Benefit-Cost Analysis of Public Health Outcomes in Long Range Transportation Planning in the San Francisco Bay Area

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ABSTRACT

Walking and bicycling for transportation purposes have been shown to affect daily physical activity, but there has not been a comprehensive way to quantify the monetized benefits from the effects of individual transportation projects in regional planning. A methodology was developed that used travel model outputs along with public health data to quantify the value of reduced health care costs and lost productivity as a result of increased active transportation. This analysis identified that Bay Area residents could achieve $1.1 billion in lost productivity and healthcare cost savings if the region could meet the regional target of 70% growth in active transportation by 2035, equivalent to 15 minutes of active transportation per person per day. In order to identify which projects would most cost-effectively support growth in active transportation, projects were analyzed as part of the San Francisco Bay Area's most recent long-range transportation plan (Plan Bay Area). The results indicated that programs which specifically targeted and funded livability and bicycle improvements had some of the greatest abilities to increase physical activity per dollar expended; in particular, expansion of heavy rail, commuter rail, or express bus systems that encouraged passengers to walk or bike to transit were the top performing projects for cost-effectively increasing active transportation. One important conclusion was that not all public transit projects boosted active transportation; certain projects reduced the regional total of active individuals if they transformed a currently time-uncompetitive local transit service into a service that is time-competitive with bicycling or walking. In addition to these transit projects, many major highway projects were also forecasted to have significant negative impacts on physical activity from walking and bicycling.

BACKGROUND

The public health community has turned to transportation planners to help address the epidemic of disease types associated with physical inactivity. Inadequate physical activity contributes to a number of conditions that in turn lead to premature death and high medical costs. Walking and cycling have been recognized for their roles in helping to counteract these problems by incorporating physical activity into people's daily lives. Transit use has also been shown to provide an opportunity to help achieve minimum levels of daily recommended physical activity guidelines, as most transit trips begin or end with walking (and in more limited cases, cycling)(*1*).

A number of methods have been used to quantify the health benefits of walking and bicycling. These methods have relied on health care costs reductions associated with increases in physical activity. Transportation planners have not typically assessed individual bicycle and pedestrian projects benefits using cost savings from active transportation.

This paper introduces a tool that can be used in a benefit-cost analysis for individual projects that increase a person's physical activity over the recommended 30 minutes daily. The Metropolitan Transportation Commission's (MTC) long range transportation plan provides a 30-year active transportation target for the San Francisco Bay Area as a performance objective that individual projects can be assessed against. Because no comprehensive guidance for developing such a transportation target exists, the development of the numeric target and the analysis methodology for assessing the physical activity benefits of individual projects is outlined. This paper also highlights how health care and lost productivity savings from increases in physical activity are incorporated into project-level benefit-cost analysis. Finally, major Bay Area transportation projects are ranked by the most and least active individuals generated per dollar expended, allowing for the development of key findings.

ACTIVE TRANSPORTATION METHODOLOGY DEVELOPMENT

This methodology is similar to other studies where the increase in physical activity for projects that support bicycling and walking are shown to have a protective benefit to reduce health care costs(*2*)(*3*). The World Health Organization (WHO) has developed the Health Economic Assessment Tool (HEAT) that provides quantitative benefits based on the premature mortality savings of increased active transportation(*4*). HEAT assumes that any increase in active travel modes provides a positive health benefit based on epidemiological studies of regular European cyclists and pedestrians health outcomes versus non-walkers and bike riders. While staff consulted the team that developed HEAT, it was not ready for use during the project performance assessment due to the tool only capturing active walk trip benefits only (HEAT is now able to assess health outcomes of both cycling and walk trips.) HEAT is also designed as a web-based tool for single projects and was not available in another format such as a spreadsheet that would make it useful for multiple project assessment with multiple iterations. Additionally, one shortcoming of the tool is that it only captures the premature mortality benefit (death) and not morbidity (illness).

