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**Arterial Roadways
Research Needs
and Concerns**

*Informing the Planning, Design, and
Operation of Arterial Roadways
Considering Public Health*

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Arterial Roadways Research Needs and Concerns

*Informing the Planning, Design, and Operation of
Arterial Roadways Considering Public Health*

Prepared by
Task Force on Arterials and Public Health

December 2018

Transportation Research Board
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Washington, DC 20001
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Executive Summary

In January 2015, the Transportation Research Board (TRB) Technical Activities Council approved a Task Force on Arterials and Public Health. The purpose of the Task Force was to inform the planning, design, and operation of arterials considering public health. To accomplish this, the Task Force had planned on creating a portfolio of research problem statements that any researcher, organization, or TRB committee could advance. However, at the first meeting of the Task Force it became clear that although research problem statements could highlight gaps in knowledge, they could not capture the full complement of practical issues that transportation professionals face. To capture both the gaps in scientific knowledge and the practical problems of implementation, the Task Force decided to organize this Transportation Research E-Circular around seven case areas covering several topics to help identify the research needs for arterials and public health. The case approach was used to place the research needs in a relatable and practical context. Each case introduction provides background information to explain why the Task Force considers the issue to be important and to set the stage for the research questions raised around each case.

Associated with each case, a series of research questions, issues, and concerns are identified. The intent is for the Health and Transportation Subcommittee to pick up the gauntlet and champion the issues and research questions both inside and outside TRB once the Task Force is dissolved in April 2019. In all over 250 questions identified in this E-Circular and each one could be fleshed out into a formal research problem statement.

In addition to the seven case areas, a chapter is devoted to the viewpoints and philosophies of the Task Force members. The Task Force membership is diverse and in terms of public health and arterials each member has a unique voice and perspective. As a result, it seemed fitting to have the members introduce themselves and present their own individual statements and views. Woven throughout the individual statements are still yet more issues, questions, and concerns that embody areas for additional research.

Complementing the E-Circular and working to advance arterial health issues within the existing TRB committee structure, the Task Force combed the problem statements in the Research Needs Database to see if it was possible to add a health lens to the already developed problem statements. What emerged from this effort was a realization that the arterial-related problem statements in the database tended to focus around access management. However, when using Health Impact Assessments (HIA) as the health lens, complete street concepts as opposed to access management is the preferred direction. From a research perspective this is an area where there is a need for additional analysis and discourse comparing the two approaches to determine which one yields better outcomes for both health and transportation.

The multidisciplinary Task Force that produced this E-Circular was assembled to inform the planning, design, and operation of arterials while considering public health. The case examples, cross-cutting themes, and identified research gaps have great potential to advance the field. This E-Circular has specific strategies that transportation and public health professionals can embrace, as they both work together to ensure that public health is “at the table” during the planning, design, and operation of arterials. It is the hope of the Task Force that while its work is finished with the completion of this E-Circular, TRB and others will continue to champion the importance of asserting health considerations into the arterial roadway paradigm and move the ideas and concepts raised in this E-Circular forward.

PUBLISHER'S NOTE

The information in this E-Circular represents the collective work of the individual Task Force members and not necessarily the organizations, agencies, or companies where they work. The views expressed in this publication are those of the Task Force and do not necessarily reflect the views of the Transportation Research Board or the National Academies of Science, Engineering, and Medicine. This publication has not been subjected to the formal TRB peer-review process.

Introduction

In 2013, a work group of TRB's Health and Transportation Subcommittee discussed what it saw as a major opportunity to understand how public health could be considered in the planning, design, and operation of arterial roads. This led to the idea that TRB would be well suited to address the question of arterials and health by hosting a Task Force. The proposed Task Force would combine transportation and public health expertise and create a portfolio of research problem statements that any researcher, organization, or TRB committee could advance.

In January 2015, the TRB Technical Activities Council approved the Task Force on Arterials and Public Health. The Task Force met for the first time in January 2016. From its first discussions, it became clear that research problem statements could highlight gaps in knowledge, yet they could not capture the full complement of practical issues that transportation professionals face when combining work on public health and arterials. To capture both the gaps in scientific knowledge and the practical problems of implementation, the Task Force decided to organize this Transportation Research E-Circular around case examples. The case examples illustrate some of the most difficult trade-offs that arise when applying health considerations to arterials.

This E-Circular explores arterials and public health from multiple angles, presenting examples and pointing to areas of further research and analysis. It covers only a few of the numerous issues that deserve attention, revealing that the Task Force's work is only a first step in much longer journey—a journey that hopefully will continue.

This E-Circular comprises three distinct parts. The first presents a series of descriptive examples where arterials and health concerns appear in practice; these examples call out specific questions that need to be resolved and where research is needed. We chose to use case examples as a way to put practical context around the research needs. The second part of this E-Circular contains individual statements from each of the Task Force members. The statements allow the members to introduce themselves while drawing attention to their particular interest in the topic. The next section is an attempt to cull through the TRB Research Needs Database to identify how and where health could be included in the arterial-related research that the TRB committees have already identified. The final section of this E-Circular highlights crosscutting issues relevant to the case examples, such as equity and metrics, and offers recommendations for future research.

The TRB Health and Transportation Subcommittee will champion this E-Circular and link its many research questions across TRB's various committees. The subcommittee will also work with interested organizations, associations, and public agencies to champion and advance the research needs. Ideally, the subcommittee will be elevated to a full standing committee so it can more aptly work across the TRB committee structure to advance the themes in this E-Circular.

Background

In January 2016, TRB's Task Force on Arterials and Public Health officially convened its first meeting. The Task Force met four times during the first year, three times in 2017, and almost monthly in 2018. These meetings were used to discuss the Task Force's mission, its approach, calls for papers and sessions at the Annual Meeting of the TRB, and organizing this final E-Circular.

The purpose of the Task Force is to inform the planning, design, and operation of arterials while considering public health.

At the 2017 Annual Meeting, the Task Force sponsored two sessions in addition to a call for papers. The first session sought to bring the mission of the Task Force to the greater TRB membership and address the question:

Why does TRB need a Task Force on arterials and health? During the session, attendees and representatives of the Task Force—all from a cross-section of disciplines—had an open and frank discussion. Questions centered around (1) Why should health and transportation research focus on arterials and highways; and (2) What questions should research be considering?

The second session dealt with translating the differences between transportation measures and metrics and health measures and metrics. It explored perspectives from transportation practitioners and researchers about the emergence of public health measures in their work. This attention to metrics has, notably, been a recurring topic of discussion for the Task Force at all of its meetings. The presentation materials and substance of both these sessions helped inform the content of this E-Circular.

For the 2018 Annual Meeting, the Task Force again issued a call for papers and sponsored two sessions. These sessions sought to inform two of the case examples presented in the next section. The first was designed to have an open discussion about arterials, public health, and metrics. Traffic engineers use a whole battery of metrics but none of these necessarily take into consideration the health and welfare of the population.

The second session targeted identifying challenges and emerging partnerships that are occurring to eliminate traffic deaths in United States. It had a Vision Zero focus. Although Vision Zero programs are proliferating, it was clear from this session that there is still a great deal of research to be done and questions to be answered about their implementation and implications for arterials.

The sessions that informed the Task Force's deliberations followed a similar format. A panel with knowledge of the subject area was assembled and each member was given 10 min to introduce themselves and their connection or interest to the subject area. An additional person was given 20 min at the session outset to frame the topic as a keynote speaker. From there, an open and nonscripted discussion ensued with the attendees. To help facilitate the discussion, the moderator roamed the audience with an open microphone. The method used was important because it allowed for the discussion to be nonscripted while collecting the maximum number of ideas, comments, and opinions given the time allotted.

Besides providing substance for this E-Circular, the sessions also helped fuel two papers that Task Force members produced outside of TRB. The most recent was an article in the May 2018 issue of the *Institute of Transportation Engineers Journal* (ITE) (1). The journal is published monthly and written by and for transportation engineers, transportation planners, and others responsible for the safe and efficient movement of people and goods on our surface

transportation systems. The article addressed how we can improve arterial roads to support public health. Specifically, it called for integrating quantitative public health performance metrics into the planning, design, and operation of arterial roadway projects. The essence of the article can be seen in the section on Case Examples and Research Questions.

The second article, published in the *American Journal of Public Health*, makes the case to the health community about why arterial roadways are important to public health (2). While the linkages between arterials and public health were obvious to many on the Task Force, it became clear in one of the early meetings that “outside the room” the linkages were not all that obvious. This article, although targeted to the public health community, documented the linkages.

In short it found that

- Arterials are an integral part of the transportation system and exposure to them is ubiquitous.
- Arterials provide access to diverse commercial and cultural resources that can positively influence community health.
- Arterials can also adversely influence health, including various types of cancer; respiratory and cardiovascular diseases; poor birth outcomes; injuries; noise; and air pollution.
- Arterials present significant and unique challenges for pedestrians, cyclists, transit riders, and residents in the area.
- Arterials can function as physical barriers that diminish social and economic connections among neighborhoods.
- Arterials are subject to ongoing redesign and reconstruction, thus providing opportunities for innovative strategies and for public health and transportation professionals to work together.

Overall the article found that “practitioners in transportation, urban planning and public health have a desire for guidance and evidence to make decisions about arterial roads.” They are all striving for high-performing arterials but all using different criteria for performance. According to the article, “the key opportunity is to bring together transportation and public health, and continue to incorporate different performance measures into decision-making about arterial design, balancing the complementary and competing demands of transportation- and health-related goals.”

Coinciding with the activities of the Task Force, TRB also has a Subcommittee on Health and Transportation operating within its committee structure. The subcommittee began meeting in March 2012. It has four parent committees: Environmental Justice in Transportation; Urban Data and Information Systems; Travel Behavior and Values; and Transportation and Sustainability. It was the subcommittee that developed the proposal for the Arterial Health Task Force and championed it throughout TRB. Although they are separate entities, many of the subcommittee’s workshops and sessions have also provided inputs into this E-Circular, several of which are listed by title below.

- Why Consider Transportation and Health in a Rural Context? Discussion Session 667, 2018;
- Building Strategic Institutional Relationships at the Intersection of Health and Transportation, Session 347, 2017;
- Putting the Transportation and Health Tool to Work, Session 515, 2017;
- Institutionalizing Health in Transportation Agency Practice, Workshop 118, 2016; and

- Tools to Support Health and Transportation Planning and Analysis, Workshop 120, 2015.

The meeting notes, articles, and other relevant materials, including a 2015 *TRNews* special edition on health and transportation, can be found at the subcommittee and Task Force websites at <http://www.trbhealth.org/> and <http://www.trbarterialhealth.org/> (both accessed Aug. 19, 2018), respectively.

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1. Christopher, E. J., and C. McAndrews. Improving Arterial Roads to Support Public Health: How Can We Do This? *ITE Journal*, Vol. 88, No. 5, May 2018, pp. 13–16. Available at http://www.nxtbook.com/ygsreprints/ITE/G93877_ITE_May2018/index.php#/12. Accessed Sept. 10, 2018.
2. McAndrews, C., K. M. Pollack, D. Berrigan, A. L. Dannenberg, and E. J. Christopher. Understanding and Improving Arterial Roads to Support Public Health and Transportation Goals. *American Journal of Public Health*, Vol. 107, No. 8, 2017, pp. 1278–1282. Available at <https://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2017.303898>. Accessed Aug. 19, 2018.

Case Examples and Research Questions

This section represents a major component of the Task Force's work. The Task Force developed seven case examples covering several subject areas to help identify research needs for arterials and public health. The case approach was used to place the research needs in a relatable and practical context. Each case introduction provides background information to explain why the Task Force considers the issue to be important and to set the stage. Following the introduction, a set of researchable questions, issues, and concerns are listed with the intent that any organization, association, public agency, TRB committee, or researcher could champion them through future work.

How can we plan, design, and operate arterial roads while considering risks and benefits to public health?

The relationships between health and transportation issues are not linear or sequential, as shown in Figure 1. As such, the individual cases raise many issues, some of which overlap across the cases.

The seven cases are not exhaustive, nor are they presented in any particular order. They aim to pose questions rather than present answers. Taken together the questions illustrate the abundant opportunities to advance research, education, and practice in this exciting and emerging field.

The questions were developed from Task Force discussions at meetings (some opened and some closed), Annual Meeting sessions, individual expert opinions, and the Task Force teams that worked on the individual cases. While Task Force teams were assembled to develop each case area many were extended to include both members and nonmembers.

The questions themselves are not prioritized and care was taken not to edit them and lose the context in which they were originally presented. The purpose of the long list of questions is

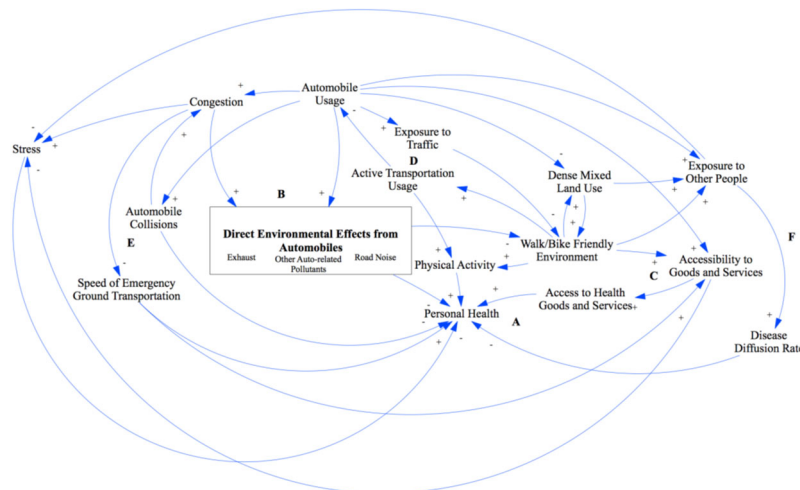


FIGURE 1 Causal loop diagram demonstrating the relationships between research agendas within the health and transportation corpus. Researchers presented this exhibit in a poster session about health and transportation at the 95th Annual Meeting of the TRB in Washington, D.C., in 2016 (1).

to demonstrate and begin to identify the many issues and concerns facing transportation and health planners. The way the questions are presented should allow anyone interested in the topic to simply pick up the E-Circular, flip to any page, and pick out a question or two of interest. From there the question could be further refined and developed into a problem statement for further research.

LINKING PUBLIC HEALTH METRICS TO ARTERIAL ROADS

Transportation and health professionals have a growing interest in bringing the two disciplines together around the planning, design, and operation of arterials. This interest arose because transportation investments have a clear influence on health-related exposures and outcomes, including air pollution, injury, physical activity, and sedentary time, as well as social factors such as connectedness, equity, and access. One key area where this collaboration is paramount is in the development of transportation-related health metrics that could be used to incorporate public health into the transportation decision-making for arterial roads.

Traditionally, the planning, design and operational decisions for arterials rely on metrics such as level of service, capacity, vehicle-miles traveled (VMT), and other design standards. While these traditional transportation metrics can answer certain health-related questions about fatal and serious injury crashes, noise and air pollution, and even a project's effect on active transportation, they only brush the surface. Transportation planners and engineers still struggle with broader questions dealing with equity, competing social agendas, and deceptively simple tradeoffs between level-of-service (LOS) improvements and quality of life. In short, the typical transportation metrics do not address many of the critical health outcomes associated with arterials.

From the perspective of health professionals, transportation's influence goes far beyond roadway operation, vehicle and pedestrian flows, and optimization of traffic flows. They are concerned with a much-broader picture, commonly referred to as the social determinants of health (SDOH). The SDOH are the conditions in our everyday environments that affect a wide range of health, functioning, and quality-of-life outcomes and risks. The SDOH include multiple transportation-themed factors: economic stability, education, social and community connections, health care, neighborhoods and other everyday built environments (2).

The Task Force has discussed transportation-related health metrics at numerous meetings. This included hosting sessions on the topic at the 96th and 98th TRB Annual Meetings (2017 and 2018, respectively), publishing an article on the topic, and having conversations on the subject at

Metrics and Public Outreach

The City Traffic Engineer in Denver, Colorado, created a one-page flyer to describe how changes to Montview Boulevard would make life better for surrounding neighborhoods.

The flyer used metrics to communicate how the actions of the Department of Public Works would shave minutes off travel times, reduce vehicle emissions, and prevent crashes on the busy arterial.

The City Traffic Engineer noted that if public health metrics had been available, the Department of Public Works could have said more about how their work served residents. He added that active transportation options can also help kids get more minutes of physical activity, make it easier for people to access health care services, and potentially prevent asthma—but we need metrics that convert transportation benefits into health benefits.

all of its working meetings since the Task Force was initiated in 2016. Through these venues and discussions countless questions were raised regarding how to bring health metrics into the planning, design and operation of arterials and what the metrics might be. One suggestion is to pull from a practice that already exists in the transportation field, and call for the creation of a guide to arterial health planning, design, and operation. A field guide or manual that would be developed with backing and support of both transportation organizations and the major public health organizations would be useful.

