Active Travel Co-Benefits of Travel Demand Management Policies that Reduce Greenhouse Gas Emissions

MTI Report 12-12

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REPORT 12-12

ACTIVE TRAVEL CO-BENEFITS OF TRAVEL DEMAND MANAGEMENT POLICIES THAT REDUCE GREENHOUSE GAS EMISSIONS

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16. Abstract

There is increasing evidence that improved health outcomes may be a significant co-benefit of land use plans and transport policies that increase active transport (or "active travel")—walking, biking or other physical activity for the purpose of transportation—as they reduce greenhouse gas emissions (GHGs). A greater understanding of these benefits may broaden the constituency for regional planning that supports local and national GHG reduction goals. In this study, California's activity-based travel demand model (ABM) is applied to (1) demonstrate how this new generation of travel models can be used to produce the active travel data (age and sex distributions) required by comparative risk assessment models to estimate health outcomes for alternative land use and transport plans and to (2) identify the magnitude of change in active travel that may be possible from land use, transit, and vehicle pricing policies for California and its five major regions for a future 2035 time horizon. The results of this study suggest that distance-based vehicle pricing may increase walking by about 10% and biking by about 17%, and concurrently GHG from VMT may be reduced by about 16%. Transit expansion and supportive development patterns may increase active travel by about 2% to 3% for both walk and bike modes while also reducing VMT by about 4% on average. The combination of all three policies may increase time spent walking by about 13% and biking by about 19%, and reduce VMT by about 19%.

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EXECUTIVE SUMMARY

There is increasing evidence that improved health outcomes may be a significant co-benefit of land use plans and transport policies that increase active transport (or "active travel")—walking, biking or other physical activity for the purpose of transportation—as they reduce greenhouse gas emissions (GHGs). A greater understanding of these benefits may broaden the constituency for regional planning that supports local and national GHG reduction goals.

In this study, California's activity-based travel demand model (ABM) is applied to (1) demonstrate how this new generation of travel models can be used to produce the active travel data (age and sex distributions) required by comparative risk assessment models to estimate health outcomes for regional land use and transport plans and to (2) identify the magnitude of change in active travel possible from land use, transit, and distance-based vehicle pricing policies for California and its five major regions for a future 2035 time horizon.

Health guidelines suggest that children and adolescents should exercise one hour a day and adults about 20 minutes a day. The results of this study suggest that if expected trends are realized in the future, then, on average, individuals will only be spending about four to six minutes a day by walking and less than a minute a day biking for purposeful travel. If a distance-based vehicle pricing policy is implemented, this active travel time may be increased by about 10% for walking and about 17% for biking, and concurrently GHG from VMT may be reduced by about 16%. Increases in transit service and transit supportive development patterns may increase active travel by about 2% to 3% for both walk and bike modes while also reducing VMT by about 4% on average. The combination of all three policies increases time spent walking by about 13% and biking by about 19%, and reduces VMT by about 19%.

The methods developed for this study are starting to be adopted by major California metropolitan planning organizations (MPOs) to create heath performance measures that may be included in regional transportation plans. Future applications of ABMs will no doubt improve the representation of spatial, travel time, and travel cost variables and thus improve the accuracy and precision of active travel- and health-related performance measures.

I. INTRODUCTION

There is increasing evidence that improved health outcomes may be a significant co-benefit of land use plans and transport policies that increase active transport (or "active travel")—walking, biking or other physical activity for the purpose of transportation—as they reduce greenhouse gas emissions (GHGs). A greater understanding of these benefits may broaden the constituency for regional planning that supports local and national GHG reduction goals. In 2009, a study by United Kingdom (UK) researchers documented a new comparative risk assessment model, the Integrated Transport and Health Impacts Model (I-THIM), designed to quantify the health effects of land use plans and transport policies that increase active transport and reduce GHGs.[2] The model was applied in London, UK, and Delhi, India, and the results indicated that large health benefits were possible from such plans and policies.[3] More recently, in the United States (U.S.), an application of the I-THIM in the San Francisco Bay Area had similar findings: large health benefits were possible from land use and transport plans that reduced GHGs by 14.5% from year 2000 levels.[4]

The comparative risk assessment model (I-THIM), used in the studies described above, requires data on the sex-age distribution of walk and bike travel (frequency, duration, and distance) that result from land use and transport plans. The UK and U.S. applications of I-THIM[5] analyzed travel behavior survey data to develop plausible increases in walking and biking based on regional subareas with high rates of active travel. These two studies give us important insight into what is possible if policies supportive of active transport were to be aggressively implemented in a region; however, they do not tell us the magnitude of change that may result from specific changes in different types of land use and transportation policies and plans. In sum, these studies tell us what is possible, but not what it might take to get there.

