Healthy T for a Healthy Region:

Health impact assessment of proposed MBTA service cuts and fare increases

Proposed changes to MBTA fares and services would carry significant human and financial costs, resulting in avoidable loss of life and hundreds of millions of dollars per year in lost time, wasted fuel, and preventable hospitalizations and accidents. In addition, the changes would contribute to our widespread obesity problem, and would isolate hundreds of households from basic health care resources.

Working under difficult fiscal and political constraints, MBTA has proposed two sets of fare increases and service cuts aimed at closing its projected deficit of $161 million this year. Under Scenario 1, fares would increase by 43% and service reductions would affect between 34–48 million trips each year. Under Scenario 2, fares would increase by 35% and service reductions would affect between 53-64 million trips each year. The Central Transportation Planning Staff (CTPS) estimated the regional impacts of each proposal on vehicle miles travelled, time spent driving, ridership loss, and air quality. Based on these estimates, our analysis shows that even seemingly modest fare increases and service cuts to the MBTA system would result in costs that far exceed the budget shortfall the proposed changes seek to address:

Annual Impact	**Scenario 1 Cost**	**Scenario 2 Cost**
Cost of additional time in traffic	$137.5 million	$186.0 million
Cost of additional fuel burned	$22.7 million	$31.8 million
Cost of additional car crashes, including crashes with bicycles and pedestrians	$33.6 million	$48.8 million
Cost of additional mortality and hospitalizations for asthma, chronic lung disease, heart attacks, heart disease, and major cardiovascular events due to air pollution	$1.5 million	$2.1 million
Cost of lives lost due to decreased physical activity	$74.9 million	$116.5 million
Cost of carbon emissions	$1.9 million	$1.7 million
Total annual cost	**$272.1 million**	**$386.9 million**

As transit ridership drops, more residents will commute by car, increasing how long it takes all drivers to get around in the region. Specifically, average travel speeds will drop by 0.2 miles per hour under Scenario 1 and by 0.3 miles per hour under Scenario 2. As a result, current drivers will spend an **additional 18,500 and 25,100 hours per year driving**, respectively. In addition, Scenario 1 would result in preventable accidents, hospitalizations, and roughly **10 avoidable deaths** per year; Scenario 2 would produce about **15 avoidable deaths** per year. These are conservative estimates that only account for automobile accidents, the loss of routine physical activity performed by transit users to reach bus and T service each day, and the health effects of several well-studied air pollutants.

Daily transit use, estimated to burn roughly 8,000 calories per rider per year, is an important source of physical activity. We estimate that approximately 30,000 people would shift from transit use to driving under Scenario 1, and 49,000 people under Scenario 2, resulting in over 70 and 120 new cases of obesity per year, respectively.

In addition to direct health impacts, the proposed changes would reduce access to health care resources. Roughly 550 transit-dependent households would be isolated from basic health care resources under Scenario 1, and an estimated 2,200 transit-dependent households would lose access under Scenario 2. Under the proposed service changes, this affected population would have to pay for or borrow a car to reach any basic health care facility.

Carbon dioxide emissions due additional personal automobile use and increased congestion will increase by over 58,000 metric tons of CO_2 emissions per year under Scenario 1, which is roughly the equivalent of consuming 134,900 barrels of oil in one year, and over 52,000 additional metric tons of CO_2 emissions per year under Scenario 2.

Introduction

The MBTA has proposed two sets of fare increases and service cuts aimed at closing its projected deficit of $161 million this year. Under Scenario 1, fares would increase by 43% and service reductions would affect between 34–48 million trips each year. Under Scenario 2, fares would increase by 35% and service reductions would affect between 53-64 million trips each year.

Working with colleagues from the Harvard School of Public Health and the Boston University School of Public Health, the Metropolitan Area Planning Council (MAPC) conducted a health impact assessment (HIA) of the two proposals, the results of which are described in this report. HIAs aim to describe the potential health effects of plans, policies, or programs under consideration for adopting (NRC, 2011). To assess how the MBTA service and fare change scenarios might impact health, we examined the Central Transportation Planning Staff's (CTPS) estimates of how the scenarios would affect vehicle miles travelled, time spent driving, ridership loss, and air quality in the region. We then applied findings from peer reviewed scientific literature to the results of the CTPS transportation models, in consultation with local experts in the fields of air quality, environmental health, and physical activity. We considered both health and indirect economic impacts to the population.

