

Transportation Research Synthesis

TRS 2201

May 2022

THE HEALTH AND TRANSPORTATION NEXUS: A CONCEPTUAL FRAMEWORK FOR COLLABORATIVE AND EQUITABLE PLANNING

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Transportation is a crucial contributor to health. It not only directly shapes the social and physical environments in a myriad of ways but also determines the types of places where people can live, learn, work, and play in their everyday life. This project develops a conceptual framework for collaborative and equitable health and transportation planning by extending the social determinants of health framework to include three major pathways through which transportation factors operate on health and equity outcomes. The three major pathways are behavioral health, environmental health, and social exclusion, which are identified via a thorough review of the academic literature and gray resources on health and transportation connections. Of the three pathway mechanisms, social exclusion and environmental health are intrinsically linked to social equity and justice issues. By integrating multiple pathway mechanisms through which transportation operates on health and equity outcomes, the proposed framework has the potential of reducing misinformed transportation investments that either have limited health benefits or unintended consequences that harm specific population groups.



Following the development of framework, we further review state-level initiatives linking transportation to health and interview six state departments of transportation that are pioneers in advocating and implementing integrated health and transportation planning. The interview results are summarized and discussed in the report. Based on the interviews, we make recommendations for the Minnesota Department of Transportation to help further its efforts on integrated health and transportation planning.

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Technical Report Documentation Page

1. Report No. MN TRS2201	2.	3. Recipients Accession No.	
4. Title and Subtitle The Health and Transportation Nexus: A Conceptual Framework for Collaborative and Equitable Planning		5. Report Date May 2022	
		6.	
7. Author(s) Yingling Fan, Peiyu Phua		8. Performing Organization Report No.	
9. Performing Organization Name and Address Humphrey School of Public Affairs University of Minnesota 301 19th Avenue South, 295E Humphrey School Minneapolis, MN 55455		10. Project/Task/Work Unit No. CTS #2022007	
		11. Contract (C) or Grant (G) No. (c) 1036342 (wo) 29	
12. Sponsoring Organization Name and Address Minnesota Department of Transportation Office of Research & Innovation 395 John Ireland Boulevard, MS 330 St. Paul, Minnesota 55155-1899		13. Type of Report and Period Covered Transportation Research Synthesis	
		14. Sponsoring Agency Code	
15. Supplementary Notes https://www.mndot.gov/research/reports/2022/TRS2201.pdf			
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17. Document Analysis/Descriptors Transportation, Public health, Equity (Justice), Cooperation, City planning, State departments of transportation, Interviewing, Literature reviews		18. Availability Statement No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 39	22. Price

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The purpose of this TRS is to serve as a synthesis of pertinent completed research to be used for further study and evaluation by MnDOT. This TRS does not represent the conclusions of either the authors or MnDOT.

1 Introduction

Transportation organizations across the nation have increasingly incorporated health considerations into transportation planning practices. These organizations often cite the social determinants of health (SDoH) framework when making transportation-health connections. SDoH have been widely defined as non-medical factors that influence health equity and health outcomes. They refer to the conditions in which people live, learn, work and play, and they are often shaped by the complex and interrelated social structures and economic systems. Figure 1 is one of the many versions of SDoH that illustrate the types of determinants in each of the six categories that could affect health outcomes. As shown in Figure 1, SDoH factors include: (1) neighborhood and environment, (2) economic stability, (3) social and community, (4) education, (5) food, and (6) healthcare.

Figure 1: The Social Determinants of Health Framework

Economic Stability	Neighborhood and Physical Environment	Education	Food	Community and Social Context	Health Care System
Employment	Housing	Literacy	Hunger	Social integration	Health coverage
Income	Transportation	Language	Access to healthy options	Support systems	Provider availability
Expenses	Safety	Early childhood education		Community engagement	Provider linguistic and cultural competency
Debt	Parks	Vocational training		Discrimination	Quality of care
Medical bills	Playgrounds	Higher education		Stress	
Support	Walkability				
	Zip code / geography				

Health Outcomes
 Mortality, Morbidity, Life Expectancy, Health Care Expenditures, Health Status, Functional Limitations

(Source: Artiga, S., & Hinton, E. (2018). Beyond health care: The role of social determinants in promoting health and health equity. Kaiser Family Foundation Issue Brief.)

SDoH provide a broad lens to examine health impacts of transportation policies. According to SDoH, place-based social and physical environments could create or limit opportunities to improve and maintain human health. Transportation is therefore a crucial contributor to health; it not only directly shapes the social and physical environments in a myriad of ways but also determines the type of places where people can live, learn, work and play in their everyday life. Despite the usefulness of the SDoH framework to illustrate the multifaceted connections between transportation and health, it does not highlight the specific pathways and mechanisms through which transportation operates on health.

In this report, we integrate SDoH with three distinct transportation-health pathway frameworks including social exclusion, behavioral health, and environmental health to illustrate how transportation affects health within the broader SDoH framework. The integration between SDoH and the specific pathway frameworks is based on a meta-narrative analysis that synthesizes both academic literature and gray resources, including journal articles by academic researchers and professional reports of influential transportation and/or health organizations such as the Federal Highway Administration, Transportation Research Board, and World Health Organization. Based

on the analysis of relevant literature and grey resources, we develop a new conceptual framework that extends the SDoH framework to include three major pathways through which transportation factors operate on health and equity outcomes. The three major pathways are behavioral health, environmental health, and social exclusion, which can all be used by the Minnesota Department of Transportation (DOTs) to inform and promote collaborative transportation and health planning.

In addition, we conducted a comprehensive review of transportation-health initiatives at the 50 State departments of transportation (state DOTs) and found eight state DOTs that are pioneers in linking transportation to health. We then conducted in-depth interviews with six of the pioneering state DOTs to further investigate the state-of-the-art practices when it comes to state-level collaborative health and transportation planning. Based on the findings from the in-depth interviews, we develop four recommendations for the Minnesota Department of Transportation (DOTs) to consider when it comes to promoting collaborative transportation and health planning.

2 General Transportation and Health Frameworks

The SDoH framework can be broadly applied to understand how human health is influenced by our infrastructure systems, built environment, and social settings. The transport framework has inspired researchers and practitioners in transportation and health to develop tools and frameworks that connect transportation to health. Table 1 illustrates the SDoH-inspired tools and frameworks for understanding the general transportation-health connections.

Table 1: SDoH-Inspired Transportation and Health Frameworks and Tools (8 frameworks & 3 tools)

ID	Name	Organization	Description and Highlighted Domains
F1	Health in Transportation Corridor Planning Framework	FHWA	The framework supports transportation agencies to incorporate health into corridor planning studies. The framework highlights the roles of air quality, biking and walking, health equity, safety, and transit in influencing the transportation-health connections.
F2	Metropolitan Area Transportation Planning for Healthy Communities	FHWA	This framework supports metropolitan planning organizations (MPOs) and partners to integrate health into metropolitan area transportation planning. The framework highlights the consideration of active transportation, safety, air pollution, and access to opportunities for healthy lifestyles.
F3	A Research Roadmap for Transportation and Public Health	TRB	This framework outlines six domains in which transportation processes and decisions may impact health, including access, active travel, community well-being, environment (air, noise, and water), resiliency, and safety.
F4	The Transportation Prescription: Bold New Ideas for Healthy, Equitable, Transportation Reform in America	Prevention Institute & Policy Link	This framework investigates how transportation policies and plans influence health via effects on pollution, climate change, physical activity, mental health, safety, and disparities in income and physical and mental abilities.
F5	Recommendations for Improving Health through Transportation Policy	CDC	This framework outlines key recommendations for bringing public health considerations into transportation issues, including recommendations related to crashes and injuries, air quality, public transportation, active transportation, community design/access, and other health and safety considerations.
F6	Transportation and Health: Policy Intervention for Safer, Healthier People and Communities	SafeTREC at the University of California, Berkeley	This framework outlines transportation-related policies promoting public health, including policies that improve the environment and environmental health; policies that enhance community design and promote active transportation; and policies that reduce motor vehicle-related injuries and fatalities.

ID	Name	Organization	Description and Highlighted Domains
F7	Transport, Environment, and Health	WHO Regional Office for Europe	This framework brings together the main effects of transportation on human health and the environment. It highlights the effects related to transport noise, accidents and injuries, air pollution from traffic, mental health and well-being, active transportation, and vulnerable populations.
F8	Health Impact Assessment of Transport Initiatives	Public Health Scotland	This framework outlines possible ways in which transport might impact health, including physical health, physical activity, injuries and deaths, air and noise pollution, mental health, safety, access and social inclusion, and climate change.
T1	Transportation Health Impact Assessment Toolkit	CDC	The toolkit provides a framework for conducting HIAs on proposed transportation projects, plans, and policies, which identifies six strategies: reduce vehicle miles traveled; expand public transportation; promote active transportation; incorporate healthy community design features; improve safety for all users; and ensure equitable access to transportation networks.
T2	Transportation and Health Tool (THT)	USDOT and CDC	The tool provides data on a set of transportation and public health indicators for each U.S. state and metropolitan area that describe how the transportation environment affects safety, active transportation, air quality, and access to destinations.
T3	Integrated Transport Health Impact Model (ITHIM)	CEDAR at the University of Cambridge	The model integrates data on travel patterns, physical activity, fine particulate matter, GHG emissions, and disease and injuries based on population and travel scenarios.

Note: SafeTREC: Safe Transportation Research and Education Center; CEDAR: Centre for Diet and Activity Research; WHO: World Health Organization.

A total of eight frameworks and three tools are included in Table 1. These frameworks and tools are chosen for their comprehensive and holistic discussion on the relationship between transportation and health. In other words, these frameworks and tools are much more comprehensive than those focusing on a specific area such as active transportation, food access, public transportation, etc. Specifically, CDC’s Built Environment Assessment Tool (BE Tool) focuses on topics related to active transportation such as walking and biking. Victoria Transport Policy Institute’s framework for evaluating public transportation health benefits specifically focuses on public transportation. USDA’s Food Access Research Atlas focuses on issues relating to food access only. These tools and frameworks were not included in Table 1. In addition, Table 1 does not include frameworks that are not health specific. For example, FHWA’s Planning and Environment Linkages (PEL) and Community Impact Assessment frameworks deal with transportation-health connections, but are not designed for understanding transportation-health connections. These non-health specific frameworks are not included in Table 1 either.

Table 1 shows similarities and differences in highlighted domains across SDoH-inspired frameworks and tools for understanding the transportation-health connections. To further illustrate the similarities and differences, we

developed Table 2 to summarize the key domains and themes of each framework/tool in Table 1. Table 2 shows that the eight frameworks and three tools in Table 1 contribute a total of nine themes including active transportation, environmental pollution, traffic safety, access to destinations, equity, public transportation, mental health and well-being, climate change, and resilience to disasters. Of the nine themes, active transportation, environmental pollution, and traffic safety have been widely acknowledged—they are highlighted across all tools and frameworks in Table 1.