Research Questions, Issues, or Concerns

Big Picture Concerns

- What are the main guidelines and standards that guide the planning, design, operation, and maintenance of arterial roads?
- What needs to be done in order to apply a health lens to arterial roads?
- What are the strategic steps to develop and implement a health lens to arterial roads?
- What evidence base do we need to design arterial roads for multiple travel modes and users?
- How does an arterial road's relationship to the surrounding network and neighborhood influence exposures and behaviors that are related to adverse health outcomes and to positive health outcomes?
- What are the existing transportation equity and health equity implications of typical auto-oriented arterial roads?
- What are the health implications of changing transportation technology on arterial roads (e.g., connected and autonomous vehicles, low-emission vehicles)?
- How can analytical tools and models be a platform for introducing health-related concerns into the planning, design, operation, and maintenance of arterial roads?
- What are the factors or process for developing cost-effectiveness or return on investments to evaluate health-promoting investments?
- What are the various points of conflict between health goals and transportation goals for arterial roads, and how can they be resolved?
- What are some of the known barriers to including public health in the planning, design, operation, and maintenance of arterial roads and what is known about dealing with these barriers?
- What can be learned from HIA that have previously been used to evaluate the health implications of proposed transportation-related projects?
- How do existing transportation assessment systems and the metrics they employ influence health, via the design and operational implications they have for arterials?
- Is it possible to redesign the transportation assessment methodologies to focus on health-based outcomes; either as the prime outcomes or as part of an integrated objective that prioritizes–balances health outcomes along with other mobility goals?
- How can metrics related to health be transferred into the planning, design, and operation of arterial roadways?

How are competing trade-offs and conflicting goals dealt with when considering arterials and public health?

Performance Measures for Assessing Public Health

- What evidence-based performance measures and metrics (e.g., inputs, outputs, outcomes) do we need in order to apply public health considerations to the planning, design, and operation of arterials?
- What performance measures are currently used in public health that could be incorporated in transportation decision-making?
- How are these health metrics different than what is currently used in transportation decision-making?
- What easily obtained health metrics can be used in place of full-scale HIA that are often resource-intensive?
- What types of data are needed to calculate these performance measures? How easily can one obtain those?
- What other sources (not necessarily currently utilized) can be used to obtain necessary data for estimating such performance measures? How is this expected to change with technology (e.g., obtaining data from traffic signals, connected vehicles)?
- How do these performance measures account for health equity?
- Do the metrics make a direct connection between arterial design and public health outcomes? What are some of the intermediate factors?
- What aspects of public health impacts are not represented by existing performance measures used in practice?
- Which performance measures should be used at which scales of effort: plans, projects, development, and/or evaluation?
- Should some or all performance measures be outcome-oriented (vs. output measures)? For example, perhaps percent active mode share is a more useful metric than the number of miles of bike lanes.

Role of Performance Measures in Decision-Making

- What transportation-related health metrics are currently used by departments of public health and departments of transportation in decision-making/project scoring?
- How should different transportation-related health metrics or public health impacts be weighted in transportation project decision-making?
- How could the health impacts of traffic operations be quantified and how can one distinguish between the contributions of transportation versus other factors?

Other

- How should transportation systems be managed to achieve health equity?
- How do you quantify health impacts of traffic operations and distinguish between the contributions of transportation versus other factors?
- A challenge is making a tangible connection between arterial design and public health—is there enough good data to be able to demonstrate this convincingly? Should this go beyond fatal and serious injury crashes, noise and air pollution, and a project's effect on active transportation?

- Once we have the health-related metrics, is it feasible to collect this data across a community, metropolitan planning organization (MPO), or state?

Areas Where Some Progress Has Been Made

Street Smart. Street Smart promises to be an evidence-based tool linking transportation strategies and tactics with goals and performance. It is being developed by a nonprofit organization that is working with organizations like ITE and others. Available at <http://thinkstreetsmart.org/index.html>. Accessed Aug. 19, 2018.

TCRP Research Report 187: Livable Transit Corridors: Methods, Metrics, and Strategies. In 2009, the U.S. Department of Housing and Urban Development, U.S. DOT, and U.S. Environmental Protection Agency articulated six “Livability Principles” of their Sustainable Communities Partnership. Out of this project emerged a planning-support tool and a handbook that provide all the necessary data to analyze urban quality as it relates to the six principles. Available at <http://www.trb.org/Main/Blurbs/174953.aspx>. Accessed Aug. 19, 2018.

Guide to Transport and Health Performance Metrics. The Transportation Public Health Link, International Professional Association for Transport and Health, and ITE are working in collaboration to create this guidebook. The project deliverable is the result of three working sessions held during the International Conference on Transport and Health at Mackinac Island, Michigan, in 2018. It is anticipated that the guidebook will be completed/published in 2019.

LOCAL VISION ZERO POLICIES AND ARTERIAL ROADS AS A PUBLIC HEALTH HAZARD

Vision Zero, an approach to road safety imported from Sweden focuses on designing a transportation system where human error does not result in loss of life or severe injury, particularly for the most vulnerable road users. Vision Zero centers on creating safe, forgiving transportation systems that anticipate human error and prevent the most severe consequences. This innovative approach contrasts with traditional traffic safety practices in the United States that have focused on individual responsibility and changing human behavior, namely through education, and that have tacitly accepted death and severe injuries as an inevitable by-product of efficient mobility. There are two distinct initiatives worth noting: Toward Zero Deaths and Vision Zero.

Safety Data Points to Arterials

Vision Zero's implementation emphasizes data-driven decisions. In turn, injury indicators have increased attention on urban arterials, traffic safety, and equity. A focus on the most-severe outcomes of traffic crashes is also helping to elevate the importance of speed management for traffic safety and barriers to its implementation on urban arterials.

Data from San Francisco, Boston, Portland, Los Angeles, Philadelphia, and other cities have found that traffic deaths and severe injuries are disproportionately concentrated on arterial streets in low-income communities, communities of color, communities that have historically had less road safety infrastructure than more-affluent communities, and those that have been less engaged in the transportation planning decision processes.

Many of these same communities also have concerns regarding racial bias by law enforcement being unintentionally exacerbated through enforcement initiatives in support of Vision Zero, including the use of racial profiling in traffic stops and deportation contributing to adverse public health impacts. The use of automated enforcement as an enforcement approach with less subjectivity has received more attention, though there are still concerns with respect to equity and potential unintended and negative health impacts of associated fines.

Toward Zero Deaths began in 2009 at a National Strategic Highway Safety Plan Stakeholder workshop, which grew into Toward Zero Deaths: a National Strategy on Highway Safety. The national strategy document outlines strategies and tactics to reduce roadway fatalities and focuses on six areas: drivers and passengers, vulnerable users, vehicles, infrastructure, emergency medical services and safety management. The national strategy also defines and provides guidelines for the creation of a traffic safety culture where drivers reject risky behaviors and safety is incorporated into the decision-making of everyone involved in the transportation system. To date, most Toward Zero Deaths participants are state organizations and government associations; there are also higher education institutions, private-sector businesses, and other associations adopting the strategy.

Vision Zero initiatives in the United States began in 2014 and have been distinct from Towards Zero Deaths in that they originated at a local government level and thus focus on local-level policy and practice, often at the direction of elected officials and in response to local advocacy efforts. Vision Zero initiatives are led by local transportation agencies, in collaboration with police, public health, public works, and other city stakeholders, and with leadership from the mayor and other elected officials. First started 20 years ago in Sweden, Vision Zero efforts there have cut traffic deaths in half. Vision Zero cities create city-specific action plans, informed by local data, and with a focus on public engagement and government accountability. To date, local action plan strategies center around lowering speed limits, redesigning streets, managing behavior-change campaigns, and enhancing data-driven traffic enforcement and are often grounded in a focus on addressing equity issues for low-income communities, communities of color, seniors, people walking and biking, and other vulnerable populations. In contrast to Towards Zero Deaths, Vision Zero has an explicit goal of eliminating traffic deaths, with no death as acceptable. The Vision Zero Network (3), established in 2015, is a nonprofit organization providing leadership, support, and networking opportunities for leaders of city and county Vision Zero initiatives (4).

Both approaches trace their roots to Vision Zero in Sweden and the "safe systems" approach. Safe Systems acknowledges the responsibility rests with system designers, including transportation planners and engineers, and policy makers in designing and maintaining a safe

system that protects the most vulnerable users while individuals share a responsibility to abide by the systems, laws, and policies set. If safety problems persist, the responsibility comes back to the system designers and policy makers to take further measures to ensure safe conditions. A Safe Systems approach is a paradigm shift in approaching roadway safety as an “upstream” systemic issue for system designers to address, not one simply resting with individuals (5).

In 2014, San Francisco became the second of more than 30 cities in the United States to adopt Vision Zero. The city’s approach is led by a mayor’s task force and is co-chaired by the San Francisco Municipal Transportation Agency and the San Francisco Department of Public Health. The task force also includes stakeholders from other city agencies and community organizations.

San Francisco relies on a 2-year action strategy to advance Vision Zero, which focuses on creating safe streets, people, and vehicles through engineering, education, enforcement, policy, and evaluation actions—while advancing core principles of prevention, saving lives, equity, and the critical role of safe speeds. Partners work through the task force to update the strategy every 2 years. Other cities have followed variations of this organizational approach and framework, including New York, Portland, Oregon; Seattle, Washington; Los Angeles; Boston; Philadelphia; Fort Lauderdale, Florida; Denver; and Durham, North Carolina, with San Francisco being the only city with a public health department co-chairing the initiative along with the local transportation agency. Vision Zero is strengthening collaboration between public health departments, transportation agencies, police departments, government officials, and community stakeholders to eliminate traffic deaths.

Vision Zero’s focus on data-driven decisions has directed attention to arterial roads. For example, in San Francisco, 75% of severe and fatal injuries are concentrated on just 13% of city streets and similar patterns have been identified in cities across the country. Many of these streets are urban arterial roadways. As traffic deaths have been increasing in recent years in the United States, particularly among people walking and biking, understanding and addressing critical challenges to realizing Vision Zero on arterial roadways are even more relevant and timely.

Research Questions, Issues, or Concerns

Arterial Design and Policy

- What are the best design elements to protect all road users on arterial roads?
- What design elements can protect the safety of vulnerable users like people who bicycle or walk on arterial roads?
- Should the design of arterials differ by the land use context or population density?
- How should the design of arterials accommodate high pedestrian concentrations in suburban settings?
- How should arterials be designed to accommodate safe public transit in the suburban and rural setting?
- In what context does it make sense to restrict single-occupancy vehicles to promote safety on arterial roads?
- Can the implementation of congestion pricing strategies improve safety on arterial roads?
- What existing initiatives and innovative design guidance that cities are already utilizing can be built upon to improve safety on arterials roads?

Can arterial roadways address injury hazards for all users?

- What policy changes are needed to overcome challenges in implementing design guidance for arterials (e.g., jurisdiction with the state or localities)?
- What are the most salient challenges to improving arterial designs and related policies, which could improve public health? And what is needed to address those challenges? How could a public health approach help address these challenges?
- What should be considered with respect to arterial design and prioritizing the safety of all road users with the emergence of autonomous vehicles?
- What are the opportunities for synergies between federal, state, MPO and local partnerships to address these issues, particularly under the umbrellas of Vision Zero or Toward Zero Deaths efforts?

Speed Management on Arterials

- How does speed management affect cyclists and pedestrians?
- What are effective methods for speed management on urban or suburban arterials?
- What are the barriers to their implementation?
- What additional research is needed?
- What additional data should be collected?
- How does the need for arterial speed management complement or conflict with transit operations? Congestion management? How can conflicts be better managed?
- How do speed management and vehicle restrictions impact vulnerable populations like children, the elderly, or disabled populations?
- Can specific speed interventions on arterials proximate to places where these vulnerable populations congregate impact safety (e.g., slow zones, automated enforcement around schools and senior housing, and transit centers and stops)?
- How does signal timing, phasing, vehicle speed, and progression on arterials affect pedestrian movement and safety, as well as air quality?
- What is the role for emerging vehicle technologies and autonomous vehicles with respect to speed management on arterials?

Equity

- How are equity, vulnerable users, and vulnerable populations living near and using arterials defined? This potentially includes people walking, biking, motorcycling, and taking transit as well as communities of color, low-income communities, seniors, youth, people with disabilities, homeless and marginally housed residents, immigrants, non-English-speaking communities, and others experiencing or at risk for injury inequities.
- What are best practice strategies both for vulnerable populations living on or near transportation projects, as well as vulnerable users using the transportation system irrespective of residential location?

Community Engagement

- As Vision Zero Cities are identifying the need for more community engagement around transportation projects, particularly among vulnerable populations along urban arterials and in

suburban communities receiving displaced populations, what are best practices for community engagement for transportation projects?

- What are the unique considerations along arterials which often serve to divide and isolate communities and stakeholder groups? How can such factors be brought out and discussed?
- What best practices in community engagement from public health can be leveraged to support transportation projects on arterials to reach diverse populations that may be impacted? This could include people walking, biking, motorcycling, and taking transit as well as communities of color, low-income communities, seniors, youth, people with disabilities, homeless and marginally housed residents, immigrants, non-English-speaking communities, and others experiencing or at risk for injury inequities.
- What metrics are being used for accountability or to address community concerns regarding equity and community engagement?

Law Enforcement

- How are communities addressing concerns regarding law enforcement and racial bias in the context of Vision Zero, and what approaches are effective? What is the evidence with respect to Vision Zero contributing to or exacerbating racial bias and deportation, and what are recommendations to mitigate these impacts?
- What is the role of automated enforcement, and if so how should it be strategically deployed on arterials?

Accountability

- How can the operating procedures, policies, and practices of government agencies and officials support the production of equitable outcomes, particularly on and along arterial corridors, through the implementation of Vision Zero?

Displacement

- How are concerns regarding the displacement of people and businesses due to Vision Zero and its implementation in arterial corridors being considered? Is displacement an issue? Is anything being done to address this concern? Are these efforts being evaluated and if so, what are the findings?
- Are Vision Zero road improvements contributing to displacements along and proximate to major arterial corridor projects? Can this be quantified, including who is being displaced, to better understand the public health impacts and trade-offs for those vulnerable to displacement?

Injury Data

- What data are currently used to inform Vision Zero efforts and how accurate is it with respect to severity and other key data elements?
- What is the magnitude of injury underreporting in police records based on less-utilized data sources? These data sources may include emergency room and hospital discharge data by mode, by race and ethnicity, by primary language, and by other important equity factors including income, age, housing status, immigration status, or primary language.

- Are data discrepancies between police and hospital records, such as emergency room or hospital discharge data, more or less pronounced along arterial versus nonarterial roadways? What other factors predict underreporting? How does this potentially impact resource allocation for safety improvements when relying solely on police data, including for vulnerable road users?
- What are the strengths and weaknesses of different injury data sources? What are opportunities for data improvements to each source, including to better facilitate record linkage of multiple data sources?
- What is the impact of this underreporting with respect to data-driven prioritization of traffic safety investments?
- Are there any observed benefits for agencies who have adopted the streamlined crash data collection system (e.g., City of Philadelphia Police Department's Traffic and Criminal Software)?
- What are approaches to addressing injury underreporting, at varying levels of resource intensity?
- Are there best practice recommendations that could be developed to address underreporting in different scenarios?
- How could police, hospital (such as hospital discharge, emergency room, or trauma center data), ambulance or emergency medical response data integration be supported and institutionalized?
- What additional variables should be collected on transportation injuries to inform Vision Zero efforts and address equity impacts—either in police or hospital data?

Metrics and Evaluation

- In what circumstances are safety and health-based goals and metrics conflicting with other standard transportation goals and metrics that are specific to arterials? What are potential measures that could address these conflicts (e.g., challenges related to safety aspect of various designs for on-street light rail and bus rapid transit as part of arterials (comparing center-of-street versus side-of-street)?
- What are the critical metrics for assessing Vision Zero progress and accountability on arterials? How frequently should they be collected and reported?
- What are the data needs for Vision Zero metrics, potentially including speed data, latent demand measures, near misses, traffic volume, origin and destination information (for localized exposure rates and equity analyses), quality and impacts of pre- and post-Vision Zero safety engineering, enforcement, and education interventions?
- What is the role of benefit–cost analysis in light of Vision Zero goals, and how do Vision Zero goals alter traditional benefit–cost analysis assumptions?

Education

- What additional skills and training do transportation, public health, and public policy professionals need to help address these challenges with respect to safety on arterial roads in particular?
- What perceptions about arterial roads and their function by transportation professionals are barriers to equitable, effective, and universal Vision Zero implementation?
- What are the shortcomings of previous traffic safety educational strategies in the United States to combat traffic injuries and deaths, especially on arterials? Can these programs be improved

or expanded, or must they be completely redeveloped from the ground up? In either case, what are the likely obstacles (funding, cultural or institutional resistance, etc.) and how can they be overcome?

