Effective Interventions to Mitigate Adverse Human Health Effects from Transportation-Related Air and Noise Pollution

A Rapid Review

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Region of Peel
Working for you

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Key Messages

1. Transportation is a major source of air and noise pollution in urban areas and people living near major roads have a higher risk of developing or exacerbating a range of health impacts including hypertension (noise), and childhood asthma, respiratory symptoms, impaired lung function, premature mortality, cardiovascular morbidity, preterm birth and childhood leukemia (air pollution).

2. Two strong reviews indicate that strategies effective in mitigating adverse human health effects from transportation-related air and noise pollution include: traffic calming measures, vehicle and fuel modifications, and transport and land use policies that promote shifts to non-motorized transport, public transport and more compact land use.

3. Interventions intended to mitigate transportation-related emissions and noise will require a coordinated and collaborative approach between municipal, regional, provincial and federal governments including health, planning and traffic engineering, and land use and transportation departments.

4. With over half of Peel's population, including 103 schools, 175 licensed daycares, and 18 long-term care facilities within 300 meters of major roads, interventions that reduce adverse transportation impacts from air and noise pollution have the potential to impact a large number of people in Peel.

Executive Summary

The research question addressed is: What are effective interventions to mitigate adverse human health effects from transportation-related air and noise pollution?

The built environment in Peel consists of an extensive network of highways and major roads, and is predominately an automobile-oriented suburban design resulting in reliance on personal vehicles. Transportation is a major source of air and noise pollution and people living near major roads have a higher risk of developing or exacerbating a wide range of health effects including asthma, respiratory symptoms, impaired lung function, cardiovascular morbidity and mortality, and hypertension. Interventions that reduce adverse transportation impacts have the potential to impact a large number of people in Peel.

The initial search was limited to English-language synthesized literature published in the last 10 years that addressed a road traffic or transportation intervention as well as air or noise pollution. Over 600 potentially relevant documents were found in the peer-reviewed and grey literature. Seven articles were critically appraised. Two reviews were of high quality and were included in the review.

The evidence indicates strategies effective in mitigating adverse human health effects from transportation-related air pollution and noise pollution include: traffic calming measures, vehicle and fuel modifications, and transport and land use policies that promote shifts to non-motorized transport, public transport and more compact land use.

Traffic calming strategies that are most effective at reducing emissions are those that reduce speed variations, idling times and traffic volumes. Improvements in fuel efficiency and vehicle technology much complement, rather than replace, policies that emphasize a more balanced modal split including better quality public transport, rapid transit, and active transit measures. Increased urban density is associated with less motorized travel, which reduces emissions. Additional avoidance of speed bumps on routes frequented by heavy vehicles reduces traffic related noise.

Based on the evidence, it is recommended that Environmental Health:

1. Collaborate with Chronic Disease and Injury Prevention (CDIP) on measures to support healthy built form, specifically by incorporating air quality mitigation messaging into the Healthy Development Assessment Tool (User Guide) and School Travel Plan, and other opportunities as plans and tools are updated or amended.

2. Use the findings from this review to influence land use planning policies and practices by informing air quality comments on the Regional Official Plan Transportation Policies, the Regional Long-Range Transportation Master Plan, goods movement, land use plans, the siting of sensitive land uses, and other municipal and provincial road projects.

3. Present the findings of the rapid review, the background reading on health effects of traffic related air and noise pollution, and Peel specific air quality data to regional and municipal Transportation, Roads Engineering/Public Works, and Planning departments, the Ministry of Transportation, the Regional Air Quality Working Group

and the Greater Toronto Area Clean Air Council to influence the knowledge, skill, and policies and practices of key stakeholders on strategies to mitigate health impacts of transportation-related air and noise pollution.

4. Collaborate with CDIP to meet with the school boards to present the findings of the rapid review to influence school siting policies.

5. Continue to advocate to federal and provincial regulators for improvements in vehicle and fuel efficiency and technology (through the Environmental Registry, Canada Gazette, or other opportunities), and continue to monitor the emerging literature on electric vehicles.

6. Continue to monitor the evidence on measures to mitigate exposure to transportation-related noise pollution.

7. Present the findings of this rapid review to the Active Transportation Leadership Group and collaborate with municipal and regional members to incorporate air quality messaging into active transportation initiatives.

8. Forward a copy of this review to the Ministries of Health and Long Term Care, Transportation, Municipal Affairs and Housing, and Education, as well as Public Health Ontario, Metrolinx, the Association of Municipalities of Ontario, the National Collaborating Centre for Environmental Health, and the Area Municipalities for information.

1 Issue

High volume roads adversely affect the public's health through a range of pathways and exposures including traffic related air and noise pollution, vehicle collisions and by deterring walking and cycling.

The built environment in Peel is dominated by an extensive network of highways and major roads, and is predominately an automobile-oriented suburban design characteristics resulting in reliance on personal vehicles. Use of local municipal transit, provincial GO transit, walking and cycling, and other modes, comprise just 14% of the daily trip share in Peel (Transportation Tomorrow Survey, 2011).

Peel is also one of Canada's most important multi-modal goods movement hubs, moving approximately $1.5 billion worth of goods daily, carrying a significant fleet of heavy-duty diesel trucks.

The population in the Greater Toronto and Hamilton Area (GTHA) is expected to increase by 2.2 million people by 2031, and where the population is located relative to the transportation network will have important implications for the public's health and the economy.

Interventions that reduce adverse transportation impacts have the potential to positively impact a large number of people. In 2014, a report of the GTHA Medical Officers of Health estimated that reduced emissions through full implementation of the Metrolinx Big Move public transit plan, and model increases in active transportation through

increase public transit use, would result in the prevention of 338 premature deaths each year, with an associated economic benefit of $2.2 billion (Peel Public Health, 2014).

This review examines interventions to reduce adverse health effects associated with high volume traffic corridors, specifically from transportation-related air pollution and noise pollution. The findings from this review will inform healthy land use and transportation policy recommendations in Peel.

2 Context

Background reading was conducted to inform this review regarding the range of exposures and adverse health effects associated with close proximity to traffic. Traffic-related air pollution and traffic-related noise were identified as the exposures of interest. Injury outcomes (e.g., traffic collisions) were excluded since these were attributed in the literature to mitigation measures or risk factors unrelated to high volume traffic, e.g., individual behaviour. The background reading report is found in Appendix A.

Transportation-Related Exposures

Transportation is a major source of air and noise pollution in urban areas. Motor vehicles emit over 40 pollutants including a range of combustion and non-combustion emissions. Combustion emissions include carbon dioxide (CO_2), carbon monoxide (CO), oxides of nitrogen (NO_x), particulate matter of various size fractions (PM_{10}, $PM_{2.5}$, and ultrafine) and a suite of volatile organic compounds (VOC's). Emissions vary according to factors such as vehicle type, age, operation, maintenance, engine and fuel, speed of travel, roadway conditions and density traffic. Non-combustion emissions

include dust that is re-suspended or from tire and brake wear. The International Agency for Research on Cancer (IARC) classifies gasoline engine exhaust and diesel engine exhaust as possible and known human carcinogens, respectively (IARC, 2012).

Noise is measured in decibels (dB), in a logarithmic scale. Traffic volume is a major contributor to traffic-related noise. The United States Environmental Protection Agency and the World Health Organization (WHO) report traffic related noise and its health burden are of growing concern. The recommended level of night-time noise not to be exceeded in Ontario in urban areas is 55 dB (Ontario Ministry of the Environment and Climate Change, 2013). Urban diesel buses and heavy trucks can emit noise levels of 80-85 dB when travelling at speeds between 45-60 km/hr and can exceed 90 dB during acceleration from a stop (Edmonton Trolley Coalition Bulletin).

Transportation-Related Health Effects

People living near major roads have a higher risk of developing or exacerbating a wide range of health impacts.

A comprehensive critical review of traffic-related emissions, human exposure and associated health effects in 2010 concluded sufficient evidence for a causal relationship between traffic related air pollution and asthma exacerbations in children (Health Effects Institute, 2010). The reviews conclusions with respect to other health effects are summarized in Table 1.

More recent reviews and meta-analyses report consistent associations between road traffic related air pollution and preterm birth (Curran, 2014), and significant positive associations with childhood leukemia (Boothe et al, 2014).

Table 1: Transportation-Related Air Pollution Health Effects (HEI, 2010)

Level of Evidence	Health Outcomes
Sufficient evidence for a causal relationship	Exacerbation of asthma children
Suggestive but not sufficient evidence for a causal relationship	Childhood asthma onset Non-asthma respiratory symptoms Impaired lung function Total and cardiovascular mortality Cardiovascular morbidity
Inadequate and insufficient evidence for a causal relationship	Adult asthma onset Chronic obstructive pulmonary disease Allergy Adverse birth outcomes Cancer

Populations at greatest risk from air pollution include the elderly, children, people with existing cardiovascular or respiratory conditions such as asthma or COPD, obesity or diabetes, pregnant women, and those engaged in strenuous exercise.

Meta-analyses report road traffic noise pollution is positively associated with hypertension (Ndrepepa and Twardell, 2011; van Kempen and Babisch, 2012). The effects of road traffic related noise and air pollution on cardiovascular outcomes is suggested to be independent (Tetreault et al, 2013).

