Routine Assessment of Health Impacts of Local Transportation Plans: A Case Study From the City of Los Angeles

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Objectives. To determine the health impacts of three future scenarios of travel behavior by mode for the City of Los Angeles, California, and to provide specific recommendations for how to conduct health impact assessments of local transportation plans on a more routine basis.

Methods. We used the Integrated Transportation and Health Impact Model to assess the health impacts of the Los Angeles Mobility Plan 2035 by using environmental impact report data on miles traveled by mode under alternative implementation scenarios as inputs. The Integrated Transportation and Health Impact Model links region-wide changes in travel behavior to population exposures to physical activity, air pollution, and traffic collisions and associated health outcomes and costs.

Results. The largest impacts were on cardiovascular disease through increases in physical activity. Reductions in air pollution–related illnesses were more modest. Traffic injuries and deaths increased across all scenarios but were greatly reduced through targeted roadway safety enhancements accounted for outside the model.

Conclusions. By establishing miles travelled as the metric for transportation impacts of statewide and regional plans, states can leverage existing data sources to more routinely consider health impacts as part of environmental impact reports. While not insurmountable, challenges remain regarding the incorporation of land use and roadway safety strategies into health impact estimates. (*Am J Public Health*. 2019;109:490–496. doi:10.2105/AJPH.2018.304879)

The health effects of land use and transportation policies are increasingly well understood. The Community Preventive Services Taskforce recently recommended built environment interventions combining land use and transportation strategies based on a systematic review yielding substantial evidence of their effectiveness in increasing physical activity.[1] With the recent uptake of health impact assessments in the United States, a variety of land use and transportation projects and policies have been subject to careful consideration of potential health impacts.[2–8] However, in the absence of standardized metrics and analytic tools, these efforts will continue to be ad hoc and labor-intensive.

A recent amendment to the California Environmental Quality Act has helped set a course toward more routine assessment of the health impacts of local transportation plans in California. As part of broader efforts to reduce greenhouse gas emissions, the act now requires that transportation impacts, including those assessed in Environmental Impact Reports (EIRs), be measured in terms of vehicle miles traveled (VMT) rather than level of service.[9] Not only does this orient transportation planning toward emission reduction rather than traffic congestion, but it also provides an EIR metric that can be more readily linked to health outcomes. This health impact assessment uses the city of Los Angeles Mobility Plan 2035 (Mobility Plan) —an updated transportation element of the city of Los Angeles general plan—as a first case study of this opportunity to quantify the health impacts of local transportation plans in California and help inform their implementation through more careful consideration of health impacts.

With projected aggregate city-level changes in per-capita daily miles traveled by mode as inputs, we used the Integrated Transportation and Health Impact Model (ITHIM) to conduct a health impact assessment of the Mobility Plan to inform its implementation with data on the potential health impacts of different implementation scenarios. An advisory group of Los Angeles planning and transportation officials helped shape the scope of the project and were the primary audience for its findings and recommendations. After describing ITHIM and the transportation scenarios modeled, we present results across a range of disease and injury outcomes and their associated costs. We then summarize our recommendations to local stakeholders and discuss future opportunities and challenges for incorporating health considerations into local transportation planning and project implementation in other jurisdictions.

METHODS

Health effect estimates in ITHIM are based on the concept of population attributable risk, yielding changes in disease and injury in a population resulting from shifts in risk factor

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exposures from baseline to alternative scenarios. ITHIM links changes in travel patterns across modes to 3 transportation-related exposures with implications for health: physical activity, air pollution, and traffic collisions. Changes in these exposures are then used to project health outcomes based on relative risk (RR)–exposure gradients with strong evidence from systematic reviews. All outcomes are expressed as changes in premature deaths and disability adjusted life years (DALYs), for a single accounting year (see Model Assumptions section). Projected changes in disease-specific mortality rates incorporate anticipated improvements in public health and medical care based on the judgment of clinical and public health experts.[10] A more complete description of the methodological underpinnings of ITHIM can be found elsewhere.[11,12] Here, we provide an overview of the model calibration process, the health outcomes and health costs modeled, and some key model assumptions. A description of the scenarios modeled for the health impact assessment is also provided.