During the assessment valuation of transportation projects, a parallel effort to quantify the benefits of active transportation in long-range planning scenarios was in development. A study led by the California Department of Public Health, Centre for Diet and Activity Research (UK), MTC, California Office of Environmental Health Hazard Assessment and the Bay Area Air Quality Management District examined CO_2 reduction scenarios and associated co-benefits of achieving these reductions from scenarios with heavy emphasis on walking, cycling and transit use(*5*). The CA Department of Public Health applied the Integrated Transport Health Impact Model (ITHIM) to the Bay Area using travel model, air quality, U.S. Census and public health data(*6*). This model uses relative risk assessment to quantify the co-benefits and harms of

physical activity, traffic injuries and air pollution from active transport and other CO_2 reduction scenarios. Impacts are measured in disability adjusted life years (DALYs) as well as deaths which is one of the only methods for scenario planning that examined the benefits of both mortality and morbidity.

CONNECTIONS TO LONG-RANGE TRANSPORTATION PLANNING

MTC has long recognized the benefits of walking and cycling in the region's multimodal transportation system, but the health benefits from walking and bicycling had not been historically quantified as part of the long-range planning process. Under Plan Bay Area, the region's first integrated land use and transportation plan, physical activity is finally recognized as a critical goal throughout the planning process. As such, the effects of major regional transportation projects on physical activity are evaluated for the first time.

The goal of increasing physical activity from active transportation fits well with the overarching requirements of Plan Bay Area, which is initiated in response to California Senate Bill 375's requirement for major California Metropolitan Planning Organizations (MPOs) to develop a Sustainable Communities Strategy to coordinate land use and transportation on a regional level. These plans are designed to help combat climate change and reduce greenhouse gas emissions; increasing the mode share for active transportation modes is a key strategy in achieving these envisioned reductions.

PERFORMANCE ASSESSMENT PROCESS FOR PLAN BAY AREA

Plan Bay Area relies upon a performance-based planning approach to assess both individual transportation projects and long-range planning scenarios; this process utilizes quantifiable performance measures to evaluate the outcomes of integrated transportation investments and land use policies. Benefit-cost (B/C) analysis is used to help identify measureable outcomes for policy decisions in Plan Bay Area *(7).*

At the beginning of the process, a broad range of regional goals – including land use, economic vitality, and public health – are added to traditional transportation planning goals such as mobility and air quality. Building upon these goals, the set of identified regional targets reflects the region's wide-ranging objectives, which can be addressed through a broad spectrum of policies. This process enabled the Plan to better connect performance results to long-range planning and funding decisions impacts of Plan Bay Area.

All major capacity-increasing transportation projects (with total costs exceeding $50 million and/or with regional impacts) are evaluated using a quantitative, model-based methodology to determine each project's benefit-cost ratio. This process went beyond the adopted performance targets to consider as many quantifiable benefits as possible, seeking to determine which projects are most cost-effective in providing benefits to users and society.

MTC's activity-based travel model, known as Travel Model One, is used to analyze both region-wide land use and transportation scenarios and individual transportation projects – which created a level playing field for evaluation of both scenarios and projects. This approach allows for fair comparison of B/C ratios between individual projects, as each project's benefits are calculated using an identical methodology. To determine the impacts of a particular project, a no-build model run is conducted to determine the baseline conditions (e.g. total regional travel time, tons of airborne emissions, fatality collisions, etc.). After changing the baseline conditions to represent project-related improvements – e.g. travel lanes are added, or a rail line is extended – the model is then run again to analyze with-project conditions. Every model run is performed for the geographical scope of the entire Bay Area, meaning that no-build and with project conditions captured the travel impacts of a given project for simulated travelers across the region. The impacts to each plan targets are calculated by comparing the no-build and with-project model

runs. The methodology discussed in this paper focuses on the physical activity benefits from the individual project assessment rather than the various planning scenarios.

PLAN BAY AREA METHODOLOGY FOR EVALUATING ACTIVE INDIVIDUALS

The active transportation target differs from many other Plan Bay Area targets, since it was not based on pre-existing state or federal guidelines. While the Centers for Disease Control (CDC) and the California Department of Public Health (CDPH) have established targets for daily physical activity, there are no specific forecasts for the amount of physical activity an individual should expect to engage in future years. Additionally, existing guidelines do not disaggregate the physical activity resulting solely from transportation. As such, MTC had to develop its own target using the best available data.

