September 2016

Rapid Health Impact Assessment (HIA) On The Implementation Of High Occupancy Toll (HOT) Lanes On Highways In Toronto

Faiza Waheed, PhD, MEnvSc
Postdoctoral Fellow

UNIVERSITY OF TORONTO
DALLA LANA SCHOOL OF PUBLIC HEALTH

intrinsik
SCIENCE INTEGRITY KNOWLEDGE

Acknowledgements

The following individuals provided invaluable assistance and guidance in the development of this Rapid HIA.

Postdoctoral supervisors of the author:

Donald Cole, MD, FRCP(C)- Professor, Dalla Lana School of Public Health, University of Toronto
Glenn Ferguson, PhD- Vice President- Eastern Region, Senior Environmental Health Scientist, Intrinsik Corp.

Project Advisory Committee:

Donald Cole
Glenn Ferguson
Ronald Macfarlane, Manager, Healthy Public Policy, Toronto Public Health

Stakeholders who participated in the Scoping workshop and/or provided assistance in specific sections of the HIA:

Members of the Project Advisory Committee
Douglas Bryant, Senior Associate Scientist, Intrinsik
Ray Copes, Chief, Environmental and Occupational Health, Public Health Ontario
Matthew Davis, Senior Transportation Planner, Toronto Transportation Services
Melissa Evers, Team Lead, Environmental Policy Office, Ministry of Transportation of Ontario
Kevork Hacatoglu, Senior Policy Analyst, Ministry of Transportation of Ontario
Stewart Houghton, Senior Economic Advisor, Ministry of Transportation of Ontario
Kim Jarvi, Senior Economist, Registered Nurses' Association of Ontario
JinHee Kim, Public Health Physician, Environmental and Occupational Health, Public Health Ontario
Lindsay McCallum, Environmental Health Scientist, Intrinsik
Peter Miasek, President, Transport Action Ontario
Leila Monib, Health Equity Specialist, Toronto Public Health
Jake Schabas, Senior Advisor, Metrolinx
Kevin Vuong, Co-Chair, Toronto Youth Equity Strategy

Funding: This postdoctoral project was funded by MITACS, a national non-profit organization committed to building partnerships that support industrial and social innovation in Canada, and Intrinsik Corp.

Disclaimer: The author, Faiza Waheed, takes sole responsibility for any errors (of omission or commission) in this report.

Summary

Traffic congestion is a growing problem in the Greater Toronto and Hamilton Area (GTHA). As the population of the region grows, implementation of new sustainable transportation measures, as well as improvement of the measures that currently exist becomes more important. Currently, the dominant mode of transport in the GTHA is driving. However, if the region is to reduce congestion, which costs the GTHA $6 billion per year (Metrolinx, 2008a), improve air quality and reduce commute times, regional congestion management measures are needed. High Occupancy Toll (HOT) lanes are a type of congestion pricing policy that allow High Occupancy Vehicles (HOV), transit and emergency vehicles to travel for free, but charge Single Occupancy Vehicles (SOV) a toll to use the lane(s). Depending on the jurisdiction in which they have been implemented, HOT lane tolls may be variable depending on the time of use and level of congestion (for example, rush hour vs night time). In the United States, several cities such as Minneapolis and San Diego have converted underused or congested HOV lanes to HOT lanes.

The Ontario Ministry of Transportation recently announced a pilot project to convert an existing HOV2+ lane to a HOT lane on a 16.5 km stretch of the Queen Elizabeth Way (QEW), a major highway in the GTHA (MTO, 2016). More locally, Toronto Transportation Services conducted a preliminary study for Toronto City Council on the implications of implementing HOT lanes on Toronto's highways: the Gardiner Expressway and the Don Valley Parkway (DVP). The report (City of Toronto, 2015) suggested that *"A review of the transportation impacts of the tolling system indicates that tolling would have a small but positive effect on travel times on the Gardiner Expressway and Don Valley Parkway. Under the $3 flat toll scenario, travel times would be reduced by three to five minutes. On a system-wide basis, the tolling system has a very small but still positive effect on overall network performance."* The major difference between Toronto's highways and those in the GTHA, which are under the jurisdiction of the Province of Ontario, is that the Gardiner and the DVP do not have any HOV lanes and are, in some places, only three lanes in each direction. Currently, HOV lanes only exist on specific sections of three highways in the wider GTHA: the QEW, Highway 403 and Highway 404. In all other sections and other highways, including the Gardiner and the DVP, tolling would require converting one General Purpose Lane (GPL) to a HOT lane.

Previous studies on HOT lanes that have been successful show that they reduce traffic congestion not only in the tolled lanes, but also in the GPLs (Goel and Burris, 2012). HOT lane efficiency is dependent upon several city-specific factors, including level of traffic congestion, population density, transit ridership, etc. (Canada's Ecofiscal Commission, 2015). Moreover, HOT lanes can generate much-needed revenue that can potentially be utilized not only in the maintenance of the HOT lanes, but also to improve public transit. This investment in public transit has tremendous gains for a society over the long term, as better, more connected and frequent transit service not only encourages commuters towards higher physical activity levels but also towards a potential mode shift from driving. Increased physical activity reduces chances of chronic illnesses such as diabetes, cardiovascular disease, and obesity (Rissel et al., 2012; Improving Health by Design, 2014).

Hence, transportation mode and availability play a major role in determining health and can have both positive and negative impacts on health. The positive impacts of transportation include access to goods and services, healthcare, employment, education and recreational

activities, increased mobility and social cohesion, and increased physical activity (i.e., active transportation). Negative impacts of motorized transportation include air and noise pollution, traffic-related injuries, traffic congestion (including reduced discretionary time), and reduced physical activity. Yet, although transportation infrastructure and policy can have impacts on health and the determinants of health, this connection is not oft explored. In order to evaluate potential health impacts of the implementation of HOT lanes in Toronto, and more generally in the GTHA, this rapid Health Impact Assessment (HIA) was conducted.

Health Impact Assessment (HIA) is a process by which the magnitude and distribution of broad potential health impacts of a project, plan or policy can be forecasted (WHO, 1999). The process consists of a series of six core steps that may be iterative: Screening, Scoping, Assessment, Recommendations, Reporting, and Evaluation and Monitoring. This rapid HIA was conducted as part of a postdoctoral fellowship by Dr. Waheed to evaluate the potential health impacts of implementing HOT lanes on highways in Toronto and the GTHA.

To ensure that health concerns arising from the transportation policy were well represented in the rapid HIA, a focussed scoping workshop with key stakeholders was held on February 9, 2016. The workshop resulted in a refined scope for the HIA, which included qualitative assessment of the following five determinants of health:

- Congestion
- Mobility and accessibility
- Social capital and social cohesion
- Air quality
- Equity considerations and socioeconomic factors

Due to the rapid nature of the HIA, assessment was limited to qualitative assessment of the above determinants of health using the following data sources:

- Literature search (peer-reviewed and non-peer-reviewed literature) on known impacts of congestion pricing on health and each determinant of health
- Qualitative assessment of impact of HOT lanes on each determinant of health
- Qualitative assessment of impact of reduction in congestion/travel time on potential change in health
- Assessment of jurisdictional data on known impacts of congestion pricing on overall congestion and air quality
- Comparison of travel times on HOV lanes (during the 2015 Toronto Pan Am games) to GPLs (using existing data)
- Identification of existing data with geomapping of poverty and racialization on to maps of interchanges with high congestion and more pollutants

The table below provides a high-level summary of the key findings from the rapid HIA on some potential impacts on health (specifics and then impact direction) due to implementation of HOT lanes on highways in Toronto, compared to HOV lanes and business as usual (BAU):

	HOT lane	**HOT lane + revenue invested in transit**	**HOV lane**	**BAU**
Congestion	• Depending on the pricing, most likely little or no congestion in the HOT lane and likely reduced congestion in GPLs • Improved travel reliability and speed for transit	• If revenue invested in public transit, greater travel time savings, and possible increase in transit use with accompanying benefits to all determinants of health	• Little or no congestion in HOV lane as it may be potentially underused. Likely increased traffic congestion in the two GPLs • Improved travel reliability and speed for transit	• Continued traffic congestion in all lanes. May get worse as increase in population predicted, which will increase traffic volume • No change in transit use
Impact direction	Neutral-positive	Positive	Neutral-negative	Negative
Mobility and Accessibility	• Substantial increase in mobility and accessibility for users who can afford tolls • By charging some for use of HOT lane, traffic volume on GPLs may reduce, with higher mobility and accessibility for all	• Increased mobility and accessibility for all users in Toronto, and those to commute to and from Toronto	• HOV-compliant and transit users have higher mobility and accessibility • GPL users have neutral or negative impact	• Overall neutral, or more likely substantial negative impact on mobility and accessibility for all users
Impact direction	Neutral-Positive	Positive	Neutral	Negative
Social Capital and Cohesion	• Lack of effective communication and outreach to public before HOT lane implementation may negatively affect social cohesion. However, case studies show public support for congestion pricing policies increased after implementation, provided time savings are achieved • Improved travel times due to HOT lanes may increase travel time	• Increased travel time savings lead to increased discretionary time available for social networking; increased overall social value for all income groups, but especially for low-income groups with higher bus/transit	• HOV compliant users with higher time savings reap greater social capital rewards • Non-HOV compliant GPL users face higher congestion and reduced time savings for social networking.	• If congestion levels don't change, neutral-negative impact on overall time savings and level of social interaction • If congestion increases with increased population growth, substantial negative impact on social capital and cohesion in

	HOT lane	HOT lane + revenue invested in transit	HOV lane	BAU
	savings and hence social capital for all users • HOT lanes offer added choice to drivers, especially when time savings are of greater value than cost of tolls, regardless of income group	usage		Toronto, and for all those commuting to and from Toronto
Impact direction	Neutral-Positive	Positive	Neutral-Negative	Negative
Air Quality	• No significant difference overall air quality	• Air quality improvement more likely as increased transit use may lead to fewer SOVs on the road	• Due to chronic underuse, HOV lanes have not, historically, resulted in overall air quality changes • Air quality along HOV lane specifically might be better due to lower traffic volume	• Due to projected increase in population, and hence, traffic volume, air quality may deteriorate if no alternative mode of transportation is promoted. • Transit on highways may be negatively impacted by increasing congestion
Impact direction	Neutral	Neutral-Positive	Neutral	Negative
Equity considerations and Socioeconomic factors	• Case studies in the US show that all income levels use HOT lanes; although usage among high-income groups is higher • If tolls not variable and not implemented judiciously, likelihood for negative impact on equity	• Low-income groups more likely to use transit in Toronto. Potential negative impacts on equity due to HOT lanes mitigated with increased transit spending and use	• Neutral impact on equity due to HOV lanes • Improved travel time for buses on HOV lanes may have positive impact on equity, as low-income groups tend to use transit more	• Increased or continuing congestion on highways may negatively impact transit/bus travel, resulting in increased travel times for those who use transit most
Impact direction	Neutral-negative	Neutral	Neutral	Negative

Table of Contents

List of Figures

List of Tables

List of Abbreviations

BAU	Business As Usual
CAC	Criteria Air Contaminant
CIHI	Canadian Institute for Health Information
COPD	Chronic Obstructive Pulmonary Disease
DOH	Determinant of Health
DVP	Don Valley Parkway
ETL	Express Toll Lane
FHWA	Federal Highway Authority
GHG	Greenhouse Gas
GPL	General Purpose Lane
GTA	Greater Toronto Area
GTHA	Greater Toronto and Hamilton Area
HIA	Health Impact Assessment
HEI	Health Effects Institute
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
IBTTA	International Bridge, Tunnel and Turnpike Association
MOHs	Medical Officers of Health
MTO	Ministry of Transportation of Ontario
NCHRP	National Cooperative Highway Research Program
NGO	Non-Governmental Organization
NO_x	Nitrogen oxides
PAC	Project Advisory Committee
PHO	Public Health Ontario
PM	Particulate Matter
RCCAO	Residential and Civil Construction Alliance of Ontario
QEW	Queen Elizabeth Way
SOV	Single Occupancy Vehicle
SO_x	Sulphur oxides
TDM	Traffic Demand Management
TPH	Toronto Public Health
TRAP	Traffic-Related Air Pollution
TRB	Transportation Research Board
UCLA HIA-CLIC	University of California at Los Angeles Health Impact Assessment Clearinghouse Learning and Information Centre
UFP	Ultra Fine Particles
VKT	Vehicle Kilometers Travelled
VMT	Vehicle Miles Travelled
VOC	Volatile Organic Compounds
WHO	World Health Organization

1. Introduction and Background

Traffic congestion costs the Greater Toronto and Hamilton Area (GTHA) $6 billion yearly (in 2006 Canadian dollars), and includes the price of lost wages, lost time and the cost of fuel (Metrolinx, 2008a). This price tag for congestion can climb to $11 billion annually when the social costs of families and residents foregoing social activities are included (Dachis, 2013). Moreover, according to a recent report, "*Improving Health by Design in the GTHA*", published by the Medical Officers of Health (MOHs) in the GTHA, traffic-related emissions in the GTHA are estimated to cause 712-997 premature deaths yearly, with an economic impact of over $4.6 billion per year (Improving Health by Design, 2014). The cost of doing nothing to reduce congestion may end up costing the GTHA $15 billion annually by 2031, which includes the costs of delay to commuters and the economy (Metrolinx, 2008a). Congestion pricing, and High Occupancy Toll (HOT) lanes specifically, are a part of Metrolinx's *The Big Move* strategy to generate much-needed revenue for building transit infrastructure, but they're also part of a recommended strategy to reduce congestion and get Toronto and the GTHA moving more efficiently (AECOM|KPMG, 2013; Canada's Ecofiscal Commission, 2015; Dachis, 2011; Srivastava and Burda, 2015; Hall, 2016; Toronto Board of Trade, 2010). The "*Big Move Implementation Economics: Revenue Tool Profiles*" report, commissioned by Metrolinx, a Government of Ontario agency created to improve the coordination and integration of all modes of transportation in the GTHA, provides detailed context of implementation of HOT lanes in the GTHA (AECOM|KPMG, 2013).

1.1. Congestion Pricing and High Occupancy Toll (HOT) Lanes

Congestion pricing is a transportation policy that puts a price on road use to control demand and alleviate traffic congestion (Verhoef et al., 2008). The aim is to implement a (usually) small fee in order to reduce congestion and benefit road users, the environment, businesses and the local economy. It is a charge on driving/road use that is added to the cost of fuel and other vehicle taxes. Congestion pricing also contributes to making drivers pay the full cost of this mode of transportation.

High Occupancy Toll lanes are a type of congestion pricing policy. They are customarily single lanes that may be barrier-separated and allow High Occupancy Vehicles (HOVs) to travel for free but charge Single Occupant Vehicles (SOVs) a toll to access the lane. HOT lanes may allow HOVs with either two or three occupants to travel for free (HOV2+ or HOV3+, respectively). In almost all cases, public transit and emergency vehicles use HOT lanes for free. Additionally, depending on the jurisdiction where they have been implemented, HOT lanes may also have variable pricing that reflects the level of congestion in real time - when congestion in the General Purpose Lanes (GPLs) (i.e. the free lanes) is high, tolls are adjusted to optimize traffic flow. The recent report on revenue tools commissioned by Metrolinx (AECOM|KPMG, 2013) as well as the report by the C.D. Howe Institute on "*Congestive Traffic Failure: The Case for High-Occupancy and Express Toll Lanes in Canadian Cities*" (Dachis, 2011) provide a policy brief on the use and benefits of HOT lanes and their application in the GTHA/Canadian context. A short summary is provided here.

Regional networks of HOT lanes, rather than isolated instances are most effective due to the greater reliability of travel time offered over a longer distance (Dachis, 2011). The United States currently has over 470 km of HOT lanes, with more being added every year (Urban Land Institute, 2013). Also called Express Toll Lanes (ETLs), HOT lanes in the United States are usually converted from underused HOV lanes. Different technologies are used to charge non-compliant vehicles; the more common being a transponder on the car or through photographing the license plates (Dachis, 2011). Vehicles enter and exit HOT lanes at clearly marked points, and if the toll is variable, the current toll is also clearly indicated at the entrance points. Similar to the current billing system employed by the fully tolled 407 Express Toll Route (ETR) highway in the GTHA, bills for use of HOT lanes are mailed monthly to the user.

1.2. Policy Context: HOT lanes in Toronto and the GTHA

Historically, decision-makers within the Province of Ontario and its municipalities have shown reluctance to discuss tolling of roads and highways; potentially due to the unpopularity of road pricing within the Province. However, congestion pricing, in general, and HOT lanes in specific, have been gaining momentum in Ontario and more widely in North America. This may be evident in the large number of articles and reports published in North America in the last several years on congestion pricing, including: Hall, 2016; Dachis, 2011; Srivastava and Burda, 2015; Canada's Ecofiscal Commission, 2015; Finkleman et al., 2011; Urban Land Institute, 2013; Ecola and Light, 2009; Lindsey, 2007; Lindsey, 2012; Finkleman, 2010; and Chicago Metropolitan Agency for Planning, 2012. Although widely distributed in the United States, HOT lanes were absent in Ontario, until recently, when the Minister of Transportation of Ontario announced a HOT lane pilot project on a 16.5 km stretch of the Queen Elizabeth Way (QEW), a major highway in the GTHA. The pilot, which begins in September 2016 and may last 2-4 years, converts the existing HOV lane on the QEW to a HOT lane and charges non-HOV2+ users a $60 flat monthly fee for a HOT permit (MTO, 2016). More locally, the City of Toronto General Manager of Transportation Services submitted a preliminary report to Toronto City Council on implementation of HOT lanes on highways in Toronto (i.e. the Gardiner Expressway and the Don Valley Parkway (DVP)):

"A review of the transportation impacts of the tolling system indicates that tolling would have a small but positive effect on travel times on the Gardiner Expressway and Don Valley Parkway. Under the $3 flat toll scenario, travel times would be reduced by three to five minutes. On a system-wide basis, the tolling system has a very small but still positive effect on overall network performance."

And added:

"The findings in this study are limited by its scope as a planning-level review based on a range of input assumptions. Further refinement under detailed study and/or preliminary design is needed to develop detailed cost estimates and revenue forecasts. It is therefore recommended that City Council authorize the General Manager of Transportation Services to undertake a more detailed study on tolling and pricing of the Gardiner Expressway and Don Valley Parkway, including, but not limited to, more detailed cost and revenue projections, impacts on other elements of the transportation network, and impacts on economic competitiveness and to report back to the Executive Committee in 2016."

-(City of Toronto, 2015)

The major difference between Toronto's highways and those in the GTHA, which are under the jurisdiction of the Province of Ontario, is that the Gardiner and the DVP do not have HOV lanes and are, in some places, only three lanes in each direction. Tolling the Gardiner or the DVP would require converting one of the three GPLs to a HOT lane. The other highways in the GTHA, including the QEW, Highway 401, Highway 403, Highway 400, Highway 410, Highway 404 and Highway 427, are, in general, wider and bigger, though only the QEW and Highway 403 have HOV lanes in some sections.

1.3. Some lessons learned from existing HOT lanes

The efficiency of HOT lanes may depend on the jurisdictional context of implementation. According to a recent case study presented by Canada's Ecofiscal Commission on the MnPASS HOT lanes in Minnesota, city-specific factors, such as existing network and use of HOV lanes, level of traffic congestion, population density, transit ridership, enforcement capacity, use of other concurrent traffic demand management strategies, and public perception play a vital role in the success and efficacy of HOT lanes (Canada's Ecofiscal Commission, 2015; Eisele et al., 2006; Transport Canada, 2010). In instances where they have been successful, HOT lanes reduce traffic congestion not only in the tolled lanes, but also in the GPLs (Poole and Orski, 2000; Goel and Burris, 2012); although free-flow conditions in the GPLs were less optimal than in the HOT lanes (Government of Minnesota, 2013; Metropolitan Transportation Commission, 2007). One of the most important lessons learned from HOT lanes has been that they provide users with a choice between paying the toll and reducing travel time (dependent on urgency of trip), or using the free GPLs. Depending on how much drivers value their time, they can optimize their travel conditions.

An added benefit of congestion pricing/HOT lanes is that it generates revenue, which apart from being used for maintenance of the road/highway tolling infrastructure can also potentially be invested in public transit funding (AECOM|KPMG, 2013). This investment in public transit has tremendous gains for a society over the long term, as better, more connected and frequent transit service encourages commuters towards a mode shift from driving. This further increases physical activity levels and potentially reduces the risk for obesity and chronic diseases (reviewed in Rissel et al., 2012; Improving Health by Design, 2014). While implementation of HOT lanes is unlikely to be the 'silver bullet' solution to the twin problems of traffic congestion and lack of adequate funding for implementation of *The Big Move*, it is a potentially useful tool in the traffic demand management (TDM) toolbox that together with other policies and TDM strategies may reduce congestion and generate revenue.

1.4. Transportation and health in Toronto and the Greater Toronto and Hamilton Area (GTHA)

1.4.1. What shapes people's health?

There are many factors that impact human health beyond our biology, genetics and immediate physical environments. Figure 1 shows the diverse range of impacts we experience and the social, economic, political, community, behavioural, public and livelihood factors that determine our health. These factors that determine/influence health, or Determinants of Health (DOH), can be changed and improved to benefit whole community or population health; yet they are not normally assessed in the planning of major infrastructure projects, which may have the potential to impact community health for decades to come.

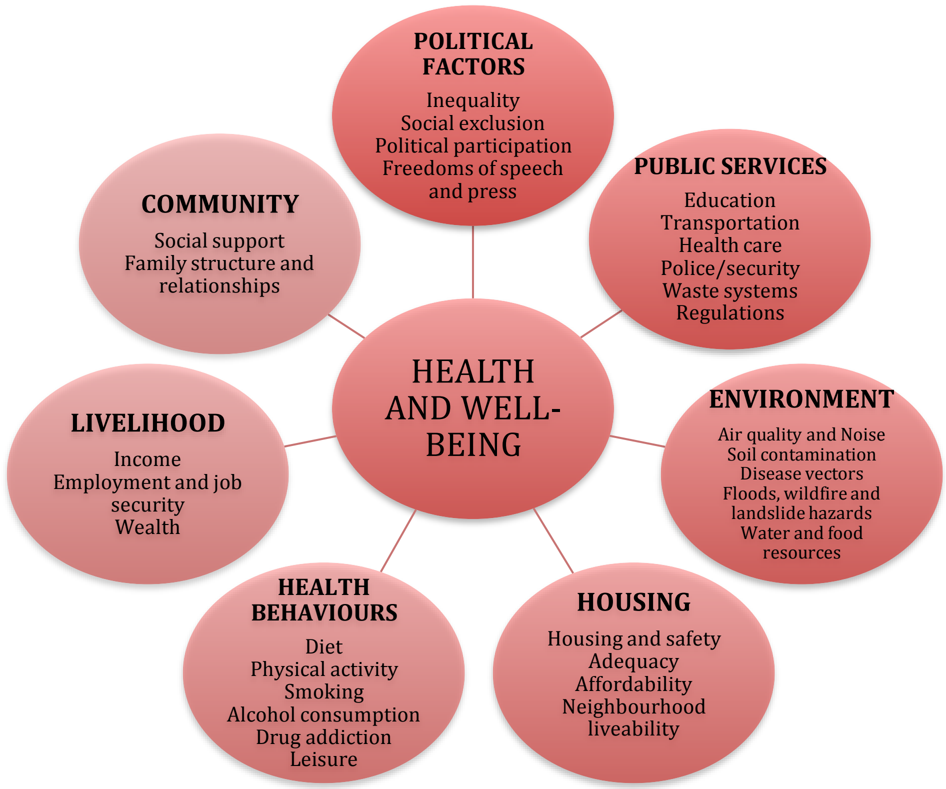

Figure 1: The determinants of health and well-being. Adapted from Bhatia (2011).