Pathways linking transit and health

The proposed service cuts and fare increases would impact human health through multiple environmental, social and economic pathways, as shown in Figure 1 (Cole et al. 2008). We are able to quantify effects associated with seven of eleven pathways known to link transit policy to health. Data constraints prevented a complete quantitative analysis of impacts that would occur under all eleven pathways, but we were able to assign impact estimates in the following areas:

1. **Time Spent and Fuel Burned in Traffic**
2. **Air Pollution**
3. **Physical Activity**
4. **Crashes**
5. **Access to Healthcare**
6. **Carbon Emissions**
7. **Noise**

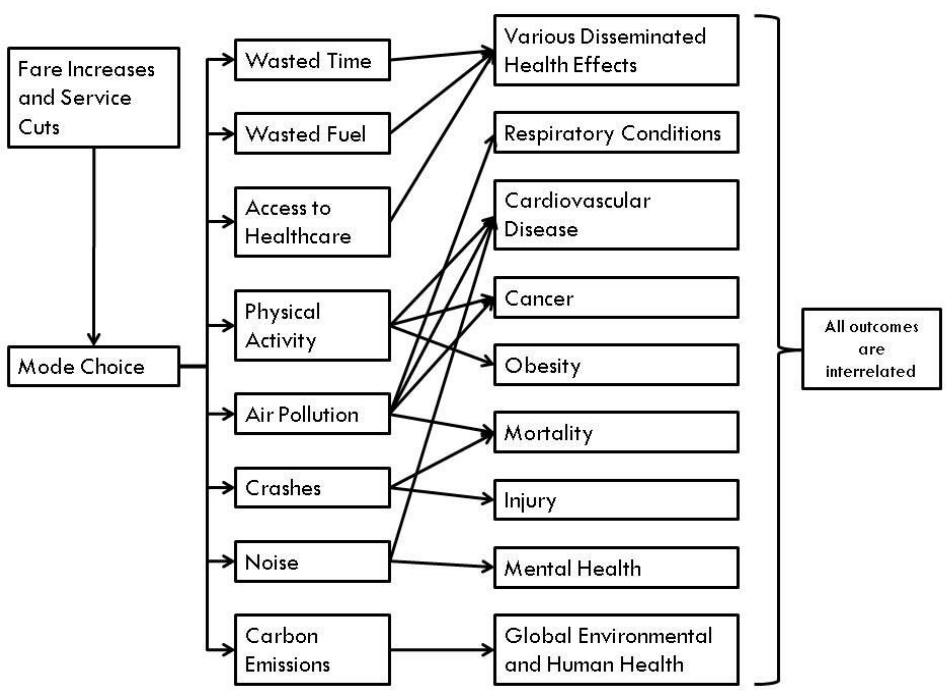


FIGURE 1.
PATHWAYS FOR TRANSIT USE TO IMPACT HEALTH FROM COLE ET AL. 2008.

Time Spent and Fuel Burned in Traffic

Fare increases and service cuts impact transportation behaviors. CTPS projects that increased costs and reduced MBTA service will cause transit ridership to drop, leading to more drivers on our region's roads and consequently an increase in the number of hours the residents will spend in cars, collectively. This shift imposes costs for the region as more drivers lead to more congestion, increasing average driving time for everyone.

Impacts

SCENARIO 1:

- 30,400 people shift from transit to driving
- $137.5 million per year in time wasted
- $22.7 million per year in fuel wasted

SCENARIO 2:

- 48,600 people shift from transit to driving
- $186.0 million per year in time wasted
- $31.8 million per year in fuel wasted

Source data

We obtained transportation, traffic, and emissions data from CTPS that describe "baseline" current conditions, meant to represent patterns from 2010 under full MBTA service, and for the two proposed service change scenarios (CTPS Models 2012). These transportation and traffic estimates provided vehicle-miles traveled (VMT) by automobiles and trucks, and vehicle-hours traveled (VHT) for each affected traffic analysis zone (TAZ), but did not include MBTA vehicles. CTPS's Impact Analysis and transportation models also provided an estimated percent of total vehicles that are commercial vehicles versus passenger vehicles, and the number of daily transit trips by TAZ under each scenario. Average fuel costs, vehicle occupancy, and monetary value of time were taken from the widely utilized annual publication, Texas Transportation Institute (TTI) Urban Mobility Report (Schrank et al., 2011). TTI, the nation's largest transportation research organization and a member of the Texas A&M University system, synthesizes a wide range of transportation-related data from across the U.S., providing excellent estimates of current transportation system performance and costs associated with various aspects of travel in the nation.