Existing Legislation

A range of federal, provincial and local legislation and guidelines exist regarding transportation and the built environment to protect the public's health.

Federal

Under the *Canadian Environmental Protection Act, 1999* (CEPA, 1999) Environment Canada regulates emissions from on-road vehicles and engines through the *On-Road Vehicle and Engine Emissions Regulations*, which align emission standards with the U.S. federal standards for light-duty vehicles, light-duty trucks, heavy-duty vehicles, heavy-duty engines and motorcycles.

Provincial

The Provincial government sets standards and guidelines for air quality and noise in Ontario. Ambient air quality is monitored and reported annually in Ontario relative to provincial and federal standards and ambient air quality criteria. These criteria apply to air quality in general, they are not source specific.

Environmental Noise Guidelines from the (MOECC) exist to assist municipal land use and planning authorities in developing noise mitigation strategies. The Guideline, which includes limits for transportation-related noise, was developed using a range of tools including the WHO Europe Guidelines, and environmental scan, historical data and a public consultation process (4).

Local

The Regional Official Plan contains policies on both air quality and transportation to inform and support municipal land use and infrastructure planning processes. Air quality policies call for the Region of Peel to model and monitor air quality (Council approved a 5-year program in 2011), provide more detail on policies and strategies for reducing air pollution, raise awareness of local air quality issues, develop tools to assess the air

quality implications of development that minimize adverse human health effects, and develop outreach programs to promote air quality and to encourage behaviour change in order to reduce air pollution.

The Region of Peel Long Range Transportation Master Plan addressed the major transportation challenges, as well as policies, strategies and road improvement plans to address these challenges over the next 20 years.

The *Ontario Municipal Act, 2001* enables municipalities to enact noise by-laws to control sound. Many municipalities draw upon the provincial noise guidelines to enact municipal noise by-laws under the Act.

3 Literature Review Question

The research question addressed in this review is: What interventions are effective to mitigate adverse human health effects from transportation?

PECO	
Population	Population living or spending significant amounts of time on or near transportation corridors
Exposure	Transportation-related air pollution and transportation-related noise emissions
Comparison/Control	n/a
Outcome	Adverse human health effects including: respiratory outcomes (particularly exacerbation of asthma symptoms in children), cancer (especially childhood leukemia), birth outcomes (particularly premature birth), cardiovascular effects (particularly hypertension), and mortality.

4 Literature Search

In November, 2014, a search of the peer-reviewed and grey literature was conducted, with no date limits imposed on the search. Databases searched included: Medline,

Globalhealth, Healthstar and the Environmental Health databases. Grey literature sources searched are listed below:

- United States Environmental Protection Agency
- World Health Organization
- National Collaborating Centres for Healthy Public Policy, Environmental Health, and Methods and Tools
- Agency for Healthcare Research & Quality
- National Institute for Health and Clinical Excellence
- California Air Resources Board
- Victoria Transport Planning Institute
- British Columbia Ministry of the Environment
- Canadian Urban Transportation Association
- Centre for Disease Control, United States
- California Air Resources Board
- Transportation Research and Innovation Portal
- Department of Environment, Food and Rural Affairs, United Kingdom

The full search strategy can be found in Appendix B.

5 Relevance Assessment

Two reviewers independently reviewed the titles and abstracts of all search results for relevance. Discrepancies were addressed through discussion and mutual agreement and/or discussions with a third party team. Articles selected for critical appraisal met the following criteria: (1) addressed road traffic or transportation as well as air or noise

pollution, (2) were synthesized research, (3) addressed an intervention, (4) were written in the English language, and (5) were published in the last 10 years. Articles were excluded if they were duplicate articles, were single or case studies, did not examine an intervention, examine air, marine or rail transport, were published in 2003 or earlier, a setting not relevant to Peel, or were a non-English language publication.

6 Results of the Search

The search identified 136 potentially relevant documents in the peer-reviewed literature and over 467 potentially relevant documents in the grey literature. One duplicate was excluded in the peer-reviewed search. Based on title and abstract review, 24 articles from the peer-reviewed literature and nine articles from the grey literature passed the initial relevancy assessment and were further assessed for relevancy based on the full text review. Applying the relevancy criteria cited above in the full text review, 22 articles in the peer-reviewed literature and four from the grey literature were excluded. Seven articles were critically appraised, two systematic reviews from the peer-reviewed literature and five from the grey literature. The search results flow chart is presented in Appendix C.

7 Critical Appraisal

Two reviewers independently assessed the quality of seven articles using the Health Evidence Quality Assessment Tool. Discrepancies were addressed through discussion and mutual agreement. Results from the assessed articles revealed that two reviews in the grey literature were strong (National Collaborating Centre for Healthy Public Policy,

2011 10/10 and World Health Organization, 2011 8/10). The remaining five reviews were weak, with three papers scoring 1/10 and two papers scoring 4/10. Based on the quality assessment scores, only the two strong articles were included in this review.

8 Description of Included Studies

Data extraction tables for the two reviews can be found in Appendix D.

National Collaborating Centre for Healthy Public Policy (2011). Urban Traffic Calming and Health: A Literature Review

The 103 primary studies from the peer-reviewed and grey literature included in the NCCHPP (2011) review examined the effects of traffic calming measures in urban environments on four determinants of health: road collisions, air quality, environmental noise, and physical activity associated with active transportation (13). Traffic calming measures include engineering measures and strategies structuring their implementation to reduce vehicle speeds and/or vehicle volumes on existing roads.

Studies were conducted in urban settings similar to Canada: the United States, Europe and Australia. Data were compiled in extraction tables, systemically reviewed for methodology including conceptual and internal validity and reliability of results. Quality assessment was integrated narratively throughout the review.

Twenty-nine articles examined direct impacts of traffic calming measures and 74 papers examined the mechanism of action of traffic calming measures. Two main approaches of traffic calming policy were examined: black spot approaches, e.g., isolated measures

installed at specific points on the road network, and area-wide approaches, e.g., measures integrated into a wider geographic area comprising several roads.

Air quality impacts were examined in five studies on black spot approaches and five studies on area-wide approaches, respectively. Noise impacts were examined in three studies on black spot approaches and three studies on area wide approaches, respectively. The other studies included in the review examined traffic calming effects on: the frequency and severity of road collisions or physical activity associated with active transportation, which were not of interest for this review.

World Health Organization (2011). Health in the Green Economy: Health Co-Benefits of Climate Change Mitigation – Transport Sector

Over 300 observational studies, modelling studies and evaluations included in the WHO (2011) review examined the expected environmental and health co-benefits and risks of three categories of transportation mitigation identified by the International Panel of Climate Change 4th Assessment Report Working Group (14). The mitigation strategies examined included modified vehicles and fuels, transport pricing, and transport and land use policies that promote shifts to non-motorized transport, public transport and more compact land use.

The likelihood of impacts on health outcomes of a given mitigation measure or package of strategies were synthesized and classified on a scale from strongly negative (--) to strongly positive (++). The strength of evidence was classified from 0 (no evidence) through weak (small number of observational studies) to moderate (large number of observational studies). A strong classification was not used because there are few

randomized control trials in this area of research. There was no attempt to routinely assess biases in primary studies. Strategies to maximize health and climate co-benefits while minimizing risks were summarized.

9 Synthesis of Findings

Effective strategies to mitigate adverse human health effects from transportation-related air pollution

The evidence indicates strategies that may be effective in mitigating adverse human health effects from transportation-related air pollution include:

- traffic calming measures,
- vehicle and fuel modifications,
- transport pricing, and
- transport and land use policies that promote shifts to non-motorized transport, public transport and more compact land use.

A comprehensive list of examples of vehicle and fuel modification policies, measures and instruments related to each of these strategies is found in Table 2.

Table 2: Examples of Mitigation Measures

Mitigation Measure	Examples
Traffic Calming Measures	Bike box, bike lane, chicane, chocker/pinch point, crosswalks/zebra crossing, curb extension, cycle track, diagonal diverters, forced turn islands, full street closures, gateways, mini roundabouts, one-way streets, pedestrian refuges, raised crosswalks, raised intersection/junction, raised median/traffic island, lane reduction, roundabout, speed bump, speed cameras, speed cushions, speed humps, speed limit painted on the asphalt, speed table, speed activation sign, stop sign, textured crosswalks
Modified Vehicles and Fuels	Mandatory fuel economy/CO_2 standards for road transport; shifts to lower-carbon fossil fuels, biofuels, compressed natural gas & hybrid/electric vehicles; other vehicle design modifications, drive train efficiency, diesel and alternative fuels, imposing tighter fuel economy standards for road

	transport, reducing vehicle loads, more efficient driving techniques, labelling requirements for vehicle fuel efficiency, vehicle maintenance requirements and lower speed limits on roadways
Transportation Pricing	Taxes on vehicle purchase, registration, use, taxes on motor fuels; road and parking pricing; congestion/area pricing, fuel pricing and taxation, vehicle license/registration fees, annual circulation taxes, tolls and road charges and parking charges, congestion pricing
Land Use Changes and Mode Shifts from Private to Public or Non-Motorized Transport	Influence mobility needs through land-use design/regulations and infrastructure planning; prioritizations of, and investment in, public transport and non-motorized transport infrastructure and amenities, influence mobility needs through land use design/regulations and infrastructure planning; prioritization of, and investment in, public transport and non-motorized transport infrastructure and amenities; walking and cycling, bus rapid transit and light rail transit, transportation demand management, employer based travel plans, removal or parking subsidies, telecommuting, computer based or remote shopping and marketing

Traffic Calming Measures

The traffic calming strategies that are most effective at reducing emissions are those that reduce speed variations, idling times and traffic volumes (13).