1.4.2. Transportation infrastructure and planning shapes our health

The links between public health and transportation have been increasingly acknowledged and explored. Transportation can have both positive and negative impacts on health. The positive impacts include access to goods and services, healthcare, employment, education and recreational activities, increased mobility and social cohesion, and increased physical activity (i.e., active transportation). Negative impacts of motorized transportation include air and noise pollution, traffic-related injuries, traffic congestion, reduced discretionary time, and reduced physical activity.

As cities grow and become more urbanized, balancing transportation needs while optimising public health is vital. The amount of time spent by individuals commuting by car has steadily increased in Toronto and in major cities in North America (CIW, 2014; Statistics Canada, 2013; Texas A&M Transportation Institute, 2015). In Toronto, commute times increased from an average of 32.8 minutes one way in 2011 (Statistics Canada, 2013) to an average of 42 minutes one way in 2013 (Oxford Properties and Environics Research Group, 2013). This time could instead be spent working, playing, relaxing, or engaging in social activities. The mode of transportation chosen has far-reaching and long-lasting impacts on air quality, noise pollution, climate change, physical activity levels and risks for acute and chronic diseases (Toronto Public Health, 2013). Equitable transportation planning and infrastructure growth that enables communities to connect and access their day-to-day activities, goods and services, while also promoting physical activity, may have the most beneficial impacts on urban health and equity (reviewed in Dora and Hosking, 2012). Hence, funding and designing affordable transport systems that promote equal access to employment, education, goods and services is vital to support the economic, environmental and social needs of Toronto and the wider Greater Toronto and Hamilton Area (GTHA).

1.4.3. Population growth in the GTHA

The current population of Toronto is 2.8 million people (City of Toronto, 2016). The map in Figure 2 below shows areas in the city of Toronto that have experienced mid-to-high levels of population growth. The darkest green shows parts of the downtown core that experienced the most growth. The downtown core has experienced significant intensification between 2006 and 2011, and according to recent reports, continues the trend of intense growth (Neptis Foundation, 2015a). According to a recent report, "*Improving Health by Design in the GTHA*", published by the Medical Officers of Health (MOHs) in the GTHA (Improving Health by Design, 2014), the population of the GTHA is expected to continue its rapid growth and add another 2.2 million people to the area by 2031 (Improving Health by Design, 2014). This, according to the report, is "equivalent to moving the current populations of the cities of Montreal and Vancouver into the GTHA". Enabling efficient transportation infrastructure and policies to move everyone is a major priority for the GTHA. The GTHA Growth Plan encourages and promotes intensification to accommodate this forecast increase in the population of the GTHA (Places to Grow, 2016). Additionally, the Ontario Population Projections Update from the Ministry of Finance reports an expected population growth of 42.9% by 2041 within the Greater Toronto Area (GTA) alone, the fastest growing region in Ontario. According to this update by the Ministry, by 2041 the GTA population could reach 9.5 million people (Ontario Ministry of Finance, 2016). This would add more cars to the road and increase traffic congestion.

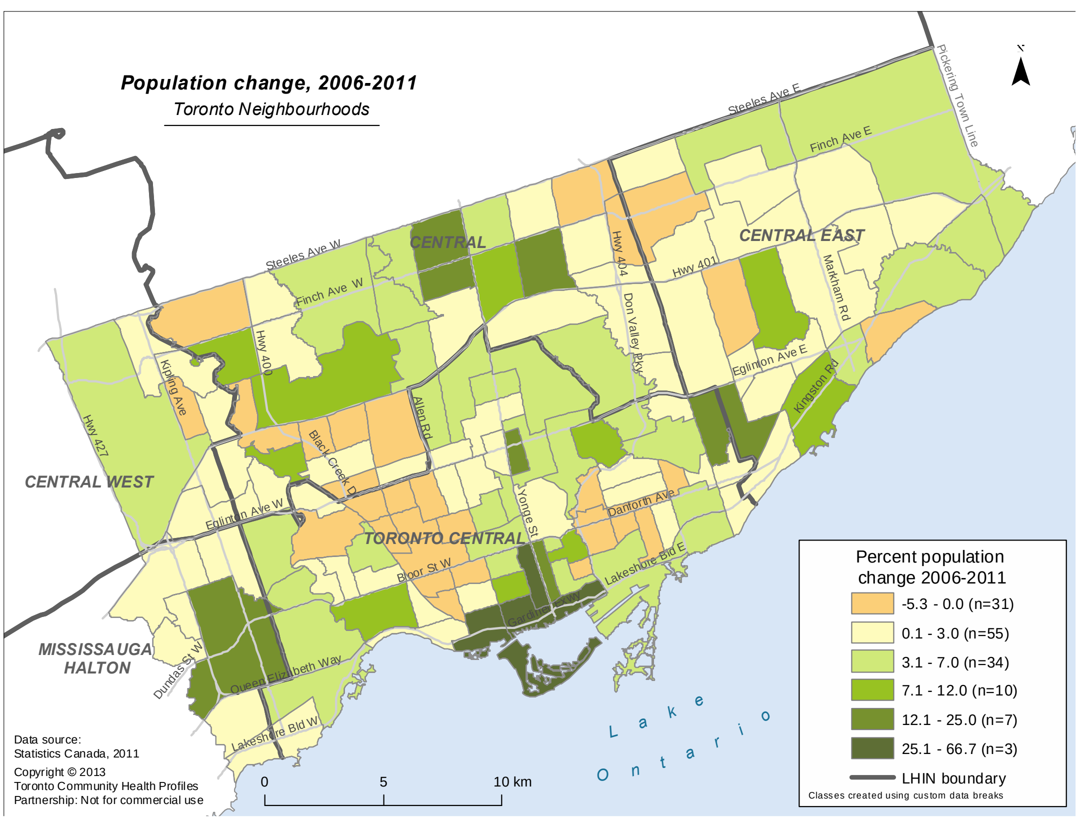

Figure 2: Percent population change in Toronto from 2006-2011. Source: Toronto Community Health Profiles

1.4.4. Health Implications of urban growth patterns

The MOHs report highlights the importance of optimal accommodation of population growth in the region as this has significant implications for:

- Traffic congestion and economic prosperity
- Greenhouse Gas (GHG) emissions
- Air pollution
- Public health

As such, transportation is a priority issue for the GTHA. How people move/travel to work, school and all other everyday destinations is a significant contributor to the overall levels of physical activity achieved. Walking, cycling and using public transit to travel increases physical activity and can only be achieved with a shift in mode of transportation, which is currently heavily oriented towards driving. Increased physical activity, in turn, has significant potential positive health impacts. These impacts are limited not only to the reduction in incidence of widely prevalent chronic diseases, such as diabetes, heart disease, cancer and obesity, but may also extend to the reduction in air pollution due to reduced transportation-related emissions and reduction in traffic congestion (Improving Health by Design, 2014). According to the report published by Cancer Care Ontario and Public Health Ontario "*Taking Action to Prevent Chronic Disease: Recommendations for a Healthier Ontario*" in 2007, chronic diseases, including cancers, cardiovascular diseases, chronic respiratory disease and diabetes were responsible for 79% of all deaths in the province (Cancer Care Ontario, 2012). As identified in Table 1 below, chronic disease incidence rates present a great health challenge; rates of obesity and diabetes have rapidly increased, and depending on the disease, physical inactivity accounts for a significant percentage of the cases (Bull et al., 2004). Hence, of the four interventions identified to prevent incidence of these chronic diseases, increasing physical activity is a major recommendation (Cancer Care Ontario, 2012).

Table 1: Number of Incident Cases of Chronic Diseases Attributable to Physical Inactivity, GTHA (Table from *Improving Health by Design, 2014*).

Disease	Total Incident Cases	Physical Inactivity Attributable Fraction	Number of Incident Cases Attributable to Physical Inactivity
Diabetes	56,956	22.1%	12,588
Ischemic Heart Disease*	7,006	26.9%	1,887
Ischemic Stroke*	4,632	18.7%	867
Colon Cancer**	2,547	24.5%	623
Breast Cancer**	4,211	19.4%	818

The number of new cases reflects the average for the years 2005 to 2009.
Estimates of physical activity are obtained from 2011–2012 Canadian Community Health Survey. Physical inactivity includes moderately active and inactive categories.
The relative risks used to calculate the physical inactivity-attributable risk fraction obtained from: Bull et al., 2004.
*Incidence data obtained from Institute for Clinical and Evaluative Sciences, special data request.
**Cancer incidence estimates obtained from Cancer Care Ontario – SEER*Stat October 2012 release.

The Big Move is the Ontario government's plan to increase public transit and modes of active transportation (cycling and walking) (Metrolinx, 2008b). Physical inactivity and obesity now costs the GTHA $4 billion annually, which includes the direct medical costs of $1.4 billion (Improving Health by Design, 2014). Figure 3 depicts the balance between the potential investments, including *The Big Move*, and the benefits gained (Improving Health by Design, 2014). It is evident from the figure that the benefits of the proposed investment outweigh the costs. Implementation of *The Big Move* over the next 25 years is expected to cost approximately $50 billion in capital investments for public transit and transportation systems in the GTHA.

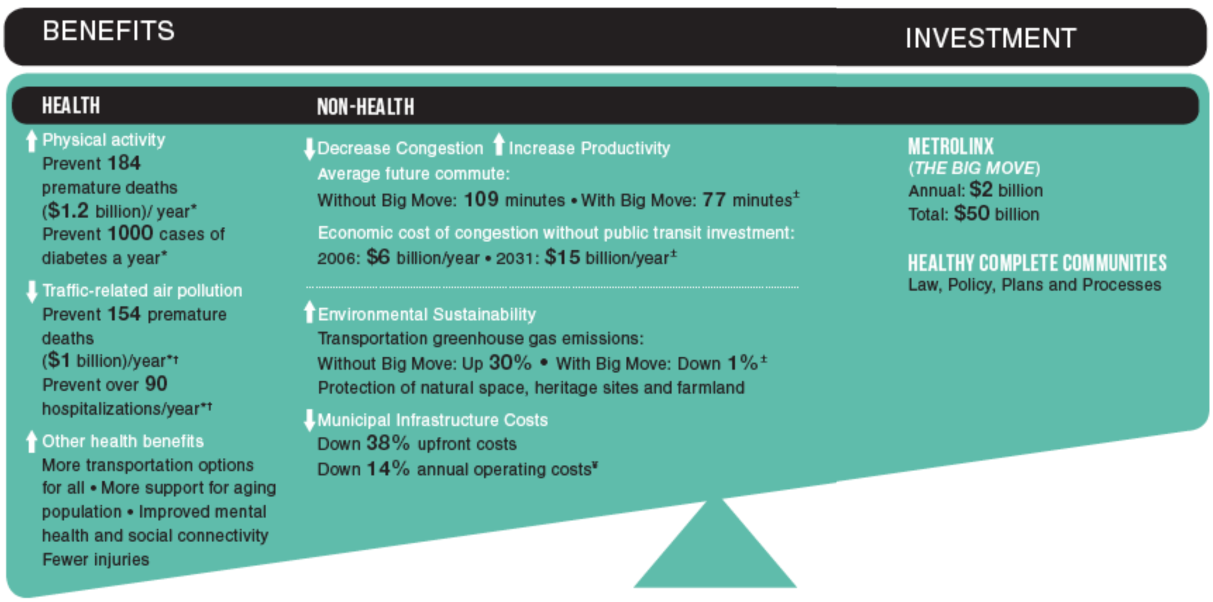

Figure 3: A summary of the balance between benefits gained and the cost of investing in *The Big Move* and *Healthy Complete Communities*. Image taken from "*Improving Health by Design in the GTHA*" (2014).

2. Health Impact Assessment Approach

As discussed, transportation projects and policies have far-reaching short- and long-term impacts on the health of the population in which they are implemented; yet their potential impact on the determinants of health is seldom assessed. Instead, evaluation is limited to Environmental Impact Assessments, which primarily assess the physical impacts to health, including impacts due to air pollution, exposure to chemical contaminants, and noise pollution. As public appetite for evaluating broad health implications of major infrastructure projects, plans and policies gains more traction, a newer health impact evaluation process called Health Impact Assessment (HIA) has been increasingly implemented since the late 1990s.

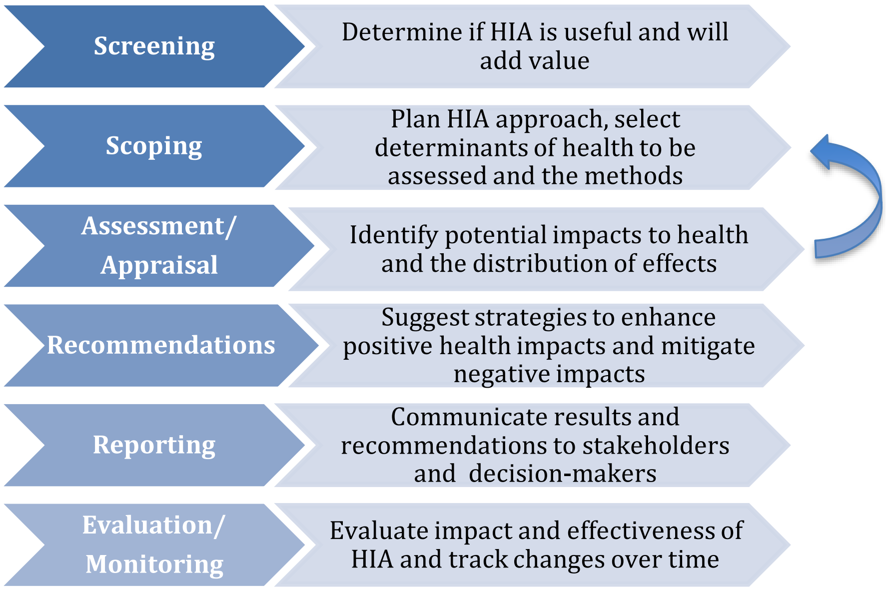

Figure 4: Core steps of an HIA. Taken from Waheed et al. (submitted manuscript). The arrow indicates the iterative nature of some of the steps.

Increasingly, HIAs have been used internationally to assess the health impacts of transportation projects, policies, plans and programs (reviewed in Waheed et al., unpublished manuscript). Waheed and colleagues identified 154 HIAs as part of a systematic scoping review conducted globally on transportation-related projects, policies, plans and programs (Waheed et al., unpublished manuscript). The review incorporated HIAs conducted since 2000 and reported in English. The evidence-informed multi-disciplinary approach taken by an HIA allows it to bring together experienced stakeholders from traditionally siloed public health and transportation planning backgrounds. Although usually conducted by public health departments, HIAs are gaining traction in other sectors, such as in the housing and oil and gas development industries. If a proposed HIA passes the screening step and is seen as a useful and valuable analysis, a 'Rapid' HIA with minimal budget, resources and timeline requirements can be undertaken. With more interest, funding and time availability, longer and more detailed 'Intermediate' and 'Comprehensive' HIAs can be conducted. Depending on the timeline and the resources available, detailed HIAs can collect quantitative data on air, noise and water pollution in the project area, as well as conduct surveys on other community-identified potential impacts. Additionally, for criteria such as air quality, potential future changes that may occur due to project or policy implementation can be modelled.

The next sections describe in detail the different steps of this Rapid HIA, including the rationale and funding (sections 3), scope (section 4), findings (section 5), conclusions and recommendations (section 6 and 7), reporting (section 8) and evaluation (section 9).

3. Screening

Screening is the first of six steps that make up the HIA process. The rationale and usefulness of the HIA are decided in this step. The HIA is a feasible option if: (1) the HIA will provide useful information or analysis that assists in the decision-making process of the project, policy or plan under consideration, and (2) there is sufficient public interest in the project or policy, which has the potential to impact the health of the community where it will be implemented. Screening tools such as the ones developed by Toronto Public Health (TPH) (2008a) and described in McCallum et al. (2016), although not used for the screening of this Rapid HIA, can systematize this step.

This Rapid HIA on the implementation of HOT lanes on highways in Toronto did not undergo a formal screening process. It was conducted as part of a postdoctoral fellowship by the author (FW). At the time this project was conceived, the local news in Toronto had reports of a transportation policy that may likely be implemented within the city and the GTHA. Since part of the postdoc fellowship involved reviewing transportation HIAs carried across the world, it was seen as a logical step to advance the knowledge gained from the review towards a practical application in the context of transportation planning. An additional aim was to build HIA capacity in Toronto and Canada. Both the academic and industrial supervisors of the project agreed to go ahead with the project, and a Project Advisory Committee (PAC) was formed, which included both project supervisors as well as an experienced stakeholder from TPH.

Funding for the project was gained from MITACS, a non-profit Canadian funding agency that funds graduate and post-doctoral research projects and connects student/postdoctoral researchers with industry (in this case Intrinsik Corp.). Intrinsik also partially funded the postdoc project. However, funding was only received upon peer-review of the project proposal by MITACS to conduct the Rapid HIA, which also indirectly allowed the reviewers to act as stakeholders and 'screen' the HIA for usefulness and value.

4. Scoping

This is the second step in the HIA process and establishes the boundaries of the HIA; the timeline, resource allocation, geographic extent, and selection of the most relevant and important determinants of health impacted by the project, policy or plan being assessed. Setting a clear scope for the assessment and providing rationale for the chosen scope is essential in maintaining transparency and credibility during an HIA. Scoping tools, such as the one available on the University of California, Los Angeles (UCLA) HIA Clearinghouse Learning and Information Centre (HIA-CLIC) are recommended, as they enable a more systematic step-by-step scoping process. For this Rapid HIA, the UCLA HIA-CLIC scoping tool was adapted and used.

A half-day scoping workshop involving relevant key stakeholders from Toronto Public Health; Public Health Ontario; Toronto Transportation Services; Ministry of Transportation of Ontario; three Non-Governmental Organizations (NGOs); Intrinsik; and Dalla Lana School of Public Health, University of Toronto was held during the initial stages of the Rapid HIA. The primary aim of the workshop was to create a multi-disciplinary atmosphere and allow professionals from relevant fields to use their respective expertise to guide the scope of the Rapid HIA. A secondary aim was to encourage dialogue, collaboration and knowledge sharing amongst stakeholders. Thirdly, the workshop allowed for the dissemination of knowledge and purpose of an HIA, thereby increasing HIA visibility and community of practice. After the scoping workshop, a second meeting was held with the PAC to further narrow and finalize the scope.

A detailed scoping report that was completed and shared with stakeholders after the scoping workshop and meeting with the PAC is attached as an Appendix to this Rapid HIA report (Appendix I). Due to the Rapid nature of the HIA, it was decided that time permitting, the HIA would include a more detailed assessment of Toronto, and a higher-level more general assessment of the Greater Toronto and Hamilton Area. The pathway diagram represented in Figure 5 below may be used as a guide to explore some of the main potential impacts of introducing highway toll lanes in Toronto. A short summary of final scope is provided here.

- The scenario evaluated in this Rapid HIA is the potential conversion of one GPL on each highway to a HOT lane, as not all sections of the Gardiner and DVP (the two highways under the jurisdiction of the City of Toronto) have sufficient adjoining area to create an extra lane.

- Options compared:
    1) HOT lanes (converting from GPL): within this option also evaluate the impact of revenue spent to increase public transit or active transport infrastructure
    2) HOV lanes
    3) Business as usual (BAU)- “do nothing approach”

- Determinants of Health (DOH) evaluated:
    - Congestion
    - Mobility and accessibility
    - Social capital/social cohesion
    - Air quality
    - Equity considerations and socioeconomic factors

- Methods used:
    - Literature search (primary peer-reviewed and grey (non-peer-reviewed) literature) on known impacts of congestion pricing on health and each DOH
    - Qualitative assessment of impact of HOT lanes on each DOH
    - Qualitative assessment of impact of reduction in congestion/travel time on potential change in health
    - Assessment of jurisdictional data on known impacts of congestion pricing on overall congestion and air quality
    - Comparison of travel times on HOV lanes (during the 2015 Toronto Pan Am games) to GPLs (using existing data)
    - Identification of existing data with geomapping of poverty and racialization on to maps of interchanges with high congestion and more pollutants

- Baseline health profile/community profile for Toronto was gathered from available data sources, including the Toronto Community Health Profiles website, Toronto Public Health, Canadian Institute for Health Information and Transportation Tomorrow Survey. The information provided as part of the baseline profile includes:

- Socioeconomic profile for Toronto
- Baseline of prevalence of asthma, chronic obstructive pulmonary disease, hypertension and mental health visits in Toronto
- Transit score for the city (published by Martin Prosperity Institute, as reported by TPH) to establish baseline of public transit access and availability in Toronto.

Although stakeholders suggested assessment of other relevant DOH and use of more extensive methodology, they were not included in the scope as this Rapid HIA was conducted in limited time with minimal resources. For instance, noise as an important DOH of a transportation policy was not included in the assessment as impacts due to noise are closely related to impacts due to air quality, which was assessed in this rapid HIA.

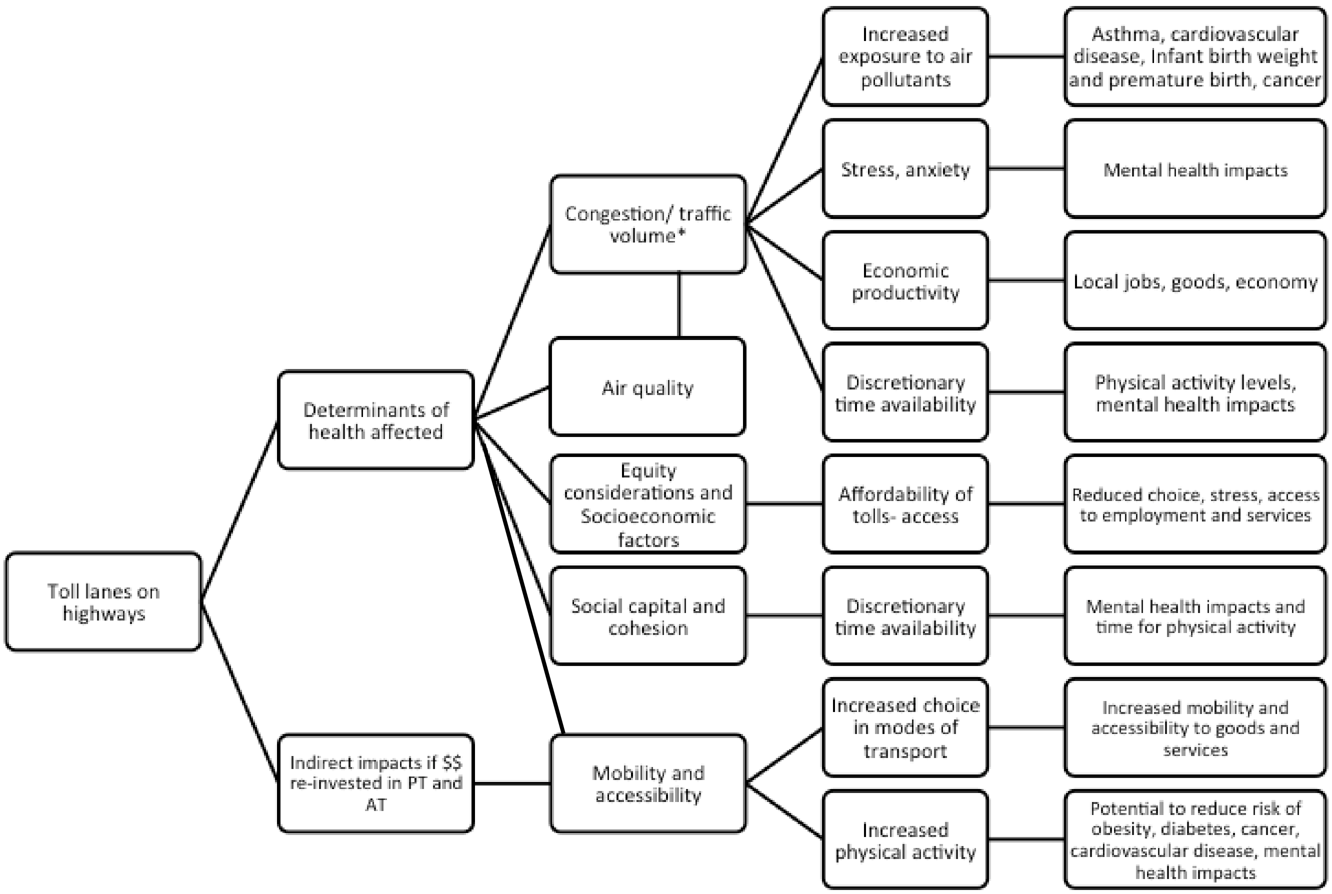

Figure 5: Pathway diagram highlighting some of the main potential impacts of introducing HOT lanes in Toronto. PT= Public Transit; AT= Active Transportation. *Note: Congestion as a determinant of health has an impact on air quality, environmental noise, social cohesion and mobility.