Mode shift estimation

In order to estimate the number of individuals switching from transit to driving, we first calculated the difference between the number of daily transit trips that currently take place and those that would occur under Scenarios 1 and 2. We assumed, in consultation with CTPS, that each weekday transit rider completes two MBTA trips per day (i.e., to and from work) and that 95% of individuals shifting from transit would instead drive under the proposed scenarios.

Time and fuel spent in traffic calculation and valuation

As transit ridership drops, more residents will commute by car, increasing how long it takes all drivers to get around in the region. Specifically, average travel speeds will drop from 32.7 miles per hour (mph) to 32.5 mph under Scenario 1 and to 32.4 mph under Scenario 2. To estimate how much time the region's drivers would lose due to driving at slower average speeds, we divided the current regional VMT by the current average speed (32.7 mph) and then by average travel speeds under Scenarios 1 (32.5 mph) and 2 (32.4 mph). These calculations gave us estimates of how much extra time the region's drivers would spend to cover the same distance under Scenario 1 (18,565 hours) and under Scenario 2 (25,100 hours). Based on CTPS' estimates of the region's automobile/truck VHT mix, we then allocated 95% of these additional hours to passenger vehicles (i.e., automobiles) and 5% to trucks. The additional time spent driving in automobiles was then multiplied by 1.25, or the average number of passengers/vehicle given by the TTI Report, to account for the fact that many vehicles experiencing travel delays contain more than one person. We multiplied this number of extra person-hours by $16.94, or the value of one hour of travel time in the greater Boston region in 2012 dollars (Schrank et al., 2011). We valued time spent driving in trucks at $91.60/hour per vehicle in 2012 dollars, assuming trucks are used for commercial purposes, and assumed only one occupant per truck. Finally, we annualized these daily costs based on the CTPS-provided annualization factor of 300, resulting in $137 million in lost time costs under Scenario 1 and $185 million under Scenario 2 annually. It is important to note that we calculated these losses based on current VMT, ignoring the impact of slower speeds on new drivers.

Average speed, an estimate required to assess fuel use, was calculated for each scenario by dividing VMT by VHT. Fuel use under each scenario, in gallons, was calculated by using TTI equations below and the average speed to calculate average fuel economy in gallons per mile for trucks and automobiles separately (Schrank et al., 2011).

$$Automobile\ Fuel\ Economy = 0.0066 \times (speed)^2 + 0.823 \times (speed) + 6.1577$$

$$Truck\ Fuel\ Economy = 1.4898 \times \ln(speed) - 0.2554$$

We then calculated the miles driven under each scenario by multiplying the VMT for automobiles and trucks (using the commercial mix provided by CTPS). The miles driven for automobiles and trucks were then multiplied by the cost of fuel for each vehicle type, assuming that automobiles are fueled exclusively by gasoline and trucks are fueled exclusively by diesel, and using the TTI Report's estimates for Massachusetts 2010 average gasoline cost of $2.86 / gallon and an average diesel cost of $3.16 / gallon (2012 dollars). Note that any future increases in fuel costs would result in even greater overall cost of fuel used.

Air Pollution

Under the two scenarios, vehicle miles driven will increase and, accordingly, so will air pollution. Increased congestion will lead to more cars idling in traffic, which will drive up air pollution levels further. An extensive body of epidemiological evidence links air pollution to mortality and hospitalizations due to asthma, chronic lung disease, heart attacks, ischemic heart disease, and major cardiovascular disease.

We developed estimates of health impacts due to vehicular air emissions for the two proposed scenarios. Estimates of the public health impacts due to vehicular air emissions were developed using a risk assessment approach and air quality model used by the U.S. Environmental Protection Agency (EPA) and peer-reviewed research papers.