Table 2: Key Domains and Themes Highlighted in Each of the Frameworks and Tools in Table 1

Key Domains/Themes	F1	F2	F3	F4	F5	F6	F7	F8	T1	T2	T3	Total
Active transportation	X	X	X	X	X	X	X	X	X	X	X	11
Environmental pollution	X	X	X	X	X	X	X	X	X	X	X	11
Traffic safety	X	X	X	X	X	X	X	X	X	X	X	11
Access to destinations		X	X		X			X		X		5
Equity	X			X			X	X	X			4
Public transportation	X				X				X			3
Mental health and wellbeing			X	X			X					3
Climate change				X				X				2
Resilience to disasters			X									1

In the domain of **active transportation**, it is emphasized that sedentary lifestyles and inadequate physical activity are major contributors to the high obesity prevalence in the U.S. and that obesity contributes to a myriad of health problems, including elevated risk of heart disease, depression, diabetes, some cancers, hypertension, stroke etc. (CDC, 2021). Although one’s physical activity level largely depends on personal choices, having a well-designed active transportation system is an effective way to help offer more opportunities to integrate physical activity into one’s daily routines by encouraging one to walk or bike more daily (USDOT, 2015c). According to the CDC’s Recommendations for Improving Health through Transportation Policy framework (i.e., F5 in Table 1):

“Physical activity and active transportation have declined compared to previous generations. The lack of physical activity is a major contributor to the steady rise in rates of obesity, diabetes, heart disease, stroke and other chronic health conditions in the United States... Many Americans view walking and bicycling within their communities as unsafe because of traffic and the lack of sidewalks, crosswalks and bicycle facilities.”

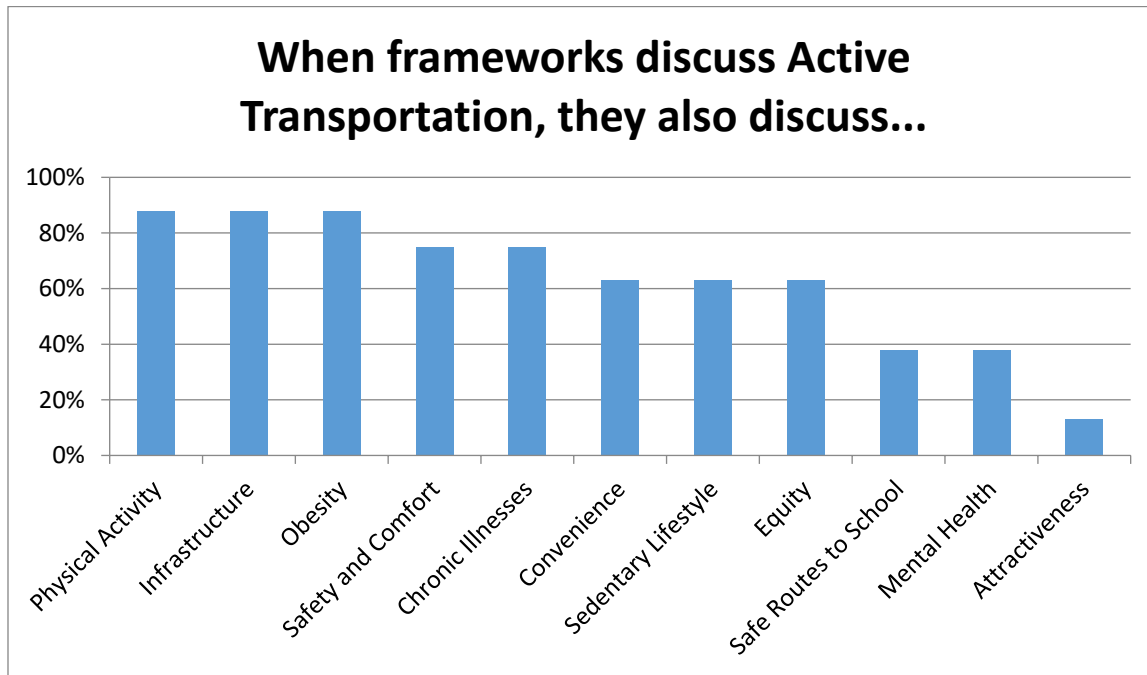
In the Transportation Prescription framework by the Policy Link and Prevention Institute (F4 in Table 1), Bell and Cohen argue:

“Walking and bicycling not only for recreation but also for transportation are the more practical ways to improve fitness. They are often the only viable option for low-income residents who live in neighborhoods without parks, who cannot afford gym memberships, and who do not have the luxury of leisure time.”

Figure 2 shows the main topics mentioned with **active transportation** in the eight selected frameworks. When connecting transportation with health, researchers and practitioners cited active transportation together with discussions of physical activity, infrastructure, obesity, safety, comfort, chronic illnesses, convenience, sedentary lifestyle, and equity at least more than 40% of the time. It is interesting to note that the topic of safety and comfort is more frequently mentioned than the topics of equity and mental health when the frameworks elaborate on the domain of active transportation. Besides emphasizing safe and convenient pedestrian and bicyclist infrastructure systems, the frameworks call for the following land use and urban design solutions that can make the built environment more attractive and convenient for pedestrians and bicyclists:

- Transit-oriented development and/or mixed-use development
- Multimodal transportation system, intermodal connectivity or transit mode share
- Smart growth
- Regional plans for non-motorized trails, sidewalks, and bicycle lanes

Figure 2: Topic Co-occurrence when frameworks discuss active transportation

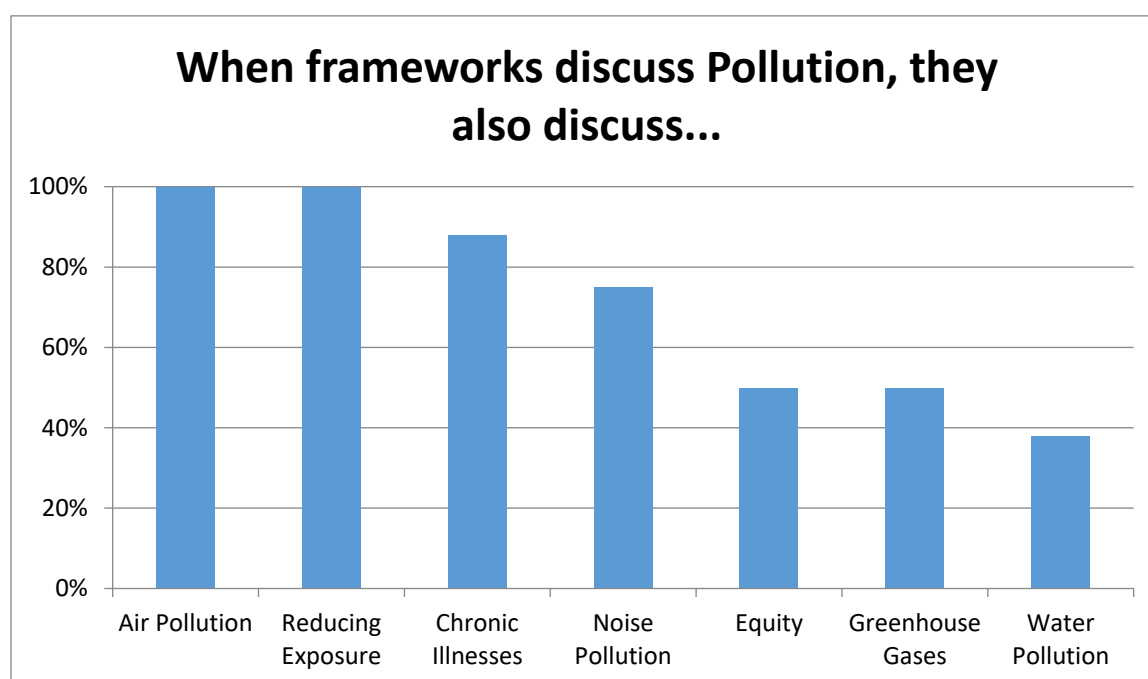


In the domain of **environmental pollution**, it is often emphasized that motor vehicles are the leading source of air pollutants that can affect human health, including asthma, reduced lung capacity, chronic pneumonia and bronchitis, especially among vulnerable populations (USDOT, 2015; UCS, 2014). Transportation measures to improve air quality often involve reduction in emissions, with the following interventions most frequently suggested:

- Reduce Vehicle Miles Traveled (VMT) by increasing well-integrated public transit or active transportation options,
- Encouraging the use of electric-powered, newer or alternative-fuel vehicles, and
- Replacing older diesel vehicles and restricting vehicle idling.

Besides the need to reduce emissions, the frameworks have mentioned the need for reduction in exposure to emissions and the equity issues associated with exposure to emissions. Figure 3 shows the main topics co-mentioned with environmental pollution in the eight selected frameworks. Besides air pollution, noise and water pollution are relevant pathways connecting transportation to health. As shown in Figure 3, although the mentioning of water pollution is far less frequent than the mentioning of air and noise pollution, it is not a negligible component of the transportation-health connection. It is worth noting that equity is mentioned 50% of the time when the transportation-health frameworks discuss the environmental population pathway.

Figure 3: Topic Co-occurrence when frameworks discuss environmental pollution



The **traffic safety** domain in transportation and health is largely focused on bodily harm and injury associated with traffic accidents. With motor vehicle crashes as the second leading cause of death from unintentional injuries in the U.S, improving traffic safety is DOT’s highest priority (DOT, 2021). Below are the interventions most commonly suggested and undertaken to improve traffic safety:

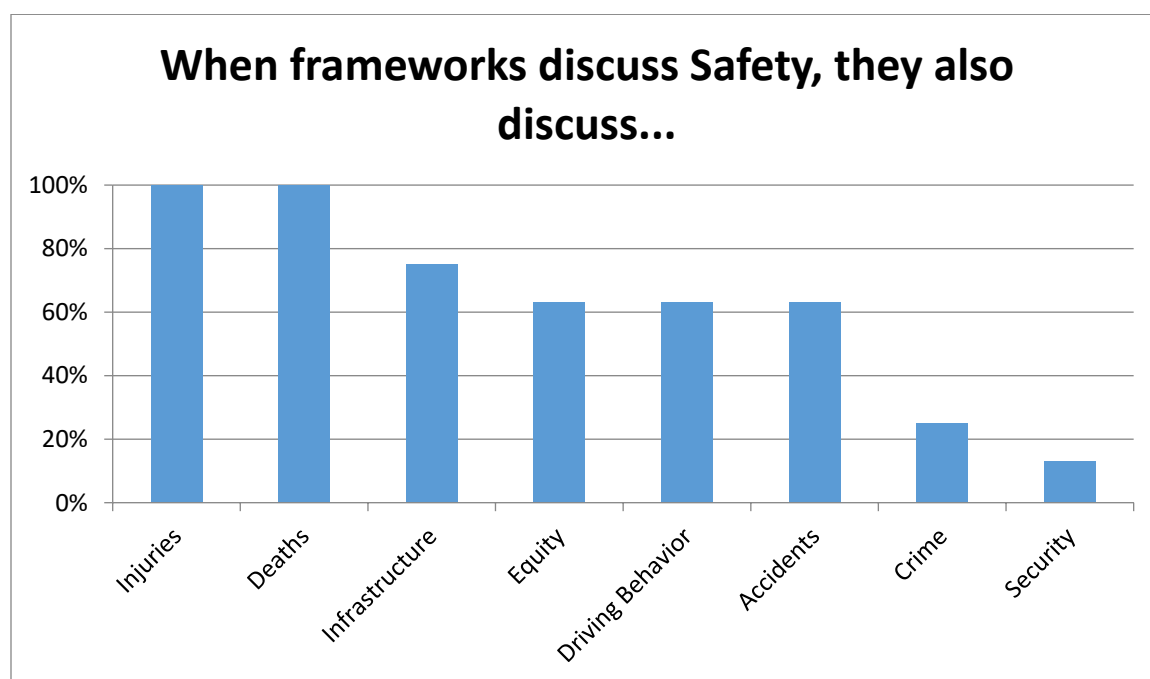
- Controlling vehicle speed;
- Preventing driving under the influence (DUI);
- Improving and encouraging safe driving behaviors (e.g. non-distracted driving);
- Improving traveler information systems and pedestrian signalization;
- Road improvements such as wider sidewalks, curb extensions, well-marked crosswalk, on-street parking, and narrow travel lanes for cars;
- Complete Streets;
- Increasing the use of seat belts;
- Improving child restraint systems; and

- Improving vehicle design standards (e.g., airbags and rear view cameras).