5. Assessment

Identification of potential impacts and their distribution within a population occurs in the assessment step of an HIA. Since this is a Rapid HIA, primarily qualitative assessment methods, such as analysis of peer-reviewed and grey literature, were utilized.

5.1. Baseline profile for Toronto

Before delving into the health impacts of introducing tolling on Toronto's highways, a baseline profile or a community profile of the area of focus provides a brief look at current socioeconomic, demographic and policy-relevant health-related chronic disease prevalence rates. Ideally, a baseline profile provides a foundation for conducting the HIA and identifying potential changes in health status (positive or negative) as a result of implementation of proposed project or policy. However, as this is a Rapid HIA where quantitative analysis of potential impacts due to implementation of the policy is out of scope, the author hopes this baseline profile provides the reader with a brief snapshot of some relevant current health information within Toronto. Most of the data presented here is from the Toronto Community Health Profiles website (http://www.torontohealthprofiles.ca/a_thematicMaps.php?varTab=TMtbl#curDC), a data-sharing partnership that includes government, public health professionals, community health providers and researchers.

Figure 6 represents distribution of average individual income in Toronto, which is $46,666 (CDN). Although these values are representative of Canada Revenue Agency data from 2012, a comparison to Figure 7, which is representative of Statistics Canada data from 2006, indicates a possible relationship between low-income (orange) areas in Figure 6 and a higher percentage of visible minority individuals in the dark brown areas in Figure 7. Neighbourhood visible minority maps for Toronto later than 2006 could not be located.

5.1.1. Age-standardized chronic illness prevalence in Toronto, 2012

Chronic disease prevalence in Toronto is presented here as rate ratio maps obtained from the Toronto Community Health Profiles website. The rate ratio map represents the rate of a mapped variable, such as hypertension, compared to overall rate in Toronto. For example, in Figure 8, the shades of red/orange indicate rates that are higher than the overall rate in Toronto, and the blue shaded areas indicate neighbourhoods with hypertension incidence rates lower than the overall rate in Toronto. Neighbourhood hypertension rates that are statistically higher ($p<0.05$) than Toronto rates are indicated 'H' and neighbourhood rates statistically lower than overall Toronto rates are indicated with an 'L'.

Prevalence of hypertension (Figure 8) is high in the east (Scarborough area) and the north-west areas of the city. Prevalence of diabetes (Figure 9) shows a similar pattern with pockets of high diabetes incidence in central Toronto. Taken from the MOH report, Figure 10 shows the increasing and projected trend of diabetes in the GTHA into 2027 (Improving Health by Design, 2014). Current projections of diabetes are around 13% and could potentially reach almost 17% by 2027. As discussed earlier, the GTHA has almost 57,000 new cases of diabetes every year, of which, 22.1% could potentially be prevented by increasing physical activity levels among individuals in the area (Bull et al, 2004; Improving Health by Design, 2014).

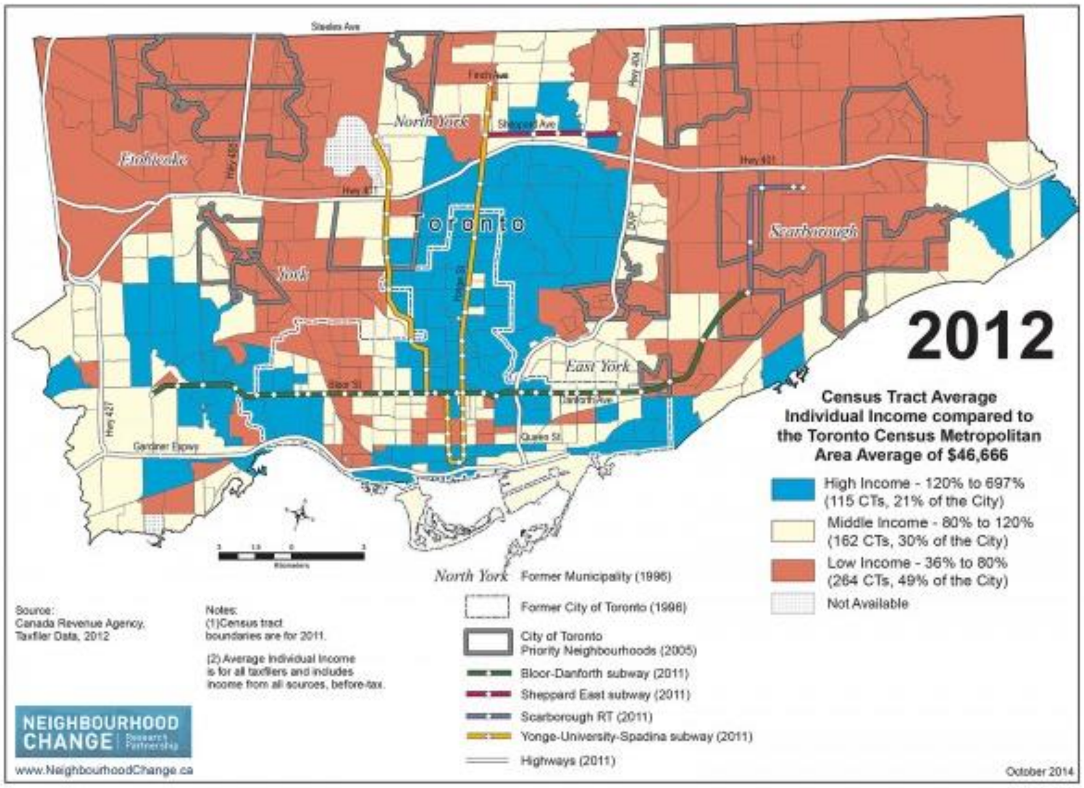

Figure 6: Average individual income, City of Toronto, 2012. Source: Neighbourhood Change and Canada Revenue Agency.

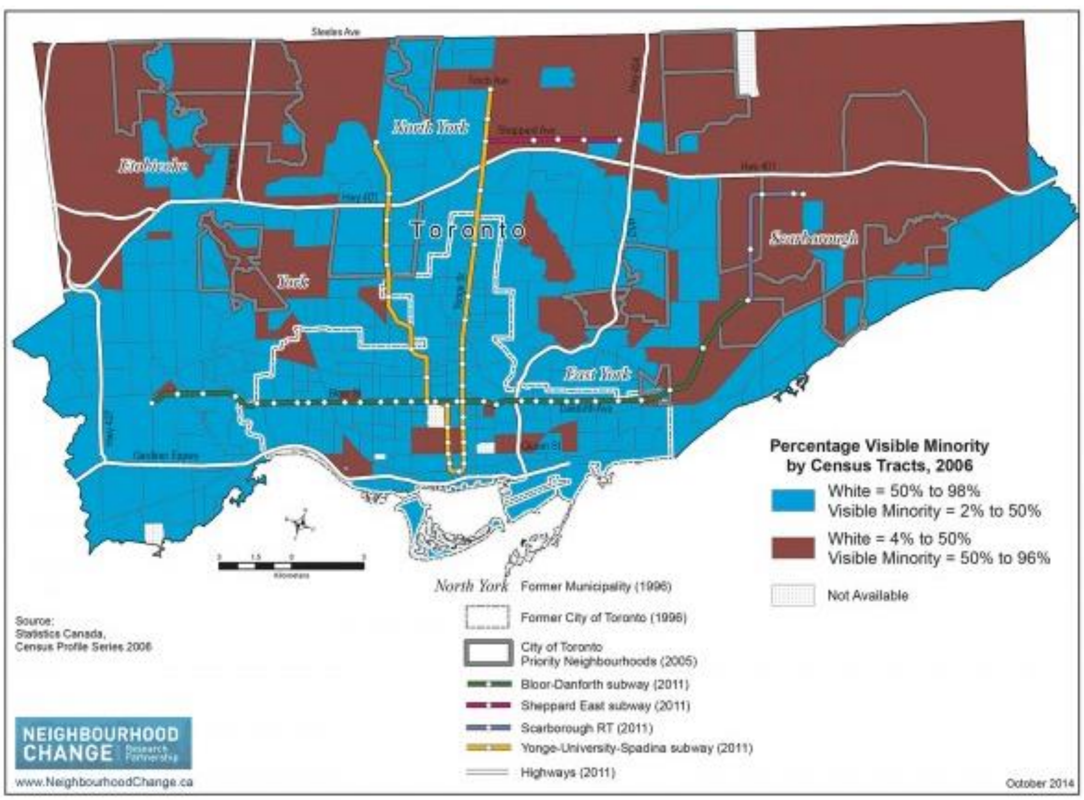

Figure 7: Percentage Visible Minority, City of Toronto, 2006. Source: Neighbourhood Change and Statistics Canada.

Hence, transportation infrastructure and planning that promotes physical activity and reduces car dependency can play an important role in controlling diabetes incidence, which arguably, is one of the most serious health issues facing the GTHA.

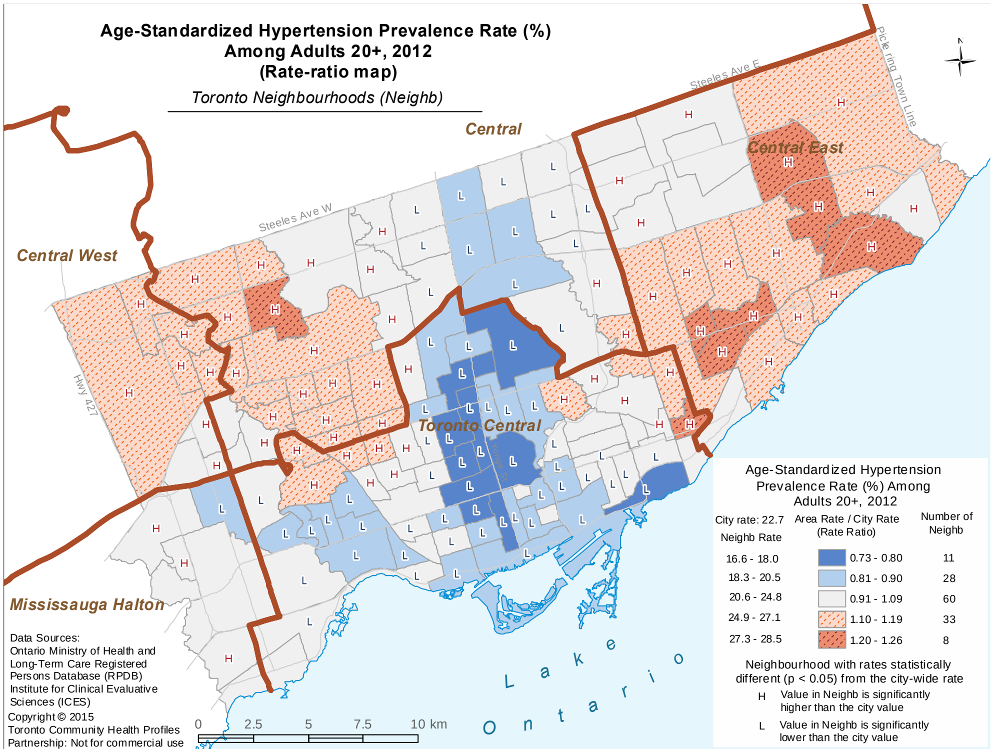

Figure 8: Rate-ratio map of age-standardized hypertension prevalence (%) among 20+ adults in Toronto, 2012. Source: Toronto Community Health Profiles

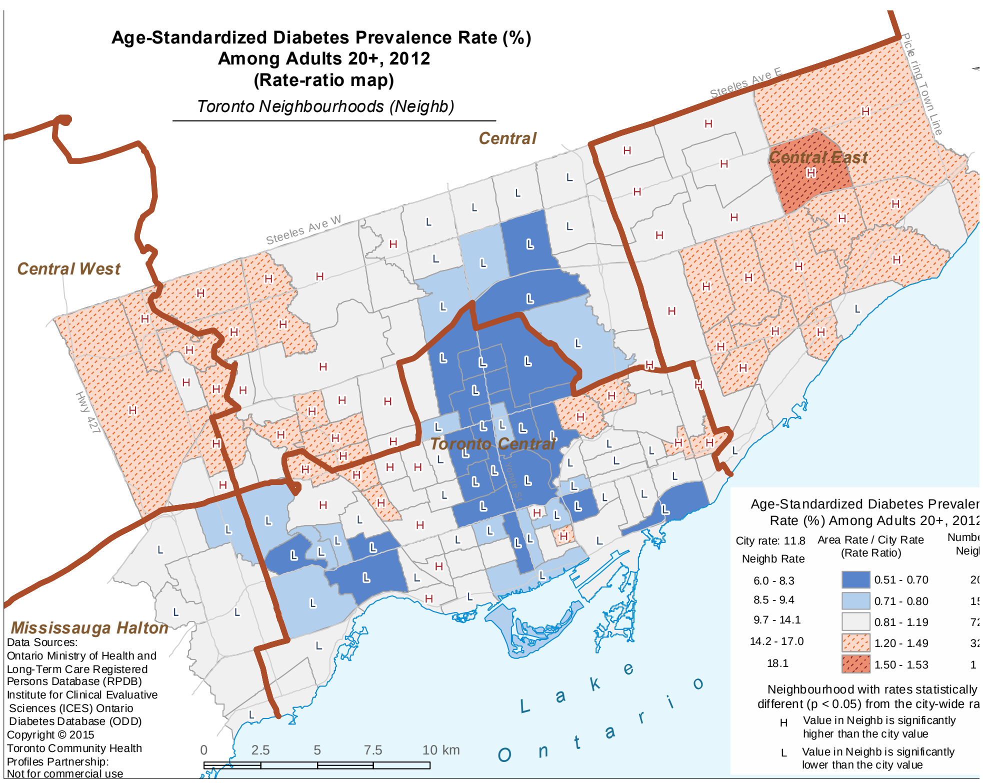

Figure 9: Rate-ratio map of age-standardized diabetes prevalence (%) among 20+ adults in Toronto, 2012. Source: Toronto Community Health Profiles

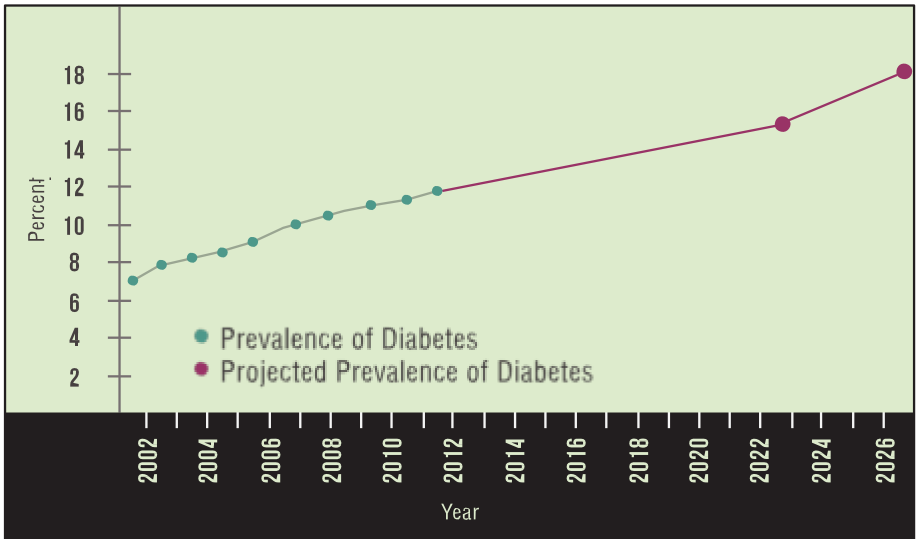

Figure 10: Actual and projected prevalence of diabetes in the GTHA, 2002-2027. Sources: Improving Health by Design, 2014; Ontario Diabetes Database, 2011; Rosella et al.,

Figures 11 and 12 show prevalence of asthma and Chronic Obstructive Pulmonary Disease (COPD) in 20+ adults in Toronto. Although discussed later in the report, there was no available data for the prevalence of asthma among children (or even age range <20) in Toronto.

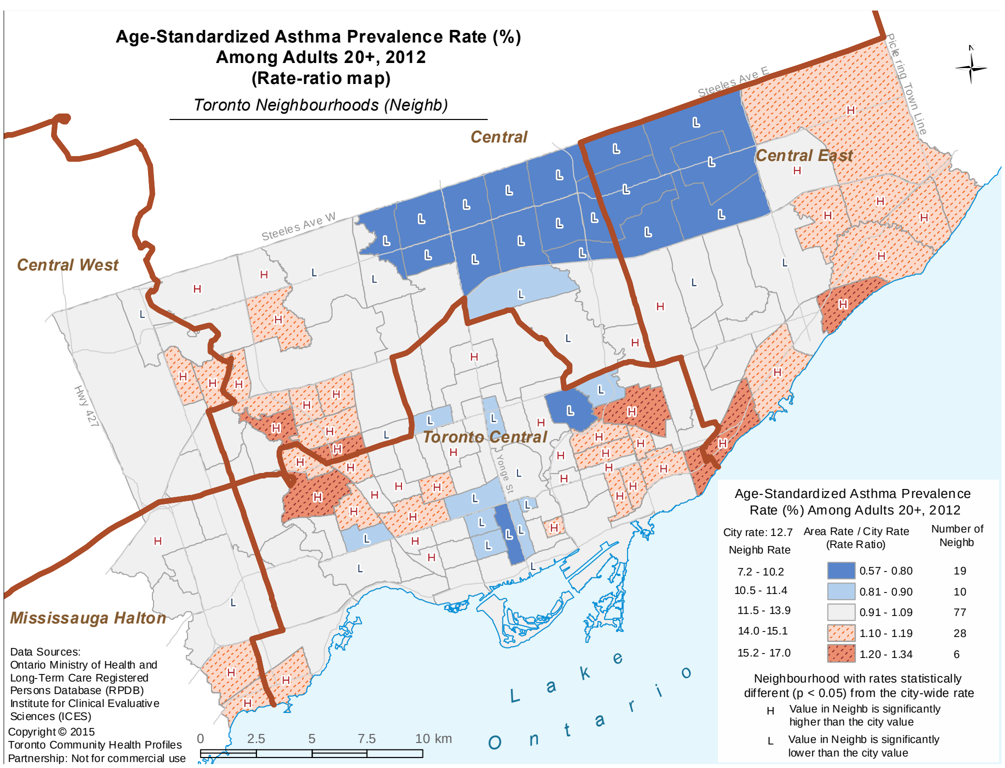

Figure 11: Rate-ratio map of age-standardized asthma prevalence (%) among 20+ adults in Toronto, 2012. Source: Toronto Community Health Profiles

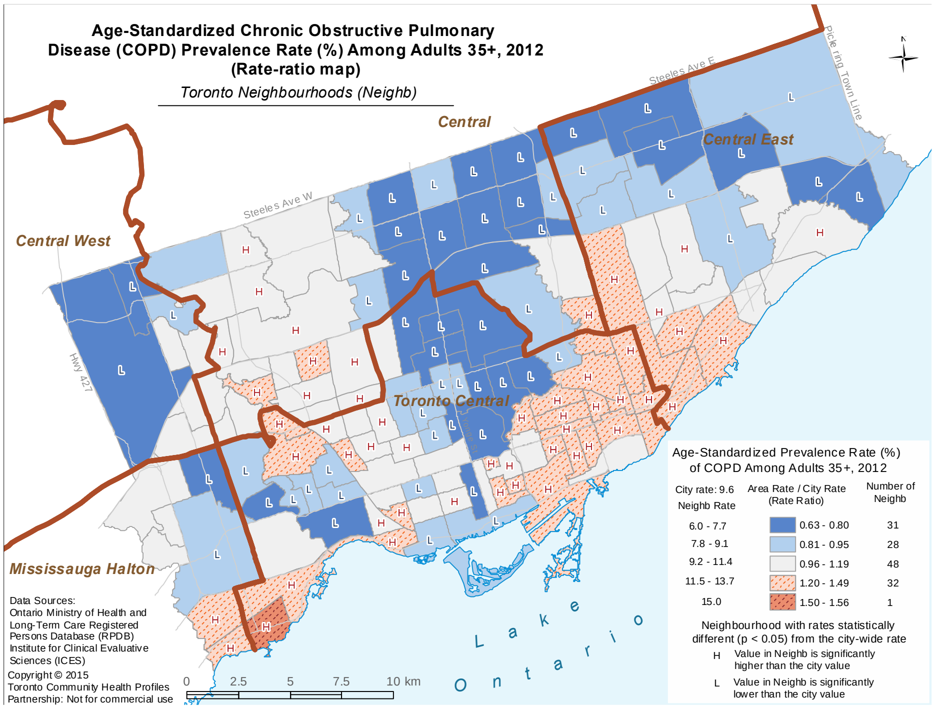

Figure 12: Rate-ratio map of age-standardized Chronic Obstructive Pulmonary Disease (COPD) prevalence (%) among 20+ adults in Toronto, 2012. Source: Toronto Community Health Profiles

Prevalence of Mental Health Visits (MHVs) in Toronto is shown in Figure 13. Lack of efficient or equitable transportation can lead to stress-related mental health impacts (reviewed in Cohen et al., 2014). In general, mobility and accessibility have been shown to have an impact on mental health of a population (Vallée et al., 2011). A Statistics Canada report found that seniors' social opportunities were significantly impacted by their level of access to transportation (Turcotte 2007). Moreover, it is well-known that exposure to daily traffic congestion can result in experiences of high chronic stress. A potential solution could be increased physical activity (walking, biking, exercise), which is known to be an effective anti-depressant, as it reduces depression, clinical or non-clinical, by half (North et al., 1990; Klaperski et al., 2013; Gerber et al., 2010).

