior housing, senior centers, and senior trip generators. Collectively,

19 percent of NYC's senior population lives within SPFAs, and about one-third of all pedestrian fatalities and serious injuries occur within SPFAs.

Importantly, the SPFAs process not only identified areas of concentrated risk for seniors, but they also narrowed the spatial scope of the project. Because NYC DOT narrowed the population and spatial focus, they effectively "piloted" systemic safety countermeasures, like LPIs and crossing islands, within a relatively small scope—a much more tenable goal than fixing everything at once. Piloting the treatments to improve safety for seniors and documenting the treatments' success secured buy-in to use the countermeasures more broadly.

Promising Practice: Transportation agencies can "start small" with a single, well-defined safety challenge. Through addressing safety for one specific population or one specific context, transportation agencies build trust, familiarity, and acceptance for strategies that could be applied more broadly.

Strategy 3: Think Broadly About Where and How Populations Experience Risk

Focusing on seniors proved to be strategic for NYC DOT in another way: NYC DOT's senior-centric strategy demonstrated to stakeholders the effectiveness of addressing the root causes of risk for a specific population across a wide variety of locations. This approach is different from other population-specific countermeasure programs, which often only consider a specific kind of travel destination and travel modes (e.g., SRTS, which typically focuses on sidewalk and crossing improvements near schools). NYC DOT understood that seniors live full and complete lives and not just in locations around the specific institutions that serve them. NYC DOT operationalized their understanding of the seniors by implementing countermeasures in many locations within neighborhoods where there are more seniors. The result of this broader understanding of their focus population is that NYC DOT distributed countermeasures at locations with more traffic—and more risk—than the researchers might see in SRTS countermeasures. Many elementary-school SRTS programs focus on neighborhood streets immediately around schools, which are not the streets causing the most harm.

Bus Stops Can Save Lives

Several bus routes stop underneath elevated trains in NYC. Because of structural support columns for the elevated train, buses cannot get close to the curb in many locations, requiring riders to board and alight the bus in the roadway, away from the curb and sidewalk, a situation that is especially inaccessible and unsafe for older pedestrians. NYC DOT received 5310 Federal Transit Authority grant dollars to add pedestrian bus boarding islands along dozens of stops, creating a safe place for people to wait and improving bus operations by precluding bus lowering for accessibility. See figure 9.

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A. Before.

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B. After.

Figure 9. Photos. Pedestrian islands at the 228th Street bus stop under the El in the Bronx.

Promising Practice: If transportation organizations want to improve safety for a population, then they must think more broadly about two facets of safety: how that population travels within the system; and what actually causes risk for that population.

Strategy 4: Document the Effectiveness of Countermeasures So That What Is Initially Cutting-Edge Becomes Institutional Practice

Even with limited deployment of these countermeasures to the areas shown to be important for seniors, staff collected and evaluated data on usage and safety, finding them to be widely effective not just for seniors but for everybody. Over time, as evidence supported the countermeasures, the public got used to them, and engineers adjusted to what had previously been new engineering measures. NYC DOT leveraged these documented successes to gain support for safety countermeasures more broadly: what started as a limited systemic deployment in SPFAs for seniors to systematic for all or nearly all locations. Similarly, what were initially cutting-edge new practices—such as cutting expected pedestrian crossing time from 4 to 3 ft/s—overtime became the institutional practice as the safety benefits of this approach were demonstrated to the engineering teams.

Promising Practice: Transportation agencies should define metrics and study how effective their safety countermeasures are to showcase broad applicability and institutionalize best practices.

Strategy 5: Engineering Is Crucial

While institutional change is necessary to set equitable safety strategies in motion, engineering strategies that physically remove or mitigate risky contexts are necessary to achieve measurable safety impacts. NYC DOT focused on engineering solutions first and foremost, with great success. They built consensus among many different kinds of partners to show that seniors may need more time or protected space to safely cross the street or wait on transit, which logically

called for design and operations (i.e., engineering) changes; there is no way for enforcement to make the same impacts, and no amount of education would help seniors cross the street faster.

An example demonstrates this point: NYC DOT found that left-turning pedestrian crashes were three times more severe than right-turning crashes, and the difference in safety outcomes was nearly entirely attributable to seniors and turning speeds. The slightly higher left turning speeds (versus right turns) creates more kinetic energy that can be fatal for seniors, who have lower tolerances to external forces on their bodies. Given this reality, education or enforcement could not be as effective as longer crossing times, protected phasing, and crossing islands to prevent crashes between pedestrians and drivers turning left.

When NYC DOT used education to address safety, the conversation flowed both ways. The city's approach to education functioned more like public engagement: learning from seniors about what their needs and concerns were. They also paired education with engineering changes to support acceptance of new designs and countermeasures, instead of relying on education alone to attempt to change behavior. But as countermeasures became institutionalized and shifted from specific systemic treatments to ubiquitous systematic treatments, the role of education shifted with it. The improved standard for street design led to better public understanding of safety countermeasures.

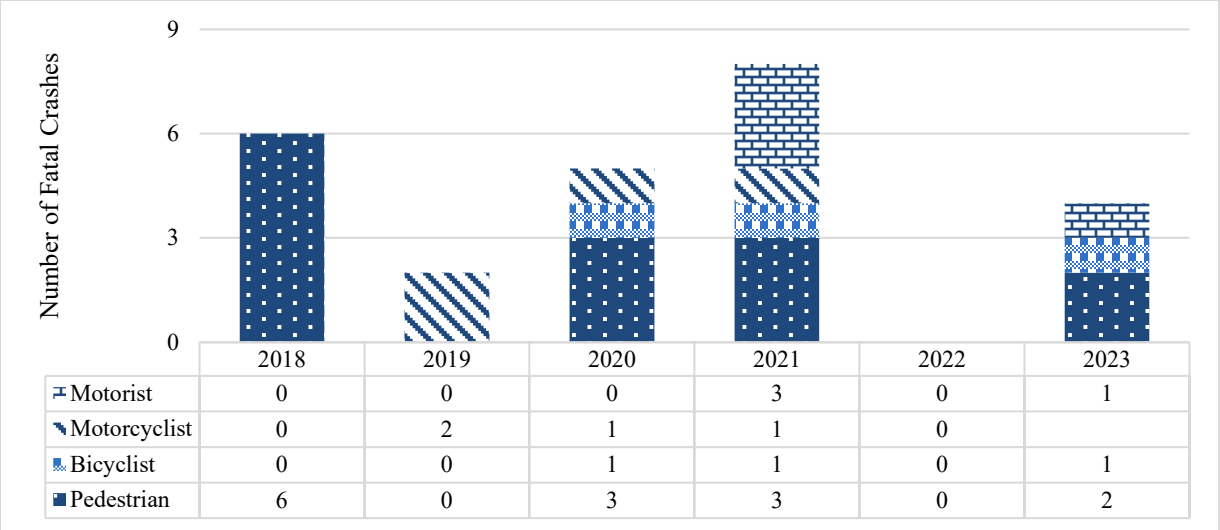
Promising Practice: Engineering, education, and enforcement are not equivalent. Transportation agencies should prioritize engineering solutions, as no amount of education or enforcement can substitute for an environment designed for safe travel. When agencies do employ education strategies, they can maximize their effectiveness by pairing them with engagement best practices and tailoring them to complement their engineering efforts.

3.2.2 Vision Zero Action Plan—JC

The interview with JC was conducted on December 28, 2023, by FHWA staff. Findings from the interview and review of related documents are summarized in the following subsections.

3.2.2.1 Background

Since committing to Vision Zero in 2018, JC, NJ, has worked to eliminate traffic fatalities through the systemic application of quick-build projects that serve everyone who travels in the city. In 2022, the city reported zero roadway fatalities along streets under its jurisdiction (figure 10). This achievement is distinguishable, particularly for a U.S. city at a time when annual roadway fatalities have continued to rise across the Nation. Yet the deaths of four people caused by crashes on JC's streets in 2023 demonstrate that Vision Zero is an ongoing effort. As Mayor Steven Fulop stated in JC's 2023 Vision Zero Annual Report, "there is still work to be done." (Jersey City 2024).



	2018	2019	2020	2021	2022	2023
Motorist	0	0	0	3	0	1
Motorcyclist	0	2	1	1	0	
Bicyclist	0	0	1	1	0	1
Pedestrian	6	0	3	3	0	2

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Figure 10. Graph. Fatal traffic crashes on JC's city-owned streets, 2018–2023 (Jersey City 2024).

3.2.2.2 Strategies

Strategy 1: Encourage Strategic Innovation

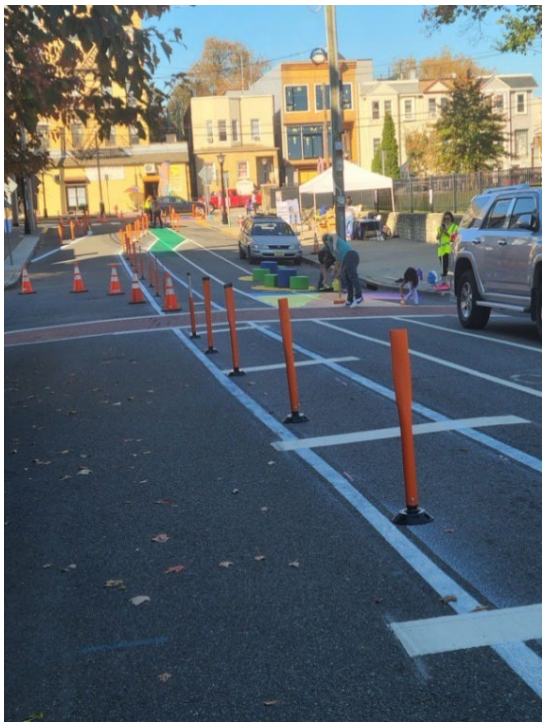
Early into their Vision Zero commitment, JC's engineering team decided on a quick-build, low-cost approach (i.e., focusing on paint and temporary materials, rather than moving curbs and breaking ground) to install safety projects on its streets. JC implements quick-build projects when opportunities arise (e.g., when a street is up for repaving). This approach has had several benefits. First, quick installations often lead to quicker results. In recent years, JC's engineering team has installed the following:[8,9]

- Protected bike lanes: 20 mi.
- Speed humps: 679.
- Locations prohibiting right turns on red: 183.
- Intersections with LPIs: 14.
- Parklets and pedestrian plazas: more than 30.
- Quick-build curb extensions: more than 100.

[8]More details about JC's progress toward zero roadway fatalities can be found in their *2022 Annual Report* (https://www.jerseycitynj.gov/cityhall/infrastructure/transportation_resources/visionzero).

[9]An important aspect of making quick-build projects "accessible to and usable by people with disabilities," as required by law, is to provide the same benefits to all pedestrians. APS installation at LPIs allows people who are blind or have low vision to have the same safety advantage of starting their crossing before vehicles enter the intersection. Resources about accessibility can be found on FHWA's website (https://highways.dot.gov/civil-rights/programs/ada/resources).

As safe infrastructure has been installed, traffic crashes, injuries, and fatalities have decreased, and public support and momentum for projects has grown. Figure 11 shows two quick-build project examples.



© 2024 Jersey City Department of Infrastructure.
Note: Anyone on foot in a temporary traffic control zone should wear safety vests (standard in MUTCD part 6).

A. Chicane on North Street next to Washington Park.

© 2024 Jersey City Department of Infrastructure.

B. Pedestrian refuge island on Monticello Avenue.

Figure 11. Photos. Quick-build traffic calming projects in JC.

Second, taking action, even if an intermediate step is not the perfect or final solution, has provided JC opportunities to learn lessons for future projects. JC has chosen to build quickly (i.e., rapid experimentation) and then learn from the experience, both in terms of noteworthy design practices and meaningful public engagement practices, to ensure that projects meet communities' needs. As required by law, accessibility for individuals with disabilities is considered during project development and factored into each quick-build project.

Promising Practice: Agencies can implement quick-build projects as opportunities arise to improve safety for all users.

Strategy 2: On-Call Contracting of Quick-Build Experts Leads to Rapid Implementation

Administrative delays related to selecting and processing contractors slow down safety project installation. Preselecting teams of consultants and contractors with on-call availability streamlines contracting and accelerates the design and construction process for projects that do not require major construction. The on-call team includes concrete and asphalt contractors, a striping contractor, a traffic signal maintenance contractor, and traffic engineering and transportation planning design consultants. When there is an opportunity for a quick-build project (e.g., when a street is up for repaving), JC and the relevant on-call contractors immediately begin planning and design, saving the time usually spent on team selection and contract approval. For larger and more complex capital projects, JC solicits bid proposals in accordance with local public contract law.

Promising Practice: Agencies can pair on-call contracting teams with quick-build implementation to get safety projects on the ground.

Strategy 3: Use Safety Projects to Both Reduce Crash Risk and Enhance Community Placemaking

Placemaking is the urban design and planning practice to create a common vision for a public place, developed from the people who live, work, and play in that place.[10] The JC team uses quick-build projects to accomplish two goals at once: to improve roadway safety and enhance community character through infrastructure. The following examples show how transcending the silos between safety and urban design decisionmakers improves the sense of safety and quality of life in multiple ways*:* People can walk and bicycle more safely and comfortably in these transformed spaces, and the community now has artwork or installations that highlight cultural richness, provide opportunities for emerging artists, and/or increase economic vitality.

India Square Placemaking

"India Square" along Newark Avenue is a commercial district in JC that has a concentration of Indian restaurants, supermarkets, and businesses. In 2023, the JC engineering and planning team installed concrete curb extensions to enhance safety, and they also contributed to neighborhood placemaking by painting an intersection mural of a mandala and adding lighting at both gateways to the street (figure 12). The team developed this project and design through robust outreach with the community (e.g., public meetings, informational materials translated into many languages) to ensure that the project reflected community values and preferences. Such an integrated approach makes a difference: people see the placemaking and experience the safety, and then they want more.

[10]The definition of placemaking used here aligns with the FHWA Office of Operation's publications glossary (https://ops.fhwa.dot.gov/publications/fhwahop12004/glossary.htm).

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Figure 12. Photo. India Square mandala mural (Jersey City 2024).

Heights Neighborhood Curb Extension Mural

Palisade Avenue is a heavily traveled, multimodal, north–south corridor that connects multiple neighborhoods and Hudson County municipalities. JC's Office of Innovation, working in coordination with the Division of Transportation Planning and Division of Sustainability on a Year of Open Space (YoOS) initiative, identified the intersection of Booraem Avenue and Palisade Avenue as a prime location for safety improvements due to the challenging historic intersection geometry, unsafe vehicular turning conditions, and underutilized space.

To address these safety concerns and activate the space, the YoOS team, supported by a placemaking and transportation planning consultant, used a series of quick-build Vision Zero strategies. These strategies included installing a two-block-long, pop-up, protected bike lane and adding painted curb extensions that reduced corner radii and may reduce the crossing distance. To enhance the curb extensions and build community support for the project, the team commissioned a JC student who had been involved in the Jersey City Mural Arts Program (JCMAP)[11] to design and lead a group of local volunteers in painting a mural in the reclaimed street space. The JCMAP links established emerging local, national, and international mural artists with property owners as part of a beautification program that reduces graffiti, engages local residents, and is transforming JC into an outdoor art gallery (figure 13). By engaging artistically inclined youth, the city also cultivates a talent pool of local artists who can be called on to contribute to a lively streetscape.

[11]For information about the Jersey City Mural Arts Program, see https://www.jcmap.org/.

© 2024 Beatriz Bofill, Bike JC.

Figure 13. Photo. Traffic calming mural designed by a local youth artist.

Grove Street Protected Bike Lane and Pedestrian Plaza

As part of JC's commitment to install protected bike lanes and multimodal infrastructure to improve safety on high-injury network streets, the city built its first permanent protected bike lane on Grove Street in 2019 using its tested formula of green waterborne paint, flexible delineator posts, and on-call striping contractors. Running past City Hall to the Grove Street PATH station and adjacent to the most heavily utilized bike-share station, this project created protected bike lanes by reducing the travel lane width rather than removing travel lanes or on-street parking.[12]

The Transportation Planning and Traffic Engineering Divisions collaborated to incorporate the city's first protected intersection into the striping plan at the high-crash intersection of Grove Street and Grand Street in 2020. The intersection's paint and flexible delineator posts significantly slow turning vehicles and separate users in space to allow cyclists to cross the intersection with fewer conflicts (figure 14).

[12]Grove Street's 16-ft travel lanes were first narrowed to 11 ft with the addition of the conventional bike lanes, then further narrowed to 10 ft to accommodate the protected bike lane.

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A. Striping of two-way separated bike lane.

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B. JC's first protected intersection.

© 2024 Jersey City Department of Infrastructure.

C. Adding shrubs to parking lane.

© 2024 Jersey City Department of Infrastructure.

D. Pedestrian plaza with outdoor dining.

Figure 14. Photos. Quick-build protected intersection project in JC.

This project further served to create new public space at the start of the COVID-19 pandemic, when restaurants were struggling and people craved more outdoor space. With support of the Mayor's Office, the Transportation Planning team quickly took advantage of the opportunity to further transform Grove Street by converting one direction of travel and a parking lane into pedestrian space using planters and parklets for outdoor dining. In 2023, Transportation Planning completed a visioning study to engage the community in a long-term plan to make these improvements permanent.