Figure 4 shows the main topics co-mentioned with traffic safety in the eight selected frameworks. It is worth noting that equity is mentioned more than 50% of the time when traffic safety is discussed in the frameworks. Further, the topic on crime and general security have not been examined explicitly in most of these frameworks, although Litman (2020) stated the following when it comes to the connections between transportation and crime:

“Increased walking, cycling and public transit travel tends to increase overall security and reduce crime rates by providing more monitoring of city streets and transit waiting areas. Actual and perceived security risks can be reduced by targeted efforts such as... monitoring of transit vehicles and waiting areas... crime prevention through environmental design.”

Figure 4: Topic Co-occurrence when frameworks discuss traffic safety

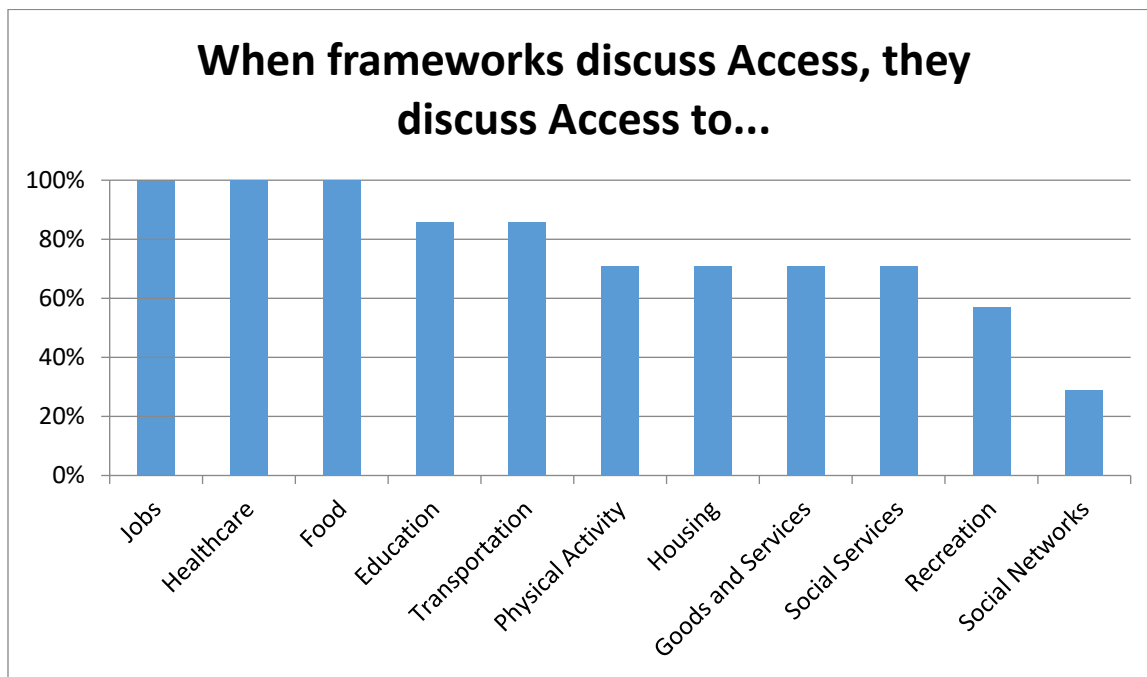


Almost half of the frameworks and tools highlighted the **access to destinations** domains, which is the fourth most highlighted domain, right behind active transportation, environmental pollution, and traffic safety. As shown in Table 2, four frameworks (F2, F3, F5, F8) and the THT tool suggest that the ability to reach everyday destinations is critical to improving health. Having access to destinations is crucial to achieving several SDoH factors like employment, healthy foods and healthcare. According to the National Household Travel survey, an estimated 25.5 million Americans have disabilities that make traveling outside the home difficult; and these people accounted for 8.5 percent of the population age 5 and older in 2017 (Bureau of Transportation Statistics, 2018). Similar to interventions that promote active transportation, interventions that increase access to destinations include multimodal transportation solutions as well as land use and urban design solutions such as transit-oriented development (TOD), land use mix, and smart growth.

Figure 5 shows that access is frequently mentioned in conjunction with jobs, healthcare, food, education and transportation. In addition, in making the transportation-health connections via access to destinations, physical

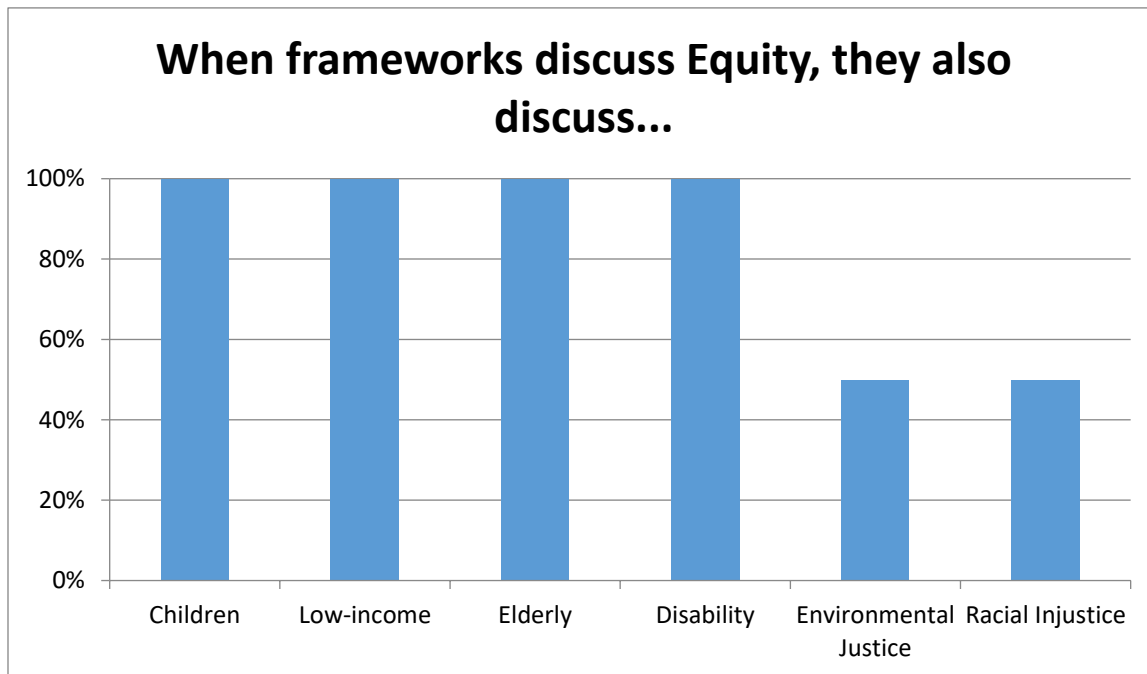
health via providing healthy food and healthcare services and economic well-being via providing employment and educational opportunities are often discussed. It is important to note that these tools and frameworks fail to highlight how lack of access to destinations can exclude people from the decision-making process, further exacerbating SDoH and other equity issues (Lucas, 2012). The connection between access and emotional and mental well-being is also rarely mentioned in these tools and frameworks.

Figure 5: Topic Co-occurrence when frameworks discuss access to destinations



Equity is the fifth most highlighted domain. The Health in Transportation Corridor Planning Framework defines health equity as everyone having the opportunity to attain their full health potential and no one being disadvantaged from achieving this potential because of their social position or other socially determined circumstance. Despite the broad definition of health equity, when being considered, disadvantaged populations in health equity are mostly described as children, low-income, elderly, the disabled, or communities of color (Figure 6). Many other aspects of equity, such as gender or cultural differences, have not been widely discussed in these frameworks linking transportation to health. There are other vulnerable populations such as women (in the safety context), people with lower education levels, people who are homeless, people who face language or cultural barriers, people without health insurance etc. that have yet to be widely discussed when connecting transportation to health.

Figure 6: Topic Co-occurrence when frameworks discuss equity



The remaining domains (public transportation, mental health and well-being, climate change, and resilience to disasters) are highlighted in fewer frameworks and tools. Figure 7 is a graphical representation of the words that are most frequently mentioned in the documents describing the selected transportation-health frameworks in Table 1. The larger the word appears, the more often it has been mentioned within the framework documents. The findings in Figure 7 coincide with the findings in Table 2. The most frequent words correspond to the three most highlighted domains: active transportation/physical activity, pollution, and safety.

Figure 7: Word Frequency Analysis using the Reports on Transportation and Health Frameworks



Overall, these SdoH-inspired transportation-health frameworks have made attempts to highlight specific transportation domains that have strong connections to health outcomes. Their emergence has helped transportation and health professionals to make a compelling case for collaborative health and transportation planning. However, the highlighted domains do not provide a systematic understanding of the transportation-health pathways. Some domains are more highlighted than others.

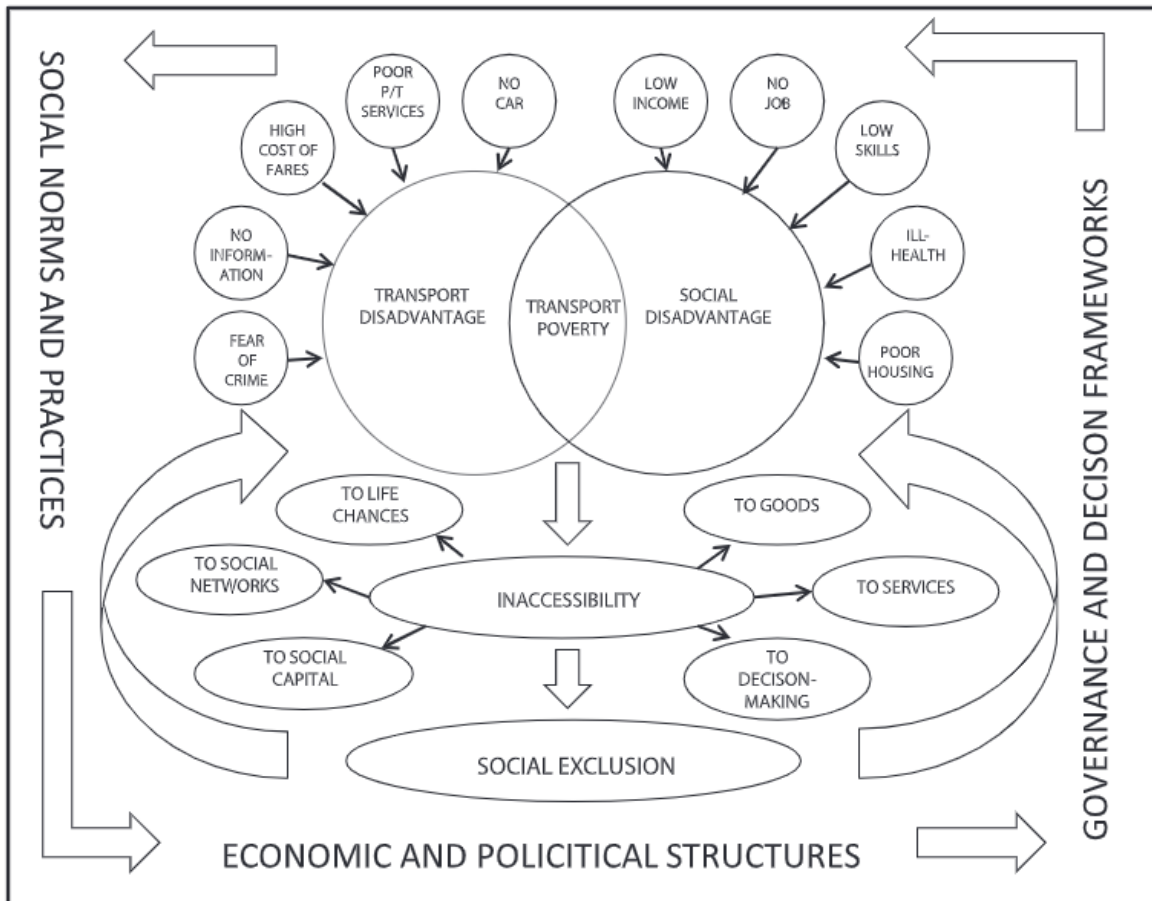
3 Specific Frameworks on Transportation-Health Pathways

Social Exclusion

Since the late 1990s, transportation academics and policy makers in the United Kingdom (UK) have made more explicit links that transportation can influence the level of participation and inclusion in social, economic, and political lives. Their efforts have led to widespread policy concerns centered around transportation disadvantage, inaccessibility, and social exclusion. In 2003, the UK Social Exclusion Unit published its now internationally recognized report titled “Making the Connections: Final Report on Transport and Social Exclusion”. In 2006, the UK Department for Transport published “Full Guidance on Accessibility Planning”, which required local authorities in the UK to undertake accessibility assessments when developing their Local Transport Plans.