A buffer analysis of Bay Area residents living within ½ mile of a rail or ferry station showed that these residents received 15.5 minutes of active transportation due to dense land uses and access to transit via walking or cycling. In contrast, the same analysis revealed that the average Bay Area resident engaged in only 7 minutes of physical activity from transportation alone(*8*). All active transportation in the 2005 base year is calculated from Travel Model One at 8.88 minutes per person per day. The active transportation target in Plan Bay Area is a 70% increase in the year 2035 or approximately 15 minutes per person daily over the base year – an ambitious target, given that it would require the typical Bay Area resident in year 2035 to engage in as much physical activity as the present-day subset of individuals living within a convenient walking distance of public transit (typically in moderate-to-high density locations, with walkable destination and sufficient pedestrian amenities).The Center for Disease Control (CDC) recommends a minimum of 30 minutes of daily moderate to vigorous physical activity for adults to ensure a healthy lifestyle and reduce the incidence of disease(*9*). Moderate activity would include any health enhancing activity that raises the heart rate and is over and above any sedentary baseline physical activity. Walking and cycling to get to work, school, or other destinations are considered moderate activity. People that are below the threshold of 30 minutes are considered “inactive”.

While the plan target for the entire Bay Area population is 15 minutes per person daily in the year 2035, projects are assessed based on how much they were able to affect an individual’s behavior to engage in physical activity from less than 30 minutes daily to over 30 minutes daily. While there is some benefit to physical activity less than 30 minutes daily, the health literature assesses the health benefits from this 30 minute threshold. To gauge how much a project affects an individual’s daily active transportation, the change in the level of physical activity per person per day is measured and compared to the base condition.

To determine the level of active transportation from a specific project, the minutes of walk, bike, and walk to transit time are calculated from MTC’s Travel Model One. The model assumes Bay Area specific speeds for walking and bicycling trips of 3 mph and 12 mph, respectively; while each project has marginal impacts on trip distances, regional average trip distances remain relatively consistent between projects (0.3 miles for walk trips and 2.2 miles for bike trips). Each model run provides the number of walk, bike, and walk to transit trips in the region, making possible the calculation of active transportation minutes per project as shown below:

<u>Active Transportation Minutes per Project</u>
*average minutes spent walking or bicycling for transportation = (# trips / Bay Area population in year 2035 * average trip length per mode) * (average trip length per mode / average speed per mode * 60 minutes/hour)*

To determine the population share that become active as a result of the project, the active transportation minutes were applied to the number of the Bay Area population considered inactive – less than 30 minutes of physical activity daily. The California Health Interview Survey (CHIS), a random digit telephone survey conducting biannually, provides data for residents by county that are considered inactive (less than 30 minutes of exercise per day by any activity), which can be used to estimate the percent of Bay Area individuals that are inactive (*10*). In 2005, 62% of the Bay Area population was considered inactive with each person engaging in 0 to 29 minutes of physical activity daily. The number of minutes of physical activity that an inactive individual would need to achieve to become active is estimated using a methodology developed by Gotschi for an analysis of bicycling benefits in Portland, Oregon (*11*). The number of minutes that inactive individuals (less than 30 minutes) are assumed to engage in is an average of 15 minutes. Active individuals with greater than 30 minutes of physical activity are assumed to engage in an average of 45 minutes. The average between the inactive individuals' minutes and the active individuals' minutes was 30 which was the amount needed to make an individual active. The percent of active individuals as a result of the project is determined by:

<u>Number of Individuals Becoming Active from the Project</u>
*individuals becoming active = [(difference in minutes/person/day from base case to project) * (percent of Bay Area population that is inactive – 62%) / (30 minutes required to be active)] * (Bay Area population in year 2035)*

PLAN BAY AREA COST SAVINGS OF INCREASES IN PHYSICAL ACTIVITY

Each individual that increased their physical activity over the 30 minute threshold through active transportation is expected to experience monetary benefits from reduced health care costs and cost savings through lost productivity. A study by the California Center for Public Health Advocacy in 2006 examined costs related to being overweight, obesity and physical inactivity and the resulting health conditions related to premature illness, disability and death. Diseases related to these health conditions include coronary heart disease, type 2 diabetes, forms of cancer, and stroke; these diseases are responsible in part for rising medical costs(*12*). Both public and private hospitals health care costs from health care claim data for California adults for certain medical conditions that epidemiological studies have linked to overweight, obesity and physical inactivity. The costs of care for these conditions are added together to provide costs for lack of physical activity in California. Lost productivity costs are based on the same three health conditions as the healthcare costs but examined three worker outcome measures: absenteeism, short-term disability, and presenteeism (or the portion of an employee's work load that could not be completed due to a compromised health status). Lost productivity costs are estimated based on the average annual number of work hours lost per person associated with the prevalence of the three factors in each county. Costs for the nine Bay Area counties are summed and an average cost per person is calculated. Each person that became more active due to the project is valued at $326 for health care cost savings and $717 for lost productivity annually.