In this study, the California's activity-based travel demand model (ABM) is applied to (1) demonstrate how this new generation of travel models can be used to produce the active travel data (age and sex distributions) required by I-THIM to estimate health outcomes for regional land use and transport plans and to (2) identify the magnitude of change in active travel possible from land use, transit, and distance-based vehicle pricing policies for California and its five major regions for a future 2035 time horizon.

II. BACKGROUND

That active transport – walking and biking – is related to better health is intuitively understood by many. While there has been an explosion in the health literature of studies documenting and in some cases quantifying the health benefits of these modes,[6] evaluating the active transport and health effects of new transportation projects and land use plans is relatively new.

Europe, with higher levels of walking and biking than the U.S., also leads in modeling the health effects of active transport. Thus, as described above, one of the first region-scale efforts in the U.S. to quantify health benefits of active transport by Maizlish et al.[7] used the I-THIM developed by UK researchers.[8] Statistics on travel patterns and injuries, physical activity, fine particulate matter, and GHG emissions in the San Francisco Bay Area, California, were input to the I-THIM that then calculated the health impacts of walking and biking short distances usually traveled by car or driving low-emission automobiles. The I-THIM estimated changes in disease burden in disability-adjusted life years (DALY) based on dose-response relationships and the distributions of physical activity, particulate matter due to cars and trucks, and traffic injuries. A hypothetical, but not unreasonable, increase in median daily per capita walking and biking from 4 to 22 minutes reduced the burden of cardiovascular disease and diabetes by 14% (or 32,466 DALY), increased the traffic injury burden by 39% (5,907 DALY), and decreased GHG emissions by 14%. Use of low-carbon vehicles (e.g., alternative fuel and/or electric) reduced GHG emissions by 33.5% and cardio-respiratory disease burden by less than 1%. The increased physical activity associated with active transport resulting from these plans was responsible for almost all the health benefits.

This trial exercise of the I-THIM predicts that increased physical activity associated with active transport could generate a large net improvement in population health – far more than the savings in roadway costs and operations usually cited as benefits of these modes. The study acknowledges that measures would be needed to minimize pedestrian and bicyclist injuries. Finally, Maizlish et al.[9] note that active transport and low-carbon driving could achieve GHG reductions sufficient to meet California's GHG goals.

It is noteworthy that the key input data required by I-THIM are generally available to, and used by, all California metropolitan planning organizations (MPOs) (i.e., travel surveys, travel demand models, emissions models, Statewide Integrated Traffic Records System (SWITRS) roadway accident data, U.S. Census data, and California Department of Finance population and employment forecasts). Only the Centers for Disease Control and Prevention's National Health Interview Survey data and California Department of Public Health data may be unfamiliar to California MPO planners.

HEALTH IMPACT ASSESSMENTS IN THE U.S.

Debate over health care and health care costs has helped foster an interest by local governments, planners, and non-governmental organizations in considering how the land use (or the built environment) and transport systems affect health and health costs. In 2011, the National Research Council published *Improving Health in the United States: The Role*

of Health Impact Assessment.[10] The report begins with the premise that considering health-related costs in decision making is essential to confronting the nation's health problems and enhancing public well-being. Some policies and programs historically not recognized as relating to health may in fact have important health consequences. As examples, public health has been linked to an array of policies that determine the quality and location of housing, availability of public transportation, land use and street connectivity, agricultural practices and the availability of various types of food, and development and location of businesses and industry.