Promising Practice: Agencies can leverage infrastructure projects to improve roadway safety and enhance community character.

Strategy 4: Institutionalize a Safety Culture Around a Shared Vision for Zero Deaths by Involving Agency Staff, City Leadership, Advocates, and the Community

A strong network of JC community and staff advocates convinced elected officials to adopt safe mobility and access for all road users as a priority. In 2018, JC's Mayor, Steven Fulop, signed Executive Order 2018-007 2018, which committed JC to the goal of zero traffic fatalities and serious injuries by 2026 (Fulop 2018). Executive Order 2018-007 2018 was followed by another Executive Order (2019-007) to establish a Vision Zero Task Force, which brings together multiple stakeholders—including city, county, and State representatives; departmental leaders in public health, policing, engineering, parking, and public works; and local advocates—to review the city's progress (Fulop 2018, 2019). Through the Task Force, support from political and agency officials has grown. As a result, when opportunities for transportation projects arise, all teams who must develop and champion the projects—traffic operations, pavement, planning, engineering, elected officials—prioritize safety.

This shift to a safety culture—collaboration toward a shared vision of roadway safety—did not happen immediately. Much of this successful interdepartmental working relationship has been built over years of intentional effort, including through personal relationships.

This cultural shift led to institutional transformation: JC's Traffic and Engineering Divisions integrated with the Divisions of Transportation Planning, Innovation, Sustainability, and Architecture to create a single Department of Infrastructure. This department streamlines decisionmaking across all parts of the built environment, including planning, traffic engineering, architectural design, sustainability, and public engagement. Within the same department, decisionmakers across all aspects of the built environment develop and design projects that improve roadway safety, perceived safety, comfort, and interest.

Promising Practice: Agencies can break down administrative silos across departments by institutionalizing a safety culture to build streets that are safe and feel safe and comfortable for all users.

FHWA Notes

Agencies can use Safe Streets and Roads for All funding to implement demonstration projects. In addition, FHWA has many other Pedestrian and Bicycle Funding Opportunities available to support multimodal infrastructure development (FHWA 2023a).

Accessibility for people with disabilities is a critical component of an equitable approach. The ADA requires accessibility for all programs and activities of State and local governments (Title II) and public accommodations (Title III), while Section 504 requires accessibility by entities receiving Federal financial assistance (Americans With Disabilities Act of 1990 (2014).

When using quick-build materials or methods, an agency must ensure the facilities can be utilized by people of all abilities. Information about pedestrian accessibility and the U.S. Access Board's public rights-of-way accessibility guidelines may be found on FHWA's Civil Rights webpage (FHWA 2024a).

Strategy 5: Be Strategic and Transparent with Project Implementation to Maintain Accountability

Sometimes, the people and communities who need safety countermeasures the most have the least influence on government processes and/or ability to participate in traditional engagement processes. JC balances an increased volume of requests, a need for public accountability and transparency, and their vision for equity in several ways:

- First, they create an annual plan for which projects will be prioritized that year. These plans provide transparency in the face of many requests for quick-build projects. By publicly outlining what their priorities are ahead of time, the plans help people understand why some requests are addressed more quickly than others. See the callout box, Incorporating Equity Quantitatively into Planning, to read how JC incorporates equity into its planning process.

- They use a rubric within these annual plans and the Vision Zero Action Plan (Jersey City 2024) that guides much of their work that helps them equitably and transparently allocate projects across the city. The rubric includes measures of both equity and community input and is more fine-tuned than the North Jersey Transportation Planning Authority's (NJTPA) more generalized environmental justice metric, which captures 80 percent of the population in JC.

- They use storytelling as a form of accountability by publishing annual reports and mapping infrastructure improvements and other installations, like LPIs, that the public may not know. These highly visual and transparent data show the community what has been done and illustrate the city's priorities.

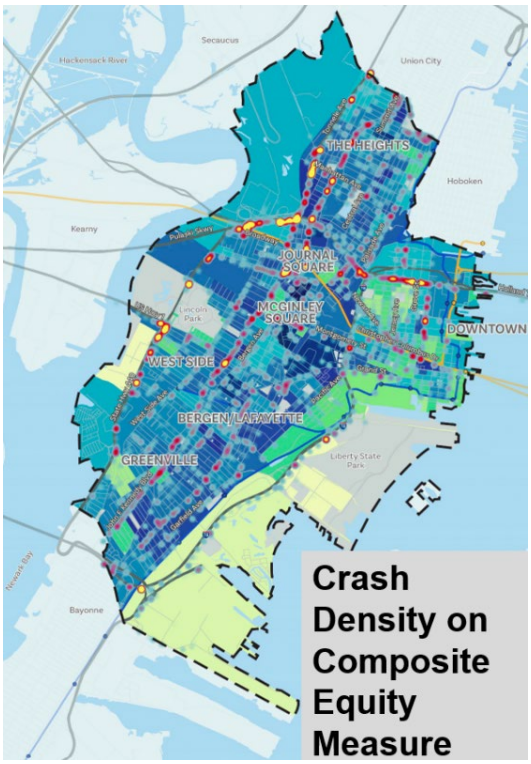
Incorporating Equity Quantitatively into Planning

JC staff use a multistep process to thoroughly consider equity while developing their plans for the following year. The first step is to follow NJTPA's equity analysis methodology, which includes using census data to examine the concentration of the following factors within each CBG:

- BIPOC population.
- Low-income population.
- Limited English proficiency.
- Disability status.
- Young children (less than 5 yr old).
- Children (between 5 and 17 yr old).
- Seniors.
- No vehicle access.
- Foreign-born population.
- Female population.
- Highest education attainment.

The concentrations for each factor are then "scored" from 0 to 4 based on their standard deviation from the citywide average, and those scores are summed to create a composite equity measure that is specific to JC.

The composite scores are then mapped and compared with the density of crashes and traffic calming measures, as shown in figure 15.



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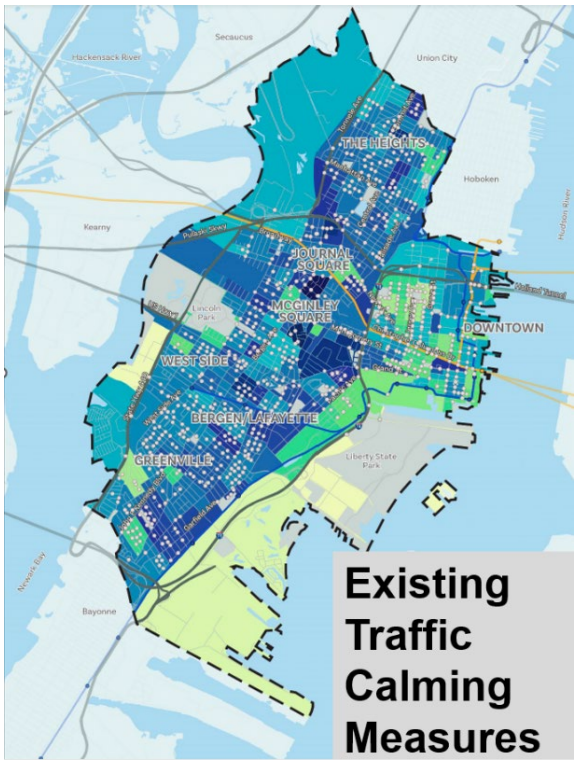
A. Traffic crashes.



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B. Traffic calming measures.

Figure 15. Maps. Overlap of equity areas with traffic crashes and traffic calming measures (Jersey City 2024).

Promising Practice: *Agencies can publicly publish plans, including the methodologies and data that inform them, to show communities what is planned, what has been done, and which priorities guide future work.*

3.2.3 Design Your Neighborhood Program—Nashville Civic Center, Vanderbilt University, TDOT, and NDOT

The interview with the Nashville Civic Design Center was conducted on November 28, 2023, by FHWA staff and members of the research team. Findings from the interview and review of related documents are summarized in the following subsections.

3.2.3.1 Background

Nashville's Civic Design Center, in partnership with Vanderbilt University, TDOT, and NDOT and Multimodal Infrastructure, installed youth-led, quick-build projects to improve access and safety and increase joy for Nashville's communities. The Civic Design Center's programs create rich opportunities for youth to visualize what they want their city to look like, elevating hopes and visions about youth-related opportunities in Nashville's communities. These youth-led visions are then funneled to transportation agencies and community leaders and materialized

through quick-build projects. The built projects serve to garner support from local agencies and leaders and further invigorate youth toward community leadership.

Transportation agencies can learn from the success of the Civic Design Center's programs and prioritize empowering youth to be cocreators of their own communities.

3.2.3.2 Strategies

Strategy 1: Youth Should Be Cocreators of Change

The Civic Design Center and its programs, Design Your Neighborhood and Nashville Youth Design Team (NYDT), start with the belief that youth should be cocreators of their communities, not just recipients of their communities' decisions. Because youth experience their communities differently than the adults who typically design the places where kids live and play, youth provide insights that are often missed in transportation decisionmaking. The NYDT seeks to capture those perspectives and center them within planning and design processes. See Cydney's Story in the callout box as an example of a youth-led initiative that benefited Nashville's Antioch community.

Cydney's Story: A Positive-Sum Approach

As a part of her work with the Civic Design Center, Cydney found that many teens want to play soccer but do not have a place to safely and affordably do so. Cydney and her team of youth leaders created an outreach campaign, reaching many young people in the Antioch neighborhood to talk about barriers to playing in the local Antioch Park. Based on their community outreach findings, Cydney and her team decided that a temporary mini-soccer pitch at this park would give teens access to a place to play. They presented their ideas to industry partners who provided funds for materials, and Cydney and her team installed the mini-soccer pitch. The value of the mini-soccer pitch was recognized through Nashville's participatory budgeting process, which recently allocated funding for a permanent, regulation-sized field with an equipment rental program. Additionally, the success of the mini-soccer pitch created momentum to work with TDOT to envision safer sidewalks and street crossings from Blue Hole Road to the pitch. Cydney and her team's work shows that community projects can (and should) occur in tandem with transportation safety projects—a positive-sum approach.

Promising Practice: Agencies should seek out opportunities to center youth in their decisionmaking processes.

Strategy 2: Ground the Process in Best Practices

The Civic Design Center and NYDT designed their approach to youth and community engagement through a specific methodology, youth participatory action research (YPAR).[13] This method, led by Vanderbilt University Community Research and Action[14] Doctor of Philosophy (Ph.D.) students, derives research questions, hypotheses, research designs, and potential solutions from the youth (and their communities) who are most impacted by a community problem. The NYDT applied YPAR through five steps:

- Action-oriented research questions and hypotheses: Youth developed a question based on an evaluation of community needs and from their own experiences, facilitated by Civic Design Center staff.

- Research tools, data collection, and mapping: Students worked with community partners and mentors to develop a method (i.e., research tool) for collecting data about their question. Example research tools include surveys, interviews, and PhotoVoice.[15] The youth then analyzed qualitative and quantitative data received from their research tools.

- Exploration of the built environment: Based on the collected data, participants experienced the built environment for themselves, detailing their observations.

- Understanding of community context: NYDT participants also familiarized themselves with the characteristics of the community for which they were designing, such as neighborhood history and socioeconomic factors.

- Data-informed design proposal and advocacy: The youth applied findings from each step of the YPAR process to their transportation and community project designs.

YPAR is a best practice in community engagement and problem solving that garners community buy-in and ensures that the designs reflect the communities' stated needs.[16]

Promising Practice: When exploring ways to reduce socioeconomic disparities through transportation projects, agencies should lead these processes with specific methodologies that reflect best practices for engaging these communities and youth.

Strategy 3: Demonstration Projects Can Lead to Permanent (and Larger) Change in Infrastructure and Organizational Processes

Dickerson Pike is a high-crash corridor in northeast Nashville, especially for pedestrians. In 2020, more pedestrians died on Dickerson Pike than on any other corridor in the city

[13]To see how the Civic Design Center uses YPAR, visit their website (https://youth.civicdesigncenter.org/high-school/youth-led-process).

[14]More information about Vanderbilt University's Community Research and Action program can be found on their website (https://peabody.vanderbilt.edu/academics/phd-programs/community-research-action-phd/).

[15]PhotoVoice is a qualitative research method that uses photos taken and selected by research participants as a tool for reflection on lived experiences. Learn more about PhotoVoice and other YPAR research tools on their website (https://yparhub.berkeley.edu/investigating-problem).

[16]To learn more about YPAR, see UC Berkeley's *YPAR Hub* (https://yparhub.berkeley.edu/home).

(Rains 2023). The Civic Design Center, NYDT, Walk Bike Nashville, and other partner organizations applied for a grant from the Tennessee Department of Heath to improve safety along the corridor, which has high bus ridership. The NYDT used the grant to install a quick-build intervention to demonstrate the benefits of creating extra space for pedestrians at crosswalks. They also made several design recommendations in addition to the quick-build installation, including relocating an existing crosswalk and installing a pedestrian hybrid beacon and pedestrian refuge island to improve safety for people crossing Dickerson Pike to ride the bus. After several rounds of design revisions, the NYDT presented their recommendations to TDOT, advocating for a permanent renovation at Dickerson Pike and Hart Lane. This project has now received funding for implementation.

NYDT's successful project along Dickerson Pike has created momentum far beyond the original crosswalk enhancement. The Dickerson Pike demonstration project led to several partnerships and institutional shifts, including the following:

- NDOT, TDOT, and Tennessee Department of Heath collectively provided funding for permanent safety installations along this corridor.

- Tennessee was selected for Smart Growth America's Complete Street Leadership Academy, a technical assistance program designed to help cities and State decisionmakers work together for safer streets.

- The Metropolitan Nashville City Council agreed to earmark $500,000 for future quick-build projects that enhance safety within the city, in addition to funds allocated for quick-build Vision Zero projects.

- NDOT is now regularly engaged during NYDT's design process, vetting and supporting bringing youth ideas to life (figure 16).

- NDOT aims to employ more quick-build projects as a part of the larger Vision Zero efforts.

- Civic Design Center created an application form for DOTs that allows community members/organizations to apply to install quick-build projects to improve safety.

© 2024 Civic Design Center.

Figure 16. Photo. Students participating in Dickerson Pike demonstration project installation.

Promising Practice: Transportation agencies should embrace the possibilities of grassroots and/or demonstration projects to advance safety and community engagement.

Strategy 4: Youth Voices Can Create Momentum That Inspires New Strategies

Young people can inspire decisionmakers to try innovative approaches that elevate safety for all. For example, the Civic Design Center proposed several quick-build-style projects on other State routes before NYDT successfully installed their crosswalk improvements, but none of these prior propositions successfully moved through the decisionmaking process. Youth involvement and energy was critical to gain the support needed for the work.

Promising Practice: Transportation agencies should leverage youth voices and the momentum of community- and youth-led projects to create community buy-in for new safety approaches.

Strategy 5: Engage Youth Early To Build Pipelines for Sustainable Leadership

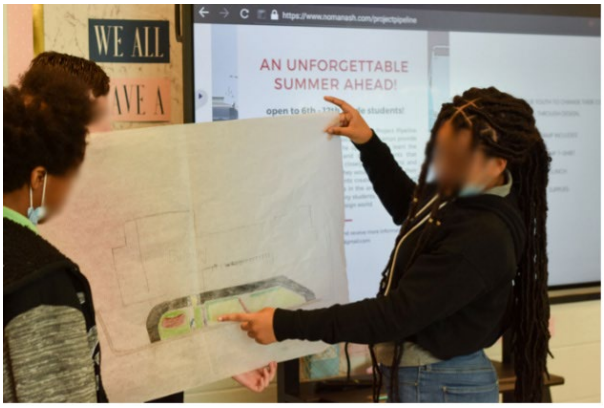
To leverage youth energy within their communities, the Civic Design Center has deliberately developed a pipeline of student leadership in the following ways:

- The Civic Design Center partnered with schools and teachers to create civics coursework designed to empower students. This coursework helps students become change agents, rather than just passive recipients of their environments and the related safety hazards those environments present.

- Students in sixth through eighth grade in participating schools take the "Design Your Neighborhood" curriculum, which teaches middle school youth how to problem-solve neighborhood issues through a project-based curriculum (Civic Design Center 2024).

- Eighth grade students can apply to become paid, 4-yr interns in the Civic Design Center via the NYDT. These internship positions cultivate leadership skills and knowledge throughout the high school tenure and result in community-engaged transportation safety projects.

This strategy—engaging students over many years at school and nurturing their leadership potential—creates institutional continuity and strong student leaders. As a result, there are always new, bright students entering the NYDT program with a passion for civic engagement and the training to lead new YPAR projects for their communities (figure 17). The strategy ensures long-term partnership among the NYDT, Civic Design Center, DOTs, and community partners.



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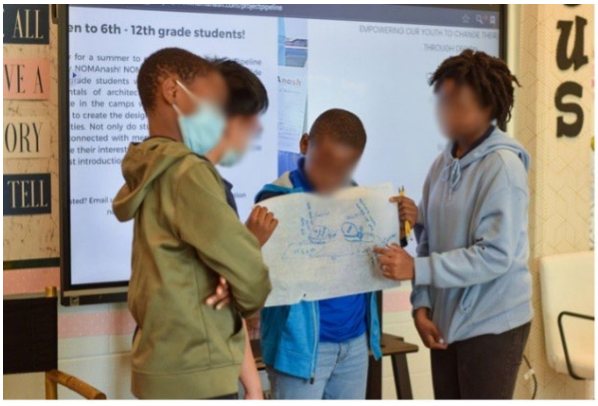
A. Students presenting their design project.



