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The integrated transport and health impact modeling tool in Nashville, Tennessee, USA: Implementation steps and lessons learned

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ABSTRACT

The Integrated Transport and Health Impact Model (ITHIM) is a comprehensive tool that estimates the hypothetical health effects of transportation mode shifts through changes to physical activity, air pollution, and injuries. The purpose of this paper is to describe the implementation of ITHIM in greater Nashville, Tennessee (USA), describe important lessons learned, and serve as an implementation guide for other practitioners and researchers interested in running ITHIM. As might be expected in other metropolitan areas in the US, not all the required calibration data was available locally. We utilized data from local, state, and federal sources to fulfill the 14 ITHIM calibration items, which include disease burdens, travel habits, physical activity participation, air pollution levels, and traffic injuries and fatalities. Three scenarios were developed that modeled stepwise increases in walking and bicycling, and one that modeled reductions in car travel. Cost savings estimates were calculated by scaling national-level, disease-specific direct treatment costs and indirect lost productivity costs to the greater Nashville population of approximately 1.5 million. Implementation required approximately one year of intermittent, part-time work. Across the range of scenarios, results suggested that 24–123 deaths per year could be averted in the region through a 1–5% reduction in the burden of several chronic diseases. This translated into $10–$63 million in estimated direct and indirect cost savings per year. Implementing ITHIM in greater Nashville has provided local decision makers with important information on the potential health effects of transportation choices. Other jurisdictions interested in ITHIM might find the Nashville example as a useful guide to streamline the effort required to calibrate and run the model.

1. Introduction

Transportation systems can impact health through changes in physical activity, injury, and air pollution mediated disease (Centers for Disease Control and Prevention, 2010). These health pathways account for a large burden of mortality in the United States (Caizzo et al., 2013; Lee et al., 2012; United States Department of Transportation and National Highway Traffic Safety Administration, 2015). Quantitative estimates of the net expected change in health status attributable to changes in future transportation behavior could help governments efficiently allocate resources and reduce health care costs. The Integrated Transport and Health Impact Model (ITHIM) is a relatively new, comprehensive tool that might fill this need (Woodcock et al., 2009). To date, ITHIM has been used infrequently in the United States, primarily in densely-populated areas on the West Coast (Iroz-Elardo et al., 2014; Maizlish et al., 2013). Implementations of ITHIM in sprawling metropolitan areas with diverse mixes of rural, suburban, and urban areas are lacking. Such a project could demonstrate ITHIM's effectiveness across a range of settings and identify additional sources for calibration data.

The Nashville Area Metropolitan Planning Organization (NAMPO) is responsible for transportation planning for 1.5 million residents in seven counties in north central Tennessee (TN), which lies in the southeastern United States. Notably, this area has a high burden of chronic disease and associated risk factors (Yoon et al., 2014). The NAMPO has recognized transportation's role in addressing these health

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concerns and is actively embracing public health concepts in transportation planning, influenced by support for active transportation (e.g. walking and bicycling) registered in public opinion surveys. For example, the NAMPO has adopted a project-selection scoring rubric where 80 of 100 points are dedicated to elements of Complete Streets design standards, thereby increasing substantially the number of funded projects that meet these standards. Further, the NAMPO has reserved 15% of its US Department of Transportation Surface Transportation Program allocation for active transportation infrastructure and education projects and 10% for public transit-related projects. The NAMPO elected to use ITHIM to estimate the potential health impacts of these initiatives that collectively aim to increase walking, bicycling, and transit use in the region. The outputs of the ITHIM model would also help the NAMPO educate stakeholders and the general public on the relationship between transportation and health.

ITHIM uses comparative risk assessments to estimate the health impacts of changing transportation behaviors through three pathways: physical activity, air pollution, and injuries (serious and fatal). By taking into account both potential benefits and harms, ITHIM provides a comprehensive estimate of health impacts not available in some other models (World Health Organization, 2014), but its comprehensiveness requires extensive calibration data. Early use of ITHIM in the US relied on robust transportation and health data from the state of California (Maizlish et al., 2013), and similar data are not uniformly available in other geographic areas. Therefore, the purpose of this paper is to describe (a) the implementation, including model calibration, scenario development, and selected results, of ITHIM in greater Nashville and (b) important lessons learned during the process. In doing so, this paper might serve as an implementation guide for practitioners or researchers in other geographic areas, especially, but not limited to, other mid-sized US metropolitan areas.

