Center for Health Impact Evaluation

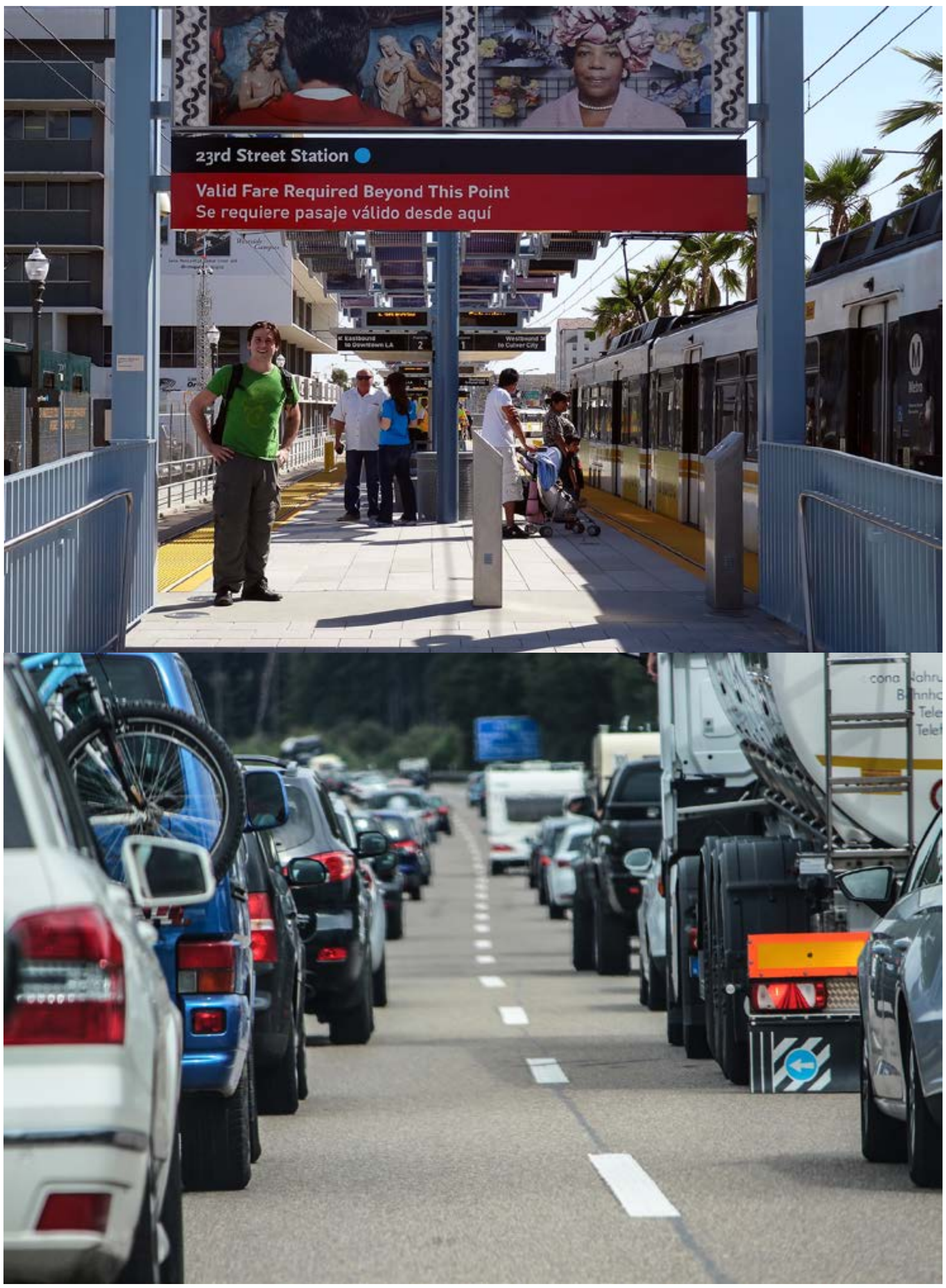
Better policies for healthy communities

County of Los Angeles Public Health

Implementing the City of LA's Mobility Plan 2035: Public Health Implications

Health Impact Assessment

May 2018



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Executive Summary

This Health Impact Assessment (HIA) uses the *Integrated Transportation and Health Model (ITHIM)*[*] to quantify the health impacts of the City of Los Angeles Mobility Plan 2035 (MP)—an updated transportation element of the City general plan—applying a health lens to the various policy, programmatic, and project options available to City Planning and Transportation officials as they implement the MP.

Methods

ITHIM uses established research evidence to model the impacts of changes in travel behavior on health outcomes through three health pathways: 1) air pollution, 2) traffic collisions, and 3) physical activity. For the purpose of this report, and potential future health impact analyses, the Los Angeles County Department of Public Health's (DPH) Center for Health Impact Evaluation (CHIE) calibrated ITHIM for use at both the LA City and LA County level.

Scenarios Modeled

This report compares the health impacts of three alternative future scenarios (all in 2035) of MP implementation to a future "business as usual" (BAU) scenario projecting conditions in 2035 without the implementation of the MP. The first alternative scenario (conservative) is derived from the MP's *environmental impact report (EIR)*. The second and third alternative scenarios (aspirational) reflect one of the stated objectives in the MP, namely to decrease per capita *vehicle miles traveled (VMT)* by 20% by 2035. Since the MP targets a 20% decrease in VMT but does not specify changes in other travel modes, our second scenario is further divided into two sub-scenarios: low and high active transport.

Targeted Literature Review

To address elements of the MP not accounted for in the conservative scenario quantified in the EIR, but assumed to be part of a more comprehensive implementation of the MP reflected in the aspirational scenarios, we reviewed research evidence on the relationships between travel behavior and three other policy components of the MP; namely land use, safety, and *transportation demand management (TDM).* We focused our review on existing systematic reviews and meta-analyses of the relevant literature where available.

Technical Advisory Group Engagement

A Technical Advisory Group, comprised of representatives from relevant City and County departments, was convened to help ground and interpret the findings in local context and generate practical and actionable recommendations for implementing the MP.

[*] Glossary terms are noted by italicizing the word or phrase upon first use in the report. The glossary can be found on page 29 of the report.

Findings

Projected Changes in Travel Behavior

In 2035, without the MP, LA residents are projected to travel, on average, .24 miles per day by walking, .30 miles per day by cycling, 1.89 miles per day by public transit, and 28.34 miles per day by car. Under the conservative scenario, residents are projected to travel .33 miles per day by walking, .82 miles per day by cycling, 2.96 miles per day by transit and 27.71 miles per day by car. Under both aspirational scenarios, daily car miles per capita are 23.25 miles per day. Under the low active transport scenario, we set walk and bike travel equal to the conservative scenario and increased transit miles to 5.93 per day. For the high active transport scenario, we projected .46 miles per day by walking, 1.16 miles per day by cycling, and 5.46 miles per day by transit.

Cardiovascular Disease and Diabetes

For cardiovascular disease (CVD), projected annual deaths averted in 2035 ranged from 71 for the conservative scenario to 191 for the high active transport aspirational scenario. *Disability-adjusted life years (DALYs)* averted from reductions in CVD ranged from 2,010 to 4,647. For diabetes, projected annual deaths averted in 2035 ranged from 12 for the conservative scenario to 30 for the high active transport aspirational scenario. DALYs averted from reductions in diabetes ranged from 580 to 1,294. To put these projections in context, the CVD and diabetes deaths averted in the high active transport aspirational scenario represent 3.3% and 3.6% of total mortality for these diseases in 2013.

Air Pollution Related Diseases[*]

For air pollution related diseases, no health impacts are projected under the conservative scenario. However, the larger VMT reduction under the aspirational scenario yielded a population weighted average ambient *fine particulate matter (PM 2.5)* reduction of .17 $\mu g/m^3$ for the City of LA. This PM 2.5 reduction led to 23 deaths averted and 187 DALYs averted from reductions in air pollution related diseases.

Traffic Injuries

Since all three scenarios represent increases in biking and walking from BAU, and collisions involving bikes and pedestrians are more likely to result in severe injury or death, increases in the latter were projected across all three scenarios. The highest increase—23 additional deaths and 1,014 additional DALYs—is for the conservative scenario. The lowest increase—7 additional deaths and 317 additional DALYs—is for the low active transport aspirational scenario. These projected increases do not account for efforts to improve the safety of road conditions for pedestrians and cyclists.

Health Cost Impacts

The greatest cost savings are from reductions in CVD which range from $47.6 million for the conservative scenario to $113.4 million for the high active transport aspirational scenario. The greatest costs are from increases in traffic injuries. While both aspirational scenarios produce net

[*] Asthma, chronic obstructive pulmonary disease (COPD), lung cancer, pneumoconiosis, and other chronic respiratory diseases.

savings ($79.1 million and $162.4 million, respectively), the conservative scenario produces net costs due to the high costs of traffic injuries. We estimated that a greater than 1% reduction in traffic injury burden (i.e., through safety measures) under the conservative scenario would lead to net savings in the scenario.

Conclusions

We found notable positive health impacts across all three scenarios, with the greatest impacts resulting from reductions in CVD and diabetes. Estimated DALYs averted from reductions in CVD alone ranged from 2,010 to 4,647. We found some positive impacts on air pollution related diseases, but only under the aspirational scenarios. In order for those impacts to be realized, large VMT reductions would have to be achieved through strategies other than the transportation network enhancements. While there is some research evidence for effects of other MP strategies on VMT, the largest impacts on VMT over the next 20 years are likely to come from activities outside of the MP, namely expansions and enhancements to the subway and light rail network, such as those planned under *Measure M*.

Of perhaps greatest concern, is the increase in traffic related serious injuries and deaths predicted under all three scenarios. However, traffic injury impacts estimated in ITHIM do not account for any strategic efforts to improve safety conditions for pedestrians and cyclists included as part of the MP or via initiatives such as *Vision Zero.*

Our literature review revealed that certain land use strategies are likely to have stronger effects on reductions in car travel and increases in active transport. Specifically, strategies designed to increase *destination accessibility* by aligning multi-modal transportation networks with existing and future commercial and residential development are particularly promising, as are efforts to connect these networks in ways that allow travelers to get to their destinations via the shortest possible route. Evidence of the effectiveness of TDM strategies, designed to incentivize behavioral shifts from car travel to more active modes, is more limited.

Recommendations

Based on the findings of this HIA we offer the following recommendations--described in more detail in the full report—regarding the ongoing implementation of the Mobility Plan:

- Prioritize Mobility Plan policies, projects, and programs that increase travel via walking and cycling (especially cycling) through enhanced *network connectivity*.
- Leverage Measure M transit infrastructure dollars to accelerate reductions in VMT.
- Increase investment in effective strategies for reducing pedestrian and bicycle road traffic injuries and fatalities through Vision Zero.
- Promote equitable implementation of transportation policies, projects, and programs to increase health equity.
- Improve data reporting and sharing to facilitate assessment of health impacts of a wide variety of local transportation planning efforts.

Introduction

The significant health effects of land use and transportation policies are increasingly better understood. Most recently, the Community Preventive Services Taskforce, established by the U.S. Department of Health and Human Services, recommended built environment interventions combining land use and transportation strategies, based on a systematic review of 90 studies yielding sufficient evidence of effectiveness in increasing physical activity.[1] Efforts to improve health outcomes through land use and transportation planning have traditionally employed one of two strategies: 1) assessing the health impacts of specific land use/transportation projects, or 2) addressing health in general plans by adding a health element or incorporating health language across existing elements. The former strategy can be quite effective at elevating and addressing health concerns in the design and implementation of individual projects, but is time and resource intensive. The latter strategy – part of a *health in all policies*[*] approach – can achieve broader reach but impact at the project-level can become diluted.