© 2024 Youth Civic Design Center.

B. Student's collaborating on a project.

Figure 17. Photos. Students presenting their work as part of the Civic Design Center Sustainable Transportation Project (Civic Design Center Youth 2024).

Promising Practice: Agencies should seek to partner with community organizations who have this type of long-term engagement with youth and their communities. If such a pipeline does not yet exist, agencies can encourage or sponsor a similar local effort.

Strategy 6: Transportation Is Only Part of What Makes Communities Safe for Youth

The NYDT and the Civic Design Center's approach to institutional shifts succeeded because they realized that transportation issues are deeply interconnected with other facets of lived experiences in the city. Collectively, the contextual challenges in which people travel—their socioeconomic environment, access to public spaces, and ability to feel safe and comfortable in their neighborhoods—must be addressed alongside transportation solutions for places to be safe and equitable for youth and others.

To this end, the NYDT and Civic Design Center broke down silos between transportation and other city issues by problem-solving community and transportation issues at the same time through Dream City Workshops. More than 2,000 Nashville youth were engaged through 74 of these workshops, which were designed to help participants express their versions of a "dream city," a city made for youth (figure 18). The NYDT provided examples of dream cities to workshop participants, who were then encouraged to create plans for youth-focused spaces. Workshop participants also completed a survey about what they liked or did not like about living in Nashville. They were also encouraged to share what factors in cities make them feel like they belong. The NYDT synthesized responses from these youth workshops, and their findings are currently informing the Imagine Nashville plan.[17] This plan is a community-based visioning process to direct the future of Nashville that includes transportation initiatives. NYDT found a common theme from these workshops: youth desire safety, including feeling safe in one's community both generally and specifically while walking. Their finding that safety is a priority encouraged the NYDT to focus their research and action plans toward transportation and youth-centered spaces near important places in the community.

© 2024 Civic Design Center.

Figure 18. Photo. Dream City workshop (Civic Design Center Youth 2024).

Promising Practice: Transportation and other planning agencies will benefit from intentionally engaging youth in planning processes related to transportation and beyond.

3.2.4 Roadway Safety Audits in Amish Communities—Buchanan County, IA

The interview with Buchanan County was conducted on February 7, 2024, by FHWA staff and members of the research team. Findings from the interview and review of related documents are summarized in the following subsections.

[17]Learn more about the *Imagine Nashville* plan at their website (https://imaginenashville.org/).

3.2.4.1 Background

It is important for leadership and staff in Buchanan County, IA, to meet the specific needs of all roadway users of the rural Fairbank Amish Boulevard and C-57, particularly the needs of the Amish communities who are considered vulnerable users along these roadways. People walk, bike, and drive horse-drawn vehicles, motorized vehicles, agricultural equipment, and heavy trucks on these corridors. Between 2007 and 2017, there were 51 reported crashes on this section of Fairbank Amish Boulevard, including one fatal crash and six crashes resulting in suspected serious injuries. In 2017, a severe crash involving several children in a horse-drawn buggy catalyzed the County engineer and community leaders to conduct a road safety audit (RSA) to identify risks for Amish communities traveling along Fairbank Amish Boulevard and recommend steps to improve their safety (FHWA 2023b). Since completing the RSA, the county engineer, in partnerships with experts and the Amish communities, has worked to implement interventions to improve the safety of all people in the community (figure 19). Through strategies such as the RSA, Buchanan County has reduced fatal and serious injuries on Fairbank Amish Boulevard by 83 percent (from 12 to 2) between the 2015–2017 period and the 2021–2023 period, including no fatal crashes since 2015.

© 2024 Buchanan County.

Figure 19. Photo. RSA team at Fairbank Amish Boulevard and 120th Street.

3.2.4.2 Strategies

Strategy 1: Seek Out Diverse Expertise and Invest in Relationships with Communities to Identify Effective Interventions.

The Buchanan County engineer worked with a variety of experts—including the local technical assistance coordinator, highway patrol officers, local and State engineering staff, representatives from the Governor's Traffic Safety Bureau, the Buchanan County Board of Supervisors and other county officials, and public health officials—to develop a spectrum of safety recommendations through the RSA process. Each member of the RSA team offered different expertise and approaches to addressing road safety concerns, resulting in a variety of safety interventions, including the following:

- Implementing infrastructure and signage updates.
- Establishing an Amish community association to advise regarding safety needs.
- Conducting a more indepth corridor study.
- Hosting educational events for Amish communities and people who travel through the Amish communities.

This multidisciplinary team has continued to work together to implement the RSA recommendations. They are currently developing an updated local road safety plan (LRSP), continuing Buchanan County's strategy of bringing diverse perspectives to address transportation safety needs.

Validating the technical safety recommendations with the Amish communities was a critical part of Buchanan County's strategy to ensure effectiveness. One proposed idea was not acceptable to the Amish community: a conflict discovered during vetting directly with the Amish that was facilitated by Buchanan County engineers' longstanding personal relationships within the community. These deep relationships, built through transportation officials' personal visits over time, allowed for a final RSA plan that was effective both from a technical and community standpoint. Learn more about how county engineers aligned their decisionmaking processes with Amish culture in the callout box, Cultural Understanding Underlies Planning and Engineering.

Cultural Understanding Underlies Planning and Engineering

In the early 1990s, the County Board of Supervisors wanted to build a farm-to-market route through Amish communities that created access to their farms and accommodated Amish travel needs. To begin this process, the county engineer invited Amish bishops and elders to a meeting. During the meeting, the Amish members did not want to speak directly about their thoughts on roadway designs; instead, they wanted to discuss options and take votes within their communities. The bishops consulted with their communities and then agreed to a county solution to build 10-ft-wide shoulders along these routes. These wide shoulders provide safe and comfortable places for people to use their buggies and walk, which is especially important during cold and rainy seasons. During the 2017 RSA process, the engineers' understanding of Amish communities' group decisionmaking practices informed a key recommendation: create a coalition of Amish community members to discuss and advise on safety projects. Buchanan County's ongoing and future efforts to improve safety will be more successful because they have aligned their decisionmaking processes with the Amish communities' processes.

Promising Practice: Transportation agencies will benefit from involving stakeholders representing a spectrum of expertise and experience, including community representatives with knowledge of specific local customs and lived experiences, in decisionmaking processes.

Strategy 2: Partner with Public Health Experts to Advance Road Safety and Address Health Disparities

The county engineer partnered with the director of the Buchanan County Public Health Department (BCPHD), a registered nurse, to help develop the RSA and LRSP. The engineers benefitted from public health expertise in two ways. First, the BCPHD director had established relationships with members of the Amish communities through vaccination efforts and health education support. Second, public health practitioners think about safety interventions through the lens of population-level health impacts, which supplements the engineers' focus on road safety. For example, the BCPHD director worked with researchers at Iowa State University to improve buggy design and thereby enhance safety at the community level. Engaging a public health practitioner in the RSA provided opportunities to meaningfully involve Amish communities in the planning process and expertise to bridge transportation and health efforts.

Promising Practice: Engage public health experts in rural transportation planning and project development to bridge road safety and public health concerns and meaningfully engage with underrepresented communities.

Strategy 3: Be Open to Design Innovations and Systemically or Systematically Apply Them to Improve Road Safety; Design Interventions Are Always Preferred to Efforts that Rely on Changing Individual User Behavior

Buchanan County's engineer attributes much of their success to remaining open to new and innovative practices for improving road safety design. For example, Amish children and adults often drive buggies on or alongside roadways between their homes and schools. To separate them in space from other motorized vehicles, engineers have been systemically adding 10-ft shoulders on roadways around Amish neighborhoods for many years. Now, nearly all roadways in Buchanan County have wide shoulders, evidence of a long-term commitment toward systemwide solutions to improve buggy driver and passenger safety. The county engineers have also installed a buggy turnaround to facilitate crossing traffic to enter a school, as recommended by the RSA, as shown in figure 20. The shoulders and turnarounds were supported by Federal (Highway Safety Improvement Program), State, and local transportation funds.

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Figure 20. Photo. Buggy turnaround along a rural road.

Additionally, in 2019, engineers tested 6-inch-wide pavement markings in lieu of standard 4-inch-wide markings based on research from FHWA (figure 21).[18] While there are too few data points to draw firm conclusions on safety outcomes, the predominant feedback from the community is that these wider edge lines make the road feel narrower and encourage slower driving. Given the success of the wider pavement markings, the Iowa DOT will take steps to codify this change in its standards.[19] In April 2024, 6-inch-wide pavement markings will be the standard for the entire State. By being willing to try new recommended countermeasure practices, evaluating the results, and then elevating those practices to systemwide standards, local engineers can establish the basis for statewide policy changes that systematically improve road safety.

[18]Research from FHWA indicates that wider pavement markings on the outside edge of travel lanes is a proven safety countermeasure for enhancing visibility and reducing vehicle run-off crashes. For further information, see https://safety.fhwa.dot.gov/provencountermeasures/wider-edge-lines.cfm.

[19]See Iowa DOT's website for details (https://iowadot.gov/design/Pavement-marking-changes).

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Figure 21. Photo. Six-inch-wide edge lines along a rural road.

The RSA team has prioritized actions that systemically, or systematically apply, design interventions that accommodate Amish people's travel needs. This strategy highlights that systemic design solutions are more effective and equitable than expecting Amish communities to change their travel patterns (where they are trying to go) or cultural practices (how they are getting there), which would create dangerous conditions and perpetuate inequities in underserved communities.

Promising Practice: Piloting innovative safety countermeasures that serve all users allows transportation agencies to evaluate promising practices in various contexts and, if effective, incorporate these designs systemically by institutionalizing them in standards. Systemic design interventions that serve the needs of underrepresented communities improve road safety.

3.2.5 Pedestrian Crossings and Safety on Four Anishinaabe Reservations—Minnesota

The interview with MnDOT was conducted on January 25, 2024, following an introductory meeting on November 6, 2023. FHWA staff and members of the consultant research team conducted both the meeting and the interview. A member of the consultant research team held followup meetings on May 1, 2024, and May 17, 2024, to discuss the agency's review of a draft case study. Findings from the interview and other meetings and review of related documents are summarized in the subsections.

3.2.5.1 Background

Nationally, Native American people have by far the highest traffic fatality rates per mile and per population. They are five times more likely to die walking and close to three times as likely to die in passenger vehicles, on a per-mile basis (Glassbrenner et al. 2022) than White people. This risk is the result of compounding systemic problems: Native American communities are more likely to rely on walking in daily life, despite a roadway system that is not designed to serve

pedestrians, pedestrians are more vulnerable than drivers or passengers in crashes in general, and pedestrian crashes are underreported, particularly in Native communities (Tribal Transportation Safety Management System Steering Committee 2027). Recognizing the disproportionate risks experienced by Anishinaabe people in Minnesota, MnDOT worked to support Tribal leaders and Tribal transportation officials' efforts to improve road safety in Anishinaabe Country (Lindsey et al. 2020).

Addressing pedestrian safety problems for indigenous communities and in other rural contexts presents practical challenges. Rural highways operate at high speeds, and driver expectancy for pedestrians may be low. Quantitative data like pedestrian volumes and crash history may be unavailable or incomplete due to underreporting. Even when pedestrian volume data are available, State and Federal *Manual on Uniform Traffic Control Devices* (MUTCD) volume warrants for major pedestrian crossing countermeasures like signalization or pedestrian hybrid beacons may be higher than typical pedestrian volumes in these types of locations (FHWA 2023c). The 11th edition of the Federal MUTCD reinforces that other factors, beyond warrants, should be considered as part of a study to justify the installation of traffic control signals, and the MUTCD includes the flexibility for agencies to consider these relevant factors - a necessary option when evaluating lower volume rural and Tribal sites. While these challenges may be common across much of Indian Country or many indigenous communties, each Tribe is unique and many location-specific factors further influence safety planning, design, and decisionmaking.

Leaders from four Tribal Nations[20] (figure 22), the Advocacy Council for Tribal Transportation (ACTT), MnDOT, and researchers from the University of Minnesota (UMN) collaborated to document traffic safety risks for people walking on the reservations. MnDOT's *Pedestrian Crossings and Safety on Four Anishinaabe Reservations in Minnesota* report is part of an ongoing project (Lindsey et al. 2020). MnDOT has two goals for the project: to address pedestrian safety at sites identified by Tribal leaders, and to continue building a collaborative working relationship between Tribes and MnDOT in order to improve traffic safety for Native American populations. In the report, researchers recorded pedestrian crossings and pedestrian-vehicle interactions at 10 sites among the 4 Tribes. The data collected from these sites gave the information they needed to select countermeasures to improve pedestrian safety on Anishinaabe Reservations.

[20]The Tribal partners included in phase I of this project were the Bois Forte Band of Chippewa, Fond du Lac Band of Lake Superior Chippewa, Grant Portage Band of Lake Superior Chippewa, and Mille Lac Band of Ojibwe.

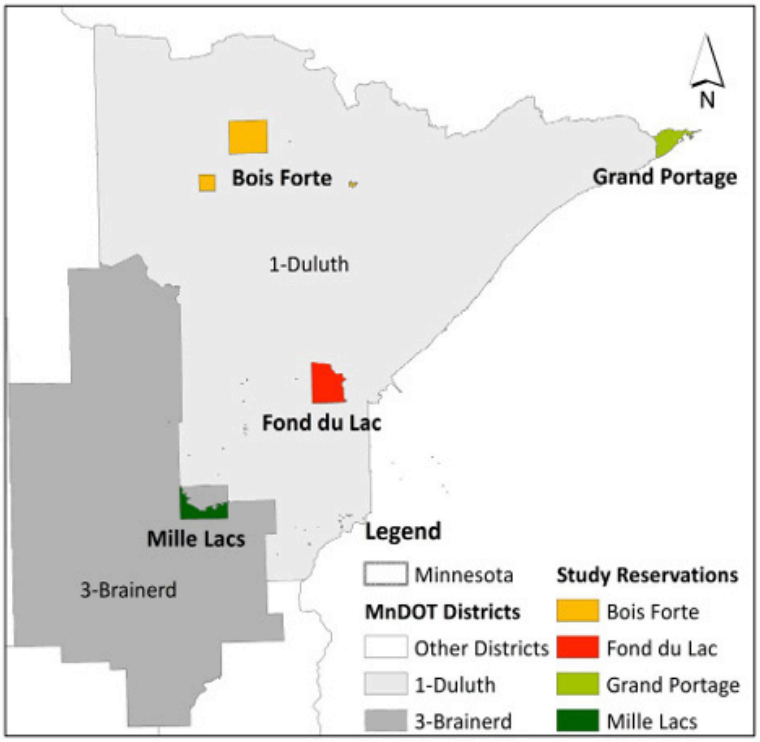

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Figure 22. Illustration. Four Anishinaabe Reservations in Minnesota that participated in phase I of the study (Lindsey et al. 2020).

This case study describes actions and strategies that MnDOT took to better collaborate with Tribal leaders of the four Anishinaabe reservations on pedestrian safety and implement pedestrian safety countermeasures in Tribal and rural contexts. Since the completion of this work, MnDOT and Tribal partners have begun working on phase II.

3.2.5.2 Strategies

Strategy 1: Build Trust Over Time by Institutionalizing Government-to-Government Relations into Agency Culture

The phase I pedestrian safety study did not just happen by chance: the study was made possible by decades of effort and collaboration between the Tribal governments and Minnesota State government. MnDOT's equity policy acknowledges the harms the agency has caused to indigenous communities (MnDOT 2024). In 2002, 11 Tribal governments, MnDOT, and the Minnesota Division of FHWA signed the Government-to-Government Transportation Accord (Tribes & Transportation Government to Government 2002). Since then, MnDOT has invested time and resources to create an environment within the agency that supports rebuilding long-term trust and centering Tribal processes and voices:

- An MnDOT Tribal Nations policy (MnDOT n.d.) was passed in 2014, and a State Statute on Tribal Relations (Minnesota Legislature 2024) was passed in 2021. These mandate consultation and coordination with Tribes.

- MnDOT cofounded the Tribal State Relations Training program, in partnership with Tribal Nations, to provide learning opportunities for State employees and leadership on Tribal history, Federal Indian Policy, and on areas of significant Tribal interests. This program ensures that MnDOT staff understand how their work relates to the Tribes.

- MnDOT created leadership positions within the agency that are specifically devoted to Tribal affairs. These leaders advise on policymaking, build partnerships, and develop capacity to work effectively with Tribal Nations since everyone at MnDOT has a duty to coordinate with Tribal officials on transportation-related programs.

The cumulative result of these efforts over decades is a culture of government-to-government relations between Tribal Nations and MnDOT that strengthens positive interactions with Tribal partners.

In 2016, MnDOT named pedestrian safety in Indian Country as a top priority in their statewide *Minnesota Walks* policy document (Minnesota Departments of Transportation and Health 2016). Because this action happened in the context of decades of collaboration, the agency garnered attention for the Tribes' own safety concerns and set the stage for funding for effective projects like the "Pedestrian Crossings and Safety on Four Anishinaabe Reservations in Minnesota" study (Lindsey et al. 2020). Together, these organizational and policy transformations ensured that Tribal populations are not a priority in name only but recognized as sovereign Nations and active partners throughout the transportation planning and engineering processes.