This line of work subsequently resulted in an innovative pathway framework illustrating how transportation policy may affect the social exclusion of low-income groups and minorities and further affect health and well-being outcomes. Developed by Lucas (2012), Figure 8 illustrates the pathways through which transportation disadvantage leads to inaccessibility and then social exclusion. As shown in Figure 8, the concept of inaccessibility is centered in the framework and transportation advantage interacts with social advantage to produce social exclusion via inaccessibility.

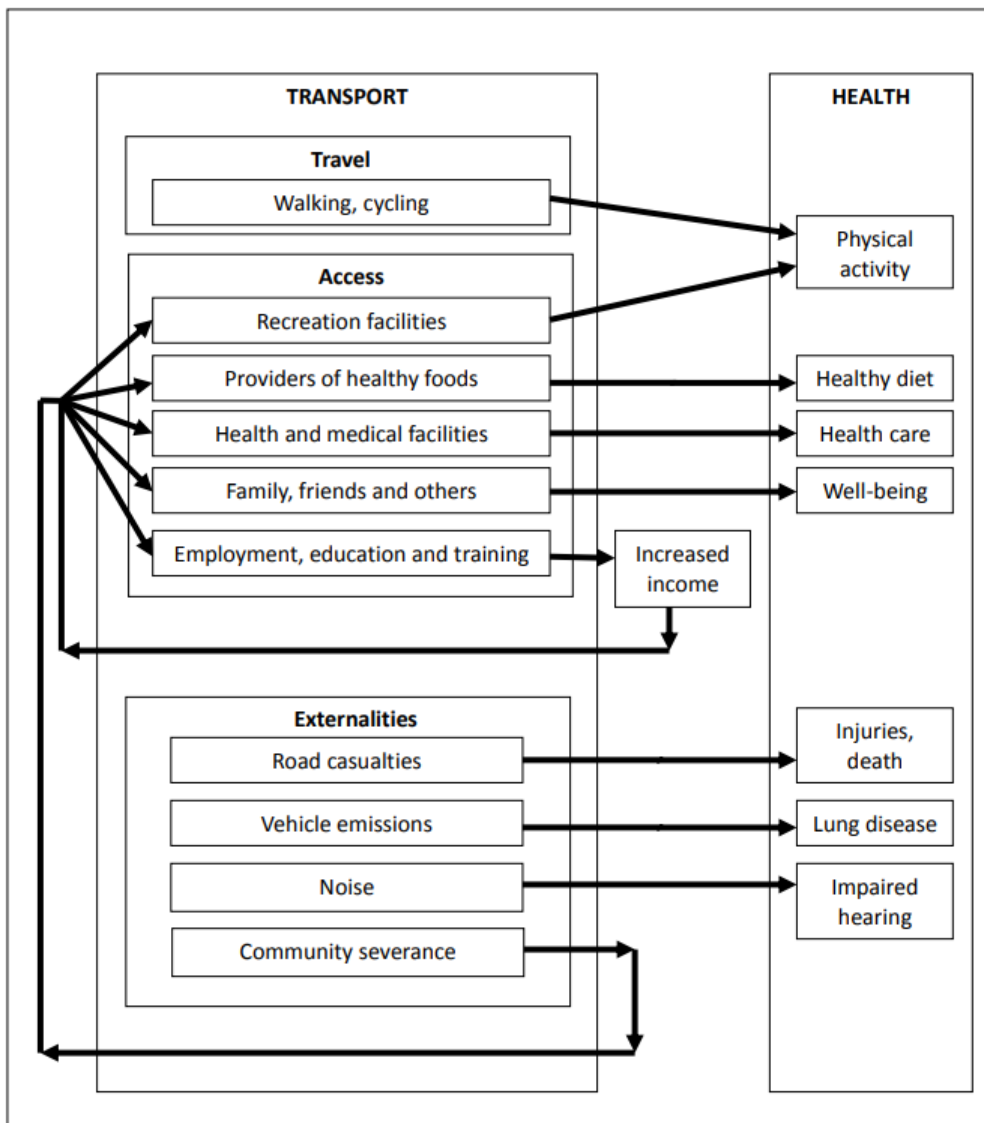
Figure 8: The transportation disadvantage and social exclusion framework developed by Lucas, 2012



Source: Lucas, K. (2012). *Transport and social exclusion: Where are we now?*. *Transport policy*, 20, 105-113

Developed by Mackett and Thoreau (2015), Figure 9 illustrates the pathways through which accessibility connects to health outcomes. Mackett and Thoreau (2015) extends the social exclusion framework of Lucas (2012) and explicitly illustrates a transportation-health pathway via social exclusion and inaccessibility.

Figure 9: The transport, social exclusion, and health framework developed by Mackett and Thoreau, 2015.



Source: Mackett, R. L., & Thoreau, R. (2015). *Transport, social exclusion and health*. *Journal of Transport & Health*, 2(4), 610-617.

Adopting the social exclusion approach to understand the transportation-health pathways have multiple advantages:

- It recognizes that the transportation-health pathways operate in multiple life dimensions, including economic opportunities, daily activity participation, and civic and political engagement. Social exclusion involves “the lack or denial of resources, rights, goods and services, and the inability to participate in the normal relationships and activities, available to the majority of people in a society, whether in economic, social, cultural or political arenas.”
- It emphasizes the interactions between transportation disadvantage and social disadvantage, acknowledging that individuals affected by transportation disadvantage may experience multiple,

intersecting deprivations such as poor housing, low educational attainment, unemployment, and low levels of existing health and well-being conditions. In this way, it moves away from the traditional systems-based transportation service provision approach towards a more people-oriented and needs-based social policy approach that focuses on accessing key life-enhancing opportunities.

- The innovative concept of social exclusion goes beyond illustrating how transportation disadvantage affects the life conditions of individuals, and relates the problems back to how the policy decisions and practices of local authorities and agencies may have systematically excluded certain individuals and/or communities from the benefits. It raises questions about systemic inequity in the distribution of transportation and non-transportation resources.

Following the social exclusion framework, research and practice addressing transportation disadvantage would have the most impact if they are sensitive and responsive to the social disadvantage of specific individuals and communities. As the key factors underlying social disadvantage (e.g., gender, age, income, race, disability) interact with the key factors underlying transportation disadvantage (e.g., availability, costs, quality, and information of public and private transportation services), the pathways between transportation and health via the social exclusion framework are intrinsically linked to social equity and justice issues.

Environmental Health

Environmental health is a branch of the public health discipline that emphasizes the protection of people from environmental hazards. The development and implementation of environmental health policy often involves risk assessments of human exposures to pollutants and other risk factors to determine whether the exposures pose significant risk to human health. In transportation, air pollution, noise, and crashes associated with motor vehicle traffic have been widely considered as environmental risks that pose adverse health impacts (Frank et al, 2019). Khreis et al. (2016) summarized the empirical literature on the health effects of traffic-related environmental risks and found at least six categories of traffic-related environmental factors that have quantified, negative impacts on human health. These six categories are illustrated in Table 3. They include motor vehicle crashes, physical activity reduction, emissions, noise, heat island effects, and dwindling green spaces.

Table 3: The traffic-related exposures and health framework developed by Khreis et al., 2016

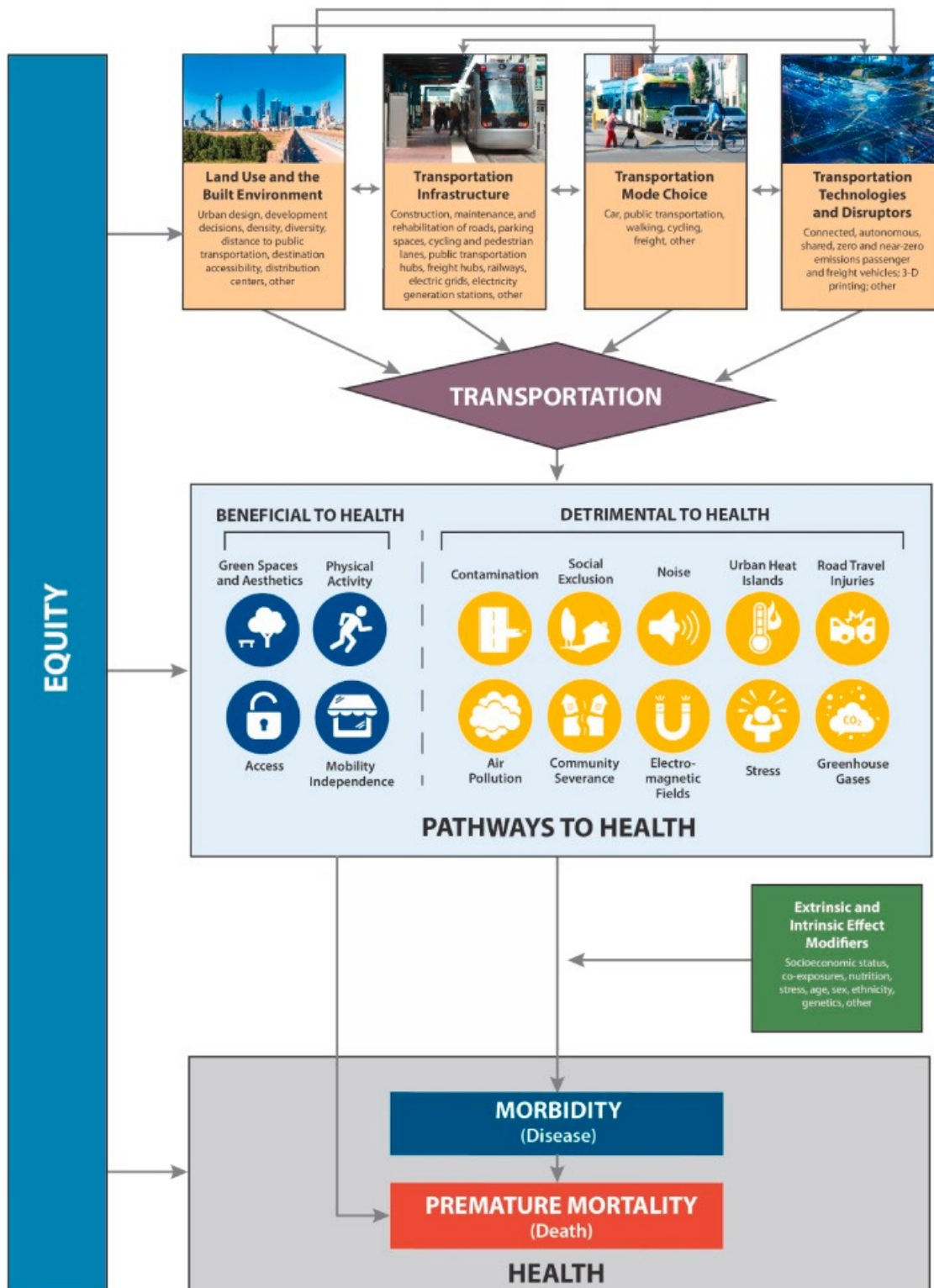
Traffic-related factors	Pathway	Quantified health effects
Motor vehicle crashes	Crashes	Road deaths, serious road injuries
Physical activity reduction	Lack of active travel/ mobility	All-cause mortality, cardiovascular diseases, cerebrovascular disease, cancer (colon, breast and lung), type 2 diabetes, dementia, anxiety, depression, obesity
Air pollution exposure	Motor vehicles exhaust and non- exhaust emissions, secondary pollution formation	All-cause mortality, low birth weight, cardiovascular mortality and morbidity, cerebrovascular mortality and morbidity, decreased lung function in children, diabetes, hospital admissions, infant mortality, lung cancer, obesity, pregnancy- induced hypertensive disorders, preterm birth, respiratory infections, respiratory mortality and morbidity
Noise exposure	Traffic noise (engine, tire/ road contact, honking)	All-cause mortality, annoyance and sleep disturbance, adverse reproductive outcomes, cardiovascular mortality and morbidity, cognitive