PERFORMANCE OF BAY AREA TRANSPORTATION PROJECTS

Due to the time-consuming nature of modeling individual transportation projects to determine their regional impacts on transportation patterns, MTC focused on major, capacity-increasing projects for which capital costs exceeded $50 million. Due to the cost threshold, these projects tend to be expansion or major efficiency projects, rather than minor enhancement or livability improvements. As such, most bicycle and pedestrian projects are too small for this type of assessment and are instead merged into programmatic categories for analysis purposes. For example, individual bicycle and sidewalk improvements are analyzed as a single county-wide

bicycle and pedestrian program. Given the types of projects evaluated in this effort, bicycle and pedestrian benefits tend to be secondary benefits (or positive externalities) of larger investments – e.g. a new rail line might encourage additional walking and bicycling to access newly constructed stations. Nevertheless, this enabled MTC to sort projects by their cost-effectiveness in increasing physical activity and identify how major investments might affect public health in the region.

Table 1 identifies the regional investments that are the most cost-effective in increasing the number of active individuals in the Bay Area. Several key trends can be identified in this high-performers list. First, regional programs that specifically target and fund livability and bicycle improvements have some of the greatest abilities to increase physical activity per dollar expended. This is demonstrated by the Transportation for Livable Communities (TLC) and Regional Bikeway Network (RBN) results, which had the largest total impact on increasing active individuals. Given that both projects focus on increasing active transportation by creating inviting streetscapes, pedestrian amenities, and bicycle facilities, this is not entirely unanticipated. For a perspective of cost-effectiveness in achieving these active transportation gains, these projects ranked as the 4th and 5th most cost-effective projects analyzed. This is due to the high cost of implementing these projects, despite their significant regional benefits.

TABLE 1: Most Cost-Effective Transportation Investments towards Active Transportation Target

Rank	Project Name/Description	Project Type	Total Annualized 2035 Benefits (millions)	Total Annualized 2035 Costs (millions)	B/C Ratio	Active Individuals	Active Individuals/ million
1	BART Metro Program (including Bay Fair Connection and Civic Center Turnback) - *Increases the efficiency of BART in the urban core by constructing new turnbacks and providing new express train service.*	Transit Efficiency	$161.3	N/A	>60	2,735	>2,338
2	Congestion Pricing Pilot - *Charges a $3 toll to enter/exit the northeast quadrant of San Francisco during peak hours; net revenues designated for transit service.*	Pricing	$227.4	$5.1	45	11,899	2,338
3	Treasure Island Congestion Pricing - *Charges a $5 toll for residents to enter/exit Treasure Island during peak hours; net revenues designated for transit service.*	Pricing	$69.1	$1.2	59	2,483	2,108
4	Regional Bikeway Network - *Completes a regional network of Class I, II or III bikeways.*	Bicycle/ Pedestrian	$124.5	$73.2	2	54,406	743
5	Transportation for Livable Communities - *Builds infrastructure to promote pedestrian and bicycle travel in transit corridors.*	Livability	$874.8	$254.7	3	167,639	658
6	Irvington BART Station - *Constructs a new infill BART station in the Irvington district of Fremont.*	Transit Efficiency	$18.7	$1.5	12	763	496
7	SR-29 HOV Lanes and BRT (Napa Junction to Vallejo) - *Adds a High Occupancy Vehicle (HOV) lane to an existing state highway with new express Bus Rapid Transit service.*	Road Efficiency	$10.9	$4.2	3	976	231
8	San Mateo Countywide Shuttle Service Frequency Improvements - *Adds additional commuter rail shuttle service to provide faster and more frequent service during peak hour*s.	Transit Efficiency	$10.3	$6.3	2	1,321	211
9	BART to San Jose/Santa Clara (Phase 2: Berryessa to Santa Clara) - *Extends BART from the Phase 1 terminus in Berryessa (North San Jose) through a new BART subway to Alum Rock, Downtown San Jose, Diridon Station, and Santa Clara.*	Transit Expansion	$323.5	$69.9	5	12,117	173
10	Caltrain Service Frequency Improvements (6-Train Service during Peak Hours) + Electrification (SF to Tamien) - *Electrifies the Caltrain line and purchases additional train vehicles to provide faster, more frequent service during peak hours.*	Transit Efficiency	$152.5	$33.9	5	5,760	170