Promising Practice: Structural organizational change is necessary to acknowledge past harms and rebuild trust with communities that have experienced displacement, discrimination, and disinvestment.

Strategy 2: Within an Organizational Culture of Equity, Respect the Tribes' Decisionmaking Autonomy

Given MnDOT's organizational mission of government-to-government relationships with Tribes (MnDOT n.d.), MnDOT centered Tribal nations' needs from the beginning of the safety project. Tribal leaders guided the study at many points:

- MnDOT consulted with Tribal officials early on to determine which of the Tribes wanted to participate in the safety study. Four tribes ultimately participated in phase I at their own discretion.

- MnDOT and UMN researchers reassured Tribal partners that the study's intended outcome was to support the Tribes' self-identified safety needs and goals. The project did not surveil Native populations or extract knowledge or resources from the communities; rather, researchers gathered information to inform Tribal decisionmaking. Surveillance and extraction are significant concerns rooted in historical trauma and abuse by Federal and State government agencies and universities.

- MnDOT has supported the ACTT as part of the agency's efforts to collaborate and consult with Tribal nations. The ACTT includes representatives from the 11 Tribal

nations that share geography with Minnesota as voting members as well as representatives from Federal, Minnesota State, and local agencies. This project used that standing relationship to invite individual Tribes to engage with the study as technical advisors to the project, shaping the study's methodology and creating additional political leverage for the Tribes within the project process.

- Tribal leaders vetted methods of data collection, counting site locations, and were involved in selecting countermeasures.

- Tribal leaders also decided the project's time frame. Originally, MnDOT and UMN researchers planned a quick-paced study, but due to deliberate coordination, in addition to delays from the COVID-19 pandemic, phase I ultimately took 4 yr. Phase II took another 4 yr. While the project took much longer than anticipated, the process resulted in more trust between the Tribes and MnDOT and the successful implementation of countermeasures.

MnDOT has been successful because leadership and staff in the agency recognized the collaboration as a government-to-government partnership. MnDOT formally embedded the Tribes' judgment and authority into decisionmaking at every step of the process. For future phases of this work, MnDOT has the momentum to continue centering Tribes' judgment.

Promising Practice: Successful collaboration with Tribal communities results from approaching Tribal leaders as sovereign partners through a government-to-government lens. In general, agencies can better meet needs in harmed or underserved communities by centering the communities' lived experiences and employing their professional and personal expertise throughout all parts of the process.

Strategy 3: Document Safety Risks Using Methods and Data That Are Relevant to the Context

Transportation agencies may struggle to address pedestrian safety and crossing concerns in rural settings like Tribal areas. Typical pedestrian volumes in these types of locations tend to be lower than State or Federal MUTCD volume warrants for signalization or pedestrian hybrid beacons, necessitating consideration of other factors beyond motorist and pedestrian volume totals. MnDOT, the Tribes, and the University researchers realized that even though pedestrian volumes may be relatively lower than in urban locations, the risk for people walking is no less real and indeed is usually higher on a per-person basis. Because of established partnerships with the Tribes and an organizational conviction to meet the needs of sovereign nations, MnDOT, and the researchers strategically framed the phase I study's goal as a research study to document pedestrian risk, not as a countermeasure warrant study. This framing allowed the project team to use several alternative approaches to measuring risk: they recorded hours of video at each of 10 State-funded or State-owned highway locations (figure 23). From these video data, researchers classified and coded vehicle–pedestrian interactions, identified pedestrian behavior and crossing locations, measured pedestrian volumes, and noted the presence of children or other vulnerable populations.

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Figure 23. Photo. Video camera installation collecting data at sites identified by Tribal leaders (Lindsey et al. 2020).

MnDOT's approach succeeded. Despite limited pedestrian volumes, video recordings and photographs that captured pedestrian–vehicle interactions clearly indicated that people face real danger at these crossings. Engineers saw the risky interactions between drivers and people crossing the high-speed roadway intersecting indigenous communities and understood the need, even if crossing volumes were too low to meet traditional warrants. See the Highway 61 Crossing callout box for more details.

Highway 61 Crossings

The Grand Portage Band of Lake Superior Chippewa, one of the four participating tribes in the phase I study, selected two intersections along Trunk Highway 61 for observation: one at Stevens Road and one at Blaze's Pit Road. Researchers recorded approximately 2 w of video at each location during daylight hours. The recordings showed overt risk in both locations. In total, the researchers recorded 365 pedestrian crossings. Around 20 percent of all crossings (including people pushing bikes) at these locations involved interaction with vehicle traffic, which concerned the research team. At both crossings, people crossed the highway in places traveling drivers would not expect to see pedestrians or cyclists. Also, some of the people who crossed during the recordings were children who traversed the highway with bicycles (figure 24). The researchers' data documented the risk and showed that crossing accommodations were necessary.

Promising Practice: Agencies can explore alternative ways of documenting and personalizing risk for pedestrians that capture the real risk that pedestrians face every day, especially in rural areas. Qualitative, visual, and other types of information may better characterize risk in these contexts than raw pedestrian volumes or other traditional warrants.

Strategy 4: Use Professional Engineering Judgment and Flexibility Within the System to Find Ways to Say "Yes" to Safety and Equity

Based on their established relationships with Tribal leaders, MnDOT district staff recognized that they needed to deviate from traditional methods for justifying pedestrian countermeasures. Warrant criteria are professionally accepted as "objective," and agencies tend to apply them universally to preclude the appearance of differential treatment across communities in an attempt to treat all communities the same, which may not address disparities in communities that face greater risks. Some MnDOT district staff expressed concern that deviating from these warrants, for example, by installing countermeasures in places where warrants are not met, might spark overwhelming demand for countermeasures from other (non-Tribal) communities even in places where they may not be needed.

This project showed that locations like these, in rural contexts with significant indicators of risk like high motorist speeds, may be overlooked due to low pedestrian volumes. The risk may be even further underestimated due to underreporting of pedestrian crashes in Indian Country generally and gaps between Tribal and State crash database systems. Even though the application of uniform warrants, standards, or thresholds appears equal and fair in theory, these risks and data gaps may produce disparities and inequities in practice.

MnDOT and the researchers agreed that professional judgment and design flexibility were necessary. For this, they relied on both historic context and other types of data. MnDOT acknowledged that in several cases the walking routes used by the Tribal members predated the highway crossing those routes by thousands of years, which was not a factor considered in any documented warrant. Video data painted a clear picture of risk that conveyed the need for safety

countermeasures at these locations (figure 24). Viewing video recordings helped engineers recognize the real and significant risks people endured crossing the street. MnDOT engineers used their engineering judgment—informed by the combination of visually obvious risk and institutional norms upholding equity and Tribal sovereignty—to recommend pedestrian countermeasures.

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Figure 24. Photo. People walking bikes across Highway 61 at Blaze's Pit Road (Lindsey et al. 2020).

Thanks to MnDOT's long-standing government-to-government partnership with Tribes and recognition of significant disparities experienced by individuals living on reservations, MnDOT recognizes the importance of addressing the safety needs of Tribes as sovereign nations when granting warrant exemptions. By specifically focusing on reservations given the safety and equity use cases, district staff's fears about being overwhelmed by requests for pedestrian countermeasures in all rural areas were assuaged and allowed them to honor their Tribal partners' judgment. Because of this distinction, MnDOT engineers felt comfortable using professional judgment and alternate measurements of risk to "say yes" to safety and addressing long-standing disparities in safety on reservations. At the same time, deferring to Tribal leaders' decisions allowed MnDOT engineers the opportunity to see pedestrian crossing countermeasures like rectangular rapid flashing beacons (RRFBs) in action in these relatively low-volume, high-risk contexts where they might not otherwise have been considered. Most importantly, the infrastructure safety improvements resulting from these partnerships serve Tribal and non-Tribal users and travelers.

In addition to using flexibility in engineering judgment, MnDOT also leveraged flexibility in funding to "say yes" to meeting Tribes' needs. The researchers framed phase I of the study as academic research when they applied for funding, even though the content in phase I is more akin to a feasibility study. They used professional discretion to frame this project through its potential contributions to research, which had two benefits. First, they leveraged MnDOT research dollars to directly help Tribal Nations. Second, framing this work as research gave the

team additional resources to study each location with more depth than would be typical in a feasibility study, which proved to be important for understanding risk at low-volume locations. Now, in addition to supporting the Tribes, they also developed methodologies that are replicable anywhere, including other Tribal locations and non-Tribal urban and rural locations with low-pedestrian volumes and high risk. In both cases, design flexibility and funding flexibility empowered agency staff to try to say "yes" instead of "no."

Promising Practices: Agencies can empower staff to exercise professional judgment and find flexibility in funding programs to advance the agency's equity goals and meet communities' needs. Agencies can also empower their engineering staff to leverage inherent flexibility in design guidance and apply professional judgment, especially in rural or other contexts where the default standards may not adequately address equity and pedestrian safety needs.

3.2.6 Changing Lanes on Gender Equity and Transportation—LADOT

The followup interview with LADOT was conducted on July 18, 2024, by a member of the research team. Findings from the interview and review of related documents are summarized in the following subsections.

3.2.6.1 Background

In 2019, LADOT commissioned a study about gender inequities in the transportation system. The resulting report, *Changing Lanes*: *A Gender Equity Transportation Study* (LADOT 2021a), examined women's travel experiences in three Los Angeles (LA) neighborhoods: Sun Valley in the Valley region, Watts in the Central City region, and Sawtelle in the Westside region. These neighborhoods were chosen in part because of their high shares of women of color, women with low incomes, and women living in zero-car households. To understand women's needs across a spectrum of ages, incomes, races and ethnicities, and disability statuses, LADOT used community-based research (CBR) practices, which leverage expertise from academics and community-based organizations (CBOs) to develop research questions and synthesize responses to drive decisionmaking.[21]

Transportation agencies can learn from LADOT's approach to exploring specific transportation needs of women and the application of CBR to direct investments toward more equitable transportation experiences and outcomes for women.

3.2.6.2 Strategies

Strategy 1: Question the Assumptions of Existing Data and Methods and Document Known Gaps.

LADOT sought to understand to what extent their internal data and systems reinforced gender inequities in the transportation system. They found that a major barrier to creating an equitable transportation system was a general lack of data focusing on women's experiences and needs.

[21]One of the findings from the study was that these methods, as implemented in this study, did not provide sufficient data about diverse gender identities, like nonbinary and transgender people, to make many recommendations specifically for these communities.

This data gap is not unique to LADOT; the gap arises from standard methods and data sources used across transportation agencies. For example, planners and forecasters typically use data from travel surveys or travel diaries for demand modeling and investment decisions. The "average" travel patterns that rise to the top of these datasets and have the largest influences on investment decisions are home-to-work commute trips starting in residential areas during peak hours. Prior research in the LA area showed that this pattern does not represent the travel patterns that are common among primary caregivers and people who work variable or nontraditional work schedules, and that women are overrepresented in these roles. This information set the direction for the study.

The study team began by reviewing what, if anything, existing transportation system and demographic data (from LADOT, LA Metro, the U.S. Census Bureau, and various local organizations) and academic literature could tell them about women's travel patterns and needs, both how they varied among women of different backgrounds and how they differed from men's.

The research team first audited LADOT's existing data assets to understand which datasets could be disaggregated by gender in a meaningful way. The team also investigated how both gendered and nongendered data could be used to understand women's travel needs. Among the datasets reviewed, only crash data and census data could be explicitly disaggregated by gender. Geospatial facility data did not have an inherent gender dimension, although the data have implications for women's safety and comfort (e.g., street lighting). Transportation service or usage data (e.g., pedestrian or bicyclist counts, transit boardings) could not be disaggregated by gender.

Analyzing these data and surveying prior research showed that women in LA are more likely to travel at off-peak hours, have multiple stops per trip, and rely on transit for their trips. Additionally, researchers found meaningful differences across neighborhoods on several variables relevant to women's safety and comfort, including the density of intersections with a traffic signal (8.5 to 27.5 per square mile) and the density of streetlamps (346.5 to 801.9 per square mile). Safety data in particular showed concerning patterns related to gender and intersectional inequities. While men are overrepresented among severe crash victims both nationally and in Los Angeles, the relative proportion of KSI pedestrians that were women varied across neighborhoods as well, with lower income neighborhoods having a higher relative proportion of women victims.

Promising Practice: One of the first steps toward repairing an inequity is identifying and documenting the data gaps that feed it. Transportation agencies can examine gaps and biases in their own internal data systems to see how inequities in these systems contribute to inequitable outcomes.

Strategy 2: When Information About a Population Is Missing, Create New Data Using Holistic Research and Accessible Engagement Strategies

One of LADOT's goals for the *Changing Lanes* study (LADOT 2021a) was to collect new disaggregated data about gender and transportation using surveys. To capture detailed information and ensure that the survey reached women, they collected travel data through CBR methods. Underlying CBR methods is the principle that people's stories and lived experiences

are essential to understand problems and design solutions. CBR elevates a collaborative and participatory approach between researchers and community members to produce and share data that drive more effective decisionmaking than top-down data collection. Applying the principles of CBR, LADOT collected data about women's travel patterns and gender inequities in three ways:

- Convening local community groups through local organizations: An important element of CBR is leveraging the expertise of relevant CBOs. CBOs in LA have established trust with communities, so they served as the go-between among women in the three neighborhoods and LADOT's project team. For example, CBOs in each neighborhood recruited working group participants from each organization's existing programs, including schools, faith-based organizations, cultural organizations, and businesses. In total, the working groups consisted of five to eight residents per group of diverse gender identities, cultures, and ages. These working groups provided input on the study process and methods over the course of 12 meetings.

- Collecting survey data: The study team conducted more than 400 surveys that included open-ended elements in the three neighborhoods. The survey asked participants about their trips, how people move around, their experiences traveling, challenges they face, and changes that would improve mobility for all travel modes.

- Conducting travel pattern interviews: While surveys are an important tool for understanding participants' travel, they cannot capture the nuance of everyone's daily travel. To supplement the survey data, the *Changing Lanes* (LADOT 2021a) team also conducted 74 travel interviews. The 30- to 40-min interviews included questions about care travel, trip-chaining, intersectionality, opportunity costs, and the impacts of the COVID-19 pandemic.

Collectively, the information gathered from these methods provided insights into contributors to gender inequities and opportunities for change in LADOT's transportation planning and design processes. They revealed new patterns and transportation needs that were not apparent from analyzing existing quantitative data and nongendered data. For example, while geospatial data showed a high density of street lamps in the lowest income neighborhood in the study, CBO working groups revealed that many street lamps were nonoperational, resulting in dimly lit and unsafe conditions for women traveling at night. The survey and interview findings also showed that women in the lower income study neighborhoods were less likely than men in the same neighborhoods to own a smartphone or have a driver's license. They were more likely than men to fear for their safety on public transit, travel long distances for typical household errands (e.g., groceries), and miss out on recreational or leisure activities due to transportation burdens.

LADOT used these findings to develop recommendations and strategies for making the transportation experience more equitable for women, especially low-income women of color. The strategies presented in the *Changing Lanes* study (LADOT 2021a) spanned four key areas: closing the data gap, investing in inclusive infrastructure that increases women's mobility, offering better services that meet women's needs, and infusing gender equity into programming initiatives.

Promising Practice: When transportation agencies lack data on specific populations who experience barriers to safe mobility and access, especially communities not well served by the existing decisionmaking processes, agencies can invest in collecting data about these communities' travel needs. Community-based research produces valuable insights that inform specific and effective policies to improve people's travel and quality of life.

Strategy 3: Understand the Relationship Between Transportation and Intersectional Inequities

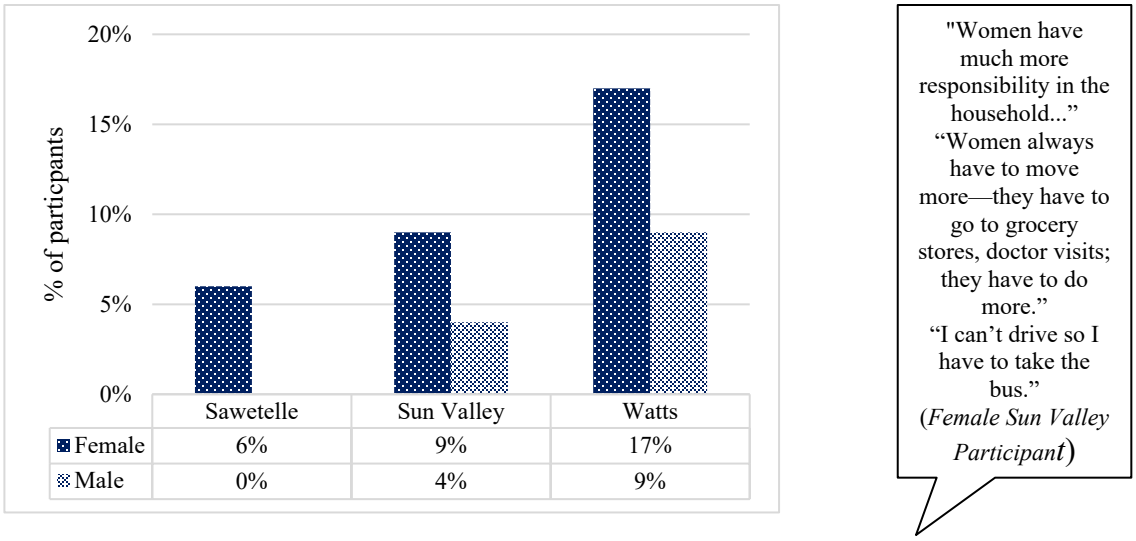
LADOT found that barriers to safe travel are rooted in existing disparities on many dimensions, not just gender. Race, income, and family structure interacted with gender to shape these inequitable outcomes.