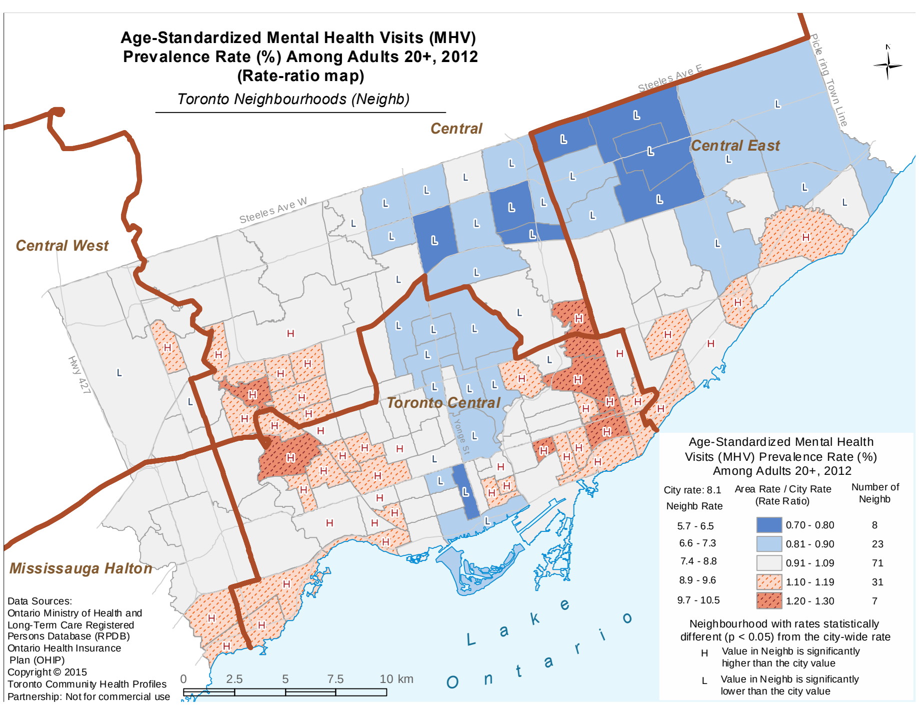

Figure 13: Rate-ratio map of age-standardized Mental Health Visits (MHVs) prevalence (%) among 20+ adults in Toronto, 2012. Source: Toronto Community Health Profiles

The following sections provide analysis of specific health determinants identified in the Scoping step of the Rapid HIA:

I. Congestion
II. Mobility and Accessibility
III. Social Cohesion/Social Capital
IV. Air Quality
V. Equity considerations and Socioeconomic factors

5.2. Congestion

Traffic congestion is a condition on roads and highways (i.e. transportation networks) that develops as use of vehicles on the networks increases. It is characterized by reduced speeds, prolonged trip times, and increased vehicular queuing. Depending on the perspective, traffic congestion may be defined as:

Volume is greater than capacity: Engineer
Demand is greater than supply: Economist

Additionally, congestion can be recurring or non-recurring. Recurring congestion results from typical daily demand fluctuations, thereby increasing the vulnerability of the system to incidents and non-recurring congestion. It is also difficult to manage, requiring traffic demand management measures, including change in travel behaviour, increase in capacity and improvement in traffic operations. Non-recurrent congestion results due to isolated incidents, such as those caused by collisions, work zones and weather. It can be managed through improvements in incident management/clearance, safety and traveller information.

Excessive traffic congestion increases levels of stress and anxiety among commuters (WHO, 2000; TPH, 2006). It also reduces the amount of discretionary time available to commuters for physical activity, family time and socializing. These in turn have significant mental health impacts (reviewed in Cohen et al., 2014). Moreover, congestion has spill-over impacts related to increased air pollution, which is discussed in greater detail in Section 5.5.

As discussed, traffic congestion is steadily increasing in the GTHA, especially in the City of Toronto, which has the highest density of jobs of anywhere in the Ontario and experiences a daily influx of workers from all over the GTHA (Neptis Foundation, 2015b). Due to increasing housing unaffordability in Toronto, the population has moved further and further away in order to afford a home. This makes travel times very high. A poll commissioned by the Greater Toronto CivicAction Alliance revealed that 71% of GTHA residents are "fed up" with gridlock and traffic congestion (CivicAction Forum, 2013a). Toronto has the highest commute times in Canada (see Mobility and Accessibility section below). The average one-way commute time in Toronto is 32.8 minutes, when compared to the Canadian average commute time, which is 25.4 minutes one-way (Statistics Canada, 2013). Moreover, according to Metrolinx, the average GTHA commuter spends 82 minutes travelling to and from work each day, which is an average of 41 minutes one-way (Metrolinx, 2008b). Using modelling forecasts, this Metrolinx report also advises that unless improvements are made in the GTHAs transportation system, this travel time could grow to 54.5 minutes one-way (109 minutes total). Figure 14 demonstrates how traffic congestion has worsened on highways and major arterials from 2011-2014. The data is part of a report by McMaster Institute of Transportation & Logistics, "Congestion Trends in the City of Toronto: 2011-2014" and demonstrates the deteriorating nature of arterial and highway travel times in Toronto.

Key Performance Indicators		2011 (Sep-Nov)		2013 (Sep-Nov)		2014 (Sep-Nov)		Change (2011-2014) **	
		Arterials	Freeways	Arterials	Freeways	Arterials	Freeways	Arterials	Freeways
Speed (km/h)	AM Peak	42	75	43	75	37	73	- 5	- 2
	PM Peak	42	72	42	74	35	70	- 7	- 3
Delay Hours (ff = 85th pct.)	AM Peak	4,800	9,100	3,900	10,100	12,000	11,800	+ 7,200	+ 2,700
	PM Peak	4,300	9,800	4,000	9,500	11,800	11,800	+ 7,400	+ 2,000

Figure 14: Latest peak hour congestion trends in Toronto, 2011-2014
**2014 decrease in speed under investigation; ff = free-flow; the 85th percentile speeds were used as free-flow. Source: City of Toronto, 2015. Monitoring and Managing City of Toronto Road System Performance.

As mentioned above, congestion costs the GTA around $6 billion, and can be as high as $11 billion if the social costs of families and residents foregoing social activities are included (Metrolinx, 2008a). Although it is not economically feasible to completely eliminate congestion, as a certain level of congestion is a sign of a strong, healthy economy, the mounting costs of increasing levels of congestion may easily surpass the benefits of prosperity, mobility and economic health (Metrolinx, 2008a). These include costs related to reduced productivity, negative environmental impacts (including diminished air quality), wasted energy (including idling of vehicles in traffic), and a reduced standard of living (Metrolinx, 2008a). In his book *Gridlock*, John Sutton writes about UK transportation planning and policy, words that may also summarize challenges faced in Toronto and the GTHA:

> *"Transport and mobility has become an arena in which competing political philosophies are put into practice, often behind a veneer of economic theory and environmentalism. The result is gridlock on the streets as well as in policy."*
>
> \- John Sutton, Gridlock

5.2.1. 'De-congesting' solutions

A search of the peer-reviewed and grey literature found three main proposed means of reducing congestion:

1. Increase capacity by adding new lanes, roads or public transit routes
2. Traffic demand management methods, such as road pricing, change in mode of travel or travel behaviour (e.g. carpooling) and travelling during less congested times
3. Intelligent Transport Systems that use technology-based interventions to manage congestion dynamically in real time. Examples of Intelligent Transport Systems include programming traffic lights to respond in real time to changing traffic and reduce delay at

intersections by almost 60% (RCCAO, 2013), and using computerized system to implement dynamic road pricing based on real-time levels of congestion

However, there is no one single ideal solution, rather a combination of the three main points suggested here may serve as a possible remedy. A recent independent study commissioned by the Residential and Civil Construction Alliance of Ontario (RCCAO) suggests that the solution may be a combination of increasing capacity where required, implementing traffic demand management strategies and applying intelligent systems to dynamically improve current system (RCCAO, 2013).

An added important consideration is that dealing with traffic congestion on a regional scale may require implementation of strategies and policies that encourage a mode of transport shift from driving in personal single-occupancy vehicles to using public transit and car-pooling. It is well known that using public transit allows individuals to get more physical activity than if they drove everywhere (reviewed in Rissel et al., 2012). As discussed in the MOHs report, committing the GTHA towards a mode shift by increasing physical activity in daily commute is one of the reasons the MOHs of the GTHA support funding of Metrolinx's Regional Transportation Plan, *The Big Move* (Improving Health by Design, 2014). One of the revenue-generating tools recommended by Metrolinx and conditionally approved by Toronto council for potential future implementation are HOT lanes on Toronto highways. Although widely appreciated that The Big Move is a necessary investment, there is no clear consensus on how it may be funded.

5.2.3. Potential impacts of HOT lanes on traffic congestion

The Federal Highway Administration (FHWA) studied the impacts of different kinds congestion pricing implemented in jurisdictions around the world (FHWA, 2010). Table 2 has been adapted from this report and indicates impacts of simulated and actual congestion pricing policies on traffic volume, Vehicle Miles Travelled (VMT), air quality, noise levels and equity. No Canadian city has as yet implemented HOT lanes on highways. Hence, American cities such as Minnesota and San Diego (where existing HOV lanes were converted to HOT lanes) may serve as examples/models for Toronto or the GTHA to implement tolling on highways. In the case of Toronto, where the scenario being examined is the conversion of GPLs to HOT lanes, potential impacts may be slightly different.

Table 2: Synthesis of Congestion Pricing-Related Environmental Impact Analyses. Source: U.S. Department of Transportation, Federal Highway Administration (FHWA), 2010.

Project studied	Year of study	Traffic volume and Vehicle Miles Travelled (VMT) findings	Air quality and noise levels findings	Equity impacts findings
Before-After Project Evaluations				
Minnesota I-394 MnPASS HOT Lanes (HOV to HOT Lane Conversion)	2003-2006	– Up to 5% increase in peak hour corridor throughput – 6% average increase in speeds in general purpose lanes – Speeds increased in the general purpose lanes and MnPASS lane for many locations – Travel times generally unchanged or	– HOT lanes had no substantial impact on air quality – HOT lanes had no statistically significant change in	– Beneficiaries of the HOT lane included a diverse population across all income, age, race/ethnicity, employment, and mode usage

Project studied	Year of study	Traffic volume and Vehicle Miles Travelled (VMT) findings	Air quality and noise levels findings	Equity impacts findings
		slightly increased – Project benefits distributed relatively evenly amongst population	average neighbourhood sound levels	groups. No significant correlation between socio-demographics and project benefits and attitudes
San Diego I-15 HOT Lanes (HOV to HOT Lane Conversion)	1997-2000	– 48% increase in express lane traffic volumes – 76% of FasTrak customers would leave at a different time in the morning if there were no FasTrak.	– The HOT lanes moderated emission levels in the project corridor – On the study roadway, emissions increased significantly more on the HOT lanes than on the GPLs	Not studied
Stockholm Cordon Pricing Trial	2003-2006	– 16-24% reduction in peak hour traffic volumes – 14% reduction in VKT in charging zone – 33-50% reduction in peak hour average queue wait times – 3% reduction in average journey (travel) times – Car trips across the pricing zone decreased by 20 percent – No project-attributable changes in walking, bicycling, telecommuting or carpooling – Trip chaining increased slightly – 6% increase in total transit ridership – 4% decrease in the proportion of transit users that are satisfied with service quality	– 8.5 -14% decrease in emissions depending on the pollutant – Non-significant reduction in noise levels	– Great variation in congestion charges paid by individual – Wealthy, inner-city men pay the most – Higher income earners pay more than lower income earners – Commercial traffic and business trips are “net winners”
London Congestion Charging	2002-Present	– 15% reduction in VKT after first year – 18% reduction in number of vehicles entering the pricing zone – 25% reduction in delays – 14% reduction in journey times – 21% increase in speeds – 37% increase in passengers entering central zone by bus – 30% decrease in excess bus wait time in first year – 20% reduction in bus kilometers not operated due to congestion – (Central charging zone) 50-60% of trips formally made by car now made by	– Emissions decreased by between 13 and 16% depending on the pollutant, for the original project – Emissions decreased by between 2 and 6%, depending on the pollutant, for the Western Extension	– Actual impacts were less than travelers themselves expected – Issues of greatest concern are not project related – Majority of respondents found the charge affordable

Project studied	Year of study	Traffic volume and Vehicle Miles Travelled (VMT) findings	Air quality and noise levels findings	Equity impacts findings
		transit; 20-30 percent driving around the charging zone; 8-10 percent bicycling, motorcycling or walking; <1% eliminated trips; and <1 shifted car trip to non-priced times	– No significant, project-attributable changes in noise levels	
Singapore Area Pricing	1975-Present	– 44% reduction in traffic volumes into the priced zone – Share of HOV 4+ trips increased from 8 to 19%; bus share increased from 33 to 46% – A.m. peak speeds inside priced zone increased by 20% or more – Speeds increased 10% on inbound roadways leading to the priced zone – Motorists shifted trips to non-priced times and routes	– CO reductions in a.m. peak, monthly average NOx reductions, and reduced smoke and haze (immediately after first project)	– Although not all people benefitted equally, overall, the project did not significantly and disproportionately impact lower income people
Simulated Pricing Field Demonstrations				
Oregon Mileage Fee Concept and Road User Fee Pilot Program	2006-2007	– 10% reduction in total VMT – 13% reduction in peak hour VMT – Peak hour mode choice influenced by the pricing	Not studied	Not studied
Puget Sound Traffic Choices Study	2005-2007	– 7% reduction in total weekly vehicle trips – 12% reduction in weekly VMT – 8% reduction in total weekly travel time – 13% reduction in weekly VMT on tolled roads	Not studied	Not studied
Atlanta Mileage Based Value Pricing Demonstration	2003-2006	– 3% reduction in total VMT	Not studied	Not studied

As discussed, HOT lanes allow single-occupancy vehicles (SOVs) to drive on high occupancy lanes for a nominal charge or toll. Not only are HOT lanes a revenue-generating tool that can raise significant funding for transit planning (Dachis, 2011), they're also an important approach that could relieve traffic congestion if used effectively as a traffic management strategy. One of many reports published in Ontario on impacts of HOT lanes on congestion was by the C.D. Howe Institute, which reported that conversion of all existing and planned HOV lanes in the GTHA to HOT lanes would generate $926 million annually (Dachis, 2011). This amount could be used towards funding of The Big Move to improve public transit, or at the very least, add and improve express bus service routes that can use the HOT lanes on highways for free and encourage more commuters to shift to public transit.

As seen from Table 2, in most cases, congestion pricing and HOT lanes reduced traffic congestions, travel times and VKT/VMT to various degrees. Studies and reports also show that

HOT lanes reduced congestion and improved travel speed not only in the HOT lanes, but also in the GPLs, albeit to a lesser degree (Poole and Orski, 2000; Small et al., 2006; Metropolitan Transportation Commission, 2007; Sorensen et al., 2008; Dachis et al., 2011; Goel and Burris, 2012; Canada's Ecofiscal Commission, 2015; Hall, 2016, Government of Minnesota, 2013). Road pricing, however, may not necessarily reduce travel. The International Bridge, Tunnel and Turnpike Association (IBTTA) recently released a report that indicates that 2015 was a 'record-breaking' year for the use of bridges, tolls and turnpikes, with a 7% increase in usage from 2014-2015 (IBTTA, 2016). Given that most individuals intuitively assume that tolling people to drive reduces the amount of trips taken, this result from the IBTTA shows that improving throughput and travel time may encourage drivers to pay and use tolled lanes on highways. This finding may be an important source for recommendations to mitigate potential adverse impacts and enhance the positive outcomes.

The closest the City of Toronto has come to HOV lanes on its two highways (i.e. the Gardiner Expressway and the Don Valley Parkway) was during the Pan Am games held in the GTHA in 2015. In addition to lanes on Highway 401 and the Queen Elizabeth Way (both highways in the GTHA), the left-most lanes on the Gardiner and the DVP were temporarily converted to HOV lanes for an approximate one and a half-month period. During the month-long Pan Am period the HOV requirement was HOV 3+, and the Para Pan Am period had an HOV2+ requirement. A stakeholder from Metrolinx shared data obtained from GO Transit buses (a regional passenger bus and train network) during the Pan Am and Para Pan Am games. This HOV case study was undertaken by GO Transit/Metrolinx to understand potential impacts of a permanent and expanded HOV network or congestion pricing policies such as HOT lanes, on free-flow conditions of GO transit buses. However, it is important to note that the Pan Am and Para Pan Am games were special events and as such, results obtained during this period may not be directly comparable to the regular commuting experience and travel volumes. In the United States, HOV lanes have been reported to be underused and also to be more congested when compared to GPLs due to slow-driving vehicles that hold up flow in the lane (Guin et al., 2008).

Avg.	Time Saved (min)	% of Non-HOV Travel Time
AM peak	7 min	44%
PM peak	6 min	40%

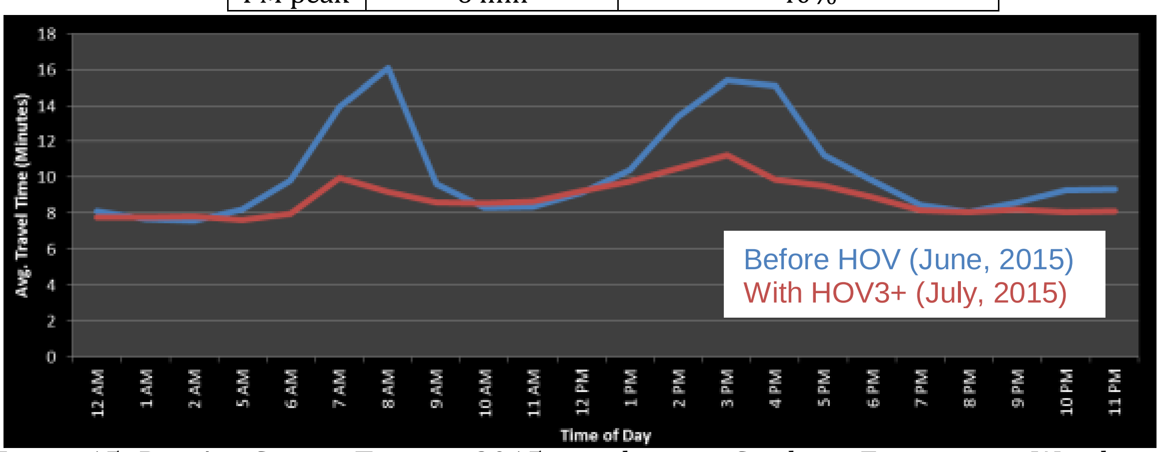

Figure 15: Pan Am Games, Toronto 2015 travel times: Gardiner Expressway Westbound – Simcoe St. to Hwy 427. Source: Metrolinx, 2016. GTHA Transit: A HOT Opportunity to Improve Service? Transport Futures Conference, 2016.

Figure 15 shows that travel times in GO transit buses on the Gardiner between the Simcoe St. and Hwy 427 stretch experienced 7 min and 6 min time savings in the AM and PM rush hours, respectively. These travel time savings if monetized show substantial savings (Figure 16, Metrolinx, 2016). Depending on the route of the bus, these can be $500-$800 per bus per day. Figure 17 shows the greatly improved reliability of travel time on HOV3+ lanes (after June 29), compared to business-as-usual (before June 29).

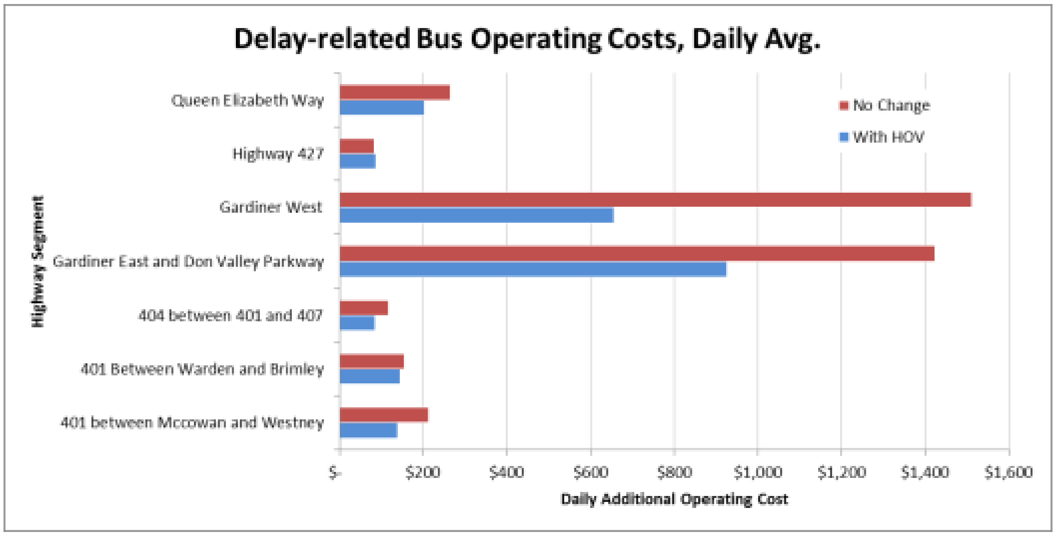

Figure 16: Daily average of GO Bus costs due to traffic delay. Source: Metrolinx, 2016. Note: Figures are approximate. 'No Change' reflects June, 2015 data; 'With HOV' reflects July, 2015.

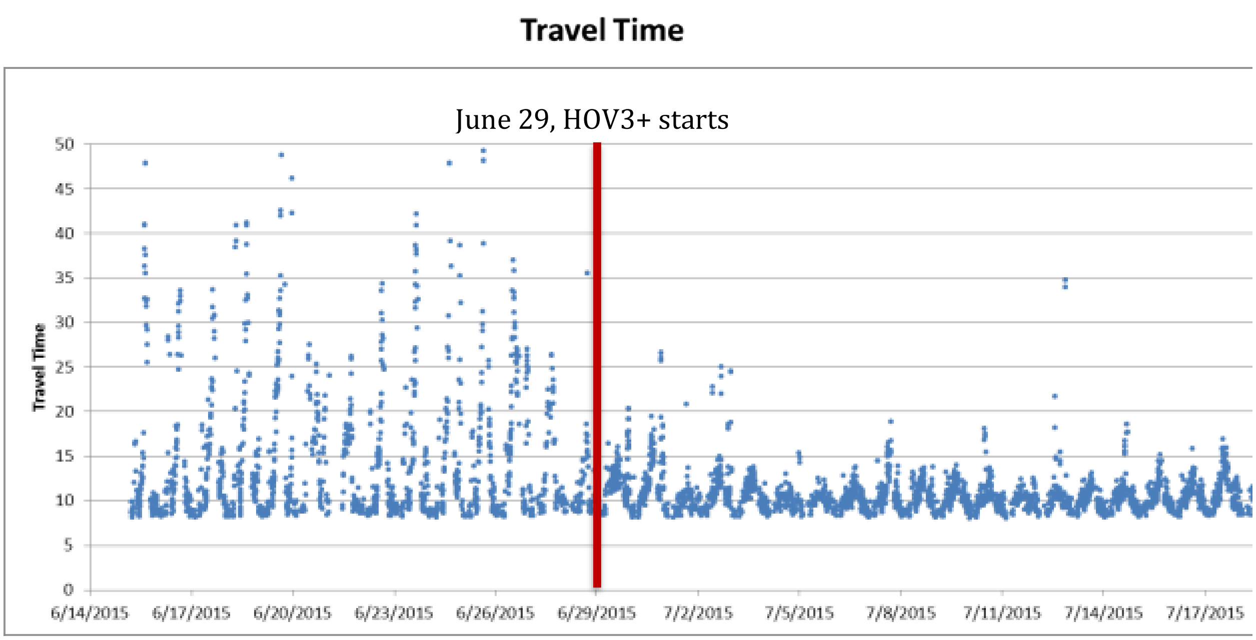

Figure 17: Travel time variability significantly decreased for GO Buses on the DVP between Jarvis/Gardiner and Hwy 401, with standard deviation in travel times decreasing from 7'30" to 2'15" with HOV3+. Source: Metrolinx, 2016.

Recently opened I-405 ETLs in Seattle faced early criticism from media that the project was a failure and had potentially made congestion worse. However, data from Washington State Department of Transportation showed that overall travel times (on ETLs and GPLs) for most commuters improved, especially for public transit riders and SOVs accessing the entire length of the highway (Washington State Department of Transportation, 2015). However, shorter trip commuters on the GPLs experienced longer travel times. Overall, the United States Department of Transportation reported in 2008 that "*generally, HOT Lane conversions* (from HOV lanes) *have achieved their goals of gaining better use of underutilized HOV lanes and maintaining congestion free travel for toll paying users without subjecting HOV and transit users to lower service levels*" (Newmark, 2012; K.T. Analytics and Cambridge Systematics 2008).