Increases in per vehicle emissions are attributed to greater speed variations and idling time; whereas, decreases in emissions are attributed to constant travelling speeds and reduced idling.

Interventions that reduce traffic volume in an area (e.g., by promoting active and public modes of transport) can lead to reduced overall emissions. However, strategies that simply divert traffic to other roads in the network, instead of reducing it, risk displacing emissions rather than reducing emissions. The configuration of the calming measures, their spacing and how they manage the right-of-way determines their impact on pollutant emissions.

Conclusions were drawn from five articles, which assessed various calming measures and pollutant emissions through different methods, not all equally rigorous (13). Uncertainties in the evidence include:

- impacts on air quality (versus emissions)
- impacts on health effects in nearby residents
- co-effects of other interventions / contextual changes
- medium- and long-term impacts of the traffic calming measures

Modified Vehicles and Fuels

Improvements in fuel efficiency and vehicle technology must complement, rather than replace, policies that emphasize a more balanced modal split including better quality public transport, rapid transit, and active transit measures. Improving vehicles and fuels can reduce health impacts from air pollution emissions. However, total emissions will increase if total vehicles kilometers travelled (VKT) outpaces improvements in vehicle technology and fuels in the absence of other measures to reduce emissions.

The potential effect of modified vehicles and fuels to mitigate air quality and health impacts was rated from negative to strongly positive, with the strength of the evidence considered “moderate” with relatively few studies available (14). Uncertainty remains regarding the impacts of the use of the most current technologies for alternative fuel and modified vehicles on urban air pollution exposure and the associated risks to human health.

Transport Pricing

The potential effects of transport pricing strategies on air quality and human health are variable and wide-ranging (14). Transport pricing that incentivizes shifts from private vehicle travel to rapid transit and active transit could have broad positive health benefits. Transport pricing that encourages use of improved vehicles and fuels could reduce air pollution. Subsidies for improved vehicles and fuels may cause increased motor travel, but increasing the price of undesirable vehicles and fuels could decrease overall motorized vehicle travel.

The strength of the evidence is rated as “weak” with potential impacts of measures on air quality and health ranging from negative to strongly positive. While indicative, the evidence is limited by few studies which have assessed the direct health effects of pricing of vehicles, fuels and infrastructure (14).

Transport and Land Use Policies (that promote shifts to non-motorized transport, public transport and more compact land use)

Increased urban density is associated with less motorized travel, which reduces air pollutant emissions. Lower air pollution exposure is associated with higher density and less sprawl, greater use of active transport and public transport, lower car use and car ownership and traffic volumes, and infrastructure facilitating walking and public transport use. However, compact growth may be best accompanied by complementary strategies to reduce exposure and health effects from air pollution because density also concentrates both emissions and populations within a small area, potentially increasing personal exposure to air pollution. The strength of the evidence was rated by authors as “moderate” with potential effects rated as strongly positive (14).

Effective strategies to mitigate adverse human health effects from transportation-related noise

The evidence indicates strategies that may be effective in mitigating adverse human health effects from transportation-related noise pollution include:

- traffic calming measures,
- vehicle and fuel modifications, and
- transport and land use policies that promote shifts to non-motorized transport, public transport and more compact land use.

Traffic Calming Measures

The traffic calming interventions most effective in reducing traffic noise are those that reduce speed variations and driving speeds, while reducing traffic volumes and avoiding the use of vertical deflections (e.g., speed bumps) on routes frequented by heavy vehicles (e.g., buses and commercial vehicles).

Reduced noise from car traffic is attributed in part to reductions in speed, in speed variation, and in traffic volume. Increased noise levels from heavy vehicles is attributed to increased rattling from suspension systems and metal with vertical deflections and also increased speed variations with the implementation of traffic calming measures.

Traffic calming strategies that explicitly aim to encourage constant speeds (by implementing calming measures close enough that they discourage acceleration and deceleration between them) can reduce noise levels. Whereas, strategies that divert

traffic instead of reducing it (e.g., by increasing the modal share of active transportation) can contribute to an increase in noise levels elsewhere on the road network.

Evidence is limited by a small number of studies which lacked explicit description of methodology and statistical testing (13). Conclusions are based on interventions conducted in specific contexts, with not all effects are known. Uncertainties remain regarding the medium- and long-term impacts of the interventions.

Modified Vehicles

No conclusions could be drawn with respect to the impact of modified vehicles (e.g., electric vehicles) on noise. While much quieter than conventional vehicles, electric vehicles are suggested to have potential to reduce community noise levels. However, no empirical research was identified (14). The strength of the evidence was thus rated as “weak”. The impact of electric vehicles on community noise is unknown and requires further primary study.

Transport and Land Use Policies (that promote shifts to non-motorized transport, public transport and more compact land use)

No evidence was identified on the impact of land use and transportation policies and community noise. The potential effects were rated by authors as strongly positive as the factors affecting the amount of motorized travel provide indirect evidence to support an effect on noise, but the evidence was rated as “weak” because empirical study is needed (14).

10 Applicability and Transferability

A meeting was held on September 3, 2015 to discuss the applicability and transferability of the research. The facilitated the session included staff and management from the Medical Officer of Health, Environmental Health, Chronic Disease and Injury Prevention, and Transportation Planning Divisions. Highlights from the discussion are provided below. Refer to Appendix E for further details of the meeting discussion.

Applicability (feasibility)

Political Acceptability or Leverage

- Current political climate is supportive of interventions to reduce air and noise pollution from ground transportation.
- The interventions align with existing public health strategies related to chronic disease prevention and with community aspirations outlined in the Regional Official Plan and Long-Range Transportation Master Plan.
- Measures, policies and interventions intended to reduce negative impacts of transportation-related air and noise pollution would have a positive impact on public relations.

Social Acceptability

- Traffic calming measures are typically implemented to improve safety and quality of life of residents in the areas adjacent to the roadway.
- Improving road safety by introducing traffic calming and other design treatments to decrease exposure of vulnerable road users aligns with safety objectives.

- Air quality benefits of introducing traffic calming measures (e.g., roundabouts) nicely complements safety benefits.
- The introduction of traffic calming measures are not always meet with full support from all community stakeholders (e.g., public service providers such as transit, fire and emergency services) depending on the treatment of the design.

Available Essential Resources

- Essential partners for local implementation include planning and transportation departments in the Region and local municipalities and the Ministry of Transportation.
- There are many internal opportunities to share the results including: the Regional Air Quality Working Group and internal cross-divisional meetings between Environmental Health, Chronic Disease and Injury Prevention, and Active Living.
- The traffic calming measures and their application are generally well understood; however, additional training of engineering staff is required to support the implementation of context specific design approaches.
- The Health Development Assessment tool currently does not address the inclusion of green spaces or other air quality considerations in new and development projects.
- *Improving Health by Design in the GTHA* (May 2014) indicates the implementation of the Big Move transportation plan would result in a net decrease in all traffic related emissions (except SO2), and a corresponding decrease in annual premature mortality and hospitalizations.

Organizational Expertise and Capacity

- Alignment of 2014-2019 Setting the Pace strategy, the Regional Official Plan, Peel Climate Change Strategy, Transportation Master Plan and Health Development Index, and section 1.5.1.a) of the Provincial Policy Statement.

- Interventions that address transportation-related emissions and noise require a coordinated and collaborative approach between municipal and regional departments including public health, municipal planning and traffic engineering, and regional land use and transportation departments.

Transferability (generalizability)

- The 2008 Comprehensive Health Status report documents 5,000 emergency department visits each year by Peel residents for the treatment of asthma; with the most frequent visits among those aged 0-4 years.
- The same report indicates that improving traffic management and reducing vehicle operating speeds in and around school zones may have a significant positive impact for children aged 4-12 years.
- The introduction of traffic calming measures to influence the transportation systems ability to support enhanced active travel and shared modes of travel (e.g., carpool, public transit) will required extensive stakeholder engagement.

11 Recommendations

1. Collaborate with Chronic Disease and Injury Prevention (CDIP) on measures to support healthy built form, specifically by incorporating air quality mitigation messaging into the Healthy Development Assessment Tool (User Guide) and School Travel Plan, and other opportunities as plans and tools are updated or amended.

2. Use the findings from this review to influence land use planning policies and practices by informing air quality comments on the Regional Official Plan Transportation Policies, the Regional Long-Range Transportation Master Plan, goods movement, land use plans, the siting of sensitive land uses, and other municipal and provincial road projects.

