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TRANSPORTATION AND HEALTH GEOGRAPHIES

Michael J. Widener

Transportation, broadly conceptualized as the movement of people across space, is connected to personal and population health in complex ways. It directly and indirectly influences health outcomes both positively and negatively, simultaneously enabling pathways to improved well-being (e.g., increasing access to health services or inducing physical activity) and producing exposures that result in higher rates of morbidity and mortality (e.g., the production of pollutants or fatal car crashes) (Widener and Hatzopoulou, 2016). Given the inherently spatial nature of transportation infrastructure, networks and behaviors, geographers have played an important role in establishing and expanding the study of transportation and health. Their contributions range from research on the effects of automobility and active transportation on health, international air travel and disease spread, and inequities in access to health care via public transit networks, in diverse regions across the Global North and Global South.

This chapter documents the role that geographers and geography have played in furthering research on the links between health and transportation over the past half-century, noting important theoretical and methodological contributions. While the emphasis is primarily on the theoretical developments of geographers or research published in geography journals, researchers from other disciplines (e.g., public health, engineering, planning) who have improved understandings of transportation and health geographies will also be included. The next two sections review major theoretical and methodological contributions by identifying significant themes within the literature, and the chapter concludes with a section that notes gaps and limitations where future research can drive transportation and health geographies forward.

Theoretical contributions

Geographers have been active in studying the links between transportation and health for the past half-century, with a theoretical emphasis that has evolved alongside the rest of the discipline. However, despite the diverse scope of this domain, much of the research covered in this chapter uses quantitative methodologies, thanks in part to the dominance of this methodological framework in cognate fields like transportation engineering and public health. As discussed later, this methodological bias has potentially left many questions about the links between transport and health unanswered, with researchers often relying on sometimes incomplete data to help generate and answer questions. The following subsections identify some of the major theoretical contributions, along with a selection of example studies.

Health-care-facility location

Some of the earliest work on transport and health geographies comes out of the quantitative revolution in the 1950s and 1960s, in which geographers began using newly developed computers and location-modeling techniques to solve facility-location and demand-allocation problems (Scott, 1970). Early on, researchers discovered that these models, developed with economic geography in mind, were useful when deciding where to locate hospitals. They explicitly accounted for travel times and costs to a facility or service, the relevant demand (i.e., population distributions) and facility capacities (Morrill and Kelley, 1969). Of course, many assumptions and generalizations (e.g., simplifying the topology of road networks or assigning residential locations to polygon centroids) were required when implementing these models, given the limited computing power and data availability of the time. However, as computational resources increased and higher-resolution datasets have become available, this same methodology has been used in more sophisticated ways and expanded to additional types of transportation and health-related locations. Examples are locating ambulances (Church and Meadows, 1979), helicopter emergency medical services (Schuurman et al., 2009) and a range of other health facilities and services (Wang, 2012).

Spatial access to health services and healthy places

Other early work linking transportation and health geographies was related to the previously described research on location modeling. Rather than taking a proactive approach to determining the best distribution of health services (at least from a positivist approach), studies of spatial accessibility focused on the established health facilities and services to which a population was geographically proximate. Like location models, the role of transportation in understanding access to health services relied on the fact that a person's mode of transportation could either enable or constrain his or her ability to get to some relevant health service or healthy place. It is important to note that *spatial* access is seen as just one of many dimensions of access to health care and services, with affordability, accommodation, availability and acceptability also contributing to a person's ability to acquire the needed health-related opportunities (Penchansky and Thomas, 1981).

The ability to measure the role and effectiveness of transportation systems in facilitating access to health care and services was greatly aided by the proliferation of geographic information systems (GIS), which can readily compute accurate travel times and costs on road networks, in the 1990s and early 2000s (McLafferty, 2003). With this methodology established, geographers have examined how various populations' spatial access (estimated via travel times and costs) differs to a range of health services and healthy places, including primary care physicians (Schuurman, Berube and Crooks, 2010), healthy food (Widener et al., 2013), mammography clinics (Dai, 2010) and trauma centers (Lerner et al., 1999), to name only a few. Finally, it is worth noting that much of the work in this area has focused on urban and suburban regions, using either automobile travel or simplified representations of other modes. A smaller literature has begun to investigate how transportation affects access to health care and services in a rural context (Martin et al., 2002), as well as how more accurate representations of urban-transit travel times (e.g., accounting for transfers and departure times) can be computed for those using public transportation (Farber et al., 2014).

Active transportation

Another relatively recent health-related focus of transportation geographers and other transport researchers is on how active modes of transportation (e.g., walking or bicycling), rather than passive modes (e.g., using an automobile), can improve population health (Dill, 2009). This work builds on a vast literature that documents the positive effects of physical activity and active living on a range of health outcomes and considers transportation as a critical dimension of improving population health. Some of the more popular areas of

research on active transport are children's use of active modes to get to school (McDonald, 2008), active transport behaviors in different built environments (Buehler and Pucher, 2012) and how transit use increases overall levels of active transportation (Miller et al., 2015). While most of this work is focused on locations in North America and Europe, there is increasing interest in the topic around the world (Sallis et al., 2016).

