METROPOLITAN AREA PLANNING COUNCIL

Smart Growth & Regional Collaboration

HEALTH IMPACT ASSESSMENT • SPEED LIMIT BILL

POSITIVE IMPACTS

2,200 CRASHES

18 FATALITIES

1,200 INJURIES

PREVENTED ANNUALLY IN THE COMMONWEALTH

SAVINGS PER YEAR FOR MEDICAL PAYMENTS AND MISSED WORK:

$30 MILLION FROM PREVENTED FATALITIES

$180 MILLION FROM PREVENTED INJURIES

TOTAL ANNUAL SAVINGS **$210** MILLION

NEGATIVE IMPACTS

$127 MILLION PER YEAR COST FOR TIME SPENT IN TRAFFIC

$21 MILLION COST OF ADDITIONAL FUEL BURNED ACROSS THE COMMONWEALTH

AIR POLLUTION-RELATED HEALTH COSTS APPROX. **$500**

ESTIMATED YEARLY NUMBER OF DEATHS AND HOSPITALIZATIONS DUE TO WORSENED AIR QUALITY IS CLOSE TO ZERO

TOTAL ANNUAL COSTS **$148** MILLION

Executive Summary

The Massachusetts Legislature will be considering a bill that would lower the default speed limit on local roads from 30 miles per hour (mph) to 25 mph. The bill would apply only to "functionally classified local roads," as designated by the Massachusetts Department of Transportation (MassDOT). It excludes main arteries and the streets that feed them.

Lower speed limits are demonstrably safer for pedestrians, cyclists, and children. Therefore, the Speed Limit Bill could have far-reaching and important public health impacts. The Metropolitan Area Planning Council (MAPC), in partnership with Massachusetts Department of Health (DPH), conducted a Health Impact Assessment that examines potential health impacts of the proposed bill.

Collisions, Fatalities, and Injuries Prevented

Evidence has consistently shown that reducing traffic speeds decreases the frequency and severity of crashes. Small reductions in speeds produce large increases in collision survival rates, especially for cyclists and pedestrians struck by motor vehicles. Statistical models estimate that the Speed Limit Bill would **prevent roughly 2,200 crashes, 18 fatalities, and 1,200 injuries across the Commonwealth each year.**

Savings due to Fatalities and Injuries Prevented

Preventing fatalities and injuries would save $210 million per year in costs to society due to medical payments and missed work. Of this total savings, **prevented fatalities would account for $30 million per year, and prevented injuries $180 million per year in savings.** These savings would affect those involved in collisions and their families, as well as employers, property owners, and taxpayers across the state.

Time Spent and Fuel Burned in Traffic

While the Speed Limit Bill is expected to reduce crashes and prevent injuries and fatalities, it would prompt drivers to reduce cut-through traffic by seeking faster, though often longer, routes on higher capacity roads, resulting in an additional 55.3 million vehicle miles travelled per year. At the same time, slower travel speeds on local roads and higher traffic volumes on newly preferred, higher capacity roads would result in 5.8 million additional vehicle hours traveled per year. The resulting increases in **time spent in traffic would cost approximately $127 million per year, while additional fuel burned in traffic would cost $21 million per year across the Commonwealth.**

Impact on Residential Property Values

A small body of literature indicates that lower traffic speeds are associated with higher adjacent residential property values. However, the literature is not strong enough to reliably predict how the Speed Limit Bill would impact the value of homes on local roads.

Air Pollution

Traffic congestion induced by the Speed Limit Bill would increase the amount of time vehicles spend on the road. Because speed affects the ways in which vehicles burn fuel, slower average traffic speeds would also change the composition of vehicle emissions. Due to these factors, air pollution emissions are expected to rise slightly as a result of the bill. While air pollution can increase mortality rates and hospitalizations due to asthma, chronic lung disease, heart attacks, ischemic heart disease, and major cardiovascular disease, air pollution increases would be very small, and therefore the air pollution-related health effects of the bill would be quite modest. **Air pollution-related health costs would be approximately $500 per year for the state. The estimated annual number of deaths and hospitalizations due to worsened air quality is extremely close to zero**, with statistical models estimating that health effects would be negligible.[1]

Pedestrian and Bicyclist Perceptions of Safety

Roads that feel safe may encourage more walking and biking. Lowering speeds is a step towards making pedestrians and cyclists feel safer on roads and sidewalks, which in turn would create more opportunities for physical activity through walking and biking. However, it was not possible to calculate a quantitative estimate of the bill's potential perceived safety impacts.

Parental Safety Perceptions and Children's Levels of Physical Activity

Research suggests that reducing speeds on local roads would increase parents' willingness to allow children to walk and ride bicycles, leading to increases in physical activity levels among children. However, it was not possible to calculate a quantitative estimate of the bill's potential perceived parental safety or children's physical activity impacts.

Conclusions

The Speed Limit Bill proposes to lower speed limits statewide as a strategy to reduce crashes and make the roads safer for all users. Based on a literature review, case studies, and statistical models, this HIA predicts that the bill would have a positive public health impact, particularly by preventing traffic fatalities and injuries. Potential co-benefits include enhanced walking and biking environments that may encourage physical activity, as well as increased desirability of properties on local roads due to quieter and safer streets. The HIA also concludes that the bill is economical. Although slower speeds and additional congestion may cost the Commonwealth money in extra time spent, fuel burned, and air pollution emitted, these costs are overwhelmed by financial savings generated by preventing injuries and road fatalities.

Because road design features and enforcement also help to determine traffic speeds, municipalities should implement traffic calming interventions and educational and enforcement campaigns to maximize the safety benefits of the bill. Improving bicycle and pedestrian facilities in concert with a speed limit reduction would likely be more effective in fostering walking and biking than would a speed limit reduction alone.

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[1] Air pollution induced by the bill is projected to cause 0.000057 new deaths per year and 0.000103 new hospitalizations per year across Massachusetts.

Document Guide

This document is divided into three Parts. Part I provides background on the Speed Limit Bill, reviews the concept of Health Impact Assessments, and discusses our stakeholder engagement process. Part II examines the pathways to health that might be impacted by the Speed Limit Bill, explaining our methodology and describing the expected changes in health outcomes due to the bill. Part III summarizes the conclusions from Part II and provides recommendations based on these conclusions.

Part I

1.1 Background

The Massachusetts State Legislature is considering a bill that would lower the default speed limit on "functionally classified local roads" from 30 mph to 25 mph. The bill would not affect roads with regulatory speed limits. If a speed study was conducted that changed the speed limit on a local road from the default, this bill would not affect the road.

The U.S. Department of Transportation's Federal Highway Administration uses functional classifications to group streets and highways into 'classes' according to the character of service they are intended to provide. Roads have two main purposes: mobility and access. Functional classification defines the role a road or street should play in serving mobility or access (Federal Highway Administration 2000). There are three highway functional classifications (Figure 1): arterial, which provides mobility at the greatest speed for the longest uninterrupted distance; collector, which provides service at a lower speed for shorter distances by collecting traffic from local roads and connecting them with arterials; and local, which primarily provides access to land with little or no mobility (Federal Highway Administration 2000).

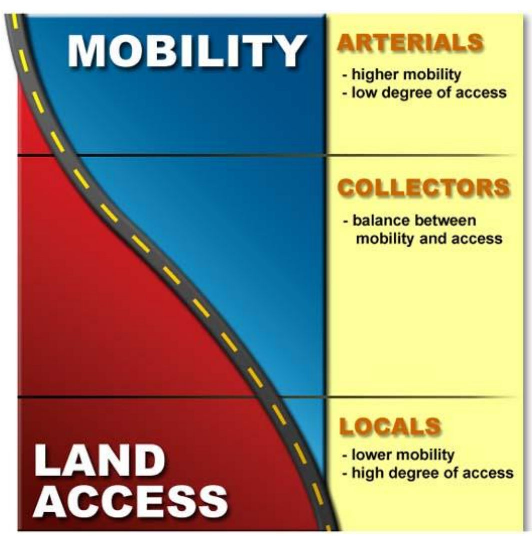


Figure 1: Diagram of Highway Functional Classifications (Transportation & Public Facilities, State of Alaska 2011)

The aim of the legislation is to reduce vehicle speeds on local roads to a level that is safer for pedestrians, cyclists, and children. The legislation also allows for municipalities to officially lower speed limits on their roads, which is currently a difficulty for many cities and towns in Massachusetts.

The passage of the proposed legislation could have far-reaching and potentially important public health impacts. For example, lower default speed limits have the potential to:

- affect the number of fatalities and serious injuries to motorists, cyclists and pedestrians;
- promote active transportation by making local roads feel more hospitable to cyclists and pedestrians; and
- change the concentration and composition of both near-roadway and regional pollutants, thereby potentially affecting cardiovascular and respiratory health across the Commonwealth.

The Metropolitan Area Planning Council (MAPC) in partnership with Massachusetts Department of Health (DPH) conducted a Health Impact Assessment (HIA) that examines the proposed Speed Limit Bill.

Decision-makers and Decision-Making Process

Representative Denise Provost of Somerville, along with ten cosponsors, filed House Bill 1808 at the beginning of the 2011-2012 legislative session. Working with state agencies, regional planning agencies, and advocacy organizations, Representative Provost suggested amended language that was adopted during the Joint Committee on Transportation's review process, and the amended bill became House Bill 4165. The legislation was ordered to a Third Reading and made it to the House Calendar. This is the bill's second session, and it often takes several sessions for a bill to become law. Representative Provost plans to file the bill again in the 2013-2014 legislative session. An analysis of the potential health impact of the proposed legislation would help legislators and their constituents develop more comprehensive and informed positions on this issue.

Health Impact Assessment

The Metropolitan Area Planning Council (MAPC) conducted a Health Impact Assessment (HIA) on the potential health impacts of the proposed bill in coordination with the Massachusetts Department of Public Health, Central Transportation Planning Staff (CTPS), and stakeholders in the Commonwealth of Massachusetts. HIAs aim to describe the potential health effects of plans, policies, or programs under consideration (Committee on Health Impact Assessment; National Research Council 2011).

To assess how changes to speed limits on functionally classified local roads might impact health, MAPC:

- Reviewed transportation-related literature to estimate how lowering speed limits would affect traffic speeds across the state;

- Worked with CTPS to build statewide models that estimated the impact of new traffic speeds on vehicle miles traveled, vehicle hours traveled, and air quality in the region; and
- Applied findings from peer-reviewed public health literature to the results of the CTPS transportation models to predict likely health outcomes, in consultation with local experts in the fields of transportation safety, environmental health, and active transportation.

It should be noted that because this project was selected for an HIA in spring of 2012, the short time frame did not allow for an extensive review and modeling of health impacts. Therefore, the assessment presented in this report is from a "rapid" HIA.

HIA Process

The standard steps of an HIA include screening, scoping, assessments, recommendations, reporting, and monitoring.

Screening

Screening determines whether or not there is a potential for significant health impacts of a policy, project, or project. The screening process for this HIA took place in spring 2012 and involved a selection process at Massachusetts Department of Public Health (DPH). The Speed Limit Reduction HIA was one of three policy/projects chosen to be completed in the summer of 2012.

Scoping

The objective of scoping is to create a plan and timeline for conducting an HIA that identifies priority issues, research questions, methods, and participant roles. This HIA scoping process was initiated in June 2012 and included HIA training by Human Impact Partners. This training educated community stakeholders about the process and steps of HIA, discussed a variety of roles for stakeholders to play in the process, and described how HIA can be effectively used with the proposed Speed Limit Bill. Priority issues and research questions emerged as part of the training process.

Assessment and Recommendations

Assessment provides a profile of existing conditions and evaluates the potential health impacts of the proposed Speed Limit Bill. Assessments (Part II) are followed by evidence-based recommendations (Part III) to mitigate negative and maximize positive health impacts of the project.

Reporting

Reporting communicates the findings and recommendations gleaned during the HIA process to stakeholders and decision makers. The report considers the nature and magnitude of the health impacts and their effect on the population. It summarizes the key health impact issues, and is followed by recommendations to improve heath determinants and outcomes.

Monitoring

Once HIA findings are disseminated in a report, the monitoring phase begins. The objective of monitoring is to review the effectiveness of the HIA process and evaluate the actual health outcomes as a result of the project.

Stakeholder Engagement

Stakeholder engagement ensures that an HIA is a comprehensive and transparent tool. MAPC and DPH engaged stakeholders through an HIA training in June 2012. The goal of this training was to gather cross-sector stakeholders, introduce the goals and steps of HIA, and provide an overview of the Speed Limit Reduction HIA specifically. Eight stakeholders attended the HIA training in Boston, including Massachusetts State Representatives, bicycle and pedestrian organizations, representatives from the City of Boston, and transportation and air pollution specialists. To follow up with stakeholders after the training, we distributed a draft scope for the HIA for comment, including a diagram that outlined pathways between the Speed Limit Bill and health. Stakeholders also reviewed draft recommendations and provided comments later in the process.

In addition to the cross-sector stakeholder engagement conducted as part of the HIA training, MAPC leveraged its status as one of the thirteen regional planning agencies (RPAs) in Massachusetts to incorporate additional perspectives in the scoping process. We presented our draft scope and methodology to the executive directors of the thirteen RPAs at a monthly Massachusetts Association of Regional Planning Agencies (MARPA) meeting. Our goal was twofold: to make the executive directors representing the other regions of the state aware of the project and allow them an opportunity to provide feedback, and to ask for their support of our asking each RPA's transportation planners to vet a transportation modeling methodology to estimate the impact of the Speed Limit Bill on traffic patterns across the state (See Traffic Modeling). With support from all 13 RPA directors, we solicited and incorporated feedback on our modeling approach from transportation planners across the state. The stakeholder engagement strategy for this rapid HIA focused largely on decision makers, transportation experts, and advocacy groups.

Part II

In Part II, we discuss the specific causal pathways linking speed limit reduction and health identified by stakeholders as most important. Each pathway represents a potential route through which the Speed Limit Bill could affect health, including changes in air pollution, risk of collision, perceived traffic safety, and more. We describe how the bill relates to health via each of these pathways; explain our methodology for estimating the effect of the bill on each intermediate outcome; profile relevant existing conditions; present results of our evaluation; and summarize our interpretation of the overall impact of the bill via each pathway.

Traffic Modeling

To assess the potential health impacts of the bill, we first had to understand the effects of the bill on transportation patterns. MAPC subcontracted with the Central Transportation Planning Staff (CTPS), a multimodal transportation planning and analysis agency for Eastern Massachusetts, to model the statewide transportation impact of reducing speed limits on functionally classified local roads from 30 mph to 25 mph. This model predicted how changes in speed limits would likely affect average traffic speeds, mode shares (i.e., the percentage of trips taken by car, transit, and other modes), vehicle miles traveled, vehicle hours traveled, and air pollution emissions.

We assumed that the new speed limit would slow traffic, but not by the full 5 mph proposed by the bill (i.e., there would not be full compliance with the reduced speed limit). Based on data from multiple traffic studies, Elvik (2012) found a non-linear relationship between changes in speed limits and subsequent changes in average traffic speeds. Specifically, Elvik's analysis predicts that a 5 mph decrease in the speed limit would translate to roughly a 1.8 mph decrease in average traffic speeds under free flow conditions where the speed limit, rather than congestion, determines vehicle speeds.

CTPS then modeled the impact of a 1.8 mph decrease on local roads under free flow conditions on 24 hour averages, which incorporated congestion. The CTPS model revealed that there would be a 0.67 mph decrease in 24 hour average speeds, accounting for congested periods, during which the speed limit is irrelevant.

Outputs from traffic modeling helped us predict likely health outcomes associated with the proposed bill. Like all models, the CTPS traffic model must make assumptions, interpolate, and extrapolate data. We sent a draft model for review by the 13 RPAs' transportation planners and received feedback that we incorporated into the final model. For details about model assumptions, see Technical Appendix A.