The *Improving Health* report offers guidance to officials in both the public and private sectors on conducting Health Impact Assessments (HIAs) to evaluate public health consequences of proposed decisions – such as those to build a major roadway, plan a city's growth, or develop national agricultural policies – and suggests actions that could minimize adverse health impacts and optimize beneficial ones. A six-step framework is presented for conducting HIA of proposed policies, programs, plans, and projects at federal, state, tribal, and local levels, including within the private sector. This recommended framework is flexible and adaptable to many types of projects. It is, however, oriented to the project scale, and does not provide guidance regarding health effect measures that might be used by California MPOs as criteria for HIAs of transportation plans and projects within their regions.

CALIFORNIA MPO HEALTH INDICATORS

In 2012 and 2013, the California Strategic Growth Council (SGC) set out to identify priority policy issues and indicators in use or planned for adoption by the 18 MPOs in California.[11] This inventory identifies nearly 200 indicators adopted or being considered for adoption by one or more of California's MPOs or a statewide agency. Only five indicators are classed as public health indicators, and only two of these have been adopted by a single MPO, the San Francisco Bay Area Metropolitan Transportation Commission (MTC). The two indicators are "premature deaths due to particulate emissions" and "time walking or biking." On the other hand, nearly 30 indicators relate to bike and walk mode shares, and over 30 indicators relate to compact land use, which is vital to realizing increased use of active travel modes.

III. METHODS

Travel demand models use the location and characteristics of population and employment and the activities they generate, along with a physical representation of the transportation system (roadways, buses, rail, sidewalks, and bike lanes), to forecast the total quantity of travel and the quality of travel (time and cost) by different methods (automobile, transit, walking, and bike) to and from different destinations and using certain routes. Travel networks represent physical and cost attributes of roads and transit services. The outputs are use, distance, and travel time and cost between residential and non-residential locations. Outputs also include roadway volumes and speeds, and levels of transit use, walking and biking.

In the U.S., the requirements of federal transit funding and climate change legislation at the California state level have spurred the development of ABMs at the microsimulation level that are sensitive to a broad range of policies, such as transit, land use, and distance-based vehicle pricing. The current study uses the California Statewide Travel Demand Model (CSTDM) activity-based model. The CSTDM was funded by the California Department of Transportation (Caltrans) and developed by the Urban Land Use and Transportation Center (ULTRANS) at the University of California, Davis, and HBA Specto. The CSTDM is the first ABM to be applied at a large state-level geographic scale and to forecast both personal and commercial vehicle travel on a typical weekday in the fall/spring (when schools are in session).

The CSTDM, like other ABMs, is characterized by its use of a disaggregate framework that enables a more complete and consistent representation of microeconomic theory throughout the model system. The probability of an individual traveler selecting a given alternative is a function of his or her socioeconomic characteristics and the relative attractiveness of the alternative including travel time and costs. Activities or day patterns drive the individual's need to travel and are composed of tours. Microsimulation is the mathematical technique used to track individuals' activities and travel throughout the model system.

Four California travel surveys were assembled to estimate the parameters for the sub-models implemented in the CSTDM: the 2000 California Department of Transportation Statewide Travel Survey, the 2006 San Diego Association of Governments Travel Survey, the 2001 Southern California Association of Government Travel Survey, and the 2000 Metropolitan Transportation Commission Bay Area Travel Survey. The 2008 roadway network volumes were validated against observed 2008 vehicle count data.

A unique feature of ABMs, like the CSTDM, is the rich set of socio-economic attributes it uses to characterize California households by location based on census, and statewide and regional household travel survey data. These characteristics include, for example, age, income, sex, and household structure (e.g., single parent and number of children). All individuals and their socioeconomic characteristics are generated through a statistical process known as a population synthesis based on the U.S. Census Public Use Microdata Sample (PUMS).

The CSTDM population synthesizer uses marginal targets for total persons and households by various geographic units of analysis in categories such as household sizes, housing types, household income groups, person age categories, automobile ownership categories, employed workers by occupation category, and students by education level. For this study, future year targets were developed using population forecasts that were obtained from 17 California's MPOs, four Rural Transportation Planning Agencies (RTPAs), and the California Department of Finance, as of August 2011. The population synthesizer matches these targets by drawing household samples from the PUMS.

