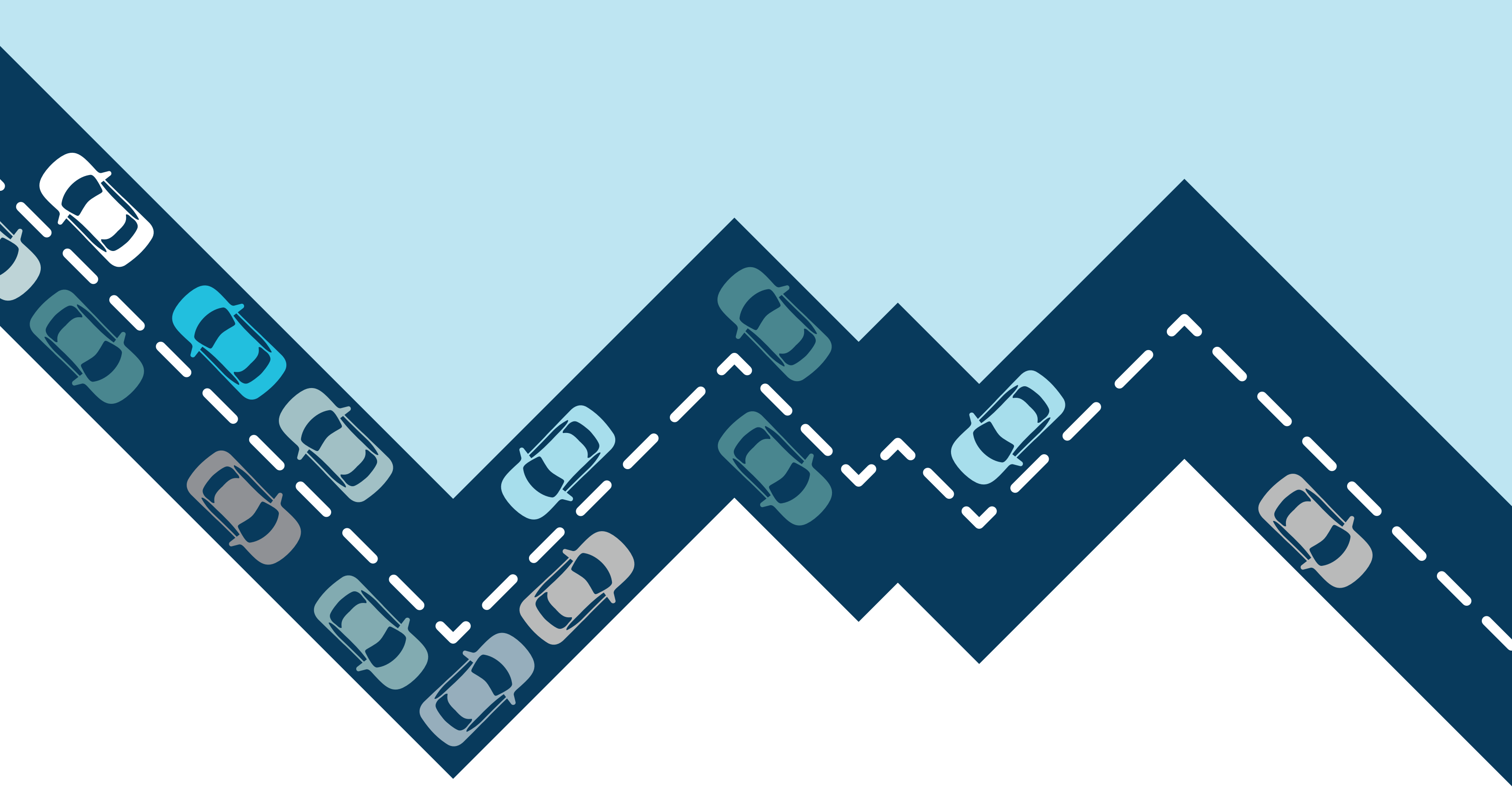


Impacts of Reduced Transportation on Air Quality in Alberta Associated with COVID-19 Project Team