Pathways Linking Speed Limits and Health

The proposed bill could influence human health through multiple environmental, behavioral, and economic pathways, as shown in Figure 2. While data constraints prevented a complete quantitative analysis of impacts that would occur under all pathways, we were able to quantify effects associated with the following pathways linking speed limits to health:

- **Collisions, injuries, and fatalities**
- **Fuel burned and time spent in traffic**
- **Health effects of air pollution**

While we could not quantify expected impacts, we estimated the likely direction and magnitude of effects of the bill on the following:

- Perceived pedestrian and bicycle safety and physical activity
- Property values

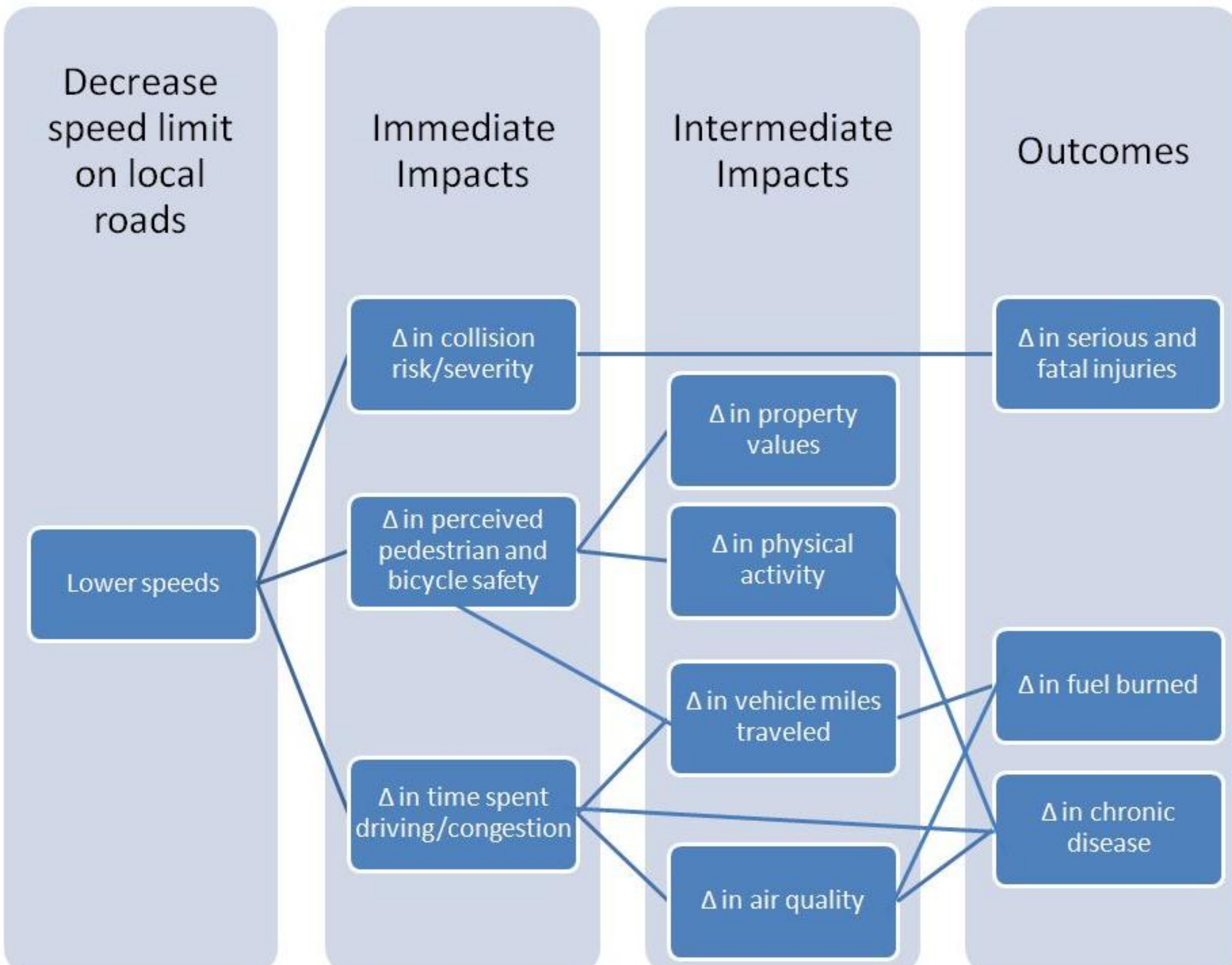


Figure 2: Speed Limits and Health Causal Pathway Diagram

Collisions, Fatalities, and Injuries

Background

Motor vehicle crashes are the top cause of death among people ages 5 to 34 in the United States, and a leading cause of injury among all age groups (Centers for Disease Control and Prevention 2011). Decreasing traffic speeds increases the amount of time drivers have to react to road hazards, potentially averting collisions, and makes crashes that do happen less severe (Rune Elvik 2012). Consistent evidence over the past century has confirmed that lowering traffic speeds decreases the frequency of crashes, as well as rates of fatalities and injuries due to vehicle collisions. This holds true on urban and residential roads (Lindenmann 2005; Kloeden, Woolley, and McLean 2007). This impacts both individuals traveling in vehicles, as well as pedestrians and cyclists who often share roadways with vehicles. Therefore, there is great potential for the Speed Limit Bill to decrease motor vehicle collisions and subsequent fatalities and injuries associated with these crashes.

Methods for Assessment

In order to estimate the effect of lowering the speed limits on functionally classified local roads from 30 mph to 25 mph, we reviewed health and transportation literature on speed limits and traffic behavior, as well as on traffic speeds and health. We reviewed Massachusetts data on crashes, fatalities, and injuries and used geographic information systems (GIS) to link these crashes to local roads. As outlined above, we worked with CTPS to estimate average traffic speeds and incorporated this into our analysis. All of these data combined allowed us to estimate a range of expected impacts of the Speed Limit Bill on collisions, fatalities, and injuries.

Relationship between Traffic Speed and health Outcomes

Our literature review revealed a number of methods to estimate the impact of changes in traffic speeds on health outcomes. We reviewed the available methods to find an analytic approach for this HIA that was both scientifically valid and feasible to implement, given the data available to us. After considering alternative approaches, we selected a tool known as the "Power Model" to help us in the assessment phase of this HIA. The Power Model describes the relationship between changes in average traffic speed and changes in the number of crashes and crash victims; it is named after the fact that a set of exponential, or "power," functions are behind the model's calculations. Using predicted traffic speed reductions from the statewide transportation model described above, the Power Model estimated how the number and severity of injuries and collisions would likely change if the Speed Limit Bill were passed. First developed by Swedish road safety researcher Goran Nilsson in 2004, the model is parsimonious and conservative in its predictions of how changes in speed will affect changes in safety outcomes, and has been validated in numerous follow-up studies (R. Elvik, Christensen, and Amundsen 2004; R. Elvik 2009; Rune Elvik 2012). It combines 526 data points from 115 traffic studies to estimate how much a given decrease in speed will lower the risk of various types of crashes. For example, the model uses different estimates to predict how fatal crashes versus injury-only crashes would decline as a result of lower speeds. Because this model, like all models, has its limitations, we report measures of uncertainty associated with our predictions. Readers can learn more about the Power Model in Technical Appendix B.

To estimate how the number and types of collisions would change in Massachusetts if the Speed Limit Bill were to pass, we first collected baseline information on motor vehicle crashes. We collected statewide crash data for 2006 through 2009, the most recent years for which data are available, from the Registry of Motor Vehicles (RMV) Crash Data System (CDS). The RMV Division of MassDOT obtains crash reports from local police, State Police, other police agencies, and operators (motorists) who were involved in crashes, and enters the data into CDS. Any crash involving an injury or fatality, or damage to any one vehicle or other personal property in excess of $1000 is reported, while those that are less severe, such as "fender benders" that don't result in injury or substantial damage, are left out of the system. Crashes on private roads are often, but not always, excluded. The quality of this RMV dataset depends on police agencies and the public to send crash reports in a complete and timely fashion, meaning that it is likely that the database undercounts actual collisions. It should be noted that crash statistics are usually underreported (Amoros et al. 2008; Jeffrey et al. 2009; Hu, Baker, and Baker 2011) in other settings as well, but that in Massachusetts, 2009 data is of particularly poor quality. Beginning in 2009, the RMV did not have the resources to enter many of the crashes that were reported by vehicle operators. Due to changes in RMV reporting, 2009 data will not contain many of the crashes that presumably occurred on local roads. The Highway Division of MassDOT has geocoded (where possible) the RMV crash data and makes the crash data files available upon request.

The year 2009 statewide crash data contain 111,192 crashes, compared to 120,970 crashes in 2008, 120,667 crashes in 2007, and 124,274 crashes in 2006. MAPC mapped locations of crashes across MA from 2006-2009 to identify which took place on functionally classified local roads that would be affected by the Speed Limit Bill. This established baseline rates of total crashes, fatalities, injuries, pedestrian fatalities, pedestrian injuries, cyclist fatalities, and cyclist injuries specific to local roads.

We used the Power Model to evaluate the following outcomes on local roads:

- **Total Crashes**
- **Fatal Crashes**
- **Injury Crashes**
- **Total Fatalities**
- **Total Non-Fatal Injuries**
- **Pedestrian Fatalities**
- **Pedestrian Injuries**
- **Cyclist Fatalities**
- **Cyclist Injuries**

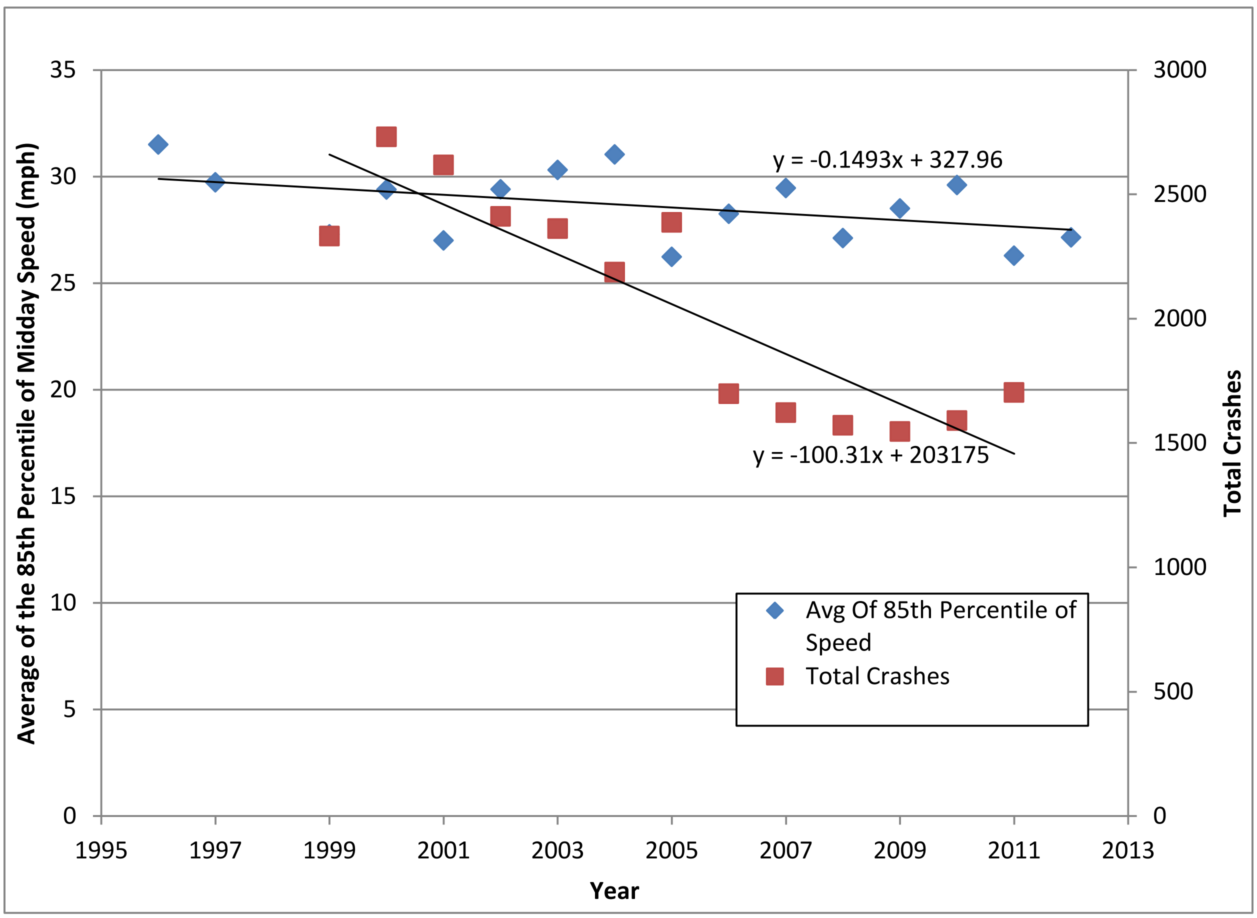
For each outcome, we explored what would happen under the following speed reduction scenarios:

- Average speed declines by 1.8 mph, the change resulting from a 5 mph speed limit reduction based on estimates by Elvik et al. (2012)
- Average speed declines by 0.67 mph, the change resulting from a 5 mph speed limit reduction based on estimates by Elvik et al. (2012) and taking into account congested traffic conditions as modeled by CTPS

LOCAL SPOTLIGHT: CAMBRIDGE

Although the relationship between traffic speeds and crashes has been established through an extensive body of literature, a recent local analysis by a traffic engineer confirms this relationship in Cambridge, Massachusetts. The traffic engineer examined data on crashes from Registry of Motor Vehicles (RMV) Crash Data System (CDS) for the entire City of Cambridge from 1996-2011 and compared the total number of crashes to the mid-day average for the 85th percentile of traffic speeds for all roads in Cambridge for the same time period. Traffic speed data came from traffic studies collected routinely by the City of Cambridge.

The following Figure demonstrates the relationship observed between traffic speeds and crashes over time. Overall, the 85th percentile speeds were seen to decrease about 0.15 mph per year due to various traffic calming measures instituted over time, while crashes concurrently decreased by approximately 100 crashes per year. While other external factors beyond just traffic speeds may be driving this relationship, it is worth noting that the data are consistent with the peer-reviewed literature linking decreasing traffic speeds to decreased crashes.



Existing Conditions

Urban local roads make up about 52% (18,945) of Massachusetts' 36,247 miles of roads (MassDOT 2012). Tables 1-3 shows crash data for Massachusetts. From 2006-2009, there were 477,103 total collisions reported by the RMV. Twenty-nine percent of these collisions (136,262) occurred on "functionally classified local roads" that would be impacted by the Speed Limit Bill. Of total collisions, 23% (314) of fatal injuries and 26% (44,580) of nonfatal injuries occurred on these local roads from 2006-2009. Approximately 37% of crashes involving pedestrians and crashes involving cyclists occurred on local roads.