The CSTDM requires employment data for workers by both industry and occupation. The industry categories describe the type of activity at a person's place of work, and the occupation categories describe the kind of work a person does. The model uses North American Industrial Classification System (NAICS) categories and Standard Occupational Classification (SOC) categories. For this study, employment forecasts by MPOs and RTPAs were used to develop the industry and occupation categories in the CSTDM for future years. Base year employment was obtained from the U.S. Census Transportation Planning Package (CTPP), PUMS, California Employment Development Department, and Longitudinal and Household Dynamics (OnTheMap) data.

Transportation supply is represented in the CSTDM by the transportation analysis zone system (geographic units of analysis) and roadway and transit networks. The future zones and network system include 5,421 zones and 248,424 roadway links in 2035. The following modes are represented in the CSTDM: single occupant vehicle (SOV), high occupant vehicle (HOV) 2 person, auto HOV 3+ person, bus, rail, bicycle, walk, air, light commercial vehicle, single unit truck, and multiple unit truck. Mode shares and mode use are a function of socio-demographic attributes, travel activity patterns, mode specific travel time and cost variables to and from origin and destinations zones, and variables that represent aspects of the built environment. The parameters for these variables are estimated using travel survey data described above. The road network represents all freeways, expressways, and most arterial roadways explicitly, with collector and local roads mostly represented by zone centroid connector links. The transit network combines explicitly coded fixed guide-way transit, including all air and rail lines and services, with algorithmically derived local transit (bus) service. In general, smaller zones and more detailed networks will tend to improve the accuracy of the estimates of travel time and cost in the model by mode and thus the uses of those modes.

For local bus transit, a simplified model is used to give level of service times and costs, based on road network speeds, land use variables, and transit operator service measures. For this study, observed data (collected through the Google Transit platform) were used to develop the model. Future roadway and transit projects were obtained from regional transportation plans (RTPs) developed by California MPOs and RTPAs prior to August 2011. Future rail transit information was also compiled from transit organizations' documentation, such as, Amtrak, MPOs, and Cities.

Networks were developed for the following time periods: early off-peak (3 a.m. to 6 a.m.), morning peak (6 a.m. to 10 a.m.), midday (10 a.m. to 3 p.m.), p.m. peak (3 p.m. to 7 p.m.), and off-peak late (7 p.m. to 3 a.m.). Traffic is assigned to the network using static assignment

processes. Modeled flows on major screenlines were validated to observed flows. For detailed information on the CSTDM see ULTRANS and HBA Specto.[12]

The active transport measures are produced from the raw trip list data (CSV format, 10GB total) from the CSTDM, which is a record of each trip produced by the short distance personal travel model. Each trip record contains a unique identification number for the trip maker, which relates to the PUMS records for demographic information. Scripts were developed with relational databases that joined every trip record to demographic information and then summarized the data to produce the active travel measures by age and sex categories. The steps undertaken in this procedure include the following: (1) read the CSV-encoded trip list files into SQLITE database;[13] (2) subset the trips that are of walk or bike mode; (3) attach the demographic variables (age and sex) to the subset of trips from step 2; (4) create an index on the unique ID for efficiency; (5) group the trips by region/mode/sex/age; and (6) calculate sum, average, standard deviation, and coefficient of variation for each category.

Note that results for walking do not include walk access to transit, which may tend to underestimate total walk travel. Also, this analysis does not account for the possibility that an individual may substitute active travel for an existing exercise regime and thus may overestimate the benefits of active travel in this analysis. However, the significance and magnitude of this effect is unclear.

IV. SCENARIOS

The base or business-as-usual scenario for the future year 2035 is based on demographic projections from MPOs and rural governments in California as well as the California Department of Finance as of August 2011. Table 1 documents total population by age and sex for the state of California. Future roadway and transit projects were obtained from MPO and rural government plans prior to August 2011. Future rail transit information was also compiled from transit organizations' documentation, such as, Amtrak, MPOs, and Cities. Figure 1 describes the base, transit, land use, and auto-pricing policies simulated in this study. The scenarios were designed to simulate what might be possible in terms of active travel and vehicle miles traveled/greenhouse gas (VMT/GHG) reduction for very aggressive auto-pricing and land use policies.