Calibrating the Model for Local Use

To estimate the health impacts of a transportation plan, the user must first populate ITHIM with required input parameters consisting of aggregate state-, regional-, or municipal-level data on population demographics, disease-specific mortality rates, and health-related behaviors and exposures. For the Mobility Plan assessment, we derived parameter data from a variety of sources, including the California Household Travel Survey, the California Department of Public Health Death Statistical Master File, the California Health Interview Survey, the California Emissions Factor Model, the California Statewide Integrated Traffic Records System, and the California Department of Finance. We were able to obtain parameter data at the Los Angeles city level for most input parameters, though several (traffic injury rates, non-travel related physical activity time, and age–sex–specific ratio of disease-specific mortality rates) were only available at the Los Angeles County level. For the latter, we scaled the data down to the city population when needed and assumed consistency of rates between city and county.

Physical Activity

We multiplied Los Angeles city-level input data from the 2012 California Household Travel Survey and the 2009 California Health Interview Survey[13] on active travel time and non–travel-related physical activity time by weights to produce metabolic equivalent task hours, which reflect energy expenditures for walking and bicycling at average speeds and for occupational tasks.[14] We derived health outcome estimates from established research on the RR relationships between metabolic equivalent task hours and the following health conditions: cardiovascular disease (CVD), diabetes, dementia, depression, breast cancer, and colon cancer.

Air Pollution

We obtained Los Angeles city-level input data on population-weighted ambient concentrations of fine particulate matter ($PM_{2.5}$) with the assistance of modelers at the South Coast Air Quality Management District by using the Community Multi-Scale Air Quality Model (CMSAQM).[15] The emission inventory for the business-as-usual (BAU) scenario was developed based on the 2016–2040 Regional Transportation Plan/Sustainable Communities Strategy by the Southern California Association of Governments. We estimated emission changes for the alternative future scenarios with light-duty vehicle travel activity data from the Southern California Association of Governments and emission factors generated by the 2014 California Emission Factors Model.[16] We derived health outcome estimates from established research on the RR relationship between increments of $PM_{2.5}$ concentrations and the following air pollution–related diseases: lung cancer, asthma, acute respiratory infection, chronic obstructive pulmonary disease, pneumoconiosis, and CVD.

ITHIM does not directly account for health effects associated with changes in traffic congestion. Local stakeholders have expressed concerns about potential increases in congestion attributable to reductions in car travel lanes. To account for potential health impacts of increased idling emissions from traffic congestion, the South Coast Air Quality Management District incorporated EIR-estimated vehicle speed reductions into the Community Multi-Scale Air Quality Model.

Traffic Collisions

We used California's 2006–2010 Statewide Integrated Traffic Records System database to derive ITHIM input parameters on severe and fatal traffic injuries per mile traveled by victim and striking vehicle and roadway type (local, arterial, and highway) for the city of Los Angeles.[17] Severe injuries include broken bones, dislocated limbs, severe burns or lacerations, and unconsciousness at the scene of the collision.

Health-Related Costs

ITHIM contains a module that monetizes death and disability outcomes by using the cost of illness methodology, based on cost estimates from published studies.[18–24] The cost of illness methodology accounts for direct health care costs associated with an illness or injury and indirect societal costs from loss of productivity because of illness or premature death. Costs and cost savings associated with health impacts are inflation-adjusted and expressed as annual costs in 2010 dollars.