Table 1: Motor Vehicle Crashes from 2006-2009 reported by the Registry of Motor Vehicles

	2006	2007	2008	2009	Total	Annual Average
Crashes on All Roads	124,274	120,667	120,970	111,192	477,103	119,276
Crashes on Local Roads	34,832	34,953	34,319	32,158	136,262	34,066
Fatal Crashes on All Roads	384	400	321	292	1,397	349
Fatal Crashes on Local Roads	97	93	69	55	314	79
Fatalities on All Roads	410	426	345	316	1,497	374
Fatalities on Local Roads	101	100	71	59	331	83
Injury Crashes on All Roads	33,038	31,289	31,017	28,933	124,277	31,069
Injury Crashes on Local Roads	8,543	8,196	7,845	7,560	32,144	8,036
Injuries on All Roads	45,934	42,947	42,321	40,077	171,279	42,820
Injuries on Local Roads	11,991	11,334	10,741	10,514	44,580	11,145

Table 2: Pedestrian Crashes from 2006-2009 reported by the Registry of Motor Vehicles

	2006	2007	2008	2009	Total	Annual Average
Crashes on All Roads	124,274	120,667	120,970	111,192	477,103	119,276
Crashes on Local Roads	34,832	34,953	34,319	32,158	136,262	34,066
Crashes Involving Pedestrians on All Roads	1,577	1,584	1,765	1,671	6,597	1,649
Crashes Involving Pedestrians on Local Roads	576	585	672	615	2,448	612
Pedestrian Fatalities on All Roads	58	65	72	46	241	60
Pedestrian Fatalities on Local Roads	19	15	28	13	75	19
Pedestrian Injuries on All Roads	1,116	1,192	1,316	1,331	4,955	1,239
Pedestrian Injuries on Local Roads	408	437	478	479	1,802	451

Table 3: Cyclist Crashes from 2006-2009 reported by the Registry of Motor Vehicles

	2006	2007	2008	2009	Total	Annual Average
Crashes on All Roads	124,274	120,667	120,970	111,192	477,103	119,276

Crashes on Local Roads	34,832	34,953	34,319	32,158	136,262	34,066
Crashes Involving Cyclists on All Roads	1,069	1,069	1,227	1,248	4,613	1,153
Crashes Involving Cyclists on Local Roads	398	393	458	455	1,704	426
Cyclist Fatalities on All Roads	6	11	10	6	33	8
Cyclist Fatalities on Local Roads	1	8	4	1	14	4
Cyclist Injuries on All Roads	753	744	866	882	3,245	811
Cyclist Injuries on Local Roads	277	281	309	313	1,180	295

Assessment

Table 4 shows expected annual decreases in crashes, injuries, and fatalities under two speed reduction scenarios. The first scenario assumed that crashes serious enough to cause injury or fatality, or damage to any one vehicle or other personal property in excess of $1000 were unlikely to take place in congested conditions, and therefore modeled the impact of the bill without accounting for congestion. The second scenario conservatively assumed that serious and fatal crashes are just as likely to take place in congestion as they are in free flow traffic conditions and therefore modeled changes due to the 24 hour average speed reduction, which accounted for congestion. Table 4 includes our best estimate and 95% confidence intervals (CIs) to explain statistical uncertainty behind each estimate. For a speed reduction of 1.8 mph, the model predicts 18 fewer fatalities from motor vehicle collisions, 4 fewer pedestrian fatalities, and about 1 fewer cyclist fatality; and a 0.67 mph speed reduction results in 7 fewer fatalities, 2 fewer pedestrian fatalities, and no reductions in cyclist fatalities. Improvements in safety outcomes under the more conservative estimate of 0.67 mph are smaller, but still significant.

Table 4: Power Model Results

Estimated Annual Decrease in	1.8 mph speed reduction estimate (95% confidence interval)	0.67 mph speed reduction estimate (95% confidence interval)
Total Crashes	2219 (286, 4042)	811 (102, 1505)
Fatal Crashes	15 (2, 27)	6 (1, 11)
Injury Crashes	772 (460, 1072)	285 (168, 401)
Fatalities	18 (-4, 35)	7 (-1, 15)
Injured Road Users	1239 (369, 2039)	460 (133, 77)
Pedestrian Fatalities	4 (-1, 8)	2 (0, 3)
Cyclist Fatalities	1 (0, 1)	0.3 (-0.1, 0.6)
Injured Pedestrians	50 (15, 82)	19 (5, 31)
Injured Cyclists	33 (10, 54)	12 (4, 21)

Note: These numbers should not be summed across types of crashes/health outcomes. Some categories are subsets of other categories

To demonstrate this across the Commonwealth, we ran the Power Model based on a 1.8 mph decrease for all 351 municipalities (See Appendix A). Table 5 summarizes collision reduction benefits associated with a 1.8 mph speed decrease by "community type." In order to understand how regional trends will affect the region's diverse communities over the coming decades, MAPC identified five basic community types in its 30-year regional plan, MetroFuture—built with extensive participation of thousands of "plan builders" to betters the lives of the people who live and work in the Greater Boston Region. The criteria used to define Community Types include land use and housing patterns, recent growth trends, and projected development patterns. The 5 community types for the state are:

Inner Core – These municipalities are high density cities as well as more residential "streetcar suburbs" and are essentially "built out" with little vacant developable land.

Regional Urban Centers – These municipalities are urban centers outside of the Inner Core and are characterized by an urban-scale downtown core with multiple blocks of multi-story, mixed use buildings; and moderately dense residential neighborhoods surrounding this core. Some of these communities are "built out," while others still have vacant developable land around the periphery of the community.

Maturing Suburbs – These municipalities are moderate-density residential communities with a dwindling supply of vacant developable land. Less than 25% of their land area is still developable. Less than 20% of their land area is devoted to commercial and industrial uses, although some of these towns comprise significant job centers. More than half of their housing units are owner-occupied single family homes.

Developing Suburbs – These municipalities are less-developed towns with large expanses of vacant, developable land. Most have recently experienced high rates of growth, primarily through large lot single-family homes. Some towns have a locally-significant stock of rental units and units in modestly-sized multifamily structures. Many of these towns have a well-defined, mixed-use town center. Others have town centers with historical and civic significance but no commercial or neighborhood function.

Rural Towns – These municipalities are low density communities with no significant town center and no compact neighborhoods. Vacant developable land is greater than 35% of the total town area, and generally Rural Towns are growing rapidly (population and households) with conventional low-density subdivision development on vacant land.

Table 5: Expected percent decrease in crashes with a 1.8 mph reduction on local roads by community type. The crashes involving pedestrians and crashes involving cyclists are a subset of the crashes on local roads.

	Community Type	Frequency	Predicted Crashes with a 1.8 mph Decrease on Local Roads	Expected Percent Decrease in Crashes with 1.8 mph Reduction on Local Roads
Crashes on Local Roads	Inner Core	1,268	1,186	7
	Regional Urban Centers	1,517	1,419	7
	Maturing Suburbs	330	309	6
	Developing Suburbs	172	161	6
	Rural Towns	12	11	8

Crashes involving Pedestrians on Local Roads	Inner Core	37	35	5
	Regional Urban Centers	35	33	6
	Maturing Suburbs	5	4	0
	Developing Suburbs	2	2	0
	Rural Towns	no data	no data	no data
Crashes involving Cyclists on Local Roads	Inner Core	32	30	6
	Regional Urban Centers	20	19	5
	Maturing Suburbs	4	4	0
	Developing Suburbs	2	2	0
	Rural Towns	1	1	0

Despite the predicted magnitude of these benefits, there are a number of limitations to this analysis. The Power Model, while parsimonious, is fairly crude. Like any model, it makes assumptions and is not 100% precise and accurate. Confidence intervals are provided to explain the statistical uncertainty of each estimate. Additionally, while speeds decrease and safety increases on local roads, the CTPS model demonstrates that traffic volume may increase on highways and arterials. It should be noted, however, that average speeds on highways and arterials will decrease slightly due to increased congestion, potentially increasing safety on these roads as well. Finally, our estimates are based on imperfect data. As stated earlier, crash data is consistently underreported. As such, the estimates presented here are conservative, and more accurate data would reveal greater decreases in crashes, injuries, and fatalities.

Summary

There is consistent evidence that reducing traffic speeds decreases the frequency and severity of crashes. Therefore, the Speed Limit Bill should be effective in decreasing crashes, injuries, and fatalities on functionally classified local roads.

Estimates that assume traffic on local roads would slow by 1.8 mph, on average, in response to a 5 mph lower speed limit, show that the Speed Limit Bill could prevent roughly 2,200 crashes, 18 fatalities, and 1,200 injuries per year across the Commonwealth.

Estimates that consider congestion would slow traffic by 0.67 mph on average and could prevent roughly 810 crashes, 7 fatalities, and 460 injuries per year across the Commonwealth.

Costs of Collisions

Background

Deaths and injuries due to motor vehicle crashes have a tremendous economic impact: medical and work loss costs for deaths and emergency department-treated nonfatal injuries exceeded $90 billion in 2005 (Centers for Disease Control and Prevention). Lowering speed limits has the potential to decrease the frequency and severity of crashes, and this can reduce their associated costs and the burden that they place on society.

Methods for Assessment

To estimate of the economic benefits of preventing crashes through reduced speeds, we used the CDC Web-based Injury Statistics Query and Reporting System (WISQARS) Cost of Injury Reports application (http://wisqars.cdc.gov:8080/costT/) to analyze the cost savings that would result from the collision reductions reported above. The WISQARS database is an interactive query system that provides customized reports of injury-related data. It provides state-specific statistics on the costs associated with unintentional fatal and non-fatal injuries, including injury deaths, hospitalizations, and emergency department (ED)-treated (i.e., treated in the ED but not hospitalized) cases by mechanism and intent of injury. Cost estimates are presented in three mutually exclusive categories that reflect the severity of injury: (1) injuries resulting in death, including deaths occurring within and outside a healthcare setting; (2) injuries resulting in hospitalization with survival to discharge; and (3) injuries requiring an ED visit not resulting in hospitalization.

Estimates reflect total costs to society, which means they include all costs regardless of who pays for them. Medical and work loss costs of each death were estimated using 2005 National Vital Statistics System incidence data, while medical costs of non-fatal injuries primarily were derived from databases of the Healthcare Cost and Utilization Project. For more information on the WISQARS methodology, please visit http://www.cdc.gov/injury/wisqars/pdf/WISQARS_Cost_Methods-a.pdf. Medical costs for outpatient and physician office visits are not included, nor are non-medical costs to society. Those include, but are not limited to, disability, mental/emotional anguish of surviving family member or co-workers, property damage, lowered property values, community fear, law enforcement, judicial, and litigation costs. As such, these are extremely conservative estimates.

Existing Conditions

Recent CDC estimates show that the cost of death from motor vehicle crashes in Massachusetts was $394 million in 2005 (Centers for Disease Control and Prevention 2011). Work loss costs made up $388 million of these costs, while medical costs made up $6 million. Figure 3 shows of the total costs, 18% ($73 million) is based on motor vehicle occupants, 15% ($60 million) is based on motorcyclists, 2% ($6 million) is based on bicyclists, and 12% ($46 million) is based on pedestrians. Children make up 3% ($12 million) of costs, teens 17% ($67 million), young adults 48% ($188 million), adults 28% ($112 million), and older adults 4% ($14 million).

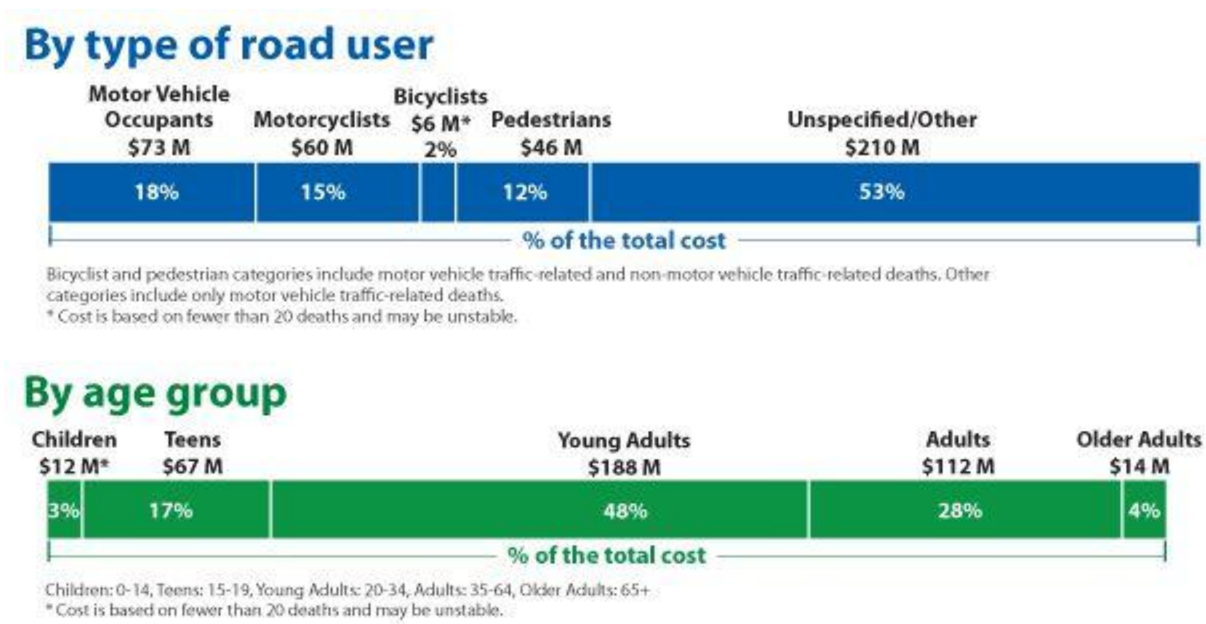


Figure 3: Cost of Crashes in Massachusetts in 2005 (Centers for Disease Control and Prevention 2011)

Assessment

Based on an average speed decrease of 1.8 mph on functionally classified local roads, we estimate that 18 fatalities would be prevented each year, and that the annual number of injured road users would decrease by 1,239. Table 6 shows the estimates of how much preventing these injuries and fatalities could save in terms of both work loss and medical costs. Table 7 also shows savings in terms work loss and medical costs for a 0.67 decrease in traffic speeds. Both scenarios result in savings ranging from $11 million to $30 million in prevented fatalities and $67 million to $180 million in prevented injuries.

Table 6: Cost of Crashes for a 1.8 mph decrease in traffic speeds from CDC's WISQARS in 2012 dollars

	Fatalities	Pedestrian Fatalities	Cyclist Fatalities
Annual Decrease in Deaths	18	4	1
Medical Cost Avoided	$346,721	$76,699	$18,912
Work Loss Cost Avoided	$29,347,334	$6,521,513	$1,630,641
Combined Cost Savings	$29,694,055	$6,598,212	$1,649,553

	Injured Road Users	Injured Pedestrians	Injured Cyclists
Annual Decrease in Number Hospitalized	1,239	50	33
Medical Cost Avoided	$63,872,373	$2,703,376	$1,652,705
Work Loss Cost Avoided	$116,610,789	$5,164,047	$3,766,654
Combined Cost Savings	$180,483,163	$7,867,423	$5,419,359

Table 7: Cost of Crashes a 0.67 mph decrease in traffic speeds from CDC's WISQARS in 2012 dollars

	Fatalities	Pedestrian Fatalities	Cyclist Fatalities
Annual Decrease in Deaths	7	2	0

Medical Cost Avoided	$133,435	$37,824	$0
Work Loss Cost Avoided	$10,990,016	$3,140,455	$0
Combined Cost Savings	$11,123,451	$3,178,279	$0

	Injured Road Users	Injured Pedestrians	Injured Cyclists
Annual Decrease in Number Hospitalized	460	19	12
Medical Cost Avoided	$23,713,638	$1,027,556	$600,984
Work Loss Cost Avoided	$43,293,937	$1,962,653	$1,370,075
Combined Cost Savings	$67,007,575	$2,990,209	$1,971,058

Limitations to this analysis include the lack of data on costs for collisions that did not result in an injury or fatality. Including these personal damage costs would increase cost savings estimates. This analysis assumes that all injuries prevented by the modeled reduced speeds would have otherwise resulted in a hospital visit. This assumption is based on the fact that our baseline data came from the RMV CDS, which only registers serious crashes.

Summary

Conservative predictions show the Speed Limit Bill would decrease fatalities and injuries by lessening the risk and severity of motor vehicle collisions.