Another important trend for high-performing projects relates to higher-speed transit investments that enable longer-distance commuting due to auto-competitive travel times. As evidenced in the list of top-performing projects for active transportation, top investments focused on improving or expanding heavy rail, commuter rail, or express bus systems. These systems, unlike more localized transit projects (as discussed later in this section), offer much faster travel times than an individual would be able to achieve by walking or bicycling directly from their origin to destination. For example, the BART (Bay Area Rapid Transit) Metro project will upgrade the heavy rail system with new turnbacks and express services, allowing for operating cost efficiencies that cancel out any initial upfront capital costs. This project will encourage additional active transportation trips to and from BART stations, particularly in the urban core where service will be most significantly enhanced. This led to the project being recognized as the most cost-effective investment for active transportation, resulting in 2,735 individuals becoming active as a result of the project. Similarly, congestion pricing initiatives in San Francisco are highly cost-effective in boosting active transportation trips. These projects will toll auto travelers entering key zones of San Francisco and reinvest revenues into transit, bicycle, and pedestrian infrastructure; by discouraging suburban auto commuters through tolls and incentivizing them to take advantage of existing high-capacity transit systems such as BART and Caltrain, both projects yield over 2,000 active individuals per million dollars in annualized costs. Other examples of time-competitive transit investments that boosted active transportation included an express bus rapid transit service operating at highway speeds, shuttle services to the Caltrain commuter rail service, and frequency improvements to increase the attractiveness of Caltrain. All of these projects attract travelers who would otherwise be driving, resulting in greater levels of active transportation, as they serve long-distance commute patterns that are not currently time-competitive for pedestrians or cyclists.

However, some transit projects could also reduce active transportation where the project transforms currently time-uncompetitive service into a service that is time-competitive to bicycling or walking. In the Bay Area, over half of all transit ridership are made on routes with an average speed of only 9 miles an hour.(*13*), Cyclists traveling in the Bay Area have an average speed of 12 miles per hour which offers a travel time savings over many transit lines and provides direct door-to-door service with zero wait time. Table 2 highlights the regional investments that actually reduce the number of active individuals per dollar expended; as noted above, many of these projects are local transit projects that convert slow local services into rapid services. While this results in increased overall utility for the region and faster commute times for many transit riders, it may have unexpected adverse impacts on physical activity from transportation.

TABLE 2: Least Cost-Effective Transportation Investments towards Active Transportation Target