3. Present the findings of the rapid review, the background reading on health effects of traffic related air and noise pollution, and Peel specific air quality data to regional and municipal Transportation, Roads Engineering/Public Works, and Planning departments, the Ministry of Transportation, the Regional Air Quality Working Group and the Greater Toronto Area Clean Air Council to influence the knowledge, skill, and policies and practices of key stakeholders on strategies to mitigate health impacts of transportation-related air and noise pollution.

4. Collaborate with CDIP to meet with the school boards to present the findings of the rapid review to influence school siting policies.

5. Continue to advocate to federal and provincial regulators for improvements in vehicle and fuel efficiency and technology (through the Environmental Registry,

Canada Gazette, or other opportunities), and continue to monitor the emerging literature on electric vehicles.

6. Continue to monitor the evidence on measures to mitigate exposure to transportation-related noise pollution.

7. Present the findings of this rapid review to the Active Transportation Leadership Group and collaborate with municipal and regional members to incorporate air quality messaging into active transportation initiatives.

8. Forward a copy of this review to the Ministries of Health and Long Term Care, Transportation, Municipal Affairs and Housing, and Education, as well as Public Health Ontario, Metrolinx, the Association of Municipalities of Ontario, the National Collaborating Centre for Environmental Health, and the Area Municipalities for information.

12 References

1. Region of Peel Open Data Centre. *Transportation tomorrow survey 1999-2011* [Internet] [date unknown]; Available from http://opendata.peelregion.ca/data-categories/transportation/transportation-tomorrow-survey.aspx

2. Peel Public Health. (2014). *Improving health by design in the Greater Toronto – Hamilton Area: A Report of Medical Officers of Health in the GTHA;* Available from: https://www.peelregion.ca/health/resources/healthbydesign/pdf/highlights-report.pdf

3. International Agency for Research on Cancer. (2012). *IARC: Diesel engine exhaust carcinogenic*; Available from: http://www.iarc.fr/en/media-centre/iarcnews/2012/mono105-info.php

4. Ontario Ministry of the Environment and Climate Change. (2013). *Environmental noise guideline: stationary and transportation sources- approval and planning. Publication NPC-300;* Available from: https://dr6j45jk9xcmk.cloudfront.net/documents/1681/162-environmental-noise-guideline-en.pdf

5. Edmonton Trolley Coalition [Internet] [date unknown]; Available from: http://www.trolleycoalition.org/noise.html

6. Health Effects Institute. (2010). Traffic-related air pollution: a critical review of the literature on emissions, exposure, and health effects. Special Report 17. Boston, Massachusetts, USA; Available from: http://pubs.healtheffects.org/view.php?id=334

7. Curran. (2014). Exposure to traffic-related air pollution and perinatal health. Vancouver, BC: National Collaborating Centre for Environmental Health.

8. Boothe et al. (2014). Residential traffic exposure and childhood leukemia: a systematic review and meta-analysis. *Am J Prev Med,* 46(4): 413-422.

9. Ndrepepa and Twardella. (2011). Relationship between noise annoyance from road traffic noise and cardiovascular diseases: a meta-analysis. *Noise & Health,* 13(52): 251-259.

10. van Kempen and Babisch. (2012). The quantitative relationship between road traffic noise and hypertension: a meta-analysis. *Journal of Hypertension,* 30: 1075-1086.

11. Tétreault et al. (2013). Cardiovascular health, traffic-related air pollution and noise: are associations mutually confounded? A systematic review. *Int J Public Health,* 58: 649-666.

12. Canada Environmental Protection Act. (1999). *Regulations Amending the On-Road Vehicle and Engine Emissions Regulations and Other Regulations Made Under the Canadian Environmental Protection Act, 1999. Vol. 149, No. 15 – July 29, 2015;* Available from: http://canadagazette.gc.ca/rp-pr/p2/2015/2015-07-29/html/sor-dors186-eng.php

13. National Collaborating Centre for Healthy Public Policy. (2011). *Urban Traffic Calming and Health: A Literature Review;* Available from: http://www.ncchpp.ca/175/publications.ccnpps?id_article=686

14. World Health Organization. (2011). *Health in the Green Economy: Health Co-Benefits of Climate Change Mitigation – Transport Sector;* Available from: http://www.who.int/hia/green_economy/transport_sector_health_co-benefits_climate_change_mitigation/en/

Appendices

Appendix A: Background Reading

Appendix B: Search Strategy

Appendix C: Literature Search Flowchart

Appendix D: Data Extraction Tables

Appendix E: Applicability and Transferability Worksheet

Appendix A: Background Reading

Issue:

What adverse human health effects are associated with exposure to high volume road traffic?

Background:

The built environment in Peel Region includes an extensive network of highways and major roads, and is overwhelmed with automobile-oriented suburban design characteristics resulting in increased reliance on cars [1]. Peel Public Health found that in 2011, over half of the population resided within 300m of major roads and over a third resided within 100m of major roads. Also, 103 schools, 175 licensed daycares and 18 long-term care facilities were located within 300m from major roads.

Heavy road traffic may adversely affect health through various exposures including air and noise pollution, vehicle collisions, and deterrent effects on walking and cycling [2]. The nature and extent of research on the range of exposures and health effects associated with high volume roads/highways was unknown to the Environmental Health team, although this knowledge would be useful in land use planning policies to benefit health.

A rapid evidence review will be conducted to investigate what mitigation strategies can reduce adverse health effects of high volume road traffic. To inform this rapid review, published literature was identified and summarized to determine the range of exposures and adverse health effects associated with close proximity to traffic. Injury outcomes (e.g. from traffic crashes) were excluded since these were attributed in the literature to mitigation measures or risk factors unrelated to high volume traffic.

Findings from this background literature review will provide context for the rapid review that will seek strategies to mitigate negative health effects of exposure to heavy road traffic.

Current Status:

Peel Public Health developed a set of policies[3] to improve air quality. These policies inform and support municipal land use and infrastructure planning processes, air quality monitoring and modelling. In addition the policies help raise awareness and engage all levels of government, the private sector and public organizations regarding local air quality issues.

The Ontario Ministry of Environment (MOE) developed an Environmental Noise Guideline[4] that is used by municipal land use and planning authorities in developing noise mitigation strategies. This guideline, which includes limits for transportation-related noise, was developed using the World Health Organization (WHO) Europe guidelines [5,6]an environmental scan, historical data and a public consultation process. MOE guideline limits for transport-related noise are similar to the WHO's guidelines.

Summary of the literature:

Description of included research:

- Eight relevant review articles were retrieved from the literature search (**Appendix 1**). Four of these reviews examined air pollution, two examined noise pollution, and two examined both exposures.
- Road traffic-related exposures were investigated in relation to adverse health outcomes, primarily cardiovascular and respiratory conditions, as well as birth outcomes and cancer.
- Only three of the eight reviews conducted meta-analyses due to heterogeneity of included studies.
- Following quality assessment by two independent reviewers, four were rated strong, two moderate and two weak. The weak quality reviews were excluded. (**Appendix 2**).

Findings:
Main findings of the strong and moderate quality reviews are presented in **Appendix 3**.

Traffic-related air pollution

- A 2010 review[7] demonstrated:
    - "Sufficient evidence" for a causal association between traffic-related pollution exposure and the exacerbation of symptoms in children with asthma.
    - Evidence in the grey zone between "sufficient" or "suggestive but insufficient evidence" for causal associations with asthma incidence and prevalence in children
    - "Suggestive but insufficient evidence" for causal associations with all-cause mortality, cardiovascular mortality, cardiovascular morbidity, pulmonary function, and respiratory symptoms in adults.
    - "Inadequate and insufficient evidence" for causal associations between traffic-related air pollution and exacerbation of respiratory symptoms in children without asthma, health care utilization for respiratory problems in children, adult-onset asthma, chronic obstructive pulmonary disease (COPD), allergies, cancer, and birth outcomes (including preterm birth, low birth weight and small for gestational age).
- However, traffic-related pollution was found to be consistently associated with preterm birth in a 2014 review [9].
- Postnatal exposure to traffic-related pollution, as measured by residential proximity to traffic, was significantly positively associated with childhood leukemia in a 2014 meta-analysis [8].

Traffic-related noise pollution

- Based on two meta-analyses[10,11] of studies mainly from Europe on road traffic-related noise or noise annoyance, a significantly positive association was found with hypertension.
- A borderline positive significant association was found between road traffic noise annoyance and ischemic heart disease[10].

Traffic-related air and noise pollution

- One review found low risk of mutual confounding effects of noise or air pollutants on cardiovascular outcomes [12].

Conclusions and Recommendations:

Conclusions:

- Road traffic-related exposures studied were mainly air pollution and noise.

- **In children**, sufficient evidence was found for a causal association between road traffic-related air pollution and exacerbation of asthma symptoms. The evidence for causal associations between road traffic related air pollution and asthma incidence and prevalence in children was weaker. A significant association with preterm birth was found in one recent review. One review reported a significant association between traffic-related air pollution and childhood leukemia.
- Inadequate and insufficient evidence was found for causal associations with respiratory symptoms in children without asthma, health care utilization for respiratory problems and birth outcomes.