In all three of the *Changing Lanes* study neighborhoods, women on average earned less than men (LADOT 2021a). Income matters substantially in transportation since income offers the option of paying for safe and reliable transportation or of living in neighborhoods with more amenities. Among women participants in the study, women with lower incomes reported that the transportation options they relied on imposed greater burdens like cost, time poverty, stress, and safety risks. These inequitable burdens came into sharper focus in the early days of the COVID-19 pandemic and lockdowns, when women in the lowest income neighborhood reported having the fewest opportunities to shift their mode of travel from public transit to less exposed modes like walking or driving alone. In aggregate, women in the study were less likely to have a driver's license than men, less likely to have regular access to a vehicle, and less likely to have essential services, like grocery stores, nearby. These barriers reduced women's access to jobs, medical appointments, and other necessities. When LADOT looked deeper and stratified by survey respondents' race and income, lower income BIPOC women experienced these barriers more often and more acutely than middle income or wealthier White women.

What Is CBR?

The *Changing Lanes* study defines CBR as a research model in which professional researchers partner with diverse community members, understanding that the lived experience of community members is equally as valuable as theory or professional expertise (LADOT 2021a). CBR is participatory: It engages those affected by the research topic in data collection, analysis, and dissemination.

Intersectional inequities in travel were readily apparent when examining trips that serve household or caregiving needs. Statistically, women on average make more of these types of trips, including running errands or grocery shopping for the household, transporting children, or traveling to care for elderly or disabled relatives. Figure 25 shows that, across all study neighborhoods, women were more likely than men to spend more than 45 min traveling to a grocery store. But women and men alike in the lowest income study neighborhood experienced longer grocery store travel than in the highest income study neighborhood.



Original image: © 2021 LADOT. Modified by FHWA (see Acknowledgments section).

Figure 25. Graph. Grocery store travel time over 45 min (LADOT 2021a).

The study results further showed that these intersectional mobility inequities extend far beyond the transportation system; they are the result of poorly integrated transportation, land use, housing, and economic systems combined. Historic underinvestment, racist housing and zoning practices, and economic disenfranchisement all interact with the transportation system and gender to contribute to transportation inequities.

LADOT and the project team's investment in detailed qualitative research allowed them to document how people's complex lives, social systems, and built environment all impact people's travel and quality of life. The qualitative data's nuance gave LADOT the stories to make recommendations for transportation improvements and recommendations for partnering agencies, like the Mayor's Office, Recreation and Parks, the Housing Authority of the city of Los Angeles, LA Metro, and the Bureaus of Street Services and Engineering.

LADOT also applied this lesson of intersectional equity throughout its own practices. LADOT commissioned a gender equity action plan to help them work toward a gender-inclusive transportation system (LADOT 2021b). The strategic plan is centered around this intersectional equity lens, prioritizing the needs of residents with the greatest barriers to travel first.

Promising Practice: When transportation agencies recognize that transportation outcomes result from intersectional layers of inequities and deficiencies across multiple systems (e.g., transportation, housing, land use), they can expand the toolbox of strategies to improve safe and reliable transport in their regular work and partner with other agencies to make cross-system recommendations.

Strategy 4: Embed Equity into the Transportation Planning Processes

LADOT understood that the *Changing Lanes* study was just the beginning of reducing transportation inequities for women (LADOT 2021a). Not only did LADOT's study recommend policies and programs that could reduce gendered inequity for women in LA, but they also recommended changes to planning processes that can help prevent future inequitable outcomes. The project team recommended two changes:

- LADOT embeds gender equity into transportation planning processes, including women-specific outreach in public engagement processes and developing a gender and racial equity project prioritization framework.

- LADOT regularly collects data about women, following the monitoring, evaluation, accountability, and learning (MEAL) framework. Learn more about this monitoring approach in the callout box, MEAL for Monitoring. Without regularly sampling data from LA women, LADOT is limited in its ability to deliver specific, meaningful countermeasures and policies.

MEAL for Monitoring

To ensure LADOT and its partners continue to build knowledge about women's travel needs, the *Changing Lanes* study recommends that all LADOT projects be evaluated with a gendered MEAL framework:

- Monitoring: Collect data about women at regular intervals, disaggregated by other intersecting identities.

- Evaluating: Assess outcomes of programs and projects, specifically their impact on women.

- Accountability: Ensure that processes and outcomes are held responsible for outcomes and center on women and sexual minorities.

- Learning: Reflect on outcomes with the goal of continuous improvement.

LADOT's framework will base each step of the MEAL process on gender-specific indicators, like women's total daily trips. LADOT will also vet its framework with partner CBOs that serve women, girls, and gender and sexual minorities (LADOT 2021a).

Since the completion of the *Changing Lanes* study (LADOT 2021a), LADOT has continued to incorporate its lessons throughout the agency's regular planning activities, especially community engagement. Their regular engagement practices have adapted to center transportation system users who have been marginalized because of gender, SES, race, ethnicity, and disability. The agency uses a "promotora" model of training community ambassadors to gather input from their

fellow community members and harder-to-reach populations and shape the outcomes for their Vision Zero and other transportation projects. LADOT followed this model and oversampled older women to develop a Safe Routes for Seniors program to ensure that the program's design reflected the complex and multifaceted needs of the program's intended users.

Promising Practice: Transportation agencies can intentionally build gender and other equity criteria into all stages of the planning process, from community engagement to project screening and prioritization. They can ensure representatives from that population are well-integrated in the decisionmaking processes and establish programs to monitor travel needs more regularly.

3.2.7 TNDL in the Twin Cities—MET Council

Members of the team that worked on the study presented here also authored this case study. Findings from the interview and review of related documents are summarized in the following subsections.

3.2.7.1 Background

In 2014, the MET Council named equity as a primary goal for the region and began scoring and prioritizing funding applications based on their likely equity impacts. This policy was based on findings from a study titled Choice, Place, and Opportunity: An Equity Assessment of the Twin Cities Region, which was conducted as part of their Sustainable Communities Regional Planning Grant (Metropolitan Council 2014).

A key part of implementing their equity goal is authentically engaging with residents and achieving equitable outcomes, the agency has continued to evaluate and refine how equity is defined, described, measured, and incorporated into regional policies and plans. Community feedback showed agency staff that stigmatizing, deficit-based language around equity initiatives perpetuated harm.[22] The MET Council published the results of engagement on this topic and pivoted both its language and its general approach toward more qualitative, community-based strategies.[23] The MET Council began evaluating their other processes through this lens to more fully advance equity throughout the agency.

As part of this evaluation, MET Council staff recognized a significant limitation of the quantitative travel demand modeling and forecasting data that they both generate and use for long-range regional planning decisions. They found that these metrics alone do not capture the barriers that people experience in their daily travel, such as challenges getting to medical appointments, trips not made due to lack of transportation, burdening friends and family with ride requests, travel anxiety, and fear for one's personal security. Furthermore, these challenges and barriers are not distributed equitably: historically underrepresented and marginalized communities are disproportionately likely to face these barriers. Compounding these findings is a methodological barrier: MET Council had struggled to achieve representative samples of these populations in the surveys used to generate forecasts. MET Council recognized that failure to

[22]See Met Council. "Rethinking Areas of Concentrated Poverty" (https://metrocouncil.org/News-Events/Council-News/Newsletters/Rethinking-areas-of-concentrated-poverty-2020.aspxz).

[23]Publications about MET Council's Place-Based Equity Research are available from the Council website: https://metrocouncil.org/Data-and-Maps/Research-and-Data/Place-based-Equity-Research.aspx.

consider these barriers limits the tools they can use to meaningfully improve safe access for all road users, particularly the ones most underserved by status quo approaches; and they needed better quality data about people's travel experiences in daily life to help them improve transportation safety and reduce transportation inequities, especially for underrepresented and marginalized communities.

So, MET Council launched the TNDL study to learn more about people's daily travel experiences and fill gaps in the existing data analysis (Metropolitan Council Team 2023). The study employed an equity-forward CBR approach to learn about people's daily travel, including their transportation barriers and challenges. The study results spanned a range of topics, including safety and comfort for people walking, biking, and using transit. In summary, MET Council performed the following:

- Hosted 32 focus group discussions across the metropolitan area, engaging more than 180 people in face-to-face conversations.
- Asked open-ended questions that elicited narratives about the relationships between people's values, identities, and travel needs and experiences.
- Summarized the findings from the focus groups through thematic coding and analysis.
- Developed policy recommendations and presented key findings for the metropolitan planning organization to refine and improve recommendations derived from more traditional quantitative data sources.

What Is CBR?

CBR is a model for doing research in which community members collaborate with researchers, and their lived experiences are regarded as equally valuable to theory and professional expertise. In this project, MET Council partnered with community-based organizations to refine data collection methods, recruit focus group participants, and host focus group sessions. Participants were also invited to participate in a followup session to validate the study's findings and ensure their input was interpreted and presented faithfully.

By collecting and analyzing rich qualitative data about people's transportation experiences, MET Council makes regional planning decisions with a deeper understanding of how people's social needs and perceptions influence their travel options and decisions, which impacts their safety and quality of life.

3.2.7.2 Strategies

Strategy 1: Evaluate How Existing Transportation Metrics and Data Systems May Reinforce an Inequitable Status Quo

MET Council, like most metropolitan planning organizations in the United States, uses travel demand models as the backbone of decisionmaking. Their models are based on surveys that ask respondents how many trips they make, where and when they travel, and what purpose each trip serves.

These data reveal existing travel patterns based on the kinds of trips people are already able and willing to make. Measuring only completed trips provided MET Council with only a limited view of the region's transportation needs since these data fail to capture data about where the system falls short—namely, trips that people were unable or unwilling to make. MET Council was concerned that relying on completed trip data may lead to a self-fulfilling prophecy in which they double down on transportation investments that serve existing travelers best and fail to recognize and address the needs of people already underserved by the system.

Because MET Council's demand modeling and forecasting team recognized these limitations in their existing processes, they were able to design more equitable data collection approaches to fill this important gap. Specifically, MET Council decided to incorporate focus group data strategies to understand how people's values, daily needs and social identities influenced their transportation needs and barriers in the Twin Cities region.

Promising Practice: Agencies can evaluate who is left out of existing metrics and how these omissions hinder the agency's ability to advance the mission of a safe and connected transportation system that serves everyone.

Strategy 2: Leverage Open-Ended Qualitative Data to Address Gaps in More Commonly Used Quantitative and Coded Survey Data

Regional travel demand models are represented by precise numbers that give a false impression of objective information that appeals to decisionmakers. However, these data are not impartial: The data are incomplete and systematically underrepresent the needs of disadvantaged communities.

With a biennial sample of approximately 7,500 households in a region of 3 million residents, MET Council's regional travel survey does not fully capture how people's intersecting identities (like race, SES, native language, gender, caregiver responsibilities, and age) influence how, when, and why people travel. Structured and coded travel survey data can also only capture the correlation of travel choices, not the causes of travel choices. In other words, survey responses may explain how people traveled but not why they made those decisions. Finally, travel diary data are limited in their ability to capture the complexity of all of people's trips, as travel demand models typically simplify people's travel for modeling. Collectively, these limitations mean that certain people's travel needs simply cannot be interpreted through travel diary or survey data alone.

MET Council decided to invest in different metrics and methodologies to make the data more complete and more accurate. Open-ended focus group data—in the form of narratives, themes, and stated values—complements travel demand models' missing pieces. They provide decisionmakers with additional context to understand and interpret quantitative survey data. To gather this kind of data, MET Council developed a data collection plan that included 29 focus groups around the region.

MET Council's investment proved important: the TNDL study showed that the relationships between people's economic, social, cultural, and family resources and identities directly impact how they travel. The focus group format allowed MET Council to hear stories that traditional surveys do not capture. Focus group participants shared what barriers prevent them from traveling when, where, and how they need to. They shared how driving can be inaccessible due to cost, age, or disability. At the same time, public transit may not serve the destinations they need in a timely manner, and age and disability are also barriers to accessing buses and trains. Personal safety and security concerns are barriers for many people to travel, but these barriers are much more disruptive for certain marginalized identities, such as women of color and women without stable housing. See the callout box, Human Stories for Understanding Travel Needs, to read an example of how narratives can be used to inform policy and transportation investments.

Human Stories for Understanding Travel Needs

MET Council's TNDL study leverages people's lived experiences as a means for improving transportation decisionmaking. One way that the study does this is by showcasing anonymized human stories of how people use the transportation system to meet daily needs. C's story, for example, shows the complex web of transit services that people use when they do not have access to reliable transportation. C lives in Waconia and does not drive. To get to their medical appointments in the Twin Cities, they regularly use a combination of walking, ride-hailing services, two different dial-a-ride medical transport services, taxis, and rides from family. They do not bike due to fears of being hit by cars. C stated that their biggest challenges while traveling are reliability and long travel times from the many sources of mobility that they use. They need to make these trips for their health, but the system makes it difficult and sometimes unsafe for them to meet their daily needs. C's story, and similar stories heard during the TNDL focus groups, led to two policy recommendations in the study: improve connectivity and efficiency of dial-a-ride services, and provide subsidies for ride-hailing services in areas where there is not dependable transit.

When presenting focus group results to policymakers, MET Council used visual styling to make the qualitative data "pop" on the page in the same way that charts and graphs draw attention to quantitative data (see figure 26 for an example). The agency also educated decisionmakers about the importance, value, and rigor of qualitative data.

Promising Practice: Agencies can collect narrative data through focus groups to shape regional transportation decisionmaking.

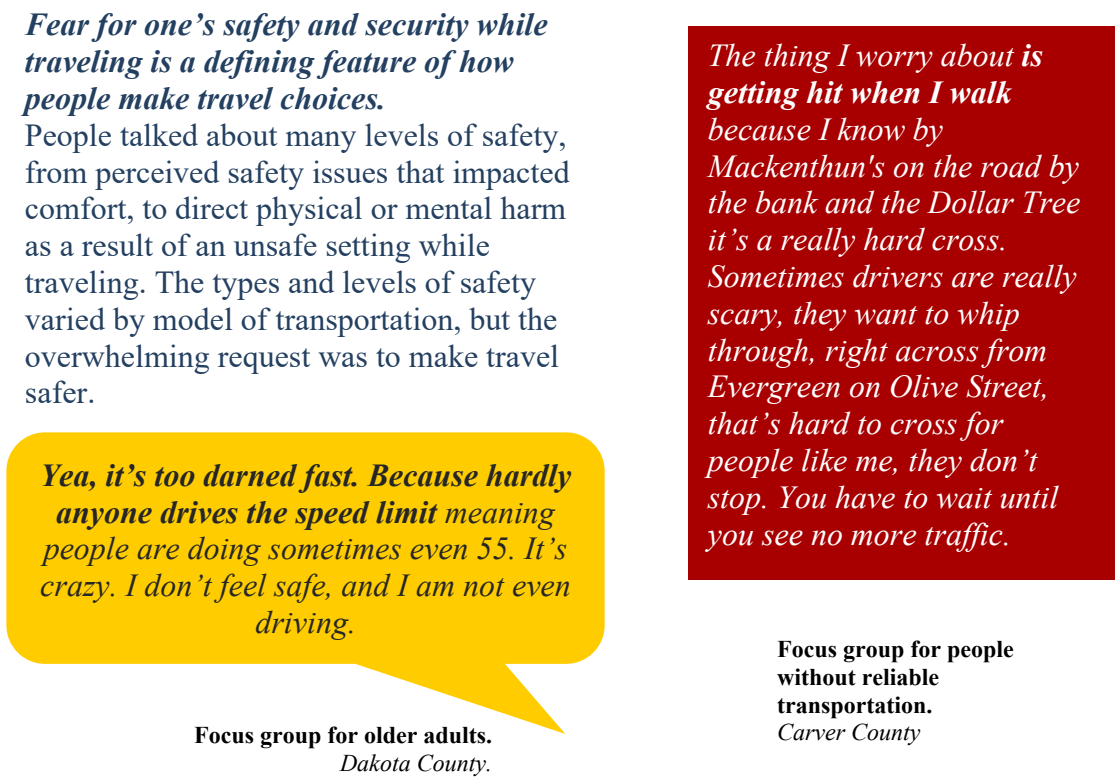


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Figure 26. Illustration. Use of callout boxes with direct quotes from focus group participants (Metropolitan Council Team 2023).

Strategy 3: "Oversample" Stories and Experiences from Underserved Groups Who Are Underrepresented in Other Data Sources

MET Council was challenged to reach a representative sample of historically disadvantaged populations in their regular survey and data collection efforts. Although undersampling is unintentional, and modelers attempt to mitigate its impacts via survey weighting, this pattern leads to a weaker understanding of these communities' existing travel needs and patterns. While MET Council is taking active steps toward achieving a more equitable sample of travel survey respondents, the effort is costly and uncertain, and incorporating alternative methods of data collection and analysis helps bridge the information gap quickly.