Model Assumptions

Some key model assumptions are as follows:

1. Future health outcomes, costs, and cost savings associated with alternate travel behavior change scenarios occur in a single future "accounting year" specified by the user (2035 for this analysis), although the exposures contributing to those outcomes are likely to occur gradually over time;
2. Future health impacts are modeled on the basis of aggregate region-level travel data and thus do not capture potential neighborhood-level variability;
3. Increases in physical activity because of active transportation are not compensated for by a decrease in nontransport physical activity;
4. Traffic injury levels begin to slow down at very high levels of biking and walking. This "safety in numbers" phenomenon is incorporated into the model[25]; and
5. ITHIM incorporates projected truck miles associated with goods movement from travel demand models (TDMs) of regional transportation planning agencies.

Additional changes in goods movement are typically not included in ITHIM's user-generated travel scenarios.

Travel Scenarios Modeled

Using ITHIM's user-generated scenario tool, we compared the health and health cost impacts, in 2035, of 3 alternative scenarios of Mobility Plan implementation to a 2035 BAU (i.e., no Mobility Plan implementation) scenario (Table 1). The BAU and first alternative scenarios were derived from the Mobility Plan's EIR, which used the city of Los Angeles's Travel Demand Forecasting Model[26] to estimate the combined impacts of 3 major transportation infrastructure elements of the Mobility Plan: (1) the enhanced vehicle network (adding vehicle lanes on designated roadways), (2) the enhanced transit network (converting vehicle lanes to bus-only lanes on designated roadways), and (3) the enhanced bicycle network (converting vehicle lanes to bike lanes on designated roadways). Per new California Environmental Quality Act guidelines, the EIR included VMT as a measure of transportation impact, and we supplemented this with a request to the city of Los Angeles's EIR contractor for additional impact data on miles traveled walking, biking, and on public transit. Because the Mobility Plan includes several other elements that have been shown to reduce VMT and increase active travel (e.g., land-use strategies, transportation demand management, and roadway safety enhancements), we consider this first scenario from the EIR to be conservative as it represents only partial implementation of the Mobility Plan.

For an aspirational scenario representing full implementation of the plan, we used one of the stated objectives of the Mobility Plan—namely, to decrease per-capita VMT by 20% by 2035. Because this Mobility Plan objective does not specify changes in other travel modes, our second scenario is further divided into 2 subscenarios: (1) low active transport sets daily walk and bike miles per capita to the levels predicted in the EIR (approximately 2 times BAU levels) and (2) high active transport sets combined daily walk and bike travel per capita to approximately 3 times the BAU level. Transit miles in both scenarios are adjusted up or down based on the assumption that total miles across modes remains constant.

RESULTS

We describe our results by 3 domains of health outcomes: cardiovascular disease and diabetes, air pollution–related illness, and traffic injuries. We end this section with a description of health-related costs associated with each of the scenarios modeled.

Cardiovascular Disease and Diabetes

For CVD, compared with BAU, projected deaths averted in 2035 ranged from 71 for the conservative scenario to 191 for the high active transport aspirational scenario (Figure 1). DALYs averted in 2035 from reductions in CVD ranged from 2010 to 4647 (Figure 2). For diabetes, compared with BAU, projected deaths averted in 2035 ranged from 12 for the conservative scenario to 30 for the high active transport aspirational scenario. DALYs averted in 2035 from reductions in diabetes ranged from 580 to 1294. To put the mortality figures in context, under the high active transport scenario, CVD and diabetes deaths averted in 2035 were equivalent to 3.3% and 3.6% of total deaths from those causes in 2013.[27]

Air Pollution–Related Illness

Based on the relatively small per-capita daily VMT reductions in the conservative scenario, the CMSAQM modeling did not yield any significant effects on ambient concentrations of $PM_{2.5}$ and, thus, no health impacts were projected. However, the larger VMT reduction under the aspirational scenarios yielded a population-weighted average ambient $PM_{2.5}$ reduction of 0.17 micrograms per cubic meter. This reduction is derived from decreases in vehicle exhaust emissions and in resuspended road dust from tire and brake wear. This $PM_{2.5}$ reduction, compared with BAU, was associated with 23 deaths and 187 DALYs averted in 2035 from reductions in air pollution–related illnesses (Figures 1 and 2).