Due to a new California law, *Senate Bill 743 (SB 743)*, as well as analytic groundwork established by the California Department of Public Health, cities and counties in the state are now able to integrate these two strategies in a way that capitalizes on the strengths of each. This Health Impact Assessment (HIA) uses the City of Los Angeles Mobility Plan 2035 (MP) as a first case study of this new opportunity to quantify the health impacts of local planning documents. The MP, adopted in 2016, is an updated transportation element of the city's general plan designed to promote a balanced, multimodal transportation network that meets the needs of all users, including motorists, pedestrians, bicyclists, and users of public transportation.

Passed in 2014, SB 743 set in motion a process for changing the way that transportation impacts are analyzed under the *California Environmental Quality Act (CEQA)*. This legislation shifted the state away from an emphasis on reducing traffic congestion, as measured by *level of service (LOS)*, toward a new emphasis on reducing *greenhouse gas emissions (GHGE)*, as measured by *vehicle miles traveled (VMT)*. As SB 743 was making its way through the legislature, the California Department of Public Health was adapting an analytic tool from the United Kingdom (the *Integrated Transportation and Health Impact Model—ITHIM*) to quantify the health impacts of state efforts to reduce GHGE in the transportation sector. These parallel efforts set the stage for both a broad requirement (through SB 743) that all CEQA compliant local plans consider transportation impacts in a way that can be directly linked to health impacts, and the ability to quantify (through ITHIM) the health impacts of these plans.

While the details of SB 743 implementation had not yet been fully developed, the MP's *environmental impact report (EIR)* included estimated changes in VMT and active transportation mode share as supplementary metrics. The MP itself also includes VMT reduction as a specific objective. This HIA uses ITHIM to estimate the potential health impacts of the MP and thus represents the first HIA of a local transportation plan under new SB 743 transportation impact

[*] Glossary terms are noted by italicizing the word or phrase upon first use in the report. The glossary can be found on page 29 of the report.

guidelines. This HIA applies a health lens to the various policy, programmatic, and project options available to City Planning and Transportation officials as they address the ongoing implementation of the MP. In keeping with standard of practice for HIA, the Los Angeles County Department of Public Health (DPH) considers how policies impact health not only at the aggregate population level but also how they impact *health equity*, i.e., the equitable distribution of health assets in the population. Since the current version of ITHIM does not disaggregate modeled outcomes by race/ethnicity or socioeconomic status we were not able to project potential inequities in health impacts.[*] However, there is evidence that land use and transportation policies have important health equity implications.[2] To address these implications, we discuss opportunities to promote health equity through MP implementation in our recommendations and encourage readers to consult additional resources focused on equitable transportation policies for LA County.[3]

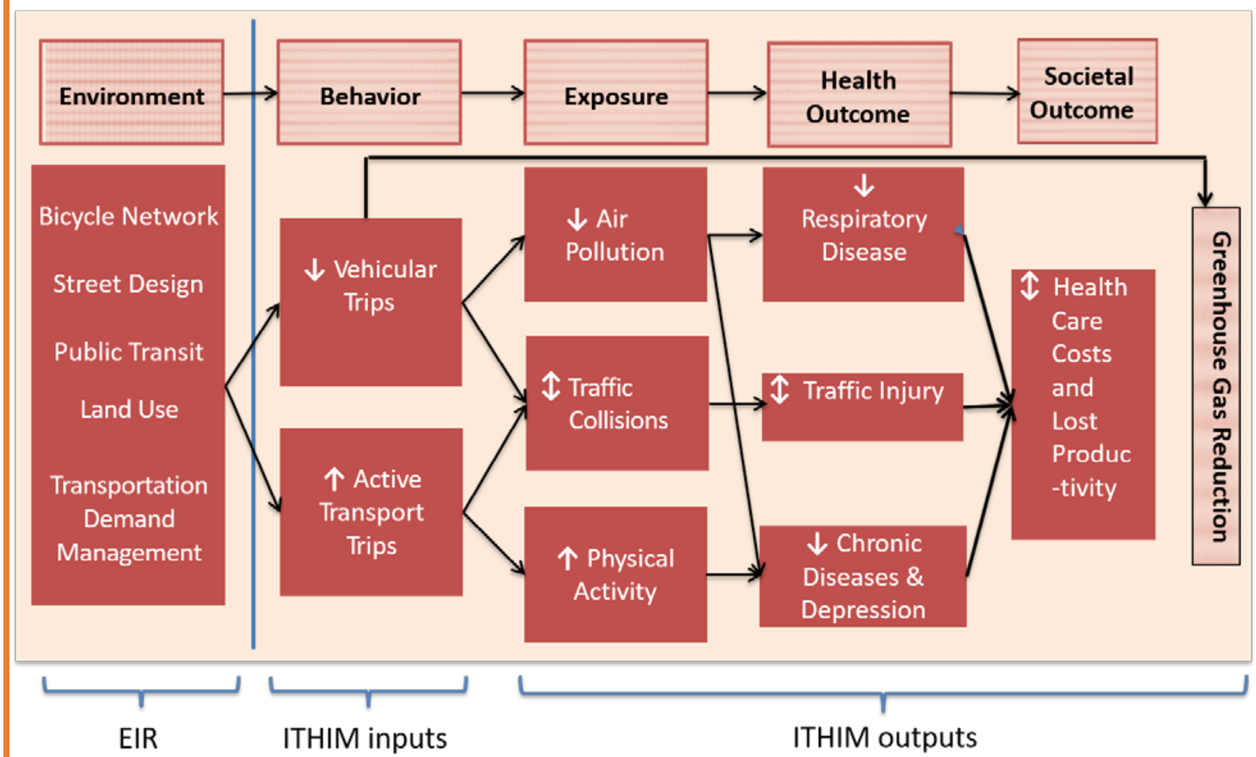
It is important to note that the MP was released during a time of heightened attention to transportation policy in the Los Angeles area. In 2015, as the MP was being finalized, the City of Los Angeles launched its *Vision Zero* initiative, thereby joining cities around the world working to prevent and reduce the severity of traffic collisions. Then, a few months after the MP was adopted, LA County voters approved *Measure M*, a ½ cent sales tax that will generate approximately $860 Million per year for public transportation and other traffic relieving strategies. These two initiatives are likely to have a substantial influence on the implementation of the MP and are largely supportive of the MP's goals and objectives. We thus refer to both of these initiatives as important contextual factors as we describe our methods, findings, and recommendations.

Methods

ITHIM uses established research evidence to model the impacts of changes in travel behavior on health outcomes through three health pathways: 1) air pollution, 2) traffic collisions, and 3) physical activity (Figure 1). Effect estimates are based on the concept of comparative risk assessment which yields changes in disease and/or injury burden resulting from shifts in exposures (i.e., to different travel behaviors) from a baseline scenario to alternative scenarios.

[*] The next version of ITHIM will incorporate data to enable projections of outcomes disaggregated by population sub-groups (in addition to gender and age) that will allow for equity analyses.

FIGURE 1: ITHIM Model Schematic



Scenarios Modeled

This report compares the health impacts of three alternative future scenarios (all in 2035) of MP implementation to a future "business as usual" (BAU) scenario projecting conditions in 2035 without the implementation of the MP (Table 1).

The BAU and first alternative scenario are derived from the MP's EIR, conducted by Fehr & Peers. The transportation section of the EIR models the collective impact on VMT and mode share of the three major transportation infrastructure policies in the MP: 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).[*] The EIR compared future travel behavior with and without these enhanced networks based on the City of Los Angeles' *Travel Demand Forecasting Model*. Because the MP includes a number of other policies (in addition to the three network enhancements modeled in the EIR) that have been shown to reduce VMT and increase active travel, we considered this first scenario to represent a conservative estimate of the potential health impacts of the MP.

[*] The EIR did not include travel projections across all travel modes and roadway types as required by ITHIM. Fehr & Peers provided these additional estimates by special request. When the request was made, Fehr & Peers had updated their travel demand model so all data we used was based on their 2016 model.

The second alternative scenario reflects one of the stated objectives in the MP, namely *to decrease per capita VMT by 20% by 2035*. While a 20% reduction in per capita daily VMT is

TABLE 1: SUMMARY OF SCENARIOS MODELED

Scenarios (all in 2035)	MP Implementation	Per capita miles traveled by mode of transportation		
				
Future Business as Usual (BAU)	None	Projected in EIR	Projected in EIR	Projected in EIR
Conservative (EIR)	Partial	2% reduction from BAU	~2X increase from BAU	~1.5X increase from BAU
Aspirational – Low Active Transportation	Full	20% reduction from 2016 (17% from BAU)	~2X increase from BAU	~3.1X increase from BAU
Aspirational – High Active Transportation	Full	20% reduction from 2016 (17% from BAU)	~3X increase from BAU	~2.9X increase from BAU

considerably higher than the VMT reduction predicted in the EIR, we included this more aspirational scenario to represent what the future might look like under an idealized full implementation of all elements of the MP. Since the MP targets a 20% decrease in VMT but does not specify changes in other travel modes, our second scenario is further divided into two sub-scenarios: low active transport sets daily walk and bike miles per capita to the levels predicted in the EIR (approximately two times BAU for walk/bike combined) and adjusts transit miles up based on the assumption that total miles across modes remains the same over time; high active transport sets combined daily walk and bike travel per capita to three times the BAU level, but preserves the ratio of bike to walk miles from the conservative scenario and adjusts transit travel down accordingly.

In both aspirational scenarios, we assumed marked increase in public transit use to compensate for the decrease in VMT. Even though this increase in public transit use is significantly above the projected levels of public transit use in the conservative scenario, we think this is achievable through improvements in public transit infrastructure above and beyond the MP through Measure M, which will generate substantial revenue, a significant amount of which will be allocated for building and improving public transit infrastructure in Los Angeles City.

ITHIM Calibration for Los Angeles City and County

For the purpose of this report, and potential future health impact analyses, the Los Angeles County Department of Public Health's (DPH) Center for Health Impact Evaluation (CHIE) calibrated ITHIM for use at both the Los Angeles City and Los Angeles County level.[*] This calibration involved an extensive process of requesting, compiling, analyzing, and formatting local-level data from multiple cross-sector sources in order to arrive at the precise input parameters required by the model. Based on this calibration work, ITHIM can now be used to assess the potential health impacts of LA City or County policies whose projected effects on travel behavior have been quantified. For a full description of the methodological underpinnings of ITHIM, the reader is encouraged to consult other sources.[4,5] Here, we provide a brief overview of each of the three health pathways modeled:

Physical Activity

Input data on active travel time and non-transport physical activity time (e.g., jogging in the park) are multiplied by weights to produce *metabolic equivalent task (MET)* hours based on data from the Fehr & Peers' Travel Demand Model and California Household Interview Survey 2009.

Health outcome estimates are derived from established research on the *relative risk (RR)* relationships between MET hours and the following health conditions: cardiovascular disease (CVD), diabetes, dementia, depression, breast cancer, and colon cancer. Outcomes are expressed as premature deaths and *disability adjusted life years (DALYs)*. Because the shape of the dose-response function at higher physical activity levels is uncertain, the gradient is limited using a square root function. ITHIM also accounts for the strong influence of age and gender on physical activity and health outcomes by performing calculations across 16 age groups by gender strata.

We assumed similarity in non-transport physical activity time in 2009 and 2035 as no projection of non-transport physical activity time in 2035 is readily available.

Air Pollution

Input data on population weighted ambient concentrations of *fine particulate matter (PM 2.5)* for the BAU and aspirational scenarios were produced by the South Coast Air Quality Management District (SCAQMD) using a photochemical transport model called the *Community Multi-Scale Air Quality Model (CMAQ)*. The emission inventory for the BAU scenario was developed based on the 2016-2040 Regional Transportation Plan/Sustainable Communities Strategy (2016 RTP/SCS) by the Southern California Association of Governments (SCAG). The emission changes for the aspirational scenarios were estimated with grid-specific light duty vehicle travel activity data from SCAG and emission factors generated by the *California Emission*

[*] For this report, we were able to specify most of ITHIM's input parameters at the City level. For parameters not available at the City level, we used County-level values (scaled down by population size where appropriate) and assumed similarity between the City and County for these parameters.