Final Report

CASA
Clean Air Strategic Alliance

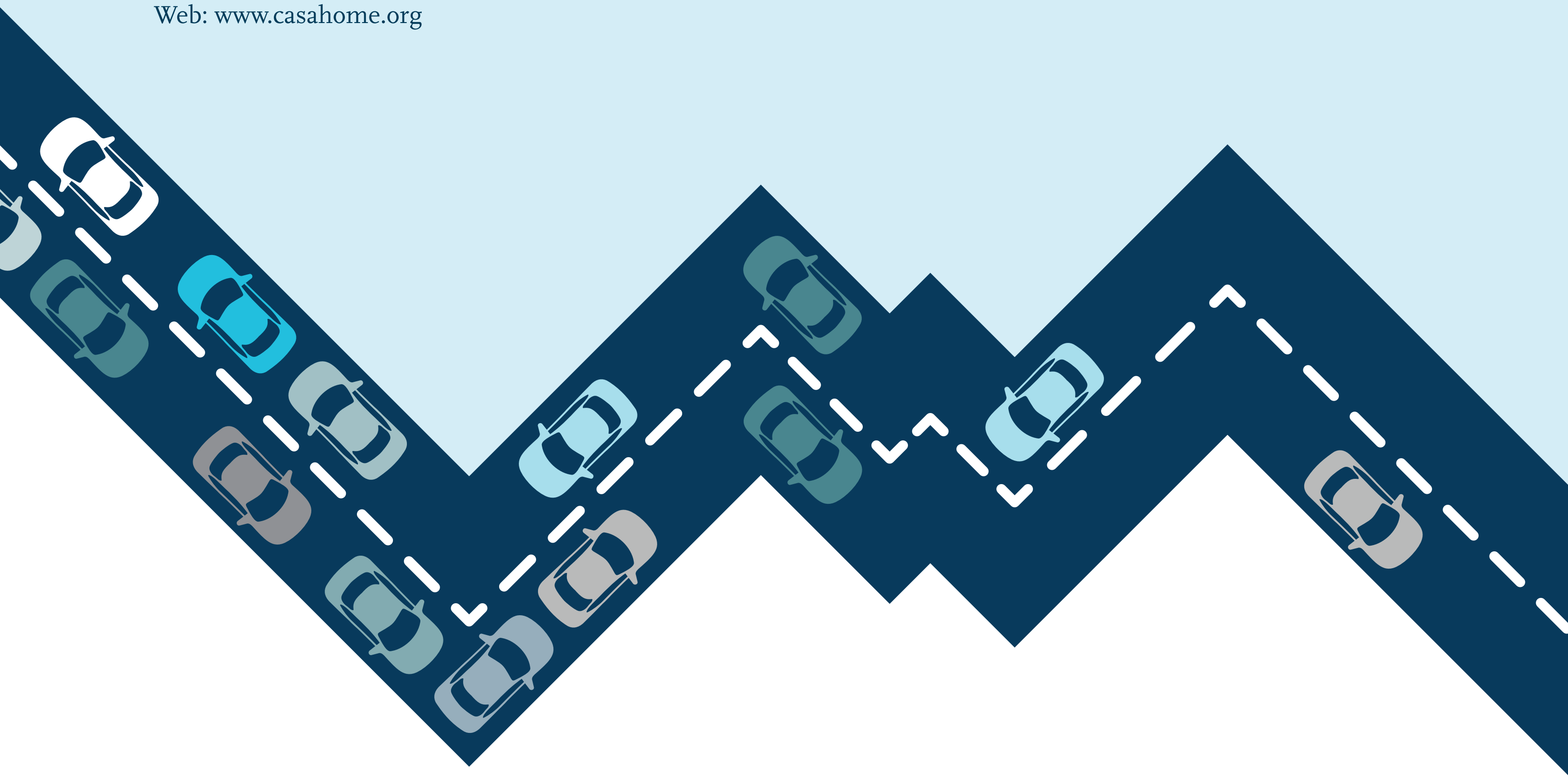
August 2022

About the Clean Air Strategic Alliance

The Clean Air Strategic Alliance (CASA) is a multi-stakeholder partnership. It is composed of representatives selected by industry, government, and non-government organizations to provide strategies to assess and improve air quality for Albertans using a collaborative consensus process. Every partner is committed to a comprehensive air quality management system for Alberta.

Clean Air Strategic Alliance
14th Floor, Petroleum Plaza South Tower
9915-108 Street Edmonton,
AB T5K 2G8

Tel: 780-427-9793
Email: info@awc-casa.ca
Web: www.casahome.org



Acknowledgements

The Clean Air Strategic Alliance (CASA) thanks the members of the Impacts of Reduced Transportation on Air Quality in Alberta Associated with COVID-19 (IRTAQ) Project Team, their member organizations, and the workshop participants for their contributions in completing this work.

Corresponding members diligently stayed abreast of the project. The administrative support provided by CASA staff are also acknowledged.