When changes in vehicle speed were incorporated into the Community Multi-Scale Air Quality Model (to account for increased traffic congestion), the effect on $PM_{2.5}$ was insignificant. This is largely attributable to the fact that most VMT impacts on $PM_{2.5}$ come from road dust and tire and brake wear rather than from tailpipe emissions, and traffic congestion has a greater impact on the latter.

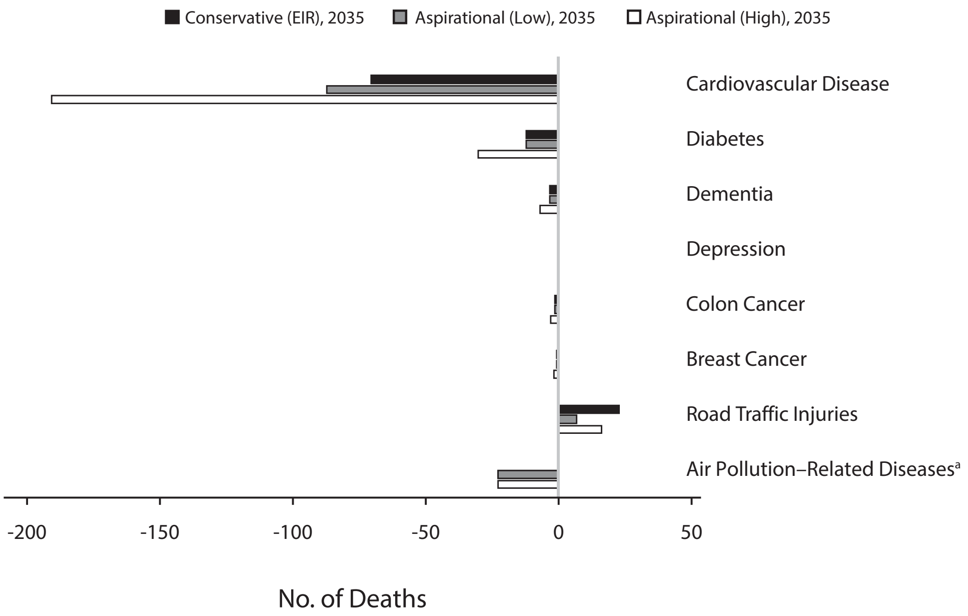
Traffic Injuries

Compared with BAU, increases in severe traffic injuries and deaths were projected across all 3 scenarios (Figures 1 and 2). The highest increase—23 additional deaths and 1014 additional DALYs in 2035—was observed with the conservative scenario, as walk or bike travel doubled while car VMT only decreased slightly. The lowest increase—7 additional deaths and 317 additional DALYs—was seen with the low active transport aspirational scenario, as walk or bike travel remained at the conservative level, but car VMT decreased by almost 20%, reducing the exposure of additional cyclists and pedestrian to cars on the road. Importantly, these injury estimates do not account for any Mobility

TABLE 1—Description of Future (2035) Mobility Plan Implementation Scenarios for City of Los Angeles, CA

		Per Capita Daily Miles Traveled by Mode		
Scenarios (all in 2035)	Source	Car	Bike/Walk	Transit
Future business as usual	Environmental Impact Report	28.3	0.5	1.9
Conservative	Environmental Impact Report	27.7	1.2	3.0
Aspirational—low active transportation	Mobility Plan Objective	23.7[a]	1.2	5.9
Aspirational—high active transportation	Mobility Plan Objective	23.7	1.6	5.5

[a]Vehicle miles traveled under the aspirational scenario is 20% lower than 2016 baseline but only 17% lower than 2035 business as usual.



Note. EIR = environmental impact report.