		function, diabetes type-2, high blood pressure in children, mental health and well-being, stroke
Exposure to local temperature rises	Heat island effects from infrastructure and greenhouse gas effects	All-cause premature mortality, cardiorespiratory morbidity, children’s mortality and hospitalization, heat stress, hospital admissions, increased health service use and respiratory symptoms, preterm birth, reduced lung function, traffic accidents
Exposure to green space and biodiversity loss	Land acquisition and right of way for infrastructure and motor vehicles	All-cause mortality, cardiovascular disease, adverse birth outcomes, reduced mental health, adverse sleep patterns, slow recovery from illness, children's behavioral problems, immune diseases related to the microbiome, childhood asthma incidence

Source: Khreis, H., Warsow, K. M., Verlinghieri, E., Guzman, A., Pellecuer, L., Ferreira, A., ... & Nieuwenhuijsen, M. (2016). The health impacts of traffic-related exposures in urban areas: Understanding real effects, underlying driving forces and co-producing future directions. Journal of Transport & Health, 3(3), 249-267.

Based on literature review and expert consultation in the fields of public health, urban planning, and transportation, Glazener et al. (2021) identified 14 pathways between transportation and health as shown in Figure 10. Their framework highlighted four pathways through which transportation has a positive impact on health including green space and aesthetics, physical activity, access, and mobility independence; and ten pathways through which transportation has a negative impact on health including contamination, social exclusion, noise, urban heat islands, road travel injuries, air pollution, community severance, electromagnetic fields, stress, and greenhouse gases. Glazener et al. (2021) represents one of the most comprehensive and significant efforts to highlight the complex intersectionality of transportation and health and the wide range of pathways and health outcomes associated with transportation.

Figure 10: The transportation-health pathway framework developed by Glazener et al., 2021.



Source: Glazener, A., Sanchez, K., Ramani, T., Zietsman, J., Nieuwenhuijsen, M. J., Mindell, J. S., ... & Khreis, H. (2021). Fourteen pathways between urban transportation and health: A conceptual model and literature review. *Journal of Transport & Health*, 21, 101070.

However, despite the systematic effort by Glazener et al. (2021), some of the identified pathways have significant overlaps that may result in inconsistent understanding among the key concepts. For example, Glazener et al. (2021) identified access as a positive pathway, and at the same time, social exclusion as a negative pathway. A close reading of their framework shows that they narrowly interpreted social exclusion as the effects of accessibility inadequacy on social isolation and loneliness, which is significantly different from the prevailing definition of social exclusion in the transportation literature that centers around accessibility to all life-enhancing opportunities including goods, services, social networks, social capital, life changes, and decision making as shown in Figure 8. Despite the inclusion of the social exclusion concept, Glazener et al. (2021) followed the environmental health framework rather than social exclusion framework. They interpreted social exclusion as one of the transportation-related environmental risks, which fails to acknowledge the multidimensionality of the social exclusion concept and is inconsistent with the well-established literature on transportation disadvantage and social exclusion.

In addition, almost all the positive pathways in Glazener et al. (2021) can be reversely interpreted into negative ones. For example, both physical activity and green spaces and aesthetics could be turned into negative pathways, i.e., physical activity reduction and green space and biodiversity loss as illustrated in the earlier environmental health framework by Khreis et al. (2016) in Table 3. It appears to be arbitrary how some of the pathways are defined as positive while others are defined as negative.

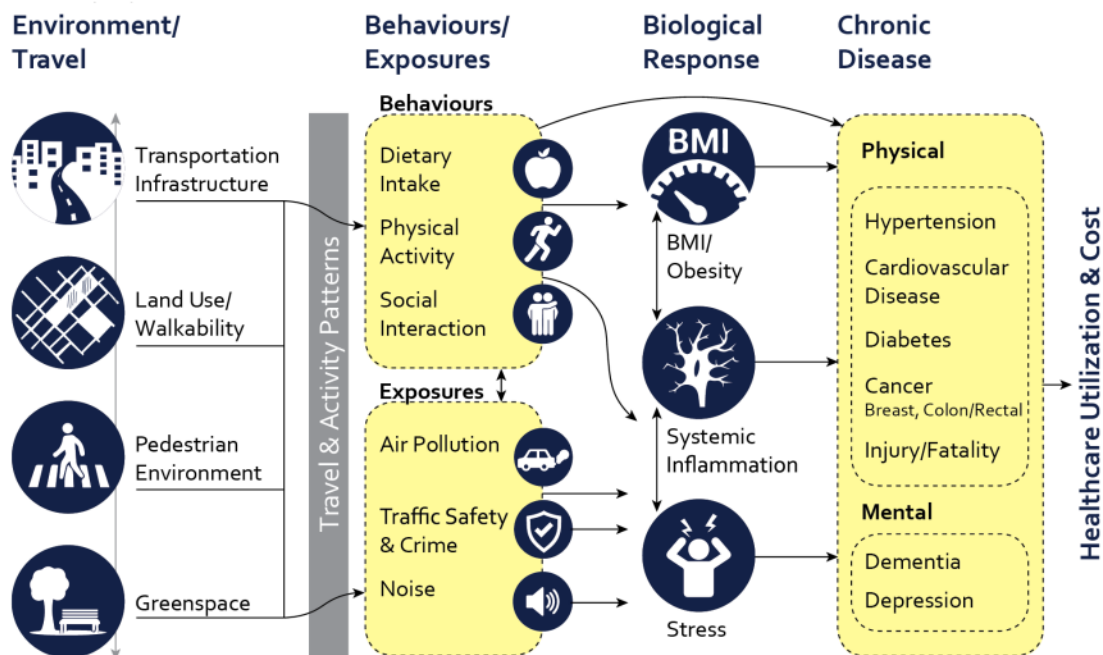
Finally, although comprehensive, the pathway framework in Glazener et al. (2021) mainly follows the environment health approach to create a list of transportation-related environmental factors that may be beneficial or detrimental to health. It does not integrate other approaches or create a new approach in the broader literature that connects transportation and health. Its innovation is limited when compared to the social exclusion approach to link transportation to health. On a positive side, similar to the social exclusion approach, the environmental health approach is intrinsically linked to social equity and justice issues because transportation externalities disproportionately affect areas where the most disadvantaged reside, e.g., along highway corridors where land is cheapest and most affordable housing is located (Frank et al., 2019).

Behavioral Health

The behavioral health approach to connect transportation with health is supported by a growing body of evidence documenting how land use and transportation can support or hinder healthy behaviors such as physical activity and healthy diet. This growing literature is grounded in physiology of metabolic expenditure with a heavy emphasis on obesity and the associated chronic diseases such as cardiovascular disease, respiratory illness, Type 2 diabetes, and poor mental health (Telford, 2007). A metabolically healthy individual maintains “energy balance” where food intake and energy expenditure is balanced (Frank et al., 2019). As transportation is an important component of daily life, people’s travel behavior such as mode choice and trip duration can play an important role in influencing the daily levels of physical activity. More frequent and longer uses of active transportation are associated with higher levels of physical activity and come with significant health benefits.

Besides influencing physical activity via daily travel behavior, transportation has also been found to influence food intake via food access and influence mental well-being via daily travel experience and access to social interaction opportunities (Frank et al., 2019; Zhu and Fan, 2019). Figure 11 illustrates the built environment-health framework developed by Frank et al (2019), which highlights both the behavioral health pathways and the environmental health pathways.

Figure 11: The built environment-health pathway framework developed by Frank et al., 2019.



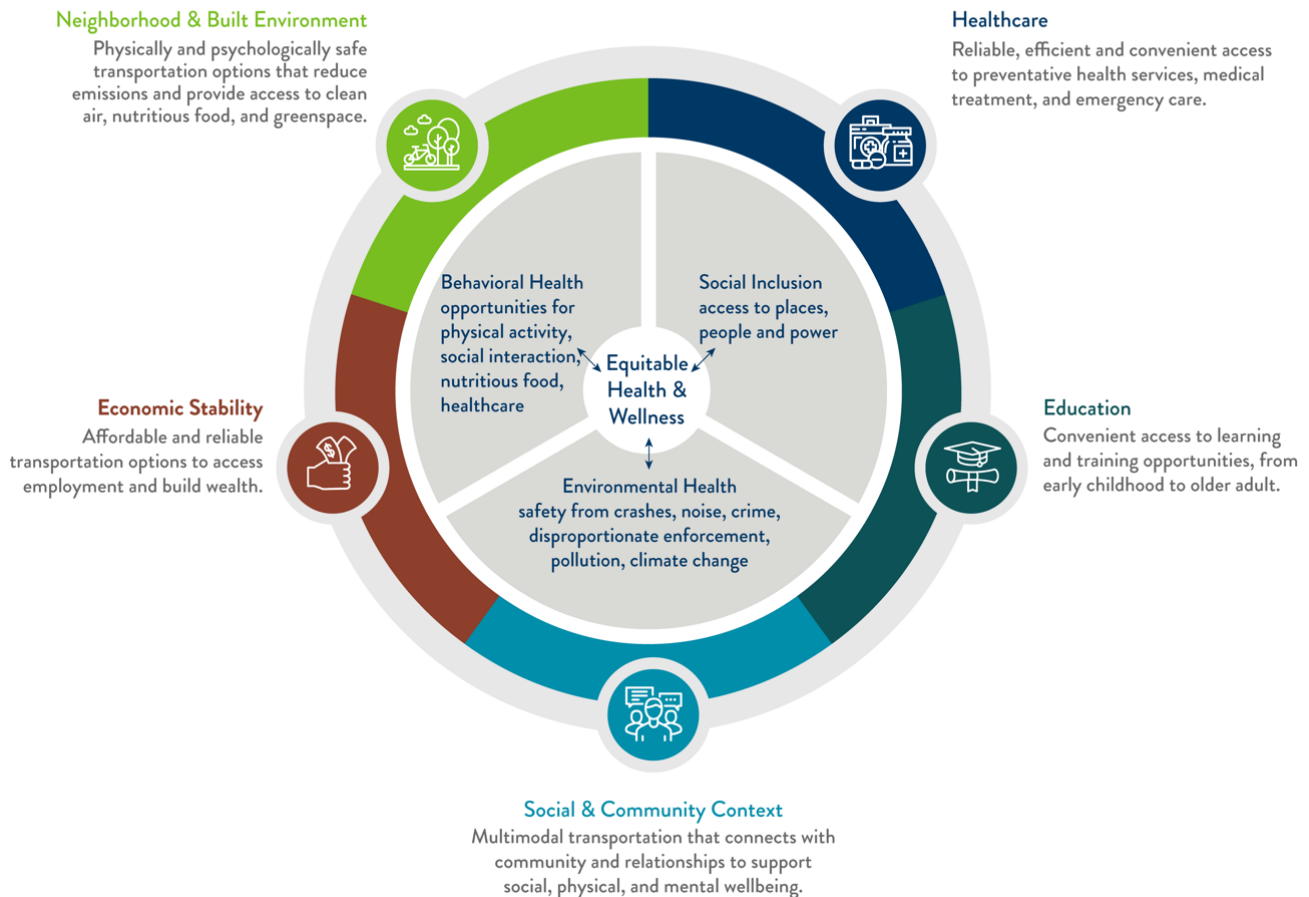
Source: Frank, L. D., Iroz-Elardo, N., MacLeod, K. E., & Hong, A. (2019). Pathways from built environment to health: a conceptual framework linking behavior and exposure-based impacts. *Journal of Transport & Health*, 12, 319-335.