- **In adults**, a significant positive association between exposure to road traffic-related noise and hypertension has been demonstrated. There was no significant association with ischemic heart disease although it approached statistical significance.
- Suggestive but insufficient evidence existed for causal associations between traffic-related air pollution and all-cause mortality, cardiovascular morbidity and mortality, pulmonary function and respiratory symptoms.
- Inadequate and insufficient evidence was found for causal associations between traffic-related air pollution and adult-onset asthma and COPD.

- Inadequate and insufficient evidence was also found for causal associations between traffic-related air pollution and allergies and cancer in both adults and children.
- The effects of road traffic-related noise and air pollution on cardiovascular outcomes may be independent based on the current literature.

Recommendations:

It is recommended that the rapid review focus on mitigation measures for traffic-related air pollution to reduce

- respiratory outcomes (particularly exacerbation of asthma symptoms in children)
- cancer (especially childhood leukemia)
- birth outcomes (particularly premature birth)
- cardiovascular effects
- mortality and mitigation measures for traffic-related noise to reduce
- adverse cardiovascular outcomes, particularly hypertension.

Submitted by:	*Michelle Ng, 905-791-7800 ext. 2472*

Submitted to:	*Paul Callanan, 905-791-7800 ext. 2802*

Date: *October 24, 2014*

Appendix B: Search Strategy

Academic Literature Search Strategy

Database: Global Health <1973 to 2014 Week 47>, Ovid Healthstar <1966 to October 2014>, Ovid MEDLINE(R) <1946 to November Week 3 2014>, Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations <November 26, 2014>

Search Strategy:

1 road transport* policies.ti. (5)
2 road transport* policy.ti. (0)
3 road transport*.ti. (212)
4 intervention*.ti. (177248)
5 3 and 4 (6)
6 highway*.ti. (2284)
7 road*.ti. (22483)
8 transport*.ti. (157487)
9 expressway*.ti. (69)
10 (arterial adj7 road*).ab. (157)
11 6 or 7 or 8 or 9 or 10 (181873)
12 intervention*.ti. (177248)
13 prevent*.ti. (417744)
14 policy.ti. (63926)
15 policies.ti. (18177)
16 (land adj7 design*).ti,ab. (461)
17 planning.ti. (69458)
18 setback*.ti. (770)
19 "land use".sh. (1430)
20 exp transportation/ (100899)
21 11 or 20 (271903)
22 exp public policy/ (230464)
23 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 22 (914624)
24 noise pollut*.ti,ab. (726)
25 plan*.ti. (337375)
26 23 or 25 (1176030)
27 exp noise,transportation/ (1989)
28 exp vehicle emissions/ (12798)

29 exp air pollution/ (95460)
30 exp air pollutants/ (120526)
31 noise pollut*.ti. (301)
32 air pollutant*.ti. (2419)
33 decibel*.ti. (102)
34 emission*.ti. (56388)
35 health.ti. (914251)
36 sound*.ti. (23647)
37 transport* noise.ti. (63)
38 exp environmental exposure/ (356482)
39 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 (1427109)
40 21 and 26 and 39 (1323)
41 review*.ti. (535146)
42 meta-analys*.ti. (79933)
43 41 or 42 (592515)
44 1 or 2 or 5 or 40 (1324)
45 remove duplicates from 44 (668)
46 43 and 45 (13)
47 remove duplicates from 46 (13)
48 limit 47 to english language (10)
49 limit 48 to yr="2008 -Current" (6)
50 from 47 keep 1-13 (13)
51 limit 45 to english language (597)
52 limit 51 to yr="2008 -Current" (283)
53 road*.ti. (22483)
54 transport*.ti. (157487)
55 53 or 54 (179586)
56 52 and 55 (123)

Grey Literature Search Strategy

Keyword Search

1. Road OR traffic OR transportation
2. 1 + air
3. 1 + noise

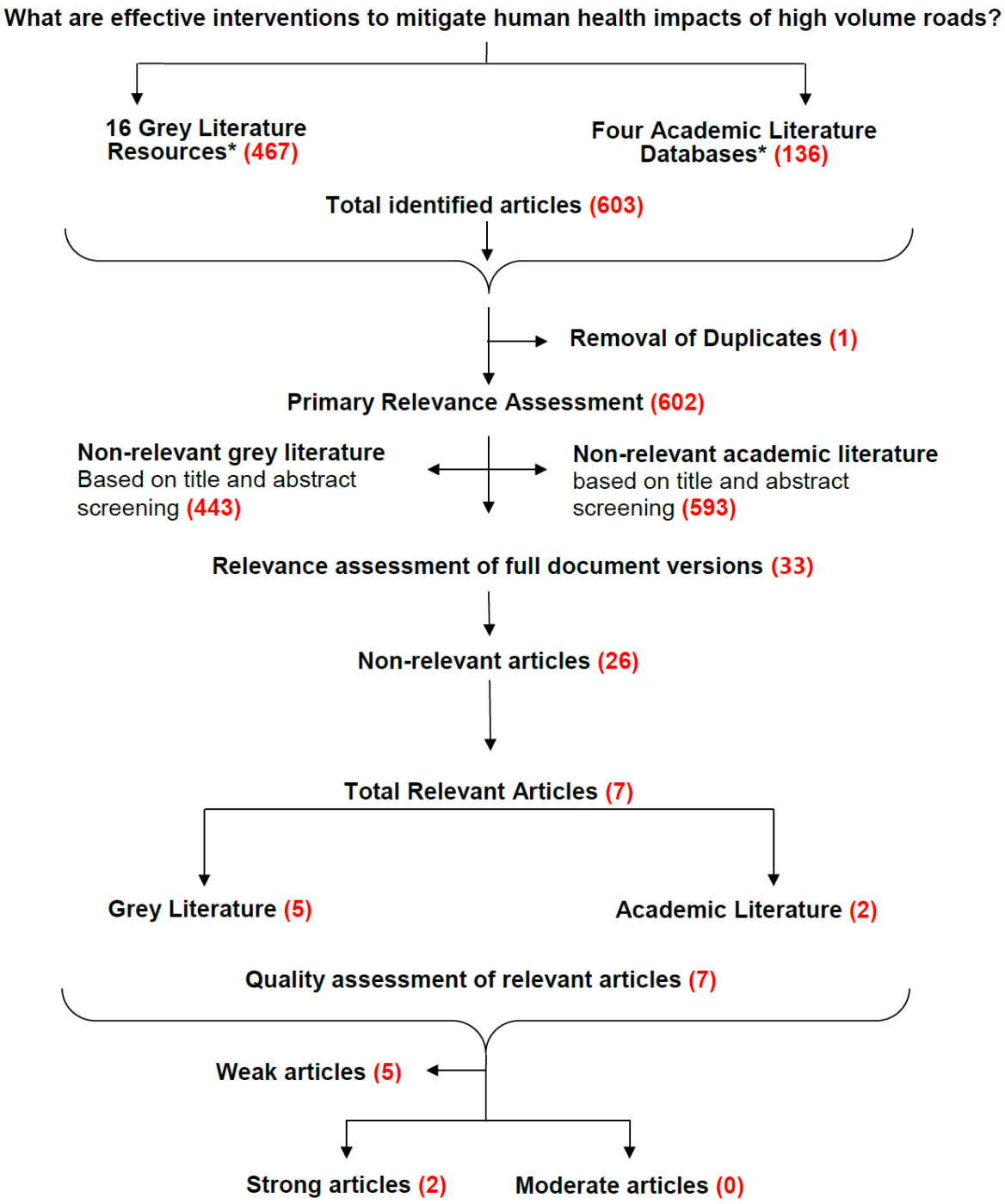
Websites Searched

Centre for Disease Control	Health Effects Institute
US Environmental Protection Agency	California Air Resources Board
World Health Organization	Victoria Transportation Planning Institute
National Collaborating Centre for Healthy Public Policy	BC Ministry of the Environment
AHQR	National Collaborating Centre for Environmental Health
NICE	National Collaborating Centre for Methods and Tools
Peel Public Health Library	Canadian Urban Transportation Association
	Transportation Research and Innovation Portal
	European Union - DEFRA

Exclusion Criteria

Single/case studies, does not examine an intervention, examines air, marine or rail transport, publication earlier than 2003, not a similar setting non-English publication

Appendix C: Literature Search Flowchart



*see Appendix B for details of the grey literature resources and academic databases searched