Rank	Project Name	Project Type	Total Annualized 2035 Benefits (millions)	Total Annualized 2035 Costs (millions)	B/C Ratio	Active Individuals	Active Individuals/ Million
1	SFMTA Transit Effectiveness Project - *Improves reliability and reduces travel times on key Muni bus corridors through signal prioritization and bus lanes.*	Transit Efficiency	$89.5	$7.8	11.4	(3,811)	(486)
2	I-80 Auxiliary Lanes (Airbase Parkway to I-680) - *Constructs additional auxiliary lanes on Interstate 80 to reduce merging conflicts and to improve vehicle flow.*	Road Efficiency	$18.0	$3.5	5	(399)	(112)
3	Alameda-Oakland BRT + Transit Access Improvements - *Adds Bus Rapid Transit service to link the City of Alameda with downtown Oakland and adjacent neighborhoods.*	Transit Efficiency	$13.6	$2.1	6	(200)	(96)
4	Bay Bridge Contraflow Lane - *Provides infrastructure to operate a peak-period reversible lane for carpools and public transit.*	Road Efficiency	$66.8	$30.5	2	(2,591)	(85)
5	Silicon Valley Express Lanes Network - *Constructs High Occupancy Toll (HOT) lanes on select freeways in Santa Clara County.*	Express Lanes Network	$407.8	$69.9	6	(5,430)	(78)
6	Muni Service Frequency Improvements - *Adds additional local bus service in San Francisco to provide faster and more frequent service.*	Transit Efficiency	$24.7	$14.0	2	(1,058)	(76)
7	AC Transit Service Frequency Improvements (Restoration of 2009 Funding Levels) - *Adds additional local bus service to provide faster and more frequent service in the East Bay.*	Transit Efficiency	$108.5	$64.9	2	(4,761)	(73)
8	Fremont/Union City East-West Connector - *Constructs a new arterial to provide a cross-town connection between the cities of Fremont and Union City.*	Arterial Expansion	$65.5	$10.0	7	(449)	(45)
9	CTC Application + Alameda County Authorized Lanes Express Lanes Network – *Constructs High Occupancy Toll (HOT) lanes on the regional freeway network.*	Express Lanes Network	$601.6	$118.2	5	(5,050)	(43)
10	Better Market Street - *Improves transit frequency and reliability on the Market Street corridor in San Francisco.*	Transit Efficiency	$56.5	$10.0	6	(423)	(42)

A prime example is the San Francisco Municipal Transportation Agency's (SFMTA) Transit Effectiveness Project, which will improve the reliability and reduce the travel time of key bus corridors in San Francisco by providing bus lanes and transit signal priority. Given the notably slow speeds of Muni buses due to high ridership demand and significant traffic congestion, this project is forecasted to attract additional riders, some of whom are currently bicycling or walking directly to their destinations to avoid today's slower services. Per dollar expended, this project has by far the most significant impacts on active transportation; while this should not detract from the project's obvious benefits in making Muni's most popular bus routes operate more efficiently – and at the same time reducing travel times for passengers – it is important to consider the public health drawbacks that may occur. This effect can also be evidenced in other cost-ineffective projects for active transportation. The Alameda-Oakland Bus Rapid Transit project will expedite buses and improve frequencies along prime transit corridors in Alameda County, resulting in mode shift from active modes to public transit. Similarly, frequency improvements on Muni and AC Transit will increase the time-competitiveness of these transit services by reducing wait times; bicyclists and pedestrians will respond to these services by shifting medium-distance trips to public transit instead of relying on the relatively slower active transport modes.

Highway projects are also forecasted to have significant negative impacts on pedestrian and bicycle modes. In particular, the proposed regional networks of high-occupancy toll lanes (also known as Express Lanes) are forecasted to result in more than 10,000 individuals becoming inactive. This is likely to due to the projects' ability to make automobile travel more attractive than public transit (due to reduced travel times on freeways resulting from highway widening associated with the projects); when individuals switch from public transit to auto modes, many experience reduced physical activity from transportation as a result of no longer needing to walk or bicycle to their nearest station or stop. Similarly, road widening projects such as the I-80 Auxiliary Lanes and Fremont/Union City East-West Connector encourage driving to the detriment of active transportation modes.

PERFORMANCE EVALUATION CONCLUSIONS

When local bus services operate at low speeds, improvements to these systems may have unexpected effects on active transportation. Individuals have a finite time budget for transportation by any mode and projects that offer time savings over walking and biking can actually decrease a person's active travel. Projects that improve travel time for intracity bus service, particularly in locations where the residents can easily access the service from home, can easily outcompete bicycling and walking. People that are reluctant to use slow bus service with long wait times (that are using active modes directly to their destination) may be enticed to use improved bus service if it provided a faster service. One important caveat is that these findings are contingent on a significant share of existing trips occurring by pedestrian or bicycle; in other major U.S. cities, there may be many fewer individuals participating in active modes already who might be influenced by improved local transit services.

Projects that improve already time-competitive modes (and instead attract ridership from highways by encouraging auto mode shifts) may have greater benefits for active transportation by encouraging station access via walking or bicycling. Since these individuals do not have a vehicle during their trip, they are likely to continue to make trips by walking or biking during the course of the day. As expected, projects that make it easier to drive, such as road efficiency or expansion projects, provide very little benefit to increasing active transportation. These projects continue to maintain the auto-dominant infrastructure and ignore other modes that may have a positive health co-benefit.