The active transport outcomes in this report are presented for the state of California and its five major regions. The San Francisco, Los Angeles, Sacramento, and San Diego regions correspond to regional MPOs. The San Joaquin Valley is composed of eight councils of governments that correspond to counties. Figure 2 depicts the five major California regions. In 2008, San Francisco had the highest transit to work mode share (9.6%), followed by San Diego (5.3%), Sacramento (2.7%), Los Angeles (2.2%), and finally the San Joaquin Valley (0.8%). Los Angeles made up almost half of California's population in 2008. The San Joaquin Valley and the Sacramento region are projected to have the fastest growing population in the state.

Table 1. Population by Age and Sex in 2035 for California

Age Group (years)	Population (1,000s)	
	Male	Female
0-4	1,727	1,660
5-14	3,305	3,185
15-29	5,140	4,715
30-44	5,032	4,791
45-59	3,866	4,159
60-69	2,182	2,423
70-79	1,714	2,164
80+	1,003	1,592
Total	*23,971*	*24,689*

Source: Populations based on California MPO and rural government and California Department of Finance demographic projections, to August 2011.

Base Case: Regional planning organizations forecasted population growth to 2035 and planned roadway and transit projects.
VMT Fee: Per mile vehicle operating costs doubled: passenger vehicles from $0.14 to $0.28, medium trucks from $0.49 to $0.98, and heavy trucks from $0.58 to $1.16.
Transit: Rail headways reduced by half and local bus service doubled.
Transit-Oriented Development (TOD): The growth in households and employment from 2008 to 2035 in zones within 3 to 12 miles outside of the nearest passenger transit station (light and heavy rail) to zones within 3 miles of that transit station (4 million people moved, or 8.2% of the 2035 population).

Figure 1. 2035 Scenario Policies

Figure 2. Map of California and Five Major Regions

V. RESULTS

Figure 3 documents the average distance traveled (in miles) by walk and bike modes by age and sex categories in the 2035 base case scenario (or the total distance traveled by walk or bike modes by age and sex category divided by the total number of individuals in each age and sex category). On average, individuals travel less than a mile a day and tend to bike shorter distances than they walk. The lowest rates of walking and biking are in the 45 to 69 year age range and the highest is among school-age children aged 4 to 15 years. Men tend to walk more than women in their younger years, from age 30 to 59 years, but women walk more than men after age 60 years. The model shows that on average individuals walk 2 to 16 minutes daily (based on a 3 mile per hour pace) for purposeful travel depending on their age and sex. Again, average walk and bike travel time is the total time in minutes traveled by walk or bike modes by age and sex category divided by the total number of individuals in each age and sex category.

The base case results, described above, were compared to other reports that document walking and biking for the 2009 National Household Travel Survey (NHTS) data.[14] An apples-to-apples comparison is difficult because the NHTS data include walk and bike trips for exercise (which is the most common walk trip propose) and the CSTDM results do not. In addition, these sources also generally present average times for those who walk and bike rather than average walking and biking across the entire population, as is done in this study. However, when walkers and non-walkers are combined in the NHTS data, then similar trends are found to those presented here.

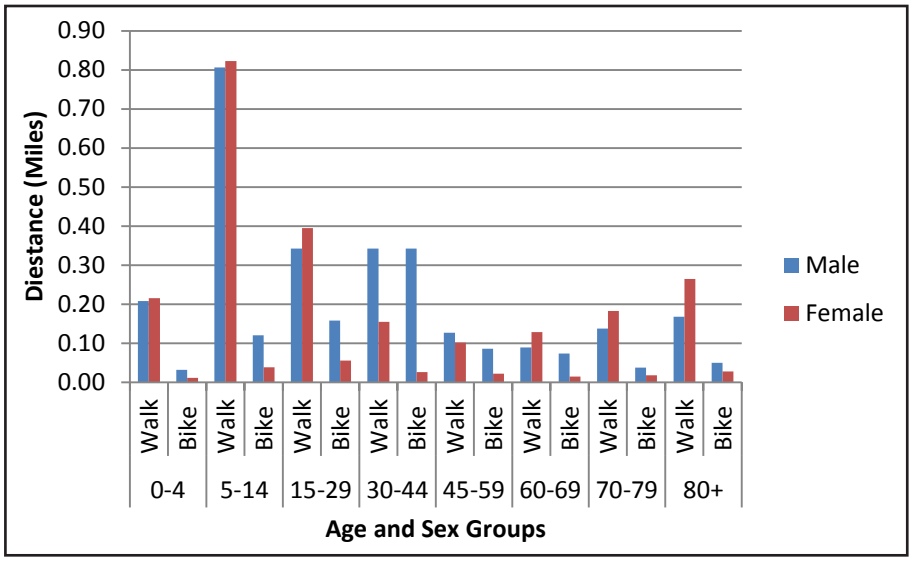

Figure 3. Average Person Mile Distance by Age and Sex for Walk and Bike Model in 2035 Base