Appendix D: Data Extraction Tables

Criteria	**Report 1: Urban Traffic Calming and Health: A Literature Review**
Author(s), Date, Country	Bellefleur & Gagnon (2011). Quebec, Canada
Journal or Organization	National Collaborating Centre for Healthy Public Policy (NCCHPP)
Quality rating	10 - Strong
Objective(s) of report (Includes description of exposure and primary outcomes)	Examine the effects of traffic calming* in urban environments on four determinants of health. The two primary outcomes of interest to this review are bolded. • number and severity of road collisions • **air quality** • **environmental noise** • physical activity associated with active transportation *Defined as: engineering measures and approaches to reduce vehicle speeds and/or traffic volumes on existing roads to achieve various goals and objectives. Examples of traffic calming *measures* include but are not limited to: speed humps, curb extensions, crosswalks, 30-km/hr speed limits, etc. The *approaches* structuring the implementation of traffic calming measures are categorized as “black spot approaches” – interventions at one or two discrete points, and “area wide approaches” – interventions applied on a more or less large geographic area.
Types of studies included	Evaluative research studies Studies were mainly conducted in European countries or the USA
Search period	January 2000 to October 2010
Databases searched	PubMed, TRIS, Scopus, Scirus, IngentaConnect, Repere, CSA Illumina platform, EBSCOhost platform, OvidSP plateform, Google and Google Scholar (Transport Canada, TDME, Montreal, Ottawa, Toronto, North Vancouver, Institute of Transport Engineers, US Transport, Federal Highway Administration, Pedestrian and Bicycle Information Centre, Transport Research Laboratory, SWOV Institute) Snowballing using bibliographies
Inclusion/exclusion criteria	<u>Inclusion</u> • evaluate at least one effect on a determinant of health through an intervention aimed at traffic calming • studies not directly focused on calming measures but on their mechanism of action

	• setting similar to Canadian: USA, Europe, Australia • documents written in English and French • studies based on both objective and subjective epistemological/philosophical approaches <u>Exclusion</u> • rural settings • documents with methods not well documented • economic evaluation studies • studies with methods involving before-after design (shown to have significant bias) • there were no exclusions based on method of inquiry, data collection technique, or analytical procedures
Number of primary studies	The report included 103 primary studies on all four determinants of health. This included 19 peer-reviewed scientific studies and 10 grey literature studies on traffic calming measure interventions, as well as a literature review of 36 scientific studies and 38 grey literature studies on the mechanism of action of the traffic calming measures and approaches. Only studies related to the two determinants of health of interest to this review (air quality and noise) were examined. Air Quality - The report identified 10 articles on air quality impacts of traffic calming measures (5 examined black-spot approaches and 5 examined area wide approaches). All studies examined impacts on emissions; only 3 studies reported impacts on air quality as the outcome measure. Noise – The report identified 6 articles on noise impacts of traffic calming measures (3 examine black-spot approaches and 3 examined area wide approaches).
Study population	Urban populations
Review methods	• All documents were retained and reviewed in their entirety by the two authors of the review • Data were compiled in extraction tables, systematically reviewed for methodology, conceptual and internal validity and reliability of results. Quality criteria were not provided. • Evaluations of the methodological strengths and weaknesses of the studies and of implications for the robustness of results are integrated into the narrative summaries in the review and discussed in the conclusions of the review.
Main results of review	**Air Quality** <u>Impacts of black-spot approaches & isolated measures</u> • Isolated measures lead to increases in per vehicle emissions because they typically reduce traffic speeds and increase speed variations. Isolated measures lead to increases in vehicle emissions of varying size (from +1% to +1000%) depending on the traffic calming measure and the pollutant - Two studies with statistical analysis conducted reported statistically significant increases in vehicle

	emissions with the implementation of isolated traffic calming measures. The three other studies included in the review did no statistical analysis. - One study that evaluated air quality reported an increase in air pollution (deterioration in air quality) following the implementation of isolated measures. - One survey of residents perceptions reported that residents were significantly less unhappy with vehicle fumes after calming measures were introduced (positive impact). - One study reported that replacing a stop sign with a mini roundabout reduced pollutant emissions by reducing speed variations. <u>Impacts of area-wide approaches</u> • Area-wide traffic calming approaches have variable effects on per vehicle emissions. - Two studies reported reduced emissions in calmed areas with reduced traffic volumes, although no statistical tests were reported. - There was no effect on air quality reported in two studies that measured the impacts of area wide measures on ambient air quality - There were no changes in residents perceptions of air quality following the implementation of area wide traffic calming schemes in two studies **Environmental Noise** <u>Impacts of black-spot approaches</u> • One study reported that calming measures with vertical deflections reduced maximum noise levels of cars travelling at constant speeds, but with the exception of round top speed humps, increased maximum noise levels of buses and heavy vehicles. There were no statistical tests reported. • One study reported that residents were significantly less unhappy with road noise following the installation of traffic calming measures. Residents reported a 2.83 point improvement in happiness towards noise (on a scale from 1 to 7) following the intervention. • One study reported that replacing an intersection controlled by traffic lights with a roundabout reduced average noise levels by 1 dB in the day (L_{Aday}) and 2.5 dB in the night (L_{Anight}); however, the methodology used was not explicitly described nor were statistical significance tests mentioned. <u>Impacts of area-wide approaches</u> • An area-wide scheme that includes mini roundabouts in an area with few heavy vehicles encourages constant speed which is suggested to reduce noise. - One study reported calming measures reduced maximum noise levels for cars but increased maximum noise levels of heavy vehicles; however, no statistical tests accompanied the results. - Two studies of resident perceptions reported that residents noticed no change in noise level after their area was calmed through interventions.

Criteria	Report 2: Health in the Green Economy. Health co-benefits of climate change mitigation – transport sector
Author(s), Date, Country	Hosking et al., 2011. World Health Organization
Journal or Organization	World Health Organization
Quality rating	Strong - 8
Objective(s) of report	• This report is part of the World Health Organization's Health in the Green Economy Series. This review examines the health co-benefits of transportation policies and mitigation strategies discussed in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Working Group III). The linkage between transportation and air quality and noise is documented in the IPCC report. • Strategies that appear to have the best potential win-win outcomes for health and climate are summarized and tools for assessing, planning and financing healthy, low emission transport systems are reviewed.
Number of primary studies	300 peer-reviewed articles reporting individual studies.
Types of studies included	Observational epidemiological studies (case-control, cross-sectional, cohort), modelling studies, evaluations of interventions.
Search period	Not described
Databases searched	Medline, Web of Science
Inclusion/exclusion criteria	Inclusion Land transport, passenger transport Exclusion Other than land transport (e.g., air, marine), freight transport
Description of Exposure(s) / Interventions	• Modified vehicles and fuels • Transport pricing strategies • Transport and land use policies that promote shifts to non-motorized transport, public transport and more compact land use
Study population	Total population
Primary outcomes	• Air pollution/GHG associated with transportation (e.g., black smoke, ozone, particulate matter, oxides of nitrogen, volatile organic compounds, diesel exhaust, sulphur dioxide). • Road traffic related noise
Review methods	• Scoping review • Targeted search strategy based on available knowledge of expected impacts of IPCC reviewed measures. • Not all data from all reports was extracted, only the statistically significant findings (positive and negative) • There was no attempt to routinely assess primary studies biases. • The impacts on health outcomes of a given mitigation strategy were classified from strongly negative (--)

<table>
<tr><td></td><td>through no impact (0) to strongly positive (++).
• The strength of evidence was classified from 0 (no evidence) through weak (small number observation studies) to moderate (large number observation studies). A strong rating was not used due to few randomized control trials in this research area.
• The number of studies for a particular intervention were not provided.
• The types of health co-benefits, or risks, arising from each mitigation strategy, as well as the relative expected magnitude of benefit/risks are presented.</td></tr>
<tr><td>Main results of review</td><td>Modified vehicles and fuels

<table><tr><th>Outcome</th><th>Effect Size</th><th>Strength of Evidence</th></tr><tr><td>Air pollution</td><td>– to ++</td><td>moderate</td></tr><tr><td>Noise</td><td>0</td><td>weak</td></tr></table>
• Diesel fuel: although newer diesel vehicles emit lower concentrations of particulate matter (PM); efficiencies can be overwhelmed by policies that promote large shifts to diesel vehicles. Diesel is also an important source of black carbon.
• Biofuels: impacts on air quality remain unclear; potential threats to global food security
• Compressed natural gas: can achieve GHG emissions savings comparable to diesel, with far lower PM.

Pricing of vehicles, fuels and infrastructure

<table><tr><th>Outcome</th><th>Effect Size</th><th>Strength of Evidence</th></tr><tr><td>Air pollution</td><td>– to ++</td><td>weak</td></tr><tr><td>Noise</td><td>0 to ++</td><td>weak</td></tr></table>
• Direct empirical evidence for pricing strategies impacts on health is indicative but is still currently limited.
• Pricing that incentivizes shifts from private motorized travel to rapid transit and active travel could have broad health benefits.
• Pricing that encourages use of improved vehicles and fuels could reduce air pollution.
• Subsidies for improved vehicles and fuels could increase motor travel, whereas increasing the price of undesirable vehicles and fuels would decrease overall motorized vehicle travel.

Land use changes and mode shifts from private to public or non-motorized transport

<table><tr><th>Outcome</th><th>Effect Size</th><th>Strength of Evidence</th></tr><tr><td>Air pollution</td><td>++</td><td>moderate</td></tr><tr><td>Noise</td><td>++ (indirect)</td><td>weak</td></tr></table></td></tr>
</table>

<table>
<tr><td></td><td>

Increasing urban density is associated with less motorized travel, which reduces air pollutant emissions; however, increasing density also concentrates both emissions and populations in a smaller area, potentially increasing exposure to transport emissions.
No studies were identified on land use and noise; however, the importance of traffic volume in noise emissions and of land use factors in affecting the amount of motorized travel provide indirect evidence of effect of land use factors on noise, but empirical studies are needed.