By offering an integrated framework that considers both behavior and exposure-based pathways, Frank et al. (2019) illustrates how the different pathways may interact and collectively impact a range of public health outcomes. For example, although increased regional investments in active transportation can potentially lead to regionally desirable increases in physical activity, for some population groups, such investments may result in increased risk of injury and increased exposure to pollutants through longer travel time and higher inhalation rates (Cepeda et al, 2017). Without considering both behavior and exposure-based pathways, the overall health impacts of transportation are likely to be misestimated.

4. Integrating transportation-health pathways into SDoH

Understanding and integrating the multiple pathways between transportation and health can lead to more effective policies that reduce misinformed transportation infrastructure investments that either have limited health benefits or unintended consequences that harm specific population groups. In this project, we aim to integrate the major conceptual approaches in the existing literature that connect transportation to health, including SDoH, social exclusion, environmental health, and behavioral health. Figure 12 below presents our attempt to illustrate such integration efforts.

Figure 12: The Proposed Framework for MnDOT



With this proposed framework and graphic, we hope to extend the SDoH framework to include three major pathways through which transportation factors operate on health and equity outcomes. The three pathways are illustrated as behavioral health, social inclusion, and environmental health in Figure 12. Note that “social inclusion” represents the social exclusion pathway framework we reviewed in Chapter 3 above. By integrating SDoH with the transportation-health pathways, Figure 12 illustrates the following:

- All five dimensions of social determinants of health, which are the conditions in the places where people live, work and play are also relevant to transportation and health. These five dimensions are highlighted in the outer ring in Figure 12. The **neighborhood and built environment** provide safe, multimodal routes for convenient access to healthy destinations, including **education** and **healthcare**. Transportation not

only provides access for one to obtain a good paying job for **economic stability**, but also the means for people to interact with the **community** and stay connected **socially**.

- The social determinants of health interact with transportation and operate on health and equity outcomes via three major transportation-health pathways:
 - Behavioral health: transportation operates on health and equity by providing opportunities for physical activity, social interaction, nutritious food, and healthcare.
 - Environmental health: transportation operates on health and equity by providing safety from crashes, noise, crime, disproportionate enforcement, pollution, and climate change.
 - Social inclusion: transportation operates on health and equity by providing access to places, people, and power.
- The three transportation-health pathways can overlap and interact with one another to moderate the effects of social determinants of health on health and equity outcomes. For example, traffic accidents can be studied from both the environmental and behavioral health perspectives. Social inclusion affects the level of environmental exposure (through social confinement) and therefore interacts with environmental health.
- Health promotion is inseparable from equity promotion. As the pathways between transportation and health via the social inclusion and environmental health frameworks are intrinsically linked to social justice and equity issues, the goal of collaborative transportation and health planning is not only better health but also more equitable health and wellness.

5. Initiatives at the State Departments of Transportation (State DOTs)

In addition to reviewing the general frameworks and the specific pathway frameworks, we reviewed the webpages of the 50 state DOTs in the U.S. and identified eight state DOTs who are pioneers in linking transportation to health. Information about these eight state DOTs and their transportation-health initiatives is summarized in Table 4.

Table 4: States in which their DOTs are pioneers in linking transportation to health

State-Agency Name	Program Name (Start Year)	Description
California-Caltrans	California Transportation Plan 2050 (2021)	This long-range transportation plan's vision is a safe, resilient, and universally accessible transportation system that supports vibrant communities, advances racial and economic justice, and improves public and environmental health. The eight goals of the plan include safety, climate, equity, accessibility, quality of life & public health, environment, economy, and infrastructure.
Massachusetts-MassDOT	Healthy Transportation Compact (2009)	The Healthy Transportation Compact (HTC) facilitates multiagency collaboration that advances transportation reforms to promote better health outcomes. The HTC has prompted key policies, resources, and initiatives to improve access for individuals with mobility limitations, increase opportunities for physical activity, and increase bicycle and pedestrian travel.
Minnesota-MnDOT	Office of Sustainability and Public Health (2020)	The MnDOT Office of Sustainability and Public Health develops and coordinates sustainability and public health activities for MnDOT to focus on maximizing the health of people, the economy, and the environment. The establishment of this office is built on the interagency agreement signed by MnDOT and Minnesota Department Health in 2015 to collaborate and integrate health into transportation decisions. MnDOT was one of the first state DOTs to adopt a Complete Streets Policy.
New Mexico-NMDOT	The New Mexico 2040 Plan (2015)	This long-range transportation plan's vision has three fundamental elements: 1) support a robust economy, 2) foster healthy communities, and 3) protect New Mexico's environment and unique cultural heritage.
Oregon-ODOT	Health and Transportation Memorandum of Understanding (2013)	The Oregon DOT and the Oregon Health Authority have entered into a voluntary agreement to work collaboratively to identify, develop and promote connections between public health and transportation. The agreement was first signed in 2013, reconfirmed in 2018, and updated in 2021.
Pennsylvania-PennDOT	Transportation and Health Webpage (2017)	PennDOT has an official webpage titled Transportation and Health. The webpage acknowledges that transportation and health are linked in multiple ways and indicates collaborative efforts with the PA Department of Health.

Rhode Island-RIDOT	The Moving Forward RI 2040 Plan (2020)	This long-range transportation plan envisions a multimodal transportation network that connects people, places, and goods in a safe and resilient manner by providing effective and affordable transportation choices that are supportive of healthy communities, provide access to jobs and commercial centers, and promote a sustainable and competitive Rhode Island economy.
Washington State-WSDOT	Active community environments program (Unknown)	The program is a transportation and public health partnership intended to 1) increase the adoption of Complete Streets policies, 2) promote safe and convenient walking and bicycling opportunities, 3) encourage mixed-use development and a connected grid of streets, and 4) provide a venue for public health and transportation coordination, networking and learning.

Compared to other state DOTs, the eight state DOTs in Table 4 have made more explicit and comprehensive efforts to connect transportation and health. More specifically:

- There are many state DOTs who have developed state-wide plans for active transportation. Examples include [Colorado Bicycle/Pedestrian Plan](#), [Move Utah](#), [Kansas Active Transportation Plan](#), [Maryland Bicycle and Pedestrian Master Plan](#), and [North Dakota Moves](#). These states are not included in Table 4.
- Several state DOTs mentioned health-related topics (e.g., access to healthcare, quality of life, livability, safety, and social needs) in their long-range transportation plans. However, the health-related topics were not highlighted throughout the plans as fundamental elements. These states are not included in Table 4 either.
- Of the eight states included in Table 4, California, New Mexico, and Rhode Islands are included due to the strong integration of public health components into the visions and/or goals in their long-range transportation plans. Massachusetts, Minnesota, Oregon, Pennsylvania, and Washington are included due to their dedicated programs (or webpage) to initiate interagency collaboration and promote collaborative health and transportation planning.

The review above shows that MassDOT made the earliest effort among state DOTs to initiate a dedicated program for connecting transportation with health as early as in 2009. The formats of the dedicated programs vary significantly, ranging from programs with dedicated staff and funding (e.g., MassDOT’s HTC program and MnDOT’s Office of Sustainability and Public Health), to programs based on a MOU (e.g., ODOT’s agreement with the Oregon Health Authority), and to programs that simply promoting the idea of transportation-health connections (e.g., PennDOT’s webpage on transportation and health).

We reached out to seven of the eight state DOTs listed in Table 4 to request for an interview. We did not reach out to PennDOT because we did not find any initiatives or programs with a strong focus on health at PennDOT except a specific webpage dedicated to linking transportation to health. Of the seven state DOTs we reached out, we further excluded New Mexico DOT from our in-depth interview efforts. An agency representative at New Mexico stated that, although their 2040 Plan was quite innovative in involving transportation-health stakeholders and emphasizing transportation and health connections, they later realized that many of the transportation-health goals started in the 2040 plan were not realistic or supported by upper management. They no longer consider themselves pioneers in linking transportation to health, and declined our interview requests. In the end, we successfully interviewed representatives from six state DOTs - California, Massachusetts, Minnesota, Oregon, Rhode Island, and Washington. The list of questions we used in the interviews can be found in the Appendix.

California Department of Transportation (CalTrans)

We interviewed Chris Ganson from CalTrans. Ganson recently joined CalTrans as the Deputy Division Chief in the Division of Transportation Planning. Prior to joining CalTrans, Ganson worked at the Governor's Office of Planning and Research for about a decade.

The state of California began to recognize the connections between transportation and health when Ganson was still in his previous position at the Governor's Office. CalTrans had initially put forth some mode-share targets, which were used by Neil Maizilish--the developer of the ITHIM model--to measure how much benefit or harm to human health they can expect from achieving these targets, and the answer was significantly substantial. Ganson then took this piece of information and published it, and that sparked CalTrans' initiatives in linking transportation to health. Additionally, CalTrans also refers to the Clean Air Act and Climate Law to connect transportation to health.

Traditionally, CalTrans, like many other state DOTs, has been focused on mitigating air quality issues. CalTrans, together with the U.S. Environmental Protection Agency, recently put a stop to the [I-710 freeway project](#) due to concerns that the project would not meet the desired outcomes for air quality, equity, mobility, sustainability and health. More importantly, CalTrans has turned a big corner in acknowledging at the highest executive levels that they are shifting away from roadway capacity projects. According to Ganson,

"Travel Inducement is a real phenomenon, [and] we are not going to successfully combat congestion by adding roadway capacity and all those things have big implications for health. Generally speaking, adding roadway capacity is going to be bad for health through a number of pathways: mode-shift, emissions, speeds etc."

There has also been a lot of focus shifting away from the old automobility-focused paradigm of Safety in Caltrans, focusing on driver behaviors rather than making the driver environments simpler. For example, instead of straightening the roads, clearing obstacles and keeping speeds up, CalTrans is now focusing on Complete Streets, bike and pedestrian safety, and traffic calming and speed reduction.

Although CalTrans does not have their own definition for 'health', their scoring criteria for ordering projects have come to include some health factors as follows:

- If the project has potential for interregional travel mode shift, including to rail, transit or active transportation
- If the project has potential to reduce single occupancy VMT, include or improve access to zero emission charging or fueling infrastructure
- If the project supports public health
- If the project includes and documents meaningful public engagement process, including targeting underrepresented communities
- If the project incorporate local community needs
- If the project reduces fatalities and severe injuries for all users
- If the project improves climate adaptation and resiliency
- If the project minimizes impact on natural resources and ecosystems

Incorporating transportation-health connections into scoring projects has been influential. Ganson however, does caution that the current incorporation is qualitative and not quantitative, which is not as comprehensive as the ITHIM model. Ganson argues, that there is certainly room for improvement, and if they could expand the scoring criteria to include explicit quantitative health factors such as how many lives they could expect to save or lose because of health factors each project is likely to create, like the ITHIM model, that will really help influence decisions, and carry along other interests even beyond health. That said, CalTrans is also in the process of

obtaining and utilizing an Accessibility Tool to help measure access to opportunities, and incorporating that in their scoring criteria in the coming months.