Figure 4 presents the percentage change in average distance by walk and bike mode by age and sex categories for the 2035 scenarios relative to the base scenario. The greatest change for the alternative scenarios is among men and women in the 30- to 69-year age range and children age 0 to 4 years, who are now likely to accompanying their parents as they walk and bike more. There is only a relatively small change in school age walking

and biking (5 to 14 years), which is likely due to the fact that school destinations remain relatively constant in the scenarios. The VMT fee policy shows walking and biking increases across age groups ranging from 3% to 22% for men and 3% to 24% for women. This policy tends to have a greater effect on biking distances compared to walking distances because biking can substitute for longer automobile trips, which have become more expensive in this scenario. The transit and TOD scenario shows modest changes across all age groups in walking and biking, ranging from about -4% to 14% for men and -2% to 15% for women. Improved transit access in this scenario allows some school age children to substitute walk and bike trips for transit and thus there is actually a decline in walking and biking for this group. We also see a substitution of walk trips for transit trips among 15- to 30-year olds in this scenario. The transit, TOD, and VMT fee policies combined increase walking and biking from 3% to 36% for men and from 3% to 37% for women.

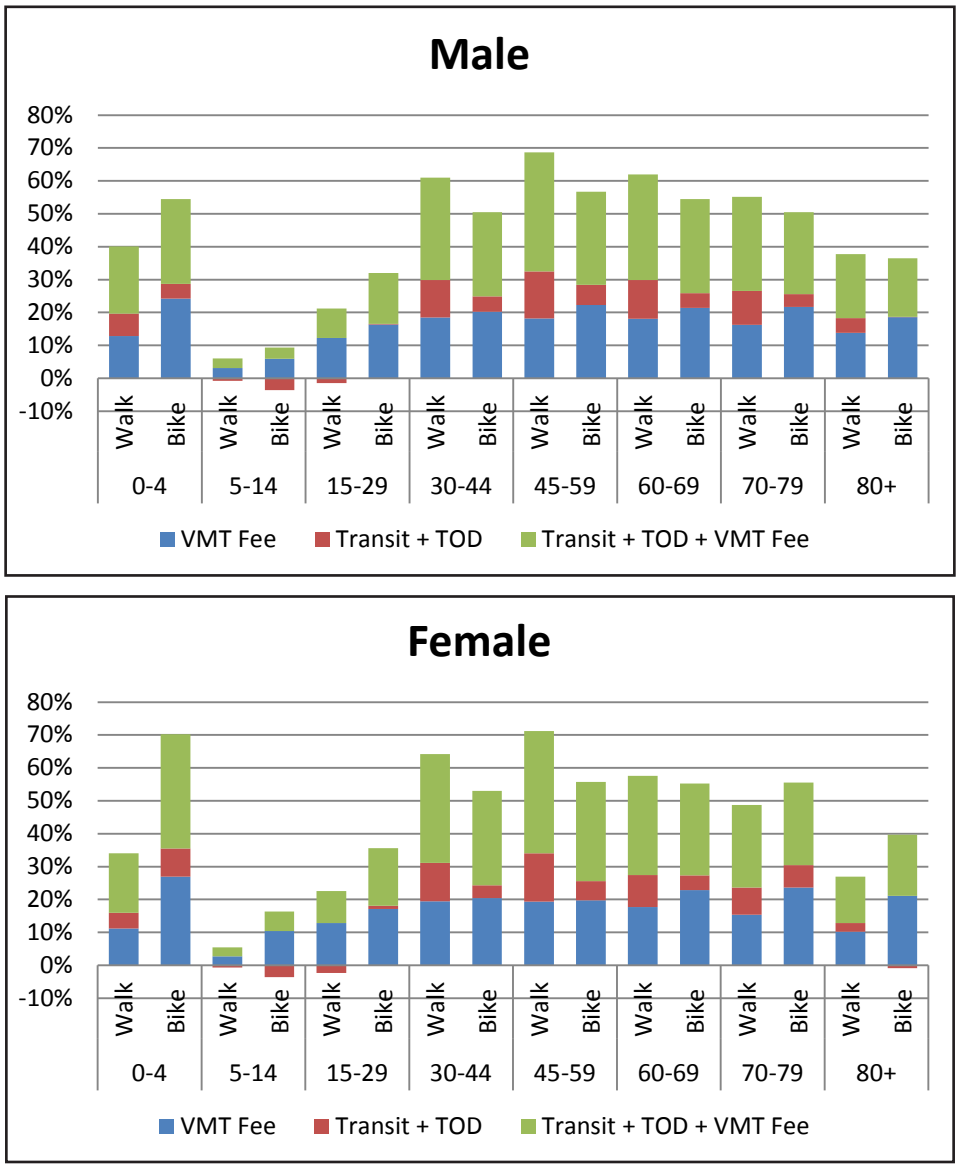

Figure 4. Percentage Change in Average Distance by Walk and Bike Mode by Age and Sex for 2035 California Scenarios Relative to Base

Table 2 shows the 2035 base case daily walk and bike mode shares, average walk and bike distance traveled, and passenger and light duty VMT for California and its five major regions. Note that mode shares are the total number of walk or bike trips divided by the total number of trips. Percentage change from the base case to the alternative policy scenarios is also presented for the same metrics.