Four key strategies are identified to maximize co-benefits of transport while minimizing health and climate risks
<table>
<tr><th>Strategy</th><th>Key Pathways</th></tr>
<tr><td>1. Develop compact land use that reduces the need for travel, particularly by clustered and mixed use commercial and residential development built around transit and active transport networks; increase density and diversity of uses</td><td>Increases proximity of destinations, reducing need for car travel and vehicle kilometers travelled (VKT); improves access by walking, cycling and rapid transit / public transit</td></tr>
<tr><td>2. Invest in and prioritize for active transport network space for pedestrian and bicycle infrastructure</td><td>Improves access by walking and cycling; encourages shift from car use to walking and cycling, reducing VKT</td></tr>
<tr><td>3. Invest in and prioritize for transport network space for rapid transit/public transportation infrastructure</td><td>Improves access by rapid transit / public transport; encourages shift from car use to rapid transit / public transport, reducing VKT</td></tr>
<tr><td>4. Undertake engineering and traffic calming / speed reduction measures to moderate the leading hazards of motorized transport protecting vulnerable road users</td><td>Reducing speed improves safety of walking and cycling; increasing separation of vehicles from walkers and cyclists improves safety of walking and cycling; encourages walking and cycling by increasing safety; technological improvements reduce production of hazards per vehicle, noise, pollutants, GHG</td></tr>
</table>
</td></tr>
<tr><td>Conclusions / Key Messages</td><td>

To optimize gains from both a climate and health perspective, available evidence suggests transport mitigation needs to rely more upon better land use planning, along with increasing access to active transport and public transport/rapid transit modes.
a shift to active transport and rapid transit/public transport combined with land use can yield much greater immediate health co-benefits than improving fuel and vehicle efficiencies
potential health gains of a shift from private motorized transport to walking, cycling and rapid transit/public transport include reduced cardiovascular and respiratory disease from air pollution and less traffic related stress from noise.
Shifting from gasoline to diesel vehicles could increase emissions of health damaging small particulates.
Improvements in fuel efficiency and vehicle technology must complement, rather than replace, policies that emphasize a more balanced modal split, including better quality public/rapid transport and active transit.

</td></tr>
</table>

Appendix E – Applicability and Transferability Worksheet

Starting a New Program
Applicability and Transferability Worksheet

Factors	Questions	Notes
Applicability (feasibility)		
Political acceptability or leverage	• Will the intervention be allowed or supported in current political climate? • What will the public relations impact be for local government? • Will this program enhance the stature of the organization? o *For example, are there reasons to do the program that relate to increasing the profile and/or creative a positive image of public health?* • Will the public and target groups accept and support the intervention in its current format?	• Recession: financial implications • Aligns with many existing public health strategies • The Region's policy is to consider roundabouts for TDM first if intersection gets to capacity • Work is being done by the California Air Resources Board and US Environmental Protection Agency • Acceptable intervention in its current format • Roundabouts more costly to install than signalized intersections, but long term savings in terms of operations and maintenance, actually cost less. • Roundabouts decrease liability for Region relative to alternatives • Yes current political climate is supportive of interventions to reduce air and noise pollution related to ground transportation • A positive public relations impact would be attributed to the introduction of measures, policies and interventions intended to reduce and mitigate the negative impacts of air and noise pollution related to ground transportation • Yes since the associated interventions align with community aspirations as outlined in the Official Plan and Transportation Master Plan • The single most important aspect of the review findings relates to the impact of motor vehicle speed including speed variation on air quality and noise pollution. http://www.ontario.ca/environment-and-energy/drive-clean-test
Social acceptability	• Will the target population find the intervention socially acceptable? Is it ethical? o *Consider how the program would be perceived by the population.* o *Consider the language and tone of the key messages.*	• Yes • Safety is primary reason Region is interested in roundabouts – they are safer and decrease liability • Air quality benefits of roundabouts nicely complements safety benefits • Exposure to transportation emissions needs to be considered in the discussion of school siting locations • CDIP and Environmental Health should discuss how to suggest a 'healthy

	o *Consider any assumptions you might have made about the population. Are they supported by the literature?* o *Consider the impact of your program and key messages on non-target groups.*	development credit for developers' idea to municipalities • Yes however policy directions that support 'stick' approaches are best introduced in combination with supportive measures that provide 'carrot' incentives. • Improving road safety by introducing traffic calming and other design treatments to decrease exposure of vulnerable road users is in line with traffic safety objectives. • Injury outcomes related to traffic and the influence that traffic calming can have on reducing volume and risk were excluded due to the absence in the literature of mitigation measures and risk factors unrelated to high volume traffic, eg. individual behaviour, however the Vision Zero approach first introduced in Sweden in 1997 has a primary goal of reducing motor vehicle fatalities to zero by 2020. The secondary goals of Vision Zero include: providing an accessible transport system and a high standard of transport quality, enhance traffic safety, create a good environment and promote positive regional development. http://cbpp-pcpe.phac-aspc.gc.ca/interventions/vision-zero/ • A 2011 study reported in the Journal of Physical Activity and Health found that a majority of adults view neighbourhood infrastructure as highly important to physical activity.
Available essential resources (personnel and financial)	• Who/what is available/essential for the local implementation? • Are they adequately trained? If not, is training available and affordable? • What is needed to tailor the intervention locally? • What are the full costs? o Consider: in-kind staffing, supplies, systems, space requirements for staff, training, and technology/administrative supports. • Are the incremental health benefits worth the costs of the intervention? o Consider any available cost-benefit analyses that could help gauge the health benefits of the intervention. o Consider the cost of the program	• Available/essential for local implementation include: planning and transportation departments, the Ministry of Transportation • Internal collaborations to share results – regional air quality working group, as well as CDIP/AL/EH meetings at staff and management level, monthly • Traffic calming measures are typically implemented by municipal traffic engineering and/or transportation departments to reduce motor vehicle speeds, improve safety of motorists and vulnerable road users and to generally improve the quality of life of residents in the areas adjacent to the subject roadway. • The design of traffic calming treatments and their application are generally well understood; however additional training of engineering staff is required to support the implementation of context sensitive design approaches. • Land use practices that support the objectives are also well understood; however there's a gap between the knowledge and the application of the practices. • The use of the Health Development Assessment a.k.a. Health Background Study Framework requires additional implementation activities related to policy and practice; and the current version of the HDA includes measures

	relative to the number of people that benefit/receive the intervention.	specific to the provision of 'green space' as it relates to service proximity, i.e. At least 90% of the proposed dwelling units are situated within 400 m of a playing field, park, square or natural open space; and land use mix. • The HDA does not specifically address the inclusion of green space such as, green roofs, planted areas, and linear parks adjacent to roadways, in new and redevelopment projects for the purposes of mitigating air pollution and urban heat island effect. • A recent report from the Suzuki Foundation concerning the ability and impact that urban green spaces have to filter pollution from the air and reduce local air and ground temperature provides an added dimension for mitigation measures. This report analyzed 102 peer-reviewed studies published over the past five years that explored the role of urban green space in providing cooling effects and reducing air pollution. • http://www.davidsuzuki.org/publications/ImpactofGreenSpaceonHeatandAirPollutioninUrbanCommunities.pdf • Yes - as outlined in the May 2014 - Improving Health by Design in the GTHA – MOH report that indicates the implementation of The Big Move (transportation plan) would result in a projected net decrease in all traffic related emissions except SOx; and a corresponding decrease in annual premature deaths (129 to 179) and hospitalizations (78 to 107). • Challenge – based on attributable fractions, which are estimates • 1.3 million residents in Peel could receive the intervention
Organizational expertise and capacity	• Is the intervention to be offered in line with Peel Public Health's 10-Year Strategic Plan (i.e., 2009-2019, 'Staying Ahead of the Curve')? • Does the intervention conform to existing legislation or regulations (either local or provincial)? • Does the intervention overlap with existing programs or is it symbiotic (i.e., both internally and externally)? • Does the intervention lend itself to cross-departmental/divisional collaboration? • Any organizational barriers/structural issues or approval processes to be addressed?	• Yes and the 2014-2019 Setting the Pace strategy that is a revision to the 2009-2019 Staying ahead of the curve and there's alignment with the Peel Official Plan, Peel Climate Change Strategy, Transportation Master Plan and Health Development Assessment. • The recommended interventions are supported by Provincial policy and the 2014 Provincial Policy Statement makes specific reference in section - 1.5.1 Healthy, active communities should be promoted by: o a) planning public streets, spaces and facilities to be safe, meet the needs of pedestrians, foster social interaction and facilitate active transportation and community connectivity; • Currently Mississauga does not implement traffic calming measures on existing roadways, however we are aware of a Traffic Calming Pilot Project that was approved in June 2013 - Recommendation GC-0421-2013. • Yes the proposed Interventions that address automobile emissions and noise require a coordinated and collaborative approach between municipal and regional departments, including but not limited to: Public Health,