An added concern arising from HOV-to-HOT lane conversion on highways is the potential negative impact on transit ridership, which could in turn effect levels of congestion. Transit riders could potentially mode-shift from public transit on freely moving HOV lanes or congested GPLs, for the luxury of travelling as SOVs on paid HOT lanes. However, research conducted by Chum and Burris (2008) estimated that "(f)*or all scenarios, only a small percentage of transit passengers would choose to switch to driving alone on the HOT lane. Transit passengers shifting to SOVs on the HOT lane would reduce average vehicle occupancy on the lane by only about 1% to 2%*". The authors further conclude that it is important to use appropriate 'dynamic pricing' and maintain free-flow conditions on HOT lanes in order to efficiently manage traffic conditions and prevent decrease in average vehicle occupancy on the HOT lanes (Chum and Burris, 2008).

In a more recent review of HOT lanes in the United States, Goel and Burris (2012) found that higher numbers of commuters used transit travelling on HOT lanes on the I-95 in Miami, I-25 in Denver, I-394 in Minneapolis (Diamond section) and SR 167 in Seattle. The authors suggest two main reasons behind this finding: improvement of travel time on the HOT lanes and increase in gas prices. This finding may be of importance to the Toronto and GTHA contexts, where the region aims to not only reduce congestion but also promote increased public transit use (Metrolinx, 2008a; Improving Health by Design, 2014). However, in the Atlanta I-85 HOV-HOT lane conversion, bus ridership did not show any significant change (Guensler et al., 2013). The authors of the report hypothesized that this could be due to significant transit fare increases at the time the HOT lanes were implemented; five of eight buses servicing the corridor raised fares (Guensler et al., 2013).

Constraints that hinder congestion pricing policies from reaping the maximum benefits have been reported. Express toll lanes in San Francisco and Los Angeles have been minimally successful so far in reducing highway traffic congestion due to the unwillingness to implement variable congestion pricing to control congestion (Poole, 2016). In the case of California, it was mandated that HOV2+ (versus HOV3+, for example) vehicles travel for free and that alternative fuel vehicles also travel free (Poole, 2016). With 85,000 green stickers issued in California authorizing hybrids to travel for free in HOV lanes and ETLs, and over 90,000 white stickers for electric and natural gas cars for the same purpose, toll-paying traffic during rush hour averages only 17% of all vehicles on the SR 237 ETLs in San Jose. Moreover, during periods when traffic congestion reduces travel speeds below the federal standard of 45 mph (about 72 km/h), the policy excludes toll-paying vehicles entirely (Poole, 2016). These are important lessons for the Toronto/GTHA context.

5.2.2. Simple cost-benefit analysis of time savings due implementation of tolling on highways in the GTHA

As discussed in Section 2.1, in a recent report to Toronto City Council, the General Manager of Toronto Transportation Services provided an estimation of potential time savings gained (3-5 minutes) if a $3 flat toll was charged each time a vehicle entered the Gardiner Expressway or the Don Valley Parkway and passed a tolling point (open system tolling) (City of Toronto, 2015). With the help of a stakeholder at the Ministry of Transportation of Ontario, a simple calculation was conducted to evaluate the monetary savings gained (in CDN dollars) upon implementation of such a $3 flat toll each time a vehicle enters a highway in the GTHA and assuming an average time savings of 3 - 5 minutes per vehicle. This open system flat toll scenario was used for ease of calculation, as time savings for HOT lanes vs GPLs is difficult to calculate. It is important to note, that a cost-benefit analysis for 3 min savings per vehicle assumes the best-case scenario and calculates the dollar value of every single vehicle on the specific highway receiving a 3 min time savings every day for a year (which is assumed to be 250 days, excluding weekends and public holidays). Nonetheless, this analysis purports to highlight that although a 3 or 5 min savings per vehicle seems very small, it does, when aggregated across all vehicles, provide a substantial monetary saving over the course of a year. In the calculation, the following assumptions from the 2015 Metrolinx Business Case Guidance were made (Table 3):

Table 3: Category and value of benefits assumed in the cost-benefit analysis.

BENEFIT INPUTS	Per vehicle
Value of Time ($/hr)	$16.71
Vehicle Operating Cost ($/km)	$0.63
GHG Emissions Benefit ($/km)	$0.01
GHG Tonnes per km	0.00022
Accident Cost ($/km)	$0.08

This calculation also assumes a typical annual volume of vehicles on a GTHA highway (385,000) and that implementing tolling on a highway in the GTHA will slightly reduce number of vehicles (380,000) (Table 4).

Table 4: Travel demand inputs included in the calculation for BAU vs tolling, assuming commencement from 2021. Savings of 3 min and 5 min per vehicle are included in the calculation.

TRAVEL DEMAND INPUTS	Business As Usual (BAU)	Flat toll rate implemented
Passenger Vehicles	385,000	380,000
Passenger Vehicle km	3,000,000	2,950,000
Passenger Hours	62,000	43,000 (with 3 min savings) 30,333 (with 5 min savings)

Hence, accounting for the benefits listed in Table 3, a **3 min** average savings per vehicle could realize a benefit stream of approximately **$88 million** in 2021, equivalent to around **$233 per vehicle**. Similarly, a 5 min average savings per vehicle could realize a benefit stream of approximately $141 million in 2021, equivalent to around $372 per vehicle. It should be noted that the above figures do not account for any costs incurred in providing tolling infrastructure.

Table 5: Comparison between implementing HOT, HOV and BAU options in Toronto for potential impacts on Congestion

	HOT lane	HOT lane + revenue invested in transit	HOV lane	BAU
Congestion	• Depending on the pricing, most likely little or no congestion in the HOT lane and likely reduced congestion in GPLs • Improved travel reliability and speed for transit	• If revenue invested in public transit, greater travel time savings, and possible increase in transit use with accompanying benefits to all determinants of health	• Little or no congestion in HOV lane as it may be potentially underused. Likely increased traffic congestion in the two GPLs • Improved travel reliability and speed for transit	• Continued traffic congestion in all lanes. May get worse as increase in population predicted, which will increase traffic volume • No change in transit use
Impact direction	Neutral-positive	Positive	Neutral-negative	Negative

5.3. Accessibility/Mobility

Transportation plays a major role in an individual's and in a city's level of accessibility and mobility. Mobility is the ability of individuals to get from place to place, and accessibility is the ease and extent to which mobility is achieved. Good mobility takes into consideration mode of transport and speed of the journey, and for accessibility, distance travelled, destination of travel, and cost of travel are important. Figure 18 shows that a mix of mobility, accessibility and ride experience are elements of good transportation options (Bowman, 2011). Limited access to transportation restricts access to essential services such as healthcare, employment, education, goods and services, and recreational and cultural programs (TPH, 2013). Hence, any transportation policy or project must consider how accessibility and mobility will be affected.

Figure 18: Mobility, accessibility and journey experience are all ingredients of optimal transport. Source: Bowman, 2011.

Commissioned by the Ontario Trillium Foundation, the Ontario-focused 2014 Canadian Index of Wellbeing study titled "How Are Ontarians Really Doing?" reported that those living in Toronto had the highest commute times in Ontario – 32.8 minutes one-way on average (CIW, 2014). Within the province, commute times have increased by 12% between 1994-2010, and expected to go higher due to increase in population density and traffic congestion (CIW, 2014). Although this 12% increase, or an average increase of 6.4 minutes per day, might not appear to be a large difference, "*over a typical work-year, it represents an additional 27 hours of commuting*" (CIW, 2014) and reduces overall mobility and accessibility.

The CIW report also highlights the importance of a "*broader and more coordinated public transit system*" in the province. The suggestion is to alleviate some pressure associated with congestion and high commute times by developing an "*accessible, efficient and affordable*" public transit policy (CIW, 2014). The focus of such a transit or transport policy should be *accessibility*, and not just mobility (CIW, 2014).

Public transit, especially for those from low-income groups, is an important means of transportation (TPH, 2013), and hence, mobility and accessibility. However, as seen from Figure 19, rapid transit service (subway, bus and streetcar) in Toronto is quite low (yellow) in many areas of the city (Martin Prosperity Institute, 2010). The highest rapid transit scores are in the downtown area (dark blue). Majority of the places in the city with higher percentages of low-income populations (refer to Figure 6), appear to have low transit scores, and arguably reduced mobility. Hence, before implementing a tolled lane on highways in Toronto, policy-makers should consider how tolling will impact mobility and accessibility in Toronto, especially for vulnerable populations such as low-income groups.

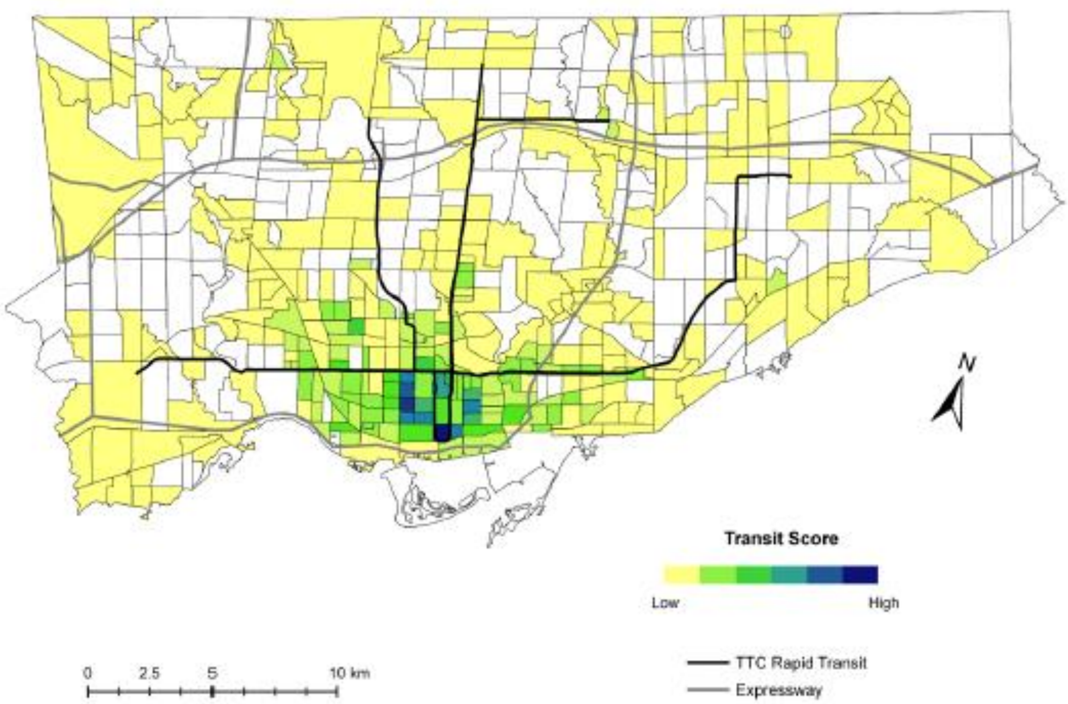

Figure 19: Intensity of Transit Service in the City of Toronto. Source: Martin Prosperity Institute, 2010; map by Zara Matheson. Data Source: Statistics Canada

5.3.1. Potential impacts of HOT lanes on accessibility/mobility

If HOT lanes are planned efficiently to optimize traffic flow, those using HOT lanes will experience improved mobility and accessibility. For users on the GPLs, improvement in mobility and accessibility may depend on the degree to which traffic flow on HOT lanes impacts the GPLs. It has been reported that improved traffic flow conditions on HOT lanes also improve travel flow on GPLs, though to a lesser degree (Goel and Burris, 2012; Government of Minnesota, 2013). HOV lanes also improve mobility and accessibility for transit and HOV-compliant users. Transit travel time reliability was higher during Toronto's Pan Am games experiment with HOV lanes

(Figure 17). However, for HOV non-compliant users, congestion on the GPLs may be higher, thereby decreasing mobility.

Additionally, for individuals who cannot afford to pay tolls and take advantage of the (potentially) faster HOT lanes, there may be a potential negative impact on mobility and accessibility. To avoid such circumstances, it is important to implement variable pricing to maintain close to free-flow conditions in the HOT lanes and also potentially improve congestion in the GPLs (Hall, 2016). Experiences in the United States (reviewed by FHWA, 2010; Goel and Burris, 2012), as well as research conducted on the subject (Hall, 2016) suggest this is possible. While tolling may provide more efficiency in commuting for some by providing them with an added choice, it should not significantly negatively impact those in the GPLs more than they are already currently impacted by congestion. Further, if revenue from the tolls (after use on maintenance of the tolling system) is invested in transit expansion, the public benefits, especially for vulnerable populations who are most reliant on public transit for their accessibility and mobility needs, could be substantial (US Department of Transportation, 2008; Goel and Burris, 2012; Burda and Haines, 2012). Hence, implementing efficient affordable rapid transit along the highway corridor could offset adverse impacts of implementing a tolled lane.

Table 6: Comparison between implementing HOT, HOV and BAU options in Toronto for potential impacts on Mobility and Accessibility

	HOT lane	**HOT lane + revenue invested in transit**	**HOV lane**	**BAU**
Mobility and Accessibility	• Substantial increase in mobility and accessibility for users who can afford tolls • By charging some for use of HOT lane, traffic volume on GPLs may reduce, with higher mobility and accessibility for all	• Increased mobility and accessibility for all users in Toronto, and those to commute to and from Toronto	• HOV-compliant and transit users have higher mobility and accessibility • GPL users have neutral or negative impact	• Overall neutral, or more likely substantial negative impact on mobility and accessibility for all users
Impact direction	Neutral-Positive	Positive	Neutral	Negative

5.4. Social Capital/Social Cohesion

The term 'social capital' is used in the discussion of people's social ties and may function at a group or community level, unlike social network or social support, which function at the level of an individual (Kavanagh et al., 2005). However, the stronger and wider the social network, the greater the social capital and hence, social cohesion (Wray, 2013). Social capital can also be defined as the degree to which individuals experiences a belonging or affinity to a socially cohesive community, and participates in its activities, and utilizes community resources (Ross, 2007). Stronger social capital also implies better access to opportunities and resources (Wray, 2013), including those associated with employment, education and healthcare. This is especially important for those subgroups of the population that are the most vulnerable to social isolation, including low-income families, elderly and individuals with a physical or mental disability (Barton and Tsourou, 2000; Tremblay et al., 2014). Access to affordable (and equitable) transportation or public transit services aids in breaking out of social isolation (Barton and Tsourou, 2000; Tremblay et al., 2014). Social capital and cohesion impact health in several ways. Individuals with high levels of social cohesion have higher life expectancy and improved mental and physical health (Jackson and Sinclair, 2012; Ross, 2007; Greenville Parks and Trails HIA, 2013).

Although many variables can influence opportunities for social cohesion in a particular area, one that is common to all areas is the ability of people to be able to come into contact with each other. Access to affordable transportation has an important impact on social networks and social capital and cohesion. Reduced ability to connect with social networks has negative impacts on the strength and diversity of social capital (Wray, 2013). Providing society with equal opportunities for social interaction and networking creates a community that is overall more cohesive.

The Martin Prosperity Institute recently released a report called 'Segregated City', which charts patterns of economic segregation for three Canadian cities, including Toronto (Martin Prosperity Institute, 2015). The report compares levels of economic segregation in Canadian cities compared to that of United States major metropolitan cities. The Economic Segregation Index is based on a scale of 0 to 1, where 0 reflects no segregation and 1 reflects complete segregation. Montreal has a segregation index of 0.41 and is the most economically segregated metro of the three compared. Toronto was second with a segregation index of 0.37, followed by Vancouver at 0.32. This study by the Martin Prosperity Institute develops detailed measures of not just income, but also educational and occupational segregation, which are cumulatively used to create the index of Overall Economic Segregation. When compared to segregation levels for America's three largest metro cities: New York (0.89), Los Angeles (0.89), and Chicago (0.87), the overall segregation in Toronto seems relatively small, implying, arguably, that Toronto is a more cohesive city by comparison.

5.4.1. Potential impacts of HOT lanes on social capital/cohesion

Variably priced HOT lanes that reduce congestion, provide users with an added choice in cases of urgency, and bolster public transit, would allow Torontonians to benefit from travel time savings and better connected means of transport. Hence, potential impacts of HOT lanes on both social capital and mobility/accessibility are dependent on the possibility of HOT lanes to improve congestion. If effective, HOT lanes may increase opportunities for social interaction, social engagement, learning and employment. Further, allocating revenue from HOT lanes towards funding better transit increases the likelihood of improved social capital and cohesion, especially for those who use public transit more, such as low-income families and students.

Non-congested HOV lane users may also experience increased time-savings. HOV lanes promote carpooling, which increases an individual's social network and social capital. Increased time-savings provide HOV users with more discretionary time. However, HOV non-compliant users in the GPLs experience higher congestion and travel times, which decreases their social capital.

Tolling of highways in Toronto and the GTHA has so far been an unpopular subject with politicians and some of the public. Hence, if social capital can also be 'defined as the degree to which individuals experiences a belonging or affinity to a socially cohesive community', the discussion surrounding HOT lanes has led to the development of at least two sides, those in favour and those opposed. Those that are in favour of HOT lanes look at this transportation policy as a means of TDM and revenue collection. Some also consider HOT lanes to be a means through which a mode shift towards transit and active transportation can occur. From those that are opposed, two main arguments offered are that HOT lanes are 'Lexus lanes' (see 'Socioeconomic status' section above) and that the highways have already been 'paid for' by public taxes and paying again is unfair.

Previous studies of congestion pricing and HOT lanes have shown that although highly unpopular at first, acceptability and a popularity of congestion pricing and HOT lanes increased once the project/policy had been implemented and the public had a chance to experience any benefits (FHWA, 2010; Guensler et al., 2013; Goel and Burris, 2012; City of Stockholm, 2006). A study conducted by the National Cooperative Highway Research Program (NCHRP) on public opinion on tolling and road pricing across the United States and internationally found that "..*in the aggregate there is a clear majority support for tolling and road pricing*" and "*(o)ur results highlight an apparent disconnect between political perceptions of the public attitude toward tolling and actual public opinions. The application of tolling programs and pricing policies largely depend on the willingness of public officials and policy makers to do so.*" (NCHRP, 2008). In fact, in a recent local poll by Pembina Institute and the Environics Research Group, 1,000 GTA commuters with an average commute time of at least 30 minutes one way were surveyed (Burda and Haines, 2012). The survey found that "*57% of drivers thought a toll was a somewhat or very reasonable way to help pay for transportation improvements in the GTA*" and "*54% of drivers who commute by major highway were likely to pay to use an optional express lane that would allow them to by-pass highway congestion (HOT lane)*" (Burda and Haines, 2012). Of those respondents who supported a user-based road toll, a majority (68%) thought that tolling should only be implemented on routes with alternative transport choice, i.e. access to rapid transit (Burda and Haines, 2012).

An important subject raised in the study report that bears more reflection on the part of policy-makers involved in potential HOT lane implementation is that the researchers designed the study in a manner in which survey respondents were first exposed to education, context and examples about the questions being asked, rather than just presenting them directly with a question (e.g. Do you support a road toll?) and receiving YES/NO answers (Burda and Haines, 2012). Educating the public on congestion pricing in general and raising the subject of possible earmarking revenue towards public transit, may allow them to make informed decisions and be more accepting of such initiatives. Such an exercise may improve social cohesion within the community.

Table 7: Comparison between implementing HOT, HOV and BAU options in Toronto for potential impacts on Social Capital and Cohesion

	HOT lane	HOT lane + revenue invested in transit	HOV lane	BAU
Social Capital and Cohesion	• Lack of effective communication and outreach to public before HOT lane implementation may negatively affect social cohesion. However, case studies show public support for congestion pricing policies increased after implementation, provided time savings are achieved • Improved travel times due to HOT lanes may increase travel time savings and hence social capital for all users • HOT lanes offer added choice to drivers, especially when time savings are of greater value than cost of tolls, regardless of income group	• Increased travel time savings lead to increased discretionary time available for social networking; increased overall social value for all income groups, but especially for low-income groups with higher bus/transit usage	• HOV compliant users with higher time savings reap greater social capital rewards • Non-HOV compliant GPL users face higher congestion and reduced time savings for social networking.	• If congestion levels don't change, neutral-negative impact on overall time savings and level of social interaction • If congestion increases with increased population growth, substantial negative impact on social capital and cohesion in Toronto, and for all those commuting to and from Toronto
Impact direction	Neutral-Positive	Positive	Neutral-Negative	Negative

5.5. Air quality

Numerous studies have demonstrated that Traffic-Related Air Pollution (TRAP) is a significant source of negative health impacts. In Ontario, the transportation sector has the highest contribution to GHG emissions (35%) (GHG Report, 2015). In a recent report by Toronto Public Health 'Path to Healthier Air: Toronto Air Pollution Burden of Illness Update' (2014), the biggest local source of air pollution is identified as traffic, estimated to cause 280 premature deaths and 1090 hospitalizations annually (TPH, 2014). Although these numbers have decreased since 2007, probably due to improved emission standards for vehicles, they still represent a significant health impact (TPH, 2014). In 2007, traffic congestion (and related air pollution) was estimated to be linked to 440 premature deaths, 1700 hospitalizations and 200,000 restricted activity days per year in Toronto alone (TPH, 2007). The economic costs related to mortality were estimated to be around $2.2 billion (TPH, 2007).

As discussed above, communities living within 200-500 m of a highway are most prone to exposure and potentially significant health impacts due to TRAP. In addition, it impacts individuals in vehicles sitting on congested highways and arterials by increasing their exposure to air pollution. The most recent study published by Public Health Ontario shows that over a quarter (27.8%) of Ontarians live within 100 m of a major road or within 500 m of a highway (PHO, 2016). Over a quarter of schools (26.3%) and almost half of long-term care facilities (48.4%) in Ontario are situated in TRAP-exposed areas (PHO, 2016). This places vulnerable populations, namely children, older adults and individuals with pre-existing health conditions in positions of greater risk (PHO, 2016).

At the municipal level, 43.8% of Torontonians live within 100 m of a major road or within 500 m of a highway (PHO, 2016). One of the main traffic-related pollutants is NO_x, which is released from cars and trucks. Upon release into air it transforms into NO_2, a pollutant that has been consistently associated with significant health impacts (HEI, 2010). As seen from Figure 20, the highest annual concentrations of NO_x are found along and close to major highways in Toronto (Golder, 2011; TPH, 2014). Concentrations of NO_2 and $PM_{2.5}$ remain high (about 60% and 80% of maximum concentrations, respectively) up to 500 m from the edge a road (Karner et al., 2010). Efforts to increase residential density in Toronto have led to an increasing number of tall residential buildings being built close to high volume and often congested highways, such as the Gardiner Expressway (TPH, 2014). In some cases, residential buildings are within metres of the highway.

Figure 20: NO_x levels across the City of Toronto, 2006. The darker colours represent higher concentrations. Source: TPH, 2014; adapted from Golder Associates, 2011.