- What methods are most effective to educate the public and shift attitudes and behaviors toward Vision Zero achievement, including on arterial roads?
- How can children, teens, and adults be most effectively and universally educated surrounding safe driving, biking, and walking techniques and habits? What are the legislative needs and barriers surrounding public primary and drivers' education on this topic? What are the lessons and shortcomings from international examples?
- Where are the policy opportunities with respect to licensing, license renewals, mandatory safety rules, and testing as tools to improve the quality of people driving?

As We Learn More There Is More to Learn

In November 2016, the City of Philadelphia adopted Vision Zero and set the goal of reducing traffic deaths on Philadelphia streets to zero by 2030. With the Three-Year Action Plan released in September 2017, the City of Philadelphia has set priorities in the areas of Equity, Evaluation, Engineering, Education and Enforcement. Recognizing that traffic crashes disproportionately impact Philadelphia's low-income neighborhoods, the City is committed to data-driven decision making that would identify equitable solutions by prioritizing investments in areas of need. While developing the Three-Year Action Plan, the City collected a significant amount of responses (23,187) to frame the Vision Zero Safety Map that focused on reporting dangerous behaviors Philadelphians have observed. As part of its ongoing Vision Zero work, the City is launching a pilot study for what it calls the Safety Six, which emphasizes enforcement to prevent traffic violations that most often result in major injuries and deaths. The City is also working on metrics identification for "Measures of Connectivity", a tool to assess the long-term equity impacts on future Vision Zero projects. Forging partnerships among various stakeholders is another approach the City is emphasizing to ensure Vision Zero is a coordinated effort. A good example is the coordination between the City's Office of Transportation, Infrastructure, and Sustainability and the Philadelphia Police Department where the education (e.g., educational palm card about Vision Zero) followed by the enforcement offered an opportunity to change behavior across modes. In May 2018, the City of Philadelphia hosted a Vision Zero Research Partnership that challenged researchers and practitioners to build an understanding of current and future research, and to cultivate the relationship and sustainable connections between individuals and institutions working on Vision Zero related research projects. Workshop discussion items included, but were not limited to, advanced crash data collection systems, a traffic safety culture index, immigrant communities, as well as pediatric pedestrian injury status.

PROXIMITY TO ARTERIAL ROADS AS A PUBLIC HEALTH CONCERN

In October 2015, the U.S. DOT and the Centers for Disease Control (CDC) released a jointly developed Transportation and Health Tool (THT). The THT was developed to provide easy access to data that practitioners can use to examine the health impacts of transportation systems. The tool provides data on a set of transportation and public health indicators for each U.S. state and metropolitan area. These indicators describe how the transportation environment affects safety, active transportation, air quality, and connectivity to destinations. One can use the tool to see how one's state or metropolitan area compares with others in addressing key transportation and health issues. It also provides information and resources to help agencies better understand the links between

transportation and health and to identify strategies to improve public health through transportation planning and policy (6).

The story with the tool, however, is not with its use or application but concerns one of its indicators—proximity to major roadways. Proximity to major roadways is one of 14 indicators indexed in the THT and estimates the percentage of people who live within 200 m, or approximately 650 ft or one-tenth of mile, of a high traffic roadway that carries over 125,000 vehicles per day.

The concern for the Task Force is with the traffic volume established for this metric. There is ample evidence to suggest that living near major roadways increases the risk of numerous health outcomes but there is a debate about the amount of traffic needed before proximity becomes a concern. When the THT was being developed the project team working on the tool planned to use 25,000 vehicles per day, however, the Federal Highway Administration (FHWA) Air Quality Office insisted the number should be higher and even suggested to eliminate the metric. They argued that there were too many variables to consider when dealing with the health impacts of living near a major roadway so it was not a simple question of vehicular traffic. At the 11th hour, a compromise was reached and 125,000 vehicles per day was used. So the question still remains, what is a reasonable number? Is it 25,000 or more aptly 125,000 vehicles per day? For the THT project team the need to compromise was important so as not to lose the metric all together. But some may believe the compromise rendered the metric useless since only the most heavily traveled interstates carry more than 125,000 vehicles per day.

Another concern for the Task Force was the issue of trade-offs. Trade-offs between the benefits of living close and dis-benefits associated with health. Living near arterials can be a plus because of pressures to increase housing in cities, desirable access to transportation and economic benefits of higher density. However, this can contrast with some known negative health effects associated with respiratory disease, cardiovascular disease, diabetes, cancer and other negative health outcomes. Work needs to be done to identify how much, if any, health risk is tolerable.

L.A. Keeps Building Near Freeways, Even Though Living There Makes People Sick

For more than a decade, California air quality officials have warned against building homes within 500 ft of freeways. And with good reason. People there suffer higher rates of asthma, heart attacks, strokes, lung cancer, and pre-term births. Recent research has added more health risks to the list, including childhood obesity, autism, and dementia.

Yet Southern California civic officials are allowing a surge in home building near traffic pollution, according to a *Los Angeles Times* analysis of U.S. Census data, building permits, and other government records. In Los Angeles alone officials have approved thousands of new homes within 1,000 ft of a freeway—even as they advised developers that this distance poses health concerns.

How close to the highway are you?

T. Barboza and J. Schleuss
Los Angeles Times
March 2, 2017

<http://www.latimes.com/projects/la-me-freeway-pollution/>.
Accessed Aug. 19, 2018.

Research Questions, Issues, or Concerns

- What are the health-related issues, concerns and outcomes associated with living near major roadways?
- How close can one live to major roadways before it is a public health concern? How does one define “near a major roadway?” Distance? Traffic density?
- What is the interplay between the vehicular volume, number of lanes and public health outcomes?
- What characteristics of major roadways are most relevant/can best predict health issues (e.g., size, vehicular speed, fleet composition and volume, start–stop driving)?
- How is proximity to major roadways correlated with environmental exposures (e.g., ambient air pollution and noise)?
- What levels of noise are acceptable from a public health perspective? How serious of an issue is noise?
- If living, working, and playing near major arterials has health consequences how much exposure risk is acceptable?
- Are current modeling tools adequate to assess relevant impacts?
- What do trends in electric/hybrid vehicle acceptance mean for these impacts?

Can the negative health effects of proximity to busy arterials be reduced?

Who Wants to Live on a Busy Arterial?

According to CDC, more than 11 million people in the United States live within 150 m (or approximately 500 ft) from a major highway (1). The vehicle traffic on these roadways is a major source of noise and air pollutants, such as particulate matter, nitrogen oxides, carbon monoxide, and ozone, which are known to be associated with adverse health (2). Specifically, exposure to traffic-related pollution is linked to asthma and other respiratory symptoms, development of childhood asthma, and cardiovascular disease and death (3). For example, one study estimated that 8% of childhood asthma cases in Los Angeles County, California, could be partly attributed to living within 75 m (approximately 1 city block) of a major road (4). Living near a major road also has been associated with decreased lung function in adults with asthma (5). By increasing the distance from the road to greater than 150 m, or approximately 500 ft, might decrease concentrations of some air pollutants by at least 50% (6). Also, research has demonstrated that noise from traffic at urban levels can also lead to stress and sleep disturbances, both of which can lead to a higher risk for Type 2 diabetes (7).

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REINVENTING, RETROFITTING, AND REMODELING URBAN ARTERIALS

The subject of this case cuts across many of the concepts and themes found in the other cases. It deals with the struggle of bringing health considerations to an existing urban arterial that is in a “tired” state. While Case 5 focuses on arterials in a changing suburban–exurban context, the Task Force felt it was important to put a spotlight on those old, established arterials that can be found inside our urbanized areas and are pervasive across the county.

Many cities in the United States are facing challenges associated with antiquated urban arterials, whose purpose has changed greatly since their development. Once considered the main streets of the city with thriving businesses and attractive residential development, many have deteriorated over the decades for a number of reasons, including shifting demand for housing and retail development and the construction of parallel high-speed urban expressways (7).

In looking at a cross section of urban arterials, it is clear they were designed at different points in time and serve a variety of sometimes competing purposes. Some are high-capacity, high-speed thoroughfares whose main purpose is to move vehicles a long distance across an urban area while others serve neighborhood communities and act as dense retail and residential corridors, with a side purpose of providing a high level of vehicle capacity. Then there are arterials that were developed around transit and are less auto-centric. Finally, there are arterials that do a mixture or blend of both.

Given this diversity of purposes, development considerations, age, state of decline or disrepair, and vitality of the area, dealing with urban arterials is a very complex undertaking. In the broadest sense it behooves the larger planning and engineering community to revitalize and reinvent these arterials while assuring for the health of the community they serve and the economic sustainability of the region. Is the design of the street and the fronting land uses meant to prioritize people who drive their own vehicles? Can we redesign arterials where people would like to live and shop while traffic and transit can operate efficiently? How do we interweave the pedestrian environment into this design? Can we have the optimal arterial when considering all

Does This Sound Familiar?

The following is an illustrative example of a Main Street found in many urbanized areas across the United States and elsewhere. It is typically a four-lane, essentially flat with no on-street parking. It stretches 5 mi from north to south in a city of 200,000 people. It has a 35-mph speed limit in the southernmost portion and is signed at 30 mph for most of the route. Signalized intersections are spaced approximately 1,000 ft apart in most locations, and up to 4,000 ft apart in some sections. Sidewalks are provided on both sides of the street although many segments are broken, cracked, or missing. Utility poles line the road and are centered in the middle of the sidewalk in many places. Pedestrian infrastructure at signalized crossings is minimal—some have painted crosswalks but most are in disrepair. Pedestrian signals do exist in a few places. Many segments have no signalized or marked pedestrian crossings and there are no facilities for cyclists. Land use is mostly light commercial with parking lots fronting the road with an abundance of driveway access curb cuts. Buildings are of mixed use with many setbacks from the road. There is municipal bus service, with peak period service at a 20-min frequency. For a portion of the road a center two-way left turn is provided, increasing the width of the street. In this area, blocks are larger and connections into the adjacent neighborhoods are few. The city was founded in the early 1800s and the arterial shows up on the earliest maps of the city.

the needs, interests and desires? These are just a few of the many questions that have resonated in the discussion among the task force members.

Research Questions, Issues, or Concerns

Scoping the Issues

- What is a healthy and unhealthy arterial? What examples of arterials are health promoting and why? What examples are not health promoting and why?
- How prevalent are health-promoting arterials nationwide?
- Where are unhealthy corridors?
- Are unhealthy arterials concentrated in certain areas?
- What characteristics do unhealthy arterials share?
- What do unhealthy arterials look like in various contexts?
- Who is most affected by healthy and unhealthy corridor conditions, and what is the magnitude of these impacts?
- How do unhealthy corridors perform in terms of transportation, economics, equity, health, and safety? How do healthy corridors perform on these measures?
- How do current design standards impact health outcomes in relation to arterials? Is this quantifiable?
- Are there policies and practices that lead to unhealthy corridors? Zoning? Parking requirements? Setbacks? Intersection spacing?
- How are development impacts measured? LOS? VMT? Vehicle access? Travel time?

How can existing arterials be reinvented in ways that promote health?

Addressing the Issues

- How can arterials be transformed to become safe, healthy, vibrant, mixed-use places with next-generation infrastructure? This includes displacements and gentrification as well.
- What changes in transportation engineering and city planning practices are required for arterials to undergo true revitalization?
- What are healthy design elements and what are their costs compared to their benefits?
- Are there supplementary guidelines that can ameliorate negative health impacts of the design standards? To what degree?
- Can a relationship be defined between public health and the implicit inequity present in the auto-focused design and operation of arterials?
- What are the best means to engage community residents and arterial users in the design process when redeveloping an arterial?
- What policies contribute to prioritization of the automobile? (See [Land Use and Arterials in an Ever-Changing Exurban Context](#).)
- How can the needs of drivers and other users be satisfied while prioritizing health?

- Can engineering standards for arterial design be improved to promote health? (See Linking Public Health Metrics to Arterial Roads.)
- Could the use of multi-modal level of service indicators help create more health promoting arterials?
- Use of sustainable transportation modes is understood to be closely related to the surrounding patterns of land use and urban design. These modes support greater physical and mental health. Can this be quantified?

Arterial Operations

- What is the relationship between auto-focused signal timing phasing design and operation, and public health? Does limiting pedestrian access through these strategies impact community mental or physical health?
- What are the trade-offs between health and traffic performance? Is there an appropriate balance?

Pedestrians

- What are the implications for access management for motor vehicles, transit, pedestrians, and bicyclists?
- Is there a relationship between provision of sidewalks and public health? Does this change depending on the width of the sidewalk? Some cities and guidelines [e.g., National Association of City Transportation Officials' (NACTO) *Urban Street Design Guide*] specify minimum clearway widths. Is there a quantifiable relationship between (minimum) clearway width and public health?
- What effect does lighting have for both personal safety (crime prevention) and to act as a countermeasure against bicycle and pedestrian crash occurrences?
- What impact do street trees have on health (e.g., providing enclosure and enhancing livability, and mitigating vehicle pollution)?

Transit

- How does arterial design and condition affect transit service (e.g., frequency, directness, spacing of stops, average speed, and connections to other routes) and level of transit use?
- Can transit be sustainable on an auto-focused arteria?
- What are the barriers related to arterial design and function that inhibit walking and cycling? Do they relate to safety, incidence of crime, lack of connectivity or access to important goods (food and medication), and services like health care?
- Could well-designed arterials that support safe bicycle and pedestrian travel help improve transit ridership and revenues?
- Could complete street approaches be considered symbiotic prerequisites for the effective revitalization of typical North American commercial and retail corridors and arterials?
- Does the inclusion of dedicated design treatments for transit (i.e., reserved lanes or a dedicated right-of-way) have an impact on public health?

- How does the transit service provided on arterial streets relate to pedestrian and cyclist activity? Does it promote these modes or inhibit their use? Typically suburban arterials do not appear to provide a high level of support for trips combining some or all of these modes.

Cycling

- What are the barriers related to arterial design and function that inhibit cycling? Do they relate to safety, incidence of crime, lack of connectivity, access to important goods (food and medication), and services like health care?
- Does the inclusion of cycling infrastructure have an effect on public health? Is there a difference in outcome based on the type of cycling infrastructure?

Areas Where Some Progress Is Underway

Framework for Better Integrating Health into Transportation Corridor Planning. The FHWA framework provides action-oriented information about incorporating health into the corridor planning process. In addition, it includes a step-by-step guide for transportation practitioners. Available at https://www.fhwa.dot.gov/planning/health_in_transportation/planning_framework. Accessed Aug. 19, 2018.

Urban Land Institute Healthy Corridor Project. Using a healthy corridor approach, ULI worked with communities to implement improvements along specific corridors with the goal of making positive changes in the health of the people who live, work, and travel along them. The healthy corridors approach considers how the corridor contributes to the overall health of the surrounding community, including supplying opportunities to be physically active. It also considers safety, housing affordability, transportation options, environmental sustainability, and social cohesion, as well as modifications that would link residents to the corridor and improve connections to jobs and other parts of the community. Available at <http://uli.org/wp-content/uploads/ULI-Documents/Building-Healthy-Corridors-ULI.pdf>. Accessed Aug. 19, 2018. Also <https://uli.org/healthycorridors>. Accessed Sept. 30, 2018.

LAND USE AND ARTERIALS IN AN EVER-CHANGING EXURBAN CONTEXT

Arterial roadways serve an important transportation and health purpose. They facilitate regional travel and provide key routes to health care facilities as well as serving as an important location for jobs, health care, and essential goods. However, from a health perspective, they can also prove harmful to health. Over the past 60 years, the high-volume, high-speed arterial has undermined health through designs that create high-speed conflicts between modes and users contributing to crashes that cause disability and death, through exposures to near roadway pollution that harms health, and through insurmountable safety barriers to people who want to walk or bike across their community.

Towns and cities all over the United States continue to grow. And current transportation and land use planning often lacks the authority to direct development where transportation capacity is greatest. Given current development policies, this growth pattern converts rural land uses to suburban ones along the exurban fringe. As these communities expand into surrounding areas, the rural roads that once connected farms to market become major arterials.

In many areas across the country there are countless examples where rural areas have progressed along an incremental evolutionary path that leaves residents with an infrastructure

that many may consider completely at odds with a healthy community. Most every populated place in America has an existing high-volume, high-speed arterial in their community that houses important commercial and institutional destinations for the region while serving as the primary connection from the residential areas. As a result, major arterials support almost every type of trip whether it is a regional work commute, or a local trip to the doctor's office, retail establishment, entertainment facility, dinner or school.

One key way to address the health problems posed by these arterials is to integrate them into the community while understanding the transportation and public health goals, needs and concerns, and how they inter-relate. A more direct way to address the health concerns is to reduce demand for the arterial and leverage the design of the entire street network. To do so will require a detailed systematic approach that extends the focus beyond those issues typically associated with transportation planning to include land use, development and urban form.