These decreases in fatalities and injuries would also mean financial savings: $11 million up to $30 million for fatalities prevented and $60 million up to $180 million for injuries prevented in costs to society due to medical payments and missed work. These savings would affect those involved in collisions and their families, as well as employers, property owners, and taxpayers across the state.

Time Spent and Fuel Burned in Traffic

Background

Slower speeds on functionally classified local roads would result in more time behind the wheel for some individuals. In addition to more time driving, because cars often run at lower efficiencies in slow speeds, this could mean additional increases in the amount of fuel burned in traffic. This section estimates the likely additional time and fuel costs that could result from slower speeds on local roads.

Methods for Assessment

We obtained 2010 traffic and emissions data from CTPS, meant to represent current conditions. We then commissioned CTPS to model the same parameters assuming that average speeds on local roads declined by 1.8 mph as a result of the Speed Limit Bill (Central Transportation Planning Staff 2012).

These transportation and traffic parameters included vehicle-miles traveled (VMT) by automobiles and trucks, and vehicle-hours traveled (VHT) for each affected Transportation Analysis Zone (TAZ). Average fuel costs, vehicle occupancy, and monetary value of time were taken from a widely utilized annual publication, the Texas Transportation Institute (TTI) Urban Mobility Report (Schrank, Lomax, and Eisele 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.

Changes in VMT and VHT due to speed limit changes were estimated by CTPS. We multiplied the change in person-hours (VHT) by $16.94, or the value of one hour of travel time in the greater Boston region in 2012 dollars assuming that 1.25 persons were in each car (Schrank, Lomax, and Eisele 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.

Fuel use under each scenario, in gallons, was calculated by using TTI equations below and the average speed on all road types 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 Massachusetts Executive Office of Energy and Environmental Affairs (EEA) 2012 average gasoline cost of $3.48 / gallon and an average diesel cost of $3.79 / gallon (Executive Office of Energy and Environmental Affairs 2012).

Existing Conditions

Based on the base year conditions from the CTPS model, the total daily VMT for the state are 155.1 million, of which 26.6 million were on local roads, making up 17% of total daily VMT. The total daily VHT were 4.6 million.

Assessment

The CTPS model results are shown below in Table 8. The model shows that under the 1.8 mph reduction in traffic speeds on local roads, daily VMT on total roads will increase by 184,000, while daily VHT on total roads will increase by 19,000 as a result of the Speed Limit Bill. Daily VMT overall would increase as drivers choose new, less direct routes to avoid slower speed traffic on local roads. Daily VMT on local roads will decrease by 355,676, while daily VHT on local roads will increase by 2,860 as a result of the bill.

Table 8: Model Results from CTPS

Base year

	Local	Minor Arterial/Collector	Major Arterial	Highway	Totals
Statewide Daily VMT	26,609,299	36,891,481	21,756,539	69,830,732	155,088,051
Statewide Daily VHT	1,178,600	1,217,400	658,800	1,508,000	4,562,800

1.8 mph Reduction

	Local	Minor Arterial/Collector	Major Arterial	Highway	Totals
Statewide Daily VMT	26,253,623	37,111,285	21,765,540	69,998,692	155,272,426
Statewide Daily VHT	1,181,460	1,225,799	663,570	1,511,190	4,582,018

Using the TTI equations, we found that fuel costs would increase by $21 million per year and the increased time spent in traffic would cost the Massachusetts' drivers $127 million in lost time.

CTPS also modeled whether participants would shift from commuting by automobile to biking, walking, or public transit as a result of the 1.8 mph decrease on local roads. Their model estimated that there would be no appreciable mode shift due to the 1.8 mph decrease.

Summary

While the Speed Limit Bill is expected to reduce crashes and prevent injuries and fatalities, it would prompt drivers to reduce cut-through traffic by seeking faster, though often longer, routes on higher capacity roads, resulting in an additional 55.3 million vehicle miles travelled per year. At the same time, slower travel speeds on local roads and higher traffic volumes on newly preferred, higher capacity roads would result in 5.8 million additional vehicle hours traveled per year. These increases in time spent in traffic would cost approximately $127 million per year, while increases in fuel burned in traffic would cost $21 million per year.

Air Pollution

Background

Vehicles emit a number of air pollutants, including particulate matter (PM), carbon dioxide, and nitrogen dioxide. Ozone can also form as secondary pollutant due to vehicle exhaust. 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 (US EPA and Abt Associates, Inc 2010; Roman et al. 2008; Schwartz et al. 2008; Health Effects Institute 2003; Moolgavkar 2000b; Moolgavkar 2000a; Peters et al. 2001). If the Speed Limit Bill leads to more time spent in congested traffic, air pollution emissions may rise. Additionally, vehicles are designed to burn fuel most efficiently at certain speeds, typically around 40-50 mph, though optimal fuel economy is different for every vehicle (US Department of Energy 2012). Because speed affects the ways in which vehicles burn fuel, slower average traffic speeds would change the composition of vehicle emissions.

Methods for Assessment

We developed estimates of health impacts due to vehicular air emissions based on emissions models run by CTPS. Estimates of the public health impacts due to vehicular air emissions were developed using a risk assessment approach, incorporating information from an air quality model used by the U.S. Environmental Protection Agency (EPA) and peer-reviewed research papers.

Emissions Estimates

CTPS estimates of statewide transportation patterns under the baseline and Speed Limit Bill 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 (US EPA 2011).

CTPS's MOBILE6.2 outputs provided estimates for emissions of particulate matter smaller than 2.5 microns in aerodynamic diameter (PM2.5), particulate matter smaller than 10 microns in aerodynamic diameter (PM10), VOCs and NOx; however, SO2 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.

Pollutant Concentrations

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 (US 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 spent, and fuel burned due to traffic congestion (Levy, Buonocore, and von Stackelberg 2010). The source-receptor (S-R) matrix gives coefficients describing the effect that an emission of primary PM2.5, NOx, or SO2 has on concentrations of PM2.5 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 NOx and SO2 undergo chemical processes in the atmosphere and convert to what is called secondary PM2.5. The S-R 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 were then calibrated to observed monitoring data for PM2.5.

Health Data

We used population data from the U.S. 2010 Census (US 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 2011), and data on mortality rates from the U.S. Centers for Disease Control (CDC) Wide-ranging Online Database for Epidemiologic Research (WONDER) database (Centers for Disease Control and Prevention 2008). We obtained data at the county level, meaning each county had its own population estimate and rate of hospitalization and mortality.

Calculation and Valuation of Impacts to Public Health

Using the S-R Matrix, we calculated the impact that changes in emissions from vehicular travel in each county in Massachusetts affected by the proposed bill would have on air pollution concentrations in Massachusetts, as well as neighboring states. The public health impacts due to these air pollution 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) (US EPA and Abt Associates, Inc 2010)– mortality (Roman et al. 2008; Schwartz et al. 2008), hospitalizations for asthma (Health Effects Institute 2003), cardiovascular disease (CVD) (Moolgavkar 2000b), myocardial infarction (MI) (Peters et al. 2001), chronic obstructive pulmonary disease (COPD) (Moolgavkar 2000a), and ischemic heart disease (IHD) (Health Effects Institute 2003). This body of epidemiological research estimates the relative risk between changes in air pollution concentrations and subsequent changes in health outcomes. 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.

$$\text{Health Endpoint} = \text{Change in Air Quality} \times \text{Baseline Rate} \times \text{Relationship Between } PM_{2.5} \text{ and Health Endpoint} \times \text{Population}$$

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 et al. 2004), as is used in U.S. EPA regulatory impact analyses (US EPA 1999; US EPA 2011). The values of a hospitalization event from the U.S. EPA software BenMAP (US EPA and 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 may change as an impact of the bill, including SO2, 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. These aggregated numbers do not demonstrate the distribution of risk among different populations. Finally, our estimates also do not include increased exposures specific to commuters, who may spend more time in traffic in close proximity to elevated concentrations.

Existing Conditions

In general, most monitored air pollutants in the state of Massachusetts are at levels below health-based standards, and levels have been declining over time (MassDEP 2012). Concentrations statewide under baseline conditions can be seen in Table 9 below.

Table 9: Statewide Baseline Conditions

	CO	NOx	VOC	PM2.5	PM10
Baseline Levels (kg)	553,185.07	47,895.57	18,026.08	1,121.33	1,852.03

Assessment

Estimates of increases in air pollutants due to the Speed Limit Bill are shown below in Table 10. Increases due to the 1.8 mph reduction would be minor.

Table 10: Changes in Concentration of Pollutants due to the Speed Limit Bill

	CO	NOx	VOC	PM2.5	PM10
Changes in Concentration (kg)	1,262.22	142.21	98.92	1.18	1.82

These increases in pollutant concentrations would lead to slight increases in risk for the citizens of Massachusetts. The total expected number of new cases due to the increase in air pollution is shown below in Table 11, accompanied by the total cost of these new cases.

Table 11: Total Expected Number of New Cases due to Increased Air Pollution

	Increased Cases per Year	Cost per Year
Total Mortality	0.000057	$470.81
Total MIs	0.000026	$2.75
Total IHD	0.000003	$0.11
Total CVD	0.000011	$0.31
Total COPD	0.000003	$0.05
Total Asthma	0.000002	$0.02
Total Hospitalizations	0.000103	$3.25
Total		$474.07

Summary

The Speed Limit Bill would lead to more time spent in congested traffic, and subsequently air pollution emissions will rise.

Small increases in air pollution are expected as a result of the Speed Limit Bill. These increases in air pollution would result in an increase in mortality and hospitalizations due to asthma, chronic lung disease, heart attacks, ischemic heart disease, and major cardiovascular disease although these increases would be negligible.

Air pollution-related health costs would be approximately $500 per year.

Pedestrian and Bicyclist Perceptions of Safety

Background

Walking and bicycling for transportation helps people incorporate physical activity into everyday life, reducing the risk of many chronic diseases. A recent study by Lee et al. (2012) estimates that physical inactivity causes 6% of the global burden of disease from coronary heart disease, 7% (range 3.9-9.6) of type 2 diabetes, 10% (range 5.6-14.1) of breast cancer, 10% (range 5.7-13.8) of colon cancer, 9% (range 5.1-12.5) of premature mortality. If inactivity were decreased by 10% to 25%, between 533,000 and 1.3 million deaths could be averted every year. Meeting the Surgeon General's recommendation of 30 minutes of moderate intensity physical activity on most days of the week reduces risk of all-cause mortality, cardiovascular disease, and type 2 diabetes (de Nazelle et al. 2011; Haskell, Blair, and Hill 2009). One way to increase the population's rate of physical activity is by shifting the mode of transportation from automobiles to active modes, such as walking and bicycling. For example, a meta-analysis by Hamer and Chida (2008) examined the association between commuting physical activity and cardiovascular risk and found that active commuting that incorporates walking and biking was associated with an 11% reduction in cardiovascular risk. One of the barriers, however, to facilitating this shift to active transportation may be negative perceptions of road safety due to excessive speeds of motorized vehicles.

Methods for Assessment

We conducted a rapid review of peer-reviewed literature on individuals' perceptions of road safety as related to traffic speed and speed limit reductions, and on the health impacts of walking and bicycling. We used U.S. Census and Behavioral Risk Factor Surveillance System (BRFSS) data, both from 2010, to describe current conditions in Massachusetts. The BRFSS is an annual telephone survey that collects data on public health issues, health conditions, and risk factors and behaviors.

Existing Conditions

According to the 2010 BRFSS, nearly 200,000 (6%) Massachusetts workers bike or walk to work, however about 20% of Massachusetts residents report engaging in no leisure time physical activity (US Census Bureau 2012). Although higher than the U.S. average, Massachusetts lags behind Europe in utilizing active means of transportation (Buehler, 2008). For example, in Ireland 15% of commuters bike or walk to work (Bassett et al. 2008). Although Massachusetts is considered one of the healthiest states in the country, 60% of adults are overweight and 24% of adults are obese, highlighting the significance of interventions that help residents become more active (Massachusetts Department of Health and Human Services 2010).

Assessment

Over the past several decades, researchers across disciplines have begun to examine traffic and its relationship with physical inactivity. According to a recent literature review on Urban Traffic Calming and Health by the National Collaborating Centre for Healthy Public Policy in Canada, in urban settings a significant portion of car trips cover short distances, and given favorable conditions, these trips could be made on foot or by bicycle (Morency, Demers, and Lapierre 2007; National Collaborating Centre for Healthy Public Policy 2011). Therefore, while traffic calming strategies are primarily promoted as a way to reduce crashes, injuries and deaths, they may also be a feasible method to promote physical activity by helping create an environment that encourages active transportation. The World Health Organization has suggested that traffic may have a strong negative impact on health by reducing the ability to engage in active transportation (WHO Regional Office for Europe 2000). One pathway that the negative impact of traffic may have on physical activity is through the perception of safety. Studies that consider traffic and perceptions of safety generally agree that pedestrians and bicyclists have negative perceptions of traffic and that real and/or perceived danger and discomfort in traffic discourages walking and bicycling (Addy et al. 2004; Hoehner et al. 2005; McGinn et al. 2007; Pucher and Dijkstra 2003; Wahlgren and Schantz 2012; Jacobsen, Racioppi, and Rutter 2009; Pucher, Garrard, and Greaves 2011). Safety concerns appear to be strongest in children, the elderly and women, thus contributing to health inequalities for these sensitive groups (Bassett et al. 2008; Pucher, Garrard, and Greaves 2011). The National Collaborating Centre for Healthy Public Policy (2011) also notes that by discouraging active transportation, perceived danger from traffic may produce a feedback loop in which fewer people participate in active transportation, which increases traffic volume, which in turn creates roads that are perceived as increasingly unsafe. The authors state that reducing traffic volumes and speeds could help reverse this pattern.

Two studies, one domestic and one in Scotland, do attempt to estimate improvements in perceived safety through reducing speeds on roads, in conjunction with other traffic calming measures. In the latter study (Morrison, Thomson, and Petticrew 2004), researchers assessed health impacts of a traffic calming scheme on a community, including perceptions of safety. In Glasgow, Scotland, traffic calming measures were introduced to a main road which bisected a deprived urban housing estate. The researchers utilized a survey to study a cohort before and after the measures were implemented. Perceptions of safety, including problems with speeding traffic, road safety, and crossing the road, were improved after the introduction of the traffic calming scheme. The authors also observed an increase in pedestrian activity and cycling. Although the findings may have been affected by low response rates and potential selection bias, they do suggest that traffic calming can improve perceptions of road safety and increase physical activity.

The other study assesses a traffic calming program in Cambridge, Massachusetts (Watkins 2000). The study notes that one of the goals of traffic calming is to improve the comfort level, i.e., the perception of safety, for all users of the street. Watkins utilized a survey to understand residents' views after the introduction of the traffic calming measures. Fifty-seven percent of respondents believe that pedestrian safety improved after the traffic calming project, as did 33% of cyclist safety, which could lead to an increase in active modes of transportation. As with the previous study, this one has important limitations, including a lack of reported data to determine statistical significance of the findings.

Overall, National Collaborating Centre for Healthy Public Policy (2011) notes that while the mechanisms of action posited by the literature support traffic calming interventions, the methodology and results of the studies reviewed do not support the definitive conclusion that traffic-calming interventions encourage active transportation. The authors do explain that traffic calming seems to improve all road users' perception of safety and traffic calming is commonly part of the policies of cities that have succeeded in increasing the modal share of active transportation. Therefore, they believe that the existing lack of evidence is likely due to the methodological difficulties in designing appropriate studies to examine this complex topic.