Figure 21 shows the distribution of releases of criteria air contaminants in 2005 in Toronto (Pollution Watch, 2008). The dark brown and red areas indicate higher releases of CACs due to a higher number of industrial sources (yellow dots) that report CAC concentrations to the National Pollution Release Inventory. The criteria air contaminants are:

- Nitrogen oxides (NO_x)
- Particulate Matter of 10 microns or less (PM_{10} and $PM_{2.5}$)
- Carbon monoxide (CO)
- Volatile Organic Compounds (VOCs)
- Sulphur oxides (SO_x)

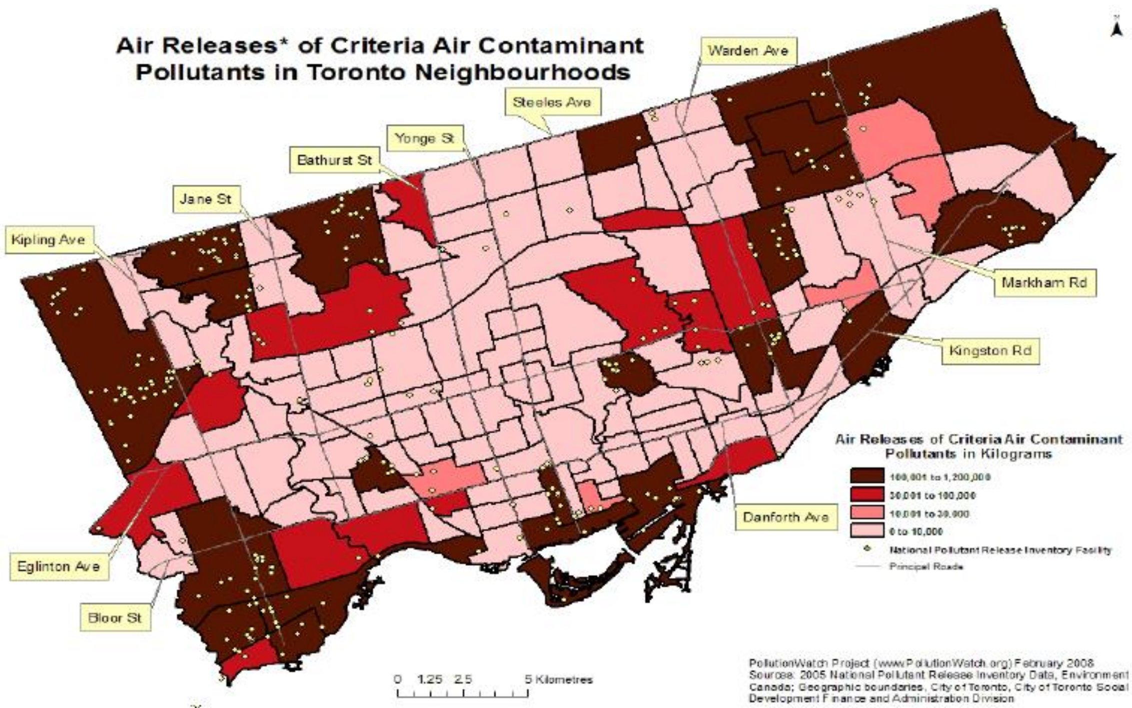

Figure 21: Air releases of criteria air contaminants (kg) from National Pollutant Release Inventory facilities in neighbourhoods in Toronto in 2005. *From industrial sources reporting criteria air contaminant pollutants to the National Pollutant Release Inventory. Source: Pollution Watch, 2008.

Due to high levels of TRAP, air quality is poor in Toronto around areas close to the major highways (Figure 20), as well as in the western boundary, downtown core, and eastern end (Scarborough area) (Figure 21). A TPH review on the burden of illness of air pollution from traffic (2007) highlighted the health impacts from exposure to NO_2, $PM_{2.5}$, SO_2 and CO, including increased incidence and duration of respiratory problems, reduced lung function, acute and chronic bronchitis, asthma attacks, elevated mortality rates and increased hospitalization (TPH, 2014). As the review by the Health Effects Institute (HEI) shows, TRAP plays a causative role in exacerbation of asthma (HEI, 2010). And although not definitive, there is suggestive evidence for a causal relationship exists between TRAP and cardiovascular mortality and morbidity, impaired lung function, onset of asthma in children, and non-asthma respiratory symptoms (HEI, 2010; Brauer et al., 2012). The International Agency for Research on Cancer has classified air pollution, diesel exhaust and $PM_{2.5}$ as carcinogenic to humans (IARC, 2013; 2014).

Hundreds of studies conducted in communities around the world have demonstrated that short-term increases in concentrations of common air pollutants are linked with increases in a broad range of acute health impacts due to cardiovascular and respiratory disease (Hoek et al., 2013, Pope et al 2006; Brugge et al., 2007). The American Heart Association, in a substantive review of health literature on fine particulate matter ($PM_{2.5}$), a common air pollutant with strong association to chronic health impacts, concluded that (Brook et al., 2010):

- A causal relationship exists between exposure to $PM_{2.5}$ and cardiovascular disease and mortality;
- Chronic long-term exposure (i.e. a few years) to high concentrations of $PM_{2.5}$ increases risk for cardiovascular mortality and reduces life expectancy; and
- Reductions in $PM_{2.5}$ concentrations in air can reduce risk of cardiovascular mortality within a few years

A long-term study of about 6,000 children in 12 communities in Southern California since 1993, the Children's Health Study, suggested that air pollution decreases lung function among adolescents, with increased risk of childhood asthma among those who grow up in areas with high levels of air pollution (Gauderman, 2000; Peters, 2004). Overall, exposure to TRAP has been shown to lead to early onset and exacerbation of childhood asthma (Brauer et al., 2012; HEI 2010). Most recently, a Canadian study involving over 65,000 children revealed that exposure to TRAP during pregnancy increases the risk of the child for developing asthma in the first five years (Sbihi et al., 2016). Additionally, if the mothers lived close to major highways during pregnancy, the relative risk of the child for developing asthma before age five increased by 25% (Sbihi et al., 2016).

Although little is known about Ultrafine Particles (UFPs), which are PM less than 0.1 microns in size, short-term studies indicate adverse chronic cardiovascular and respiratory outcomes (reviewed in Weichenthal, 2012). Ultrafine particles are also TRAP constituents, and like $PM_{2.5}$ are able to penetrate deep into lungs. More recently, Weichenthal and others (2016) collected ambient UFP data during a mobile monitoring campaign conducted in Toronto for two weeks in September 2010 and one week in March 2011 (Figure 22). Highest concentrations of UFPs are

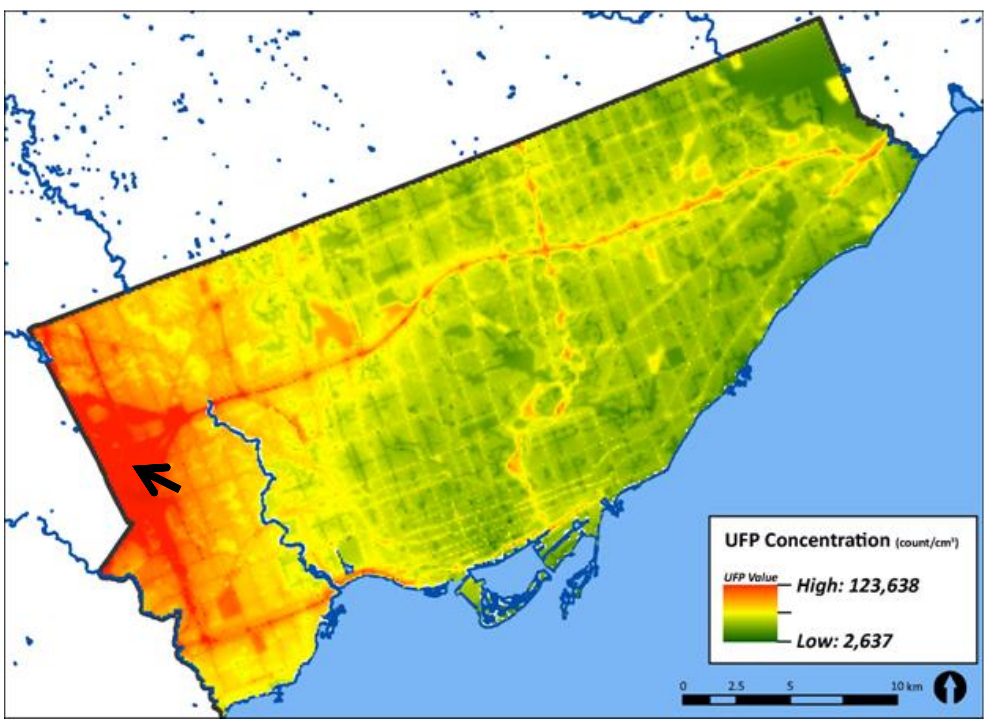

Figure 22: Predicted spatial distribution of ambient UFPs in Toronto, Canada. Black arrow indicates Pearson International Airport, Toronto, as an important source of UFPs. Source: Weichenthal et al., 2016

found around Toronto's international airport, as well as along major highways.

The growing scientific literature linking high traffic corridors with increased adverse health impacts has lead to growing pressure to step up responses to address TRAP and traffic congestion. Public Health Ontario and Toronto Public Health suggest a number of strategies that could be implemented to reduce TRAP and congestion. Some of these include strengthened vehicle emission standards, encouraging active transportation and use of public transit, reducing dependency on cars, use of buffer zones between major roads and highways and buildings with vulnerable populations, and implementing transportation policies that reduce congestion (PHO, 2016; TPH, 2014). Hence, a TDM strategy such as HOT lanes, if implemented efficiently has the potential to address concerns on reducing congestion and at the same time generate revenue that can be used towards improving public transit.

5.5.1. Potential impacts of HOT lanes on air quality

In the HOV-HOT lane conversion in San Diego, it was found that the HOT lanes reduced emission levels in the I-15 corridor by 3-fold in comparison to a control traffic corridor (I-8). However, in the study roadway itself the emissions during peak hours on the HOT lanes were significantly higher than in the GPLs, owing to increased use of HOT lanes (Supernak et al., 2002). The research paper "Traffic Congestion and Infant Health: Evidence from E-ZPass" demonstrated that reducing traffic congestion along the New Jersey turnpike in the United States by introducing an electronic toll, was associated with significant reductions in the incidence of premature birth and low infant birth weight among mothers living near highway toll collection areas (toll plazas) (Currie and Walker, 2011). This case study presents an important case on the significant benefits of reducing congestion and improving air quality. However, the study informs on impacts of tolling the entire highway, in which the E-ZPass lanes improved stop-and-go of traffic by automating the toll collection. In the case of HOT lanes, unless the variable tolling maintains free-flow conditions in the tolled lanes and reduces congestion (and continual stop-and-go of traffic) in the GPLs, air quality may not improve significantly. HOV lanes that reduce congestion may improve air quality, at least in the HOV lanes. Although HOV3+ lanes are less likely to be congested compared to HOV2+ lanes, HOV3+ lanes may also be underused (Guensler et al., 2013). In Texas, converting HOV2+ lanes to HOV3+ reduced demand by 65% (Guensler et al., 2013).

Another study by Kall and others (2009) used the MOBILE-Matrix modelling tool to model the impact on air quality upon conversion of HOV lanes to HOT lanes on Atlanta's I-85 highway. They estimated mass emissions for hydrocarbons, NO_x, CO, $PM_{2.5}$ and PM_{10}, and found that HOV-HOT lane conversion on the I-85 would not result in significant air quality impacts (as per National Environmental Policy Act guidelines) (Kall et al., 2009). Moreover, an HIA conducted in Oregon on 'Policies Reducing Vehicle Miles Travelled in Oregon Metropolitan Areas' conducted literature search on impacts on air quality due to congestion pricing (Upstream Public Health, 2009). The authors found there is a lack of evidence in support of health benefits with regard to reductions in air pollution due to congestion pricing, with a few exceptions. As with reducing congestion and increasing transit ridership, broader congestion charging strategies used in London (UK) and Stockholm, when complemented with expanded bus service within the charging zone, were associated with reductions in emissions as well as a modest improvement in air quality for many years (FHWA, 2010; Beevers and Carslaw, 2005; Tonne et al., 2008). This was due to an overall reduction in the number of vehicles and higher speeds within the charging zone (Beevers and Carslaw, 2005; Tonne et al, 2008).

Table 8: Comparison between implementing HOT, HOV and BAU options in Toronto for potential impacts on Air Quality

	HOT lane	HOT lane + revenue invested in transit	HOV lane	BAU
Air Quality	• No significant difference overall air quality	• Air quality improvement more likely as increased transit use may lead to fewer SOVs on the road	• Due to chronic underuse, HOV lanes have not, historically, resulted in overall air quality changes • Air quality along HOV lane specifically might be better due to lower traffic volume	• Due to projected increase in population, and hence, traffic volume, air quality may deteriorate if no alternative mode of transportation is promoted. • Transit on highways may be negatively impacted by increasing congestion
Impact direction	Neutral	Neutral-Positive	Neutral	Negative

5.6. Equity considerations and Socioeconomic factors

The HIA principles of practice place high importance on applying equity and social inequalities lenses to inform the project or policy under assessment, and making recommendations to improve overall equity related to the project or policy. As a result, one of the main features of HIA is that it also analyzes the distribution of health impacts.

Equitable access to transportation enables low-income populations to access and benefit from services and goods and improves physical, social, mental and economic well-being. Hence access to transportation is a determinant of health that enables access to other determinants of health. A recently published report by Toronto Public Health "*Next Stop Health: Transit Access and Health Inequities in Toronto*" (2013) highlights the importance of affordable access to transportation of disadvantaged populations. Low-income populations are most reliant on public transit. In Toronto, public transit use to commute to work is highest among low-income groups (TPH, 2013).

5.6.1. Changes in health inequities in Toronto

"The Unequal City: Income and Health Inequalities" report by Toronto Public Health showed the existence of differences in health between income groups in Toronto; low income groups had worse health for most health status indicators, and differences in health affected not just those who were worst off, but Torontonians in all income groups (TPH, 2008b). Most health inequities for both women and men in Toronto have persisted over time (TPH, 2015). A more recent follow-up report published by, examined the strength and nature of the relationship between income and health inequities and whether this relationship has changed over time (TPH, 2015).

Changes were assessed by calculating the Relative Index of Inequality, which measures the extent of variation of health with income.

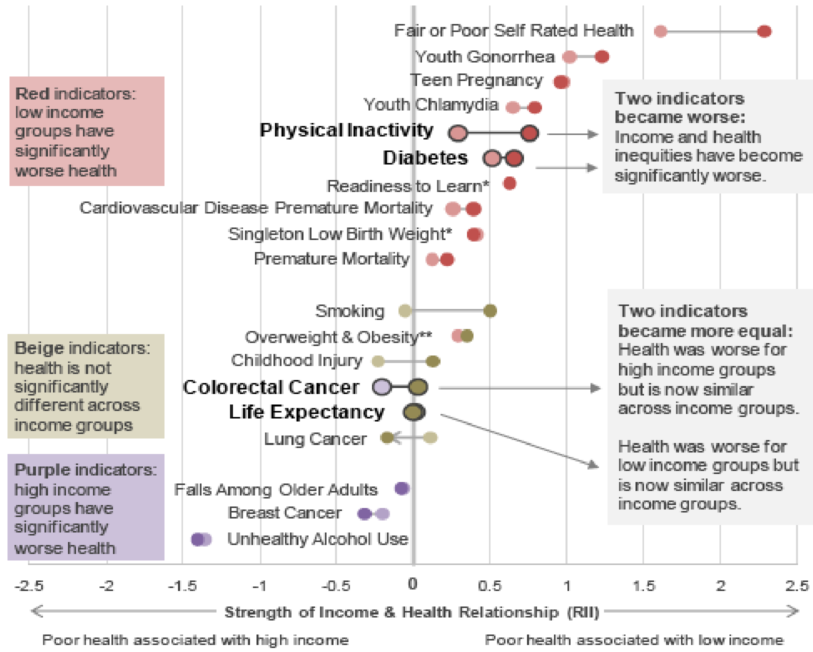

Figure 23: Change in health inequities in women in Toronto, 2015. Source: TPH, 2015.

Depending on its availability, the report used data for the most recent 7 to 12 years. Overall, the red dots (in Figures 23 and 24) indicate an inverse relationship between low-income groups and good health. As indicated in the figures below, health inequities became worse for women in the following main areas: physical inactivity, diabetes, cardiovascular disease-related mortality and premature mortality (Figure 23). However, life expectancy among women evened out regardless of income groups. Incidence of breast cancer was higher in women from higher income groups.

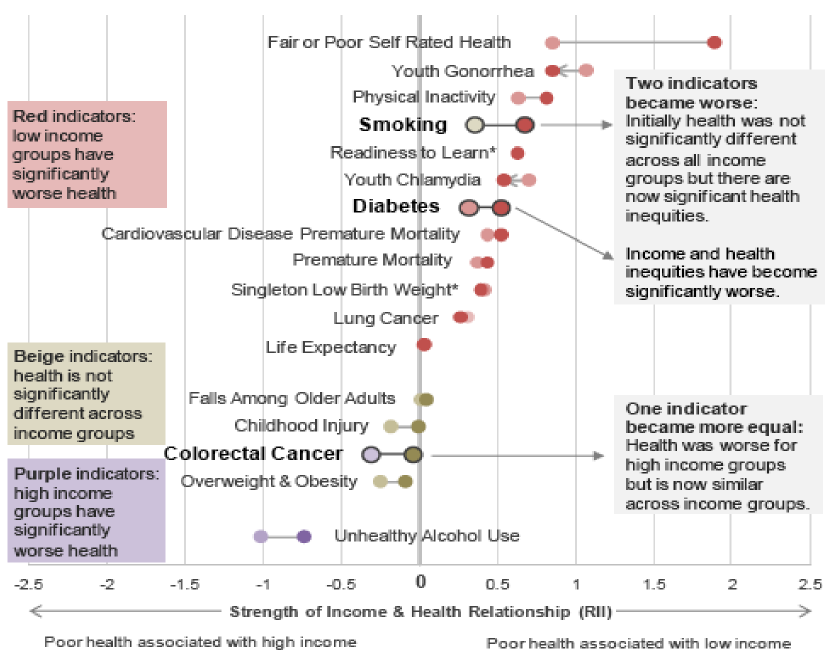

Figure 24: Change in health inequities in men in Toronto. Source: TPH, 2015.

For men, as seen from Figure 24, the strength of the inverse relationship between income and diabetes increased significantly. Prevalence of diabetes increased for all Toronto men. However, as this increase was greater for low-income groups, there is a widening gap in health inequities in this area. Additionally, although smoking rates in men were previously not significantly different across different income groups, from 2009-2012 the smoking rates in high income men have reduced, unmasking a greater impact of low income on smoking rates in men in this most recent time period. As for women, rates of physical inactivity in lower income men were significantly higher.

People's socioeconomic circumstances play a major role in deciding where they live. Zones between 200-500 m of a highway are exposed to the most health impacts of traffic-related air pollution (TRAP) (HEI, 2010). Figure 25 demonstrates that in Toronto, about half of those living closest to the portion of Highway 401 studied, are from lowest and lower-middle socioeconomic status groups (about 50-55% of area within 200m of highway) (CIHI, 2010). The highest socioeconomic status group inhabits only about 5% of the area within 200m of a highway in Toronto (CIHI, 2010). This suggests that TRAP has a greater impact on more disadvantaged populations in Toronto.

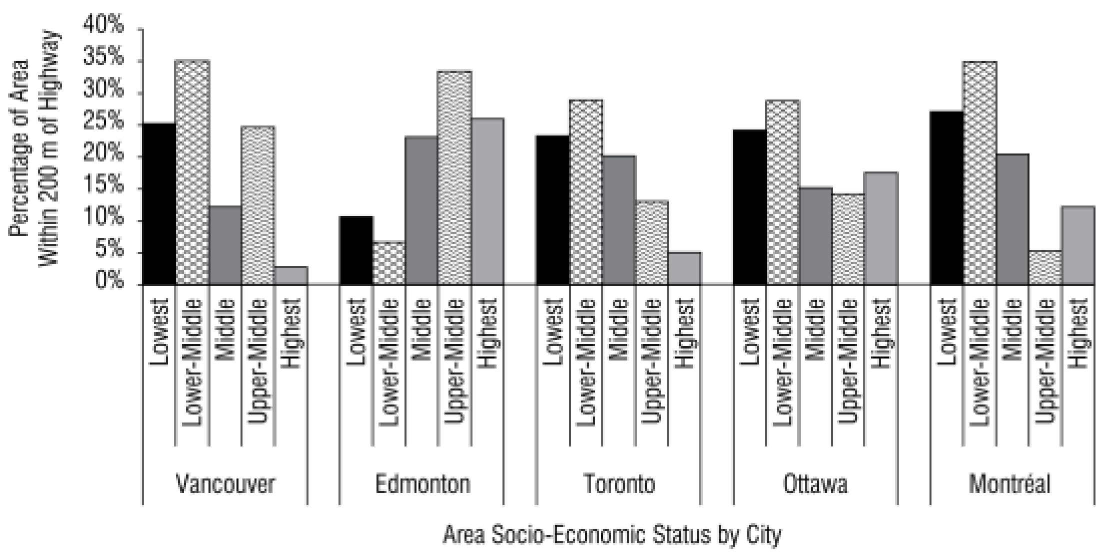

Figure 25: Percentage of land area from each socio-economic status group within 200 metres of sections of major highways in five cities, 2006. Note: All five cities are presented within the same graph to facilitate the publication of results. Because each section of highway is of a different length and various traffic volume data sources were used, comparisons between cities should not be made. Area socio-economic status defined using the National Institute of Public Health Québec's Deprivation Index, 2006. Sources: CIHI, 2010; Ontario Ministry of Transportation, 2006; City of Edmonton, Transportation Department, 2007; Transport Québec, 2008; British Columbia Ministry of Transportation and Infrastructure, 2009; and Census of Canada, 2006.

Highway 401, a major highway in Toronto with the highest traffic volumes, shows a similar distribution of higher percentage of lower socioeconomic groups (greens) living within 200 m of the highway, when compared to the highest income groups (grey) (CIHI, 2010; Figure 26). This estimation has been made by looking at the distribution of the two colours along the highway, as exact calculated percentages have not been provided.

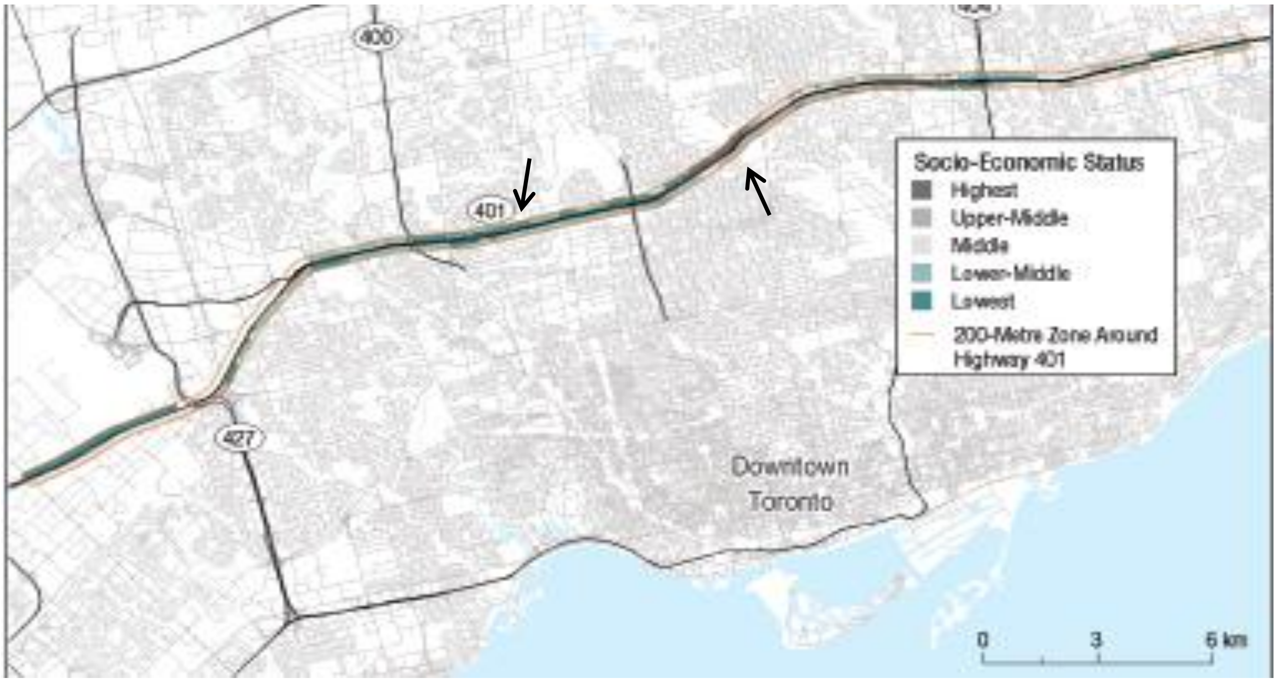

Figure 26: Socio-Economic Status Distribution of Dissemination Areas Within 200 Metres of a Selected Portion of Highway 401 in Toronto. Hwy 401 has been indicated with black arrows. Source: Canadian Institute for Health Information, 2010.