It Is About Land Use, Development, and Urban Form

College Avenue connects the airport to downtown Appleton, Wisconsin, spanning 4.5 mi. It traverses three municipalities and is the product of incremental growth and development. The arterial is crossed by a county highway, a state highway, and a local road, each with its own distinct cross section.

The road begins as a four-lane highway with a 55-mph speed limit that tapers down to 35 mph as it approaches downtown. There are frontage roads for the first 2 mi, with limited to no bicycle and pedestrian accommodations or access for transit. The land use is primarily commercial (retail stores, grocery stores) and industrial development. A shopping mall is located directly adjacent to this corridor. Businesses are generally located near the west end near the airport. Residential development is located primarily to the south of the corridor on the county highway and state highway sections.

College Avenue is typical of many arterials that developed over time.

Research Questions, Issues, or Concerns

Land Use and Zoning and Subdivision Requirements

Many would argue that it is both the separation of land uses through zoning, as well as the lack of connected local street networks through subdivisions that helps to drive up the car traffic on arterials. The same argument suggests that increasing the auto demand for arterial space propagates high volume roadways and the negative public health outcomes associated with them. While additional research on this point is needed, there are many other research questions that this raises.

- What does it take to integrate public health concerns in zoning, land use, and exurban planning decisions?
- Can plans for major road expansion trigger required land use and zoning changes that can facilitate connectivity around the road and reduce travel demand on the road?
- How can land use planning and zoning facilitate more comprehensive transportation networks that reduce travel demand on arterials in the future?
- How can land use planning ensure that neighborhood amenities exist like parks, greenspace, and neighborhood commercial centers?

- How can land use planning and zoning encourage local road networks that reduce travel demand on arterials and encourage multimodal travel?
- How can land use planning and zoning mitigate the negative health impacts of existing arterials?
 - Should there be a minimum lot size, or minimum density that reduces demand on arterial roads? Should there be maximum lot sizes on arterial roads?
 - Are there guidelines or standards that could be adopted dealing with the interval for street or network connectivity and block sizes?
 - How can urban planners obtain more input from public health professionals as part of land use planning decisions?

How can we prevent the harm that arterials pose to health before they are built and mitigate the harmful health impacts of arterials that already exist?

School Siting, Size, and Zones

Schools generate enormous travel demand on roads. Their size and location have a fundamental impact on how students travel. Their size and location can also have dramatic impacts on travel time for all road users near the school. Reducing the travel demand that schools cause on the community's arterial roads could help mitigate their negative health impacts. The research questions below are intended to explore ways in which school siting, size, and zoning can potentially reduce travel demand on community arterials.

- How can plans for school siting create measures to reduce travel demand on arterial roadways?
 - Should schools consider the full costs of school siting in the cost of building a new school (roadway expansion, injuries, travel delay, etc.)?
 - What tools can help school planners consider walking and biking of their students when deciding upon location and size?
 - Should school zones consider how well they serve active transportation to and from school to reduce vehicle travel demand (e.g., avoiding locations that require students to cross major roads or adjusting school attendance zones to avoid major road crossings)?
 - How can plans for school siting trigger measures to increase neighborhood connectivity—intersection density (e.g., zoning changes within certain proximity of schools to require connections or required connections to surrounding neighborhoods)?
 - Should subarea planning be required as part of the school siting process?
 - What measures could help facilitate local or active trips to existing schools?
 - How can school planners obtain more input from public health professionals as part of their school siting decisions?

Bicycle and Pedestrian Planning

Reduced travel demand on community arterials can allow for road designs that reduce crossing distances and reduce speeds. This would allow for right-of-way that could be converted to use for people walking or bicycling in the form of wider or physically buffered sidewalks and physically protected bike lanes. To do this, measures would need to be in place to support local trips that do not require arterial travel. One way to do this is to create activity friendly routes to everyday destinations.

This strategy is supported by the Community Services Task Force for Preventive Services at the CDC as a way to promote health. These research questions explore how to best encourage these routes.

- How can plans for road expansion or mitigation measures overcome barriers major roads pose to people crossing them on bicycles and pedestrians?
- How can plans for major road expansions trigger area improvements in bicycle and pedestrian connectivity (e.g., expansion of greenways and parallel, separated pathways)?
- What can be done to existing arterials to facilitate safe, accessible bicycle–pedestrian–collector crossings?
- How can land use and zoning require the creation of local and regional active transit corridors (e.g., along existing easements or major road expansions)?
- How can land use and zoning require active transportation connections to neighborhood and local commercial nodes and schools?
- How can land use and zoning require amenities that support active transit (e.g., benches, water fountains, bathrooms, secure bike parking, and bike share)?
- Who pays for sidewalks? Communities where adjacent property owners, rather than the city, pay for sidewalks may have fewer continuous sidewalks and poorer sidewalk maintenance. How should the equity issues dealing with low-income property owners be considered?
- How will trends in shared vehicles, autonomous vehicles, and electric vehicles impact exurban arterial design in relation to pedestrians and bicyclists?
- How can transportation planners obtain more input from public health professionals as part of pedestrian and bicycle planning decisions?

Transportation Planning

Roadways are essential to society. High-volume, high-speed arterials have a place in the transportation network, but they may have been over prescribed and many communities are suffering from having too many of them. Roadways need to serve all users including the people who live near them. They should balance throughput for automobiles with the health impacts on the community. This section explores questions to consider when designing and redesigning arterials to achieve a balance between the needs of community along with those using them for regional travel.

- How can major exurban road expansions accommodate safety for all users?
- Should plans for major road expansions include a wider subarea plan in the planned transportation improvements so that local and collector trips are removed from the community's arterial?
- How should the design speed of these major road expansions be determined?
- How should major exurban roadway expansion accommodate transit planning?
- How can major exurban roadway expansion integrate itself into the community fabric so that it doesn't pose a crossing barrier for all modes?
- What strategies can mitigate the negative health impact to the people who live in the places through which an existing arterial travels?
- Are there novel ways to use existing right of ways in more efficient ways? Can pedestrian and bicycle trail networks be expanded by increased use of existing right-of-ways used by utilities (electric, water, sewer, gas, etc.)? Can "rail with trail" networks be expanded on rail rights-of-way?

- How can transportation planners obtain more input from public health professionals as part of transportation planning decisions?

Retail and Commercial Planning

Land use and transportation planning often focuses on ways to facilitate the daily work commute without sufficiently accommodating the everyday utilitarian trips. As a result, these utilitarian destinations often also fall on the community arterials thus increasing travel demand on the road. One strategy to explore in reducing travel demand on the commercial arterial is to encourage the location of the utilitarian destinations within the community accessible by active transport networks and local roads. By making the utilitarian trip a local trip on local roads or active transport networks, land use planning can reduce demand on the community's arterials.

- Can adjustments in retail zone planning help reduce travel demand on major roadways?
 - How can access to retail developments encourage local trips or active transport trips?
 - Should subarea plans accompany plans for major roadway expansion to guide retail, commercial, and residential redevelopment?
 - Should subarea plans accompany plans for major retail development to facilitate local or active trip connections?
 - Can the creation of neighborhood commercial nodes help encourage local or active trips?
- Is this a viable approach?
- How can existing arterials be retrofit to support commercial activity accessible via local or active trip?

Environment and Metrics

In developing this case it was difficult to categorize all the issues that were discussed by the task force. Below are some of these.

- How can major roadway expansions mitigate the heat island effect?
- What level of shade should a major roadway expansion require?
- How should major road expansions manage storm water during extreme storm events?
- What are the metrics that should be used to determine how exurban roads perform?
- What is the ideal intersection density on arterials?
- Mode split within geographic subarea of the road (to measure how the road impacts communities surrounding it).
- What is the ideal land use and zoning surrounding the road?

Progress Is Occurring

There is progress being made when dealing with exurban, suburban, and urban arterials and health. Two efforts—FHWA's *Framework for Including Health in Corridor Planning Process* and the Urban Land Institute's *Healthy Corridor Project*—were noted in the previous chapter. Another relevant effort underway is being guided by the American Planning Association (APA).

APA's Metrics for Planning Healthy Communities

The information from this report and website can be used to assess, measure, monitor, and report progress toward healthy planning goals. It leverages existing indicator systems, indexes, interactive maps, and literature about social determinants of health. With it APA has identified the five domains where planners could intervene to improve health:

1. Active living,
2. Healthy food system,
3. Environmental exposure,
4. Emergency preparedness, and
5. Social cohesion.

These five domains are further divided into 14 different subdomains based on different topics—all of which have transportation implications. (Available at <https://www.planning.org/publications/document/9127204/>. Accessed Aug. 19, 2018.

Even with these tools, the larger questions raised by the Task Force in the Case Studies remain.

CHANGING TECHNOLOGY, ARTERIALS, AND HEALTH

Technology is changing rapidly in both the operation of the roadway and with the vehicles using it. Coupled to these changes are the ways people are traveling. Just a generation ago terms like shared-use mobility, ride-hailing services, transportation network companies, bikesharing, driverless vehicles, smart roadways, transportation management centers, vehicle and bike docking, autonomous vehicles (AVs), and vehicle-2-pedestrian did not exist.

What this means for arterials and health is that although the future is somewhat unclear, it is that much more important to begin to think through the implications of these various changes and plan for the future. While technology offers great promise, it can come with unintended consequences. For example, with the advent of the smartphone and its mass appeal have also come some negative consequences. First it was dealing with distracted drivers but now terms like distracted walkers and cyclists are finding its way into the transportation parlance.

Looking historically at major technological developments that have occurred in a short period of time should be reminders that we need to be asking questions and exploring potential impacts of our new technologies as we move forward. Without doing the proper due diligence there could be some serious consequences both intended and unintended. For example, would we have designed the urban Interstate system the way we did had we known then what we know now about its impacts on our communities' health and design? Would the government have stepped in earlier to protect and reform the street car industry had we known then what the impact an automobile-driven society would be?

Vehicle technology is changing rapidly, and will influence the flow and safety of vehicles on arterials. AVs offer the promise of greater safety and improved throughput on arterials. But is this technically advanced vision going to be an improvement for health, or a detriment? One study has

Seeking Harmony in Arterial Designs for All Users

In an ideal world, arterials would serve all users well, irrespective of their mode of travel, supporting healthy living in a variety of ways. The rise of the Complete Streets approach to street design is a positive sign. By providing dedicated space for each mode, safety and accessibility increase for the common good.

An example in Santa Monica, California, is the reconfiguration of Ocean Boulevard. Implementation of a Complete Streets concept which includes parallel parking, a center left-turn lane, and bicycle lanes resulted in dramatically improved safety. According to the City of Santa Monica, the total number of crashes dropped 65%, from 35 to 12, in the first 9 months after the changes occurred. Crashes that resulted in injury plummeted by 60% during that same 9-month time frame.

In parallel with greater acceptance of Complete Streets, the way streets are being used is changing, with the rise of AV and rideshare services. Will these technological advances enhance safety and public health? Proponents of AVs promise safety as a key benefit. Rideshare services can enhance access in areas with poor transit service, but do they provide an equitable transportation market? Evolution is occurring quickly, and there is a need to understand the effects of these changes, to define appropriate policy frameworks for their use.

projected increased trip-making with AVs (8). However, this might not be a major impact in terms of emissions, if electric and hybrid vehicles continue to increase their market share. But what about VMT, circulation, flow? Or the networks the vehicles use? How might these play out as we become more concerned about the public's health?

Full AVs could make walking (and cycling) safer and thus support improved health. However, this is not a foregone conclusion. Consider some potential scenarios:

- How will green time for arterials be allocated? If AVs equate to greater throughput, then some of the green time could be re-allocated to side street crossings while maintaining the current capacity instead of increasing it. However, jurisdictions may prefer to prioritize vehicular throughput instead of pedestrian safety and access. After all, this has been the historical paradigm. Governments could, however, balance the projected increase in throughput with enhanced pedestrian crossings by reducing the spacing between intersections (or pedestrian crossovers). Research is needed into policy frameworks related to AVs, to define how to balance the needs of pedestrians and cyclists with those of drivers, in terms of frequency of regulated crossings and green term allocation along and across arterials. This also reinforces the need to define a methodology which balances vehicular accessibility with health for the common good.
- Will fewer people walk or ride bikes if plentiful AV trips are available at a cheap rate? Again, how can transportation policy be formulated and regulated to balance AV control with the goal of a physically active society?

The way people use vehicles is also changing rapidly. The rise of ride hailing, app-aided services, and other car-sharing services, and the ability to call up these services on a smartphone, are all contributing to lower auto ownership rates in some age cohorts. While precise predictions for auto ownership rates are unclear, what this means for arterials is even less clear. The situation is evolving and there is a great deal of variation among jurisdictions. However, it can be stated with certainty that carshare arrangements will generally form a greater part of the traffic stream in most urban centers suggesting that there will be more pick-up and drop-off activity around and along arterials. Planning and research is needed to identify the optimal supporting networks of

collectors, local streets, and access points needed to support this activity. How should the allocation of space among modes on arterials be handled? Is there an appropriate planning policy framework in place so that carshare vehicles do not overwhelm available capacity?

Research Questions, Issues, or Concerns

- How will trends in shared vehicles, AVs, and electric vehicles impact urban arterial design in relation to pedestrians and bicyclists?
- How will arterial access design transform over time as the new modes and vehicles evolve?
- What effects and impacts can be anticipated on things like traffic, pollution, and the built environment as we move to AVs, carshare, and bikeshare environments?
- What are some potential future scenarios for urban form given the emerging technologies?
- How might cities change in face of the new technologies? What would an arterial of the future look like? Will it be more people-friendly? What policies or incentives are needed to make arterials people-friendly?
- How do we make use of flexible infrastructure as arterials become more efficient with AVs and other technological improvements?
- How will traffic signals and other infrastructure be networked into this system and what data can we get from this infrastructure?

When should questions about health implications of new and emerging technologies be topics for study and policy discussions?

Carshare Services

- How will increased use of carshare and ride-hailing services affect public health? Will this increase in use allow greater access to social, medical, and other services? Will it increase inequities in travel, for those who do not have the technology to access carshare services, and thereby reduce access to services?
- What is the appropriate planning framework for arterials, in terms of allocation of space among modes including carshare?

Autonomous Vehicles

- To what extent will the increasing prevalence of AVs or semi-AVs impact public health? There may be impacts on safety, or access to social, medical, and other services.
- What are the health benefits that AVs offer and in the same token what are the dis-benefits?

Example of Progress

Change to create arterials that balance between access and mobility across all modes is underway in many jurisdictions in North America. One example of progress is Cloverdale Avenue in Winston–Salem, North Carolina, a high-traffic corridor. Only one sidewalk was available for pedestrians traveling through the intersection to get to the local hospital, grocery store, nearby elementary school, and religious institutions. Pedestrians must cross two intersections lacking marked crosswalks, where wide-curb radii encourage motorists to speed around curves with little or no visibility. After a pedestrian fatality highlighted chronic safety concerns, neighborhood groups began working with city and Winston–Salem–Forsyth MPO officials to improve pedestrian conditions. A phased implementation of improvements has now created a safer multimodal street. (Available at <http://www.completestreetsnc.org/project-examples/ex-cloverdale/>. Accessed Aug. 19, 2018.)

TOOLS, MODELS, RESEARCH, AND ANALYSIS

This is an area that is ripe for research, development and creative thinking. Looking across the planning landscape there are a variety of tools at the intersection of health and transportation. There are tools that yield raw or processed data, analytical models that attempt to answer specific questions and policy tools that help guide decisions and analysis. Even with the variety of tools that are available and being developed they only brush the surface in terms of questions, concerns and issues facing those working at the intersection of transportation and health. Is the analysis to be regional or macro, or is it to be street-level? These are just some of the questions.

As a first step the Task Force realizes that there needs to be some sort of inventory and categorization of the models and tools available when considering arterial and health questions. In Figures 1 and 2 the Task Force has attempted to identify and annotate some of the known models by putting them into two separate classes: Data Tools and Policy/Planning/Behavioral Models.

A separate but adjunct piece of the inventory is the need to identify and annotate the relevant data sets that could be used. In an attempt to jump start the data inventory, the TRB Subcommittee on Health and Transportation has developed a working inventory that begins to document the various data sets. This inventory was done in concert with the TRB Committee on Urban Data and Information Systems. It can be found through the subcommittee’s website (<http://www.trbhealth.org/>; accessed Aug. 19, 2018) and is being maintained as part of the Travel Forecasting Resource (http://tfresource.org/Travel_Forecasting_Resource; accessed Aug. 19, 2018), an online Wiki administered by TRB.

The inventories noted above are only the beginning steps of what could be a much larger effort. They are presented as examples of where and how to begin to develop a framework around the “technical” aspects of this very complex multi-disciplinary area. Several on the Task Force felt strongly that this approach of building from the ground up with what we know was a very valid way to move forward toward the more sophisticated technical model-related issues.