Additionally, there is a challenge in isolating the specific role of speed reduction on physical activity from that of bicycle/pedestrian infrastructure improvements, traffic calming, and other determinants of perceived safety, as these factors often co-occur. Studies that attempt to quantify the independent effect of traffic speed on perceptions of safety and physical activity have found few statistically significant associations (Wahlgren and Schantz 2012; McGinn et al. 2007). In a literature review, Pucher et al. (2010) do note examples of three municipalities in Europe where reduced speed limits led to changes in bicycling and the willingness of residents to bicycle, however, the evidence was inconsistent across the three sites. Overall, the evidence is limited to assert that reducing traffic speeds alone will have a major impact on perceived safety and active transportation.

Although methodological constraints still limit full confidence in the literature, evidence generally supports the positive impact of traffic calming overall on perceptions of safety and active transportation. A lack of reliable methods and data sources limits our ability to quantify how changes in traffic speeds specifically might impact perceptions of safety and willingness to engage in walking or cycling. The choice to walk or bicycle is likely influenced by a number of factors, such as aesthetics, air quality, and development patterns, in addition to perceptions of safety. As Watkins (2000) states, to improve perceptions of safety and increase active transportation, it is necessary "to concentrate on the total pedestrian experience, not just reducing traffic speeds." Most studies that consider predictors of physical activity have found that social and environmental supports for physical activity include having accessible, aesthetically pleasing bicycle and pedestrian facilities, in addition to low traffic speeds (Addy et al. 2004; Hoehner et al. 2005; McGinn et al. 2007). It is likely, therefore, that improvements in perceptions of road safety must work in conjunction with other means of improving pedestrian and bicycle utilization.

The Speed Limit Bill should create more conducive conditions for active transportation by improving the objective safety of roads for all users. Although the research is limited regarding exactly how a change in speeds will impact perceptions of safety and physical activity, the research that does exist suggests that it will likely have a positive impact if enacted in concert with other traffic calming measures and improvements in pedestrian and bicycle infrastructure.

Summary

Walking and bicycling are a means of increasing the amount of one's physical activity, which can reduce the risk of a number of chronic diseases.

High traffic speeds may deter active transportation trips, such as walking and cycling trips.

Lowering speeds through policy and/or engineering interventions may create safer environments and improve perceptions of safety.

Improved perceptions of safety may lead to increased use of local roads for active transport.

Further traffic calming measures, along with improvements to pedestrian and bicycle infrastructure, may be required to significantly enhance perceptions of safety and increase physical activity.

Parental Safety Perceptions and Children's Levels of Physical Activity

Background

There is widespread recognition that childhood obesity and diseases related to a lack of physical activity among children, including pre-diabetes, diabetes, and asthma, are major public health challenges in the United States (White House 2012). With a dramatic rise in childhood obesity rates occurring over the past several decades alone, researchers and policy makers have concluded that changes in environmental and contextual factors, rather than innate biological or genetic drivers, are likely to blame for the childhood obesity epidemic and may therefore be promising points of intervention (Rahman, Cushing, and Jackson 2011; Garasky et al. 2009; Grow et al. 2010). One modifiable contextual risk factor that has gained considerable attention in recent years in the fight against childhood obesity has been the built environment. National efforts are currently underway to help children be more physically active by improving the quality of the built environment for walking and biking. Examples include Michelle Obama's Let's Move Campaign (White House 2012) and the national Safe Routes to Schools programs. Massachusetts also has a statewide program through the Massachusetts Department of Public Health (MDPH) called Mass in Motion. Although it was launched in 2009, Mass in Motion has grown to cover 52 municipalities and about a third of the state's population. This initiative aims to promote wellness and to prevent overweight and obesity with particular focus on healthy eating and active living. All of these initiatives acknowledge the role of the neighborhood built environment in shaping health behaviors and both promote community-based efforts to improve active transportation infrastructure for children.

Community-based interventions to encourage higher levels of physical activity among children via improvements to the built environment frequently focus on reducing traffic speed and volume. Efforts to slow and reduce the number of automobiles on roads, or "traffic calming," may promote physical activity among children when changes to the built environment are actually effective in reducing vehicle speeds and volume, thereby preventing crashes and improving safety. Secondly, these changes may lead to increased perceptions of safety, causing parents and schools to encourage walking and biking among children, and increasing children's willingness to walk and bike (Morrison, Thomson, and Petticrew

2004). Not only can this benefit children by increasing their physical activity, it also may make them safer. Data indicates that the likelihood that a given person walking or bicycling will be struck by a motorist varies inversely with the number of individuals walking or bicycling (Jacobsen 2003). Motorists appear to adjust their behavior in the presence of people walking and bicycling.

Methods for Assessment

We summarized the literature on whether lower traffic speeds translate to higher levels of perceived safety among parents or children, increased willingness to allow children to play walk or bike outside, and ultimately levels of childhood physical activity.

Existing Conditions

In the United States, almost half of elementary and middle school students walked or biked to school whereas less than 15% walk or bike to school today (Jacobsen, Racioppi, and Rutter 2009). Almost 17% of children aged 2 to 5 and 11% of middle school students are overweight in Massachusetts (Massachusetts Department of Public Health 2009).

Assessment

An extensive review by Davison and Lawson (2006) shows that features of the built environment are associated with increases in children's physical activity. The authors identified 33 quantitative studies focused on physical activity among those 3-18 years and perceived and objectively measured environmental characteristics. The weight of the evidence reviewed indicates that higher traffic speed/density is associated with lower levels of physical activity among youth. Conversely, classic traffic calming measures, such as controlled intersections, and supportive infrastructure, such as sidewalks, were associated with higher levels of physical activity. Additionally, Morrison and colleagues (2004) report an increase in parents' willingness to allow children to walk and ride bicycles after the implementation of a traffic calming scheme. Objective measures of traffic were associated with physical activity such that safer pedestrian environments (e.g. slower speeds and lower traffic volume) predicted higher levels of physical activity. A 2010 study by Carver and colleagues also supported this evidence and went on to note that traffic-calming measures, quiet local streets with a speed limit of 50 km/h or less (about 31 mph), and higher street connectivity had the most positive impact on physical activity behaviors and active transportation (Carver et al. 2010). It is likely that the Speed Limit Bill will support more physical activity among children across the Commonwealth; however, this bill should be accompanied by traffic calming, bicycle/pedestrian facilities and other self-enforcing engineering interventions in order to maximize this outcome.

Summary

Higher traffic speed/density is associated with lower levels of physical activity among youth.

Implementation of traffic calming schemes increase parents' willingness to allow children to walk and ride bicycles.

Property Values

Background

As well-recognized "social determinants of health," socioeconomic factors are known to influence whether people get sick or stay healthy (Berkman and Kawachi 2000). This section examines whether property values could be affected by the Speed Limit Bill, in turn impacting health via changes in homeowner wealth or local housing conditions.

Traffic speeds on roads have been linked to adjacent property values, as homebuyers willing to pay a premium for quieter, safer streets. In a survey of homebuyer preferences, community design with low traffic ranked as the top priority out of 39 attributes used to select a home (National Bicycle and Pedestrian Clearinghouse 1995). Another study showed that a 5 to 10 mph reduction in traffic speeds increased nearby residential property values by approximately 2% (Modra 1984). Other studies have demonstrated that reducing the volume of traffic on residential streets can also serve to increase property values (Bagby 1980; Eppli and Tu 1999; Hughes and Sirmans 1992). The Speed Limit Bill therefore has the potential to impact residential property values for homes across the state. We assess the potential for the Speed Limit Bill to improve health via changes in property values.

Methods for Assessment

We reviewed the literature on the relationship between household values and traffic speeds and then reviewed 2006-2010 American Community Survey (ACS) from the US Census for estimates on median home values in Massachusetts (American Community Survey 2010). The ACS is a sample done in one-, three- and five-year increments (depending on geography) that provides estimates of housing characteristics, population characteristics, education levels, modes of transportation, age, etc.

Existing conditions

American Community Survey Data from the US Census Bureau show that the average Census tract median home value for the state of Massachusetts for 2006-2010 was $374,499. According to a recent analysis of tax data conducted by the Boston Globe, statewide home values have more than doubled since 2000; however, home values hit an all-time high in 2007 and have dropped since the 2008 recession. From 2009 to 2010, home values decreased about 4.6 percent to an average of $373,702 (Carroll and Daly 2010).

Assessment

We find a consistent relationship between lower traffic speeds and higher property values. The literature, however, is sparse and cannot be reliably extrapolated to assess the likely impact of the Speed Limit Bill on property values in Massachusetts, especially because all properties on local roads would be affected simultaneously. However, the literature indicates general preferences for the safety and quiet associated with slower speeds, suggesting that residents would likely enjoy quality of life benefits even if they were not monetized into higher home values.

Summary

Although this literature is sparse, it is consistent in showing that lower traffic speeds are associated with higher values in adjacent residential properties.

We cannot predict how the Speed Limit Bill would impact statewide property values, but the literature indicates general preferences for the safety and quiet associated with slower speeds.

Part III

Conclusions, Recommendations, and Monitoring

Summary of findings

This Speed Limit Bill proposes to lower speed limits statewide as a strategy to reduce crashes and make the roads safer for all users of the road. Based on a literature review, case studies, and statistical models, this HIA predicts that the bill would have a positive public health impact, particularly by preventing traffic fatalities and injuries. Potential co-benefits include enhanced walking and biking environments that may encourage physical activity, as well as increased desirability of properties on local roads due to quieter and safer streets. The HIA also concludes that the bill is economical. The Speed Limit Bill could prevent 2,219 crashes per year, 18 fatalities per year, and 1,239 injuries per year, which translates into a savings of up to $210 million annually in prevented medical payments and work lost. These economic benefits outweigh the costs of increased time spent in traffic and fuel burned, as well as the health impacts of the small increase in air pollution, associated with the proposed change. In addition, the lower speed limit is likely to improve children's and adults' perceptions of the road, which could lead to increased pedestrian and bicyclist physical activity and a resulting reduction in chronic disease risk. Although we cannot predict how the Speed Limit Bill would impact home values on local roads, real estate studies indicate clear buyer preferences and willingness to pay, potentially up to 2% more, for quieter, safer roads. Because this bill would apply to all local roads simultaneously and home sales prices are driven by the prices of comparable homes, it is not clear whether speed reductions would translate into higher home prices. That is, the amenity of slower speeds would be associated with all homes on local roads, such that no home would have an advantage over comparable properties in this regard. However, we predict that Massachusetts residents living on local roads could experience increased satisfaction with their neighborhoods as a result of the proposed bill even if these benefits are not monetized.

Recommendations

Further reductions in motor vehicle speeds

Small adjustments in motor vehicle speeds result in major changes in crashes, fatalities, and injuries. Further measures to decrease traffic speeds, including traffic calming, enforcement, and education, implemented in conjunction with the bill, would have greater effects on safety for road users. To explore the potential impact of greater reductions in traffic speeds, assuming a combination of traffic calming, enforcement, and education effective in slowing speeds to the posted 25 mph limit, we modeled the impact that a full 5 mph decrease in traffic speeds would have on crashes and fatalities, assuming that:

Speed limit reduction, combined with traffic calming measures, would slow traffic by an average of 5 mph on functionally classified local roads

Our analysis suggests that a 5 mph reduction in traffic speeds would offer three times the reduction in crashes and twice the cost savings of a 1.8 mph reduction. Most importantly, the 5 mph decrease would save more than twice the number of lives as a 1.8 mph reduction (Table 12).

Table 12: Crashes and Cost of Crashes in 2012 dollars

Estimated Annual Decrease in:	1.8 mph speed reduction	5 mph speed reduction
Total Crashes	2,219 (95% CI 286, 4,042)	6,265 (95% CI 855, 10,794)
Fatalities	18 (95% CI -4, 35)	44 (95% CI -11, 67)
Injured Road Users	1,239 (95% CI 369, 2,039)	3,336 (95% CI 1,077, 5,088)
Medical and Work Lost Cost of Fatalities	$29,694,055	$72,586,636
Medical and Work Lost Cost of Hospitalizations	$180,483,163	$485,949,909

Given these findings, measures to help align true traffic speeds with the regulated speed have significant health and economic benefits. Complementary traffic-calming design solutions (detailed in Appendix B) plus enforcement and education, implemented in conjunction with a speed limit reduction, may help maximize health benefits associated with reduced traffic speeds.

Case Study: 20's Plenty Campaign

In the 1990s, London introduced 20 mph zones and years later in 2007, it was accompanied by "20's Plenty," a national campaign for a 20 mph default speed limit where people live. These 20 mph zones were associated with a 41.9% reduction in road casualties and an average reduction of 8% in road causalities in adjacent areas (Grundy et al. 2009). Using conservative risk reduction estimates based on 2000-2006, Grundy and colleagues estimated the zones would prevent 203 crashes and 27 fatalities or serious injuries. This policy's success may be attributed to the slower speed limit; area-wide self-enforcing traffic calming measures for each zone; and the 20's Plenty educational campaign. We added a third scenario to this HIA that simulates a similar policy and demonstrates the greater reductions in traffic-related injuries and costs to society than the proposed Speed Limit Bill. For this third scenario, we assume that average speed declines by 3.9 mph, the change resulting from a regulated 10 mph reduction based on estimates by Elvik et al. (2012). We added this scenario to understand how a 20 mph speed limit, a move championed by many traffic safety organizations, most notably as part of the international "20 is plenty" campaign, might affect health outcomes.

Estimated Annual Decrease in	3.9 mph speed reduction
Total Crashes	4,808 (95% CI 642, 8,454)
Fatalities	36 (95% CI -8, 59)
Injured Road Users	2,605 (95% CI 816, 4,084)
Medical and Work Lost Cost of Fatalities	$59,389,161
Medical and Work Lost Cost of Hospitalizations	$379,466,535

Implementation – Dissemination

If passed, the Speed Limit Bill should be accompanied by a public information campaign that includes a media campaign and inclusion into the driver's education curriculum. Information about the new speed limits could be incorporated into RMV mailings or other documents regularly distributed to drivers.

Implementation – Enforcement

Though this bill reduces the default speed limit on local roads by 5 mph, actual speeds are only expected to drop by 1.8 mph. Enforcement policies and policing would help reduce the actual speed of traffic closer to the 25 mph limit. Currently, the bill does not incorporate any elements related to enforcement. A systematic review conducted in 2010 assessed the effectiveness of speed cameras in improving safety across 35 studies and concluded that cameras are a worthwhile intervention that help prevent speeding and prevent crashes (Wilson et al. 2010). Despite the fact the each study on its own suffered methodological challenges, the body of evidence as a whole suggests that cameras may reduce the percentage of drivers speeding by 10-35%, and may reduce crashes resulting in death or serious injury by 30-40%. While these ranges represent the authors' best approximation of effect size, percentage reductions varied widely across sites.

Evidence also suggests that drivers respond more to the threat of enforcement than to the severity of enforcement penalties, and that drivers are bad at guessing how frequently roads are patrolled (Ryeng 2012). Enforcement approaches that remind drivers that roads are patrolled for speeding, or even tell drivers how many hours per month are spent patrolling the roads, may also help raise compliance rates with new, lower speeds.

Despite the positive findings that enforcement can help reduce speeding, research suggests that design-based traffic calming interventions are even more effective. In fact, when the approaches are directly compared, researchers have found that traffic calming is better at reducing speeds than are speed cameras (Mountain, Hirst, and Maher 2005).

Implementation – Road Engineering

To truly maximize the health benefits of this bill, studies and past piloted projects show that passive, self-enforcing engineering interventions are most effective. In fact, studies that directly compare the effectiveness of enforcement versus engineering approaches in reducing speeds have come to the same conclusion (Mountain, Hirst, and Maher 2005). New local roads should be designed that support a 25 mph speed limit if the bill passes. If the road design speed differs from the speed limit on existing roads, traffic calming measures could help bring down travel speeds without the need for intensive enforcement. Traffic calming, such as raised intersections, traffic circles, road narrowing, curves, and speed humps, is one population-based and self-enforcing engineering strategy that slows traffic and reduces traffic volume (Pucher and Dijkstra 2003). Studies show that traffic calming measures can reduce road traffic injuries by roughly 15% in the areas that received design and engineering interventions (Elvik 2001).