Members of the IRTAQ Project Team

Name	Stakeholder Group
Andria Panidisz	Canadian Association of Petroleum Producers
Ann Baran	Southern Alberta Group for the Environment
Anna Kauffman	Alberta Forest Products Association
Anne Vigneau	Heartland Generation Ltd.
David Spink (Co-Chair)	Prairie Acid Rain Coalition
Kevin Warren	Alberta Airsheds Council
Mike Bisaga	Alberta Airsheds Council
Opel Vuzi	Health Canada
Rhonda Lee Curran	Alberta Environment and Parks
Ruth Yanor	Mewassin Community Council
Sean Mercer	Imperial Oil Limited/ Canadian Fuels Association
Vahid Hosseini	Simon Fraser University
Yayne-Abeba Aklilu (Co-Chair)	Alberta Environment and Parks

CASA Project Managers: Alec Carrigy, Jacqueline Noga, Katie Duffett, Anuja Hoddinott, Lauren Hall

Contents

Acronyms

A/C	Air conditioning
AAAQO/G	Alberta's Ambient Air Quality Objectives and Guidelines
AEP	Alberta Environment and Parks
AMA	Alberta Motor Association
AQHI	Air Quality Health Index
BC	Black carbon
BEV	Battery electric vehicle
CAAQS	Canadian Ambient Air Quality Standards
CASA	Clean Air Strategic Alliance
CO	Carbon monoxide
COVID-19	Coronavirus Disease of 2019
DE	Diesel exhaust
E10	10% Ethanol-blended gasoline
ED	Emergency department (hospital)
GE	Gasoline engine
GoA	Government of Alberta
H_2S	Hydrogen sulphide
HCs	Hydrocarbons
HEV	Hybrid electric vehicle
IAM	Integrated assessment model
IRTAQ	Impacts of Reduced Transportation on Air Quality in Alberta Associated with COVID-19
NGO	Non-government organization
NH_3	Ammonia
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
O_3	Ozone
PAHs	Polycyclic aromatic hydrocarbons
PHEV	Plug-in battery electric vehicle
PM	Particulate matter
PM_{10}	Particulate matter smaller than 10 microns in diameter
$PM_{2.5}$	Particulate matter smaller than 2.5 microns in diameter (fine particulate matter)
POPs	Persistent organic pollutants
ppb	Parts per billion
ppbv	Parts per billion by volume
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
USEPA	United States Environmental Protection Agency
VOCs	Volatile organic compounds
WHO	World Health Organization
$\mu g/m^3$	Micrograms per metre cubed

Glossary of Terms

Air pollutants

Toxic air pollutants cover a broad range of contaminants that are hazardous to human health and/or the environment. Examples of air toxins include but are not limited to: particulate matter (PM), nitrogen oxides (NO_x), carbon monoxide (CO), ozone (O_3), and sulphur oxides (SO_x). Air pollutants are also responsible for smog, acid rain, and eutrophication. Carbon dioxide (CO_2) is not an air pollutant, but a greenhouse gas that contributes to global warming and not to local air pollution.

Black carbon

Black carbon (BC), a significant component of soot, is recognized as harmful to human health and a contributor to regional warming. Black carbon is a short-lived small aerosol, or airborne particle, emitted by natural processes and human activities such as the incomplete combustion processes of fossil fuels, biofuels, and biomass. Black carbon is a product of incomplete combustion in vehicles but is notably higher in diesel engines' exhaust. Modern diesel engines have exhaust filtration to eliminate black carbon. Any other source of combustion could potentially generate black carbon, including industrial equipment, furnaces, and biomass burning.

Greenhouse gases

Greenhouse gases are gases that absorb thermal radiation emitted by the earth and trap heat in the atmosphere. CO_2 is the primary greenhouse gas that is not an air pollutant.

Ground-level ozone

Ground-level ozone is a secondary air pollutant formed by a chemical reaction in the atmosphere with other air pollutants, such as volatile organic compounds (VOCs) and nitric oxide (NO) in the presence of sunlight. It is harmful to human health, particularly for vulnerable populations and people who have existing lung conditions such as asthma. It can also negatively impact the environment, decreasing the productivity of some crops and harming sensitive vegetation.

Hydrocarbons

Hydrocarbons are organic compounds that consist of only hydrogen (H) and carbon (C). Examples of hydrocarbons include methane (CH_4) which is available as a fossil fuel. CH_4 is widely used for house heating and is a potent greenhouse gas that can contribute to ozone formation. Several heavier hydrocarbons are either a pollutant or contributors to the production of secondary pollutants such as air aerosols and O_3. Hydrocarbons are the main components of fuels such as gasoline and diesel. They are present in vehicle exhaust as the result of incomplete combustion. Hydrocarbons are also emitted as evaporative emissions from vehicles even when they are off.

Off-road vehicles

Off-road vehicles are designed and used primarily for the transportation of people, material, or equipment exclusively on undeveloped roads. Examples include construction, mining, farming, and forestry vehicles, and commercial generator sets, all-terrain vehicles, and lawn and garden equipment.

On-road vehicles

On-road vehicles are equipped with design features that enable them to be normally operated and mix with regular traffic on public roads. On-road vehicles are appropriately licensed for use on routes to transport people and goods.