ANALYTICAL LIMITATIONS: TARGET-SETTING

It should be noted that the physical activity benefits from transportation are underestimated from this approach since it only considers the cost of illness and not the cost savings of premature mortality. Despite a much smaller number of individuals benefiting from a protective benefit from early death due to active transportation, the value used per individual is a large figure (the statistical value of life used in the project performance assessment for fatal collision reduction was $4.6 million). Even with this undervaluation of physical activity benefits, attainment of the active transportation goal will offer substantial cost savings.

Although none of the planning scenarios met the adopted active transportation target, the monetized benefits of meeting the target are analyzed. If Bay Area residents are able to achieve the targeted 70% increase in active transportation, the savings in lost productivity and health care cost savings will total $1.1 billion. This cost savings is calculated by comparing the baseline active transportation minutes in the no-build scenario to a future scenario that is adjusted to show all residents would engage in 15 minutes of active transportation or attainment of the target. The difference between the baseline and the attainment of the target scenario to show the increase in active individuals is calculated using the project assessment methodology described earlier. If the Bay Area is able to meet the target it will require that 10.6% of the current Bay Area population receive 15 minutes or more of physical activity from transportation alone. While the monetized cost alone of active transportation is significant, the public health literature shows that there can be substantial protective health benefit due to increased physical activity less than the recommended 30 minutes daily, which itself is valuable(*14*).

While 30 minutes is a measurement used by public health officials as the minimum standard for physical activity, there is no recommendation for the portion of active transportation that contributes towards this target. It is likely that people who meet their 30 minutes daily target do so through a combination of transportation related exercise and other leisure or occupational physical activity. There is no reliable methodology to account for what activities contribute to the daily physical activity as the health data sets account for some transportation related walk time but do not have questions that deal with bicycling for transportation. Additionally, transportation data sets tend to undercount walk and bike trips, as well as walk to transit trips.

ANALYTICAL LIMITATIONS: PROJECT-LEVEL ASSESSMENT

One limitation of the project assessment methodology is the inability to capture other moderate to vigorous physical activity in daily life such as going to the gym, gardening, walking/jogging for recreation, and cycling for recreation. The two datasets used to determine the physical activity levels from transportation (the Year 2000 Bay Area Travel Survey and the California Health Interview Survey) do not have a way to identify specific individuals, which prevented us from determining if observed physical activity is due to transportation or recreation.

Further limitations were a result of MTC's Travel Model One; while the model explicitly captures walk and bicycle trips, it has several shortcomings. First, pedestrian and bicycle infrastructure are not explicitly modeled, meaning that bike lanes and sidewalks are not spatially represented in the model. While MTC is working to collect regional inventory data for these facilities, current model runs do not account for the direct influence of non-motorized transportation infrastructure. Second, the model does not account for bike to transit trips, even though a small percentage of regional trips rely on this mode combination. Further development of bike ownership models and transit capacity constraints would be necessary to accurately implement this in the regional travel model. Both of these shortcomings likely lead to somewhat underestimated forecasts of walking and biking benefits from the transportation investments listed above. Finally, behavioral studies have suggested that "self-selection bias" or behavioral inertia have significant impacts on the pedestrian and bicycling impacts of projects in specific

cities and neighborhoods. Travel Model One assumes individuals make rational decisions independent of historic experiences; it is unclear how significant an impact this might have on the model-based results.

The next iteration of Plan Bay Area will most likely rely on ITHIM for the long-range planning performance assessment as it captures both mortality and morbidity. While ITHIM is designed as a scenario analysis tool, it could be applied for individual projects in a similar manner to the modeling approach for Plan Bay Area. ITHIM also allows for the consideration of traffic collision impacts from increased exposure of pedestrians and bicyclists.

The methodology described in this paper can be used by other MPOs that use a similar process to assess their projects. Any travel model that provides the minutes of walk or bike time per person from a project can assess the health care and lost productivity costs. Region-specific health care and lost productivity costs due to physical inactivity can help to provide a more accurate estimate for a given area. MTC's methodology for quantifying morbidity in dollars coupled with a tool that considers the costs of mortality savings from physical activity would offer agencies a more complete picture of the active transportation benefits from a project.

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