Model development is also an area of concern. Blending health metrics and concerns into land use, transportation, traffic simulation–operation and design models all present an enormous challenge to the field. Are our current model constructs adequate to bring health concerns into them?

What data and models are needed? What research needs to be done to support those models? Where does one start?

Another modeling issue that the Task Force spent a fair amount of time discussing was model uncertainty. It is generally accepted that there is a high level of uncertainty in transportation (travel demand models) and some air quality-related models. It is also accepted that for transportation models, this uncertainty is rarely assessed and output for further consideration or evaluation. Bringing health outcomes into the process adds just another degree of uncertainty. Determining and communicating uncertainties in transportation, air quality and health model results is a long-standing challenge and ripe for additional research and investigation.

I-15 Corridor and Local Arterial Improvements— Environmental Impact Study

As part of an Environmental Impact Study (EIS) review FHWA noted in its comments that “information is incomplete or unavailable to credibly predict the project specific health impacts due to changes in Mobile Source Air Toxics (MSAT) emissions associated with a proposed set of highway alternatives. The outcome of such an assessment adverse or not would be influenced more by the uncertainty introduced into the process through assumption and speculation rather than any genuine insight into the actual health impacts directly attributable to MSAT exposure associated with a proposed action.

“The methodologies for forecasting health impacts include emissions modeling, dispersion modeling, exposure modeling and then final determination of health impacts with each step in the process building on the model predictions obtained in the previous step. All are encumbered by technical shortcomings or uncertain science that prevents a more complete differentiation of the MSAT health impacts among a set of project alternatives.”

FHWA-NV-EIS-09-01-F, 2010, p. 613. Available at http://ndotprojectneon.com/Archives/reference_information_documents/environmental-hazmat/Project_NEON_FEIS_6-2010_Signed.pdf. Accessed Oct. 5, 2018.

Supporting and helping to build the needed models will come from an investment in research. When considering arterials and health, and for that matter the larger intersection between transportation and health the research needs are vast and this could be an exciting time for those interested in this area. Research needs range from basic, to applied, qualitative to quantitative. Just as with the tools, data and models that are being developed the research also needs to be well inventoried and brought to one closer together. Relevant research is in the health sectors but it does not always trickle over to the transportation sections and vice versa. This was brought out in many of the Task Force discussions. One product due out in the spring of 2019 that the Task Force anxiously awaits is NCHRP 20-112: A Research Roadmap for Transportation and Public Health (<http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4151>; accessed Sept. 7, 2018).

Research Questions, Issues, or Concerns

Data

- What types of transportation and health data are needed and how should they be organized to facilitate their use?
- What if data are available at a different resolution than what the model requires?

- What quantitative measures are most representative of users and neighbors of the transportation system to air pollution exposure, noise, and safety? How do these measures differ between motorized and nonmotorized users?
- What data is needed to build that perfect transportation–health model?

Models and Tools

- What models are readily available to assess public health impacts? Traffic models? Air pollution? Noise? Accessibility?
- What public health outcomes should be considered and included in the models? At what spatial or temporal resolution would they be reported?
- Can these models be used for project-level analysis or are they focusing on regional-level impacts?
- What are the shortcomings of the models?
- Where does both traffic-derived noise and sound (like sirens) come into the analytical process? Project level? Regional level?
- What are the indicators of noise that should be considered? Is it distance from different types roadways, type of vehicle traffic, roadway design, speed, or something else?
- Can the *Highway Capacity Manual* (HCM) recognize and capture the health impacts to users of the facility?
- Can models be developed to recognize that higher vehicular speeds can equate to better performance for vehicles but may have both positive and negative health impacts of the people using them?
- How can the operational performance of arterials be assessed to understand both the operational and health impacts and the interdependencies between the impacts?
- Can the existing tools for transportation modeling or scenario planning be modified to include health outcomes?
- What is the optimal geographic scale for analysis?
- How can we bring health into the traditional travel demand models?

Public Health Research Approaches to Complete Streets and Transit

National Institutes of Health funding for research on transportation and health has addressed air pollution, access to health care and a recent emphasis on physical activity (PA) related to complete streets and transit infrastructure. This recent interest reflects the epidemics of obesity (1) and sedentary behavior (2). Active transportation research focused on health emphasizes study designs that examine causal influences of the environment on health behaviors, physiological outcomes such as fitness or obesity and disease. Recent examples include grants to evaluate complete streets, bus rapid transit and light rail programs in Houston (3), Salt Lake City (4), and Seattle (5). Health-oriented studies of transportation are adopting pre-test post-test study designs and often include a comprehensive suite of measures assessing transportation behavior, physical activity and psychological factors related to transportation and PA behavior. A major question addressed in health research has been whether increased transportation related PA is associated with reductions in total PA. The study in Salt Lake City found no evidence for such “compensation.” This work has also contributed to a growing interest in improving methods for the evaluation of natural experiments (6–8). Evaluations of arterial design and redesign projects could benefit from attention to these health studies. Every transportation project does not require evaluation aimed at assessing causal influences on behavior, but studies from the health sector can identify useful outcomes and are starting to quantify some of the health benefits of transportation infrastructure. More rigorous studies addressing arterials are needed as past studies have emphasized bus and light rail.

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FIGURE 1 Data Tools

Transportation Health Tool (DOT/CDC). This online tool allows users to understand how specific communities or states compare in terms of key transportation and health indicators. Available at <https://www.transportation.gov/transportation-health-tool>. Accessed Aug. 19, 2018.

County Health Rankings (RWJF). Measure the health of nearly all counties in the nation and ranks them within states using a variety of national and state data sources. Available at <http://www.countyhealthrankings.org/>. Accessed Aug. 19, 2018.

Walk Score (Redfin). The privately owned product is a large-scale, public-access walkability index that assigns a numerical walkability score to any address in the United States, Canada, and Australia. It also serves up data on travel time, food deserts, apartments, and neighborhoods. Available at <http://www.walkscore.com/>. Accessed Aug. 19, 2018.

Health Transportation Shortage Index (HTSI). The HTSI is a new tool (2012) developed to help identify areas and communities where transportation shortages contribute to the difficulty of children getting health care. The HTSI uses a scoring protocol to identify the most important factors associated with transportation barriers to child health care access. Available at http://issuu.com/childrenshealthfund/docs/chf_htsi-monograph__2_. Accessed Aug. 19, 2018.

EPA Smart Locations Database (SLDB). The SLDB is a nationwide geographic data resource for measuring location efficiency. It summarizes characteristics such as housing density, diversity of land use, neighborhood design, destination accessibility, transit service, employment, and demographics. It is coupled with a second data system that allows users to examine the accessibility of a region to jobs by transit and automobiles as well walkability scores. Available at <http://www.epa.gov/smartgrowth/smartlocationdatabase.htm>. Accessed Aug. 19, 2018. And <https://www.epa.gov/smartgrowth/smart-location-mapping#walkability>. Accessed Aug. 19, 2018.

America's Health Rankings (AHR). For nearly three decades the AHR has provided state by state data on national indicators of health, environmental and socioeconomic characteristics aimed at establishing national health benchmarks and state rankings. Available at <https://www.americashealthrankings.org/>. Accessed Aug. 19, 2018.

AARP Livability Index. The Livability Index scores neighborhoods and communities across the United States on eight indicators, including transportation that affects the social well-being of those in the area. Available at <https://livabilityindex.aarp.org/>. Accessed Aug. 19, 2018.

FIGURE 2 Policy, Planning, and Behavioral Models

Healthy Community Design Checklist Toolkit (CDC). The Toolkit was developed to help planners, public health professionals, and the general public consider health in community planning. Available at <http://www.cdc.gov/healthyplaces/toolkit/>. Accessed Aug. 19, 2018.

Transportation and Health Toolkit (APHA). Provides information on the links between health, equity, and transportation and APHA's efforts to ensure that transportation policy helps public health. Available at <http://www.apha.org/advocacy/priorities/issues/transportation/Toolkit.htm>. Accessed Aug. 19, 2018.

Built Environment and Public Health Clearinghouse (APA). This is a resource for training and relevant news about the intersection of health and place. It was developed by APA, APHA, Georgia Tech, and the National Network of Public Health Institutes. Available at <https://www.planning.org/nationalcenters/health/bephc/>. Accessed Aug. 19, 2018.

Integrated Transport and Health Impact Modeling Tool (ITHIM). ITHIM provides integrated health impact assessment of transport through changes in physical activity, road traffic injury risk, and urban air pollution. ITHIM can either be used as a stand-alone model, or linked to other transport and health models. It can be used for development of scenarios, for estimation of changes in exposures, and for modelling health outcomes. Available at <http://www.cedar.iph.cam.ac.uk/research/modelling/ithim/>. Accessed Aug. 19, 2018.

Health Economic Assessment Tool (HEAT) for cycling and walking. HEAT is based on European data and can be used by "novice" or small planning agencies. HEAT calculates the answer to the following question: if x people cycle or walk y distance on most days, what is the economic value of mortality rate improvements? Available at <http://www.euro.who.int/en/health-topics/environment-and-health/Transport-and-health/activities/guidance-and-tools/health-economic-assessment-tool-heat-for-cycling-and-walking>. Accessed Aug. 19, 2018.

Sleep, Leisure, Occupation, Transportation, and Home-based activities (SLOTH) model. The SLOTH model provides guidance regarding interventions that might increase physical activity in each of four non-sleep domains (economic efficiency, equity, effectiveness, and feasibility). Available at <https://www.ncbi.nlm.nih.gov/pubmed/15450624>. Accessed Aug. 19, 2018.

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Task Force Member Statements

The Task Force made a concerted effort to balance its membership with health and transportation professionals from both the public and private sectors and academia. On the transportation side, TRB committee leadership was sought from design, operations, and planning. To match the transportation perspectives and have an equal number of Task Force members from health organizations, leadership from public health agencies and academia were also sought out. The diversity of the Task Force's membership allowed members to learn from each other about their various disciplines. To assure that the diversity of expertise, opinions, and beliefs was not lost during the preparation of this E-Circular, each member was asked for a short statement introducing what they see as key issues and concerns related to the mission of the Task Force. Taken together, these statements provide another dimension of the complexity and importance of the issues that need to be addressed at the intersection health and transportation, especially where arterials are concerned.

Disclaimer:

The comments, statements, and opinions expressed by the Task Force members are solely the responsibility of the individual member and do not necessarily represent the official views of the organizations, agencies, or companies where they work.

Bruce Appleyard

San Diego State University

As one who has spent much time examining the transportation, land use connection, in particular how traffic interfaces with people and communities, arterials are key spaces where transportation and land use intersect to either work in concert, or against each other. Issues of access, form, speed, commercial long-haul transportation, and street livability, to name but a few, all come together—in short, arterials are where the rubber meets the road for the transportation land use connection and livability. These experiences have contributed to my theories about the transportation, land use imbalance, and disconnect, where institutional and professional structures are out of sync with each other, and failing to optimize multiple benefits regarding the sustainability, livability, and equity of our communities.

Often, this disconnect between top-down decisions from transportation and incremental decisions from land use can put an arterial's purpose and identity in question—actually giving them multiple personalities. Is its purpose to give people access to shops and businesses, to facilitate long trips, or to facilitate economic development and growth? In terms of place identity, do you want a causeway, or a cause to be there?

As my work on *Livability Ethics* and *Livability Justice* noted below outlines, our challenge is to intentionally mediate these conflicting pursuits in these contested spaces so that transportation land use approaches are balanced and work in concert with each other, and that the needs of the powerful (including modes) do not overrun the needs of the vulnerable. This is the way forward to ensure arterial corridors can provide the best outcomes for sustainable, livable, and equitable mobility and access for all.

I am an Associate Professor of City Planning/Urban Design at San Diego State University (SDSU), who is helping people and agencies make more informed decisions about how we live,

work, and thrive. I am a humanist/futurist working at the intersection of transportation, urban design, and behavioral economics and one of the lead authors of the American Planning Association's textbook on *The Transportation/Land Use Connection*, as well as TRB's new *Handbook for Building Livable Transit Corridors* (<http://www.trb.org/Main/Blurbs/174953.aspx>; accessed August 19, 2018) and Livability Calculator (<http://www.livabilitycalculator.com/>; accessed August 19, 2018). I am also an Associate Director of SDSU's Center for the Study of Human Dynamics in the Mobile Age and Active Transportation Research Center. I have combined GIS and a variety of visualization tools and methods to better engage members of the public in scenario planning, pedestrian and bicycle planning and design, and regional–local transportation and land use governance and policy integration. Recently I developed an online Smart Growth/Livability Calculator (<http://smartgrowthcalculator-dev.herokuapp.com/index.html>; accessed August 19, 2018) to help the people of California. I am also a recipient of the Robert Wood Johnson Foundation's Top Ten Living Heroes Awards and a member of the Mineta Transportation Institute's research team. I hold a doctorate as well as masters and bachelor degrees from the University of California, in the town of Berkeley where I grew up.

In one of my more recent talks titled *Creating Smart & Livable Cities: The Transportation/Housing Connection* and is based on the following articles: *A Manifesto for Street Livability, Health, and Humanity in the Era of Driverless Cars* (<https://www.planetizen.com/features/96769-10-principles-toward-more-sharing-and-less-sprawl>; accessed August 19, 2018) and 'Doing the Right Things' Before 'Doing Things Right': A Conceptual Transportation/Land Use Framework for Livability, Sustainability and Equity in the Era of Autonomous Vehicles (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3040783; accessed August 19, 2018).

Alina Baci

NASEM Health and Medicine Division

I direct the Roundtable on Population Health Improvement at the National Academies of Sciences, Engineering, and Medicine. Population health refers to the health outcomes of people living in a defined geopolitical area and the distribution of such outcomes within that group of people (Kindig and Stoddard 2003; Jacobson and Teutsch 2012). Multiple National Academies activities have noted the importance of examining the health and transportation interface and the need to improve collaboration toward shared aims—from the 2005 report *Does the Built Environment Influence Physical Activity? Examining the Evidence*, to the 2017 report *Communities in Action: Pathways to Health Equity*. The roundtable itself held a workshop in 2013 that showcased innovative work at the interface, such as the U.S. DOT's Transportation Investment Generating Economic Recovery discretionary grants and the Massachusetts Healthy Transportation Plan.

Public health leaders have for some time understood transportation as one of the SDOH, but the health sector more broadly has come to recognize that many of the solutions to population health challenges reside outside the clinical care sector. Hospitals and health systems acknowledge transportation as a "health-related social need" (as defined by the Center for Medicare and Medicaid Innovation in 2017) and also as a community health need in assessments they conduct to meet Internal Revenue Service requirements for tax-exempt hospitals.

Transportation touches health at many different points—from facilitating access to health-care services and other health-relevant destinations, to enabling active (and health-promoting) transit. Cross-sector efforts, such as the TRB Task Force on Arterials and Public Health can play a crucial role in enhancing dialogue, addressing disciplinary and language differences, and building common ground for health professionals and transportation planners, among others, to work together fruitfully to achieve shared objectives that advance mutually reinforcing goals of livability, greater economic opportunity, and well-being.

David Berrigan

National Cancer Institute

The subject of transportation and health has emerged as one of the most fascinating areas of my portfolio as Program Director in the Division of Cancer Control and Population Sciences at the U.S. National Cancer Institute. I see research on this topic as a path towards supporting social justice by providing evidence for policy-makers in the decisions that lead to the creation of communities that are good for people and good for the environment.

My perspectives on transportation are informed by my own life history. I have lived in highly rural environments (e.g., Albion, California, population 312); highly urban environments including Manhattan, Seattle, and Melbourne; and for the past 15 years, a quintessentially suburban environment north of Washington, D.C. Together these experiences have shaped my perspective on transportation and health and fostered a strong belief that we need to promote equity, autonomy, and mobility across the life course. My training in ecology and evolution reinforce the idea that these needs must account for environmental factors and my current work in public health indicates that active transportation can play a central role in healthy time use and can aid people in achieving levels of physical activity that reduce critical health risks, including cardiovascular disease and cancer at multiple sites.

As a high school student in Northern California in the 1970s, my friends and I hitchhiked everywhere. Our rural community understood that giving a kid a ride supported autonomy, mobility, and access. Ride-hailing services monetize a potential path towards widespread ridesharing that could address social and environmental goals related to transportation. Ride-sharing along arterial roads could be the start of IT-driven cooperation in reducing the prevalence of single-occupancy vehicles. Informal transit services and slugging are steps in this direction.

Bike and public transit commuting from 1993 to 1999 in Seattle and Melbourne, cities notable for their bike trails and fairly good transit systems, highlighted the supportive nature of adequate infrastructure for active transportation including safety, security, and facilities extending from the street to the school or office. Arterial roads could provide extended anchors for this infrastructure, incorporating bike lanes and fostering workplaces with appropriate secure bike storage and personal facilities. Active transportation can contribute to reducing disparities in physical activity. However, more work is needed to address the challenges of time use and time poverty. People dependent on public transportation may gain healthful physical activity, but they may suffer from inconvenient schedules and multiple transfers required for adequate mobility. Work on how to improve arterial roads as resources for all modalities can help address health disparities on several fronts.