Vehicle classification

Road vehicles are classified for many purposes, including regulatory objectives. The classification is primarily based on vehicle weight, termed Gross Vehicle Weight Rating (GVWR). Different jurisdictions employ their own vehicle classifications but they are mostly similar. Based on the Canadian approach, light-duty vehicles and trucks are rated below 3,856 kg GVWR, including all compact, sedan, sport utility vehicles, minivans, and most pickup trucks. A heavy-duty vehicle is rated at GVWR greater than 3,856 kg. Heavy-duty vehicles are also subcategorized into light heavy-duty vehicles (less than 8,847 kg), medium heavy-duty vehicles (between 8,847 kg and 14,971 kg) and heavy heavy-duty vehicles (heavier than 14,971 kg).

Hybrid electric vehicle

A hybrid electric vehicle (HEV) uses the combined efforts of both a gasoline engine and a battery-powered electric motor to drive the vehicle. The work of driving the car is shared between the two propulsion sources in the most efficient way possible at any given time. A hybrid electric vehicle does not use a plug-in electric power supply. The required electricity is generated onboard by the fossil fuel engine or by saving energy from slope cruising and braking. Depending on the engagement of the electric motor in vehicle operation, many levels of vehicle hybridization exist, from range extender and micro-hybrid to mild and full hybrid. Mild hybrids cannot drive on the electric motor alone, but energy-saving provides fuel economy benefits. A mild hybrid uses a smaller battery and a motor-generator that can both create electricity and help boost the gas engine's output. They can also be used to run some of a vehicle's auxiliary functions like climate control or be used as a starter/generator to reduce the load on the gas engine.

Plug-in hybrid electric vehicle

Plug-in hybrid electric vehicles (PHEVs) have a much larger capacity battery than any HEV and can run in at least two modes: "all-electric", in which the electric motor(s) and battery provide all the car's energy, and "hybrid," in which both electricity and gasoline are employed. PHEVs are meant for extended electric driving (e.g., 40 to 100 km).

Battery electric vehicle

A battery electric vehicle (BEV) is operated only by an electric motor(s). There is no internal combustion engine or fuel tank onboard. Battery capacities are large enough for driving long distances without the need to recharge. BEVs are genuinely zero-emission vehicles as they have no exhaust pipe. The cost of operation is much lower than typical internal combustion engines with fewer moving parts, no oil change requirement, and no pad brakes.

List of Figures

List of Tables

Introduction

At the June 2020 board meeting, the Clean Air Strategic Alliance (CASA) formed an ad hoc group to explore how reductions in traffic volume associated with public health measures to reduce COVID-19 transmission could inform future air quality management policy. Members noted that CASA is an ideal forum to both gather interested parties to explore this issue and share the findings with Albertans[1] to improve air quality management and stewardship.

The discussions of the ad hoc group resulted in a statement of opportunity related to messaging on vehicle emissions and air quality. Further scoping discussions by a working group following the statement of opportunity resulted in draft terms of reference for a project team to carry out. At the March 2021 meeting, the CASA Board of Directors approved the terms of reference for the formation of a CASA Impacts of Reduced Transportation on Air Quality in Alberta Associated with COVID-19 (IRTAQ) Project Team. The project team's terms of reference can be found in Appendix 1.

Project Goal and Objectives

As outlined in the IRTAQ Project Team terms of reference, the project had the following goal:

> "To collaboratively develop messaging that links changes in air quality associated with measures undertaken to reduce the spread of COVID-19. The messaging would aim to generate provincial awareness of the impacts that reductions in motor vehicle transportation can have on air quality, and how individuals, governments, businesses, and other Albertans can act to improve air quality."

The project objectives were as follows:

1. Summarize existing information on Alberta's ambient air quality and traffic counts before and during the implementation of measures taken to reduce the spread of COVID-19.
2. Link observed air quality changes associated with measures taken to reduce the spread of COVID-19 to outcomes that are relatable to Albertans.
3. Write a project final report including performance measures and recommendations.
4. Develop a plan for communicating the work of the project team on transportation reductions due to COVID-19 and the impacts on air quality.

1 For this project, "Albertans" refers to individuals and all elements of our society (i.e., governments, industries, businesses, and other organizations and institutions).

Outcomes

The project team completed its objectives. The two primary documents prepared by the team were a summary report and communications plan which are included as Appendices 2 and 3; the highlights from each document are provided below.

Summary Report

The summary report includes work completed to:

i. Summarize information about air pollution and associated human health impacts.

ii. Summarize existing information on Alberta's ambient air quality and traffic counts before and during the implementation of measures to reduce the spread of COVID-19.