Factors Model (EMFAC) 2014. Details on the air quality model used for this analysis are available in the 2016 Air Quality Management Plan[*]

Health outcome estimates are derived from established research on the RR relationship between increments of PM 2.5 concentrations and the following air pollution related diseases: lung cancer, CVD, acute respiratory infection, and respiratory disease.[**] ITHIM also links PM 2.5 to CVD outcomes. Outcomes are expressed as premature deaths and DALYs.

Despite projected decreases in VMT due to the MP, some Los Angeles City residents are concerned about increased traffic congestion, which may also have adverse health impacts due to increased tailpipe emissions from idling. In order to account for congestion effects on air quality, we incorporated EIR estimates of reductions in vehicle speed into the CMAQ model.

While shifts from car travel to more active modes of transportation may have positive health impacts among the general population through reductions in annual average ambient concentrations of pollutants, increases in active transportation expose active travelers to higher concentrations of roadway pollutants. ITHIM does not incorporate potential excess risk from this latter form of exposure, so we address it indirectly as part of our literature review (see page 21).

Traffic Collisions

The Statewide Integrated Traffic Records System (SWITRS) 2006-2010 database is used to calculate traffic injuries per mile traveled by victim and striking vehicle, stratifying on roadway type (local, arterial, and highway), which is a surrogate for injury risks associated with speed and volume of traffic. Injury severity is categorized as fatal or severe. Exposure distributions for scenarios are based on the square root of the change in scenario distances traveled by collision victims and striking vehicles. This square root function models *safety in numbers* by slowing the increase in injuries and fatalities at very high levels of biking and walking. Traffic injury outcomes are expressed as premature deaths and DALYs.

We assumed that traffic injury rates in Los Angeles City were similar to those in Los Angeles County and used Los Angeles County traffic injury rates in our study. In addition, as we did not have projections of traffic collision rates in 2035, we assumed that traffic collision rates remained constant from 2006-2010.

Cost of Illness

In addition to producing estimates of health outcomes as measured by premature deaths and DALYs, ITHIM also monetizes those outcomes using the *cost of illness (COI)* methodology, using costs from published studies. The COI methodology accounts not only for the direct health care costs associated with an illness or injury, but also the indirect societal costs from loss of productivity due to illness or premature death. Costs and cost savings associated with health

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[*] SCAQMD 2016, The 2016 Air Quality Management Plan (http://www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan/final-2016-aqmp#Chapters%20and%20Appendices). Refer Ch. 5 and Appendix V for details on the modeling and emissions inventory.

[**] The respiratory disease category includes: Asthma, Chronic Obstructive Pulmonary Disease (COPD), Pneumoconiosis, and other chronic respiratory diseases.

impacts are expressed as annual costs in 2010 dollars using the Consumer Price Index (i.e. the costs are adjusted for inflation, with 2010 as the base year).

Carbon Emissions

In addition to health outcomes, ITHIM also models the impacts of VMT reduction scenarios on carbon emissions from cars. Estimates are derived using EMFAC, which specifies emission rates from motor vehicles operating on California roads, including aggregate *carbon dioxide (CO_2)* emission rates in million metric tons (MMT) per year. EMFAC emission projections also account for changes over time in the proportion of low/zero emission vehicles on the road. ITHIM estimates changes in aggregate and per capita CO_2 emissions based on changes in VMT, population size, and CO_2 emission rates from EMFAC.

Targeted Literature Review

ITHIM quantifies the health impacts of specified changes in travel behavior by mode, but those interested in using ITHIM to predict how transportation and land use policies impact health through their effects on travel behavior must attempt to quantify those policy effects outside of ITHIM. With the aid of the travel demand modeling conducted by Fehr & Peers as part of the EIR (and now required by SB 743), we were able to quantify the health impacts of the major transportation network enhancement included in the MP. However, our predictions of the health impacts of the aspirational 20% VMT reduction scenario from the MP are less precise, as we were unable to quantify the travel effects of the other policies included in the MP. To fill this gap, we reviewed research evidence on the relationships between travel behavior and the three other major policy components of the MP; namely land use, safety, and *transportation demand management (TDM)*. We focused our review on existing systematic reviews and meta-analyses of the relevant literature where available.

Because ITHIM does not model potential excess health risk to active travelers from exposure to roadway pollutants while in traffic, we also reviewed the health impact assessment literature on roadway air pollution exposure. We focused on HIAs of shifts from cars to more active modes of transportation that compared potential harms to active travelers from increases in roadway air pollution exposure to potential benefits to the general public from reductions in ambient air pollution exposure and/or to active travelers from increases in physical activity.

Stakeholder Engagement

The Los Angeles Department of City Planning conducted extensive community outreach and engagement during the development of the MP. Thus, while it is standard practice to engage a wide range of community stakeholders in the process of conducting an HIA, in this case we chose to focus our engagement process on technical experts who could assist us with the interpretation of our findings and with the generation of actionable and relevant recommendations for implementing the MP.

We convened an HIA Technical Advisory Group (TAG) comprised of representatives from the Los Angeles Department of Transportation, the Los Angeles Department of City Planning, and the Los Angeles County Department of Public Health's PLACE Program and Chronic Disease Health and Policy Assessment Unit (see list of members on page 35). After a series of smaller meetings with City staff most directly involved in the development of MP, we convened the full TAG for a two-hour in-person meeting in February 2018 to provide information about ITHIM and its application to the MP, obtain feedback and insight on the assumptions used in the model, discuss potential recommendations, and create a dissemination plan. After the meeting, email and phone communications were conducted to follow up on specific suggestions and feedback provided during the in-person meeting. Notes from the meeting and follow up conversations were used to refine our methods and conclusions and to develop a final set of recommendations. TAG members were also given the opportunity to comment on the final draft of the HIA report.

Findings

Projected Changes in Travel Behavior Under Alternate Scenarios

Figures 2, 3a and 3b display projected changes in travel behavior by mode for BAU and each of the three alternate scenarios. Figure 2 displays average per capita daily travel in miles and combines walk and bike travel into a single category (active). Figure 3a displays walk and bike miles separately and Figure 3b displays walk and bike travel in minutes. In 2035, without the MP, LA residents are projected to travel, on average, .24 miles/4.74 minutes per day by walking, .30 miles/1.52 minutes per day by cycling, 1.89 miles per day by public transit (bus and rail combined) and 28.34 miles per day by car (including small trucks[*]). Under the conservative scenario, residents are projected to travel .33 miles/6.57 minutes per day by walking, .82 miles/4.10 minutes per day by cycling, 2.96 miles per day by transit and 27.71 miles per day by car. Note that while the total daily walk and bike miles per capita approximately doubles from BAU, the ratio of bike to walk miles increases considerably, likely due to the MP's marked expansion of designated bike lanes.

[*] Motorcycle travel is not included in the analysis since it represents a very small portion of miles traveled in the City of Los Angeles, and we were not able to estimate the effects of the MP on motorcycle travel.

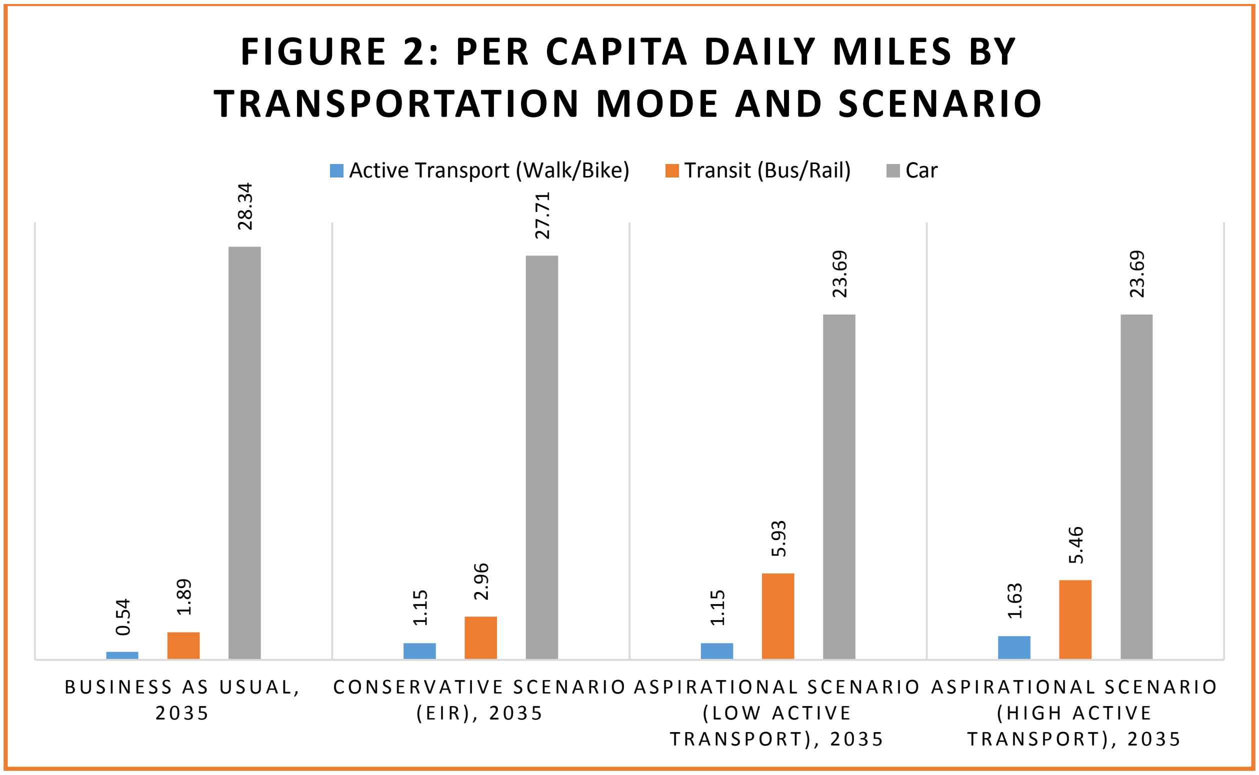


FIGURE 2: PER CAPITA DAILY MILES BY TRANSPORTATION MODE AND SCENARIO
Active Transport (Walk/Bike)
Transit (Bus/Rail)
Car
0.54
1.89
28.34
1.15
2.96
27.71
1.15
5.93
23.69
1.63
5.46
23.69
BUSINESS AS USUAL, 2035
CONSERVATIVE SCENARIO (EIR), 2035
ASPIRATIONAL SCENARIO (LOW ACTIVE TRANSPORT), 2035
ASPIRATIONAL SCENARIO (HIGH ACTIVE TRANSPORT), 2035