Impacts

SCENARIO 1:

- 0.18 additional deaths, 0.17 additional hospitalizations due to asthma, chronic lung disease, heart attacks, ischemic heart disease, and major cardiovascular events per year due to air pollution exposure
- $1.5 million in medical costs and externalities per year due to air pollution exposure

SCENARIO 2:

- 0.26 additional deaths, 0.24 additional hospitalizations due to asthma, chronic lung disease, heart attacks, ischemic heart disease, and major cardiovascular events per year due to air pollution exposure
- $2.1 million in medical costs and externalities per year due to air pollution exposure

Source Data

CTPS estimates of regional transportation patterns under the baseline and reduced service scenarios form the basis of this air quality analysis. CTPS used these estimates as inputs for MOBILE6.2, a vehicle emissions modeling software formerly used by the U.S. Environmental Protection Agency (EPA) to develop State Implementation Plans under the Clean Air Act, and other purposes (U.S. Environmental Protection Agency, 2011). CTPS's MOBILE6.2 outputs provided estimates for emissions of Particulate Matter smaller than 2.5 microns in aerodynamic diameter ($PM_{2.5}$), PM_{10}, VOCs and NO_x; however, SO_2 was not included because it is not a requirement for air quality conformity. Additional pollutants, such as ultrafine particles, are not included as an output from MOBILE6.2.

We used population data from the U.S. 2010 Census (U.S. Census Bureau 2012), data on hospitalization rates for asthma, chronic obstructive pulmonary disease (COPD), myocardial infarction (MI), and cardiovascular disease (CVD) from MassCHIP (Massachusetts Health and Human Services, 2012), and data on mortality rates from the U.S. Centers for Disease Control (CDC) Wide-ranging Online Database for Epidemiologic Research (WONDER) database (U.S. CDC 2012). All data was obtained at the county level, meaning each county had its own population estimate and rate of disease and mortality.

Pollutant concentrations were estimated by county using a Source-Receptor Matrix developed by the U.S. EPA to perform regulatory impact analyses for controls on vehicular emissions (U.S. EPA, 1999). The Source-Receptor Matrix has also been used in other studies examining the impacts of vehicular emissions, including one examining spatial patterns (Greco et al., 2007), and another estimating the public health impacts, time wasted, and fuel wasted due to traffic congestion (Levy et al., 2010). The Source-Receptor Matrix gives coefficients describing the effect that an emission of primary $PM_{2.5}$, NO_x, or SO_2 has on concentrations of $PM_{2.5}$ in the county where the pollutant was emitted (the source county) and every other county in the Lower 48 United States (the receptor counties). The chemicals NO_x and SO_2 undergo chemical processes in the atmosphere and convert to what is called secondary $PM_{2.5}$. The Source-Receptor Matrix was developed using annual average values for meteorological and chemical parameters in the Climatological Regional Dispersion Model, which uses a simplified model for atmospheric chemistry and transport of pollutants. These results are then calibrated to observed monitoring data for $PM_{2.5}$.

Calculation and Valuation of Impacts to Public Health

Using the Source-Receptor Matrix, we calculated the impact that emissions from vehicular travel in the affected county would have on air quality in the areas affected by the proposed MBTA changes, the rest of Massachusetts, neighboring states, and the rest of the U.S. The public health impacts due to these air quality changes were calculated using epidemiological research associating a subset of health endpoints with increases in air pollution levels that are used in the U.S. EPA Environmental Benefits Mapping and Analysis Program (BenMAP) (Abt Associates Inc., 2010) – mortality (Roman et al., 2008; Schwartz, Coull, Laden, & Ryan, 2008), hospitalizations for asthma (Health Effects Institute, 2003), cardiovascular disease (CVD) (Moolgavkar, 2000a), myocardial infarction (MI) (Peters, Dockery, Muller, & Mittleman, 2001), chronic obstructive pulmonary disease (COPD) (Moolgavkar, 2000b), and ischemic heart disease (IHD) (Health Effects Institute, 2003). This body of epidemiological research gives the relationship between air pollution levels and the health outcomes in terms of increases in relative risk of the health outcome. Therefore, the health impact attributable to air pollution can be calculated with the population count in each county, the baseline risk of these health outcomes, the change in air quality, and the relationship between air quality and an increase in the risk of these health endpoints.