While a range of traffic calming interventions have been proven effective in reducing speeds and preventing injuries and fatalities in a number of rigorous studies, those measures that change the height of the road surface appear to be among the most effective (Mountain, Hirst, and Maher 2005). Constructing “vertical deflections,” such as raised pedestrian crossings, speed humps, and cushions, alter the road surface height and force drivers to slow. Less effective in reducing speeds and preventing injury, narrowing the roadways and/or creating “horizontal deflections” force vehicles to veer, and therefore slow (Mountain, Hirst, and Maher 2005). Roundabouts, islands, and chicanes are examples of horizontal deflections, while constructing pinch points, removing traffic lanes, and curb bump outs all narrow the road. Low cost road treatments that simply give the appearance of narrowing and alert drivers that they are entering a lower speed area, including painting inward facing teeth on the sides of a traffic lane, can also be effective in reducing speed (Dell’Acqua 2011; Galante et al. 2010).

While academic research has not been able to disaggregate the speed reduction and “level of service” effects of pedestrian-oriented traffic signalization, high visibility crosswalks, speed humps placed in front of crosswalks, pedestrian refuge island, and other design features, all of these interventions have been shown to improve safety (Chen et al. 2012; Johansson, Rosander, and Leden 2011). Research suggests that the “level of service” roads provide to pedestrians and cyclists, which is improved by constructing facilities specifically to serve these users, and overall positive perceptions of the environment are more important determinants of active transportation than is speed (Winters et al. 2010; Wahlgren and Schantz 2012). As such, municipalities should consider implementing traffic calming interventions that also serve pedestrians and cyclists, including raised crosswalks, reducing motor vehicle lane width to serve bicycles, and signalization to accommodate active road users.

Implementation – Targeting Maximum Benefit

During the stakeholder engagement process, a number of participants posed questions that this document is not aimed to answer. These mainly focused on how to target speed reductions for maximum benefit. Suggestions included lowered speed limits or other traffic-calming measures in certain zones, such as around parks and hospitals. Others encouraged mapping and identifying the most likely locations that the majority of crashes take place and concentrating efforts these places for speed reduction strategies. While these potential interventions were not explored in this document, they warrant further exploration.

Monitoring

The goal of monitoring is to review the effectiveness of the HIA process and evaluate the actual health outcomes as a result of the project. MAPC is well positioned to monitor this HIA and the Speed Limit Reduction bill.

MAPC will continue to follow this bill as it moves through the legislative process. We will look at the number of news articles and websites that mention this HIA and its results. MAPC will continue to collect crash data annually to analyze the changes in crashes over time. If the bill passes, MAPC will work with the Massachusetts legislature or individual municipalities to recognize some of the recommendations of this HIA.

Conclusions

The Speed Limit Bill would protect health by making the roads safer for all users of the road. However, speed limit reduction alone does not reduce speeds to the regulated limits; enforcement and road engineering are also needed to slow speeds. While a lower speed will increase congestion, VMT, and worsen air quality, the benefits outweigh the costs from a health perspective. Studies and past projects show that the lower the vehicle speeds, the stronger the health benefit.

It is possible that this Speed Limit Bill could be the catalyst for promoting alternative modes of transportation. To maximize the bill's intention, state and local municipalities must work together to enforce policies and engineer roads that reflect the desired speed limit of a road and simultaneously make concrete efforts to promote alternative modes of transportation, such as walking or biking (Appendix B).

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Appendix

Glossary of Terms

ACS	American Community Survey
BenMAP	Benefits Mapping and Analysis Program
BRFSS	Behavioral Risk Factor Surveillance System
CDC	Center for Disease Control and Prevention
CDS	Crash Data System
CMF	Crash Modification Factor
COI	Cost of Illness
COPD	Chronic Obstructive Pulmonary Disease
CTPS	Central Transportation Planning Staff
CVD	Cardiovascular Disease
ED	Emergency Department
EPA	United States Environmental Protection Agency
GIS	Geographic Information Systems
HIA	Health Impact Assessment
IHD	Ischemic Heart Disease
MAPC	Metropolitan Area Planning Council

MARPA	Massachusetts Association of Regional Planning Agencies
MassDOT	Massachusetts Department of Transportation
MDPH	Massachusetts Department of Public Health
MI	Myocardial Infarction
MIT	Massachusetts Institute of Technology
Nox	Nitrogen Oxide
PM	Particulate Matter
RMV	Registry of Motor Vehicles
RPA	Regional Planning Agency
S-R	Source-Receptor
Sox	Sulfur Oxide
SWM	Statewide Model
TAZ	Transportation Analysis Zone
TTI	Texas Transportation Institute
VHT	Vehicle Hours Traveled
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compounds
WISQARS	Web-based Injury Statistics Query and Reporting System

WONDER	Wide-ranging Online Database for Epidemiologic Research
WTP	Willingness to Pay

Technical Appendix A

Extrapolating data statewide

The Boston Region MPO's regional travel demand model served an analytical base for this study. However, since this model is focused on eastern Massachusetts, a methodology to extrapolate findings statewide was necessary. As a preliminary step, roadway segments in the current base year regional model scenario were categorized according to one of four standard functional classes – Local, minor arterial and collector, major arterial, and highway. Centroid connectors, which conceptually represent local road connections in a given TAZ, were assumed as falling into the local roadway category. The regional model works on a set of smaller geographies known as Transportation Analysis Zones (TAZs). Each TAZ contains various data parameters, such as roadway types, speeds, demographic data, and traffic volumes. Base year mobile vehicle emissions (VOC, CO, CO2, NOx, PM2.5, PM10), vehicle miles traveled (VMT), vehicle hours traveled (VHT), and congested speeds, were summed for these 4 functional classes for each TAZ.

MAPC provided a GIS layer containing the state roadways to be affected by the proposed change in speed limit. These roads were compared with the roads contained in the Boston Region MPO's regional travel demand model set. Although many of these roads are directly represented in the model, many others are assumed to be represented by the proxy of centroid connectors. To confirm the adequacy of this assumption, the model's non-matched links' lane miles were summed and compared with the lane miles for centroid connectors. Slightly more than 26,000 lane miles of local roads in the overall model region are represented by nearly 54,000 lane miles of centroid connectors.

MAPC proposed testing both a 1.8 mph and a 5 mph reduction in speed limit for the affected local roads. Because the Boston MPO regional travel demand model relies on free-flow speeds and congested speeds, and does not precisely represent posted speeds on roads, free-flow speeds were deemed closest to the actual posted speed limits. Hence, one scenario featured a 6% reduction from free-flow speeds on both centroid connectors and matched local links to represent the 1.8mph decrease in posted speed limits. Another scenario assumed a 16.67% reduction from free-flow speeds on both centroid connectors and matched local links to represent the 5mph decrease in posted speed limits. In an effort to save time and expense, the MPO model was only run for the AM peak period (6-9AM) and the midday period (9AM-3AM). It was assumed travel behavior in the PM peak period (3-6PM) would be analogous to the AM peak period and travel behavior in the nighttime period (after 6PM) would be similar to the midday period.

Following the modeling of these two scenarios, functional class summations by TAZ, similar to those prepared for the base year, were calculated for the AM and midday periods. These results (mobile vehicle emissions, VMT, VHT, and congested speeds) from each of these scenarios were individually compared and contrasted to its respective base year scenario period. The percentage change from the base year scenario was calculated for each of these time periods and scenarios. The percentage change for each TAZ's individual functional class category in the AM period was then applied to the respective TAZ's individual functional class category in the PM period. A similar process was performed between the midday and nighttime periods. This then allowed for the daily summation of each TAZ's functional classification categories as well as for the entire model region.

The second major extrapolation step occurred by aggregating the regional model TAZ geography into distinct geographic areas, designed to represent 16 possible different typologies of land use and activity densities in the CTPS model area. The two sets of below density categories representing municipal residential populations and municipal employment populations were cross-classified to produce the 16 different types of land use and activity categories. The median percentage change by time period for each of the roadway types for each of the geographic categories was calculated. These results were then used in conjunction with the Statewide Model (SWM) to develop statewide data totals. The portion of Massachusetts lying outside the CTPS model area in the Statewide Model was also divided into these same 16 categories delineated in the CTPS model. A full categorized list of the municipalities can be found in the Tables below.

1. 3000 or more persons per square mile
2. 1000 to 3000 persons per square mile
3. 300 to 1000 persons per square mile
4. Less than 300 persons per square mile

1. 3000 or more jobs per square mile
2. 1000 to 3000 jobs per square mile
3. 300 to 1000 jobs per square mile
4. Less than 300 jobs per square mile

Following this classification, it was assumed that travel behavior on roadways in each of these non-CTPS SWM model geographic areas will be similar to the assigned analogous CTPS geographic area with the reduced speed limit. The median percentage change in the relationships between the different roadway types in the CTPS district due to the local roads' speed limit change was then applied to each of the roadway types' VMT in the analogous non-CTPS SWM district to reflect this impact on roadway behavior. This was done according to time period. Temporal VMT on the roadway types in each of the non-CTPS model municipalities was calculated by applying the daily temporal breakdown of the analogous CTPS model density category by functional class to the daily VMT calculated by functional class for the municipalities in the MassDOT statewide model. Statewide data by functional class was produced by combining the CTPS model data and the aforementioned calculated data for Massachusetts municipalities located outside the CTPS model area.

It is important to note that modeling done by CTPS and other transportation agencies around the country has been frequently criticized because it does not take into account the “disappearing traffic” phenomenon, whereby reducing capacity or implementing traffic calming on one road has been repeatedly shown to lead not to displacement of the same amount of traffic to other roads, but in fact to lead to less traffic overall. The “disappearing traffic” phenomenon comes from a 2002 study that reports on 70 case studies of roadspace reallocation and an opinions from over 200 transport professionals worldwide (Cairns, Atkins, and Goodwin 2002).

Categorized list of massachusetts municipalities

Note: starred municipalities located within Boston MPO model region

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF LESS THAN 300 PERSONS PER SQUARE MILE AND LESS THAN 300 JOBS PER SQUARE MILE

Alford	Goshen	Newbury *	Tyringham
Aquinnah	Gosnold	North Brookfield	Upton *
Ashburnham	Granby	Northfield	Wales
Ashby	Granville	Oakham	Ware
Ashfield	Great Barrington	Orange	Warren
Barre	Groton *	Otis	Warwick
Becket	Hadley	Paxton	Washington
Belchertown	Hampden	Pelham	Wellfleet
Berlin *	Hancock	Peru	Wendell
Bernardston	Hardwick	Petersham	West Brookfield
Blandford	Harvard *	Phillipston	West Stockbridge
Bolton *	Hatfield	Plainfield	West Tisbury

Boylston

Brimfield

Brookfield

Buckland

Carver *

Charlemont

Charlton

Cheshire

Chester

Chesterfield

Chilmark

Clarksburg

Colrain

Conway

Cummington

Deerfield

Dighton

Douglas

Hawley

Heath

Hinsdale

Holland

Hopkinton *

Hubbardston

Huntington

Lancaster *

Lanesborough

Lee

Lenox

Leverett

Leyden

Mendon *

Middleborough *

Middlefield

Monroe

Monson

Plympton *

Princeton

Rehoboth

Richmond

Rochester

Rowe

Rowley *

Royalston

Russell

Rutland

Sandisfield

Savoy

Sheffield

Shelburne

Sherborn *

Shutesbury

Southampton

Southwick

Westhampton

Westminster

Westport

Whately

Williamsburg

Williamstown

Winchendon

Windsor

Worthington

Essex *

Florida

Freetown

Gill

New Ashford

New Braintree

New Marlborough

New Salem

Templeton

Dunstable *	Montague	Sterling	Tolland
East Brookfield	Monterey	Stockbridge	Townsend
Edgartown	Montgomery	Sturbridge	Truro
Egremont	Mount Washington	Sunderland	
Erving	Nantucket	Sutton	

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF 300-1000 PERSONS PER SQUARE MILE AND LESS THAN 300 JOBS PER SQUARE MILE

Acushnet	Lincoln *	Tyngsborough *	Shirley *
Adams	Ludlow	Uxbridge *	South Hadley
Athol	Lunenburg	Wareham	Spencer
Bellingham *	Manchester-by-the-Sea *	Wayland *	Stow *
Berkley	Marion	Wenham *	Sudbury *
Blackstone	Marshfield *	West Boylston	Swansea
Bourne	Mashpee	West Newbury *	Topsfield *
Boxborough *	Mattapoisett	Weston *	Kingston *
Boxford *	Medfield *	Wilbraham	Lakeville *
Brewster	Merrimac *	Wrentham *	Leicester
Bridgewater *	Millbury	Duxbury *	Palmer

Carlisle *	Millis *	East Bridgewater *	Pembroke *
Chatham	Millville *	Eastham	Pepperell *
Cohasset *	Norfolk *	Georgetown *	Plainville *
Dalton	North Adams	Grafton	Plymouth *
Dartmouth	Northbridge *	Groveland *	Provincetown
Dennis	Norton *	Halifax *	Salisbury *
Dover *	Oak Bluffs	Hamilton *	Sandwich
Dudley	Oxford	Hanson *	Sharon *
Ipswich *	Holliston *	Harwich	Holden

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF 300-1000 PERSONS PER SQUARE MILE AND 300-1000 JOBS PER SQUARE MILE

Ayer *	Northampton	Hanover *	Greenfield
Barnstable Town	Northborough *	Hingham *	Gardner
Concord *	Norwell *	Littleton *	Southborough *
Easton *	Orleans	Middleton *	Southbridge
Falmouth	Raynham *	Tisbury	Westfield
Foxborough *	Seekonk	West Bridgewater *	Westford *

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF 300-1000 PERSONS PER SQUARE MILE AND 1000-3000 JOBS PER SQUARE MILE

Bedford *	Westborough*

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF 300-1000 PERSONS PER SQUARE MILE AND MORE THAN 3000 JOBS PER SQUARE MILE

Woburn *

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF 1000-3000 PERSONS PER SQUARE MILE AND LESS THAN 300 JOBS PER SQUARE MILE

Dracut *	Medway *	Rockport *	Scituate *

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF 1000-3000 PERSONS PER SQUARE MILE AND 300-1000 JOBS PER SQUARE MILE

Abington *	Gloucester *	North Attleborough *
Acton *	Haverhill *	North Reading *
Agawam	Holbrook *	Pittsfield
Amesbury *	Hopedale *	Reading *
Amherst	Hudson *	Rockland *
Ashland *	Leominster	Shrewsbury
Attleboro *	Longmeadow	Somerset
Auburn	Lynnfield *	Stoughton *
Chicopee	Mansfield *	Taunton *

Clinton *	Maynard *	Tewksbury *
East Longmeadow	Methuen *	Walpole *
Easthampton	Milford *	Webster
Fairhaven	Milton *	Westwood *
Fitchburg	Nahant *	Whitman *
Franklin *	North Andover *	Yarmouth

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF 1000-3000 PERSONS PER SQUARE MILE AND 1000-3000 JOBS PER SQUARE MILE

Andover *	Holyoke *	Danvers *
Avon *	Lexington *	Dedham *
Belmont *	Marlborough *	Fall River
Beverly *	Natick *	Framingham *
Billerica *	Needham *	Saugus *
Braintree *	Newburyport *	Wellesley *
Canton *	Norwood *	West Springfield
Chelmsford *	Peabody *	Wilmington *

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF 1000-3000 PERSONS PER SQUARE MILE AND MORE THAN 3000 JOBS PER SQUARE MILE

Burlington *

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF MORE THAN 3000 PERSONS PER SQUARE MILE AND 300-1000 JOBS PER SQUARE MILE

Hull *	Marblehead*

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF MORE THAN 3000 PERSONS PER SQUARE MILE AND 1000-3000 JOBS PER SQUARE MILE

Arlington *	Revere *
Brockton *	Salem *
Brookline *	Springfield
Lowell *	Stoneham *
Lynn *	Swampscott *
Medford *	Wakefield *
Melrose *	Weymouth *
New Bedford	Winchester *
Newton *	Winthrop *
Quincy *	Worcester
Randolph *	

MASSACHUSETTS MUNICIPALITIES WITH DENSITIES OF MORE THAN 3000 PERSONS PER SQUARE MILE AND MORE THAN 3000 JOBS PER SQUARE MILE

Boston *	Malden *
Cambridge *	Somerville *
Chelsea *	Waltham *
Everett *	Watertown *
Lawrence *	

Technical Appendix B

Power model

The Power Model is a monotonic function, where the higher the speed the higher the number of collisions and the worse the health outcomes. The Power Model has been evaluated and refined over the years. We apply the most recent iteration of the model that was developed in a meta-analysis by Rune Elvik (2009). This model applies specifically to urban or residential roads and is based on results from 115 studies containing 526 estimates of the effect of changes in speed on road safety. Of the studies included in the meta-analysis, 26 were from the United States. Although results incorporated into the Power Model come from many different countries, analyses support the fact that the Power Model is consistent across countries meaning that the effects of speed on road safety are universal and are not strongly influenced by conditions that are specific to a certain country. Therefore the overall estimates for the 115 studies are valid and applicable to the United States.