[a]The Integrated Transportation and Health Impact Model models the effects of fine particulate matter ($PM_{2.5}$) on air pollution–related diseases, which includes cardiovascular disease (CVD). Thus, changes in CVD mortality attributable to $PM_{2.5}$ are included under both CVD and air pollution–related diseases in this figure.

FIGURE 1—Number of Deaths in the City of Los Angeles, CA, Under 3 Future Mobility Plan Implementation Scenarios Compared With 2035 Business as Usual

Plan–related efforts to improve roadway safety conditions for pedestrians and cyclists. We account for such efforts in the "Health-Related Costs" section.

Health-Related Costs

Table 2 presents the expected costs and cost savings, in 2035, associated with various health outcomes under each of the 3 alternative scenarios, compared with BAU. The greatest cost savings are attributable to reductions in CVD, ranging from $47.6 million for the conservative scenario to

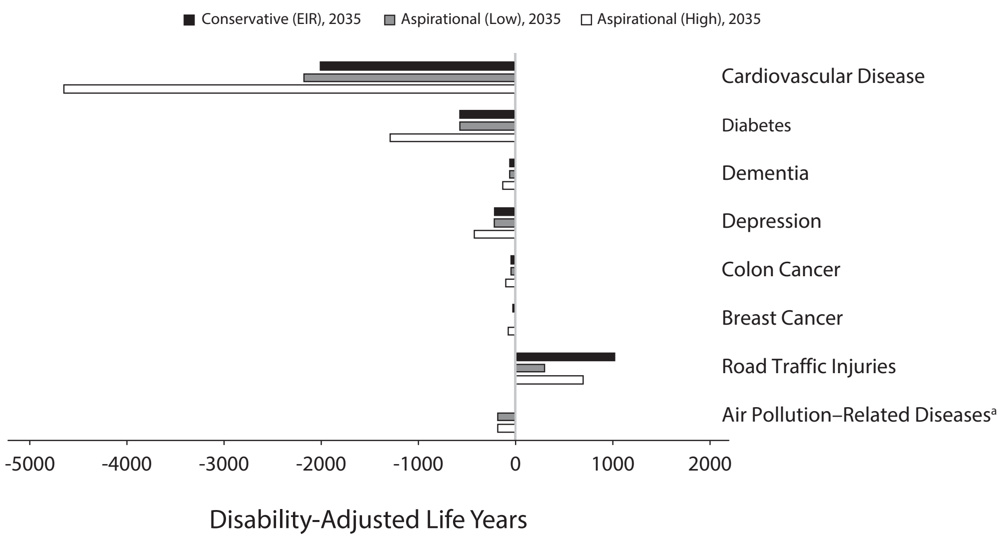


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FIGURE 2—Number of Disability-Adjusted Life Years in the City of Los Angeles, CA, Under 3 Future Mobility Plan Implementation Scenarios Compared With 2035 Business as Usual

TABLE 2—Estimated Health Costs (Savings), by Scenario, for the City of Los Angeles, CA, in 2035 (2010 Dollars)

	Scenarios		
Conditions	Conservative-EIR, $	Aspirational-Low, $	Aspirational-High, $
Cancer	(2 119 639)	(2 119 639)	(4 339 631)
CVD	(47 599 152)	(55 236 174)	(113 413 959)
Respiratory	0	(605 203)	(605 203)
Mental illness	(11 166 213)	(11 166 213)	(22 383 013)
Diabetes	(44 826 472)	(44 826 472)	(100 033 944)
Traffic injuries	117 455 860	36 744 220	80 307 070
Total	11 744 384	(79 122 535)	(162 381 735)

Note. CVD = cardiovascular disease; EIR = Environmental Impact Report.

$113.4 million for the high active transport aspirational scenario. The greatest costs are attributable to increases in traffic injuries, which occur, on average, among younger age groups, thus resulting in more productive years of life lost. Whereas both aspirational scenarios produce net savings ($79 million and $162 million, respectively), the conservative scenario produces net costs attributable to the high costs of traffic injuries.