$$\begin{aligned}&\text{Health Endpoint} = \text{Change in Air Quality} \times \text{Baseline Rate}\\&\times \text{Relationship Between } \mathrm{PM}_{2.5} \text{ and Health Endpoint} \times \text{Population}\end{aligned}$$

These health endpoints were then monetized. The value of statistical life (VSL) of $8.32 million in 2012 USD was used to monetize mortality endpoints (Dockins, Maguire, Simon, & Sullivan, 2004), as is used in U.S. EPA regulatory impact analyses (U.S. Environmental Protection Agency, 1999; US EPA, 2011). The values of a hospitalization event from the U.S. EPA software BenMAP (Abt Associates Inc., 2010) were used to place a monetary value on hospitalizations. The total value to society of an individual's avoidance of a hospital admission can be thought of as having two components: (1) the cost of illness (COI) to society, which includes the total medical costs plus the value of the lost productivity, as well as (2) the willingness to pay (WTP) of the individual, as well as that of others, to avoid the pain and suffering resulting from the illness. However, BenMAP does not contain estimates of social WTP to avoid hospital admissions, and therefore estimates of total COI are conservative (lower bound) estimates. These COI functions do not include the cost of pain and suffering in the estimate of monetized value.

It should be noted that final estimates do not include the effects of exposure to other pollutants that will rise under both Scenarios, including SO_2, CO, ozone, and ultrafine particles. We relied upon air pollution estimates from CTPS that use the EPA's MOBILE6.2 model, which does not incorporate additional emissions that would occur due to stop and go traffic.

Additionally, we were not able to calculate effects of air pollution on stroke, premature birth, infant mortality, and childhood asthma. These factors would contribute additional mortality and hospitalizations not calculated here. Furthermore, highway congestion and air quality metrics show a greater negative impact on lower income and minority communities, further exacerbating the disproportionate health burden that these communities face. These aggregated numbers do not demonstrate the distribution of risk among different populations. Finally, our estimates also do not include increased exposures for commuters, who will be spending more time in traffic in close proximity to elevated concentrations.

Physical activity

In the counties served by the MBTA, approximately 19% of adults are obese and 16% report no daily physical activity (MAPC Analysis of MDPH Behavioral Risk Factor Surveillance System Data). Commuting patterns play an important role in influencing daily physical activity. Although Americans only walk an average of about 6 minutes daily, public transit users spend a median of 19 daily minutes walking (Besser and Dannenberg, 2005). Estimates show that an individual walks an additional 8.3 minutes per day when they switch from driving to transit (Edwards et al. 2007).

Impacts

SCENARIO 1:

- 30,400 people shift from transit to driving
- 250,000 fewer minutes of walking per day
- 8.2 million fewer calories burned per day
- 70 new cases of obesity per year
- 9 additional deaths per year due to decreased physical activity
- $75 million in lives lost per year due to decreased physical activity

SCENARIO 2:

- 48,600 people shift from transit to driving
- 403,000 fewer minutes of walking per day
- 13.1 million fewer calories burned per day
- 120 new cases of obesity per year
- 14 additional deaths per year due to decreased physical activity
- $116 million in lives lost per year due to decreased physical activity

Source data

Physical activity, calories expended, and obesity risk estimates come from Edwards et al. 2007 analysis of National Household Travel Survey data. This paper modeled the change in physical activity associated with a shift from driving to transit and the subsequent changes in obesity risk based on walking. It provides a range of estimates for changes in physical activity, calories expended, obesity risk, and medical costs associated with a transportation mode shift. We chose conservative and simplified estimates taking mid-range values from this peer-reviewed analysis of nationally-representative data.

In order to calculate the mortality and economic impact associated with decreased walking, we used the web-based Health Economic Assessment Tool (HEAT) from the World Health Organization (WHO). HEAT was developed by the WHO with the guidance of an advisory group of international experts in heath, epidemiology, health economics, transport economics, practice/advocacy, and policy development and implementation.

Based on systematic reviews of the economic literature, this tool allows us to estimate the economic costs resulting from increases in mortality as a consequence of decreases in regular walking. For inputs into HEAT, we used the change in walking per day when switching modes predicted from Edwards 2007 (decrease of 8.3 minutes per person who switches to driving), the mode shift estimates under the scenarios from CTPS, the 2010 Massachusetts total mortality rate from MassCHIP (702.9 deaths per 100,000), and the 2012 value of a statistical life from Dockins et al. 2004 ($8.32 million).