Air pollution and associated human health impacts

A review of the extensive literature on the health impacts of air pollution, focused on air pollutants associated with vehicle emissions, confirmed that vehicle emissions have significant negative health impacts both globally and in a Canadian context. The health impacts associated with vehicle emissions in Canada and Alberta are both varied and significant, ranging from premature mortality to acute respiratory symptoms and reduced activity days. Studies have indicated that exposure zones for vehicle-related air pollution range from 50 to 1,500 m from highways and major roads. The health impacts of vehicle emissions are therefore particularly relevant in Canada since approximately 33% of the population lives within 250 m of a major thoroughfare (the estimate for Alberta is approximately 12%).

To relate reduced vehicle emissions and resultant improvement in ambient air quality during the COVID-19 pandemic to health benefits, the Air Quality Health Index (AQHI) was used, which is an air pollution health risk indicator. Health Canada developed the AQHI based on pollutant mortality effects determined from epidemiological studies in major Canadian cities. To evaluate changes in air quality associated with reduced traffic volume, the project team summarized existing information on Alberta's ambient air quality and traffic counts before and during the implementation of public health measures taken to reduce the spread of COVID-19.

A technical report covering this portion of the summary report is in Appendix 2a.

Alberta's ambient air quality and traffic counts before and during the implementation of measures to reduce the spread of COVID-19

Vehicular traffic volume in some urban thoroughfares in Alberta during the same period was lower in 2020 relative to previous years (2015–2019). This decrease was most notable during the morning and afternoon commuter periods.

Concentrations of NO_2, and to some extent $PM_{2.5}$, were lower in 2020 relative to previous years, with the largest decrease observed during the morning commuter period. Ozone concentration was higher in 2020 relative to previous years during the same period. This change in ozone was most likely due to reduced destruction of ozone by oxides of nitrogen (NO, NO_2).

Despite the mixed results for ambient concentrations, the AQHI, which is calculated using NO_2, ozone, and $PM_{2.5}$, was up to 13% lower in 2020 at some urban stations compared to previous years during the same period.

This CASA project, while not quantifying the specific health implications or benefits associated with reduced transportation volumes during periods of active public health measures, shows that reduced traffic volumes reduce air pollution. Based on health-based air quality metrics like the AQHI, reduced traffic-related air pollution levels translate to reduced air pollution related health impacts with associated quality of life and economic benefits. A detailed technical write-up for this portion of the summary report is in Appendix 2b.

Communications Plan

This is a summary of the communications plan which is included in Appendix 3.

The goals of the communications plan as part of the overall project were to:

i. Identify target audiences (recipients of messages) and possible partners to deliver messages to those audiences.

ii. Develop and provide key messages and guidance on delivering those messages.

The project team completed these communication goals.

The team prepared a draft set of key messages and a draft list of potential audiences for the messages. The draft content was presented to a diverse set of communications experts for feedback in a virtual workshop on February 11, 2022. There were 17 attendees (excluding project team members) at the workshop.

In addition to the key messages and potential audiences, the team developed guidance for stakeholders to assist in delivery of the key messages, which is in Appendix 3a. Proceedings from the workshop are in Appendix 3b.

Key Messages

The key messages are the primary outcome of this project. This section provides an overview of why the key messages are important to Albertans, followed by the messages themselves.

Introduction

As seen in the IRTAQ Summary Report (Appendix 2), some of the COVID-19 response measures taken in Alberta resulted in reductions in vehicle traffic counts and these reductions translated to measurable reductions in ambient air pollutant levels. Air pollution from vehicular traffic (and other sources) has health implications for all Albertans, the details of which are in the Summary Report.

While vehicle use is an inherent part of our current society and our economy, air emissions significantly contribute to air pollution levels throughout the province, particularly in urban areas. Approximately 12% of Albertans live within 250 m of a major thoroughfare with associated higher vehicle emission-related air pollution levels.

Reducing air pollution levels associated with motor vehicle emissions is a complicated and challenging issue with many considerations, such as the ubiquitous presence of emitting vehicles, the variability in the types and condition of vehicles on the road (e.g., diesel trucks vs. small passenger cars), and the location of roadways relative to residents and commercial activities. In addition, air pollution that originates in one area often flows to other areas. This means that air emissions from motor vehicles are a shared issue because all Albertans are exposed to these pollutants. More importantly, the way individuals interact with transportation has consequences for both themselves and those around them.

Motor vehicle emissions management involves the complementary roles of federal, provincial, local governments, and other stakeholders. The federal government sets air emission and fuel efficiency standards for new and imported vehicles which become more stringent over time; however, turnover of the overall vehicle fleet can be slow. The provincial government has jurisdiction over in-use vehicles e.g., maintenance and local governments may contribute through land-use planning and local bylaws e.g., anti-idling. For transportation fuels, there are accompanying federal and provincial standards. New and continued actions by governments, organizations, industry, and individual Albertans will continue to be important as reflected by the project key messages.