Massachusetts Department of Transportation (MassDOT)

We interviewed Derek Krevat from MassDOT. Krevat is the manager of the Metropolitan Planning Organizations activities (MPO) at MassDOT, and has been involved in research connecting transportation to health (documents available on request). He is also the [Safe Routes to School Program](#) Coordinator.

MassDOT was formed in 2009 as an umbrella organization after the passing of the Global Warming Solutions Act and the Healthy Transportation Compact (HTC) in 2008-2009. Shortly after, MassDOT initiated the Healthy Transportation Policy Directive in 2013, in coordination with the Executive Office of Energy and Environmental Affairs (EEA). This directive has helped set the foundation of MassDOT's [Design Justification Process](#), which sets requirements on how projects need to be designed to make sure that they incorporate active transportation and transit-related elements, or comply with healthy transportation goals for roadway projects.

MassDOT's health priorities at the beginning mostly had to do with reducing GHG emissions and mitigating climate change. Over time, they learned through research that pollutants like PM2.5 are more likely to cause negative health impacts that are directly associated with higher instances of respiratory illnesses than Carbon dioxide (CO2) levels. They have monitored air pollution levels using NO2 and PM2.5 measures and incorporated the measures in their project evaluation criteria. Active Transportation and Safety are also two areas that have always been focus areas for MassDOT. MassDOT has a rigorous bike and pedestrian program within their capital plan, as well as a Strategic Highways Safety Plan (SHSP), both of which are rooted in legislation as well. In recent years, MassDOT has been shifting the conversation from mobility to equitable access, and has begun measuring and using accessibility data as part of their planning work. For example, the [Congestion in the Commonwealth 2019 report](#) analyzed how congestion impacts access to jobs across the Commonwealth of Massachusetts. MassDOT has also added criteria in their project evaluation scorecard that assess access to destinations such as jobs and healthcare, wherein projects earn extra points if they promote accessibility. Going forward, MassDOT, working with the Massachusetts Department of Health, hopes to investigate how these transportation-related health factors contribute to chronic diseases, especially asthma or other types of health conditions that disproportionately impact people living in areas with high concentrations of pollutants.

Although MassDOT does not have their own definition of 'health' as defined in the context of transportation policy and planning, they hope that they will have a statement that defines this in their Statewide Long-Range Transportation Plan within the next year or two. Currently, they refer to their project evaluation scorecard (based on which health-related indicator categories they are measuring), and their performance management report (which references public health considerations) as their working definition of health in the transportation context.

With regard to incorporating public health data into transportation planning decision-making frameworks, as opposed to using external tools, MassDOT mostly works within their internal framework, using a variety of different data sources as part of the process. In addition to project scoring and performance management, MassDOT also utilizes the Congestion Mitigation and Air Quality Improvement (CMAQ) program, to evaluate whether projects have a noticeable air quality benefit. They also have a [Community Transit Grant Program](#), to distribute funding to meet the mobility needs of seniors and individuals with disabilities, thus advancing public health goals related to accessing health facilities and providing transportation services to people with disabilities. MassDOT also has an Office of Diversity and Civil Rights that helps to advance the agency's equity goals: Using their internal public engagement mapping tool, *Engage*, as well as [Public Participation Plan](#), MassDOT intentionally tries to reach more traditionally underserved communities to get them more involved in the transportation planning process. MassDOT also conducts equity analysis as part of their annual Capital

Investment Plan (CIP), which analyzes where projects are distributed around the state, and what share of dollars are being spent in environmental justice and Title VI communities.

When asked about specific programming or planning efforts at MassDOT that intentionally link transportation to health, Krevat highlighted the [Pioneer Valley Regional Bike Share](#), the Workforce Transportation Grant Program, as well as the Boston MPO's [Community Connections Program](#).

Minnesota Department of Transportation (MnDOT)

We interviewed Nissa Tupper and Amber Dallman from MnDOT. Tupper is a Transportation and Public Health Planner in the Sustainability and Public Health Division at MnDOT. Her position was created in 2019 to work on Minnesota's Complete Streets Policy as a lever to advance public health. Tupper also develops and maintains relationships with local and state partners, leveraging their public health expertise and shared value. Dallman is a Transit and Active Transportation Planning Supervisor at MnDOT. Her group is responsible for the [Safe Routes to School Program](#), as well as statewide planning for walking, bicycling and transit in greater Minnesota. Dallman's office has close ties to the Department of Health (MDH) and working with their Office of Statewide Health Improvement on the Statewide Health Improvement Program (SHIP).

MnDOT has been successful in incorporating health into transportation decisions thus far due to a history of good collaboration, and an openness to work together to promote active living and advance health within the various state departments in Minnesota. In 2015, MnDOT and MDH signed an interagency agreement to collaborate and integrate health into transportation decisions. On top of that, MDH has been willing to seek out partnership because there is a recognition that although public health agencies do not make decisions about the built environment, they can bring added value to the table to help resource-rich departments such as MnDOT, Department of Natural Resources (DNR), Minnesota Pollution Control Agency (MPCA) etc. During the pandemic, the MnDOT pivoted some of their FTA funding so that transit systems could deliver food and medications to folks who had concerns about going out, especially in rural areas, thus demonstrating the strong relationships they had with other state departments, which allowed them to be more nimble and flexible.

Although MnDOT does not have their own definition of health, they have recognized that health itself is more than just human health, but also comprises environmental health and health of the economy. They have also been referencing the Social Determinants of Health Framework, Health and Transportation Framework from TRB, Section [174.01](#) and [174.03](#) of the Minnesota Statutes, Health Impact Assessment (HIA), and Health in all Policies to identify health priorities. Dallman mentioned the 5Es approach (sometimes 6Es) for some MnDOT programs like Towards Zero Deaths and Safe Routes to School: 'Equity', 'Evaluation of Efforts', 'Education', 'Encouragement', 'Engineering' and 'Enforcement'. They have recently dropped 'Enforcement' after receiving public feedback, although that is not an agency-wide position currently.

MnDOT, together with other state agencies initially started their collaboration with a focus on Safety and Active Transportation, and till today is still building on that work through programs like [Towards Zero Deaths](#). Social Determinants of Health and Equity have also been a focal point in MnDOT, with planning efforts like [Priority Areas for Walking \(PAWS\)](#), [Statewide Pedestrian System Plan](#) and [Community Conversations Engagement Project](#) targeting populations that are facing inequities and disparities. The populations identified include but are not limited to communities of low-income, communities of color, tribal communities, people with disabilities, older, younger, immigrant populations as well as gender inequities. An emerging area of focus is trying to figure out how MnDOT values and measures health, and working it into their development and decision-making process, and continuing to build partnerships across the state, as highlighted in the [2020 MnDOT Sustainability and Public Health Report](#). More importantly, identifying where the inner interaction points of health are, and figuring out ways to help the department create a much richer narrative and conversation to serve people better. Another focus area is continuing to build capacity within MnDOT's own

transportation professionals, ensuring that they not only have the content knowledge, expertise and ability to carry projects out, but also be comfortable in being able to communicate effectively about the projects. In addition, MnDOT has implemented several planning efforts to intentionally link transportation to health, which include the [HIA of Statewide Multimodal Transportation Plan](#) that was done in 2016. The department has also been working on improving its [Bicycle and Pedestrian Traffic Counting Program](#), and to apply it to performance measures and project evaluation.

Oregon Department of Transportation (ODOT)

We interviewed Deborah Benavidez, who is the Statewide Planning Coordinator with the Oregon Department of Transportation (ODOT) in the Policy Analysis and Data Division. ODOT began to recognize transportation-health connections after a 2012 speech to the Oregon Transportation Commission (OTC) by Governor Kitzhaber, who charged OTC to consider the important role that transportation plays in the health of Oregon's population. As a result, OTC added health as a focus area in their 2012 Strategic Plan, with a goal of including health considerations in transportation planning and decision-making. Beginning in spring of 2013, ODOT and Oregon Health Authority-Public Health Division (OHA-PHD) adopted a MOU, agreeing to communicate, coordinate, and collaborate on activities that support the link between public health and transportation. Following the development of this MOU, both organizations have participated in quarterly meetings, coordinated policy and planning initiatives and collaborated on research and data, thereby fostering an alignment of health and transportation goals at state and local levels. Benavidez is the coordinator on ODOT's side and this partnership has worked extremely well according to Benavidez. These two agencies would also co-review legislative bills. However, they do face difficulties due to the differences in organizational structures, which makes connections outside of statewide efforts challenging.

ODOT's main priorities when it comes to linking transportation to health are centered on improving traffic safety, increasing safe active transportation options, improving air quality, and improving emergency preparedness. Recently, their focus has expanded to include advancing health equity and eliminating institutional bias, and that has been the overarching goal in the State Health Improvement Plan (SHIP). Although ODOT does not have a formal definition of health, they do tend to focus on human health, with specific focus on the prevention of chronic diseases and highway accidents.

ODOT has utilized Health Impact Analysis and has updated their [Transportation System Plan \(TSP\)](#) to include guidelines for how to better integrate health considerations into local long-range planning. One of the initiatives that makes ODOT stand out from others, is the development of [OR-Plan](#), an online statewide planning database that centralizes all the transportation policies and strategies from ODOT's nine statewide modal and topic plans, which includes health as a fundamental issue. The [Healthy Communities Policy Brief](#) developed by ODOT and OHA-PHD is also incorporated into this tool. With the passage of House Bill 2017, the Oregon Legislature has also made a significant investment to advance public transportation. The [Statewide Transportation Improvement Fund \(STIF\)](#) provides a new dedicated source of funding to expand public transportation to increase access to jobs, improve mobility, relieve congestion and reduce greenhouse gas emissions.

To evaluate and measure success of their programming and planning, ODOT publishes an accomplishment report biannually (available on request), that is reviewed by both the Transportation and Health Commissions. Further, in June 2017, Oregon's Public Health Advisory Board (PHAB) established a set of [accountability metrics](#) to track progress towards improved health outcomes, including increasing active transportation. ODOT has also conducted a [Bicycle Travel Activity Study](#), for the purposes of travel monitoring, crash analysis and health impact assessment.

Rhode Island Department of Administration (RIDOA) and Rhode Island Department of Transportation (RIDOT)

We interviewed Michael D'Alessandro and Pamela Cotter from RIDOA and RIDOT, respectively. D'Alessandro is a Supervising Transportation Planner at RIDOA that works on projects including the [Long Range Transportation Plan \(LRTP\)](#), [Bicycle Mobility Plan](#), and Statewide Transportation Improvement Program (STIP). Previously a Policy Director at RIDOT, Cotter is currently the Acting Administrator of Planning, the division within RIDOT that programs the STIP.

The connection among transportation, environment and health was brought to RIDOA's and RIDOT's attention initially due to federal requirements for their air quality and transportation conformity. On top of that, Rhode Island's geography has meant that historically, it's economic health and human wellbeing is bound to the health of its surrounding waters, commercial fisheries, water quality, air quality, and natural environment, for quality of life, recreation, commerce, and tourism.

The initiative to connect transportation to health is largely a result of collaboration between various state agencies in Rhode Island. The priorities of RIDOA, RIDOT, Rhode Island Public Transit Authority (RIPTA), Rhode Island Department of Health (RIDOH) and others are closely linked and overlap, which improves facilitation and collaboration of tackling health concerns statewide. RIDOH has become a prominent voice in all working groups. RIDOH sits on the Transportation Advisory Committee and the State Planning Council. RIDOT and RIDOA also work closely with MassDOT, and participated in a peer exchange with Massachusetts, North Carolina and the Delaware Valley to discuss creating an e-STIP process, that takes factors such as human health and environmental concerns into consideration when planning and programming transportation projects.