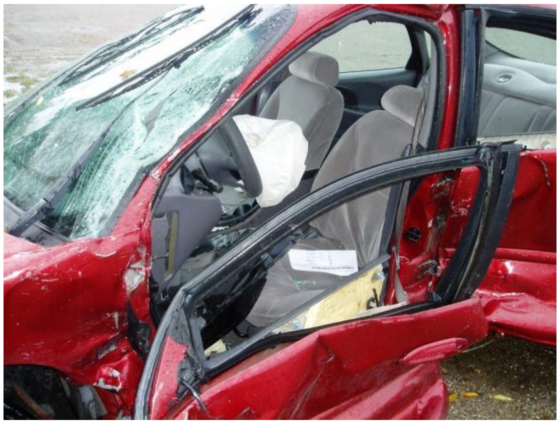
Calculations for changes in physical activity, calories expended, & obesity risk

Based on Edwards' (2007) estimate that transit use results in a gain of 8.3 additional minutes of daily walking per day, and that introducing this amount of daily walking can prevent 0.25% of that population from becoming obese despite upward national trends in obesity prevalence, we multiply the number of people shifting from transit to driving by 0.0025 to estimate new cases of obesity predicted per year by removing 8.3 minutes of daily physical activity.

Calculations for mortality from decreased physical activity

We used HEAT from WHO to calculate mortality estimates based on decreased physical activity. We simulated an intervention where walking behavior was measured before and after the intervention. In this case, the intervention was the different MBTA scenarios and our population was those estimated to shift from transit to driving. The intervention was estimated to decrease walking by an average of 8 minutes per weekday (according to Edwards et al. 2007), or an average of 40 minutes per week per person. This analysis assumed that those shifting modes from transit to driving would not replace the physical activity lost through other activities. We took a conservative estimate that those commuting by transit were already getting 30 minutes of walking per day, or 150 minutes per week. Next, we simulated an intervention in which all those who shift modes would decrease their walking from 150 to 110 minutes per week, based on 8 minutes per weekday or 40 minutes per week. We then input baseline rates for mortality from MassCHIP data and the HEAT used dose-response functions to estimate the increase in mortality due to the decreased walking in this population. A meta-analysis of epidemiologic literature on walking and mortality estimates that those who walk regularly have a lower risk of overall mortality by over 20% compared to those who are physically inactive. We then multiplied these mortality estimates by the value of a statistical life to obtain the costs of mortality due to decreased physical activity.

Crashes



Decreasing mass transit service and utilization can result in an increase in traffic-related injury by shifting a portion of daily trips from a safer mode of travel (e.g., bus or train) to a more dangerous mode (e.g., automobile travel). According to national transportation and injury statistics, the risk of fatal injury per person-trip by bus in the U.S. is 23 times less than by car (0.4 versus 9.2 fatalities per 100 million person-trips) and the risk of non-fatal injury is five times less for bus trips compared to automobile trips (161 versus 803 per 100 million person-trips) (Beck, Dellinger & O'Neill, 2007).

Impacts

SCENARIO 1:

- 0.79 new deaths due to crashes per year
- $33.6 million in increased costs due to comprehensive costs for crashes per year

SCENARIO 2:

- 1.15 new deaths due to crashes per year
- $48.8 million in increased costs due to comprehensive costs for crashes per year

Source data

Data on VMT was taken from CTPS models on traffic outlined above. Traffic fatality rates per VMT were taken from 2009 National Highway Traffic Safety Administration estimates for the state of Massachusetts. To estimate the costs of congestion and crashes, we used data from *Crashes vs. Congestion – What's the Cost to Society?* This report was prepared for the American Automobile Association (AAA) by Cambridge Systematics, Inc. The AAA study compares the costs of crashes to the costs of congestion by calculating a per person cost for crashes and multiplying by the population figures in the same 85 urban areas used by the Texas Transportation Institute (TTI) in the annual *Urban Mobility Report*. The costs of crashes are based on the Federal Highway Administration's (FHWA) comprehensive costs for traffic fatalities and injuries which place a dollar value on 11 components.