Again, we see that the VMT fee policy tends to increase biking more than walking. The walk and bike mode shares increase by 12% and 15%, respectively, in California, and across the major regions from 11% to 14% and from 14% to 16%, respectively. The walk and bike distances increase by 10% and 17%, respectively, in California as a whole, and across the major regions from 9% to 12% and from 13% to 18%, respectively. Reductions in passenger and light duty vehicle distances correspond to the increases in walking and biking: it is reduced by 16% for the state and by 17% to 19% for the five major regions.

In the transit and TOD scenario, the closer proximity of home and destination locations enable more purposeful trips to be made by the walk mode. Thus, in contrast to the VMT fee scenario, walking increases more than biking. In California, the walk and bike mode shares increase by 16% and 6%, respectively. In the slower growing regions of California, walk mode shares increase from 6% to 11% and from 25% to 51% in the faster growing Central Valley regions. The bike mode shares increase from 3% to 11% across the five major regions. Walk and bike distances decline in some regions due to substitution of transit for walk and bike travel, as described above. However, the increases in walking distances range from 2% to 11% and biking distances increase from about 1% to 3%. The increases in walking and biking in this scenario are correlated with reductions in VMT that range from 2% to 9% for the major regions and statewide by about 4%.

Mode shift synergies are apparent in the transit, TOD, and VMT fee scenario for the walk and bike modes, as mode shifts are more than the sum of the separate VMT fee and transit and TOD scenario. In California, the walk and bike mode share increase by about 30% and 22%, respectively, and by 19% to 24% for bike mode share across regions, and walk share increases of 19% to 26% in the slower growing regions and 40% to 65% in the faster growing regions. Average distance traveled by walking and biking increase by 13% and 19%, respectively, in the state, and across regions from 9% to 22% and 12% to 22%, respectively. The increases in walking and biking are correlated with significant reductions in VMT: 19% statewide and 21% to 23% across regions.

Table 2. 2035 Base Daily Walk, Bike, and VMT Metrics and Percentage Change for Policy Scenarios