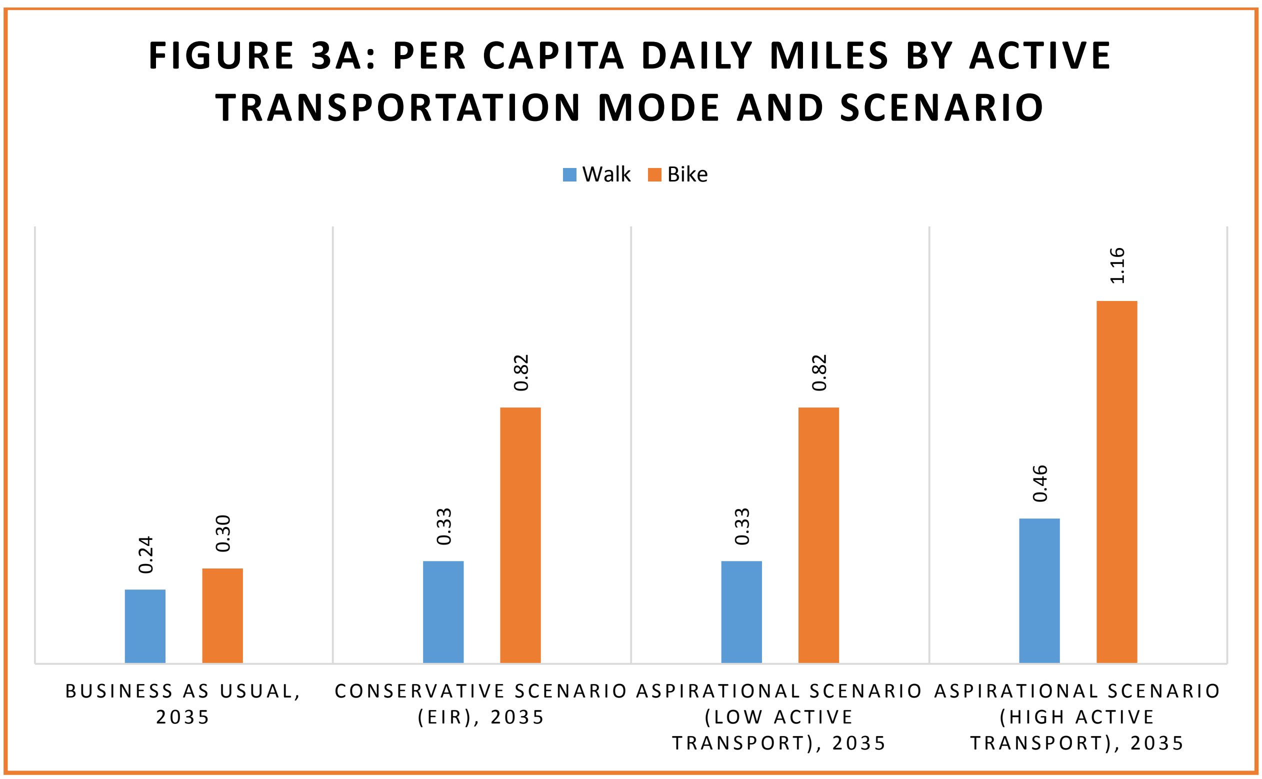
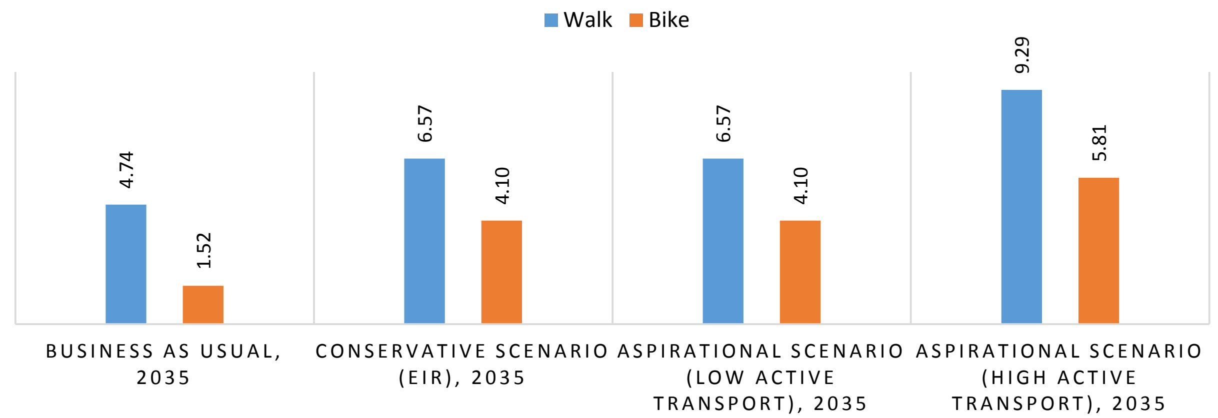


FIGURE 3A: PER CAPITA DAILY MILES BY ACTIVE TRANSPORTATION MODE AND SCENARIO
Walk
Bike
0.24
0.30
0.33
0.82
0.33
0.82
0.46
1.16
BUSINESS AS USUAL, 2035
CONSERVATIVE SCENARIO (EIR), 2035
ASPIRATIONAL SCENARIO (LOW ACTIVE TRANSPORT), 2035
ASPIRATIONAL SCENARIO (HIGH ACTIVE TRANSPORT), 2035

FIGURE 3B: PER CAPITA DAILY TRAVEL TIME (MINUTES) BY ACTIVE TRANSPORTATION MODE AND SCENARIO



Under both aspirational scenarios, as designed, projected daily car miles per capita are close to 20% less than BAU, or 23.25 miles per day.* Under the low active transport scenario we set walk and bike travel equal to the conservative scenario and increased transit miles to 5.93 per day based on the assumptions that total miles across modes would not change. Under the high active transport scenario, we set combined walk and bike miles to three times BAU, but preserved the ratio of bike to walk miles from the conservative scenario, since the aspirational scenario includes the transportation network enhancements modeled in the conservative EIR scenario. Thus, under the high active transport scenario, we project .46 daily miles/9.29 minutes per capita by walking, 1.16 miles/5.81 minutes per day by cycling, and 5.46 miles per day by transit.

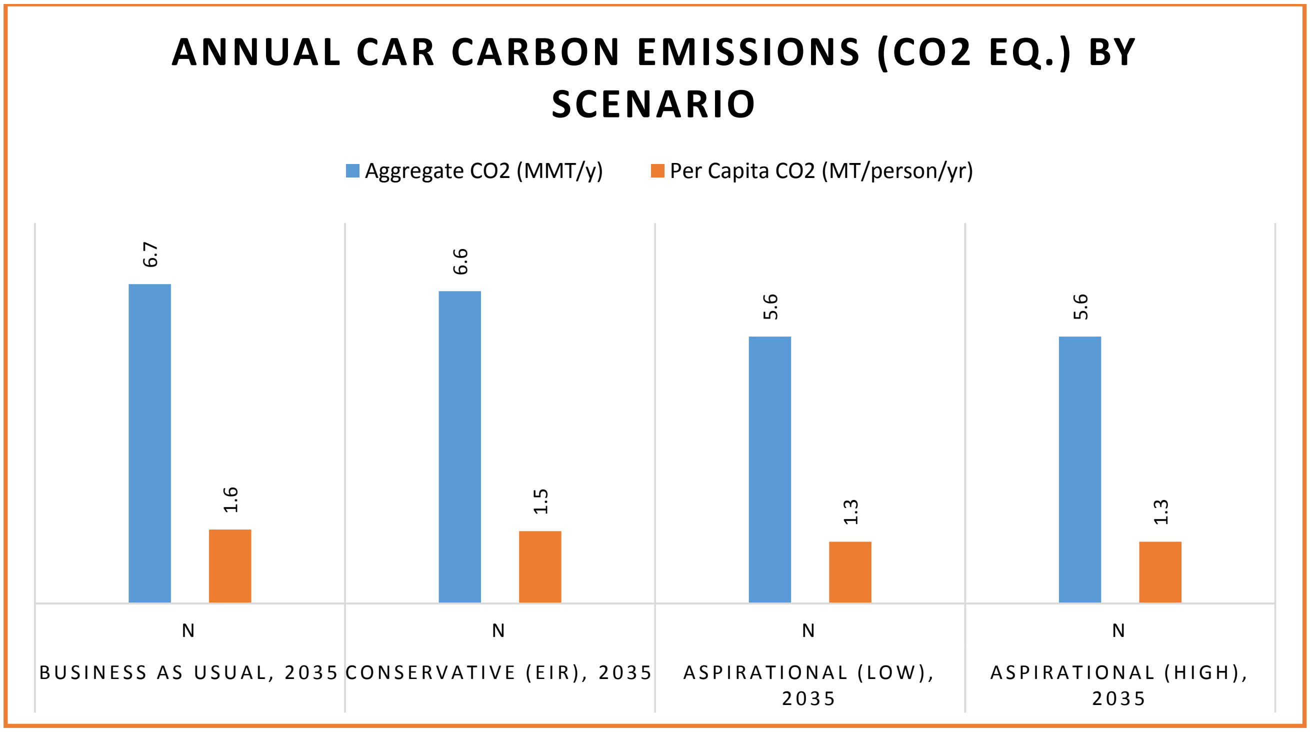
In summary, all three alternative scenarios shift Los Angeles City to a more pedestrian, bike, and transit oriented future, with the aspirational scenarios being even less car oriented than the conservative scenario. The high active transport aspirational scenario, in particular, envisions a city that triples its use of active transportation modes to get to this less car oriented future; given the low level active transport in the business as usual scenario, we believe that even this relatively marked increase in active transportation could be achievable through active implementation of the MP.

Impacts on Carbon Emissions

Figure 4 shows annual aggregate carbon emissions for BAU and the three alternate scenarios. Under the conservative scenario, CO_2 emissions are reduced slightly from 6.72 to 6.57 MMT/year, a modest 2% reduction from the 2035 BAU scenario. Under the aspirational scenarios, CO_2 emissions are reduced to 5.61 MMT/year. This represents a 16.42% reduction from 2035 BAU.

* The reason the reduction from BAU is not 20% is because we are using 2035 BAU (without the Mobility Plan) as our baseline. Projected VMT under the aspirational scenarios is indeed 20% less that current conditions in 2016.

To meet *California Senate Bill 375* targets for the SCAG region, annual CO_2 emissions in 2035 need to be reduced by approximately 10% from 2035 business as usual levels.* Our projections indicate that this reduction will not be achieved under the conservative scenario, but will be under the aspirational scenarios.