Since 2002, I have commuted to work in my own car. Our transportation decisions can and are influenced by many factors including stage in the life course, transportation

infrastructure, technology, weather, economics and family circumstances. I am convinced that we can do better in serving health, health equity, community and the environment via our transportation infrastructure. At the National Institutes of Health we have begun funding efforts to evaluate the physical activity consequences of complete streets, light rail, bus rapid transit, and other elements of active transportation infrastructure. Demonstration of net increases in physical activity associated with transportation infrastructure could lead to funding support for interventions aimed at increasing active transportation and subsequent exploration of dissemination and implementation research on how to expand the reach of healthy planning decisions related to arterial roads.

These anecdotes are intended to illustrate how many different personal, social and environmental factors influence transportation choices. Research in this topic demands multidisciplinary teams and transdisciplinary thinking. Let's keep trying to create the neighborhoods and communities we want to live in and that our children want to live in too.

Eleni Christofa

University of Massachusetts–Amherst

I am an Assistant Professor in Civil and Environmental Engineering with a focus on Transportation Engineering at the University of Massachusetts–Amherst. My expertise is on traffic operations and signal control, public transportation, and safety for nonmotorized users. My research has focused on the development of sustainable management strategies and geometric design that improve person mobility, air quality, and safety in urban multimodal transportation systems.

Transportation engineers do not typically think of health outcomes when designing roadways or transportation management strategies. While recent research has been addressing sustainability issues in transportation engineering by accounting for energy consumption, air pollutant emissions, safety, and efficiency metrics, it still lacks a direct connection to health outcomes and burden of disease that are important in the public health professional and research communities.

Personally, in addition to the sustainability work I have been pursuing, I have been recently involved in projects with interdisciplinary teams that include transportation and health researchers and professionals and have been working on calibrating tools that integrate transportation and health impacts, as well as identifying ways to incorporate health impacts in transportation project decision-making. Through this work I have experienced firsthand the challenges associated with integrating issues related to arterials and public health and I see the mission of this Task Force as one that can help overcome hurdles that separate disciplines and obstruct progress towards healthy communities.

Terminology, types of data, and data resolution, as well as types of information that are essential for assessing health outcomes, are just some of the examples that can greatly differ among disciplines. I remember having a long conversation on what the definition of an arterial is during the first few months of this Task Force.

In addition, health is impacted in multiple ways by transportation infrastructure and operations, and the impact of those on air quality, physical activity, safety, and accessibility to different types of modes, and resulting accessibility to opportunities (i.e., jobs, housing, or health

care). This creates the need for effective multidisciplinary discussions, collaborations, and solutions and makes it impossible for one person to be the expert.

There are also gaps in how to quantify the impact of transportation decisions on all of the determinants of public health, due to the unpredictability of human behavior that affects traveler decisions, but also long-term decisions on where people choose to live and work, all of which affect their health outcomes.

Another challenge is weighing the importance of the different components that contribute to health outcomes when making decisions. In addition, accounting for the multiplicative and in some cases conflicting impacts that a certain transportation project might have on health outcomes can be an issue. For example, one could claim that installation of a bike lane increases bicycling in an area and therefore it improves health outcomes for the population of that area, but if located next to a busy highway, it would also increase exposure to harmful pollutants. How should a decision be made as to whether this project is worthwhile from a health perspective? How accurately can traveler behavior be captured so it can inform the assessment of health outcomes? Data resolution that can be very different for different types of impacts (e.g., arterial level versus regional level) can impose additional challenges when trying to integrate multiple transportation impacts on health for decision-making.

I believe that the purpose of this Task Force is dual: 1) to bring a multidisciplinary group of experts in public health, epidemiology, air quality, planning, and transportation engineering to discuss and identify common grounds for assessing the connection between transportation and health, and 2) allow these experts to determine areas that require additional research, which could lead to healthy communities. I am thrilled to have been participating in this Task Force not only for contributing in this important mission to make our communities more livable, but also from a personal perspective for the opportunity it has given me to interact with experts in different areas, learn from them, and broaden my horizons in other aspects of every-day life that are important to consider in transportation-related research.

Ed Christopher

Independent Transportation Planning Consultant

I am an independent transportation planning consultant who spent 15 years in federal service, 13 with FHWA, and two with the Bureau of Transportation Statistics. I also worked 20 years at the Chicago Area Transportation Study, the MPO for the Chicago region. I first became involved with health and transportation issues in 2008 when I organized paper reviews on the topic for the TRB. This activity morphed into a co-chairmanship of the newly formed Health and Transportation subcommittee in 2011 and chair of the Arterial Health Task Force in 2015.

When it comes to health and transportation, especially the mission of the Arterial Task Force, one thing I would like to see is a sustained commitment to health from the leaders of our transportation agencies, organizations, and associations which transcends the federal, state, regional, and local levels. While we have achieved some top management acknowledgement of health in our transportation field, it has not been sustained nor has it lead toward advancing many of the issues expressed in this E-Circular.

While the focus of TRB and this E-Circular is research based, many of the issues for me are organizational, institutional, and governance related. Several years ago when the TRB Health and Transportation subcommittee was calling for the development of the arterial Task Force, I

met with Barbara McCann, Director of the Office of Policy Development, Strategic Planning and Performance at the U.S. DOT. She asked me what my health and transportation bottom line was: “If you were czar for a day and could do one thing to accomplish your health goals what would you do?” I thought for moment and said I would require the appointment of health officials on each and every transportation planning board, commission, policy committee, and decision-making body throughout the country. That was my dream.

Having spent many years in the MPO planning environment I have respect for their “inclusive” decision-making authority. I believe that if you have the right people at the table they will figure things out and do good things for society. Our problems have occurred because of exclusionary, siloed, and interest-driven decisions. As I see it, planning à la Robert Moses is not the way for equitable, socially viable, and sustainable progress.

When I first started to work with health officials, epidemiologists, and public health planners I had two observations. First, I was overwhelmed at the professional and scientific rigor they applied to their work. In my field of transportation, when we run out of data we make it up, extrapolate it, impute it, make a model, or just make an assumption and make a decision without it. However, what I have seen on the health side is that when they run out of data, they stop work. I never heard of the term “evidenced-based decisions” until I met up with health planners. I know this is an overly simplistic and general observation, but the point is I have been very impressed and overwhelmed with the adherence to professional and scientific rigor that comes from the health community. On the downside, I have seen this act as a detriment to advancing health concepts in the transportation arena because of a general lack of evidence-based cause and effect results between transportation projects and health outcomes. Hopefully this E-Circular will motivate research in this direction.

My other observation is from a public policy angle. On the surface one would think it would be a no brainer for elected officials and our administrative leadership to be on board with and embrace the notion of enhancing the health and wellbeing of the American public. Yet there seems to be somewhat of a passivity or token acknowledgement when it comes to bringing the health and transportation disciplines closer together. I cannot figure it out. Why isn’t this a priority for the U.S. DOT? Where are our transportation organizations like AASHTO, AMPO, and National Association of Regional Councils on this? Why doesn’t TRB put Health and Transportation on the same organizational level as soils and rock properties? After spending over 35 years in the transportation planning arena I know why this has occurred, but I do not understand it. Hopefully this E-Circular and the effort and discussions that went into it will help stimulate more activity and aggressive research.

Janice Daniel

New Jersey Institute of Technology

I am a professor at New Jersey Institute of Technology in the Department of Civil and Environmental Engineering where my teaching and research falls in the areas of transportation safety and operations. I have served as the Principal Investigator for several research studies in the area of motor vehicle injury prevention and policy evaluation. Some of these projects include investigating truck safety within the state of New Jersey; developing policies for implementing shoulder rumble strips without unduly creating unsafe conditions for bicyclists; evaluating the safety and operational

impacts of a bus stop design; investigating design solutions for reducing vehicle speeds; evaluating work zone safety; and developing materials for a state website on teen safety.

I was drawn to the Arterial Health Task Force through my involvement on the TRB Highway Capacity and Quality of Service Committee (HCQSC). The HCQSC is responsible for the development of the nationally and internationally recognized HCM used for estimating capacity and level of service for transportation facilities. I have been associated with the HCQSC for over 20 years, first as a friend to the committee and later as a member and chair of the HCQSC Urban Streets Subcommittee. In this role, I was involved in setting national standards for performing operational analysis of urban streets. It is through my involvement with the HCQSC that I have come to see the benefits of evaluating the performance of an arterial not just based on its operational performance but to evaluate the urban street system. The sixth edition of the HCM provides a multimodal analysis of urban streets from the perspective of motorists, pedestrians, and bicyclists. One limitation of the urban street analysis is that it does not explicitly incorporate the safety and health issues associated with the operation of the roadway. To design and operate safe roadways, there is a need to better understand the relationship between the safety and operational performance of the roadway treatments. The TRB Task Force on Arterials and Public Health can be a part of this work to relate operational performance of roadways and roadway safety.

Another area where the estimate of the performance of the urban street can be improved is by incorporating the health effects associated with air quality of urban streets. The HCM is a tool recommended by the U.S. Environmental Protection Agency to predict vehicle speeds in the estimation of emission. The HCM, however, does not include air quality in determining the performance of urban streets. Although many agencies in United States use the HCM in the design and operation of their transportation facilities, absent from the HCM is the ability to estimate the performance of a roadway based on its impact on air quality. The incorporation of air pollution estimation into the HCM will allow the roadway's operation to be assessed both from an operational and environmental aspect, ultimately creating a sustainable development for both transportation and the environment.

The work being done as part of the TRB Task Force on Arterials and Public Health provides an opportunity to bring together several TRB Committees including the HCQSC. Incorporating public health into the design, operation, and planning of our arterials and urban streets is critical to improving the relationship between arterials and the sustainability of our communities. The work of the Task Force will play a vital role in bringing public health into the engineering aspects of our arterial facilities.

Andrew Dannenberg

University of Washington, Seattle

The work on the TRB Task Force on Arterials and Public Health is an excellent step forward in raising awareness of the links between transportation and public health and identifying practical methods to advance healthier transportation choices. I joined the Task Force with 35 years of experience in public health, including 15 years working on the links between built environment and public health. I now teach on this topic at the University of Washington in Seattle and previously served as team lead of the Healthy Community Design Initiative at the CDC in Atlanta.

While at CDC in the early 2000s, we recognized that decisions made by sectors outside of public health such as transportation have major impacts on health. For example, a physician can encourage patients to walk and eat healthy food, but compliance with such advice is unlikely if there are few safe attractive places to walk and little access to healthy food. We recognized that the primary responsibility for creating healthy built environments lies not with public health but with transportation professionals, urban planners, and architects, and that we would need to build collaborations with leaders in those fields.

When we first approached transportation professionals, the initial response was “Why are you here? Health is not in our mission.” But over a few years we began working together with federal, state, local, and academic transportation professionals, facilitated by participating in the TRB annual conferences. We looked for common ground and began learning each other’s language. For example, the term “nonmotorized transportation” highlights what it is not, while the terms “walking and bicycling” and “active transportation” help highlight their benefits in the public health world. We observed that some elements of health, such as safety and air pollution, are already well incorporated into transportation planning processes.

We began to focus on an important health component missing from most interactions with transportation professionals: physical activity. Public health professionals promote walking and bicycling for their health benefits and promote public transit use because it routinely incorporates walking at one or both ends of each transit trip. We recognized the importance of Complete Streets policies to accommodate the needs of pedestrians, bicyclists, and transit users as well as motor vehicle drivers. We observed that transportation planners are gradually accepting the view that roads should serve all users and modes, especially as the younger generation of transportation professionals are advancing in their careers and the older generation is retiring. Various data suggest millennials are now obtaining their drivers’ licenses later and are considering walkability as a factor in where they choose to live and work. Such trends influence the market demand for transportation plans that incorporate the needs of all modes and are less dominated by the needs of motor vehicles. Equity and sustainability considerations are increasingly important in transportation planning and other aspects of healthy community design.

In my ideal world, every transportation agency would have a staff person with knowledge and experience in public health, and every health department would have a staff person with knowledge and experience in transportation and urban planning. Such knowledge and interactions would be greatly enhanced if every transportation planner and engineer had some exposure during training or continuing education to the health implications of their work, and if every public health professional had some exposure to how transportation and other aspects of the built environment impact health. The development of concurrent degree programs in public health and transportation planning would help such scenarios become a reality.

Over the past decade, we have made substantial progress in collaboration between the fields of transportation and public health. TRB’s Health and Transportation Subcommittee has brought together dozens of professionals interested in these fields and has supported numerous presentations at each TRB annual meeting since 2011. The work of the TRB Task Force on Arterials and Public Health is further contributing to this progress by focusing on how the design of arterials can contribute to healthier communities.

Elizabeth Deakin*University of California, Berkeley*

No statement was submitted.

Jim Gough*WSP Canada Group Limited, presenter*

I am the product of a mid-sized Canadian city. Growing up in the 1960s, I walked on a grid of streets, easily navigated by a 5-year-old, with sidewalks on both sides—to school, to the corner store, to the local swimming pool and parks. As I got older, I learned to use the public transit system by myself; buses ran on all arterial streets in Hamilton, also in a grid network, but converging on downtown. The network of walkable streets, fronted with pedestrian-oriented development, and the bus services were my pathways to freedom and exploration and expansion of my world. Arriving downtown on the bus, there was an exciting array of bookstores, record stores, cinemas, and more—main-street retail was thriving there in those days. They gave me tools to help construct my identity. I realize now that this was probably essential to my mental health, given that my family didn't really offer a lot of support, and I was a loner without a lot of friends. Transit, walking, and cycling in a city meant freedom and stimulation for me. Suburban, auto-focused areas are simply boring in my opinion—as Gertrude Stein said “There is no there, there.”

Leaving home for graduate transportation engineering school in a smaller city was also the time to get a car. To the 21-year-old me, this was true mobility and freedom (as it was to virtually everyone I knew). I did not start as a deep thinker about the meaning of what I was doing at first. I had gone into engineering partly out of a concern for the environment, but focused on transportation as a way to improve people's quality of life, and so as my career progressed I was attracted to transit projects. As I practiced, my commitment to the emerging idea of sustainability grew and that reinforced the desire to really make transit work, as part of a healthy ecosystem in which people minimized their use of the Earth's nonrenewable resources.

But what I saw happening in transportation for a long time was an increasing focus on accommodating cars—wider streets with less space for sidewalks (and wider distances to cross, decreasing safety for vulnerable users), developments set back from the street with parking in front, more exclusive-turning lanes, pedestrian underpasses—the car was king at street level. Along with many other people in transportation and city-building, I have come to realize that this is a question of equity as a pillar of sustainability. By creating a system that prioritizes drivers and provides minimal or no accommodation for people who do not have a car, we have been perpetuating a system that is bad for the planet and bad for people—in terms of their ability to socialize, to access medical, educational and other services, to reach employment – in essence, to live a full life. Not having a car in a car-centric society is bad for your mental and physical health, and your ability to make enough money to lift yourself out of your situation. It is profoundly isolating, and the results of that are now seen throughout North American society.

Arterial streets are the spines of the transportation network, and it is along arterials that you can see the good and the bad of urban transportation. Good arterials present a balanced accommodation of the various modes, and are “places,” not just conduits for traffic—they are lively places of exchange and interaction. Being physically active is important for mental health, and walking and cycling should be supported by design as low-cost paths to that goal. In my

experience that works. Badly designed arterials have a narrow focus on moving vehicles through design and operational strategies, making it difficult for nondrivers to cross, walk, or cycle, to meet their neighbors on the other side for coffee, or mental health support or community activism. In summary, good arterials support healthy urban life. And that will help to minimize health-care system costs and increase productivity—amazing how everything is connected to this, isn't it?

Finally, as the sole Canadian on the Task Force, I am also in the fortunate position of being able to see both the Canadian and American experiences of mobility and street design, and how they affect health. American cities embraced auto culture to a greater degree, and far more urban dwellers fled to the suburbs after World War II than in Canada. Maybe it was a question of money, or vision, or culture, or all three. At any rate, I think Canadian urban neighborhoods adjacent to arterials, by and large, are more supportive of walking, cycling, and transit. This is a function of the integration of land use, urban design, and transportation. We never had the flight to the suburbs seen in the United States, so we have been building on a stronger base of mixed-use development to minimize the need for auto travel, and one can see the positive effects in healthy, active residents. I strongly believe that land use and transportation must be addressed together to create a healthy, sustainable culture—one where people can walk or cycle safely and securely to all services they need, or to a convenient transit service. Arterials need to be designed for people, not simply for cars. But this is not to say that Canada has all the answers. We use the same transportation methodologies as in the United States. What I would like to see is a change in methodology for transportation projects, to explicitly reflect goals of sustainability and equity, rather than simply accommodating vehicles without regard for other users or the adjacent urban form. There is a groundswell of activity towards that objective, but more work is needed to examine case studies, draw firm conclusions about relationships, and base methods on evidence that shows the benefits of an equity-based approach that includes mental and physical health outcomes for society as a whole.