5.6.2. Potential impacts of HOT lanes on equity

5.6.2.1. The 'Lexus lanes' argument

One of the biggest concerns expressed about the implementation of HOT lanes is that they are not equitable, i.e. they place an unequal burden on those with low income, or with limited disposable income. The term "Lexus Lanes" has been coined to describe HOT lanes based on the assumption that the only people who could afford to use them are those who are wealthier. Hence, it is often assumed that HOT lanes place a disproportionate burden on low-income individuals who get shut out of the opportunity of travelling faster on these lanes as they are less able to afford the toll. This concern was studied by researchers at the Georgia Tech University, who compared the age and models of cars that used HOT lanes on the I-85 freeway in Atlanta on a day-to-day basis and compared them to those in the GPLs: the top four cars in both the tolled and GPLs were exactly the same: Honda Civic, Honda Accord, Toyota Camry and Ford F-150 (Figure 27; Khoeini and Guensler, 2013). The researchers noted that these models in the tolled lanes were, on average, a year newer. In a review of the MnPASS lanes in Minnesota (HOV lanes converted to HOT) no significant correlation was found between socio-demographics and project benefits and attitudes (FHWA, 2010). HOT lanes benefitted "a diverse population across all income, age, race/ethnicity, employment, and mode usage groups" (FHWA, 2010). Extensive research conducted on equity concerns on tolled express lane on the SR-91 highway in California that not all have a negative impact on equity. Low-income drivers do use SR-91 express lanes and approve of them as much as higher income drivers (US Department of Transportation, 2008). Fifty one percent of commuters with household incomes less than $25,000 annually approved of tolled express lanes.

Rank	HOT				GP			
	Vehicle Make	Vehicle Model	Average Model Year	Average Vehicle Value($)	Vehicle Make	Vehicle Model	Average Model Year	Average Vehicle Value($)
1	HOND	ACCORD	2004.6	9,585	HOND	ACCORD	2003.5	8,189
2	HOND	CIVIC	2005.0	8,130	HOND	CIVIC	2004.3	7,270
3	TOYT	CAMRY	2005.2	8,840	TOYT	CAMRY	2004.3	7,878
4	FORD	F150	2005.8	9,353	FORD	F150	2004.3	7,486
5	NISS	ALTIMA	2006.9	9,001	TOYT	COROLLA	2005.1	8,031
6	HOND	CR-V	2005.8	10,529	NISS	ALTIMA	2005.9	8,109
7	TOYT	COROLLA	2006.1	7,942	CHEV	SILVERADO	2005.0	8,295
8	INFI	G35	2005.0	11,236	HOND	CR-V	2005.2	9,765
9	FORD	ECONOLINE	2007.4	9,560	FORD	EXPLORER	2002.6	5,805
10	CHEV	SILVERADO	2005.3	8,421	FORD	ECONOLINE	2004.5	7,031
11	FORD	EXPLORER	2004.0	8,078	DODG	RAM	2004.9	7,734
12	HOND	ODYSSEY	2006.4	12,013	FORD	MUSTANG	2004.3	8,890
13	LEXS	RX	2004.6	15,501	HOND	ODYSSEY	2004.7	9,425
14	FORD	MUSTANG	2005.4	10,700	NISS	MAXIMA	2002.5	8,072
15	JEEP	CHEROKEE	2005.0	9,894	TOYT	TACOMA	2004.6	11,076
16	NISS	MAXIMA	2005.6	12,088	JEEP	CHEROKEE	2002.8	6,833
17	LEXS	ES	2004.6	13,425	TOYT	4RUNNER	2002.8	9,236
18	CHEV	TAHOE	2006.1	15,650	CHEV	EXPRESS	2005.5	8,778
19	HOND	PILOT	2006.7	12,252	TOYT	SIENNA	2004.7	8,941
20	TOYT	4RUNNER	2004.8	12,530	INFI	G35	2005.0	11,373

Figure 27: Rank order of vehicle make and model usage in HOT and GPLs. Source: Khoeini and Guensler, 2013.

At a recent 'HOT Lanes Forum' held by *Transport Futures* (January 2016) in Toronto to discuss implementation of HOT lanes in the GTHA and beyond, Professor Jonathan Hall, from the University of Toronto presented his recent research "Pareto Improvements From Lexus Lanes: The Effects Of Pricing A Portion Of The Lanes On Congested Highways" (Hall, 2016). This paper proposes that a "*judiciously designed toll applied to a portion of the lanes of a highway can generate a Pareto improvement even before the resulting revenue is spent*". A 'pareto improvement' in economics is a "change in the allocation of a resource to a set of individuals that is an improvement for at least one and no worse for any other" (Wiktionary, 2016). According to Hall, a variable toll that maintains high throughput in the tolled lane, even though it hurts some users who are less able to afford the toll, provides Pareto improvements (Hall, 2016). Those who can afford the priced lanes, move into them and gain the travel time savings they pay for. This leaves the free lanes slightly less congested than before, allowing their occupants better travel times than before: a Pareto improvement (Hall, 2016). This is represented in Table 9 below. Additionally, the study finds that tolling up to half the lanes yields a Pareto improvement with substantial related social welfare gains that may be up to $1,740 per road user annually (Hall, 2016).

Table 9: Projected impact of HOT lanes in a scenario where one of two lanes on a highway is tolled (Hall, 2016). The upward arrows indicate an increase and the downward arrows indicate a decrease in the respective measures.

	No Toll applied		Toll applied	
	Lane 1	Lane 2	Lane 1	Lane 2
Pricing	Free	Free	Toll	Free
Avg. queue length	Long	Long	No change	↓
Throughput	Low	Low	↑	No change
Travel time	Long	Long	↓	↓
Share of trips	50%	50%	↑	↓

5.6.2.2. HOT lanes: an added choice

HOT lanes, unlike highways that are fully tolled, provide an added choice to commuters to choose to pay a toll or travel for free, depending on the trip urgency and how much they value their time. Hence, it can be argued that judiciously tolled HOT lanes may reduce congestion while avoiding some of the equity challenges posed by tolls that are enforced on all lanes on a highway (Hall, 2016). For those from lower-income families, traffic congestion is a big burden. Individuals, especially youth entering the work force for the first time, sometimes hold down more than one job to make ends meet. For such individuals, being late to work often is not an option and the ability to get from one job to the next, on time, can become extremely important. Additionally, for those picking up children from daycare, it is more important to get to the daycare on time and avoid late fees, than pay a few dollars to use the HOT lanes and save on travel time (Ragan and Vuong, 2015). Also, it was reported that for lower-income users, the value of time-savings gained by using HOT lanes was higher than for middle-income users (Patil et al., 2011; Dachis, 2011). Hence, it can be argued that in the instances where it is more important to get to work (or daycare, an appointment, etc.) on time, paying a toll may be worth the cost.

A GTA study conducted by researchers from the University of Waterloo, found that mean willingness-to-pay on HOT lanes increases with increasing urgency of the trip and as trip conditions worsen (Finkleman et al., 2011; Figure 28). Income does play a significant role in willingness-to-pay, especially in cases when using HOT lanes results in less than substantial or very small time savings (Finkleman et al., 2011). However, the researchers note that as trip conditions worsen, all income groups in the GTA express a willingness-to-pay. It should be noted here that willingness-to-pay as a measure has its limitations, which includes lack of appropriate and sufficient information possessed by respondents to place reasonable monetary value on something (Mould Quevedo et al., 2009).

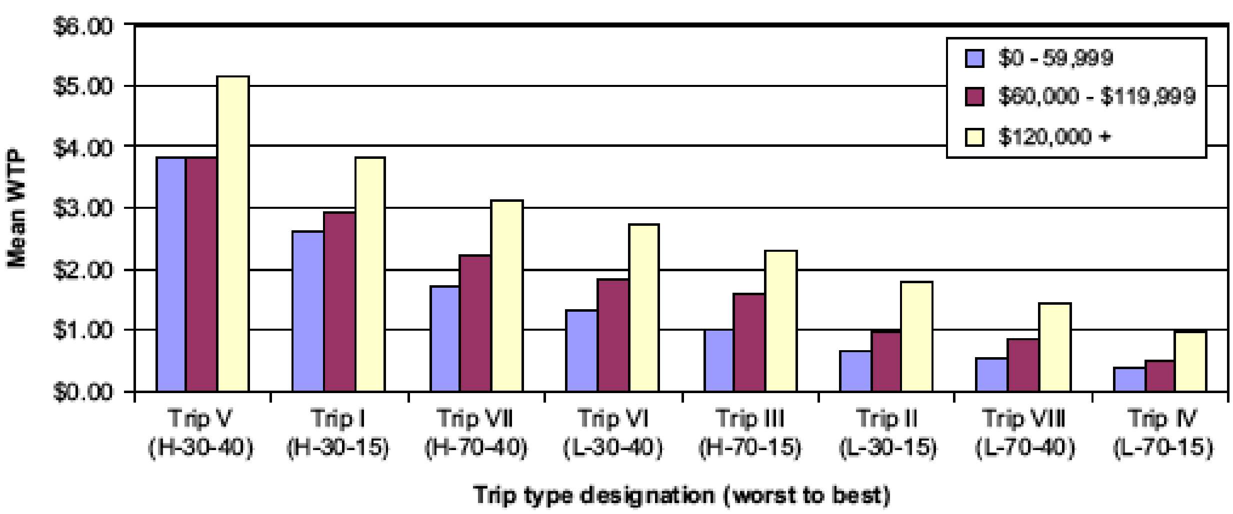

Figure 28: Willingness-To-Pay mean values of low (purple), mid (maroon) and high (yellow) income GTA respondents (n=236) for each trip designation. (H-30-40 = High urgency trip at 30 kmph and 40 km travel distance; L-30-40 = Low urgency trip at 30 kmph and 40 km travel distance). Source: Finkleman et al., 2011.

5.6.2.3. Public transit meets HOT/HOV lanes

Public transit users also potentially benefit from HOT lanes, as public transit vehicles use HOT lanes for free and take advantage of faster and more reliable travel times. Hence, lower income groups who tend to use public transit more (TPH, 2013) and may not necessarily be able to afford tolls, also benefit from HOT lanes (Schweitzer and Taylor 2008; Poole and Balaker 2005; Dachis, 2011). Research conducted over the last eight years by GO Transit, Ontario's regional bus and train service, shows that the 18-24 years age group are the majority users of the GO bus service (40-44% of total users) (Metrolinx, 2016). A GO Bus passenger survey conducted in 2012-2013 identified the main trip purpose, which was 'Travel to and from work' and 'Travel to and from school' (Metrolinx, 2016). Hence, if the proposed HOT lanes maintain free-flow conditions similar to conditions on the temporary HOV lanes during the 2015 Pan Am games held in the GTHA (Figures 15, 17), those using public transit will benefit from implementation of HOT lanes.

In the case of HOT lanes, if revenue from HOT lanes is used to fund public transit, such as increasing the number and frequency of bus routes that use the highways to move commuters to places of work and education, building additional transit infrastructure that has been planned but not fully funded in Toronto, and implementing *The Big Move*, the benefits to society as a whole would increase.

Table 10: Comparison between implementing HOT, HOV and BAU options in Toronto for potential impacts on Equity considerations and Socioeconomic Status

	HOT lane	**HOT lane + revenue invested in transit**	**HOV lane**	**BAU**
Equity considerations and Socioeconomic factors	• Case studies in the United States show that all income levels use HOT lanes; although usage among high-income groups is higher • If tolls not variable and not implemented judiciously, likelihood for negative impact on equity	• Low-income groups more likely to use transit in Toronto. Potential negative impacts on equity due to HOT lanes mitigated with increased transit spending and use	• Neutral impact on equity due to HOV lanes • Improved travel time for buses on HOV lanes may have positive impact on equity, as low-income groups tend to use transit more	• Increased or continuing congestion on highways may negatively impact transit/bus travel, resulting in increased travel times for those who use transit most
Impact direction	Neutral-negative	Neutral	Neutral	Negative

5.7. Potential health impact on the wider GTHA due to implementation of HOT lanes on highways

Although this rapid HIA is more focussed on Toronto and assesses potential impacts on health due to the transportation policy from the context of Toronto, a more general and higher-level potential impact scenario for the GTHA has been represented. As indicated earlier, the major difference between the Gardiner and DVP, and the other highways in the GTHA is that both of Toronto's highways may be considered to be relatively narrower than those in the GTHA, with only three lanes in each direction in some sections. Tolling on these two highways would mean converting one of the three GPLs to a HOT lane. Since HOV lanes on highways in the GTHA can only be found on some sections of the QEW and Highways 403 and 404, the overall potential health impacts in the GTHA would be similar to those in Toronto. However, some differences exist in the wider GTHA context, which may influence potential health impacts. These include:

- The level of income in the wider GTHA is generally higher than in Toronto (National Household Survey Bulletin, 2013).
- Although public transit (bus service) exists in most municipalities in the GTHA, only Toronto has a subway network. However, transit deserts exist even within Toronto (Figure 19).
- Since Toronto has one of the highest concentration of jobs in the GTHA, it stands to reason that many GTHA residents commute to and from Toronto everyday for work, making average GTHA commute times (41 minutes one-way) higher than Toronto's average commute time (32.8 minutes one-way) (Metrolinx, 2008b; Neptis Foundation, 2015b). For those driving, costs related to HOT lanes may be higher, especially if commute distance is long.
- Overall, GTHA residents drive more than those in Toronto, with greater implication for potential health impacts due to HOT lanes on highways. However, to better understand the magnitude of potential health impacts in a GTHA-specific context, an HIA more focussed on this region would be useful.

6. Conclusions

The main conclusions from this rapid HIA are:

- Appropriately tolled HOT lanes do reduce congestion more than HOV lanes;
- A regional/network implementation of HOT lanes is more effective;
- Reduced congestion improves quality of life and contributes to social capital, social inclusion, mobility and accessibility;
- HOT lanes are associated with a (very) small decrease in air pollution along the traffic corridor;
- Appropriately tolled HOT lanes can also result in less congestion in the GPLs;
- HOT lanes may have a negative equity impact, which if true, is very small (low-income individuals will use the HOT lanes when they get direct benefits);
- If revenue from HOT lanes is used to improve transit, any negative equity impacts are likely compensated for, and could increase mobility of more disadvantaged groups

7. Recommendations

The next step of an HIA is to make relevant and feasible recommendations based on the assessment findings and conclusions that have the potential to improve the project, plan or policy being assessed. This Rapid HIA recommends that HOT lane implementation on highways in Toronto should be accompanied with revenue investments in transit and other active transportation strategies, as well as consideration of further recommendations listed below. Readers of this report are reminded that congestion pricing/HOT lanes are but *one* TDM strategy that should ideally be complemented with other transportation policies and infrastructure policies. The findings of this Rapid HIA indicate a potential neutral-to-positive impact on health of implementing HOT lanes with the caveat that revenue is invested in improving transit and active transport infrastructure. The recommendations listed below will potentially enable the city and region to enhance the positive impacts and mitigate the negative impacts of implementing HOT lanes:

Congestion

- Use data accumulated from jurisdictional research and several congestion pricing studies to design and implement a judiciously priced variable tolling system that maintains free-flow conditions on the HOT lane and potentially also reduces congestion on the GPLs.
- Allow only HOV2+/3+ vehicles, transit and emergency vehicles to use HOT lanes for free. Studies from California, where a large number of electric and hybrid vehicles use tolled lanes for free, show that this practice does not help alleviate congestion. The aim of HOT lanes is primarily to reduce congestion.
- HOT lanes have been found to work most efficiently in reducing congestion if implemented regionally. Hence, develop a common regional plan to implement tolling in the GTHA.

Mobility and accessibility

- HOT lanes should be priced to promote increased mobility and accessibility for as many users as possible; if there is reduced congestion in the HOT lanes, it will enhance mobility for those paying the toll.
- Focus revenue from the tolls for funding transit improvements not only in areas of high-density commuters (i.e. downtown core), but also in 'transit deserts' across the city.

Social capital and cohesion

- To improve social capital, HOT lanes should be planned and implemented to also maximize time-savings.
- Educate and inform the public by providing context and examples of congestion pricing. Address the concept of 'Lexus Lanes' and provide examples from the United States to indicate that HOT lanes have had success in reducing traffic congestion across vehicle types.
- Other strategies to mitigate disruption in social cohesion should also be explored.

Air quality

- Use revenue from HOT lanes to improve and incentivize alternative methods of transportation, such as transit, active transportation and carpooling, to shift mode of transport from driving. HOT lanes are a TDM strategy that together with other transportation policies, such as promoting active transportation, can reduce gridlock and improve air quality.
- Fund regional public transportation strategies, i.e. *The Big Move*, to reap public health benefits as those listed in the *Improving Health by Design* (2014) MOHs report.
- Develop a detailed air quality model to evaluate the potential impacts of HOT lanes on air quality in Toronto and the GTHA and ways through which air quality may be improved. This may allow decision-makers to adjust HOT lanes pricing and conditions to make further improvements in air quality.

Equity considerations and socioeconomic factors

- Improve and enhance public transit BEFORE implementing tolling. Once HOT lanes implemented, add express bus routes that can utilize HOT lanes. For those who cannot use HOT lanes and may experience severe traffic congestion, alternative means of travel should be made available before this transport policy is implemented.
- Price the toll with the primary aim of reducing congestion. Generating revenue should be secondary aim of the HOT lanes to minimize inequitable impact on economically disadvantaged populations.
- Invest revenue from tolling into improving transit and active transportation infrastructure.

8. Reporting

In the reporting phase, the design, methods and findings of the HIA are communicated to a spectrum of stakeholders. This Rapid HIA report is one of the methods being used for communication. Additionally, a general public-friendly summary will also be created to communicate purpose and findings of the HIA. To add to the international practice of HIA, this report will also be abridged and submitted to a peer-reviewed journal for publication.

9. Evaluation

Evaluation is the means by which usefulness and impact of the HIA is determined. Monitoring follows the impact of the HIA over time to identify how many recommendations made by the HIA were adopted and to what extent. For this Rapid HIA, a process evaluation was conducted. Stakeholders attending the scoping workshop were requested to anonymously evaluate the workshop and the clarity and usefulness of the scoping workshop (see Appendix II for evaluation form). The results of the evaluation indicate that almost all participants evaluated the overall quality of the Rapid HIA scoping workshop as good-to-great, and identified HIA as a useful tool.

A follow-up study or a more detailed HIA that utilizes quantitative data is recommended in order to evaluate the specific HOT lane implementation plan and methodology decided upon by the city. Additionally, a monitoring plan should be set-up post-HOT lane implementation to monitor changes in the determinants of health due to the project over time.

10. References

AECOM| KPMG 2013. Big Move Implementation Economics: Revenue Tool Profiles. Project Number: 60236189. Commissioned by Metrolinx. Available: http://www.metrolinx.com/en/regionalplanning/funding/IS_Appendix_A_EN.pdf

Barton H. and Tsourou C. (2000). Healthy Urban Planning: A WHO Guide to Planning for People. Rennes, France: Association S2D/Association internationale pour la promotion de la santé et du développement durable. Retrieved from: http://www.euro.who.int/en/publications/abstracts/healthy-urban-planning

Beevers Sean and Carslaw D. 2005. The impact of congestion charging on vehicle emissions in London. Atmospheric Environment. Vol 39: 1-5.

Bhatia R. 2011. Health Impact Assessment: A Guide for Practice. Oakland, CA: Human Impact Partners. Available: http://www.pewtrusts.org/~/media/assets/2011/01/01/bhatia_2011_hia_guide_for_practice.pdf [accessed 10 June 2015].

Bowman M. 2011. Mobility vs Accessibility and Transportation Theory. Available: http://www.slideshare.net/marcus.bowman.slides/mobility-vs-accessibility-and-transportation-theory

Brauer M, Reynold C, Hystad P; University of British Colombia School of Population and Public Health. Traffic-related air pollution and health: a Canadian perspective on scientific evidence and potential exposure-mitigation strategies [Internet]. Ottawa, ON: Health Canada; 2012 [cited 2015 Dec 29]. Available from: http://allergen-nce.ca/wp-content/uploads/pubs/Traffic&Health.pdf

Brook RD et al. (2010). Particulate Matter, Air Pollution and Cardiovascular Disease: An Update to the Scientific Statement from the American Heart Association. Circulation. Vol. 121: 2331-2378.

Brugge D. et al. "Near-highway pollutants in motor vehicle exhause: A review of epidemiological evidence of cardiac and pulmonary health risk", Environmental Health. No. 6. August 2007.

Bull FC, Armstrong TP, Dixon T, Ham S, Neiman A, Pratt M. 2004. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL, editors. Comparative quantifications of health risks, Chapter 10: Physical inactivity. Global and regional burden of disease attributable to selected major risk factors. Volume 1. Geneva: World Health Organization, pp. 834-840

Burda C and Haines G. 2012. Drivers' Choice: Options to manage gridlock and fund rapid transit in the GTA. Pembina Institute. Available: https://www.pembina.org/reports/drivers-choice-gta-report.pdf

Canada's Ecofiscal Commission Report. 2015. We Can't Get There From Here: Why Pricing Traffic Congestion Is Critical To Beating It. Available: http://ecofiscal.ca/reports/traffic/

Cancer Care Ontario, Ontario Agency for Health Protection and Promotion (Public Health Ontario). 2012. Taking action to prevent chronic disease: recommendations for a healthier Ontario. Toronto: Queen's Printer for Ontario.

Chicago Metropolitan Agency for Planning, 2012. Congestion Pricing: an analysis of the go to 2040 major capital projects. Chicago, Illinois. Available: http://www.cmap.illinois.gov/documents/10180/24896/FY13-0028+CONGESTION+PRICING+STUDY.pdf/ca284fd8-43ba-479a-b328-15d3a541e3fd

Chum GL and Burris MW. 2008. Potential Mode Shift form Transit to Single-Occupancy Vehicles on a High Occupancy Toll Lane. In Transportation Research Record: Journal of the Transportation Research Board, No. 2072, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 10–19.

CIHI, 2010. Canadian Institute for Health Information, Urban Physical Environments and Health Inequalities (Ottawa, Ont.: CIHI, 2010). Available: https://secure.cihi.ca/estore/productFamily.htm?locale=en&pf=PFC158

City of Stockholm. 2006. Facts and results from the Stockholm Trials, First version – June 2006. Available: http://www.stockholmsforsoket.se/upload/The%20Stockholm%20Trial,%20facts%20and%20results_Expert%20Group%20Summary%20June%202006.pdf

City of Toronto, 2015. Tolling Options for the Gardiner Expressway and Don Valley Parkway. Available: http://www.toronto.ca/legdocs/mmis/2015/ex/bgrd/backgroundfile-83671.pdf

City of Toronto, 2016. Toronto Facts. Available: http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=57a12cc817453410VgnVCM10000071d60f89RCRD

CivicAction Forum 2013a. The poll was conducted by Forum Research on behalf of CivicAction between March 28 and April 3, 2013 using a randomly selected sample of 1491 GTHA residents. Available: http://civicaction.ca/71-per-cent-of-greater-toronto-and-hamilton-area-residents-are-fed-up-with-gridlock/

CivicAction Forum 2013b. Our Region, Our Move: Accelerating investment in our regional transportation network. May 2013. A report by the Greater Toronto CivicAction Alliance. Available: http://civicaction.ca/wp-content/uploads/2015/02/Our-Region-Our-Move-Report-CivicAction-Forum-web.pdf

CIW (Canadian Index of Wellbeing). (2014). How are Ontarians Really Doing? A Provincial Report on Ontario Wellbeing. Waterloo, ON: Canadian Index of Wellbeing and University of Waterloo. Available: https://uwaterloo.ca/canadian-index-wellbeing/sites/ca.canadian-index-wellbeing/files/uploads/files/ontarioreport-accessible_0.pdf

Cohen JM, Boniface S, Watkins S. 2014. Health implications of transport planning, development and operations. Journal of Transport and Health 1. 63–72

Crouse, D. et al. "Postmenopausal Breast Cancer Is Associated with Exposure to Traffic-Related Air Pollution in Montreal, Canada: A Case-Control Study", Environmental Health Perspectives. October 2010.