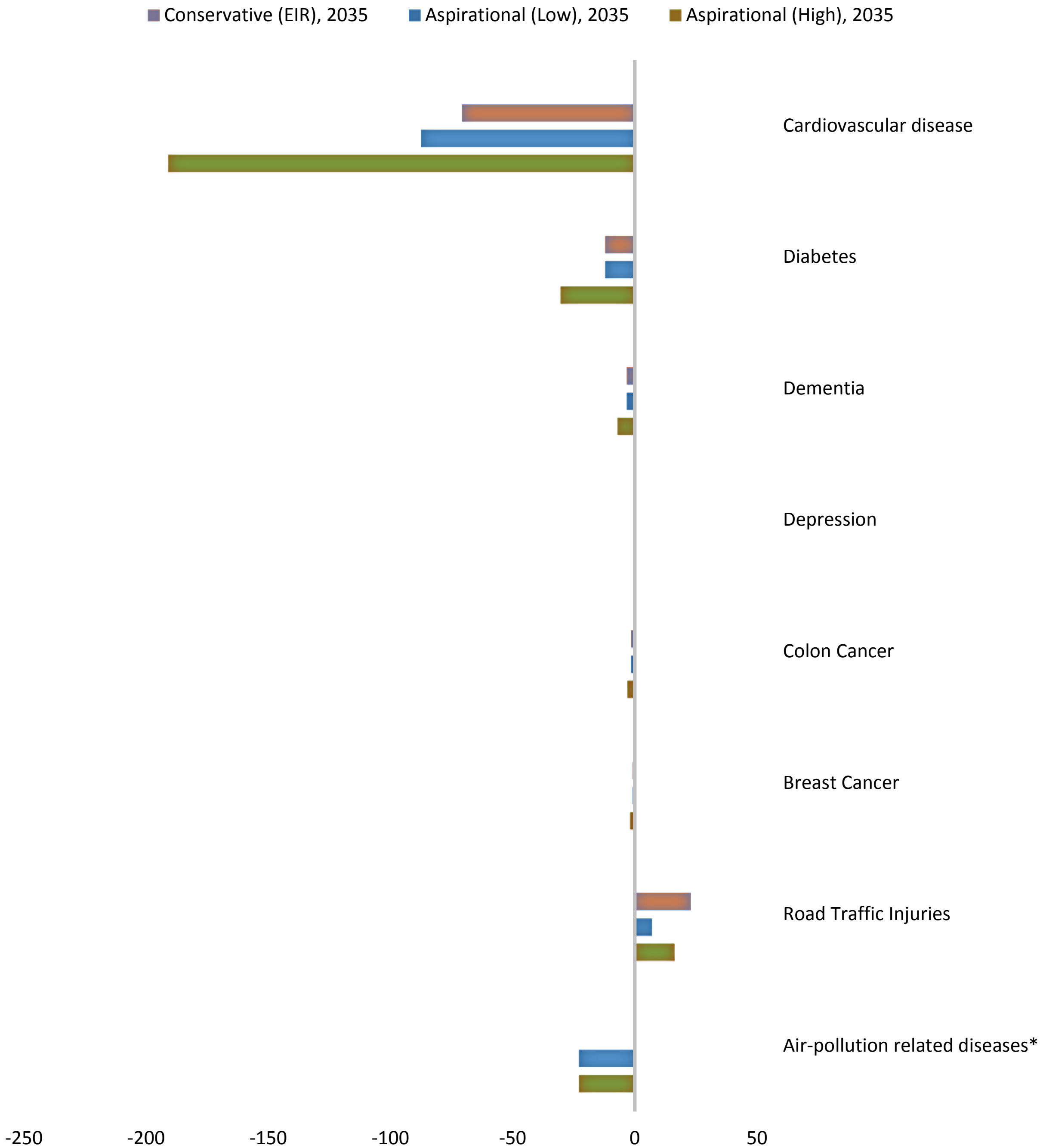


Health Impacts

Figures 5 and 6 show projected changes in the annual numbers of deaths (Figure 5) and DALYs (Figure 6) under each alternate scenario compared to BAU. The greatest reductions in mortality and DALYs across all three scenarios are for CVD, diabetes, and air pollution related illnesses. All three scenarios yielded notable improvements in DALYs averted from reductions in depression. Finally, deaths and DALYs from road traffic crashes increased under all three scenarios.

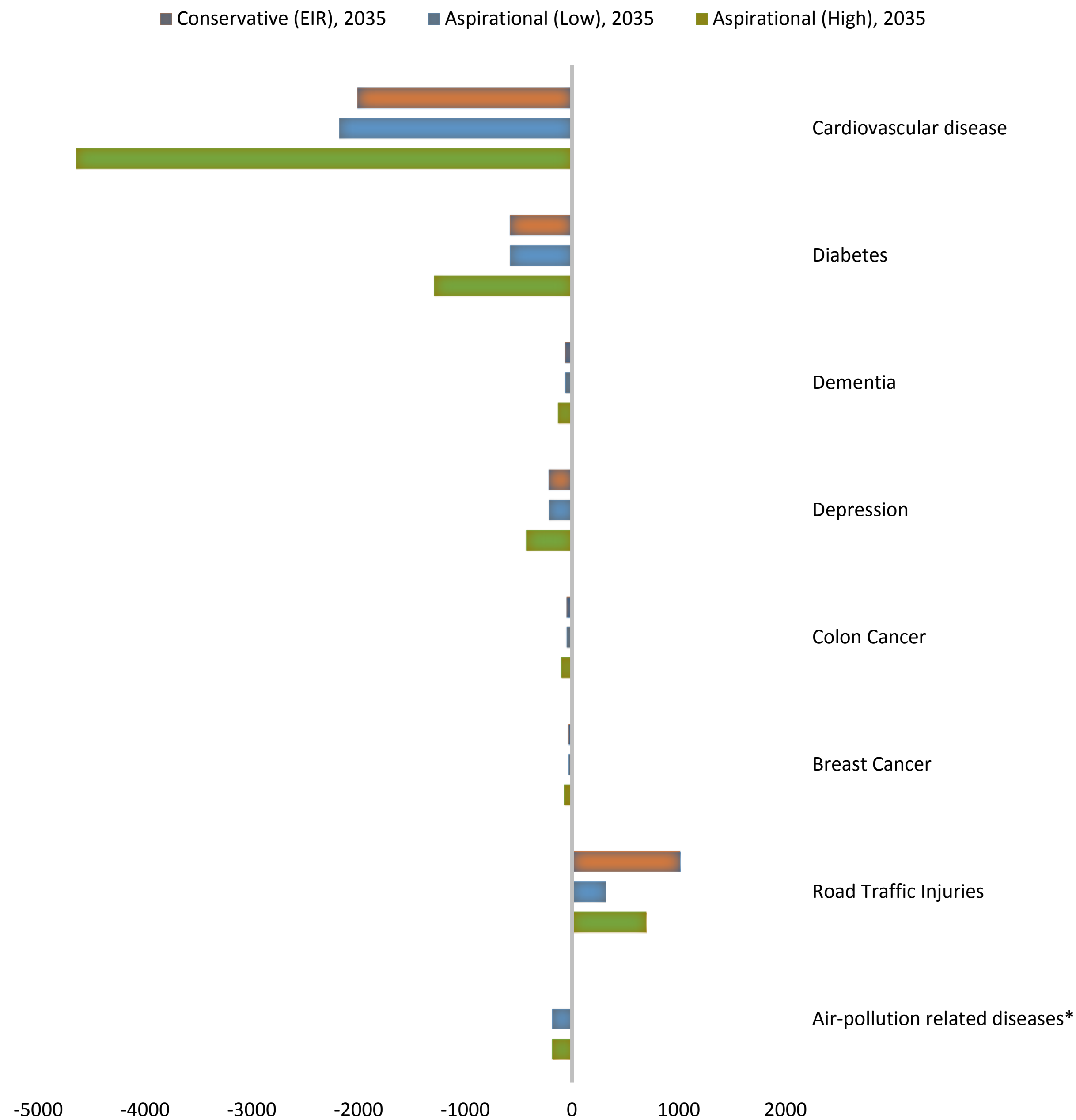
* https://arb.ca.gov/cc/sb375/mpo.co2.reduction.calc.pdf

FIGURE 5: CHANGE IN MORTALITY (NUMBER OF DEATHS) PER YEAR COMPARED TO BAU IN 2035



* ITHIM models the effects of PM2.5 on air pollution related diseases which includes cardiovascular disease (CVD). Thus, changes in CVD mortality attributable to PM 2.5 are included under both cardiovascular disease and air pollution related diseases in this figure.

FIGURE 6: CHANGE IN DISEASE AND INJURY BURDEN (DALYS) PER YEAR COMPARED TO BAU IN 2035



* ITHIM models the effects of PM2.5 on air pollution related diseases which includes cardiovascular disease (CVD). Thus, changes in CVD-related DALYs attributable to PM 2.5 are included under both cardiovascular disease and air pollution related diseases in this figure.

Cardiovascular Disease and Diabetes

For CVD, projected deaths averted ranged from 71 for the conservative scenario to 191 for the high active transport aspirational scenario. DALYs averted from reductions in CVD ranged from 2,010 to 4,647. For diabetes, projected deaths averted ranged from 12 for the conservative scenario to 30 for the high active transport aspirational scenario. DALYs averted from reductions in diabetes ranged from 580 to 1,294. Diabetes deaths and DALYs averted are identical under the conservative and low active transport aspirational scenarios because in ITHIM diabetes outcomes are solely dependent on levels of active transport, which are the same under these two scenarios. However, CVD outcomes are slightly different under these two scenarios because CVD is affected by changes in both active transport and air pollution (PM 2.5), though much less so by the latter.

To put these numbers in context, population-adjusted deaths attributable to CVD and diabetes in Los Angeles County in 2013 were 5,855 and 841 respectively, and the projected CVD and diabetes deaths averted in the high active transport aspirational scenario represent 3.3% and 3.6% of the 2013 mortality figures for these diseases.[*]

Air Pollution Related Diseases

For air pollution related diseases, no health impacts are projected under the conservative scenario. Based on the relatively small per capita daily VMT reduction predicted in the EIR, the CMAQ modeling conducted by SCAQMD did not yield any significant effects on ambient concentrations of PM 2.5, which is what ITHIM uses to model air pollution related health outcomes. However, the larger VMT reduction under the aspirational scenario yielded a population weighted average ambient PM 2.5 reduction of .17 $\mu g/m^3$ for the City of LA. This reduction is derived from decreases in vehicle exhaust emissions and in re-suspended road dust from tire and brake wear. This PM 2.5 reduction led to 23 deaths averted and 187 DALYs averted from reductions in air pollution related diseases.

After incorporating vehicle speed reductions into the CMAQ model (to account for increased traffic congestion), the effect on PM 2.5 was insignificant. This is due largely to the fact that most VMT impacts on PM 2.5 come from road dust and tire and brake wear rather than tailpipe emissions. Thus, while traffic congestion increases tailpipe emissions, it has a negligible effect on PM 2.5. That said, tailpipe emissions contain *nitrogen oxides* (NOx) which, while not as strongly associated with adverse health effects as PM 2.5, also effect health.[6,7] Nevertheless, in both the conservative and the aspirational scenarios, the NOx increase from reduction in traffic speed was too small to have a measurable effect on the reduction in NOx from reduced VMT. In summary, accounting for traffic congestion did not impact the overall positive air quality and health benefits of projected reductions in VMT due to the MP.

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[*] Los Angeles County mortality figures were adjusted proportional to the population of the City of Los Angeles. Source: Los Angeles County Department of Public Health, Office of Health Assessment and Epidemiology. Mortality in Los Angeles County 2013. Leading causes of death and premature death with trends for 2004-2013. October 2016.

Depression

While depression is seldom a primary cause of death, it can be severely debilitating. Physical activity has been shown to decrease depression. Thus, under all three scenarios, ITHIM projects a notable number of DALYs averted due to reductions in depression. These improvements ranged from 219 DALYs averted in the conservative scenario to 429 DALYs averted in the high active transport aspirational scenario.

Traffic Injuries

ITHIM predicts changes in road traffic injuries based on crash data and exposure time in traffic across travel modes. Since all three scenarios represent increases in biking and walking from BAU, and collisions involving bikes and pedestrians are more likely to result in severe injury or death, increases in the latter were projected across all three scenarios. The highest increase—23 additional deaths and 1,014 additional DALYs—is for the conservative scenario, since walk/bike travel doubles while car VMT only decreases slightly. The lowest increase—7 additional deaths and 317 additional DALYs—is for the low active transport aspirational scenario, since walk/bike travel remains at the conservative level but car VMT decreases by almost 20%, reducing the exposure of additional cyclists and pedestrian to cars on the road. It is important to note that these injury estimates do not account for the strategies for improving safety conditions for pedestrians and cyclists included in the MP and targeted by Vision Zero. As described in the targeted literature review (page 21), there is evidence that these strategies can reduce the risk of pedestrian and bicycle traffic injuries and deaths. Thus, the projected increases in traffic injuries and deaths presented here are likely overestimated.

Health Cost Impacts

Table 2 presents the costs and cost savings incurred in 2035 associated with various health outcomes under each of the three alternate scenarios. These cost estimates include both direct health care costs and indirect costs from lost productivity. Positive costs indicate increased costs, while negative costs indicate cost savings. The greatest cost savings are from reductions in CVD which range from $47.6 million under the conservative scenario to $113.4 million for the high active transport aspirational scenario. Cost savings from reductions in diabetes range from $44.8 million to $100 million. The greatest costs are from increases in traffic injuries which occur, on average, among younger age groups, thus resulting in more productive years of life lost.

Table 2. Costs associated with various health outcomes by scenarios (2010 dollars) *

Conditions	Scenarios		
	Conservative (EIR)	Aspirational (Low)	Aspirational (High)
Cancer	-$2,119,639	-$2,119,639	-$4,339,631
Cardiovascular	-$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

* Lung cancer costs are included under "cancer" and cardiovascular disease costs attributable to PM 2.5 are included under "cardiovascular". All other air pollution related disease costs are included under "respiratory".