Peter Koonce

City of Portland, Oregon

One of my colleagues asked me why a traffic signal systems engineer is involved with a public health Task Force and my answer was simple: if you don't have your health, you don't have much." Given that public health is so closely related to safety, it is relevant to consider the actions we take as practitioners to plan, design, operate, and maintain our communities in a way that considers the needs of people first.

The challenge of this group is to advance the integration of public health into everyday transportation practice. Our traditional practices of design have focused narrowly on moving cars through our city, valuing mobility over multimodal accessibility. Using vehicle level of service from the HCM, engineers (myself included) have lead the call for street widenings that impact public health and personal safety. The HCM also states that the performance of an urban arterial can be improved by reducing the density of intersections, a design decision that reduces pedestrian accessibility. Signal timing can be "optimized" by restricting pedestrian crossings on various legs of the traffic signal, allowing allocation of green time to only movements that have the most cars. This mitigation treatment for potential delays to vehicles results in pedestrians having to wait for the pedestrian WALK indication three times to cross the street. Simply getting

a cup of coffee can take longer than it ought to, making it less likely that people will walk. The NACTO Urban Street Design Guide counters many of these assumptions by making explicit recommendations for pedestrian networks. The guide challenges certain provisions that restrict signals within 400 ft of one another, and qualifies warrants and other standards that inhibit cities from projecting desired conditions, in spite of the widespread use of traffic growth projections to justify projects and make investments for the future for automobiles. Taken together, these recommendations can contribute to a design framework that can not only support, but strongly encourage the kinds of mixed-use, walkable developments cities are striving to establish.

Numerous design decisions add up to an outcome that falls short of the vision that our cities have as places to live, work, and play. By working to change our existing tools and guidance sources, we will make better decisions that can improve our lives.

John MacArthur

Transportation Research and Education Center, Portland State University

The integration of the concepts and goals of public health into transportation planning, design, and delivery is vital in the creation of more livable, safe, and vibrant communities. Though I started my career in civil engineering, I got my master's degree in public health. This experience fundamentally changed the way I approach my work and think about social change. In a previous position as the Context Sensitive Solutions and Sustainable Program Manager for Oregon Transportation Investment Act III Bridge Delivery Program, we tried to balance bridge delivery with sustainability principles. I worked with staff, consultants, and stakeholders to add and enhance active transportation and safety aspects into every project. Though this program was successful, public health was not explicitly embedded into the planning and design of transportation projects or in all levels of the department's activities. In 2012, Oregon DOT and the Oregon Health Authority established an official relationship to work together to improve the health of Oregonians by collaborating on communication and planning; safe and active transportation; research and data analysis; and leveraging opportunities. This multiagency relationship helps build a common language, shared goals, and mutual respect between transportation and public health professionals. This type of relationship is needed to create institutional change within the transportation profession. Understanding that transportation and the physical environment is a primary social determinant of health and ensuring that we create knowledge, linkages, tools, policy, and practice is essential in making steps towards healthier and more equitable communities. I look at the work of this Task Force on Arterials and Health and the Health and Transportation Subcommittee as crucial in establishing and nurturing these links for the broader transportation and public health fields.

Carolyn McAndrews

University of Wisconsin–Madison

To me, arterials represent a high-stakes opportunity for the transportation field to improve public health and reduce health disparities.

I see arterial roads as an organizing principle of the transportation and land use system. They carry high traffic volumes, serve as trunk routes for transit, provide routes vital for freight

movement, and mediate traffic between the local streets and freeways. Experts in geometric design, operations, maintenance, planning, intelligent transportation systems, public transport, land use, and parking already think about arterials. It seems important to incorporate public health into transportation's most vital functions, standards, and organizations, such as those related to arterials.

Just as arterials have consequences for transportation systems, they have critical implications for public health. They are important for injury prevention, air quality improvement, noise mitigation, greenhouse gas emissions reductions, community connections, physical activity, and a host of other factors that research has shown to influence public health and health disparities.

In Denver, Colorado, I once had a conversation with a city traffic engineer who had quantified livability benefits of its arterials management program, such as motorist safety and saved travel time. But this list did not include ways that transportation engineering can improve livability through public health. What if the list had included prevented cases of respiratory disease and child pedestrian deaths prevented? Transportation engineering does prevent cases of respiratory disease and child deaths, but these meaningful outcomes cannot be part of transportation's purpose if they are not understood and quantified.

This Task Force is a community of practice working toward two transformative aims. First, to advance the evidence base necessary for promoting public health and reducing health disparities through interventions in arterial roads. Second, to translate public health research into tools, metrics, strategies, and practices that organizations can apply in the design, planning, management, and operations of arterials.

Leslie Meehan

Tennessee Department of Health

As a transportation and health professional, I've had the unique perspective of working for both transportation and public health agencies on policy, data collection, funding, project prioritization, and evaluation of transportation's impact on health. From the transportation side, our priorities for the past several decades have centered on vehicular trips and roadway efficiency. With the increased emphasis on roadway safety in the past few decades comes increasing awareness of the implications of roadways on the lives of the people who use them. In addition to transportation-related injury and death, we are seeing an increasing emphasis on air quality, opportunities for physical activity such as walking and bicycling, and an emphasis on equity—providing transportation options for the one-third of Americans who do not drive. Along with these notions is a renewed look at the purpose of transportation systems, thinking about roadways as contributing to a sense of place and being part of the contextual economic development element of a community. In this age, we are looking at the multiple benefits of transportation and have moved beyond percent free-flow speed and level of service as our sole indicators.

The question then becomes, how do we measure the positive and negative impacts of transportation on health, and how do we use transportation planning and engineering to positively impact health? These questions are currently being tackled by transportation professionals across the nation, including the members of this Task Force. In addition, with one-third of the nation's budget devoted to the increasing costs of health care, we not only know that we are unable to treat our way out of chronic diseases to which transportation is a contributing

cause, but potential transportation dollars are being allocated to other national priorities. In order to regain the dollars transportation professionals need to build and maintain transportation infrastructure, we must rethink the functionality and purpose of transportation networks. Are we providing transportation options? Are we improving air quality and safety? And are we providing physical activity opportunities that can positively influence the nation's health?

Keshia M. Pollack Porter

Johns Hopkins University

I am a public health professional who works to advance policies that create safe and healthy environments where people live, work, play, and travel. The travel part for me—promoting policies that help people to travel safely and promote, not harm, health—is what brought me to the Task Force, and it has been a truly rewarding experience.

I completed my doctoral degree with training in injury epidemiology and policy. First leaning to understand the epidemiology of injuries, including those related to transportation, nearly 20 years ago was eye opening for me as someone who grew up thinking that she was “accident prone.” Little did I know that there was a field of inquiry—injury prevention and control—built on the great work of Hugh De Haven, William Haddon, Leon Robertson, and one of my mentors, Susan Baker, who all taught us that injuries are not accidents and that they can be predicted and studied and, thus, prevented. I built on this training and completed a postdoctoral fellowship in evaluation, which placed me at the Robert Wood Johnson Foundation, which is when I first moved into the area of active transportation and its role in supporting physical activity. I was engaged with Safe Routes to Schools and Walking School Buses, and thought about how injuries and safety were barriers to active travel to school. My research as a member of the faculty at Johns Hopkins Bloomberg School of Public Health, where I have been since 2006, has identified important risk factors, disparities, and solutions to keeping pedestrians and bicyclists safe. Since 2011 or so, I added HIA to my toolbox and used HIA, along with injury epidemiology, to further identify how transportation connects with public health. For several years I taught a course called Transportation Policy and Health, which allowed me to teach numerous students about why it is critical to work with the transportation sector, and the important role that transportation plays in supporting or exacerbating health disparities. Through these various efforts I continue to think about and advocate for Vision Zero and Complete Streets, as well as the overarching value of injury epidemiology and HIA to improve public health.

Transportation is an important determinant of health and health equity. And unless we all do a better job of thinking about transportation equity, our efforts to raise health considerations as when it comes to arterials will be in vain. As Carey, David, Andy, Ed and I stated in an article published in the American Journal of Public Health in July 2017, “Promoting health equity through arterial roads involves addressing the underlying institutional, political, economic, and social factors that have historically determined levels of transportation service and investment, as well as the distribution of service and investment across people and places. Future design of arterials can advance health equity by directing transportation investments to areas that are historically underserved and by implementing policies that promote environmental, social, and economic justice and ensure safe and healthy communities for all.”

I have always worked across sectors, and connecting with transportation professionals has been a part of my work that I greatly enjoy. I have worked with transportation engineers,

planners, and transportation decision-makers, as well as policy-makers, as part of efforts to address pedestrian and bicycle safety at the local level; connected with policy-makers at the state level to identify ways to curb the devastating public health burden of transportation crashes and related fatalities. The work of the Task Force on Arterials and Health and the contents this E-Circular serves as a reminder that elements of the transportation system can have widespread effects on public health, and also have the potential to advance health equity. Collaborations between transportation and public health can be a “win–win” for both sectors by promoting authentic partnerships that identify common goals. Integrating health and transportation goals to improve arterials could have tremendous effects on public health, transportation, and equity, which will be a great win for society.

Brian L. Ray

Kittelson & Associates, Inc.

It is fantastic for me, from the transportation consultant perspective, to interact with the health and medicine side of our arterials and public health project. My role as an engineer and planner results in me focusing my interest and passion at the project level. Our industry is moving to performance-based metrics and a big step forward is quantifying transportation safety performance (crash frequency and severity). It's a natural next step to help support project decision-making by including project performance metrics that include information about public health. This means including information about public health in the project development stage, where public health concerns can shape the purpose of and need for a project and being sure the public health objectives are considered in early project planning and concept development and evaluation.

We know that quantitative safety performance should help guide project decisions, but we have not always been able to accomplish this. As we have been able to better quantify safety performance using principles from the *Highway Safety Manual* (1st edition), we have been able to make more-informed project choices. Quantitative safety metrics have been a major advance in project development. For me, as an engineer, integrating quantitative public health performance metrics into our projects, like how we have integrated safety metrics, would allow us to evaluate a range of potential project solutions with public health as one of the guiding factors.

Pedestrians and cyclists are part of our transportation system, but we have lacked data about these users. Yet, they are important and often vulnerable users. With better data about pedestrians and cyclists, we have been able to design projects for these users. Improved data for pedestrians, cyclists, and safety point toward creating performance measures that capture public health.

Data limitations have challenged roadway design. Relying on reported data, rather than observed data, has been one of the main challenges. We have seen better data linkages between public health and transportation and this is helpful. Linking hospital and crash data, for example, could be immensely valuable. When we think about cooperation between public health and transportation, opportunities for data exchange should be a priority.

When we can truly measure safety, public health, and the travel of vulnerable users, then we can define how to bring public health into our transportation projects and guide investment of public resources into solutions that support transportation and public health needs. Design and construction offers a natural connection for public health—public health considerations and issues will inform how we define our projects and measure their success.

John Thomas*U.S. Environmental Protection Agency*

No statement was submitted.

Zhongren Wang*Caltrans*

As a practitioner on this Task Force, I worked in California Department of Transportation (Caltrans) for the past 19 years. Specifically, my experience focused on traffic operations, traffic impact analysis, traffic safety, asset management, and project programming. I serve on several TRB standing committees, such as traffic flow theory, geometric design, pavement management, and international collaborations. I also serve on quite a few NCHRP project panels.

California has strict environmental laws, such as the California Environmental Quality Act. Every project, in its planning and early phase of development, has to go through the stipulated environmental review process, where traffic, air, water, and soil impacts are evaluated quantitatively and qualitatively. This can be construed as the current practice of consideration of public health in project development practice today.

Caltrans' mission is to "provide a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability." Public health is an integral part of the mission. My 19 years of experiences saw the day-to-day carrying out of this mission in our project delivery process. Efforts are always encouraged to improve public health by introducing innovative designs. Complete streets, high-occupancy vehicle lanes along arterials, and bulb-out designs at freeway entrances are just a few to demonstrate the commitment.

The key link missing is how to evaluate and report the performance in terms of public health improvement. Solid analysis is badly sought to determine the relationship between project design and public health.

Megan Wier*San Francisco Department of Public Health*

I am the Director of the Program on Health, Equity, and Sustainability in the Environmental Health Branch at the San Francisco Department of Public Health, where I oversee a team that works with local community stakeholders and government agencies to develop and apply innovative approaches to using health data and evidence to inform safe, sustainable, and equitable transportation and land use planning decisions. My work in San Francisco at the intersection of health, equity, and transportation for over a decade has in many ways been about the health impacts of arterial streets on the people that live, work and play in the city.

Our team's work conducting HIAs on transportation policies led us to develop and apply predictive models to understand how the heavy, fast-moving traffic on arterials contributed to safety, air quality, and noise hazards for people using and living on those streets. In support of Vision Zero in San Francisco, our team identified San Francisco's high injury network—the 13% of city streets where three-quarters of crashes on our transportation system that result in severe and fatal injuries occur—many of which are arterial corridors. These streets are also more likely

to crisscross, spatially isolate, and disproportionately impact the health of low-income communities and communities of color, highlighting the importance of increased community engagement in transportation projects. Arterials are also critical corridors for public transit, providing access to needed goods, services, health care, education, and employment for people of all ages, abilities, and backgrounds. Depending on their design, arterials can also be vibrant corridors for people to walk, bike, shop, socialize, and play—bridging as opposed to dividing communities. Arterial design and management illustrates how the consideration of health impacts can shape whether transportation systems advance or degrade community health. In some cases, these are life and death decisions.

I attended my first TRB Annual Meeting in 2011, when many attendees were asking what is public health? Through the leadership of many people in both the transportation and health sectors, a number of whom are part of the Arterials and Health Task Force, TRB now has the Transportation and Health Subcommittee and this Task Force. How can decision-makers, transportation, health, and community stakeholders understand and address these issues, ultimately creating healthier communities and healthier people? I am excited to participate in the TRB's Arterials and Health Task Force to help inform a research agenda and ultimately advance the interdisciplinary collaboration required to address these pressing health issues.

Josias Zietsman

Texas A&M Transportation Institute

I am the Strategic Advisor and Assistant Agency Director at the Texas A&M Transportation Institute (TTI) and I also serve as Director for the Center for Advancing Research on Transportation Emissions, Energy and Health (CARTEEH). CARTEEH is a U.S. DOT center focusing on the intersection of health and transportation in the area of vehicle emissions exposure and health. I have 30 years of professional experience in the field of transportation engineering with a specialization in air quality, sustainable transportation, transportation planning, and the emerging topic of public health and transportation. Over the past 15 years at TTI, I have been principal investigator of more than 50 research projects, valued at more than \$30 million. I am active with TRB, where I was past chair of the Committee on Sustainable Transportation, immediate past chair of the Research Subcommittee on Transportation and Air Quality, and current member of the Task Force on Arterials and Health.

The work of the Task Force on Arterials and Health and the contents of this E-Circular are an excellent synthesis of how the transportation system affects public health. This work also highlights some of the key research gaps and open questions that researchers ought to pay more attention to. In the past, experts from transportation and public health have not traditionally worked together. But this has been changing and work such as this E-Circular brings these disciplines together to improve the health and quality of life across the nation.

Review of Health Topics in TRB Research Needs Statements

One objective of this E-Circular is to identify researchable questions about arterials and public health to inform future research agenda on these topics. To support this, members of the task force wanted to see if one could “apply a health lens” to the proposals in the TRB Research Need Statements (RNS) database. Not only was it possible to do, but some interesting things were discovered about how the transportation and health communities view arterials. Generally, there was alignment between the two disciplines on how they define problems of safety, multimodal accessibility, noise, and air quality. However, when it came to project-level concerns, the health perspective nearly always looks towards complete streets designs, whereas the transportation perspective was focused on access management. This finding raises the question: How can we bring the notion of complete streets and access management closer together?

The dive into the RNS database also turned up some ideas how to do further analysis using network analysis concepts and methods. For example, with the help of TRB staff members who maintain the database, it would be possible to analyze which TRB committees talk about arterials, which TRB committees talk about health, and what topics link them together. A similar analysis could identify groups that are working on their own on related topics and facilitate more coordination.

The TRB Research Needs Statements Database is a rich resource for helping to align the transportation and health disciplines for not only research, but project implementation.

HOW THE REVIEW UNFOLDED

The search of the RNS database (<https://rns.trb.org/>; accessed August 19, 2018) was rather straightforward.