The form of the model is:

(Crashes after / Crashes before) = (Speed after / Speed before)EXPONENT

The exponent differs according to traffic environment (in our case, urban and residential roads) and safety outcome. A table of potential exponents is listed below.

Category	Summary Estimates of Power (Exponent) for Urban and Residential Roads with 95% CI

Fatal Crashes	2.6 (0.3, 4.9)
Fatalities	3.0 (-0.5, 6.5)
Injury Crashes (All)	1.2 (0.7, 1.7)
Inured Road Users (All)	1.4 (0.4, 2.4)
Property Damage Only	0.8 (0.1, 1.5)

Appendix A

Power model results for all 351 municipalities in Massachusetts

CRASHES ON LOCAL ROADS				
Municipality	Community Type	Frequency	Predicted Crashes with 1.8 mph Decrease	Expected Percent Decrease in Crashes with a 1.8 mph Decrease
ABINGTON	Developing Suburbs	388	363	6
ACTON	Maturing Suburbs	128	120	6
ACUSHNET	Developing Suburbs	126	118	6
ADAMS	Developing Suburbs	82	77	6
AGAWAM	Developing Suburbs	327	306	6

AMESBURY	Regional Urban Centers	428	400	7
AMHERST	Regional Urban Centers	83	78	6
ANDOVER	Developing Suburbs	572	535	6
ARLINGTON	Inner Core	557	521	6
ASHBURNHAM	Developing Suburbs	76	71	7
ASHBY	Rural Towns	49	46	6
ASHFIELD	Rural Towns	16	15	6
ASHLAND	Maturing Suburbs	214	200	7
ATHOL	Developing Suburbs	223	208	7
ATTLEBORO	Regional Urban Centers	1,192	1,114	7
AUBURN	Developing Suburbs	558	522	6
AVON	Maturing Suburbs	59	55	7
AYER	Developing Suburbs	106	99	7
BARNSTABLE	Maturing Suburbs	78	73	6
BARRE	Developing Suburbs	54	50	7
BECKET	Rural Towns	31	29	6
BEDFORD	Maturing Suburbs	185	173	6

BELCHERTOWN	Developing Suburbs	181	169	7
BELLINGHAM	Developing Suburbs	193	180	7
BELMONT	Inner Core	746	697	7
BERKLEY	Developing Suburbs	66	62	6
BERLIN	Developing Suburbs	88	82	7
BERNARDSTON	Rural Towns	30	28	7
BEVERLY	Regional Urban Centers	474	443	7
BILLERICA	Maturing Suburbs	736	688	7
BLACKSTONE	Developing Suburbs	191	179	6
BLANDFORD	Rural Towns	10	9	10
BOLTON	Developing Suburbs	62	58	6
BOSTON	Inner Core	3,484	3,257	7
BOURNE	Maturing Suburbs	418	391	6
BOXBOROUGH	Developing Suburbs	22	21	5
BOXFORD	Developing Suburbs	17	16	6
BOYLSTON	Developing Suburbs	80	75	6
BRAINTREE	Maturing Suburbs	962	899	7

BREWSTER	Maturing Suburbs	140	131	6
BRIDGEWATER	Developing Suburbs	264	247	6
BRIMFIELD	Rural Towns	29	27	7
BROCKTON	Regional Urban Centers	4,121	3,853	7
BROOKFIELD	Developing Suburbs	33	31	6
BROOKLINE	Inner Core	550	514	7
BUCKLAND	Rural Towns	3	3	0
BURLINGTON	Maturing Suburbs	277	259	6
CAMBRIDGE	Inner Core	3,006	2,810	7
CANTON	Maturing Suburbs	265	248	6
CARLISLE	Developing Suburbs	22	21	5
CARVER	Developing Suburbs	66	62	6
CHARLEMONT	Rural Towns	6	6	0
CHARLTON	Developing Suburbs	247	231	6
CHATHAM	Maturing Suburbs	249	233	6
CHELMSFORD	Maturing Suburbs	559	523	6
CHELSEA	Inner Core	1,543	1,442	7

CHESHIRE	Developing Suburbs	42	39	7
CHESTER	Rural Towns	7	7	0
CHESTERFIELD	Rural Towns	2	2	0
CHICOPEE	Regional Urban Centers	1,496	1,399	6
CHILMARK	Rural Towns	5	5	0
CLARKSBURG	Rural Towns	2	2	0
CLINTON	Regional Urban Centers	179	167	7
COHASSET	Developing Suburbs	99	93	6
COLRAIN	Rural Towns	30	28	7
CONCORD	Maturing Suburbs	152	142	7
CONWAY	Rural Towns	16	15	6
CUMMINGTON	Rural Towns	7	7	0
DALTON	Developing Suburbs	103	96	7
DANVERS	Maturing Suburbs	308	288	6
DARTMOUTH	Developing Suburbs	629	588	7
DEDHAM	Maturing Suburbs	389	364	6
DEERFIELD	Developing Suburbs	134	125	7

DENNIS	Maturing Suburbs	124	116	6
DIGHTON	Developing Suburbs	54	50	7
DOUGLAS	Developing Suburbs	87	81	7
DOVER	Developing Suburbs	77	72	6
DRACUT	Developing Suburbs	483	452	6
DUDLEY	Developing Suburbs	273	255	7
DUNSTABLE	Developing Suburbs	8	7	13
DUXBURY	Maturing Suburbs	162	151	7
EAST BRIDGEWATER	Developing Suburbs	178	166	7
EAST BROOKFIELD	Developing Suburbs	53	50	6
EAST LONGMEADOW	Developing Suburbs	139	130	6
EASTHAM	Maturing Suburbs	46	43	7
EASTHAMPTON	Regional Urban Centers	67	63	6
EASTON	Developing Suburbs	97	91	6
EDGARTOWN	Developing Suburbs	31	29	6
EGREMONT	Rural Towns	14	13	7

ERVING	Rural Towns	18	17	6
ESSEX	Developing Suburbs	32	30	6
EVERETT	Inner Core	661	618	7
FAIRHAVEN	Developing Suburbs	1,027	960	7
FALL RIVER	Regional Urban Centers	8,063	7,538	7
FALMOUTH	Maturing Suburbs	618	578	6
FITCHBURG	Regional Urban Centers	646	604	7
FLORIDA	Rural Towns	11	10	9
FOXBOROUGH	Developing Suburbs	444	415	7
FRAMINGHAM	Regional Urban Centers	1,228	1,148	7
FRANKLIN	Developing Suburbs	344	322	6
FREETOWN	Developing Suburbs	132	123	7
GARDNER	Regional Urban Centers	647	605	6
GEORGETOWN	Developing Suburbs	69	65	6
GILL	Rural Towns	13	12	8
GLOUCESTER	Regional Urban Centers	162	151	7

GOSHEN	Rural Towns	13	12	8
GRAFTON	Developing Suburbs	265	248	6
GRANBY	Developing Suburbs	48	45	6
GRANVILLE	Rural Towns	7	7	0
GREAT BARRINGTON	Developing Suburbs	122	114	7
GREENFIELD	Developing Suburbs	173	162	6
GROTON	Developing Suburbs	92	86	7
GROVELAND	Maturing Suburbs	34	32	6
HADLEY	Developing Suburbs	134	125	7
HALIFAX	Developing Suburbs	56	52	7
HAMILTON	Developing Suburbs	47	44	6
HAMPDEN	Developing Suburbs	38	36	5
HANCOCK	Rural Towns	5	5	0
HANOVER	Developing Suburbs	162	151	7
HANSON	Developing Suburbs	78	73	6
HARDWICK	Rural Towns	17	16	6
HARVARD	Developing Suburbs	106	99	7

HARWICH	Developing Suburbs	115	108	6
HAVERHILL	Regional Urban Centers	1,878	1,756	6
HAWLEY	Rural Towns	2	2	0
HEATH	Rural Towns	12	11	8
HINGHAM	Maturing Suburbs	578	540	7
HINSDALE	Rural Towns	5	5	0
HOLBROOK	Maturing Suburbs	113	106	6
HOLDEN	Developing Suburbs	167	156	7
HOLLAND	Developing Suburbs	13	12	8
HOLLISTON	Developing Suburbs	148	138	7
HOLYOKE	Regional Urban Centers	1,445	1,351	7
HOPEDALE	Developing Suburbs	54	50	7
HOPKINTON	Developing Suburbs	142	133	6
HUBBARDSTON	Rural Towns	14	13	7
HUDSON	Developing Suburbs	186	174	6
HULL	Maturing Suburbs	128	120	6
HUNTINGTON	Rural Towns	6	6	0

IPSWICH	Developing Suburbs	100	93	7
KINGSTON	Developing Suburbs	341	319	6
LAKEVILLE	Developing Suburbs	122	114	7
LANCASTER	Developing Suburbs	192	179	7
LANESBOROUGH	Rural Towns	15	14	7
LAWRENCE	Regional Urban Centers	2,467	2,306	7
LEE	Developing Suburbs	36	34	6
LEICESTER	Developing Suburbs	166	155	7
LENOX	Developing Suburbs	65	61	6
LEOMINSTER	Regional Urban Centers	801	749	6
LEVERETT	Rural Towns	6	6	0
LEXINGTON	Maturing Suburbs	286	267	7
LEYDEN	Rural Towns	2	2	0
LINCOLN	Maturing Suburbs	14	13	7
LITTLETON	Developing Suburbs	96	90	6
LONGMEADOW	Maturing Suburbs	77	72	6
LOWELL	Regional Urban Centers	4,958	4,635	7

LUDLOW	Developing Suburbs	231	216	6
LUNENBURG	Developing Suburbs	236	221	6
LYNN	Regional Urban Centers	4,590	4,291	7
LYNNFIELD	Maturing Suburbs	74	69	7
MALDEN	Inner Core	1,207	1,128	7
MANCHESTER	Developing Suburbs	51	48	6
MANSFIELD	Maturing Suburbs	463	433	6
MARBLEHEAD	Maturing Suburbs	377	352	7
MARION	Developing Suburbs	82	77	6
MARLBOROUGH	Regional Urban Centers	526	492	6
MARSHFIELD	Maturing Suburbs	337	315	7
MASHPEE	Maturing Suburbs	133	124	7
MATTAPOISETT	Developing Suburbs	101	94	7
MAYNARD	Maturing Suburbs	26	24	8
MEDFIELD	Maturing Suburbs	104	97	7
MEDFORD	Inner Core	1,211	1,132	7
MEDWAY	Developing Suburbs	63	59	6

MELROSE	Inner Core	690	645	7
MENDON	Developing Suburbs	69	65	6
MERRIMAC	Developing Suburbs	79	74	6
METHUEN	Regional Urban Centers	780	729	7
MIDDLEBOROUGH	Developing Suburbs	552	516	7
MIDDLEFIELD	Rural Towns	1	1	0
MIDDLETON	Developing Suburbs	86	80	7
MILFORD	Regional Urban Centers	845	790	7
MILLBURY	Developing Suburbs	160	150	6
MILLIS	Developing Suburbs	31	29	6
MILLVILLE	Developing Suburbs	56	52	7
MILTON	Maturing Suburbs	824	770	7
MONSON	Developing Suburbs	64	60	6
MONTAGUE	Developing Suburbs	8	7	13
MONTGOMERY	Rural Towns	3	3	0
MOUNT WASHINGTON	Rural Towns	5	5	0
NAHANT	Maturing Suburbs	7	7	0

NANTUCKET	Developing Suburbs	221	207	6
NATICK	Maturing Suburbs	1,112	1,040	6
NEEDHAM	Maturing Suburbs	557	521	6
NEW ASHFORD	Rural Towns	5	5	0
NEW BEDFORD	Regional Urban Centers	3,700	3,459	7
NEW BRAINTREE	Rural Towns	9	8	11
NEW MARLBOROUGH	Rural Towns	15	14	7
NEW SALEM	Rural Towns	21	20	5
NEWBURY	Developing Suburbs	45	42	7
NEWBURYPORT	Regional Urban Centers	524	490	6
NEWTON	Inner Core	960	897	7
NORFOLK	Developing Suburbs	66	62	6
NORTH ADAMS	Regional Urban Centers	306	286	7
NORTH ANDOVER	Developing Suburbs	382	357	7
NORTH ATTLEBOROUGH	Developing Suburbs	642	600	7
NORTH	Developing Suburbs	28	26	7

BROOKFIELD				
NORTH READING	Maturing Suburbs	169	158	7
NORTHAMPTON	Regional Urban Centers	129	121	6
NORTHBOROUGH	Developing Suburbs	240	224	7
NORTHBRIDGE	Developing Suburbs	106	99	7
NORTHFIELD	Rural Towns	32	30	6
NORTON	Developing Suburbs	315	294	7
NORWELL	Developing Suburbs	79	74	6
NORWOOD	Regional Urban Centers	742	694	6
OAK BLUFFS	Developing Suburbs	90	84	7
OAKHAM	Rural Towns	16	15	6
ORANGE	Developing Suburbs	98	92	6
ORLEANS	Maturing Suburbs	144	135	6
OTIS	Rural Towns	7	7	0
OXFORD	Developing Suburbs	385	360	6
PALMER	Developing Suburbs	102	95	7
PAXTON	Developing Suburbs	69	65	6

PEABODY	Regional Urban Centers	701	655	7
PEMBROKE	Maturing Suburbs	180	168	7
PEPPERELL	Developing Suburbs	216	202	6
PERU	Rural Towns	5	5	0
PETERSHAM	Rural Towns	22	21	5
PHILLIPSTON	Rural Towns	24	22	8
PITTSFIELD	Regional Urban Centers	1,078	1,008	6
PLAINFIELD	Rural Towns	7	7	0
PLAINVILLE	Developing Suburbs	55	51	7
PLYMOUTH	Developing Suburbs	1,193	1,115	7
PLYMPTON	Developing Suburbs	13	12	8
PRINCETON	Rural Towns	24	22	8
PROVINCETOWN	Regional Urban Centers	13	12	8
QUINCY	Regional Urban Centers	3,072	2,872	7
RANDOLPH	Maturing Suburbs	736	688	7
RAYNHAM	Developing Suburbs	424	396	7