The 11 comprehensive cost components include property damage; lost earnings; lost household production (non-market activities occurring in the home); medical costs; emergency services; travel delay; vocational rehabilitation; workplace costs; administrative; legal; and pain and lost quality of life. The AAA study provides a value of $0.26 per vehicle mile traveled in 2012 dollars for very large metropolitan areas. This is the most conservative value offered by the report and is most relevant for the metropolitan Boston area.

Calculations of costs of crashes

We estimated expected traffic fatalities by multiplying projected increases in VMT under the two proposed scenarios by the fatality rate per VMT for Massachusetts from the National Highway Traffic Safety Administration (0.61 fatalities per 100 million VMT, 2009 (most recent data available)). We converted expected daily deaths to annual deaths by multiplying our results by the CTPS annualization factor of 300 to estimate annual fatalities.

To calculate the costs of congestion, we used an estimate of $0.26 per vehicle mile traveled from the AAA study. We then took the CTPS projections regarding VMT per day under each scenario and multiplied the costs per mile by the VMT. We multiplied these numbers by the CTPS annualization factor of 300 to estimate the increases in total yearly costs due to crashes under the scenarios.

Access to healthcare

Access to transportation is an important requirement for access to healthcare. Individuals who cannot easily reach healthcare facilities visit their doctor less frequently for regular checkups, as well as for serious illness, affecting health outcomes and health care costs. For carless households, MBTA service is especially important to reaching preventative and other essential health care resources in a way that is affordable and reliable. This analysis sought to quantify how many carless households live in neighborhoods that are both facing MBTA service losses and have no essential healthcare resources within walking distance. In other words, we counted how many carless households can currently access health care via the T but would no longer have access to health care via walking or transit under the scenarios.

Impacts

SCENARIO 1:

- 550 transit-dependent households would be isolated from basic health care resources

SCENARIO 2:

- 2,200 transit-dependent households would be isolated from basic health care resources

Data sources

To calculate access to healthcare, we used the *infoUSA* data from ArcGIS, Census 2010 data, and the 2010 American Community Survey.

Estimation of decrease in access to healthcare

The maintained and eliminated MBTA service routes for the two scenarios and baseline were mapped using Geographic Information Systems (GIS). Using a half-mile as walking distance, which is the commonly accepted upper bound of what Americans are willing to walk to reach destinations, we created a buffer around the eliminated routes in ArcGIS, defining this area as affected by potential service losses. We then geocoded the locations of basic health care facilities, as defined by the essential health benefits outlined in the Affordable Care Act. We used infoUSA records, limited to Standard Industry Classification Codes 801, 802, 803, 804, 805, 806, 807, and 809 as basic health care facilities. We drew a half-mile walking buffer around the maintained service routes and around the health care locations, defining these regions as maintaining health care access. Using these two buffers, we identified census blocks that meet two criteria: 1) the block currently has access to public transit, and therefore to all health care facilities accessible via T, but no health care within walking distance; 2) under the proposed cuts, that block would have no MBTA service.

We obtained household counts for these affected neighborhoods and then used tract-level American Community Survey data 2006-2010 to estimate what proportion of the affected population was likely to be carless in each neighborhood. Finally, we applied neighborhood-level car access rates to each affected block's population.

Carbon Emissions

Both scenarios are estimated to increase carbon dioxide emissions due to greater personal automobile use, congestion, and wasted fuel, contributing to global climate change.

Impacts

SCENARIO 1:

- Over 58,000 additional metric tons of CO_2 emitted per year
- Social cost of carbon estimated at $1.9 million dollars 2012 USD per year

SCENARIO 2:

- Over 52,000 additional metric tons of CO_2 emitted per year
- Social cost of carbon estimated at $1.7 million dollars 2012 USD per year

Source Data

Carbon dioxide emissions were estimated from CTPS emissions models. To estimate the cost of carbon, we used the National Academy of Sciences (NAS) social cost of carbon estimates from the *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*. The social cost of carbon is the present day value of the combined damages and benefits that will occur over many future years if an additional ton of greenhouse gas is emitted today. Estimating the discounted cost involves consideration of current greenhouse gas emissions' effects on climate over the next century or more, environmental and human welfare effects caused by climate change, how the effects may vary globally, the course of future economic development, the range and likelihood of economic and social effects arising from climate change, and the extent to which human society might adapt to climate change.