	• Is the organization motivated (learning organization)? o Consider organizational capacity/readiness and internal supports for staff learning.	municipal planning and traffic engineering, Regional (land use and transportation) • The introduction of traffic calming measures are not always met with full support from community stakeholders, and depending on the treatment design (i.e. vertical measures) public service providers such as transit and emergency services may not support the introduction of traffic calming.
Transferability (generalizability)		
Magnitude of health issue in local setting	• What is the baseline prevalence of the health issue locally? • What is the difference in prevalence of the health issue (risk status) between study and local settings? o *Consider the Comprehensive Health Status Report, and related epidemiological reports.*	• Append briefing note, background reading research on health effects from transportation with the review • Reader needs an idea of the strength of the evidence of health effects from transportation. • The 2008 Comprehensive Report on Health in Peel indicates there are 5,000 emergency department visits each year by Peel residents for the treatment of asthma with the most frequent visitors aged 0 to 4 years. http://www.peelregion.ca/health/health-status-report/chsr/pdfs/chap9.pdf
Magnitude of the "reach" and cost effectiveness of the intervention above	• Will the intervention appropriately reach the priority population(s)? o What will be the coverage of the priority population(s)?	• Based on the 2008 Peel Health report (see above) improving traffic management and reducing vehicle operating speeds in and around school zones may have a significant positive impact for children aged 4-12.
Target population characteristics	• Are they comparable to the study population? • Will any difference in characteristics (e.g., ethnicity, socio-demographic variables, number of persons affected) impact intervention effectiveness locally? o *Consider if there are any important differences between the studies and the population in Peel (i.e., consider demographic, behavioural and other contextual factors).*	• The Rapid Review did not focus on a sub-population such as children aged 0-4 years. • The introduction of traffic calming treatments and built environment measures to influence the transportation systems ability to support enhanced active travel and shared travel (i.e. carpool, transit) will require extensive stakeholder engagement.

Proposed Direction (after considering the above factors):

Opportunities over the next year to influence planning with results of the review include: Transportation Official Plan Policies, Long Range Transportation Master Plan Update, Active Transportation Master Plan, Healthy Development Index

- Environmental Health to consider further research concerning the impact that green space has on air pollution in urban communities, and that based on these findings consideration be given to address green space as an element of the (HDA) Health Development Assessment (formerly HBSF - Health Background Study)
- Peel Public Health to position traffic calming as a means to reduce vehicle emissions and to share the findings with member municipalities
- Consideration be given to enhancing traffic calming measures and activities in and around school zones
- Suggest an expanded scope or another Rapid Review to include injury outcomes since there is an emerging body of evidence that suggests road design directly influences motorist and other road user behaviour

Appendix G: Glossary

Bike box	A bike box is a facility that allows cyclists to position themselves in front of vehicles stopped at an intersection with traffic lights. This painted space on the pavement makes cyclists more visible and ensures them start-up priority when the light turns green.
Bike lane, Cycle lane	A bike lane is a portion of the road reserved for the exclusive or preferential use of cyclists. Unlike a cycle track, which is physically separated from motor vehicles using the road, a bike lane is delimited by road markings. The space needed for the bike lane is generally obtained by eliminating one traffic lane, by narrowing one or several lanes, or by eliminating parking spaces for cars.
Chicane, Serpentine, Reversing curve, Twist	A chicane is a series of horizontal deflections (usually three in a row) installed on an otherwise straight road to create an “S” shaped traffic lane.
Choker, Mid-block narrowing, Pinch point, Mid-block yield point, Constriction	A choker is an isolated narrowing of one or several traffic lanes created by the installation of horizontal deflections in the centre or on the sides of the road. The term "choker," like its equivalents, is usually reserved for narrowings located other than at intersections.
Crosswalk, Zebra crosswalk, Zebra crossing	A crosswalk is a facility designed to make crossing the road easier for pedestrians by delimiting a space with road markings to indicate that it is meant to be shared with pedestrians.
Curb extension, Bulb-out	A curb extension is a continuation of the sidewalk at an intersection intended to make pedestrians more visible and decrease their exposure to collisions by reducing crossing distances. A curb extension can also be used to reduce the width or the number of traffic lanes.
Cycle track	A cycle track is a portion of the road reserved for the exclusive use of cyclists. Unlike a bike lane, which is delimited by road markings, a cycle track is physically separated from motorized traffic by bollards, medians, parking spaces, etc. The space needed for the cycle track is generally obtained by eliminating a traffic lane, by narrowing one or several lanes, or by eliminating parking spaces for cars.
Diagonal diverters, Full diverters, Diagonal road closures	A diagonal diverter is a raised island placed diagonally at an intersection so as to allow only right turns. Diagonal diverters can be designed to allow pedestrians and cyclists to continue on their way unobstructed.
Forced-turn island, Right-turn island, Forced turn lane, Deflector island, Forced turn channelization	A forced-turn island is a median positioned at the approach to an intersection that orients vehicles in the desired direction or directions.
Full closure, Full street closure, Cul-de-sac, Dead-end	Full closures often take the form of barriers that prevent motor vehicles from continuing along the road, but allow pedestrians and cyclists to pass.

Gateway	Gateways are facilities designed to indicate entrance to a calmed area.
Mini-roundabout, Mini-traffic circles, Intersection islands	A mini-roundabout is an intersection with a central island that is usually raised and circular. Vehicles entering the circle must yield passage to those already inside and must travel around in a counter-clockwise direction.
One-way street	A street on which vehicles are authorized to travel in only one direction. One-way streets can be used, with minimal cost, to prevent through traffic from using local residential streets instead of roads designed to handle larger traffic volumes (collector roads and arteries) to cross an area. For example, the installation of two facing one-way streets going in opposite directions can force drivers to turn onto an intersecting artery, and prevent vehicles from continuing in a straight line along local streets.
Pedestrian refuge, Median refuge	A pedestrian refuge is a median typically located in the middle of the road to allow pedestrians to cross in two stages.
Raised crosswalk, Raised zebra crossing, Raised crossing, Hump pelican	A raised crosswalk is a facility designed to make crossing the road easier for pedestrians and which typically raises the pavement to the level of the sidewalks. Raised crosswalks are often made of a textured and coloured material to indicate clearly that the space is meant to be shared with pedestrians.
Raised intersection, Raised junction, Intersection hump, Table, Plateau	A raised intersection is an intersection where the pavement has been raised relative to the level of the roads leading to it. The platform created by the vertical deflection is often made of a textured material and is raised to the level of the sidewalks to indicate clearly that the space is meant to be shared with pedestrians.
Raised median, Center island narrowing, Traffic island	A raised median is a raised island usually built down the central axis of two-way roads to separate traffic going in opposite directions and reduce lane widths.
Road diet, Lane reduction	A road diet usually refers to the conversion of a four-lane road into a three-lane road, with one lane for traffic going in each direction and a central lane reserved for left turns from either direction. The space recuperated can be used to add bike lanes, sidewalks, or vegetation.
Roundabout	A roundabout is an intersection at which vehicles entering must yield right of way to vehicles already circulating around a central circular or oval-shaped island. To slow down traffic and induce drivers to yield right of way, there are horizontal deflections at the entrances which position vehicles to rotate in the correct direction. Roundabouts generally replace intersections with traffic signals on roads designed for quite high traffic volumes (collectors, arteries).
Speed bump	Speed bumps, not to be confused with speed humps, are narrow vertical deflections that generally extend less than 30 centimetres across. In cars, it is easy to travel over them at very low speeds (5-10 km/h) or very high speeds, in which case the suspension system can absorb the deflection. Thus, their use is generally restricted to areas where high speeds are impractical, such as parking lots or alleyways.
Speed camera	Speed cameras are devices that allow vehicles exceeding the speed limit to

	be identified automatically.
Speed cushions, Speed lumps	Speed cushions are vertical deflections designed to act on cars in the same way as speed humps, while having a minimal effect on heavy vehicles, such as emergency vehicles (fire truck, ambulance, etc.) and buses.
Speed hump, Road hump, Hump	Speed humps, not to be confused with speed bumps, are wide vertical deflections that typically extend three to four metres along the road. They can only be travelled over comfortably at low speeds (15-30 km/h). Thus, their use is widespread on local streets in residential neighbourhoods, in school zones, around parks, etc.
Speed limit painted on the asphalt	Road markings indicating the speed limit are often used in conjunction with other calming measures, such as vertical or horizontal deflections.
Speed table, Trapezoidal hump, Speed platform	A speed table is a vertical deflection spanning the pavement, whose top is usually flat and extends far enough along the road for a car or even a heavy vehicle to rest on it. The vertical contour of speed tables allows them to be easily crossed at faster speeds than speed humps allow, which is why they are generally used on collector roads and arteries.
Speed activated sign	A speed-activated sign is a device that usually indicates the speed of vehicles and whether they are travelling under or over the speed limit.
Stop sign	A stop sign is a traffic sign indicating that drivers must stop their vehicle and wait until the lane is free before continuing on their way. Its purpose is usually to manage right of way for users of an intersection. However, it is also sometimes used as a traffic-calming measure. For example, stop signs have been used in the past to slow down traffic in certain areas, and thus make them less attractive to through traffic.
Textured crosswalk, Textured crossing	A textured crosswalk is a facility designed to make crossing the road easier for pedestrians and which is made from a textured, and often coloured, material to indicate clearly that the space is meant to be shared with pedestrians.