Currie J and Walker R. 2011. "Traffic Congestion and Infant Health: Evidence from E-ZPass." American Economic Journal: Applied Economics, 3(1): 65-90.

Dachis B. 2011. "Congestive Traffic Failure: The Case for High-Occupancy and Express Toll Lanes in Canadian Cities." C.D. Howe Institute E-Brief 132. August 31.

Dachis B. 2013. "Cars, Congestion and Costs: A New Approach to Evaluating Government Infrastructure Investment." C.D. Howe Institute Commentary 385.

Dora C and Hosking J. 2012. Urban Transport and Health: A Review. Journeys, Nov. 2012. Available: https://www.lta.gov.sg/ltaacademy/doc/J12%20Nov-p07Carlos_Urban%20Transport%20and%20Health-A%20Review.pdf

Duranton G and Turner MA. 2011. "The Fundamental Law of Road Congestion: Evidence from US Cities." American Economic Review, 101(6): 2616-52.

Ecola L and Light T. 2009. Equity and congestion pricing: A review of the evidence. Rand Corporation, 1-45.

Eisele W, Wilner HT, Bolin MJ, Stockton WR, Burris M, Goodin GD, … HoelscherM. 2006. Evaluating criteria for adapting HOV lanes to HOT lanes: Development and application of HOT START software tool. (No. FHWA/TX-06/0-4898-1). Texas Transportation Institute, the Texas A&M University System.

Evans GJ, Jeong CH, Sabaliauskas K, Jadidian P, Aldersley S, Larocque H, Herod D. Design of a near-road monitoring strategy for Canada. SOCAAR report no. CR -WB-2011-01-01. Toronto, ON: Southern Ontario Centre for Atmospheric Aerosol Research, University of Toronto; 2010.

FHWA, 2010. U.S. Department of Transportation Federal Highway Administration (FHWA). Synthesis of Congestion Pricing-Related Environmental Impact Analyses. Report no. FHWA-HOP-11-008.

Finkleman J. 2010. "The HOT-Solution? An Examination of the Desirability for High-Occupancy/Toll (HOT) Lanes in the Greater Toronto Area." University of Waterloo Masters of Arts in Planning Thesis. Available at http://uwspace.uwaterloo.ca/handle/10012/5151.

Finkleman J, Casello J, Fu L. 2011. Empirical evidence from the Greater Toronto Area on the acceptability and impacts of HOT lanes. Transport Policy18(2011)814–824.

Gauderman WJ, et al. (2004). The effect of air pollution on lung development from 10 to 18 years of age. The New England Journal of Medicine. 351(11): 1057-1067.

Gerber M, Kellmann M, Hartmann T, Puhse U. 2010. Do exercise and fitness buffer against stress among Swiss police and emergency response service officers? Psychol. Sport Exerc. 11 (4):286–294.

Goel R and Burris M. (2012). Hot lane policies and their implications. Transportation, 39(6), 1019-1033.

Golder Associates. 2011. All Sources and Cumulative Air Quality Impact Study. Available from http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=95cf9bc4a5991410VgnVCM10000071d60f89RCRD&vgnextfmt=default Accessed March 31, 2014.

Government of Minnesota. (2013). MnPASS express lanes: Use and performance. Minnesota Department of Transportation. Available: http://www.dot.state.mn.us/rtmc/pdf/100313mnpassperfactsheet.pdf

Greenhouse Gas Report, 2015. "Feeling the Heat: 2015 Annual Greenhouse Gas Progress Report". From the Office of the Environmental Commissioner of Ontario. Available: http://eco.on.ca/reports/2015-climate-change-report-feeling-the-heat/ [accessed 20 April 2016].

Greenville Parks and Trails HIA 2013. A Health Impact Assessment (HIA) of Park, Trail, and Green Space Planning in the West Side of Greenville, South Carolina. south carolina Institute of medicine and Public Health. Available: http://www.pewtrusts.org/~/media/assets/2013/03/01/hiaofparktrailandgreenspaceplanningingreenvillesc.pdf?la=en

Guensler R, Khoeini S, Guin A, Elango V. 2013. "Atlanta I-85 HOV-to-HOT Conversion: Analysis of User Socio-spatial Demographic Changes." School of Civil and Environmental Engineering, Georgia Institute of Technology. Atlanta, GA. July 2013.

Guin A, Hunter M, and Guensler R. 2008. Analysis of Reduction in Effective Capacities of High-Occupancy Vehicle Lanes Related to Traffic Behavior. Transportation Research Record. 2065: p. 47-53.

Hall JD. 2016. Pareto improvements from Lexus lanes: the effects of pricing a portion of the lanes on congested highways. Available: http://individual.utoronto.ca/jhall/documents/PI_from_LL.pdf [accessed June 2016].

HEI (Health Effects Institute). "Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposures, and Health Effects", Special Report 17. Boston, MA. January 2010. Available from: http://pubs.healtheffects.org/getfile.php?u=553

Hoek G, Krishnan RM, Beelen R, Peters A, Ostro B, Brunekreef B, et al. Long-term air pollution exposure and cardio-respiratory mortality: a review. Environ Health. 2013;12(1):43. Available from: http://www.ehjournal.net/content/pdf/1476-069X-12-43.pdf

IARC (International Agency for Research on Cancer) 2013. Scientific Publication No. 161. Air Pollution and Cancer. Editors: Kurt Straif, Aaron Cohen, and Jonathan Samet. Available from http://www.iarc.fr/en/publications/books/sp161/index.php Accessed March 24, 2014

IARC 2014. Diesel and gasoline engine exhausts and some nitroarenenes. IARC Monographs Volume 105. Lyon, France: International Agency for Research on Cancer; 2014. Available from: http://monographs.iarc.fr/ENG/Monographs/vol105/mono105.pdf

IBTTA (International Bridge, Tunnel and Turnpike Association). 2016. National Toll Facilities Usage Analysis. Available: http://ibtta.org/sites/default/files/documents/IBTTA%20Publications/National%20Toll%20Facilities%20Usage%20Analysis.pdf

Improving Health by Design in the Greater Toronto-Hamilton Area. 2014. A Report of Medical Officers of Health in the GTHA. Mowat, D. et al. Available: http://www.peelregion.ca/health/resources/healthbydesign/pdf/moh-report.pdf

Jackson RJ and Sinclair S. 2012. Designing Healthy Communities. San Francisco, California: Jossey-Bass. ISBN: 978-1-118-03366-1

K.T. Analytics, and Cambridge Systematics. 2008. Value Pricing Pilot Program: Lessons Learned. Final Report. Washington, D.C.: US Department of Transportation Federal Highway Administration.
Karner AA, Eisinger DS, Niemeier DA. Near-roadway air quality: synthesizing the findings from real-world data. Environ Sci Technol. 2010;44(14):5334-44.

Kall DN, Guensler RL, Rodgers MO, Pandey VS. 2009. Effect of High Occupancy Toll (HOT) Lanes on Mass Vehicle Emissions: An Application to I-85 in Atlanta. Transportation Research Record: Journal of the Transportation Research Board, 2009, Volume 2123 pp. 88 – 96.

Karner AA, Eisinger DS, Niemeier DA. Near-roadway air quality: synthesizing the findings from real-world data. Environ Sci Technol. 2010;44(14):5334-44.

Kavanagh P, Doyle C, Metcalfe O. 2005. Health impacts of transport: a review. Institute of Public Health in Ireland, Dublin. Available: http://www.publichealth.ie/files/file/IPH_Transport_text_44pp.pdf [accessed April 25 2016].

Klaperski S, von Dawans B, Heinrichs M, Fuchs R. 2013. Does the level of physical exercise affect physiological and psychological responses to psycho- social stress in women? Psychol. Sport Exerc. 14 (2):266–274.

Lindsey R. 2007. Congestion relief: Assessing the case for road tolls in Canada. C.D. Howe Institute Commentary 248, Available: http://www.cdhowe.org.

Lindsey R. 2012. Road pricing and investment. Economics of Transportation 1(1-2), 49–63.

Litman T. 2004. London congestion pricing: Implications for other cities. Victoria Transport Policy Institute. Available: http://www.vtpi.org/london.pdf

Loomis D, Grosse Y, Lauby-Secretan B, El Ghissassi F, Bouvard V, Benbrahim-Tallaa L, et al. The carcinogenicity of outdoor air pollution. Lancet Oncol. 2013;14(13):1262-3.

Martin Prosperity Institute, 2010. The Geography Of Toronto's Service Class & What It Means For The City Of Toronto. Available: http://www.martinprosperity.org/media/pdfs/Toronto_election_series-Geography_of_Service_Class.pdf

Martin Prosperity Institute. 2015. Segregated City: The Geography of Economic Segregation in America's Metros. Available: http://martinprosperity.org/media/Segregated%20City.pdf

McCallum LC, Ollson CA, Stefanovic IL. 2016. Development of a Health Impact Assessment Screening Tool: A Value Versus Investment Approach. Journal of Environmental Assessment Policy and Management 18(2): 22p

Metrolinx. 2008a. "Cost of Road Congestion in the Greater Toronto and Hamilton Area: Impact and Cost-Benefit Analysis of the Metrolinx Draft Regional Transportation Plan." Report prepared by HDR Corporation.

Metrolinx, 2008b. The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Area (GTHA). Available: http://www.metrolinx.com/thebigmove/Docs/big_move/TheBigMove_020109.pdf

Metrolinx, 2016. GTHA Transit: A HOT Opportunity to Improve Service? Transport Futures Conference, January 2016.

Metropolitan Transportation Commission. 2007. In cooperation with Caltrans Consultant assistance by PB Americas, Inc. and ECONorthwest. Bay Area High-Occupancy/Toll (HOT) Network Study Final Report. Available: http://www.vta.org/expresslanes/pdf/mtc_hot_lanes_study_final.pdf.

Montreal Health and Social Service Agency. 2006. Urban Transportation, A Question of Health. (63 pp)

Mould Quevedo JF, Hernández IC, Espinosa JG, Escudero GS. 2009. The willingness-to-pay concept in question. Rev Saúde Pública;43(2)

MTO (Ministry of Transportation Ontario) 2016. High-Occupancy Toll (HOT) Lanes. Available: http://www.mto.gov.on.ca/english/highway-bridges/hot-lanes.shtml

National Household Survey Bulletin. 2013. Income, Earnings, Housing & Shelter Costs portion of the 2011 data release from the National Household Survey for Peel Region and the Greater Toronto Area (GTA). Source: Statistics Canada, National Household Survey 2011. Available: https://www.peelregion.ca/planning-maps/Income_Earnings_Housing_Bulletin_Web.pdf

NCHRP (National Cooperative Highway Research Program) 2008. Synthesis 377: Compilation of Public Opinion Data on Tolls and Road Pricing. Transportation Research Board of the National Academies, Washington, D.C. Available: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_377.pdf

Neptis Foundation, 2015a. Growing pains: understanding the new reality of population and dwelling patterns in the Toronto and Vancouver regions. Available: http://www.neptis.org/sites/default/files/growing_pains/growingpains_neptisreport_final.pdf?utm_source=NGO&utm_campaign=837959689a-Growing_Pains5_26_2015&utm_medium=email&utm_term=0_43f8c00dc9-837959689a-56042325

Neptis Foundation, 2015b. Planning For Prosperity: Globalization, Competitiveness and the Growth Plan for the Greater Golden Horseshoe. Available: http://www.neptis.org/publications/planning-prosperity

Newmark, 2012. HOT for Transit: How High Occupancy / Toll Lanes Benefit Bus Service. Draft for Transport Chicago. Available:

North T, McCullagh P, Tran V. 1990. The effect of exercise on depression. Exercise Sports Sci.Rev. 19:379–415.

Ontario Diabetes Database (2011). Institute for Clinical and Evaluative Sciences (ICES), Toronto, Ontario, 2013

Ontario Ministry of Finance. 2016. Ontario Population Projections Update, 2015-2041. Reference scenario, Spring 2016. Available: http://www.fin.gov.on.ca/en/economy/demographics/projections/#tables

Ontario Ministry of Public Infrastructure Renewal. (2005). Places to Grow: Better Choices. Brighter Future. Proposed Growth Plan for the Greater Golden Horseshoe. November 2005. Available: https://www.placestogrow.ca/index.php?option=com_content&task=view&id=420&Itemid=12

Oxford Properties and Environics Research Group, Destination Collaboration: The Future of Work (December 2013). Available: https://www.scribd.com/document/190706372/DESTINATION-COLLABORATION-THE-FUTURE-OF-WORK [accessed 24 Aug 2016].

Patil S, Burris M, Shaw WD Concas S. 2011. Variation in the value of travel time savings and its impact on the benefits of managed lanes. Transportation Planning and Technology. Vol. 34:6.

Perrotta K. 2011. Public Health and Land Use Planning: How Ten Public Health Units are Working to Create Healthy and Sustainable Communities. Prepared for the Clean Air Partnership (CAP) and the Ontario Public Health Association (OPHA). April 2011.

Peters JM et al. 2004. Epidemiological Investigation to Identify Chronic Health Effects of Ambient Air Pollutants in Southern California. Prepared at University of Southern California for the California Air Resources Board (CARB) and the California Environmental Protection Agency (CEPA), Contract 93-3.

Pollution Watch, 2008. Pollution Watch Fact Sheet: An examination of pollution and poverty in the City of Toronto. Available:
https://www1.toronto.ca/city_of_toronto/social_development_finance__administration/files/pdf/pollutionwatch_toronto_fact_sheet.pdf

Poole Jr RW and Balaker T. 2005. Virtual Exclusive Busways: Improving Urban Transit while Relieving Congestion. Reason Foundation Policy Study 337. September. Available:
http://reason.org/files/f74f4436cd5e98624899baf1c02c384f.pdf.

Poole RW and Orski CK. 2000. HOT Lanes: A Better Way to Attack Urban Highway Congestion. Regulation 23 (1). Available: http://www.cato.org/pubs/regulation/regv23n1/poole.pdf.

Poole, 2016. Managed lane projects: growth and growing pains. Surface Transportation News #149. Available: http://reason.org/news/show/surface-transportation-news-149#a

Pope CA 3rd, Dockery DW. Health effects of fine particulate air pollution: lines that connect. J Air Waste Manage Assoc. 2006;56(6):709-42.

Public Health Ontario (PHO). 2016. Traffic-Related Air Pollution: Avoiding the TRAP Zone. Available: https://www.publichealthontario.ca/en/DataAndAnalytics/OntarioHealthProfile/Pages/OHP-IWR-TRAP.aspx Accessed March 30, 2016

Raaschou-Nielsen, O. et al. “Air Pollution from traffic and cancer incidence: a Danish cohort study”, Environmental Health. No 10. July 2011.

Ragan C and Vuong K. 2015. The Star Commentary: Social mobility is the other victim of traffic congestion. Available: https://www.thestar.com/opinion/commentary/2015/11/02/social-mobility-is-the-other-victim-of-traffic-congestion.html

RCCAO (Residential and Civil Construction Alliance of Ontario). 2013. Congestion Management in the GTHA: Balancing the Inverted Pendulum. Study by Abdulhai, B. Available:
https://www1.toronto.ca/City%20Of%20Toronto/Feeling%20Congested/PDFs/RCCAO_Apr2013_CongestionManagement_LOWRES-1.pdf

Rissel C, Curac N, Greenaway M, Bauman A. Physical Activity Associated with Public Transport Use—A Review and Modelling of Potential Benefits . International Journal of Environmental Research and Public Health. 2012;9(7):2454-2478.

Rosella, LC, et al, 2010. A population based risk algorithm for the development of diabetes: development and validation of the Diabetes Population Risk Tool Diabetes Population Risk Tool (DPoRT). J Epidemiol Community Health, doi:10.1136/jech.2009.102244

Ross C. 2007. Atlanta Beltline Health Impact Assessment. Available:
http://www.healthimpactproject.org/resources/document/Atlanta-Beltline.pdf

Sbihi H, Tamburic L, Koehoorn M, Brauer M. 2016. Perinatal air pollution exposure and development of asthma from birth to age 10 years. Eur Respir J. 2016 Apr;47(4):1062-71.

Schweitzer L and Taylor B. 2008. Just pricing: The distributional effects of congestion pricing and sales taxes. Transportation, 35(6), 797–812.

SFCTA (San Francisco County Transportation Authority). 2010. San Francisco Mobility Access and Pricing Study. San Francisco County Transportation Authority, San Francisco, CA. Available at: www.sfmobility.com.

Small KA, Winston C, and Yan J. 2006. "Differentiated Road Pricing, Express Lanes, and Carpools: Exploiting Heterogeneous Preferences in Policy Design," Brookings-Wharton Papers on Urban Affairs, pp. 53–96.

Statistics Canada. (2013). Commuting to work. National Household Survey (NHS) for 2011 in Brief, Catalogue No. 99-012-2011003. Ottawa, ON: Ministry of Industry. Retrieved from http://www12.statcan.gc.ca/nhs-enm/2011/as-sa/99-012-x/99-012-x2011003_1-eng.pdf

Supernak J, Golob J, Golob T, Kaschade C, Kazimi C, Schreffler E, Steffey D. 2002. San Diego's I-15 Congestion Pricing Project: Traffic-Related Issues. Transportation Research Record, No. 1812, Paper No. 02-4169. Transportation Research Board, National Academies, Washington, D.C., 43-52.

Sutton JC. 2015. Gridlock: Congested Cities, Contested Policies, Unsustainable Mobility. Routledge; 70.05 edition. ISBN-10: 1138852015.

Texas A&M Transportation Institute, 2015. Urban Mobility Scorecard. Available: http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/mobility-scorecard-2015.pdf [accessed July 2016].

Tonne C, Beevers S, Armstrong B, Kelly F, Wilkinson P. 2008. Air pollution and mortality benefits of the London Congestion Charge: spatial and socioeconomic inequalities. Occup Environ Med. 65(9):620-7. doi: 10.1136/oem.2007.036533.

Toronto Board of Trade 2010. The Move Ahead: Funding "The Big Move". Available: https://www.bot.com/portals/0/unsecure/advocacy/The_Move_Ahead.pdf

Toronto City Summit Alliance. 2010. Time to Get Serious: Reliable Funding for GTHA Transit/Transportation Infrastructure. Prepared by Neal Irwin, IBI Group and Andrew Bevan, Sustainable Prosperity.

TPH (Toronto Public Health) 2006. The Impacts of Traffic on Health. Board of Health report. Available: http://www.toronto.ca/legdocs/2006/agendas/committees/hl/hl060410/it011.pdf

TPH 2007. Air Pollution Burden of Illness from Traffic in Toronto: Problems and Solutions. November 2007. Toronto, Canada. Available: http://www.toronto.ca/legdocs/mmis/2007/hl/bgrd/backgroundfile-8046.pdf

TPH 2008a. TPH Health Impact Assessment Framework. Prepared by Jacques Whitford for Toronto Public Health. Available: http://www1.toronto.ca/City%20Of%20Toronto/Toronto%20Public%20Health/Healthy%20Public%20Policy/PDF%20Reports%20Repository/draft_hia_framework.pdf

TPH 2008b. The Unequal City: Income and health inequalities in Toronto. Available: http://www1.toronto.ca/city_of_toronto/toronto_public_health/health_communications/about_us/files/pdf/unequalcity_20081016.pdf

TPH 2013. Next Stop Health: Transit Access and Health Inequities in Toronto, March, 2013. Available: http://www.toronto.ca/legdocs/mmis/2013/hl/bgrd/backgroundfile-56681.pdf

TPH 2014. Toronto Public Health. Path to Healthier Air: Toronto Air Pollution Burden of Illness Update. Technical Report. April 2014

TPH 2015. The Unequal City 2015: Income and Health Inequities in Toronto. April 2015.

Transport Canada. 2010. High occupancy vehicle lanes in Canada. Available: http://data.tc.gc.ca/archive/eng/programs/environment-utsp-hovlanescanada-886.htm

Tremblay É, Navert P, Blackburn M, Dufort J, Drapeau J-B, Noisel N…. Gagnon F. 2014. Health Impact Assessment of the TOD Neighbourhood Project in Sainte-Catherine. Report on potential impacts and recommendations. Montréal, Québec: National Collaborating Centre for Healthy Public Policy.

Turcotte M. 2007. "Seniors' access to transportation." Canadian Social Trends. 82: 43.

U.S. Department of Transportation (2008). "Urban Partnership Agreement: Low-Income Equity Concerns of U.S. Road Pricing Initiatives". Available: http://www.ops.fhwa.dot.gov/congestionpricing/resources/equity.htm

Upstream Public Health. 2009. Health Impact Assessment on Policies Reducing Vehicle Miles Travelled in Oregon Metropolitan Areas. Funded by the Northwest Health Foundation. Available: https://www.upstreampublichealth.org/resources/health-impact-assessment-policies-reduce-vehicle-miles-traveled

Vallée J, Cadot E, Roustit C, Parizot I, Chauvin P. 2011. "The role of daily mobility in mental health inequalities: The interactive influence of activity space and neighborhood of residence on depression." Social Science & Medicine. 73.8: 1133-44.

Verhoef ET, Lindsey CR, Niskanen E, de Palma A, Moilanen P, Proost S, Vold A. 2008. Implementation paths for marginal cost-based pricing in urban transport: Theoretical considerations and case study results. In C. Jensen-Butler, B. Sloth, M. M. Larsen, B. Madsen & O. A. Nielsen (Eds.), Road pricing, the economy and the environment (pp. 49-78). Springer Berlin Heidelberg.

Waheed F, Ferguson GM, Ollson CA, MacLellan JI, McCallum LC and Cole DC (unpublished manuscript). Health Impact Assessment Of Transportation Projects, Plans And Policies: A Systematic Scoping Review.

Washington State Department of Transportation, 2008. Equity in Tolling and Pricing: Synthesis, Transportation Synthesis Report. Available: http://www.wsdot.wa.gov/NR/rdonlyres/7AF4DF32-F50D-41D6-A093-A880ABCD8EF0/0/EquityinTollingandPricingSynthesis.pdf

Weichenthal S, Van Ryswyk K, Goldstein A, Shekarrizfard M, Hatzopoulou M. 2016. Characterizing the spatial distribution of ambient ultrafine particles in Toronto, Canada: A land use regression model, Environmental Pollution, Volume 208, Part A, pp 241-248.

Weichenthal, S., 2012. Selected physiological effects of ultrafine particle in acute cardiovascular morbidity. Environ. Res. 115, 26e36.

WHO (World Health Organization) 1999. Gothenburg Consensus Paper. Geneva, Switzerland: European Centre for Health Policy. Available: http://www.apho.org.uk/resource/item.aspx?RID=44163 [accessed 13 Aug 2015].

WHO. 2000. Transportation, Environment and Health. WHO Regional Publications, European Series, No. 89. Edited by Dora C and Phillips M. ISBN 92 890 1356 7. Available: http://www.euro.who.int/__data/assets/pdf_file/0003/87573/E72015.pdf

WHO 2013. Review of evidence on health aspects of air pollution – REVIHAAP Project. Technical Report. Available from http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report.pdf Accessed March 20, 2014

Wray, R. (2013). The spatial trap: Exploring equitable access to public transit as a social determinant of health. Policy paper. Toronto, ON: Wellesley Institute. Retrieved from http://www.wellesleyinstitute.com/wp-content/uploads/2013/10/The-Spatial-Trap2.pdf