The cost is estimated as the net present value of the impact over the next 100 years (or longer) of 1 additional ton of CO_2 emitted into the atmosphere. This marginal damage per ton of emissions is normally used as a measure of the global climate externality. The measure requires assumptions about the emissions-temperature relationship and temperature damages over time, as well as the rate at which future damages are discounted back to the present to account for differing valuation of monetary impacts felt at different points in time. Finally, uncertainties at each step of the analysis imply that different possible future conditions may yield widely differing impacts. The expected value of damages may be more sensitive to the possibility of low-probability catastrophic events than to the most likely or best-estimate values.

The NAS reviewed the literature on social cost of carbon estimates, and found a range of estimates from $1 per ton to $100 per ton of CO_2 based on different discounting rates. We chose the mean estimate of $30 per ton in 2010 USD, which is $31.18 2012 USD.

Estimation of Cost of Carbon Emissions

We took the NAS midrange estimate of the social cost of carbon and multiplied it by the annual increased carbon emissions from the CTPS transportation models to estimate an impact.

Noise

Automobile travel creates noise from engine operations, pavement-wheel contact, and wind noise. As a result, increased vehicle travel is likely to cause increased noise disturbances to communities. Because noise diminishes with distance from its source, the most serious transportation noise problems are experienced along major transportation corridors. In Massachusetts, approximately 16% of the population lives within 100 meters of a major roadway. Exposure to excessive noise levels can induce hearing loss and negatively impact mental and cardiovascular health. This analysis focused on the number of individuals exposed to noise levels greater than 60 decibels (dBA) at baseline and after the two alternative scenarios because transportation noise levels above 60 dBA have been associated with high-blood pressure, hypertension, and ischemic heart disease (Babisch, 2006).

Impacts

SCENARIO 1:

- 500 additional people will be exposed to more than 60 dB of noise on average per day

SCENARIO 2:

- 2,000 additional people will be exposed to more than 60 dB of noise on average per day

Source Data

We used outputs from the look-up tables from FHWA's Transportation Noise Model (TNM) (Table 1. No Barrier for 1000 automobiles; Hard ground) to associate vehicle volume and speed with noise levels in each TAZ, linearly interpolating between reported values in the look-up tables.

Estimations of Increases in Noise Exposure

We estimated average traffic volume per TAZ by dividing VMT by road length in the TAZ and then applied the TNM to that estimated volume. This analysis assumed basic no-barrier road configurations and characterized noise impacts occurring 100 meters from roads in order to produce a conservative lower bound of noise impacts occurring within 100 meters from roads. We assumed that all vehicles were cars to obtain conservative estimates. We obtained speed by dividing VMT by VHT under each scenario. We then looked up noise in Table 1 of the TNM with an assumed distance of 100 meters and the speed per TAZ. We then used an algorithm in the TNM to estimate noise as a function of traffic volume given TNM outputs for 1000 automobiles and used the algorithm to convert to average decibels. We assumed that each TAZ housed 16% of its population within 100 meters of a major road, reflecting the proportion of the statewide population living within 100 meters of a major road.

Conclusions

This analysis shows that even modest fare increases and service cuts to the MBTA system will result in costs that far exceed the budget shortfall that the proposed changes seek to address. Costs will take the form of:

- lost time as more residents sit in traffic;
- health care costs associated with worse air quality, fewer residents using a mode of transportation that promotes physical activity while more shift to sedentary driving, and additional accidents as more cars are on the road for more time;
- isolation from basic health care resources for hundreds of carless households;
- more residents suffering exposure to high noise levels; and
- additional greenhouse gas emissions.

This is a rapid HIA. While there are clearly uncertainties associated with any HIA, we made some simplified assumptions given the data available and need for a timely analysis in an attempt to make conservative (i.e., lower-bound) estimates where possible. While these impacts are not easy to estimate, the costs are certain to run into the hundreds of millions per year, and the health effects of the proposed changes are even likely to result in preventable deaths. In sum, implementing either MBTA service cut and fare increase proposal would be damaging to the region and its residents' health.

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Introduction

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