The following are key messages on a) overall takeaways from the study related to vehicle emissions, air quality, and health; and b) actions Albertans can undertake to reduce vehicle emissions and thereby help improve air quality. Guidance that may help stakeholders in the delivery of the key messages is in Appendix 3a.

General takeaways from the study

Alberta declared a COVID-19 public health emergency on March 17, 2020. The province implemented several measures to curb the spread of COVID-19 and protect the health care system, including closures of schools and requirements to work from home, where possible. These measures resulted in measurable reductions in motor vehicle traffic and provided an unprecedented real-world opportunity to examine the impact of motor vehicle traffic volume on air quality, and in turn, implications for human health.

The key messages below are related to an analysis of the potential changes in air quality and traffic counts by comparing data collected during the study period (March-June 2020) to previously observed pollutant concentrations (2015-2019), as well as qualitative information gathered related to the potential impacts of air quality improvements on human health.

Transportation-related emissions can notably contribute to the ambient air levels of various pollutants, including particulate matter (PM), nitric oxide (NO), nitrogen dioxide (NO2), carbon monoxide (CO), black carbon (BC), polycyclic aromatic hydrocarbons (PAHs), certain metals, and BC.

The key messages are divided into three categories as shown below.

Ambient air quality during the study period relative to past conditions

- Improvements in outdoor air quality were seen in many Alberta cities associated with the reduced traffic during the study period.

- During the COVID-19 public health emergency, the reduced levels of certain air pollutants resulted in decreases in the AQHI of up to 13% at some urban stations with an associated expected reduction in outdoor air pollutant related health impacts.

Contribution of reduced transportation to improved air quality

- During the COVID-19 public health emergency, the volume of morning commuters dropped approximately 45%, which resulted in improved outdoor air quality for many.
- Working from home helps reduce traffic volume and outdoor air pollutants and commuters' exposure to these pollutants.
- The findings from the project illustrate that taking certain actions can improve outdoor air quality.

Impacts of air quality on human health

- Even low levels of pollutant exposure can lead to negative short- and long-term health effects.
- Traffic-related air emissions have impacts on health for people in all areas of Alberta.
- Those most at risk from traffic pollutants are the elderly, the young, those with cardiovascular or pulmonary diseases, or with chronic illnesses.
- Reducing traffic pollutants is anticipated to reduce health impacts such as hospital admissions, emergency room visits, doctor visits, and lost work or school time.
- Alberta has the largest diesel exhaust emissions in Canada. There are negative health impacts from diesel emissions.

Actions Albertans can undertake to help improve air quality

Below there are examples of measures and actions that individuals, governments, industry, and organizations can take to reduce transportation-related emissions, followed by a longer list of actions that the three groups could share. Some of the measures and actions directly relate to the findings of the IRTAQ Summary Report, while others were borrowed and referenced from similar initiatives.

The intent of these example actions and measures is, at a minimum, to generate awareness of how actions and behaviours impact air quality and in turn, human health. These actions and measures vary significantly in potential impact in reducing emissions and in the ease and time needed to implement them. This is not a comprehensive list and there are many actions that are not captured. Individuals, government, and industry/organizations are encouraged to build upon or develop their own actions to reduce emissions where possible. If there was a clear target audience, it is included in brackets at the end of the message. The messaging to governments on expected policy-level actions are in the Project Team Recommendations section. In addition to air quality benefits, there may be other co-benefits to undertaking these actions such as saving fuel/money, saving time, improving the longevity of a vehicle, or reducing stress (e.g., reading on transit instead of driving).

Government (municipal, provincial, federal)

- Follow best practices in land use planning and sustainable communities to address transportation related issues.[2,3] Considerations such as 15-minute neighbourhoods,[4] accessible public transit, and active transportation corridors need priority.
- Build infrastructure to support active transportation (e.g., biking, walking).
- Consider modifying staff work schedules to allow working from home and attending meetings virtually where possible.

---

2 Webpage: Alberta Health Services. 2022. *Alberta Healthy Communities Hub*. https://albertahealthycommunities.healthiertogether.ca/

3 Webpage: University of Alberta School of Public Health. 2022. *Centre for Healthy Communities*. https://www.ualberta.ca/public-health/research/centres/centre-for-healthy-communities/index.html

4 Webpage: Smart Transport. 2021. *What is a 15-minute neighbourhood?* https://www.smarttransport.org.uk/insight-and-policy/latest-insight-and-policy/what-is-a-15-minute-neighbourhood

- Government agencies with internal or contracted fleets that provide services and have active operations in municipalities and on highways should take actions to reduce fleet emissions. Examples of fleet type activities are parks and roadway maintenance, waste collection, police, transit/bus, etc.
- Natural Resources Canada has information and resources related to improving fuel efficiency for commercial fleets (e.g., driver training in fuel efficiency, imposing maximum vehicle speed, advanced vehicle aerodynamics, automatic engine shut-off after set idling time).[5,6]