One of Rhode Island's main focal areas is Health Equity. Cotter previously served as RIDOT's representative on the state [Commission for Health Advocacy & Equity \(CHAE\)](#); she has learned about health outcomes based on zip codes and the need to come up with good, equitable solutions for accessibility, especially for people living in state-designated [Health Equity Zones](#). An example of an equitable accessibility initiative is the [Little Rody Pilot Project](#), a one-year autonomous shuttle pilot program launched in May 2019, that offered a free, 5.3-mile loop through a corridor in Providence that was both an Environmental Justice area and transit desert, thus increasing destination and job access to users. Apart from accessibility, RIDOA is also trying to raise awareness about local choices for food, highlighting the intersection between global health and sustainability.

Rhode Island takes a comprehensive look at health, and while human health is officials' main concern, they also place equal emphasis on financial health, well-being, security, traffic safety and healthy behaviors. DOT and DOA follow the LRTP framework, Complete Streets law, state climate goals and recommendations from the [Mobility Innovation Working Group](#), State Planning Council and Transportation Advisory Committee closely. The DOA also organizes public meetings, project working groups, and utilizes a [STIP decision matrix](#) to prioritize projects. D'Alessandro's team at the DOA is working to develop a scoring matrix for potential 10-year projects based on indicators related to traffic incidence, safety, bike and roadway users for project evaluation and performance measures. These are just some of the examples Rhode Island is adopting to connect transportation to health. According to Cotter,

"The work continues, we're just really starting to be able to leverage the data and the partnerships that we have to really figure out what's the best course of action. We continue to learn, and we can continue to try to improve."

Washington State Department of Transportation (WSDOT)

We interviewed Ashley Carle, the Environmental Procedures Coordinator at the Washington State Department of Transportation. She is a NEPA specialist who supports project delivery and environmental compliance. The WSDOT became a cabinet agency about seven years ago, and the Secretary reports to the legislature; The [Washington State Transportation Commission](#) conducts studies and presents to the legislature.

Washington State began to recognize the connections between transportation and health following a legislative directed Health Impact Assessment for the SR 520 bridge in 2008. In 2017, the Active Transportation division was created with the goal of health, safety and economic development. Thereafter, they have been meeting with the Department of Health to understand the connections between transportation and health better, and to explore and work together based on the environmental health disparities map that was co-created with the University of Washington. Additionally, the passing of the Healthy Environmental for All (HEAL) Act in 2021 has set the foundation for many of WSDOT's planning efforts since. The HEAL Act defines environmental justice in its state law, focuses equitable distribution of environmental benefits and reduction of environmental harms, and creates opportunities for the overburdened and vulnerable populations. It also requires using a racial justice lens and environmental justice assessment in agency strategic plans, goals, metric setting, program implementation, enforcement and reporting.

WSDOT's health priorities are centered around active transportation and health equity. The most recent active Transportation Plan has the goals of increasing access to physical activity, safe active transportation connections, as well as opportunities for participation in partnership. On equity, Washington's legislature created the Environmental Justice Task Force in 2019 to strengthen the state's role in addressing issues of race, equity, diversity and inclusion. In 2021, the Governor also created a State Office of Equity to help agencies develop their own diversity, equity and inclusion plans: The [2040 Washington Transportation Plan](#) put out by the Washington State Transportation Commission mentions "[working] to ensure that all people have access to their daily needs with dignity and independence, regardless of their ability or income, and without discrimination based on race, or other identity." It has also been suggested that the [Highway System Plan](#) will follow six analysis steps adapted from a Racial Equity Toolkit. WSDOT also has developed a [Determining Health Disparities During NEPA](#) guide, which can be found in their [Environmental Manual](#) ([Social and Community](#) and [Environmental Justice](#) chapters). More recently, complying with the HEAL Act has been a big priority for WSDOT. Prior to the HEAL Act, WSDOT focused on avoiding or mitigating negative impacts of their projects. With the HEAL Act, this priority has shifted to identifying existing health disparities, and working to reduce those disparities for the most vulnerable communities throughout the state, especially for the 60+ federally recognized tribes within Washington State.

WSDOT does not currently have their own definition of health, but Carle frequently references FHWA's transportation-health five focus areas: safety, access, air quality, active transportation and equity. The department also relies on the transportation system goals laid out in [RCW 47.04.285](#), [Executive Order 12898](#) – Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, and WSDOT's Transportation and Health Tool to support their transportation and health planning work. WSDOT has also gotten a license for CUBE Access (formally Sugar Access) to help measure access to jobs and opportunities.

When asked about challenges faced in the agency planning and implementation transportation-health initiatives, Carle talked about the lack of resources to implement more ambitious plans to incorporate "above and beyond" health equity goals, and that some transportation-health connections such as accessibility is still not part of mainstream conversations within the agency, although that might change gradually with the passing of the HEAL Act.

Summary

Overall, we noticed some similar initiatives undertaken across all state DOTs. For example, all the DOTs have identified air (and water) quality and safety as their focus areas, and have focused their planning efforts on active transportation, Safe Routes to School and VMT reduction. They have also expanded in recent years to include accessibility and health equity as their focus areas. When it came to defining equity, the DOTs are focused on identifying location-based disparities (e.g., the use of the equity zone or environmental justice zones) and are actively working to prioritize projects in these areas, instead of their previous approach to simply mitigating negative impacts of planned projects. While they have identified low-income communities of color, non-English speaking, younger and older populations as vulnerable populations, MnDOT is the only one that included gender in their discussions.

Although none of the state DOTs have a formal definition to health and how it relates to transportation, all of them do define them informally to include human health and wellbeing, financial health, physical safety, and security. Mental health however, was not mentioned in any of the six interviews. MassDOT is the only one with plans to develop a formal definition and include it in their next LRTP update.

Three of the six DOTs have either adopted, or are currently developing a scoring/decision matrix to rank the priorities of projects. These scoring criteria have included, or will include health-related topics. They are however in the early stages of development, are not as comprehensive as they can be, and are mostly qualitative and not quantitative.

When it comes to cross-organization coordination, MnDOT, ODOT and RIDOT seem to have a history of good collaboration with their partners, especially with the state health departments. The project evaluation initiatives at ODOT also stand out because they have a comprehensive database for all policies and plans, and are the only ones that has published a biannual accomplishment report, which is then reviewed by both the Transportation and Health Commissions.

When asked about challenges with the planning or implementation of transportation-health initiatives at the six DOTs, we noticed a similar trend – There has been a gap between planning and implementation due to the level of commitment, administrative barriers, and manpower/staffing issues within and outside the agencies. Many DOT staff are also not well-versed in transportation and health concepts, and transportation-health initiatives are still not part of mainstream conversations.

6. Conclusions and Recommendations

In this project, we synthesize both academic literature and gray resources to develop a conceptual health and transportation planning framework by integrating social determinants of health with three specific transportation-health pathway frameworks, including social exclusion, behavioral health, and environment health. In our framework, all five dimensions of social determinants of health are relevant to transportation and health. Transportation interacts with all social determinants of health and affects health and equity outcomes through the three transportation and health pathways.

We also reviewed planning documents and interviewed six state DOTs, all pioneers in using integrative health in their transportation planning initiatives. We found that all the DOTs have working relationships with their departments of health, as well as other agencies. They have also identified air and water quality, safety, active transportation, accessibility and equity as their focus areas. Although none have defined health in the context of transportation formally, all of them refer to frameworks or existing definitions that include human health, financial health and safety. During the interviews, however, none mentioned mental health. Out of the six, three have included or will include qualitative health-related topics to score projects.

Based on our research, we recommend MnDOT 1) continue to foster partnerships across all agencies and organizations outside of the Minnesota Department of Health, 2) develop its own definition of health and how it relates to transportation, 3) develop a scoring and evaluation matrix for project selection and evaluation, and 4) ensure MnDOT staff is well-versed and trained in transportation, health, and equity concepts.

Recommendation 1: Continue to foster partnerships across all agencies and stakeholders outside of the Minnesota Department of Health

Although MnDOT already has a good working relationship with the Minnesota Department of Health, there is still room to develop similar working relationships with other state agencies. For example, the Minnesota Pollution Control Agency (MPCA) and Minnesota Department of Natural Resources (DNR) on environmental pollution and conservation issues, and Minnesota Department of Agriculture (MDA) on food systems and accessibility to local, healthy food sources.

Recommendation 2: Develop MnDOT's definition of health and how it relates to transportation

As an important component of MnDOT's efforts to link transportation and health, MnDOT could develop its own definition of health based on the framework proposed in Chapter 4. The definition should include the following components:

- Physical and mental health
- Social determinants of health
- Social inclusion
- Behavioral health
- Environmental health, including actual and perceived safety of transportation users
- Health equity, including focus on vulnerable populations such as women and immigrant populations, which are still currently left out of mainstream transportation/health conversations

Recommendation 3: Develop a scoring and evaluation matrix for project selection and project evaluation

Developing a scoring and evaluation matrix for transportation project selection and evaluation is one of the most effective ways to put public health at the front and center of MnDOT's initiatives. Three of the six DOTs we interviewed have either adopted or are currently developing a scoring/decision matrix to rank the priorities of

projects. MnDOT may learn from the efforts of Caltrans, MassDOT, and RIDOT to incorporate health considerations into its project selection processes.

Recommendation 4: Ensure MnDOT staff is well-versed and trained in transportation, health, and equity concepts

Once MnDOT develops its definition of health, based on the proposed framework in this report, the health definition along with this report can be used to raise awareness and educate staff on transportation-health connections. It is also important for MnDOT staff to understand the inseparable connections between health and equity. When it comes to new initiatives, agency-wide awareness and support are key to bridging the gap between planning and implementation.

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Appendix A: State DOT Transportation and Health Interview Instrument

INTRODUCTION

We are part of a research team at the University of Minnesota working with the Minnesota Department of Transportation to develop a conceptual framework for collaborative health and transportation planning. As a component of our work, we reviewed state DOTs in the U.S. and identified the DOTs that are pioneers in linking transportation to health.

The purpose of this interview is to explore the history and process of, and resources your state DOT has utilized in linking transportation to health. We are interested in knowing:

- How did your state DOT begin to recognize the transportation-health connections?
- What are your state DOT's main priorities when it comes to linking transportation to health?
- What frameworks/tools have helped to guide your state DOT's approach to link transportation to health?
- Are there any specific programming or planning efforts that your state DOT has implemented in linking transportation to health?

QUESTIONS

1. Could you tell us your position at your State DOT and the roles and responsibilities associated with your position?
2. How did your state DOT begin to recognize the connections between transportation and health?
 - a. In what contexts, the initiative of linking transportation to health took place?
 - b. Did the initiative originate from your state DOT or from joint efforts with other state departments (or other organizations)? If yes, how did your state DOT collaborate with these departments?
3. What are your main priorities when it comes to linking transportation to health? Did the priorities change over time?
 - a. How does your state DOT define 'health'?
 - b. Does your DOT have high-level policies or statutes that refer to, or connect transportation to, health?
4. What frameworks/tools have helped to guide your approach, e.g, identifying priorities and setting up the agenda? Could you describe how these frameworks and tools have informed the activities at your state DOT?
5. Are there any specific programming or planning efforts that your state DOT has implemented in intentionally linking transportation to health?
 - a. Who funded the programming and planning efforts?
 - b. What worked well, what didn't?
 - c. How has the state DOT evaluated and measured the success of these programming and planning efforts?
 - d. Does your state DOT have any relevant resources or documents that you feel comfortable sharing with us?
6. Is there anything that we didn't ask but you would like us to know about your state DOT's effort linking transportation to health?