MET Council turned to focus groups as an efficient way to gain deep, nuanced insights about how people's intersecting social identities—race, ethnicity, geography, gender, age—shape their transportation needs and experiences. The agency designed a sampling frame for focus groups organized around these social identities to oversample certain populations. The strategy was simple: by partnering with community organizations and hosting more focus groups within historically marginalized communities, they successfully obtained broad representation from Black/African Americans, Native Americans, Asian Americas, Latinos, immigrants, women, people with disabilities, nondriving caregivers, and people experiencing housing insecurity. This choice was deliberate: they concentrated data collection in places where they currently have

information gaps from traditional travel surveys. They also monitored their progress as focus groups were conducted to ensure broad representation:

- Fourteen of the 16 groups organized around race engaged non-White communities.
- Six of the seven gender-based focused groups focused on women, transgender, and nonbinary people.
- Ten additional focus groups were organized around factors known to correlate with challenging transportation access, such as disability, transit dependency, nondriving caregivers, and housing insecurity.

MET Council checked to ensure they reached their intended stakeholders in two ways. First, they administered optional, short surveys at the end of each focus group. The surveys were purposefully simple and designed to capture basic self-reported demographic information about the participants. The approach worked: The focus group participants had larger shares of most of the intended respondents than are present in the region. The TNDL study and its recommendations were more informed by the people for whom the status quo is not currently serving. Second, MET Council scheduled followups with focus group participants to close the feedback loop and validate their findings. During these followups, the consulting team shared their findings and results with participants and invited participants to vet the information based on what was originally shared. All community organizations and focus group participants were compensated for their time, resources, and willingness to share.

Promising Practice: Transportation agencies can oversample from marginalized groups using qualitative approaches to mitigate underrepresentation in quantitative approaches and ensure their stories are well represented in the data. Paying people for their time, instituting checks in the data collection process, and closing the feedback loop with communities can help agencies accomplish their goals.

Strategy 4: Partner with CBOs to Facilitate Trust and Connection with Marginalized Communities

After deciding to use qualitative research methods to learn more about people's travel needs, MET Council faced the practical challenge of organizing and hosting focus groups to collect authentic stories from individuals and communities who experience barriers to transportation access. To be successful, these focus groups had to be logistically and physically accessible to participants. They also had to be conducted in a way that made participants feel safe sharing deeply personal experiences.

To create an environment where focus group participants felt welcome and comfortable sharing deeply personal experiences, MET Council partnered with 22 different community organizations to host focus groups. These organizations had meaningful, established relationships with many of the communities across the region that MET Council sought to hear from. They included community centers, senior centers, schools, food banks, women's resource centers, and cultural organizations centered around Korean, Lao, Chinese, Karen and Karenni, East African, and Black or African-American residents.

These organizations provided physical meeting space, outreach, logistical, and language translation support. The cumulative effect of these organizations' involvement was a focus group hosted in a convenient and familiar space and cofacilitated by trusted individuals. Focus group participants felt at ease and could share their stories without fear of judgment. All community organizations and focus group participants were compensated for their time, resources, and willingness to share.

Promising Practice: Community-based organizations can bridge the gap between public agencies and residents and help collect authentic stories and data. Transportation agencies can leverage the expertise and long-standing relationships of community organizations when planning public engagement activities to build trust and ensure that the engagement process fits their communities' needs.

Strategy 5: Understand How Transportation Options Are Shaped by People's Lived Experiences, Relationships, and Perceptions Of Safety and Comfort

MET Council's approach to learning about people's transportation needs, especially their safety concerns, revealed findings that would not have been apparent from traditional travel demand model data, including:

- People want to feel safer in and around cars, and fear of high-speed motorist traffic and traffic crashes can hinder travel for many people. One important finding from this study was that many residents fear traffic crashes and, in some cases, even limit their travel to avoid driving at high speed or being around high-speed drivers. Participants reported anxiety around driving, especially on highways, and they said that driving anxiety stopped them from going where they needed or wanted or reduced their activity space. They expressed fear of high speeds, other drivers' poor driving behaviors, and the risk of being struck while walking or biking. These fears also stopped parents from allowing their children to walk or bike. Council staff said the findings around fears of driving on the freeway were insightful because engineers usually consider limited access roadways to be safer than the alternative, at least on a per-passenger-mile basis. As MET Council works to develop a Regional Safety Action Plan, this finding will inform countermeasure recommendations and funding strategies for the agency.

What Does Safety Mean to You?

People's definition of safety is shaped by their identities and lived experiences. Their sense of safety also depends on the context and environment. Transportation professionals usually use the word safety to describe risk of severe traffic crashes. For many people, the word safety has broader connotations, encompassing everything from personal security and police violence to environmental risks like heat exposure and tripping on ice. Ask questions about a broad range of safety-related topics to give people opportunities to share all their concerns.

- People's relationship with their professional transit drivers and ride-share operators influences transportation feelings of safety and comfort. People with disabilities (and their caregivers), older adults who use dial-a-ride bus services, and people of color who experience racism from bus drivers are especially affected by this relationship.

Focus Group for Older Black Adults, *Hennepin County*

"Like I said, if you have money, any kind of money, they should let you get on the bus. But some drivers don't even wait for you to sit down before they take off. Or they'll wait and say, 'hey Lady, sit down' first and then we'll take off. But they do say 'hurry up' a lot too."

- People's experiences with violence shape how and when they choose to travel, especially for BIPOC. Participants shared stories of witnessing and experiencing violence from other travelers and from police while they were traveling. The study showed that many people feel on high alert when they walk and take transit, while others choose more "protected" modes of transportation altogether.

Focus Group for Women Experiencing Housing Instability, *Ramsey County*

"I've gotten off the train and the bus because I wasn't comfortable. It was a safety thing for me to do it, but it was an unsafe thing for me to do because it was below zero outside, and the next bus wasn't for 45 minutes at 11 o'clock at night. So, it's like, what's the lesser of the two evils?"

- Fear for safety and security is a defining feature of how people travel. Fear and anxiety are fundamental components of people's travel experiences and choices. This fear intersects with mode choice/access, gender, race, housing stability, (dis)abilities, weather and environmental risks, and the ability to pay for transportation. People are fearful of interacting with others and police while taking transit, and they feel anxious about traffic safety and driving on fast roadways. Native American women, in particular, emphasized safety and security as key to a better transportation experience.

Focus Group for Older Adults, Dakota County

"Yea it's too darned fast. Because hardly anyone drives the speed limit meaning people are doing sometimes even 55. It's crazy. I don't feel safe, and I am not even driving."

- People who do not have reliable transportation rely on others. Often, their reliance on family and friends comes at a price. People feel they cannot overburden their network for travel help, resulting in lost jobs, missed appointments, and delayed opportunities.

Focus Group for Latino Caregivers, *Ramsey County*

"We have lived here 22 years. It is also difficult for us to transport ourselves because there is no bus. Right now, I work in Hugo and my son is the one bringing me and picking me up. Sometimes he says, 'Why me again?' I say, 'Well, you're the driver.'"

Because MET Council invested in the TNDL study, leadership and staff in the agency have overt evidence to share with decisionmakers to address these insecurities and improve safe, reliable transport for all people.

Promising Practice: Transportation problems are complex and related to social factors. Transportation planners can elevate people's needs to understand and improve transportation safety and reliability for all people.

CHAPTER 4. PROVEN PRACTICES AND FUTURE RESEARCH

In this chapter, the researchers describe four proven practices and five substrategies based on findings from the scoping review and promising practices from the case studies. The researchers also highlight questions for future research based on gaps identified in the scoping review.

The proven practices are as follows:

- Investigate specific risks and processes that contribute to inequities in road safety:
    - Challenge assumptions and bias in data collection and analysis.
    - Conduct community-based participatory research.
    - Catalyze momentum for systematic road safety transformations.
- Shift power to communities to drive inclusive decisionmaking:
    - Acknowledge, rectify, and redress historic harms.
    - Institutionalize equitable and innovative program implementation.
- Build and sustain cross-jurisdictional collaborative approaches.
- Prioritize traffic calming on arterials in underserved neighborhoods.

4.1 INVESTIGATE SPECIFIC RISKS AND PROCESSES THAT CONTRIBUTE TO INEQUITIES IN ROAD SAFETY

To effectively make progress toward zero deaths, transportation professionals need to understand and address the risk factors contributing to disparities in roadway fatalities and serious injuries. The studies in the scoping review demonstrate the need for professionals to consider how socioeconomic difference and vulnerability impact road safety outcomes. To do this, professionals may conduct microscale analysis to identify which roadway characteristics contribute to crash risk on a specific corridor or area in relation to how neighborhood factors and specific community needs shape the travel behavior of different groups and then implement countermeasures that best address the identified risks and serve the needs of communities (Barajas 2018). Furthermore, professionals may critically analyze how traditional metrics and decisionmaking frameworks may be reproducing inequities. For example, studies highlight how traditional, purportedly objective estimations of bicycling demand like density, existing bicycling levels, and existing infrastructure attributes (i.e., filling gaps in network connectivity) may lead to distributional inequities in access to bike lanes for underserved communities (Braun, Rodriguez, and Gordon-Larsen 2019). Similarly, they show that making decisions based on incomplete data, like travel-time reliability and level of service data for motor vehicle travel, may exclude or underserve the needs of all road users, particularly pedestrians and bicyclists in underserved communities. In Tribal areas, in particular, studies elevate an acute need to reexamine existing data or develop new data, using both quantitative and qualitative methods, to better understand the transportation safety risks burdening indigenous communities, especially for pedestrians (Quick, Larsen, and Narváez 2019).

In short, studies recommend questioning potential bias in metrics to reveal assumptions underlying decisionmaking processes that may contribute to crash disparities, and conducting research to identify risks that may arise from a mismatch between infrastructure and community travel needs (Barajas 2018; Benediktsson 2017; Sanders and Schneider 2022). The case studies further elaborate promising practices by agencies prioritizing equity in transportation decisionmaking processes and metrics to identify and address risks experienced by underserved communities and improve safety for all road users. These promising practices are summarized into three strategies.

4.1.1 Challenge Assumptions and Bias in Data Collection and Analysis

Promising practices and examples from the case studies include the following:

- One of the first steps toward repairing an inequity is identifying and documenting the data gaps that feed the inequity (see section 3.2.6). Transportation agencies can examine gaps and biases in their own internal data systems to see how inequities in these systems contribute to inequitable outcomes. LADOT found that a major barrier to creating an equitable transportation system was a general lack of data focusing on women's experiences and needs. For example, planners and forecasters typically use data from travel surveys or travel diaries for demand modeling and investment decisions. The "average" travel patterns that rise to the top of these datasets and have the largest influences on investment decisions are home-to-work commute trips starting in residential areas during peak hours. Prior research in the LA area showed that this pattern does not represent the travel patterns that are common among primary caregivers and people who work variable or nontraditional work schedules, and that women are overrepresented in these roles. By recognizing this bias and gap, LADOT set out to better understand the specific needs of these communities and how to address them.

- Agencies can evaluate who is left out of existing metrics and how these omissions hinder the agency's ability to advance the mission of a safe and connected transportation system that serves everyone (see section 3.2.7). MET Council's demand modeling and forecasting team recognized limitations in their existing processes (e.g., models are designed around peak-hour motor vehicle travel, and data only measured completed trips and does not capture data about trips people are unable or unwilling to make). They were able to design more equitable data collection approaches to fill this gap. Specifically, MET Council decided to incorporate focus group data to understand how people's values, daily needs, and social identities influenced their transportation needs and barriers in the Twin Cities region.

- Agencies can explore alternative ways of documenting and personalizing risk for pedestrians that capture the real risk that pedestrians face every day, especially in rural areas (see section 3.2.5). Qualitative, visual, and other types of information may better characterize risk in these contexts than raw pedestrian volumes. MnDOT's use of video recordings and photographs captured pedestrian-vehicle interactions that clearly indicated that people face real danger at crossings in Tribal areas. Despite the limited pedestrian volumes, the high-risk relationship between high-speed roadways and the travel needs of

individuals to walk on these roadways spurred engineers to implement safety countermeasures.

- Transportation organizations, if want to improve safety for a population, must think more broadly about two facets of safety: how that population travels within the system, and what actually causes risk for that population (see section 3.2.1). By holistically understanding and addressing the root causes of risks for senior pedestrians at neighborhood levels across the system, NYC DOT effectively improved safety for this vulnerable population.

- Transportation agencies, when they lack data on specific populations who experience barriers to safe mobility and access, especially communities not well-served by the existing decisionmaking processes, can invest in collecting data about these communities' travel needs (see section 3.2.6). Community-based research produces valuable insights that inform specific and effective policies to improve people's travel and quality of life. LADOT operationalized this research approach by convening local community groups through local organizations, collecting open-ended survey data, and conducting travel pattern interviews. Collectively, the information gathered from these methods provided insights into contributors to gender inequities and opportunities for change in LADOT's transportation planning and design processes.

4.1.2 Conduct Community-Based Participatory Research

By collecting and analyzing rich qualitative data about people's transportation experiences, agencies can make decisions with a deeper understanding of how people's social needs and perceptions influence their travel options and decisions that impacts their safety and quality of life. CBR is a research model in which professional researchers partner with diverse community members, understanding that the lived experience of community members is equally as valuable as theory or professional expertise. CBR is participatory: Researchers and practitioners engage those affected by the research topic in data collection, analysis, dissemination, and decisionmaking. Underlying CBR methods is the principle that people's stories and lived experiences are essential to understand problems and design solutions. In short, CBR elevates a collaborative and participatory approach between researchers and community members to produce and share data that drive more effective decisionmaking than top-down data collection. Following are promising practices and examples from the case studies:

- LADOT, applying the principles of CBR, collected data about women's travel patterns and gender inequities (see section 3.2.5). Similarly, the Civic Design Center designed their approach to youth and community engagement through a specific methodology: YPAR[1] (see section 3.2.3). This method, led by Vanderbilt University Community Research and Action Ph.D. students, derives research questions, hypotheses, research designs, and potential solutions from the youth (and their communities) who are most impacted by a community problem. MET Council also partnered with CBOs to refine data collection methods, recruit focus group participants, and host focus group sessions.

[1]To see how the Civic Design Center uses YPAR, visit its website (https://youth.civicdesigncenter.org/high-school/youth-led-process).

Participants were also invited to participate in a followup session to validate the study's findings and ensure their input was interpreted and presented faithfully.

- Agencies can collect narrative data through focus groups to shape regional transportation decisionmaking (see section 3.2.7). The focus group format allowed MET Council to hear stories that traditional surveys do not capture. Focus group participants shared what barriers prevent them from traveling when, where, and how they need to. They shared how driving can be inaccessible due to cost, age, or disability. At the same time, public transit may not serve the destinations they need in a timely manner, and age and disability are also barriers to accessing buses and trains. Personal safety and security concerns are barriers for many people to travel, but these barriers are much more disruptive for certain marginalized identities, such as women of color and women without stable housing. The agency used these data to present to decisionmakers.

- Transportation agencies can oversample from marginalized groups using qualitative approaches to mitigate underrepresentation in quantitative approaches and ensure their stories are well represented in the data. Paying people for their time, instituting checks in the data collection process, and closing the feedback loop with communities can help agencies accomplish their goals (see section 3.2.7). MET Council worked with community organizations to host focus groups and gain deep, nuanced insights about how people's social identifies shape their transportation needs and experience. They concentrated data collection in places where they currently have information gaps from traditional travel surveys.

- Agencies can ask questions about a broad range of safety-related topics to give people opportunities to share all their concerns (see section 3.2.7). Transportation problems are complex and related to social factors. Transportation planners can elevate people's needs to understand and improve transportation safety and reliability for all people. People's definition of safety is shaped by their identities and lived experiences. Their sense of safety also depends on the context and environment. Transportation professionals usually use the word safety to describe risk of severe traffic crashes. For many people, the word safety has broader connotations, encompassing everything from personal security and police violence to environmental risks like heat exposure and tripping on ice. MET Council gained multiple insights about people's needs through a CBR approach. These insights were not apparent from traditional travel demand model approaches. They can use these insights to drive decisionmaking that makes the transportation system safe and reliable for all people.

4.1.3 Catalyze Momentum for Systematic Road Safety Transformations

By investigating and excavating risk factors contributing to disparities in road fatalities and serious injuries and equitably prioritizing the specific needs of underserved communities to address these disparities, practitioners can make a specific use case for piloting interventions in coordination with community involvement. Professionals can then build momentum, including trust and familiarity with communities, professionals, and elected officials to expand these safety interventions systematically. Following are promising practices and examples from the case studies:

- Agencies can leverage safety data and frame the safety problem in a way that will get the most support from communities and decisionmakers (see section 3.2.1). In NYC DOT's case, engineers and planners framed the safety data through the lens of risk for seniors, which helped the agency get uncontroversial support for safety projects and ultimately triggered a cascade of systemic interventions, high-quality data and evidence validating them, and broader public and professional acceptance.

- Transportation agencies should define metrics and study how effective their safety countermeasures are to showcase broad applicability and institutionalize best practices (see section 3.2.1). NYC DOT staff collected and evaluated data on usage and safety of their countermeasure deployment in neighborhoods with seniors. What were initially cutting-edge new practices—such as cutting expected pedestrian crossing time from 4 ft/s to 3 ft/s—over time became the institutional practice as the safety benefits of this approach were demonstrated to the engineering teams.