Individuals

- Where and when possible, choose an active mode of transportation (e.g., walk, bike) or use public transportation instead of driving a personal vehicle. (Commuters)
- Consider carpooling as it can help reduce traffic.
- Plan trips and choose an efficient route before you go so that you only have to travel once – saving time, money, and emissions ("trip chaining"). (Commuters)

Organizations (could include government, industry, or other groups)

Use the resources listed below for better management of fleet vehicles:

- Natural Resources Canada has information and resources related to improving fuel efficiency for commercial fleets (e.g., driver training in fuel efficiency, imposing maximum vehicle speed, advanced vehicle aerodynamics, automatic engine shut-off after set idling time).[5,6]
- The SmartWay Transport Partnership (SmartWay) is a free and voluntary program that helps businesses move goods efficiently while keeping fuel costs and environmental impact at a minimum. (Partners and affiliates: businesses, commercial trucking/carriers, logistics companies and shippers, non-profit organizations, truck/trailer leasing firms and dealerships.)
- Proven tips for commercial driving and equipment that help save money and reduce emissions through fuel efficiency are available from Natural Resources Canada.[7]
- SmartWay offers webinars on aerodynamic drag reduction and other topics for improved fuel efficiency.[8]
- SmartDriver provides free, practical training to help Canada's commercial and institutional fleets lower their fuel consumption, operating costs, and vehicle emissions. Fleet energy-management training that helps truckers, transit operators, school bus and other professional drivers improve fuel efficiency by up to 35%![9]
- Explore available resources for setting up an idle-free zone, for example through Natural Resources Canada.[10,11]

---

5 Webpage: Natural Resources Canada. 2022. *Federal vehicles and fleets.* https://www.nrcan.gc.ca/energy-efficiency/buildings/nrcans-greening-government-services/federal-vehicles-and-fleets/20053

6 Webpage: Natural Resources Canada. 2019. *Fuel efficiency benchmarking in Canada's trucking industry.* https://www.nrcan.gc.ca/energy/efficiency/transportation/commercial-vehicles/reports/7607

7 Webpage: Natural Resources Canada. 2018. *Tips for better driving and equipment.* https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/greening-freight-programs/smartway-fuel-efficient-freight-transportation/tips-for-better-driving-and-equipment/tips-for-better-driving-and-equipment

8 Webpage: Natural Resources Canada. 2021. *Upcoming SmartWay webinars.* https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/greening-freight-programs/smartway-fuel-efficient-freight-transportation/smartway-tools-and-resources/upcoming-smartway-webinars/21080

9 Webpage: Natural Resources Canada. 2019. *SmartDriver training series.* https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/greening-freight-programs/smartdriver-training-series/21048

10 Webpage: Natural Resources Canada. 2017. *Welcome to the idle-free zone.* https://www.nrcan.gc.ca/energy/efficiency/communities-infrastructure/transportation/idling/4397

11 Webpage: Parkland Airshed Management Zone. 2022. *Idle free.* https://pamz.org/idle-free/

Shared actions

Use these resources to improve fuel efficiency and reduce environmental impact

- Better fuel efficiency/fuel consumption results in fuel savings and less emissions.[12,13]
- Smooth acceleration and strategic coasting can help reduce fuel consumption and emissions. (Commuters, commercial trucking)[14]
- Learn driving techniques that can save you in fuel costs.[15]
- In the summer heat, your car's interior will cool down quicker by driving than by idling it with the air conditioner running.[13]
- Reduce use of air conditioning, as air conditioning can increase a vehicle's fuel consumption by as much as 20%.[14]
- To save money and minimize emissions, slow down and try to maintain a steady speed. At 120 km/h, a vehicle uses about 20% more fuel than at 100 km/h.[13]
- Use a block heater so you can plug in your vehicle during cold weather. Block heaters can reduce a vehicle's warm up time, increasing fuel efficiency and reducing emissions. It will also reduce wear on your engine components and help warm up your vehicle faster.[16]
- Reduce vehicle idling when warming up your vehicle or otherwise waiting.[17]
- Cut fuel consumption, reduce emissions, and save money by avoiding excessive idling.[18] Examples of excessive idling includes pick up/ drop off areas, train crossings, and warming up.[19,20]

Conduct proper vehicle maintenance

- Follow regular vehicle maintenance schedules to reduce emissions while benefiting the safety and life of your vehicle.[21] (Commuters)
- Maintain proper pressure in your tires to improve fuel efficiency (reduce emissions), reduce tire wear (save money), and improve safety by increasing traction.[22]
- Maintain your vehicle's emission control system in good working order. (Commuters, commercial trucking)
- Idling not only impacts emissions (air pollution) and fuel consumption (costs), but also vehicle wear (more costs and more frequent maintenance).