To account for the potential effect of reductions in injuries attributable to the Mobility Plan strategies targeting safer bicycle and pedestrian infrastructure, we calculated that a reduction in traffic injury burden of greater than 1% would lead to a net cost savings in the conservative scenario. Data from the Crash Modification Factors Clearinghouse[29] indicate that a greater than 1% reduction in traffic injury burden is achievable through targeted implementation in high-collision areas of any 1 of several road safety measures included in the Mobility Plan.

DISCUSSION

We have shown that a new California environmental regulation establishing VMT as the standard metric for assessing transportation impacts created an opportunity for local jurisdictions to extend the assessment of transportation plans to include an assessment of health impacts. In our assessment of the Mobility Plan, we found positive health impacts across several implementation scenarios, with the greatest impacts resulting from reductions in CVD and diabetes attributable to increases in physical activity. Air quality impacts were more modest, only occurring under the aspirational 20% VMT reduction scenario. Increased presence of cyclists and pedestrians on roadways was associated with increased injuries and deaths across all scenarios, although the latter could be greatly reduced through targeted safety measures.

Based on the findings, we developed a series of recommendations for Los Angeles city planning and transportation officials on how to maximize benefits and minimize harms to health through specific Mobility Plan implementation strategies. First, given the relative magnitude of health benefits of increases in active transportation, we recommended prioritizing active transport network expansions and increased connectivity with public transit through first- and last-mile connections.[28] Second, given our findings on the countervailing risk of traffic injuries, we recommended that efforts to encourage active transport should be accompanied by roadway safety enhancements that measurably reduce traffic collisions.[29] Finally, given the relatively small reductions in air pollution–related illness from the Mobility Plan alone, we recommended that the city would need to look beyond the Mobility Plan to leverage broader regional rail expansion initiatives to achieve greater impact on air pollution–related health outcomes. In addition to these local policy implications, some important challenges must be addressed before health impact assessment of local transportation plans can become more widespread across the state and country.

Special Data Requirements

To accurately model the health impacts of changes in local travel behavior, tools like ITHIM must first be calibrated with input parameters from local data sources on travel behavior, traffic collisions, air quality, and disease-specific mortality rates. Given that California has the requisite data for these parameters, the application of ITHIM to transportation planning in large cities across the state is feasible. However, other states and large cities wishing to use a tool like ITHIM would first have to take stock of available data. Several states and cities, including Oregon, Maryland, Massachusetts, and Nashville, Tennessee, have already embarked on analyses using ITHIM.[12,30] The fact that many large states conduct health and household travel surveys and maintain statewide traffic collision reporting systems bodes well for their ability to combine those sources with local mortality data to assess transportation impacts on traffic injuries and physical activity–related chronic diseases.

Capturing air quality–related outcomes may prove more challenging. The modeling required to link car-based pollutants to ambient concentrations of $PM_{2.5}$ is computationally intensive and can typically only be performed by air-quality regulatory agencies with access to complex modeling tools and skilled modelers. Nevertheless, under the Clean Air Act, the US Environmental Protection Agency monitors metropolitan area attainment of national ambient air-quality standards, including $PM_{2.5}$, and noncompliant areas must develop air-quality management plans to work toward attainment. Thus, metropolitan areas with relatively poor air quality are likely to conduct the kind of modeling necessary to project health impacts.