- Transportation agencies, by piloting innovative safety countermeasures that serve all users, can evaluate promising practices in various contexts and, if effective, incorporate these designs systemically and systematically by institutionalizing them in standards (Section 3.2.4). Systemic design interventions that serve the needs of underrepresented communities improve road safety for all. In Buchanan County, IA, the county engineer piloted innovative safety countermeasures, like adding 10-ft shoulders on roadways around Amish neighborhoods and testing 6-inch-wide pavement markings in lieu of standard 4-inch-wide markings, to provide safe, separated facilities for Amish children and adults to drive buggies alongside roadways. Given the success of the wider pavement markings, the Iowa DOT will take steps to codify this change in its standards.

- Transportation agencies should leverage youth voices and the momentum of community- and youth-led projects to create community buy-in for new safety approaches (see section 3.2.3). The Civic Design Center in Nashville, TN, recognized that young people can inspire decisionmakers to try innovative approaches that elevate safety for all. Because youth experience their communities differently than the adults who typically design the places where kids live and play, youth provide insights that are often missed in transportation decisionmaking. The Civic Design Center seeks to capture those perspectives and center them within planning and design processes by engaging students over many years at school and nurturing their leadership potential. As a result of young people's advocacy, the Metropolitan Nashville City Council agreed to earmark $500,000 for future quick-build projects that enhance safety within the city, in addition to funds allocated for quick-build Vision Zero projects.

4.2 SHIFT POWER TO COMMUNITIES TO DRIVE INCLUSIVE DECISIONMAKING

Studies recommend meaningfully engaging underrepresented communities in decisionmaking processes, especially as communities with greater SES may currently have more influence in the planning process and in advocacy organizations (Braun, Rodriguez, and Gordon-Larsen 2019; Sanders and Schneider 2022). The transportation needs of individuals—including trip purpose,

disability access, mode choice, destinations, and comfort—differ. Meaningful community-led decisionmaking processes directly engage community members and CBOs to spotlight these needs and shape visioning, planning, and project development. In addition to ensuring that projects serve the needs of communities, involvement ensures that communities will benefit from road safety and AT investments by elevating meaningful anti-displacement policies and practices (Serrano et al. 2023).

Promising practices and examples from the case studies include the following:

- Transportation and other planning agencies will benefit from intentionally engaging youth in planning processes related to transportation and beyond (see section 3.2.3). The NYDT and the Civic Design Center broke down silos between transportation and other city issues by problem-solving community and transportation issues at the same time through Dream City Workshops. More than 2,000 Nashville youth were engaged through 74 of these workshops, which were designed to help participants express their versions of a "dream city," a city made for youth. The NYDT synthesized responses from these youth workshops, and their findings are currently informing the *Imagine Nashville* plan.[2] This plan is a community-based visioning process to direct the future of Nashville that includes transportation initiatives.

- CBOs can bridge the gap between public agencies and residents and help collect authentic stories and data (see section 3.2.7). Transportation agencies can leverage the expertise and longstanding relationships of community organizations when planning public engagement activities to build trust and ensure that the engagement process fits their communities' needs. To create an environment where focus group participants felt welcome and comfortable sharing deeply personal experiences, MET Council partnered with 22 different community organizations to host focus groups. These organizations had meaningful, established relationships with many of the communities across the region that MET Council sought to hear from. These organizations provided physical meeting space, outreach, logistical, and language translation support. The cumulative effect of these organizations' involvement was a focus group hosted in a convenient and familiar space and cofacilitated by trusted individuals. Focus group participants felt at ease and could share their stories without fear of judgment. All community organizations and focus group participants were compensated for their time, resources, and willingness to share.

- Transportation agencies should embrace the possibilities of grassroots and/or demonstration projects to advance safety and community engagement (see section 3.2.3). The Civic Design Center, NYDT, Walk Bike Nashville, and other partner organizations installed a quick-build intervention to demonstrate the benefits of creating extra space for pedestrians at crosswalks on a high-crash corridor. NYDT presented their recommendations to TDOT, and the project has now received funding for implementation.

[2]Learn more about the *Imagine Nashville* plan at https://imaginenashville.org/.

- Transportation agencies should seek out opportunities to center youth in their decisionmaking processes (see section 3.2.3). Because youth experience their communities differently than the adults who typically design the places where kids live and play, youth provide insights that are often missed in transportation decisionmaking. NYTD start with the belief that youth should be cocreators of their communities, not just recipients of their communities' decisions.

- Transportation agencies should publicly publish plans, including the methodologies and data that inform them, to show communities what is planned, what has been done, and which priorities guide future work (see section 3.2.2). Sometimes, the people and communities that need safety countermeasures the most have the least influence on government processes and/or ability to participate in traditional engagement processes. JC balances an increased volume of requests, a need for public accountability and transparency, and their vision for equity by creating an annual plan for which projects will be prioritized that year, use a rubric that helps them equitably and transparently allocate projects across the city, and use storytelling as a form of accountability by publishing annual reports and mapping infrastructure improvements and other installations.

4.2.1 Acknowledge, Rectify, and Redress Historic Harms

The case studies also demonstrated how acknowledging, rectifying, and redressing historic and present-day harms faced by communities and recognizing the present-day specific needs of communities may require transformations in traditional institutional decisionmaking structures. They demonstrate how meaningfully prioritizing equity and safety as goals can lead to institutional and organizational changes that allow the agencies to address the risk factors contributing to disparities and make roads and streets safe, and feel safe, for all people. Following are promising practices and examples from the case studies:

- Structural organizational change is necessary to acknowledge past harms and rebuild trust with communities that have experienced displacement, discrimination, and disinvestment (see section 3.2.5). MnDOT acknowledged the harms the agency has caused to indigenous communities through historic decisions. They signed an MnDOT Tribal Nations policy that requires consultation and coordination with Tribes; cofounded the Tribal State Relations Training program in partnership with tribes to provide learning opportunities for State employees and leadership on Tribal history, Federal Indian Policy, and areas of significant Tribal interests; and created leadership positions within the agency that are specifically devoted to Tribal affairs. These efforts resulted in prioritizing effective and transformational approaches in improving pedestrian safety on four Anishinaabe Reservations.

- Agencies can break down administrative silos across departments by institutionalizing a safety culture to build streets that are safe and feel safe and comfortable for all users (see section 3.2.2). JC institutionalized a safety culture around a shared vision for zero deaths by involving agency staff, city leadership, advocates, and the community. This cultural shift led to institutional transformation. JC's Traffic and Engineering Divisions integrated with the Divisions of Transportation Planning, Innovation, Sustainability, and

Architecture to create a single Department of Infrastructure. This department streamlines decisionmaking across all parts of the built environment, including planning, traffic engineering, architectural design, sustainability, and public engagement. Within the same department, decisionmakers across all aspects of the built environment develop and design projects that improve roadway safety, perceived safety, comfort, and interest.

- Transportation agencies can intentionally build gender and other equity criteria into all stages of the planning process, from community engagement to project screening and prioritization (see section 3.2.6). They can ensure representatives from that population are well-integrated in the decisionmaking processes and establish programs to monitor travel needs more regularly. LADOT learned about the specific barriers for women to be safe and feel safe using the transportation system through their *Changing Lanes* study (LADOT 2021a). As a result, they have transformed agency processes to embed gender equity into transportation planning processes, including women-specific outreach in public engagement processes and developing a gender and racial equity project prioritization framework. They now also regularly collect data about women, following the MEAL framework. By regularly sampling data from LA women, LADOT expands its ability to deliver specific, meaningful countermeasures and policies.

4.2.2 Institutionalize Equitable and Innovative Program Implementation

Innovations in project delivery are important to build momentum and deliver timely, effective, and responsive solutions that address community concerns and improve safety for all people. The case studies elevated quick-build projects and demonstration projects as key tools. While sometimes used interchangeably, there are some differences between quick-build and demonstration projects. Quick-build projects are installations that use temporary or semipermanent materials. Often times, quick-build projects streamline many processes, including contractual and review processes, and can be integrated into traditional transportation agency efforts like repaving, resurfacing, and restoration projects. Quick-build projects can be implemented permanently or as an interim treatment until funding becomes available for a larger capital improvement project. Demonstration projects are a specific type of quick-build that include temporary installations, usually with a defined period for installation and deinstallation, that use temporary materials to show communities how a road or street could work and conduct studies to evaluate effectiveness. All demonstration projects are quick build, but not all quick-build projects are demonstrations. All transportation projects, including quick-build and demonstration projects, must be accessible to, and usable by, people with disabilities and, if receiving Federal funds, must adhere to the National Environmental Policy Act (1969) and other environmental laws. Following are promising practices and examples from the case studies:

- Transportation agencies should prioritize engineering solutions (see section 3.2.1). NYC DOT recognized that senior safety could not be addressed by changing the behavior of seniors or limiting their mobility; rather, they needed to change the environment to provide redundant layers of safety that address the specific risks and vulnerabilities experienced by seniors, allowing them to move independently. This program included changes in design and operations, including longer crossing times, protected phasing, and crossing islands.

- Agencies can implement quick-build projects as opportunities arise to improve safety for all users (see section 3.2.2). As part of their Vision Zero commitment, JC instituted quick-build, low-cost approaches, which led to quicker safety results, helped them to significantly decrease traffic fatalities, and at one point reach zero deaths on city-owned streets.

- Agencies can pair on-call contracting teams with quick-build implementation to get safety projects on the ground (see section 3.2.2). As a reminder, flexibility in design does not alleviate the requirement to provide pedestrian facilities that are accessible to people with disabilities. JC recognized that administrative delays related to selecting and processing contractors slow down safety project installation. Preselecting teams of consultants and contractors with on-call availability streamlines contracting and accelerates the design and construction process for projects that do not require major construction. The on-call team includes concrete and asphalt contractors, a striping contractor, a traffic signal maintenance contractor, and traffic engineering and transportation planning design consultants. When there is an opportunity for a quick-build project (e.g., when a street is up for repaving), JC and the relevant on-call contractors immediately begin planning and design, saving the time usually spent on team selection and contract approval. For larger and more complex capital projects, JC solicits bid proposals in accordance with local public contract law.

- Transportation agencies should embrace the possibilities of grassroots and/or demonstration projects to advance safety and community engagement (see section 3.2.3). The Civic Design Center worked with NDOT and TDOT to successful implement a demonstration project along a high-speed arterial, which created momentum far beyond the original crosswalk enhancement. This demonstration project led to several partnerships and institutional shifts, including gaining funding for permanent safety installations on this arterial and spurring investment and commitment for more quick-build efforts by NDOT.

- Agencies can empower staff to exercise professional judgment and find flexibility in funding programs to find ways to advance the agency's equity goals and meet communities' needs (see section 3.2.5). Agencies can also empower their engineering staff to leverage inherent flexibility in design guidance and apply professional judgment, especially in rural areas or other contexts in which the default standards may not adequately address equity and pedestrian safety needs. MNDOT engineers implemented pedestrian safety countermeasures, like RRFBs, on low-volume, high-speed roads when they learned about the safety risks experienced on these roads in Tribal areas and in consultation with Tribal leaders.

4.3 BUILD AND SUSTAIN CROSS-JURISDICTIONAL COLLABORATIVE APPROACHES

One principle of the SSA is shared responsibility, and multiple professionals and agencies, not just those with safety, road, traffic, or transportation in their title, play critical roles in improving road safety for all people, particularly those communities whose health and safety have been intergenerationally harmed by inequities, structural racism, and other forms of discrimination.

Achieving road safety goals requires agencies to make systemic changes to land use, transportation, and housing policies that increase pedestrian and bicyclist crash risk and severity (Sanders and Schneider 2022; Dumbaugh et al. 2022; Benediktsson 2017; Yu and Woo 2022). Multiple studies highlighted that addressing disparities in pedestrian and bicyclist fatalities for underserved communities requires not only modifications to transportation infrastructure but also coordinating to make sure that transportation system design and surrounding land use are aligned (Dumbaugh et al. 2022; Benediktsson 2017). As such, addressing local land development policies and practices is important to rectify existing gaps and prevent future issues. This work can only be achieved through interjurisdictional collaborative approaches among State, Tribal, regional, and local transportation agencies; public health agencies; other government agencies; developers; community organizations; and others. Strategies include adopting transit-oriented development (Sanders and Schneider 2022), collaborating on sidewalk improvement and maintenance (Lowe 2016),[3] and coordinating on selecting locations for new parks and retrofitting built environments around existing parks (Yu and Woo 2022).

Additionally, structural inequities in transportation decisionmaking processes have not only contributed to disparities in traffic fatalities but have also created barriers to walking and bicycling, which may exacerbate many other health disparities (CDC 2024a; Hansmann, Grabow, and McAndrews 2023). The CDC elaborates that walking and bicycling are key strategies that can help increase physical activity (CDC 2024b). Physical activity has many immediate benefits such as improved sleep quality and reductions in anxiety. Long-term benefits of physical activity include lowered risk of heart disease, stroke, types 2 diabetes, some cancers, and some infectious diseases (CDC 2024c). There is an opportunity for transportation and public health professionals to work collaboratively to institutionalize equity in their decisionmaking processes. By addressing structural inequities and creating safe networks for all people to walk and bicycle, transportation and public health professionals can work toward achieving the complementary goals of zero deaths from traffic crashes and improved health outcomes for all (Hansmann, Grabow, and McAndrews 2023).

Finally, collaboration on transportation safety is particularly important between States and sovereign Tribal governments. State DOTs can systemically and proactively coordinate with Tribal governments to address road safety challenges, recognize Tribes' special status and reconsider how State funds are allocated to address road safety in indigenous communities, and meaningfully address communication and capacity challenges to Tribe–State data sharing and quality (Quick, Larsen, and Narváez 2019).

Promising practices and examples from the case studies include the following:

- Agencies and organizations dedicated to road safety worked to build support with elected officials and working groups or committees with other agencies and community leaders.

[3]Lowe (2016) recommends that researchers and practitioners examine responsibility for sidewalk improvements across levels of government and between public and private entities to understand how these disparities in sidewalk emerge. Specifically, she notes that many bus stops without continuous sidewalks in New Orleans, LA, were on State-owned roadways, rather than municipality or city owned roads. She elaborates that despite Federal funding being used for sidewalk upgrades, localities may delegate sidewalk maintenance or charge upgrades to abutting property owners. She notes that business investment districts may generate taxes that could be used by localities to support pedestrian infrastructure improvements in certain situations.

This work includes adopting formal Vision Zero policies, Complete Streets policies, and ADA transition plans:

  - JC's mayor signed Executive Order (2019-007) in 2018 to establish a Vision Zero Task Force, which brings together multiple partners, including city, county, and State representatives; departmental leaders in public health, policing, engineering, parking, and public works; and local advocates, to review the city's progress (see section 3.2.2) (Fulop 2019).

  - LADOT used stories from their study to make recommendations for transportation improvements and recommendations for partnering agencies, like the Mayor's Office, Recreation and Parks, the Housing Authority of LA, LA Metro, and the Bureaus of Street Services and Engineering (see section 3.2.6).

  - MnDOT has supported ACTT as part of the agency's efforts to collaborate and consult with Tribal nations. This project used that standing relationship to invite individual Tribes to engage with the study as technical advisors to the project, shaping the study's methodology and creating additional political leverage for the Tribes within the project process (see section 3.2.5).

- Transportation agencies, when they recognize that transportation outcomes result from intersectional layers of inequities and deficiencies across multiple systems (e.g., transportation, housing, land use), can expand the toolbox of strategies to improve safe and reliable transport in their regular work and partner with other agencies to make cross-system recommendations (see section 3.2.6). LADOT and the project team's investment in detailed qualitative research allowed them to document how people's complex lives, social systems, and built environment all impact people's travel and quality of life. The qualitative data's nuance gave LADOT the stories to make recommendations for transportation improvements and recommendations for partnering agencies, like the Mayor's Office, Recreation and Parks, the Housing Authority of LA, LA Metro, and the Bureaus of Street Services and Engineering.

- Transportation agencies will benefit from involving stakeholders representing a spectrum of expertise and experience, including community representatives with knowledge of specific local customs and lived experiences, in decisionmaking processes (see section 3.2.4). The Buchanan County engineer worked with a variety of experts—including the local technical assistance coordinator, highway patrol officers, local and State engineering staff, representatives from the Governor's Traffic Safety Bureau, the Buchanan County Board of Supervisors and other County officials, and public health officials—to develop a spectrum of safety recommendations through the RSA process. Validating the technical safety recommendations with the Amish communities was a critical part of Buchanan County's strategy to ensure effectiveness.

- Agencies can partner with CBOs to empower youth in communities (see section 3.2.3). In Nashville, the Civic Design Center works with NDOT to develop a pipeline of student leadership and advance community-led demonstration and quick-build projects. If such a pipeline does not yet exist, agencies can encourage or sponsor a similar local effort.

- Transportation agencies can engage public health experts in rural transportation planning and project development to bridge road safety and public health concerns and meaningfully engage with underrepresented communities (see section 3.2.4). In Buchanan County, IA, the county engineer partnered with the public health nurse and other professionals to conduct an RSA that integrates multiple perspectives including those from the Amish community.