READING	Maturing Suburbs	365	341	7
REHOBOTH	Developing Suburbs	199	186	7
REVERE	Inner Core	552	516	7
RICHMOND	Rural Towns	20	19	5
ROCHESTER	Developing Suburbs	41	38	7
ROCKLAND	Developing Suburbs	175	164	6
ROCKPORT	Developing Suburbs	25	23	8
ROWE	Rural Towns	6	6	0
ROWLEY	Developing Suburbs	50	47	6
ROYALSTON	Rural Towns	3	3	0
RUSSELL	Rural Towns	12	11	8
RUTLAND	Developing Suburbs	101	94	7
SALEM	Regional Urban Centers	1,395	1,304	7
SALISBURY	Developing Suburbs	115	108	6
SANDISFIELD	Rural Towns	3	3	0
SANDWICH	Maturing Suburbs	258	241	7
SAUGUS	Maturing Suburbs	358	335	6

SAVOY	Rural Towns	10	9	10
SCITUATE	Maturing Suburbs	33	31	6
SEEKONK	Developing Suburbs	514	481	6
SHARON	Maturing Suburbs	190	178	6
SHEFFIELD	Rural Towns	16	15	6
SHELBURNE	Rural Towns	13	12	8
SHERBORN	Developing Suburbs	15	14	7
SHIRLEY	Developing Suburbs	82	77	6
SHREWSBURY	Developing Suburbs	776	725	7
SHUTESBURY	Rural Towns	5	5	0
SOMERSET	Regional Urban Centers	415	388	7
SOMERVILLE	Inner Core	1,882	1,759	7
SOUTH HADLEY	Developing Suburbs	312	292	6
SOUTHAMPTON	Developing Suburbs	33	31	6
SOUTHBOROUGH	Maturing Suburbs	85	79	7
SOUTHBRIDGE	Regional Urban Centers	552	516	7
SOUTHWICK	Developing Suburbs	150	140	7

SPENCER	Developing Suburbs	192	179	7
SPRINGFIELD	Regional Urban Centers	248	232	6
STERLING	Developing Suburbs	76	71	7
STOCKBRIDGE	Rural Towns	36	34	6
STONEHAM	Maturing Suburbs	311	291	6
STOUGHTON	Maturing Suburbs	686	641	7
STOW	Developing Suburbs	14	13	7
STURBRIDGE	Developing Suburbs	431	403	6
SUDBURY	Maturing Suburbs	143	134	6
SUNDERLAND	Developing Suburbs	15	14	7
SUTTON	Developing Suburbs	83	78	6
SWAMPSCOTT	Maturing Suburbs	194	181	7
SWANSEA	Developing Suburbs	343	321	6
TAUNTON	Regional Urban Centers	1,429	1,336	7
TEMPLETON	Developing Suburbs	117	109	7
TEWKSBURY	Maturing Suburbs	449	420	6
TISBURY	Developing Suburbs	120	112	7

TOLLAND	Rural Towns	2	2	0
TOPSFIELD	Developing Suburbs	54	50	7
TOWNSEND	Developing Suburbs	183	171	7
TRURO	Rural Towns	34	32	6
TYNGSBOROUGH	Developing Suburbs	160	150	6
TYRINGHAM	Rural Towns	2	2	0
UPTON	Developing Suburbs	108	101	6
UXBRIDGE	Developing Suburbs	160	150	6
WAKEFIELD	Maturing Suburbs	493	461	6
WALES	Rural Towns	7	7	0
WALPOLE	Developing Suburbs	275	257	7
WALTHAM	Inner Core	1,876	1,754	6
WARE	Developing Suburbs	167	156	7
WAREHAM	Developing Suburbs	597	558	7
WARREN	Developing Suburbs	35	33	6
WARWICK	Rural Towns	4	4	0
WASHINGTON	Rural Towns	2	2	0
WATERTOWN	Inner Core	1,005	940	6

WAYLAND	Maturing Suburbs	72	67	7
WEBSTER	Regional Urban Centers	241	225	7
WELLESLEY	Maturing Suburbs	1,463	1,368	6
WELLFLEET	Maturing Suburbs	67	63	6
WENDELL	Rural Towns	8	7	13
WENHAM	Developing Suburbs	64	60	6
WEST BOYLSTON	Developing Suburbs	142	133	6
WEST BRIDGEWATER	Developing Suburbs	55	51	7
WEST BROOKFIELD	Developing Suburbs	27	25	7
WEST NEWBURY	Developing Suburbs	30	28	7
WEST SPRINGFIELD	Regional Urban Centers	136	127	7
WEST STOCKBRIDGE	Rural Towns	9	8	11
WEST TISBURY	Rural Towns	13	12	8
WESTBOROUGH	Developing Suburbs	439	410	7
WESTFIELD	Regional Urban Centers	723	676	7

WESTFORD	Developing Suburbs	431	403	6
WESTHAMPTON	Rural Towns	7	7	0
WESTMINSTER	Developing Suburbs	173	162	6
WESTON	Maturing Suburbs	99	93	6
WESTPORT	Developing Suburbs	224	209	7
WESTWOOD	Maturing Suburbs	258	241	7
WEYMOUTH	Maturing Suburbs	1,857	1,736	7
WHATELY	Rural Towns	14	13	7
WHITMAN	Developing Suburbs	194	181	7
WILBRAHAM	Developing Suburbs	183	171	7
WILLIAMSBURG	Rural Towns	23	22	4
WILLIAMSTOWN	Developing Suburbs	50	47	6
WILMINGTON	Maturing Suburbs	160	150	6
WINCHENDON	Developing Suburbs	98	92	6
WINCHESTER	Maturing Suburbs	355	332	6
WINDSOR	Rural Towns	5	5	0
WINTHROP	Inner Core	364	340	7
WOBURN	Regional Urban	707	661	7

	Centers			
WORCESTER	Regional Urban Centers	9,027	8,439	7
WORTHINGTON	Rural Towns	5	5	0
WRENTHAM	Developing Suburbs	247	231	6
YARMOUTH	Maturing Suburbs	352	329	7

Appendix B

Traffic Calming measures (National Collaborating Centre for Healthy Public Policy 2011)

Bike box/
Sas vélo, Sas cyclable

A bike box is a facility that allows cyclists to position themselves in front of vehicles stopped at an intersection with traffic lights. This painted space on the pavement makes cyclists more visible and ensures them start-up priority when the light turns green.

Source: www.flickr.com.
Photographer: Richard Drdul.

Bike lane, Cycle lane/
Bande cyclable

A bike lane is a portion of the road reserved for the exclusive or preferential use of cyclists. Unlike a cycle track, which is physically separated from motor vehicles using the road, a bike lane is delimited by road markings. The space needed for the bike lane is generally obtained by eliminating one traffic lane, by narrowing one or several lanes, or by eliminating parking spaces for cars.

Source: www.pedbikeimages.org.
Photographer: Steven Faust.

Chicane, Serpentine, Reversing curve, Twist/
Chicane

A chicane is a series of horizontal deflections (usually three in a row) installed on an otherwise straight road to create an "S" shaped traffic lane.

Source: www.pedbikeimages.org.
Photographer: Dan Burden.

Choker, Mid-block narrowing, Pinch point, Mid-block yield point, Constriction/
Goulot d'étranglement

A choker is an isolated narrowing of one or several traffic lanes created by the installation of horizontal deflections in the centre or on the sides of the road. The term "choker," like its equivalents, is usually reserved for narrowings located other than at intersections.

Source: www.cyclestreets.net.
Photographer: unknown.

Crosswalk, Zebra crosswalk, Zebra crossing/
Passage piéton, Traverse piétonne, Traversée piétonne

A crosswalk is a facility designed to make crossing the road easier for pedestrians by delimiting a space with road markings to indicate that it is meant to be shared with pedestrians.

Source: www.pedbikeimages.org.
Photographer: Dan Burden.

Curb extension, Bulb-out, Bulbout/
Saillie de trottoir, Avancée de trottoir

A curb extension is a continuation of the sidewalk at an intersection intended to make pedestrians more visible and decrease their exposure to collisions by reducing crossing distances. A curb extension can also be used to reduce the width or the number of traffic lanes.

Source: www.flickr.com.
Photographer: Richard Drdul.

Cycle track/
Piste cyclable

A cycle track is a portion of the road reserved for the exclusive use of cyclists. Unlike a bike lane, which is delimited by road markings, a cycle track is physically separated from motorized traffic by bollards, medians, parking spaces, etc. The space needed for the cycle track is generally obtained by eliminating a traffic lane, by narrowing one or several lanes, or by eliminating parking spaces for cars.

Source: www.flickr.com.
Photographer: Eric Gilliland.

Diagonal diverters, Full diverters, Diagonal road closures/
Terre-plein diagonal, Îlot diagonal

A diagonal diverter is a raised island placed diagonally at an intersection so as to allow only right turns. Diagonal diverters can be designed to allow pedestrians and cyclists to continue on their way unobstructed.

Source: www.flickr.com.
Photographer: UrbanGrammar.

Forced-turn island, Right-turn island, Forced turn lane, Deflector island, Forced turn channelization/
Îlot de canalisation, Îlot tourne-à-droite, Îlot tourne-à-gauche

A forced-turn island is a median positioned at the approach to an intersection that orients vehicles in the desired direction or directions.

Source: Ewing, 1999, p. 29.

Full closure, Full street closure, Cul-de-sac, Dead-end/ *Fermeture de rue, Impasse, Cul-de-sac*

Full closures often take the form of barriers that prevent motor vehicles from continuing along the road, but allow pedestrians and cyclists to pass.

Source: www.pedbikeimages.org.
Photographer: Dan Burden.

Gateway/ *Portail d'entrée, Porte d'entrée*

Gateways are facilities designed to indicate entrance to a calmed area.

Source: www.pedbikeimages.org.
Photographer: Dan Burden.

Mini-roundabout, Mini-traffic circles, Intersection islands/ *Minigiratoire, Îlot circulaire*

A mini-roundabout is an intersection with a central island that is usually raised and circular. Vehicles entering the circle must yield passage to those already inside and must travel around in a counterclockwise direction.

Source: www.pedbikeimages.org.
Photographer: Dan Burden.

One-way street/
Rue à sens unique

A one-way street is a street on which vehicles are authorized to travel in only one direction. One-way streets can be used, with minimal cost, to prevent through traffic from using local residential streets instead of roads designed to handle larger traffic volumes (collector roads and arteries) to cross an area. For example, the installation of two facing one-way streets going in opposite directions can force drivers to turn onto an intersecting artery, and prevent vehicles from continuing in a straight line along local streets.


Source: www.flickr.com.
Photographer: Guillaume Goyette.

Pedestrian refuge, Median refuge/
Refuge piéton

A pedestrian refuge is a median typically located in the middle of the road to allow pedestrians to cross in two stages.


Source: NCCHPP.
Photographer: Olivier Bellefleur.

Raised crosswalk, Raised zebra crossing, Raised crossing, Hump pelican/
Passage piéton surélevé, Traverse piétonne surélevée, Traversée surélevée

A raised crosswalk is a facility designed to make crossing the road easier for pedestrians and which typically raises the pavement to the level of the sidewalks. Raised crosswalks are often made of a textured and coloured material to indicate clearly that the space is meant to be shared with pedestrians.

Source: www.pedbikeimages.org.
Photographer: Dan Burden.

Raised intersection, Raised junction, Intersection hump, Table, Plateau/
Intersection surélevée

A raised intersection is an intersection where the pavement has been raised relative to the level of the roads leading to it. The platform created by the vertical deflection is often made of a textured material and is raised to the level of the sidewalks to indicate clearly that the space is meant to be shared with pedestrians.

Source: www.cyclestreets.net.
Photographer: unknown.

Raised median, Centre island narrowing, Traffic island/
Terre-plein central, Îlot central

A raised median is a raised island usually built down the central axis of two-way roads to separate traffic going in opposite directions and reduce lane widths.

Source: www.pedbikeimages.org.
Photographer: Dan Burden.

Road diet, Lane reduction/
Régime routier

A road diet usually refers to the conversion of a four-lane road into a three-lane road, with one lane for traffic going in each direction and a central lane reserved for left turns from either direction. The space recuperated can be used to add bike lanes, sidewalks, or vegetation.

Source: www.pedbikeimages.org.
Photographer: Dan Burden.

Roundabout, Modern roundabout/
Carrefour giratoire, Giratoire

A roundabout is an intersection at which vehicles entering must yield right of way to vehicles already circulating around a central circular or oval-shaped island. To slow down traffic and induce drivers to yield right of way, there are horizontal deflections at the entrances which position vehicles to rotate in the correct direction. Roundabouts generally replace intersections with traffic signals on roads designed for quite high traffic volumes (collectors, arteries).

Source: www.flickr.com.
Photographer: WSDOT.

Speed bump, Bump/
Dos d'âne

Speed bumps, not to be confused with speed humps, are narrow vertical deflections that generally extend less than 30 centimetres across. In cars, it is easy to travel over them at very low speeds (5-10 km/h) or very high speeds, in which case the suspension system can absorb the deflection. Thus, their use is generally restricted to areas where high speeds are impractical, such as parking lots or alleyways.

Source: www.flickr.com.
Photographer: Bridget Ames.

Speed Camera/
Radar photo

Speed cameras are devices that allow vehicles exceeding the speed limit to be identified automatically.

Source: www.flickr.com.
Photographer: B.T. Indrelunas.

Speed cushions, Speed lumps/
Coussins berlinois

Speed cushions are vertical deflections designed to act on cars in the same way as speed humps, while having a minimal effect on heavy vehicles, such as emergency vehicles (fire truck, ambulance, etc.) and buses.

Source: www.flickr.com.
Photographer: Richard Drdul.

Speed hump, Road hump, Hump/
Dos d'âne allongé

Speed humps, not to be confused with speed bumps, are wide vertical deflections that typically extend three to four metres along the road. They can only be travelled over comfortably at low speeds (15-30 km/h). Thus, their use is widespread on local streets in residential neighbourhoods, in school zones, around parks, etc.

Source: www.pedbikeimages.org.
Photographer: Dan Burden.

Speed limit painted on the asphalt/ *Marquage au sol indiquant la limite de vitesse*

Road markings indicating the speed limit are often used in conjunction with other calming measures, such as vertical or horizontal deflections.

Source: www.flickr.com.
Photographer: Ian Britton.

Speed table, Trapezoidal hump, Speed platform/ *Plateau ralentisseur*

A speed table is a vertical deflection spanning the pavement, whose top is usually flat and extends far enough along the road for a car or even a heavy vehicle to rest on it. The vertical contour of speed tables allows them to be easily crossed at faster speeds than speed humps allow, which is why they are generally used on collector roads and arteries.

Source: Boulter et al., 2001, p.11.

Speed-activated sign/ *Signal lumineux activé par la vitesse*

A speed-activated sign is a device that usually indicates the speed of vehicles and whether they are travelling under or over the speed limit.

Source: www.flickr.com.
Photographer: Eric Allix Rogers.

Stop sign/
Panneau d'arrêt

A stop sign is a traffic sign indicating that drivers must stop their vehicle and wait until the lane is free before continuing on their way. Its purpose is usually to manage right of way for users of an intersection. However, it is also sometimes used as a traffic-calming measure. For example, stop signs have been used in the past to slow down traffic in certain areas, and thus make them less attractive to through traffic.

Source: www.flickr.com.
Photographer: Bridget Ames.

Textured crosswalk, Textured crossing/
Passage piéton texturé, Traverse piétonne texturée, Traversée texturée

A textured crosswalk is a facility designed to make crossing the road easier for pedestrians and which is made from a textured, and often coloured, material to indicate clearly that the space is meant to be shared with pedestrians.

Source: www.pedbikeimages.org.
Photographer: Richard Drdul.