1. A wild card search for “arterial,” plus related search terms such as corridor, intersections, pedestrians, bicyclists, transit, and land use was done.
2. The RNSs were read and their index terms, which were used to represent the main ideas, were recorded.
3. The database was searched again for health-related terms (e.g., health, air quality, noise) and the RNSs reviewed.

This analysis of the RNS database showed where standing committees see health fitting into transportation. RNSs that specifically discussed arterials were also concerned with multimodal access, safety, and business development (i.e., neighborhood resources). Air quality and noise were not as connected to arterials. Future research could include additional topics that are currently missing, and expand questions to ask how arterials affect specific types of road users or nearby populations.

Given that TRB committees generally propose “applied” research, the task force team chose to look at HIAs to develop the health lens for arterials that could be compared to the RNSs. HIAs of arterials were used because they discuss: (1) the scope of health-related research

problems for arterial roads, (2) how arterial roads influence health outcomes and behaviors, (3) potential pathways through which an arterial project may influence public health, and (4) relevant scientific evidence assembled through original analysis and reviews of existing research.

For the HIAs a search was performed on a database of HIAs maintained by the Pew Charitable Trusts in collaboration with the Robert Wood Johnson Foundation (<http://www.pewtrusts.org/en/projects/health-impact-project>; accessed August 19, 2018). The search process was also straightforward.

1. The database of 81 HIAs was searched for transportation-related arterial projects.
2. Thirteen HIAs were identified and coded for they said about health determinants (the health lens).
3. The project recommendations were also reviewed and coded.

When looking at the HIAs some of the findings included:

- Each HIA defined relevant health determinants and associated them with a project's proposed changes to traffic volume, traffic mix, traffic speed, mode share, access to transit, and proximity of sensitive land uses
- HIAs used pathway diagrams depicting how project alternatives can influence health. These diagrams outlined how arterials influence health through changes to mobility, noise, air quality, neighborhood resources, and economic development.
- The pathway diagrams could be useful for expanding the topics included in the RNSs.
- The sample of HIAs also contained other health determinants that were “too indirect” to fully investigate. They included water quality, disease vectors, poverty, racism, segregation, and political participation. These additional health determinants are consistent with topics included in the broader set of RNSs about health. Perhaps there might be cross-sector motivation to develop research in this area.

TABLE 1 Sampled HIAs of Arterial Roads

Location	Arterial	Characteristics of Arterial
Los Angeles, Calif.	I-710	Freeway, no adjacent property access
Wash. and Ore.	I-5 (River Crossing)	Bridge/freeway, no adjacent property access
Puget Sound region, Wash.	SR 520	Bridge/freeway, no adjacent property access
Somerville–Cambridge, Mass.	Route 28 (McGrath)	Arterial, no adjacent property access
Cuba, N.M.	US-550	Arterial, no adjacent property access
Milton, Vt.	US-7	Arterial, no adjacent property access
Clark County, Wash.	Highway 99	Arterial, no adjacent property access
Adams County, Colo.	Federal Boulevard	Arterial, no adjacent property access
New Haven, Conn.	Route 34	Arterial, no adjacent property access
Omaha, Neb.	South 24th Street	Arterial, no adjacent property access
Bernalillo County, N.M.	Second Street	Arterial, no adjacent property access
Burlington, Vt.	North Avenue Corridor	Arterial, no adjacent property access
Benton County, Ore.	53rd and West Hills Rd	Arterial roundabout

A TROUBLING COMPARISON

Although this effort started out as an attempt to put a health lens on the projects in the RNS database, it yielded an unanticipated result that was troubling, but one that also presents an opportunity for future research and coordination. To the investigating team it was clear that public health and transportation used similar lenses for defining and analyzing problems of public health and arterial roads. However, the disciplines diverged in their focus on how to design arterials. The major contrast was between transportation's access management paradigm for designing arterials and the complete streets paradigm, preferred by public health.

The HIAs in the sample almost always recommended making design and policy decisions within a complete streets framework, and their recommendations used the language of complete streets and traffic calming. Contrasting with this, almost all of the 22 arterial-related RNSs were focused on access management.

Because access management is the design paradigm codified in guidance and standards for arterials, this puts the recommendations of the HIAs in conflict with transportation's standard practices. This might explain why HIAs are not widely accepted in transportation practice. Certainly this is an area for additional research. Other research that could be pursued around this topic include:

- Under what conditions do access management approaches to arterials lead to improved health outcomes? When and where do these conditions exist? How do these scenarios compare to a complete streets alternative?
- Under what conditions do complete streets alternatives lead to improved health outcomes? When and where do these conditions exist? How do these scenarios compare to an access management alternative?
- What alternative paradigms, beyond access management and complete streets, could help advance the consideration of public health in the design, operation, planning, and management of arterials?

There is general optimism around a future research agenda for arterials and public health in this context. It could potentially examine the comparative effectiveness of complete streets and access management design paradigms, and potentially develop a hybrid approach focused on improving public health. This research agenda could also represent an opportunity to reframe public health in transportation as a shared goal rather than the desire of an alternative special interest group or a design polemic.

Access Management is the proactive management of vehicular access points to land parcels adjacent to all manner of roadways. It promotes safe and efficient use of the transportation network to control access to highways, major arterials, and other roadways. Available at https://ops.fhwa.dot.gov/access_mgmt/what_is_accsmgmt.htm. Accessed Sept. 3, 2018.

Complete Streets are streets designed and operated to enable safe use and support mobility for all users. Those include people of all ages and abilities, regardless of whether they are travelling as drivers, pedestrians, bicyclists, or public transportation riders. Available at <https://www.transportation.gov/mission/health/complete-streets>. Accessed Sept. 3, 2018.)

FINAL NOTE

As stated earlier, the TRB RNS database review proved fruitful and yielded some tangible results both from a methodological and analysis perspective. A great deal was learned yet more work could be done. It must be noted that there are limitations that may influence the results as presented. For instance, although the TRB RNS database offers a window into a broad swath of research needed to advance transportation practice, the composition of the volunteers working on behalf of TRB may not represent all perspectives in transportation. Second, the RNSs are generally focused on transportation practice in the United States. With respect to HIAs, the Pew archive includes most major HIA efforts in the United States but may not archive all of them. Moreover, HIA is a practice-oriented process that works with information relevant to decision-making, and though many HIAs are rigorous and peer-reviewed, they often lack sufficient data and resources to fully conduct a comprehensive analysis of the health effects of projects. Finally, just like the RNS database, the perspective provided by the HIAs depends of the projects selected for analysis and the cohort of public health professionals carrying out the research. Despite these limitations, the TRB research needs database and the HIA process are well-established in their respective fields and offer unique insight into each discipline's approach to arterials.

Conclusions and Implications for Research

The Task Force that produced this E-Circular was formed in recognition of the important ways that arterials can promote public health by supporting social connections and access to essential goods such as food and health care, and active transportation. In turn, arterials can also negatively impact health through safety and pollution. Across the seven case examples there are common issues that should be considered and that have implications for future research: equity, institutional structures, metrics, models, and tradeoffs. Each of these considerations is briefly described below.

EQUITY

Equity is the fairness with which benefits and costs are distributed. Arterials have important implications for health equity, which is the “attainment of the highest level of health for all people...with focused and ongoing societal efforts to address avoidable inequalities, historical and contemporary injustices, and the elimination of health and health care disparities”(2) An emphasis on health equity is central to public health and has been since the mid-nineteenth century when public health professionals and other leaders recognized that inequalities by social class and social status resulted in inequities in health (3). Today, health equity is widely viewed as “social justice in health” (4, 5).

Health equity means that everyone has a fair and just opportunity to be healthier (1).

Equity has been a part of transportation planning, design, and operation for decades, with some of the earliest codified support stemming from a mandate issued by the U.S. DOT in 1970 as part of 35 FR 10080. DOT required its agencies to comply with Title VI of the 1964 Civil Rights Act. This requirement prohibited using “criteria or methods of administration which have the effect of subjecting persons to discrimination because of their race, color, or national origin” (49 C.F.R. § 21.5) (6).

Transportation decisions have significant equity impacts that affect several factors including the users, service quality, and neighborhood impacts. According to Litman, there are three aspects of transportation equity: horizontal, vertical equity with regard to income and social class, and vertical equity with regard to mobility need and ability. In practice, transportation officials must make tradeoffs between these various types of equity. For example, when trading off transportation resources between communities as with project selection (horizontal equity); when determining subsidies for disadvantaged groups (vertical equity with regard to income and social class); and, measuring how well needs are met as compared to others (vertical equity with regard to mobility need and ability) (7).

The case examples in this E-Circular draw on these important equity considerations, as seen in the section on metrics, including those related to the SDOH; in the section on Vision Zero programs where there are concerns about the importance of enforcement and racial profiling; and in the section dealing with issues associated with proximity to arterial roads, which disproportionately impact low-income populations and communities of color. In each of these case examples, and throughout this document, it is easy to see how communities of color and

vulnerable road users have been disproportionately impacted by transportation decisions related to arterials.

As noted in an article mentioned earlier that was published by Task Force members McAndrews, Pollack, Berrigan, Dannenberg, and Christopher (2018), the “Future design of arterials can advance health equity by directing transportation investments to areas that are historically underserved and by implementing policies that promote environmental, social, and economic justice and ensure safe and healthy communities for all.”

Future research at the nexus of arterials and public health could benefit from continued monitoring of health disparities between groups, which is the metric for assessing health equity. Moreover, planners can be more proactive and use tools such as HIA and other analyses of decisions before they are made, to identify the potential impacts of transportation decisions on health equity and take steps to address them during development and implementation (4).

INSTITUTIONAL STRUCTURES

Institutional structures, organizational cultures, and bureaucratic tendencies all play a vital role in the interactions between health and arterials. Past decisions and current momentum tend to drive future policies. One thing the Task Force quickly noticed when it assembled a diverse team was that everyone in the room spoke a different “professional” language and applied slightly different value structures to their analysis. The members also had significantly different disciplinary backgrounds as well. These differences in professional cultures, terminology, and training can be barriers to effective multisector and multidisciplinary collaborations, but they are also essential because they embody essential disciplinary knowledge.

It is critically important to bring together professionals from various disciplines and aspects of transportation and public health if we are to ever effectively address health and arterials. For example, *Land Use and Arterials in an Ever Changing Exurban Context*, reflects on the important roles of planning, land use, education (via school siting), and retail, to name a few, when considering how arterials impact health. Aside from blending various disciplines, it is equally important to blend other characteristics. For instance, if a team lacks personal experience with mobility limitations, can it be effective in transportation planning? Or if no one on the team has ever had to navigate a transit system with a stroller do they really understand what is needed to do it?

The literature on building a Culture of Health in the United States provides some important insights for key elements of effective partnerships that may be useful for connecting public health and transportation professionals. Towe and colleagues in their 2016 article on essential ingredients for cross-sector collaborations noted the importance of a shared leadership model over a more centralized one; recognizing if the partnerships are truly integrative and mutually collaborative; and needing support with various resources, including financial (8). These key ingredients could easily be considered and integrated into efforts to bring together transportation and public health professionals working on arterials in a way that is mutually beneficial.

The need for effective partnerships to promote the health and well-being of populations was at the core of the work in the United States that led to the formation of the National Prevention Council, which was part of the

“Just get ALL the right people together at the table and they will figure it out.”

**—Ed Christopher
Task Force Chair**

Affordable Care Act—the landmark health care legislation passed in 2010 (9). The Council provided coordination and leadership at the Federal level on how agencies can work individually and collaboratively to improve our nation’s health. The Department of Transportation and other agencies were encouraged to think about how they could include health and wellness into their decision-making in various such as through policy and funding decisions, data and measurement, and tools such as HIA. Review of Health Topics in TRB Research Needs Statements, includes several examples of HIAs conducted at the federal, state, and local levels that have examined how transportation decisions could impact health and health equity.

METRICS

As noted throughout the E-Circular, each of the cases includes statements on the need for research and metrics; metrics that encapsulate transportation goals and policies, and also bring in health in an equitable and balanced way. It is often said that transportation is not just a means to end. That could not be more true today. Transportation is also not only about moving people and goods or providing connections, but also, as noted in the Background section of this E-Circular and in many of the works cited, is inextricably connected and party to of the SDOH. A fact that cannot be overlooked.

Rather than restate all the metrics and research that are articulated throughout this E-Circular, the Task Force wants to underscore the importance of identifying and implementing effective metrics. Metrics are needed to help practitioners, policymakers, and decision-makers understand where they have been and where they are today regarding how arterials impact health. These metrics also help address questions of how we move forward. The cases examples Vision Zero, Reinventing, Retrofitting and Remodeling Urban Arterials, and Land Use and Arterials in an Ever Changing Exurban Context delve into aspects of where our past development and design decisions have created a current situation that is arguably less than optimal for health considerations. Linking Public Health Metrics to Arterial Roads provides answers to many of the questions that could help move this effort forward. As one Task Force member put it, whichever metrics are identified they could benefit from being SMART—specific (clear and well-defined); measurable; achievable; realistic; and include a timeframe. Suffice it to say a great deal of work is needed in this area and needs to begin now.

“For highways there are metrics like Level of Service. Maybe for health—something like a Highway Health Level of Service is needed.”

**—Leslie Meehan
Task Force Member**

MODELS

Both the transportation and health planning areas are driven by and based upon a foundation of science and scientific principles. However, the rigors of the approach are not always the same between the two different disciplines. While both disciplines tend to rally around models, data, and evidenced-based decisions, they do so from different

The analytical capacity for bringing health considerations forward is in its infancy.

mindsets, value systems, and methods. This could not have been made clearer than it was in the section of this E-Circular where the TRB Research Needs Statement data base was reviewed.

Although anecdotal, as one member of the Task Force noted that when it comes to the fields of transportation and public health, their literature and research does not appear to be well integrated with each other. Each discipline seems to have an inherent approach that “if it is not in our literature it does not exist.” The point is that there are some major differences in the disciplines, and as new analytical models are developed and refined, these differences need to be understood and addressed.

Developing high-quality analytical models are critical if health is to be truly considered in the planning, design, and operation of arterials. While models like Integrated Transport and Health Impact Modeling Tool (ITHIM) and Health Economic Assessment Tool are attempts to consider health, they primarily focus on active transportation, which is only one small component of the health and transportation picture. As the Case Examples showed, the questions that need to be answered are becoming ever more complex, and the rapid developments with technology and automated vehicles are only exacerbating the situation. While automation and technology offer promise for how arterials are used, current modeling approaches fall short when trying to bring health considerations into the equation. As the future unfolds there is likely to be less of need for arterials as vehicles become more efficient, possibly serving multiple purposes. These changes will undoubtedly raise questions about how will the arterial of the future be used. Flexible infrastructure is a term that is emerging but what it will look like is only guess, a guess for which there are no real analytical models capable of asking and answering relevant questions.

Suffice it to say that further development and refinement of our scientific and analytical approach to arterials, while considering health, needs work and development. Without it there will be no way to navigate the path moving forward in an environment that at times is political, unequitable, and discriminating.

TRADE-OFFS

One final theme that surfaced in Task Force discussions of the case examples is the issue of dealing with tradeoffs. In its simplest terms when considering arterials and health it comes down to questions such as, “what gets weighted higher—the health or transportation goal?” This tension was very evident in the review of the TRB Research Needs Statements as compared to transportation related HIAs. The comparison of the Needs Statements and the HIAs revealed that although there was general alignment between health and transportation on how they defined problems of safety and multimodal accessibility, there were fundamental differences in approaches for project-level concerns. Specifically, the public health perspective generated recommendations emphasizing complete streets designs whereas the transportation perspective was more focused on access management. As noted in Review of Health Topics in TRB Research Needs Statements, because access management is the design paradigm codified in guidance and standards for arterials, recommendations from HIAs that favor the public health perspective, are often in direction conflict with transportation’s standard practices.

How does one decide on the design of an arterial while accounting for competing demands and the health and welfare of the community travelers?

So, what can be done about this moving forward? For HIAs, perhaps there is a need for additional analysis and discourse comparing the two approaches and determining which one yields better outcomes for both health and transportation. Or maybe there is some common ground that can be identified where *both* perspectives can be satisfactorily integrated in HIA recommendations and more broadly. Either way, perhaps what would be most fruitful would be to move away from asking “what gets weighted higher—the health or transportation goal” to asking “how can practices that optimally and equitably achieve both health and transportation goals be implemented?”

FINAL NOTE

The multidisciplinary Task Force that produced this E-Circular was assembled to inform the planning, design, and operation of arterials while considering public health. The case examples, cross-cutting themes, and identified research gaps have great potential to advance the field. The E-Circular has specific strategies that transportation professionals and the public health professionals can embrace, as they both work together to ensure that public health is “at the table” during the planning, design, and operation of arterials. It is the hope of the Task Force that while its work is done with the completion of this E-Circular, TRB and others will realize the importance of asserting health considerations into the arterial roadway paradigm and move the ideas and concepts raised in this E-Circular forward.

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