Projected traffic injury costs range from $36.7 million to $117.5 million. Overall, the conservative scenario results in a net cost of $11.7 million, while the aspirational scenarios result in net savings: $79.1 million saved in the low active transport scenario and $162.4 million saved in the high active transport scenario. As discussed above, the costs associated with traffic injuries do not account for potential reductions in injuries achieved through the implementation of pedestrian and bicycle safety enhancements described in the MP and targeted by Vision Zero.

To account for the impact of potential reductions in injuries due to better and safer bicycle and pedestrian infrastructure, we calculated the impact of modest injury reductions on costs in the conservative scenario. If we were able to achieve a 1% reduction in traffic injury burden in the conservative scenario through the implementation of pedestrian and bicycle safety enhancements, the conservative scenario would become cost neutral. If safety enhancements could reduce traffic injury burden even further, the conservative scenario would result in cost savings.

Preliminary evidence suggests that this 1% reduction is achievable. The *Crash Modification Factor (CMF)* Clearinghouse,[*] a key resource adopted by Vision Zero, lists many street treatment or design changes with CMFs for severe or fatal injuries significantly below 0.99, where a CMF of 0.99 indicate a 1% reduction in crashes resulting in severe or fatal injuries due to that particular street treatment or design change. Thus, concerted efforts to improve bike and pedestrian network safety by applying treatments or design changes listed in the CMF Clearinghouse throughout the City of Los Angeles can potentially reduce traffic crashes in the conservative scenario and negate the net cost increase due to increased traffic injuries.

Targeted Literature Review

Given the considerably greater health impacts and net cost savings associated with the aspirational scenarios reviewed above, it is important to review the literature on the effectiveness of proposed MP policies, projects, and programs beyond the transportation network enhancements accounted for in the conservative scenario. If these other MP elements help the city reach its more aspirational VMT reduction goal, then the health outcome and cost impacts of the MP will increase. We focus here on land use and TDM strategies for reducing VMT and increasing active transport, and roadway safety enhancements for reducing the traffic injuries and deaths associated with increases in pedestrian and bike travel.

Also, since ITHIM does not address potential harms to active travelers from increased exposure to roadway pollution, we reviewed transportation related HIAs that have quantified the health impacts of increased exposure to roadway pollution among active travelers and compared them to the health impacts of decreased concentrations of ambient air pollution and/or increased physical activity.

[*] http://www.cmfclearinghouse.org/

Land Use Strategies for Changing Travel Behavior

Urban planning researchers have identified various categories of land use strategies that influence travel behavior. Two such categories are featured prominently in the MP: *destination accessibility* and *network connectivity*. Destination accessibility refers to the proximity of frequent destinations (i.e., jobs, supermarkets, schools, parks, etc.) to the places where people live and to transit hubs. A recent meta-analysis of land use strategies for reducing VMT and increasing walking and biking found that destination accessibility was the factor with the strongest effect on reducing VMT.[8] A recent critical review of a broader set of local policies for reducing VMT also found destination accessibility to be the land use factor with the largest effects.[9] Network connectivity refers to the degree to which roadways intersect to allow all types of users to get to their destinations via the shortest possible distance. The meta-analysis cited above found that network connectivity was the land use factor most strongly predictive of increases in walking and public transit use and that it was second only to destination accessibility in terms of strength of association with VMT reduction.[8]

Importantly, effect sizes across most of these land use strategies are small, but this may be due to the fact that most studies provide only single point estimates of the relationships between land use and VMT. Thus, they do not account for difference in effects across key dimensions such as neighborhood type (e.g., urban vs. suburban) and travel purpose (e.g., commute vs. non-commute). Studies of the heterogeneity of effects across these dimensions have found that for certain trip and neighborhood types, land use factors are more strongly related to travel behavior, and that in some cases, the direction of the effect is reversed.[10] For example, transit access at work location is negatively associated with VMT in urban areas, but positively associated with VMT in suburban areas. This is likely because transit access is more prevalent for urban work locations where distance between home and work is shorter than for other neighborhood types. This suggests that an average effect size for this measure of destination accessibility would underestimate its VMT reduction effects in urban areas.

Transportation Demand Management

Another category of intervention discussed in the MP is Transportation Demand Management (TDM). TDM strategies seek to reduce single-occupancy vehicle commuting through programs that increase awareness of alternative travel modes and create incentives to promote their use. TDM interventions include strategies such as telecommuting, carpool/vanpool programs, unbundled parking/parking cash-out, transit pass subsidies, bicycle facilities, parking for rideshare/carshare users, parking for scooter/moped/motorcycle users, transportation information centers, guaranteed ride home programs, flex work hours, and commuter clubs.

A recent systematic review of the effectiveness of interventions to encourage shifts from car to active modes of transportation included six workplace-based intervention studies.[11] Four of the six studies found positive effects on mode shift. One of two studies of broad workplace transport plans, including improved bike facilities, car sharing, transit subsidies, and parking disincentives, found a significant decrease (50% to 33%) in the number of participants reporting that they usually commute by car. The study also found a significant mode shift to more active transportation, with the number of employees walking or biking to work increasing by 11% and 5%, respectively. A 27-site study of a workplace initiative in New Zealand, using educational and behavioral interventions and improved bike facilities, found that almost half of participating employees replaced car trips with cycling trips during the intervention period. The fourth study with positive findings examined a 1992 California law requiring some employers to offer parking cash-out programs. The eight-company case study found a 13% decrease in the share of solo drivers, a 9% increase in the share of carpoolers, and a 4% increase in the share of those utilizing active transportation modes. The remaining two studies focused on behavioral interventions in walk-to-work promotional campaigns and found no significant impacts on mode shift.

Another recent systematic review that focused specifically on behavioral interventions designed to change travel behavior by influencing available choices as well as knowledge, attitudes, beliefs, found little to no evidence that such interventions are associated with reductions in car use.[12] A review of VMT reduction interventions in US cities found that, in general, TDM strategies report relatively large effect sizes, but estimates apply to voluntary participants in TDM programs only, and are therefore not generalizable. This review found that among TDM strategies, telecommuting interventions had the largest effect sizes, followed by parking cash-out, voluntary travel behavior change programs, and employer-based trip reduction programs that may include a variety of TDM strategies.[9] While many of the studies included in the aforementioned reviews suggest a positive impact on mode shift, due to continued gaps in the literature as well as heterogeneity in the interventions explored and in the methodological rigor of included studies, all of the authors encourage caution in drawing conclusions regarding the effectiveness of TDM strategies.[9,11,12]

Roadway Safety Enhancements

The safety section of the MP is closely integrated with the City's commitment to Vision Zero, an international initiative that aims to eliminate transportation-related fatalities through strategies like *Complete Streets*, *Safe Routes to School*, and designing roadways for safe speeds. All of these strategies prioritize the safety of the most vulnerable roadway users, namely pedestrians and cyclists. Importantly, while these safety strategies are designed to encourage active transportation and should thus augment the physical activity and air quality related health benefits of other MP strategies, by making active modes safer, they may also dampen predicted increases in collision injury and death. To reflect the positive relationship between the volume of cyclists and pedestrians on the streets and walking and bicycling safety (i.e., "safety in numbers"), ITHIM includes an adjustment factor that reduces or increases the rate of collisions based on the volume of cyclists and pedestrians in a particular scenario.[13] However, it does not account for any of the kinds of physical safety features that the MP and Vision Zero are actively pursuing. These safety features may have injury reducing effects long before safety in numbers is achieved. Thus, available evidence for the effects of these features on collision injuries can shed light on the degree to which they might reduce the number of traffic injuries predicted by ITHIM under each of the alternate scenarios.

To inform neighborhood level strategies for initiatives like Vision Zero, the transportation industry and transportation departments in large cities across the county have conducted extensive evaluative research on the collision and injury effects of a wide variety of roadway safety interventions. For the purpose of this HIA, however, we limit ourselves to systematic reviews of observational and experimental studies in the academic literature. The latter provide a foundation of evidence upon which local jurisdictions have added the street-level of analysis required to tailor strategies to local circumstances.

A seminal meta-analysis of rigorous studies of built environment effects on pedestrian injury found that interventions in the built environment reduced the risk of pedestrian injury by 1.6 times and the risk of child pedestrian injury by 2.5 times.[14] While this analysis could not draw conclusions about the effects of specific built environment features, a subsequent systematic review found that the features most consistently associated with both increased walking and decreased injuries among child pedestrians were traffic calming measures (e.g., speed bumps, roundabouts, road narrowing, and other roadway design features), and presence of parks, playgrounds, and open space.[15] Given that these injury effects are largely mediated through reductions in vehicle speed, another recent systematic review of speed management strategies is also instructive. Promising strategies included speed cameras, vehicle activated signs, and roadway design (i.e., traffic calming).[16] The Cochrane Collaborative has conducted reviews of experimental data on a variety of roadway injury prevention interventions, including speed cameras, which they recommended as a strategy for reducing traffic injuries and deaths.[17] A recent Cochrane review of cycling infrastructure for reducing cycling injuries found insufficient evidence to draw firm conclusions,[18] although a subsequent evaluation of Boston's 2009-2012 bicycle infrastructure expansion found that the risk of being injured on a bicycle decreased by 14% annually over that time period.[19]

Exposure to Roadway Pollution Among Active Travelers

Estimating how roadway pollution impacts the health of active travelers as they shift away from car travel requires access to localized data on rates of exposure to ambient concentrations of relevant pollutants across different travel modes. These data must also account for variation in ventilation (i.e., breathing) rates by travel mode. Research-derived RR relationships between pollutant exposures and health outcomes are then used to estimate the health impacts of specific changes in the number or percentage of trips taken via active modes transport. Given accumulated research evidence that PM 2.5 is the urban air pollutant with the greatest impact on health, the majority of studies of roadway air pollution effects on active travelers have focused on PM 2.5.

These studies typically compare the health risks of increased exposure to PM 2.5 among active travelers to the health benefits of 1) reduced exposure to air pollution (PM 2.5) among the general public from reductions in car travel, and/or 2) increased physical activity among active travelers. A recent systematic review of HIAs of active transportation included four HIAs that measured air pollution effects on both active travelers and the general population and three that only measured air pollution effects on active travelers.[20] Two of the former assessed the impacts of replacing different percentages of car trips with bicycle trips in urban and suburban Barcelona on mortality and morbidity (DALYs).[21,22] Across the various scenarios, mortality impacts from both measures of air pollution were very small compared to physical activity, which averted 19.25 to 98.35 deaths per year. Furthermore, the air pollution related deaths averted in the general population (5.0 to 18.2 per year) far outweighed excess deaths among active travelers (0.2 to 1.3

per year). Impacts on DALYs were extremely low for both air pollution measures, ranging from .19 to .75 DALYs averted per year among the general population and from .41 to 2.01 additional DALYs per year among active travelers.

A cost-benefit analysis using data from Paris and Amsterdam found that physical activity benefits were 40 times greater than those from decreased exposure to air pollution among the general public and that the benefits from the latter significantly outweighed the costs from increased exposure to air pollution among active travelers.[23] A study of mode shifts to active transport in the Netherlands found that the relative mortality risk from PM 2.5 exposure among active travelers was similar in magnitude to the relative protection against mortality in the general population. Since the latter is two to three times greater than the population of active travelers, the authors conclude that the health benefits to the general population would be greater than the harms to active travelers.[24] All three studies that only measured air pollution impacts on active travelers found that these impacts were vastly overshadowed by health benefits from increased in physical activity.[25-27]

Conclusions

To estimate the potential health impacts of the latest update to the City of Los Angeles General Plan Transportation Element (Mobility Plan 2035—MP), we used the Integrated Transportation and Health Impact Model (ITHIM) to predict a variety of health-related outcomes and associated costs based on estimated changes in travel behavior resulting from the implementation of the MP. Our health impact estimates are based on three future scenarios (2035) of MP implementation: 1) car, bike, and transit network enhancements alone (conservative), 2) an idealized "full" implementation of the plan resulting in a 20% reduction in VMT by 2035, with conservative increases in walk and bike travel (low active transport aspirational), and 3) 20% VMT reduction with greater increase in walk and bike travel of 3x BAU (high active transport aspirational). All scenarios are compared to a 2035 BAU scenario, where there is no MP implementation.