Transportation and pollution

Generally, air pollutants are of concern to a range of geographers, given the impact they have on human health, ecological systems and climate. Transportation and health geographers tend to focus on transportation modes that directly produce air pollution, typically through combustion engines, and how the spatial distribution of those emissions affect the health of populations exposed to the related particulate matter (PM_{2.5}) and ozone (O₃) that are linked to adverse health outcomes (Jerrett et al., 2005). While much work by geographers has focused on pollution originating from automobiles at the intraurban scale, with a particular emphasis on the how the geography of pollution relates to different types of road infrastructure and traffic volume (Bayer-Oglesby et al., 2006), a more multidisciplinary group has examined how transportation facilities, such as airports (Franssen, Staatsen and Leuret, 2002) and seaports (Moretti and Neidell, 2011), impact health. Additionally, recent work has examined these factors in rapidly developing countries, such as China, where there is a growing number of residents with automobiles and well-established issues with pollution from both transport and non-transport sources (Zhang, Huang and Luo, 2014).

Road safety and crashes

The study of road-traffic crashes by geographers is an example of an examination of a very direct relationship between health and transportation (Whitelegg, 1987). In this arena, geographers are able to use their toolkit of spatial-analysis methods, like cluster detection, to help identify any geographic patterns in collisions and, thus, potential environmental or infrastructure-related causes. In addition to the exploratory spatial data analysis of crashes between cars (Edwards, 1996), authors have also explored the geographies of collisions between cars and pedestrians (Ha and Thill, 2011) and cars and cyclists (Vandenbulcke et al., 2009). More recently, authors have begun to look at the geography of road safety and crashes in rapidly urbanizing areas outside of the Global North, where automobile ownership and road infrastructure construction are on the rise (Loo, Yao and Wu, 2011).

New mobilities and health

One of the few examples of qualitative work being done in transportation and health geographies focuses on mobility and movement and its various relationships to healing, inclusion and exclusion, and power (Sheller and Urry, 2006). Of particular note is work by Anthony Gatrell, who has critiqued the current state of the walkability literature and suggests that a more inclusive therapeutic-mobilities framework is appropriate (Gatrell, 2013). Among other things, Gatrell calls on walkability researchers to engage in more participatory methods that are inclusive of all people (e.g., people considered obese, differently abled people or those with a mental-health condition), as well as account for a broader range of movement activities and well-being outcomes (e.g., positive spiritual and emotional experiences). Another example of work that draws from the new mobilities paradigm includes research that used interviews to explore how immigrants to Ireland sometimes return to their country of origin to receive health care (Migge and Gilmartin, 2011). While the motivations for traveling outside of state boundaries for care vary from person to person, the article illustrates how factors such as cultural norms and affordability can inspire people to travel when seeking health-care services.

Other theoretical contributions

Geographers have contributed in a variety of ways to the many other links between transportation and health that are not covered in this chapter. Two noteworthy research topics are briefly referenced here. The first is transportation-related noise, which has been linked to a number of negative health outcomes and is highly variable across space (Kim et al., 2012). The second focuses on the role that transportation networks play in the diffusion of infectious disease; researchers in this area have examined a number of modes, from transit systems (Cooley et al., 2011) to airline networks (Bowen and Laroe, 2006). For more on the various ways in which transportation and health intersect, the reader is directed to the previously cited work by Widener and Hatzopoulou (2016), which presents a causal map of the many relevant dimensions and feedbacks between health and transportation systems and includes a longer list of example papers.

Methodological contributions

Beyond the theoretical contributions described above, some techniques widely applied in transportation research have been used by geographers to better understand health outcomes. A first method is the collection of travel surveys (or travel diaries) from study participants as a way to understand where and by what mode a person travels, usually over a period of days. Although this tool is commonly used by transportation researchers, recently geographers have also harnessed this data-collection technique, realizing its ability to capture useful information about geographic context. With information from travel surveys and diaries, it is possible to compare health outcomes of people who, for example, walk to work versus those who take an automobile (Lachapelle and Frank, 2009). A second common technique extensively used in the world of transportation research and transportation geography is the use of Global Positioning System (GPS)-enabled devices. Similar to travel surveys, data collected from GPS-enabled devices can be used to explore people's daily transportation patterns and understand how they relate to access to a wide range of health services and healthy places. As one example, Zenk et al. (2011) used GPS trackers to better understand how the individual dietary behaviors of urban residents in Detroit were affected by their various spatial trajectories and exposures to the food environment.

Advancing transportation research in health geography

While the scope of health and transportation research in geography is large and diverse, there are a number of limitations to the current body of literature. For example, as previously mentioned, there is a strong bias toward quantitative methodologies. Given the varied methodologies employed by geographers, health geographers are in a unique position to supplement current work with mixed-methods and qualitative approaches, building on the work already underway by those engaging in health research that uses the new mobilities paradigm. Interviews, focus groups and ethnographies will be particularly valuable in uncovering the processes that result in uneven access and use of transportation networks that potentially exacerbate disparities in health outcomes across space. These are important directions for advancing this area of health geography.

Much of the work outlined in this chapter is conducted in the United States, Canada, and Western Europe. While there are a growing number of studies emerging from China, and some research on transportation and health geography in other parts of the world, there is a need for health geographers to collaborate with academics and institutions across the globe, where transportation behaviors and infrastructure can be substantially different from those in the Global North. With many parts of the world rapidly urbanizing and struggling to build transportation infrastructure to accommodate growing populations, there is an acute need for geographers to study how health outcomes and transportation behaviors affect each other. This includes

developing attentiveness to differing social environments, such as contexts where populations are rapidly aging, and changing physical environments, such as remote settings where transportation networks are being altered as a result of climate change.

Health geographers continue to be well-positioned to study how a wide range of health outcomes are affected by, and affect, transportation. Geographers' training in diverse methods and content areas, from social theories to atmospheric sciences, as well as their interest in spatial effects, provide them with the tools and perspective to tackle this fundamentally multidisciplinary topic.

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