- Agencies can, in general, better meet needs in harmed or underserved communities by centering the communities' lived experiences and employing their professional and personal expertise throughout all parts of the process (see section 3.2.5). MnDOT demonstrates that successful collaboration with Tribal communities results from approaching Tribal leaders as sovereign partners through a government-to-government lens.

- Agencies can leverage infrastructure projects to improve roadway safety and enhance community character (see section 3.2.2). JC uses quick-build projects to accomplish two goals at once: to improve roadway safety and to enhance community character through infrastructure. Placemaking is the urban design and planning practice to create a common vision for a public place, developed from the people who live, work, and play in that place.

4.4 PRIORITIZE TRAFFIC CALMING ON ARTERIALS IN UNDERSERVED NEIGHBORHOODS

Studies consistently find that nonaccess controlled arterials contribute to a disproportionate risk of fatal pedestrian and bicyclist crashes for all communities, but this risk is significantly pronounced in areas with BIPOC communities, people with low incomes, children, and older adults. This risk was especially pronounced at night, where there may be a lack of adequate lighting (Sanders and Schneider 2022). Traffic calming, as part of the implementation of the SSA, may include redesigning roadways to reduce speed and crossing distance, separating users in space, and improving lighting.

Studies indicated multiple institutional and infrastructural risk factors that include regional development patterns that spur higher volumes of traffic on these roads from individuals who live elsewhere passing through them; material mismatch between people's mobility needs and the built environment, resulting in part from the suburbanization of poverty; and although inconsistent, the quality of pedestrian and bicyclist infrastructure on the arterials in these communities (Benediktsson 2017; Sanders and Schneider 2022; Barajas 2018; Dumbaugh et al. 2022; Rothman et al. 2014; Hwang, Joh, and Woo 2017; Whelan et al. 2006). Specifically, the relationship between people's travel needs and their environment was implicated with nonaccess controlled arterials that aim to serve both high-speed, high-volume traffic and access to destinations for all users, particularly people with low incomes and service workers, as the primary risk mechanism. Studies further indicated that people with low socioeconomic status and BIPOC communities may be more likely to take utilitarian trips (e.g., get groceries, go to school or work) where they have to use these arterials, as opposed to recreational trips where they can choose which roads feel comfortable; and have labor or travel patterns that require them to travel at night on roads without adequate lighting (Dumbaugh et al. 2022; Sanders and Schneider

2022). These conditions were further implicated in crashes impacting children, with schools in Hispanic and Black communities and communities with low socioeconomic status more likely to be located near major arterials with high volumes (Green et al. 2004; Rothman et al. 2014; Rothman et al. 2020b; Cloutier et al. 2021).

Additionally, pedestrian safety in indigenous communities is a priority for many Tribal governments (Quick, Larsen, and Narváez 2019). The lack of pedestrian infrastructure, the tendency of pedestrians to walk long distances in Tribal communities, and concerns that drivers who do not reside on reservations may not expect to encounter many pedestrians and bicyclists and drive at fast speeds through these areas contribute to the increased risk of crash severity for pedestrians living in Tribal areas (Quick and Narváez 2018; Quick, Larsen, and Narváez 2019).

This proven practice also emerged across the case studies, for example:

- NYC DOT found that motorists taking left turns resulted in pedestrian crashes that were three times more severe compared to right turns, and the difference in safety outcomes was nearly entirely attributable to seniors and turning speeds. The slightly higher left-turning speeds (versus right turns) creates more kinetic energy that can be fatal for seniors, who have lower tolerances to external forces on their bodies. To address this, NYC DOT implemented longer crossing times, protected phasing, and crossing islands to address crashes between pedestrians and motorists turning left (see section 3.2.1).

- JC has implemented multiple traffic-calming countermeasures through their quick-build projects, including installing 679 speed humps. They have also used chicanes, pedestrian refuge islands, and murals to promote traffic calming (see section 3.2.2).

- MnDOT engineers saw the risky interactions between drivers and people crossing the high-speed roadways in Tribal areas and understood the need, even if crossing volumes were too low to meet traditional warrants. MnDOT's study revealed that certain locations, in rural contexts with significant indicators of risk like high motorist speeds, may be overlooked due to low pedestrian volumes. They installed multiple proven safety countermeasures, including RRFBs, in coordination with their Tribal partners (see section 3.2.5).

- MET Council found that many residents fear traffic crashes and, in some cases, even limit their travel to avoid driving at high speed or being around high-speed drivers. Participants reported anxiety around driving, especially on highways, and they said that driving anxiety stopped them from going where they needed or wanted or reduced their activity space. They expressed fear of high speeds, other drivers' poor driving behaviors, and the risk of being struck while walking or biking (see section 3.2.7).

As such, systemically prioritizing road safety and traffic calming strategies on arterials that bisect BIPOC neighborhoods and communities with low incomes, particularly those outside the urban core and in suburban areas, may address the disproportionate risks on these roadways and allow transportation professionals to make progress toward reaching zero deaths (Sanders and Schneider 2022; Barajas 2018; Dumbaugh et al. 2022; Rothman et al. 2014; Cloutier et al. 2021; Benediktsson 2017). Additionally, creating dense networks of lower speed streets as opposed to

arterials may reduce fatal and serious injuries in pedestrian and cyclist crashes (Dumbaugh and Zhang 2013; Rothman et al. 2020b). Similarly, implementing pedestrian countermeasures on low-volume, high-speed roads that pass through Tribal areas may address disparities in pedestrian fatalities for people living in Tribal areas, particularly indigenous communities.

4.5 FUTURE RESEARCH TOPICS

The studies in this scoping review provided multiple direction for future research.[4] Additionally, the researchers identified gaps in the research that can be investigated. These findings are summarized as follows:

- Researchers and practitioners should be mindful of how they define and frame findings related to sociodemographic categories and human geographies when conducting research on disparities. Otherwise, they can reproduce harmful narratives, like biological essentialism, that locate the sources of disparities in the bodies or decisions of individual road users rather than investigating and excavating the relationship between an individual's need, their environment, and the historic and present-day decisions made by agents in institutions that contribute to crash disparities (Schwartz et al. 2022a; Lett et al. 2022). Studies noted that "pedestrian deaths on our streets are significantly associated with factors like speed and roadway design that directly result from professional decisions and guidelines. [Professionals] can make different decisions to save these lives" (Sanders and Schneider 2022). Future research can use the frameworks elaborated in section 2.3.1 Framing Sociodemographic , center intersectionality in their analysis, engage with social scientists, and elevate community voices through community based-participatory research.

- Future research on risk factors contributing to inequities should consider data on pedestrian and bicyclist exposure and the availability and quality of ATI. Many studies noted significant limitations in the availability and quality of data on pedestrian and bicyclist exposure and infrastructure (Sanders and Schneider 2022; Dumbaugh et al. 2022). Emerging data sources and place-based analyses at more granular levels, like cities, towns, or even neighborhoods, can begin to address these gaps.

- Future research should focus on risk factors contributing to inequities in bicycling safety for children, indigenous communities, and people with disabilities. While research is emerging on disparities in bicyclist crashes, with particular attention to the needs of Hispanic communities (Barajas 2018; Braun, Rodriguez, and Gordon-Larsen 2019) and older adults (Das et al. 2019), there is little research on bicycling safety for children, for indigenous communities living in Tribal areas, and for people with disabilities. Future research could investigate potential disparities in bicyclist safety for these populations and provide direction to ensure bicycling infrastructure is safe and feels safe for children and people with disabilities and meets the needs of people living in Tribal areas.

[4]These future research themes build on AASHTO's Council on Active Transportation Research Roadmap (https://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-123-02AASHTOCATResearchRoadmap.pdf).

- Future research could evaluate the effectiveness of innovative project delivery mechanisms, like quick-build projects, particularly on high-speed, high-volume arterials in areas with high proportions of Hispanic and Black communities, as well as high-speed, low-volume arterials in Tribal areas. Additionally, this research can explore how to ensure quick-build implementation is accessible to persons with disabilities. Strategies to prioritize investments and deliver timely projects to address risks contributing to disparities can support significant progress toward the goal of zero deaths.

- Future research can explore responsibility for sidewalk improvements across levels of government and between public and private entities to understand how these disparities emerge and how they can be addressed (Lowe 2016).

- Future research can explore the historical decisionmaking processes and present-day impacts of the transportation system, particularly high-speed roads, in Tribal areas.

- Future research could further explore the relationship between the suburbanization of poverty and an aging population on pedestrian and bicyclist safety.

- Future research could explore the needs of pedestrians and bicyclists with cognitive, intellectual, and developmental disabilities. Additional research on how to consider and prioritize the needs of people with disabilities to create a safe system that promotes independence for all people is needed. Specifically, increasing the availability and quality of data on the needs of people with disability could be beneficial to address gaps in metrics on safety and accessibility for people with disabilities.

- Future research can investigate disparities in road fatalities for men beyond risky decisionmaking. Investigating cultural, systemic, and intersectional factors that contribute to higher risk for men walking and biking can provide strategies for addressing this persistent disparity.

- Future research can explore safety holistically, understanding road safety needs in relation to the way people need or choose to use the transportation system and perceptions of safety.

- Future research can evaluate the effectiveness of policies, funding processes, and data metrics in advancing safety goals.

CHAPTER 5. CONCLUSION

This report included an expansive scoping review covering risk factors that may contribute to crash disparities in pedestrian and bicyclist fatalities and serious injuries across five sociodemographic categories: race and ethnicity, SES, age, disability, and sex and gender. The report also elaborated promising practices and examples from seven case studies from State, regional, and local transportation agencies and organizations from across the country. Finally, the report concluded with five proven practices and future research topics for practitioners and researchers.

APPENDIX. SOCIOECONOMIC FACTORS USED IN QUANTITATIVE STUDIES

Table 8 reviews the units of analysis and demographic and economic factors used in selected quantitative studies.

Table 8. List of socioeconomic factors used in quantitative studies.

Author (Year)	Unit of Analysis	Socioeconomic Factors Used in Modeling	
		Demographic Factors	Economic Factors
Amoh-Gyimah, Saberi, and Sarvi (2016)	Statistical area level 2 zone	Commuters walking to work Commuters cycling to work	—
Barajas (2018)	CT	Race and ethnicity Poverty Educational attainment Limited English proficiency	Median household income Car ownership
Barajas (2021)	CT level	White (percent) Black (percent) Latino percent) Asian (percent) Population density (1/km^2)	Employment density (1/km^2) Poverty rate (percent)
Benediktsson (2017)	County	Age 65 yr and older (percent) Age 17 yr and younger (percent) Black (non-Hispanic) (percent) Hispanic (percent)	Living in unincorporated areas (percent) Poverty rate Carless households (log percent)
Chakravarthy et al. (2012)	CT	High school education Speaks English less than very well Latino Asian Multifamily residences Population density	Low income Vehicle ownership
Chakravarthy et al. (2010)	CT	Age 0–14 yr Age 64+ yr High school education Speak other language at home; speak English very well Speak other language at home; speak English less than very well Population density/km^2 (percentage of maximum)	Poverty and near poverty
Chimba and Musinguzi (2016)	CBG	Population density Population below 15 yr of age Population from 15 to 64 yr of age Population commuting to work by private cars Population commuting to work by walking Housing units with no vehicles	Median household income

Author (Year)	Unit of Analysis	Socioeconomic Factors Used in Modeling	
		Demographic Factors	Economic Factors
Chimba et al. (2014)	CTs	Total population (*n*) White population (percent) Black population (percent) Latino population (percent) Black and Latino population (percent) Population under 20 yr of age (percent) Population from 20 to 64 yr of age (percent) Population above 65 yr of age (percent) Housing units with no vehicles (percent) Housing units with 1 vehicle (percent) Housing units with 2 or more vehicles (percent) Population in labor force (percent)	Mean household income ($) Households with income below $25,000 (percent) Households with income of $2,5000 to $49,999 (percent) Households with income of $50,000 and above (percent) Population below poverty level (percent)
Chimba, Musinguzi, and Kidando (2018)	Block group	Age composition	Below poverty level Housing unit with no vehicles, 1 vehicle, 2+ vehicles
Cottrill and Thakuriah (2010)	CT	Children (percent) Speak limited or no English (percent)	Median household income No cars (percent)
Dadashova et al. (2022)	Block group	Number of adult males (age 18–39 yr) Number of adult females (age 18–39 yr) Black proportion (percent)	Number of households below poverty
Ferenchak and Marshall (2019)	CT	Population that has a high-school degree (percent) Population that identified as Hispanic (percent) Population that identified as Black (percent)	—
Flanagan et al. (2016)	CT	Non-White (percent) Change in White population (percent) Renter occupied units Change in homeownership (percent) Some college or higher (percent) Change in some college or higher (percent) New resident since 2009 (percent) Median age	Median household income Median home value Change in median home value Unemployed (percent)
Guo et al. (2020)	CBG	Population in thousands Proportion of older adults (over age 65 yr) Proportion of African American population (percent) Proportion of commuters by public transit (percent) Proportion of population less than high school (percent)	Proportion of households with zero cars (percent) Low income areas
Guo, Osama, and Sayed (2018)	TAZ	Households	Employment

Author (Year)	Unit of Analysis	Socioeconomic Factors Used in Modeling	
		Demographic Factors	Economic Factors
Haddad et al. (2023)	CBG	Total population Less than a high school education (percent) Children (<15 yr) (percent) Young adults (18–30 yr) (percent) Adults (31–64 yr) (percent) Seniors (>65 yr) (percent) High school graduates(percent) College graduates (percent) Racial diversity index	Low income (percent) Medium income (percent) High income (percent) Employment density Households with 0 vehicles (percent) Households with 1 vehicle (percent)
Hickox et al. (2014)	Block group	Age groups (yr) Race/ethnicity Visitors (percent) Homeless (percent) Residents (percent)	—
Kravetz and Noland (2012)	Block group	Blacks and Hispanics (percent) Population younger than 18 yr (percent)	Median household income Number of employees per square mile
Lee and Abdel-Aty (2018)	ZIP Code	Population Proportion of infants, toddlers, and preschoolers (0–4 yr) Proportion of school-age children (5–14 yr) Proportion of adolescents (15–19 yr) Proportion of very young people (20–24 yr) Proportion of young people (25–44 yr) Proportion of middle-aged people (45–64 yr) Proportion of elderly people (65–74 yr) Proportion of very elderly people (75 yr or older) Proportion of workers in the tertiary sector Whether median year of structure built is before 1984	Proportion of households without an available vehicle Proportion of unemployed people Proportion of households below poverty level Median household income (in thousands)
Lee, Abdel-Aty, and Cai (2020)	Metropolitans statistical area	Population density Age group: 5–14 yr (percent) Age group: 15–24 yr (percent) Age group: 25–64 yr (percent) Age group: 65–74 yr (percent) Age group: 75 yr and older (percent) Proportion of African Americans Proportion of Hispanics Proportion of Asian Americans Commuters using passenger car (percent) Education level: college and higher (percent) Median household income (U.S. dollars)	—

Author (Year)	Unit of Analysis	Socioeconomic Factors Used in Modeling	
		Demographic Factors	**Economic Factors**
		Households below the poverty level (percent) Primary sector industry occupations (percent) Secondary sector industry occupations (percent) Tertiary sector industry occupations (percent)	
Roll and McNeil (2022)	CT	Average daily population Households without vehicle (percent) Black (percent) Asian (percent) Latinx(percent)	Median income (thousands)
Roll et al. (2021)	CT	BIPOC (percent) Population that is American Indian or Alaskan Native (percent)	Composite index (poverty rate: percent of the population living at or below the poverty line)
Saha et al. (2018)	Block group	Population Population density Number of households, and household density Population age cohorts Ethnic groups Educational attainment	Household income (thousands) Proportion of population below poverty line Proportion of households with no automobile Proportion of households with one automobile
Schneider et al. (2021)	Hot spot corridor	Median age Racial composition	Area median income (percent) Households with no vehicle
Schwartz et al. (2022b)	Police reported child pedestrian motor vehicle collision	Marginalization index (material deprivation, recent immigrants (5 yr), identifying as visible minority)	—
Sener et al. (2021)	Block group	Population density Age distributions Racial distributions Different types of households (percent)	—
Siddiqui, Abdel-Aty, and Choi 2012	TAZ	Total population Total dwelling units Total number of hotel units Kindergarten through 12th grade school enrollment Higher education enrollment Households with at least one retired person (percent)	Median household income Employment Short-term parking cost Long-term parking cost Vehicle ownership
Siddiqui, Abdel-Aty, and Choi 2014	TAZ	Population Educational institutions Number of households with at least one retired person	Employment

Author (Year)	Unit of Analysis	Socioeconomic Factors Used in Modeling	
		Demographic Factors	Economic Factors
Wier et al. (2009)	CT	Employee population (*n*) Resident population (*n*) Age 65 yr and older (percent resident population) Age 17 yr and under (percent resident population)	Living below the poverty level last year Unemployed
Yu, Zhu, and Lee (2018)	CT, block group, and TAZ	Age 18 yr and younger non-White	Income level below the poverty line
Zhang et al. (2015)	CT	Population age 0–5 yr Population age 16–64 yr Population age 65 and older yr Employment rate Average household income in 1999	—

—No data.

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[1] Ms. butler has requested that her name appear in lowercase lettering to honor bell hooks.

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