We found notable positive health impacts across all three scenarios, with the greatest impacts resulting from reductions in CVD, diabetes, and depression from increased physical activity. Estimated DALYs averted from reductions in CVD alone ranged from 2,010 to 4,647. We found some positive impacts on air pollution related diseases, but these impacts only occurred under the aspirational scenarios. Thus, in order for those impacts to be realized, large VMT (i.e., PM 2.5) reductions would have to be achieved through strategies other than the transportation network enhancements within the MP. While there is some research evidence for effects of other MP strategies (e.g., land use and TDM) on VMT, the largest impacts on VMT reduction over the next 20 years are likely to come from activities outside of the MP, namely expansions and enhancements to the subway and light rail networks, such as those planned under Measure M.

Health benefits from increases in physical activity are not only substantial under the conservative scenario, but appear to be sensitive to relatively small increases in travel by active modes of transportation. For example, even if combined daily per capita walk and bike travel increased by one quarter of a mile instead of one half of a mile from the conservative level, reductions in CVD, diabetes, and depression related mortality and morbidity would still lead to proportionate improvements in health-related quality of life and reductions in health costs. Furthermore, mile for mile, the model suggests that increases in bicycle travel have a larger impact on CVD, diabetes, and depression outcomes and costs than increases in walking. And while combined biking and walking travel doubles from BAU to the conservative scenario, the ratio of biking to walking also doubles, partly due to the MP's particular focus on bike lane expansions. This increase in the bike to walk ratio under all three scenarios produces an accelerated impact on reductions in CVD and diabetes.

Of perhaps greatest concern, is the increase in traffic related serious injuries and deaths predicted under all three scenarios. Even the net health-related cost savings predicted under the aspirational scenarios is achieved only after considerable suffering and loss of life from pedestrian and bicycle injuries. However, while traffic injury impacts estimated in ITHIM do not account for strategic efforts to improve safety conditions for pedestrians and cyclists, we were able to estimate that if such efforts led to a greater than 1% reduction in traffic injury burden under the conservative scenario, then that scenario would begin to yield positive health cost savings. Given evidence that a number of proposed Vision Zero strategies have CMFs that make modest reductions in traffic injury burden entirely feasible, our results point to the critical importance of coupling efforts to increase active transportation with comparably resourced efforts to enhance the safety of road conditions for those who choose to shift to more active modes.

Our review of the literature revealed that certain land use strategies are likely to have stronger effects on reductions in car travel and increases in active transport. In particular, strategies designed to increase the accessibility of frequent destinations by aligning multi-modal transportation networks with existing and future commercial and residential development are likely to be particularly promising, as are efforts to connect these networks to each other in ways that allows travelers to get to their destinations via the shortest possible route. Research also suggests that people are unlikely to use active transportation networks unless they are perceived to be safe. Evidence of the effectiveness of TDM strategies, designed to incentivize behavioral shifts from car travel to more active modes, is more limited. This is partly due to the fact that interventions studied vary considerably in terms of the specific strategies employed, and many strategies are purposefully multifaceted, making it difficult to determine the relative merits of one strategy over another.

While ITHIM models the health benefits of decreased exposure to air pollution among the general public from reductions in VMT, it does not account for increased risk of exposure to roadway pollution among active travelers. However, our review of the HIA literature showed that the negative health impacts of air pollution exposure among active travelers were relatively small compared to the positive health impacts of reduced exposure among the general public, and that both of these air quality related health impacts were, in turn, vastly overshadowed by the health benefits of increased physical activity due to shifts from car to active transport.

Recommendations

Based on the findings of this HIA we offer the following recommendations regarding the ongoing implementation of the Mobility Plan, opportunities to leverage complementary local initiatives, investments in roadway safety, and facilitation of health impact assessment of local transportation plans. We also recommend that health equity be a guiding principle in all of these action areas.

Recommendation #1: Prioritize Mobility Plan policies, projects, and programs that increase travel via walking and cycling (especially cycling) through enhanced network connectivity.

By far the greatest health benefits of the Mobility Plan will be realized through increased physical activity leading to reductions in cardiovascular disease and diabetes. These benefits are particularly sensitive to increases in bicycle travel. The difference between modest and substantial health impacts are likely to hinge on the degree to which the City in able to use network connectivity to increase travel demand on active transport networks. To that end, we recommend that the City explore methods for enhancing network connectivity by measuring and modifying levels of bicycle traffic stress at key network linkage points. *Low stress bicycle infrastructure* can increase demand for longer trips by connecting smaller existing networks.[28]

Recommendation #2: Leverage Measure M transit infrastructure dollars to accelerate reductions in vehicle miles traveled (VMT).

Achieving health benefits from reductions in air pollution will require significant decreases in car travel. It is unlikely that Mobility Plan projects alone will have enough of an impact on car travel to achieve these health benefits. Perhaps the greatest contributor to reductions in car travel over the next 20 years will come from expanded access to rapid bus and rail. Measure M, a countywide sales tax initiative passed the year after the Mobility Plan was adopted, will generate approximately $860 million per year, mostly for public transit system enhancements. The City of LA should leverage Measure M funds, particularly those funds designated for *first/last mile* enhancements, in order to multiply the effects of its active and transit network infrastructure investments on VMT reduction.

Recommendation #3: Increase investment in effective strategies for reducing pedestrian and bicycle road traffic injuries and fatalities through Vision Zero.

Without a concerted effort to make roadways safer for cyclists and pedestrians, health benefits from increases in active travel will be offset by increases in disability and death from traffic collisions. There is substantial evidence that alterations to the built environment can reduce the risk of traffic injuries and deaths by reducing the speed of traffic flow and points of conflict between travel modes. Cities across the U.S. have joined a global initiative called Vision Zero which strives to eliminate traffic fatalities. Los Angeles is still only two years into its Vision Zero effort and early results have tempered optimism about the potential pace of change.[29] However, in the context of a broader assessment of health impacts we have shown that even small reductions in traffic injuries can turn the overall health equation toward significant savings in dollars and lives. Local officials should redouble their long-term commitment to Vision Zero through increased investment in evidence-based collision reduction strategies.

Recommendation #4: Promote equitable implementation of transportation policies, projects, and programs to increase health equity.

Health is largely socially determined and thus social inequities based on race/ethnicity, gender identity, sexual orientation, and economic circumstances manifest themselves as inequities in health. While this makes achieving health equity a challenging goal, it also means that improvements in health are sensitive to changes in policies and programs across a wide variety of social sectors, including the transportation sector. This HIA has demonstrated that transportation policies have large impacts on population health and the next version of ITHIM will allow for analysis of these impacts across socio-economic and racial/ethnic groups. In the meantime, there are a number of ways that equity considerations can and should be built into the implementation of the Mobility Plan and related initiatives to promote health equity. These are discussed at length elsewhere[3] and include:

- Define and adopt equity as a primary goal of transportation planning and implementation through inclusive and participatory outreach and engagement, definition development, hiring, and training.
- Acknowledge and address historical underinvestment in transportation infrastructure in low income communities as part of equity goals and in resource allocation formulas.
- Share decision making about transportation strategy and resources allocation among public agencies, local residents, and community-based organizations, including those with health-related wisdom and expertise.
- Use equity metrics to guide the distribution of transportation resources and accountability for transportation and health-related outcomes.

Recommendation #5: Improve data reporting and sharing to facilitate assessment of health impacts of a wide variety of local transportation planning efforts.

Thanks to the new CEQA requirement that transportation impacts be measured in VMT, and improving science on the effects of travel behavior on population health, LA City and County now have a locally calibrated tool (ITHIM) to project the health impacts of a variety of transportation planning efforts. However, the process of using ITHIM for this HIA has revealed some potential barriers that need to be addresses in order to smooth the way for similar efforts in the future:

- Encourage those conducting EIRs to report impacts on miles traveled across all travel modes and roadway types. This should require only a small amount of additional analysis and is essential for the projection of health impacts.
- Establish data sharing agreements across transportation, air quality, and highway patrol authorities to facilitate access to relevant data across key health pathways.
- Raise awareness among transportation planners about the availability of tools to assess health impacts, and among the general public about the health implications of transportation policy.

Glossary

California Emission Factors Model (EMFAC): A model used to calculate emission rates from all motor vehicles, such as passenger cars to heavy-duty tracks, operating on highways, freeways, and local roads in California which specifies CO_2 and other pollutants emitted per distance traveled and accounts for projected improvements in automotive emissions technology over time.

California Environmental Quality Act (CEQA): A California statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible.

California Senate Bill 375 (SB 375): Effective January 1, 2009, this law prompts California regions to work together to reduce greenhouse gas emissions (GHGE) from cars and light trucks by requiring integration of planning processes for transportation, land-use, and housing. SB 375 requires the California Air Resources Board to develop regional reduction targets for automobile and light truck GHGE. The regions, in turn, are tasked with creating "sustainable communities strategy," which combine transportation and land-use elements in order to achieve the emissions reduction target, if feasible. SB 375 also offers local governments regulatory and other incentives to encourage more compact new development and transportation alternatives.

California Senate Bill 743 (SB 743): A bill passed and signed into law in 2013 which created a process to change the way that transportation impacts are analyzed under the California Environmental Quality Act (CEQA). The bill represented a move away from vehicle delay and level of service (LOS) and required the Governor's Office of Planning and Research to identify new metrics for identifying and mitigating transportation impacts.

Community Multi-Scale Air Quality Model (CMAQ): Photochemical transport model recommended by U.S. EPA for simulation of ozone, PM2.5 and other photo-oxidant species subject to atmospheric dispersion and chemical reactions.

Carbon Dioxide (CO_2): A is an odorless, non-flammable gas composed of one atom of carbon and two atoms of oxygen. CO_2 is the byproduct of the combustion of fossil fuels and also of almost all living cellular respiration.

Complete Streets: A transportation policy and design approach that requires streets to be planned, designed, operated, and maintained to enable safe, convenient, and comfortable travel and access for users of all ages and abilities regardless of their mode of transportation.

Cost of Illness (COI): The aim of a COI study is to identify and measure all the costs of a particular disease, including the direct, indirect, and intangible dimensions. The output, expressed in monetary terms, is an estimate of the total burden of a particular disease to society.

Crash Modification Factor (CMF): A crash modification factor (CMF) is used to compute the expected number of crashes after implementing a countermeasure on a road or intersection. The Crash Modification Factors Clearinghouse provides a searchable online database of CMFs along with guidance and resources on using CMFs in road safety practice.

Destination Accessibility: Destination accessibility refers to the proximity of frequent destinations (i.e., jobs, supermarkets, schools, parks, etc.) to the places where people live and to transit hubs.

Disability-Adjusted Life Year (DALY): One DALY can be thought of as one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability. DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for people living with the health condition or its consequences.

Environmental Impact Report (EIR): Reports that inform the public and decision-makers of significant environmental effects of proposed projects, identify possible ways to minimize those effects, and describe reasonable alternatives to those projects.