2. Methods and materials

2.1. ITHIM Model

Details on the development of and calculations within the ITHIM model have been previously published (Maizlish et al., 2013; Woodcock et al., 2009) and will only be summarized here, as our intent is to detail implementation rather than model development and underlying mathematics. The current version of ITHIM being used in the US is constructed as a multi-spreadsheet workbook in a commonly available spreadsheet application. This allows ITHIM to be run on most computers without additional software purchases.

ITHIM estimates the hypothetical health impacts of shifting travel patterns (e.g. distance and mode of travel) within a given population, assuming no time lag for behavior change or health impacts. Given these assumptions, the purpose of ITHIM is to estimate the magnitude and direction of potential net health impacts rather than to precisely forecast disease burdens. In the case of the NAMPO, these estimates were used to facilitate a broader discussion on the links between transportation and public health, and were not used to plan health services or budget for future disease burdens.

Within the model, health impacts are calculated through three exposure pathways: physical activity, air pollution, and traffic injuries and fatalities. For each pathway, ITHIM uses comparative risk assessment to predict changes in disease burden for a given change in exposure. Comparative risk assessment is derived from calculations of population attributable fraction (Bhopal, 2008), which estimates the burden of disease attributed to a specific exposure. The results from the pathways are combined and health outcomes are presented in four summary measures: total mortality (deaths per year), premature mortality (years of life lost), morbidity (years living with a disability), and combined morbidity and mortality (disability-adjusted life years [DALYs]), which are the sum of years of life lost and years living with a disability. ITHIM can also be used to estimate changes in CO2 emissions for a given change in travel patterns, but this functionality was not used in the greater Nashville area.

2.2. Cost savings estimation

During implementation in California, two economic impact calculations were added to ITHIM that have not been previously published. The first method uses the value of a statistical life combined with ITHIM-predicted changes to mortality to estimate financial impact. The dollar value represented in the value of statistical life is the theoretical "amount that a group of people is willing to pay for fatal risk reduction in the expectation of saving one life" (Miller, 2000; Rogoff and Thomson, 2014; United States Environmental Protection Agency, 2015). The second method combines ITHIM-estimated changes in disease prevalence with published US estimates of the direct costs of treatment and indirect costs of lost worker productivity for a given illness or condition. Because the NAMPO used ITHIM results for public outreach messaging, the second, cost of illnesses method was used as this was judged more intuitive in early presentations of the data. In the Nashville implementation, this method also produced more conservative estimates than those based on the value of a statistical life. The conditions included in the cost of illness calculations and the relevant findings from the literature review are presented in Table 1. All values were inflation-adjusted to 2012 dollars (US Bureau of Labor Statistics, 2015). Nashville-specific cost estimates were calculated by multiplying the national estimate by the proportion of the US population that lives in greater Nashville (0.48%). This method is limited by assuming a similar demographic makeup and disease experience for Nashville and the US as a whole. The Nashville-estimated costs were then multiplied by the ITHIM-predicted change in disease burden to arrive at the estimated change in cost for each condition. Because this method does not account for delays between certain exposures and health outcomes (i.e. physical activity and prevention of cardiovascular diseases), the NAMPO presented the predicted financial impacts as illustrative examples that compared potential health effects to transportation spending using common units. These analyses fostered a larger discussion on transportation and health and were not used to plan healthcare resources or budgets.

2.3. Calibration data sources

For this implementation, ITHIM required 14 calibration data items covering underlying disease burdens, travel habits, physical activity participation, air pollution levels, and traffic injuries and fatalities. Multiple data sources were used; each is listed in Table 2 and explained in greater detail below. For all calibration data sources, 2012 values were preferred because this was the year of the most recent transportation planning study in greater Nashville.

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