Scenarios	Mode	California	San Francisco	Sacramento	San Diego	Los Angeles	San Joaquin
Mode Share							
Base (% share)	Walk Share	6.3	7.2	4.8	5.2	6.5	6.3
	Bike Share	0.8	0.7	0.6	0.6	0.8	0.9
VMT Fee	Walk %Δ	12.4	10.9	12.8	13.6	13.3	11.5
	Bike %Δ	15.1	13.8	14.1	15.4	16.3	13.5
Transit + TOD	Walk %Δ	15.9	6.4	24.6	10.3	10.6	50.7
	Bike %Δ	5.8	2.9	7.4	2.7	5.5	10.8
VMT Fee + Transit + TOD	Walk %Δ	30.2	19.4	40.0	24.9	25.8	64.8
	Bike %Δ	21.7	19.1	20.2	19.8	23.2	23.5
Average Distance Traveled (miles)							
Base (miles)	Walk Miles	0.28	0.25	0.25	0.21	0.30	0.30
	Bike Miles	0.06	0.05	0.05	0.05	0.07	0.07
VMT Fee	Walk %Δ	10.1	9.7	9.3	12.3	9.7	10.3
	Bike %Δ	16.9	15.0	12.7	16.5	18.2	14.9
Transit + TOD	Walk %Δ	2.5	1.5	-0.8	3.8	0.4	11.0
	Bike %Δ	1.6	1.2	-1.4	0.1	2.9	-1.0
VMT Fee + Transit + TOD	Walk %Δ	13.1	12.6	8.9	15.0	10.7	22.1
	Bike %Δ	18.6	17.2	12.0	17.4	21.7	12.6
Passenger and Light-Duty Vehicle Miles Traveled (VMT)							
Base (millions of miles)	VMT	1,027	164	67	82	419	129
VMT Fee	VMT %Δ	-16.2	-16.8	-17.7	-18.1	-18.6	-17.1
Transit + TOD	VMT %Δ	-3.7	-2.1	-6.2	-3.2	-3.4	-8.9
VMT Fee + Transit + TOD	VMT %Δ	-19.4	-20.6	-22.2	-21.1	-21.7	-22.9

Notes: %Δ = Percentage Change [(Policy –Base)/Base]

VI. CONCLUSIONS

Health guidelines suggest that children and adolescents should exercise one hour a day and adults should get about 20 minutes a day.[15] The results of this study suggest that if expected trends are realized in the future, then, on average, individuals will only be spending about 4 to 6 minutes a day by walking and less than a minute a day biking for purposeful travel (assuming an average walk speed of 3 miles per hour and an average bike speed of 10 miles per hour). If a distance-based vehicle pricing policy is implemented, this active travel time may be increased by about 10% for walking and about 17% for biking and concurrently GHG from VMT may be reduced by about 16%. Increases in transit service and transit supportive development patterns may increase active travel by about 2% to 3% for both walk and bike modes while also reducing VMT by about 4% on average. The combination of all three policies increases time spent walking by about 13% and biking by about 19% and reduces VMT by about 19%. However, in the end, the major contribution of this study is that it demonstrates how the new generation of ABMs can be integrated with comparative risk assessment models to estimate health outcomes for regional land use and transport plans. In fact, the methods developed for this study are starting to be adopted by major California MPOs to create heath performance measures that may be included in regional transportation plans. Future applications of ABMs will no doubt improve the representation of spatial, travel time, and travel cost variables and thus improve the accuracy and precision of resulting health-related performance measures.

ABBREVIATIONS AND ACRONYMS

ABM	Activity-Based Travel Model
Caltrans	California Department of Transportation
CSTDM	California Statewide Travel Demand Model
CSV	Comma-Separated Values File Format
CTPP	U.S. Census Transportation Planning Package
DALY	Disability-Adjusted Life Years
GB	Gigabyte
GHG	Greenhouse Gas Emission
HIA	Health Impact Assessment
HOV	High Occupancy Vehicle
I-THIM	Integrated Transport and Health Impacts Model
MPO	Metropolitan Planning Organization
MTC	Metropolitan Transportation Commission
NAICS	North American Industrial Classification System
NHTS	National Household Travel Survey
PUMS	U.S. Census Public Use Microdata Sample
RTP	Rural Transportation Plan
RTPA	Rural Transportation Planning Agency
SGC	California Strategic Growth Council
SOC	Standard Occupational Classification
SOV	Single Occupancy Vehicle
SQLITE	Public Domain Database Management System
SWITRS	Statewide Integrated Traffic Records System
TOD	Transit-Oriented Development
UK	United Kingdom
ULTRANS	Urban Land Use and Transportation Center
U.S.	United States
VMT	Vehicle Miles Traveled

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