Beyond these input parameters, producing data-driven estimates of health impacts of transportation plans requires that TDMs be used to project the impacts of specific transportation policies and projects on per-capita miles traveled by mode. California has taken the first step in this direction by requiring that plans adopt VMT as their measure of transportation impact. Until other states adopt similar policies, their local transportation authorities can use ITHIM to quantify the health impacts of hypothetical VMT reduction goals, rather than TDM-based estimates of VMT reduction.[31] Furthermore, ITHIM requires data on changes in per-capita miles traveled across all travel modes, not just car travel. For this analysis we had to request supplementary model estimates for walk, bike, and transit travel distances. Producing walk and bike travel distance estimates from TDMs is challenging given the relatively short trip lengths that do not often cross transportation analysis zone boundaries. In fact, to get more plausible estimates, we had to multiply estimated numbers of trips from the TDM estimates by average trip distances from the California Household Travel Survey. Thus, to capture health as well as emission-reduction benefits of transportation policies and plans involving changes in active travel, it will be important to improve the capability of TDMs to estimate changes in travel distances across all modes.

Accounting for Land Use Strategies

While TDMs can yield robust quantitative projections of transportation plan impacts on VMT, they are generally limited to projecting the impacts of plan elements with specified effects on the network of local roadways (e.g., adding, subtracting, or repurposing travel lanes). Thus, many land use strategies that have been shown to affect travel behavior are typically not accounted for in impact projections. Lacking quantitative estimates of the effects of Mobility Plan land use strategies on travel behavior, we used the stated goal of 20% VMT reduction as a proxy for full implementation of the plan, but this may be an overestimate of potential impacts. One way to produce more precise estimates of the impacts of land use strategies would be to use results of meta-analyses that provide weighted average elasticities for the effects of these strategies on miles traveled across various modes[32] or to use ITHIM in combination with land use models such as Urban Footprint.[33]

Accounting for Efforts to Improve Roadway Safety Conditions

Efforts to increase active travel will necessarily increase exposure time in traffic for pedestrians and cyclists, and collisions involving bikes and pedestrians are more likely to result in severe injury or death. Thus, improvements in health through physical activity will be offset by increases in traffic injuries among active travelers unless specific measures are taken to improve roadway safety. A "safety in numbers" effect will eventually reduce injury risk, but the Mobility Plan did not produce such an effect, even in our high active transport scenario. In the meantime, local transportation planners are increasingly focused on creating safe travel networks for cyclists and pedestrians. This is exemplified by Vision Zero, a multinational traffic safety initiative that is currently being implemented in large cities across the United States, including Los Angeles. A way to incorporate these kinds of safety measures into health impact assessments is to use the Crash Modification Factors Clearinghouse.[29] The clearinghouse provides scores for discrete street treatment and design strategies and these scores are associated with approximate percentage reductions in crashes resulting in fatal or severe injuries where strategies are implemented. These scores can then be used to calculate the potential health and economic impact of implementing such strategies in concert with other transportation plan elements.

Public Health Implications

We have shown that a California state regulation replacing level of services with VMT as the required metric for capturing transportation impacts of local plans has made it feasible to estimate the health impacts of these plans in large metropolitan areas in California and that similar estimation is theoretically feasible in other states. By using EIR findings as inputs to epidemiologic tools, like ITHIM, that link travel distances by mode to health outcomes through their associated risk factors, extending these EIRs to include health impacts can become more routine and standardized. Furthermore, we have demonstrated that city- or region-level impacts can be considerable, and, although aggregate estimates may mask neighborhood-level variation, they can help planners and policymakers prioritize the types of plan implementation strategies most likely to improve population health. Other states interested in leveraging transportation policy to improve health should consider requiring travel distance by mode as a transportation impact metric and harnessing the power of existing state data sources like those described previously. Finally, we have shown that local health departments can contribute their analytic capacity to these efforts as part of their broader mission to address the social and environmental determinants of health. AJPH

CONTRIBUTORS

W. Nicholas conceptualized the study design, oversaw the analyses, and led the writing of the article. I. Vidyanti conducted the analyses and helped with the writing and editing. E. Caesar managed study operations and helped with writing and editing the article. N. Maizlish provided expert input on the study design and analyses and contributed to the writing and editing of the article.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to disclose.

HUMAN PARTICIPANT PROTECTION

No protocol approval was necessary because no human participants were directly engaged for this study.

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