Fine Particulate Matter (PM 2.5): Airborne particulate matter (PM) is not a single pollutant, but rather is a mixture of many chemical species. It is a complex mixture of solids and aerosols composed of small droplets of liquid, dry solid fragments, and solid cores with liquid coatings. Particles vary widely in size, shape and chemical composition, and may contain inorganic ions, metallic compounds, elemental carbon, organic compounds, and compounds from the earth's crust. Particles are defined by their diameter for air quality regulatory purposes. Those with a diameter of 10 microns or less (PM10) are inhalable into the lungs and can induce adverse health effects. Fine particulate matter is defined as particles that are 2.5 microns or less in diameter (PM2.5). Therefore, PM2.5 comprises a portion of PM10. PM2.5 is more likely to travel into and deposit on the surface of the deeper parts of the lung, while PM10 is more likely to deposit on the surfaces of the larger airways of the upper region of the lung. Particles deposited on the lung surface can induce tissue damage, and lung inflammation.

First/Last Mile: Infrastructure, systems, and modes of travel used by transit riders to start or end their transit trips. This includes, but is not limited to, infrastructure for walking, rolling, and biking (e.g., bike lanes, bike parking, sidewalks, and crosswalks), shared use services (e.g., bike share and carshare), facilities for making modal connections (e.g., kiss and ride and bus/rail interface), signage and wayfinding, and information and technology that eases travel (e.g., information kiosks and mobile applications).

Greenhouse Gas Emissions (GHGE): The release into the Earth's atmosphere of any gases that contribute to the greenhouse effect by absorbing infrared radiation produced by solar warming of the Earth's surface. Those gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2), and water vapor

Health Equity: Health equity is when everyone has access to the goods, services, resources, and power they need for optimal health and well-being. Health equity is achieved when every person has the opportunity to attain his or her full health potential and no one is disadvantaged from achieving this potential because of social position or other socially determined circumstances. This requires removing basic obstacles to health such as poverty, discrimination, and their consequences, including powerlessness and lack of access to good jobs with fair pay, quality education and housing, safe environments, and health care.

Health in All Policies: A collaborative approach to improving the health of all people by incorporating health considerations into decision-making across sectors and policy areas.

Integrated Transportation and Health Impact Model (ITHIM): A mathematical model that integrates data on travel patterns, physical activity, fine particulate matter, greenhouse gas emissions, and disease and injuries based on population and travel scenarios. The model calculates the health impacts of shifts from vehicular travel distance to distance traveled using alternative modes such as walking, bicycling, and public transportation including bus and rail.

Level of Service (LOS): A term used to qualitatively describe the operating conditions of a roadway based on factors such as speed, travel time, maneuverability, delay, and safety. The level of service of a facility is designated with a letter, A to F, with A representing the best operating conditions and F the worst.

Low Stress Bicycle Infrastructure: Providing routes between people's origins and destinations that do not require cyclists to use links that exceed their tolerance for traffic stress, and that do not involve an undue level of detour.

Measure M: A Los Angeles County sales tax ballot measure, approved by voters in November of 2016, that continued an existing ½ cent traffic relief tax and passed an additional ½ cent sales tax increase to fund a Los Angeles County Traffic Improvement Plan intended to improve freeway traffic flow and safety, repair potholes and sidewalks, repave local streets, earthquake-retrofit bridges, synchronize signals, keep senior/disabled/student fares affordable, expand rail/subway/bus systems, improve job/school/airport connections, and create jobs.

Metabolic Equivalent Task (MET): A physiological measure expressing the energy cost of physical activities and is defined as the ratio of metabolic rate (and therefore the rate of energy consumption) during a specific physical activity to a reference metabolic rate.

Network Connectivity: A measure of accessibility which describes the relative degree to which a transportation network reduces the distances traveled to reach destinations, increases the options for routes of travel, and facilitates safe use of public transit, walking, and bicycling.

Nitrogen Oxides (NO_x): Nitrogen oxides is a generic term used for the nitrogen oxides that are most relevant for air pollution, namely nitric oxide (NO) and nitrogen dioxide (NO_2). These gases contribute to the formation of smog and acid rain, as well as tropospheric ozone. NO_x gases are usually produced from the reaction among nitrogen and oxygen during combustion of fuels, such as hydrocarbons, in air; especially at high temperatures, such as occur in car engines. In areas of high motor vehicle traffic, such as in large cities, the nitrogen oxides emitted can be a significant source of air pollution. NO_x gases are also produced naturally by lightning.

Relative risk (RR): In statistics and epidemiology, relative risk is the ratio of the probability of an event occurring (for example, developing a disease, being injured) in an exposed group to the probability of the event occurring in a comparison, non-exposed group.

Safe Routes to School: Initiatives and programs that aim to create safe, convenient, and attractive opportunities for children to bicycle and walk to and from school with the goal of reversing trends in childhood obesity and inactivity.

Safety in Numbers: Safety in numbers is a hypothesis that, by being part of a large physical group or mass, an individual is less likely to be the victim of a mishap, accident, attack, or other bad event. Within the context of active modes of travel, safety in numbers implies a reduced rate of collisions when large increases in the volume of cyclists and pedestrians are achieved.

Transportation Demand Management (TDM): Interventions that seek to reduce single-occupancy vehicle commuting through programs that increase awareness of alternative travel modes and create incentives to promote their use. Examples of TDM strategies include telecommuting, carpool/vanpool programs, unbundled parking/parking cash out, transit pass subsidies, bicycle facilities, parking for rideshare/carshare users, parking for scooter/moped/motorcycle users, transportation information centers, guaranteed ride home programs, flex work hours, and commuter clubs.

Travel Demand Forecasting Model: A model that simulates traffic levels and travel patterns for a specific geographic area. The model consists of input files that summarize the area's land uses, street network, travel characteristics, and other key factors. Using this data, the model performs a series of calculations to determine the amount of trips generated, the beginning and ending location of each trip, and the route taken by the trip. The model's output includes projects on traffic volumes on major roads, and peak hour turning movements at certain key intersections.

Vehicle Miles Traveled (VMT): A measurement of the number of vehicular miles traveled within a specified region over a given time period. For the purposes of this report, VMT specifically refers to car VMT.

Vision Zero: An initiative aimed at eliminating traffic deaths on city streets. Vision Zero Los Angeles looks at all available data that informs where injuries are occurring most frequently and examines the conditions that are causing these collisions. The initiative seeks to reduce traffic deaths by making safety improvements on the most dangerous streets, as well as focusing on evidence-based education and enforcement proven to change dangerous behavior.

Bibliography

1. US Community Preventive Services Taskforce. *Physical Activity: Built Environment Approaches Combining Transportation System Interventions with Land Use and Environmental Design. Task Force Finding and Rationale Statement.* US Department of Health and Human Services;2016
2. Nicholas W, Mullholland Graves, E. *Initiative Ordinance JJJ: Affordable and Transit-Oriented Housing Policies for Los Angeles--A Health Impact Assessment* Los Angeles: Los Angeles County Department of Public Health;2016.
3. Carter V, Pastor M, Wander M. *Measures Matter: Ensuring Equitable Implementation of Los Angeles County Measures.* USC Dornsife Program for Environmental and Regional Equity; 2018.
4. Maizlish N, Woodcock J, Co S, Ostro B, Fanai A, Fairley D. Health cobenefits and transportation-related reductions in greenhouse gas emissions in the San Francisco Bay area. *Am J Public Health.* 2013;103(4):703-709.
5. Whitfield GP, Meehan LA, Maizlish N, Wendel AM. The Integrated Transport and Health Impact Modeling Tool in Nashville, Tennessee, USA: Implementation Steps and Lessons Learned. *J Transp Health.* 2017;5:172-181.
6. Zhang K, Batterman S. Air pollution and health risks due to vehicle traffic. *Sci Total Environ.* 2013;450-451:307-316.
7. Krzyzanowski M, Kuna-Dibbert B, Schneider J. *Health Effects of Transport-Related Air Pollution.* World Health Organization;2005.
8. Ewing R, Cervero R. Travel and the Built Environment. *Journal of the American Planning Association.* 2010;76(3):265-294.
9. Salon D, Boarnet MG, Handy S, Spears S, Tal G. How do local actions affect VMT? A critical review of the empirical evidence. *Transportation Research Part D.* 2012;17:495-508.
10. Salon D. Heterogeneity in the relationship between the built environment and driving: Focus of neighborhood type and travel purpose. *Research in Transportation Economics.* 2015;52:34-45.
11. Scheepers CE, Wendel-Vos GCW, den Broeder JM, van Kempen EEMM, van Wesemael PJV, Schuit AJ. Shifting from car to active transport: A systematic review of the effectiveness of interventions. *Transportation Research Part A.* 2014;70:264-280.
12. Arnott B, Rehackova L, Errington L, Sniehotta FF, Roberts J, Araujo-Soares V. Efficacy of behavioural interventions for transport behaviour change: systematic review, meta-analysis and intervention coding. *Int J Behav Nutr Phys Act.* 2014;11:133.
13. Jacobsen PL. Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Inj Prev.* 2003;9(3):205-209.
14. DiMaggio C, Li G. Roadway characteristics and pediatric pedestrian injury. *Epidemiol Rev.* 2012;34:46-56.
15. Rothman L, Buliung R, Macarthur C, To T, Howard A. Walking and child pedestrian injury: a systematic review of built environment correlates of safe walking. *Inj Prev.* 2014;20(1):41-49.
16. Sadeghi-Bazargani H, Saadati M. Speed Management Strategies; A Systematic Review. *Bull Emerg Trauma.* 2016;4(3):126-133.
17. Wilson C, Willis C, Hendrikz JK, Bellamy N. Speed enforcement detection devices for preventing road traffic injuries. *Cochrane Database Syst Rev.* 2006(2):CD004607.
18. Mulvaney CA, Smith S, Watson MC, et al. Cycling infrastructure for reducing cycling injuries in cyclists. *Cochrane Database Syst Rev.* 2015(12):CD010415.
19. Pedroso FE, Angriman F, Bellows AL, Taylor K. Bicycle Use and Cyclist Safety Following Boston's Bicycle Infrastructure Expansion, 2009-2012. *Am J Public Health.* 2016;106(12):2171-2177.
20. Mueller N, Rojas-Rueda D, Cole-Hunter T, et al. Health impact assessment of active transportation: A systematic review. *Prev Med.* 2015;76:103-114.

21. Rojas-Rueda D, de Nazelle A, Teixido O, Nieuwenhuijsen MJ. Replacing car trips by increasing bike and public transport in the greater Barcelona metropolitan area: a health impact assessment study. *Environ Int.* 2012;49:100-109.
22. Rojas-Rueda D, de Nazelle A, Teixido O, Nieuwenhuijsen MJ. Health impact assessment of increasing public transport and cycling use in Barcelona: a morbidity and burden of disease approach. *Prev Med.* 2013;57(5):573-579.
23. Rabl A, de Nazelle A. Benefits of Shift from Car to Active Transport. *Transportation Policy.* 2012;19:121-131.
24. de Hartog JJ, Boogaard H, Nijland H, Hoek G. Do the health benefits of cycling outweigh the risks? *Environ Health Perspect.* 2010;118(8):1109-1116.
25. Woodcock J, Tainio M, Cheshire J, O'Brien O, Goodman A. Health effects of the London bicycle sharing system: health impact modelling study. *BMJ.* 2014;348:g425.
26. Rojas-Rueda D, de Nazelle A, Tainio M, Nieuwenhuijsen MJ. The health risks and benefits of cycling in urban environments compared with car use: health impact assessment study. *BMJ.* 2011;343:d4521.
27. Holm AL, Glumer C, Diderichsen F. Health Impact Assessment of increased cycling to place of work or education in Copenhagen. *BMJ Open.* 2012;2(4).
28. Mekuria MC, Furth PG, Nixon H. *Low-Stress Bicycling and Network Connectivity.* Mineta Transportation Institute;2012.
29. City of Los Angeles. *Vision Zero Los Angeles: 2018 Action Plan+Progress Report.* Los Angeles2018.

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