---

12 Webpage: Natural Resources Canada. 2018. *Understanding fuel consumption ratings.* http://www.nrcan.gc.ca/energy/efficiency/transportation/cars-light-trucks/buying/7489

13 Webpage: Natural Resources Canada. 2018. *Factors that affect fuel efficiency*. https://www.nrcan.gc.ca/energy/efficiency/transportation/cars-light-trucks/buying/16217

14 Webpage: Natural Resources Canada. 2021. *Fuel-efficient driving techniques*. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/personal-vehicles/fuel-efficient-driving-techniques/21038
Webpage: Alberta Motor Association. 2022. *Save money on gas by refining the way you drive*. https://amainsider.com/save-money-on-gas/

15 Webpage: Stantec. 2020. *ecoDriving online*. http://www.ecodrivingonline.ca/home.htm

16 Webpage: Alberta Motor Association. 2022. *Why your block heater is essential in winter.* https://amainsider.com/auto-expert-block-heaters/

17 Webpage: City of Edmonton. 2022. *Be idle free*. https://www.edmonton.ca/city_government/environmental_stewardship/be-idle-free#:~:text=Under%20the%20bylaw%2C%20drivers%20cannot,area%20designated%20as%20no%20idling.&text=Vehicles%20licensed%20to%20provide%20public,are%20exempt%20from%20the%20bylaw

18 Webpage: Natural Resources Canada. 2017. *Idling – frequently asked questions.* https://www.nrcan.gc.ca/energy/efficiency/communities-infrastructure/transportation/idling/4463

19 Webpage: Natural Resources Canada. 2009. *Turn it off: reducing vehicle engine idling final report.* https://oee.nrcan.gc.ca/transportation/idling/material/reports-research/turn-it-off-exec-summary.cfm

20 Webpage: Argonne National Laboratory. *Reducing vehicle idling.* https://www.anl.gov/es/reducing-vehicle-idling

21 Report: South Carolina Department of Health and Environmental Control. *Vehicle maintenance and air quality fact sheet.* Available online: https://scdhec.gov/sites/default/files/Library/CR-010092.pdf

22 Webpage: Alberta Motor Association 2022. *The right tire pressure for your car*. https://ama.ab.ca/articles/how-to-check-tire-pressure

Considerations when purchasing a vehicle

If upgrading to a newer vehicle, consider choosing a lower emission vehicle (i.e., hybrid, plug-in hybrid or ideally, a zero emissions vehicle) where possible. (Commuters, commercial fleets)

- Choosing the most fuel-efficient vehicle that meets your needs can reduce emissions and fuel costs.[23,24] (Individuals, commercial fleets)
- The Natural Resources Canada fuel consumption ratings search tool to helps identify the most fuel-efficient vehicle that meets your everyday needs by comparing the fuel consumption information of different models.[25]
- The 2022 Fuel Consumption Guide gives information about the fuel consumption of 2022 model year light-duty vehicles (passenger cars, vans, SUVs, pickup trucks) to compare vehicles as you shop for the most fuel-efficient vehicle that meets your everyday needs.[26]
- For a quick overview of battery electric vehicles and plug-in hybrid electric vehicles, check out resources from Natural Resources Canada and the Canadian Automobile Association for electric vehicles.[27],[28]
- Natural Resources Canada has tips for choosing a fuel-efficient vehicle.[29]
- Natural Resources Canada has some tips for reading EnerGuide labels for vehicles if considering a new purchase.[30]

Remote work arrangements

- Encourage or implement a policy enabling employees to work from home when or where possible. (Employers)
- Consider modifying your work schedule to work from home or attend meetings virtually when or where possible. (Employees)
- Consider reviewing resources or taking part in training opportunities for conducting or participating in remote meetings, which could reduce the need for in-person meetings. (Individuals, employees, employers)

Refer to educational resources

- Use the Alberta Motor Association (AMA) Road Reporter app to avoid unnecessary travel delays and confirm road and travel conditions.[31]
- Natural Resources Canada has an interactive Idling Quiz - check out the truths or myths![32]
- AMA has several Tips for Green Driving such as avoiding hard braking and acceleration, using cruise control on highway drives where possible, considering reducing driving speed to lower fuel consumption, and opening windows instead of using A/C below 60 km/h to cool the vehicle interior.[33]
- The Canadian Auto Association provides easy fuel-efficient driving tips.[34]

---

23 Webpage: U.S. Department of Energy Alternative Fuels Data Center. *Rightsizing your vehicle fleet to conserve fuel*. https://afdc.energy.gov/conserve/rightsizing.html

24 Webpage: Natural Resources Canada. 2020. *Choosing the right vehicle*. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/personal-vehicles/choosing-right-vehicle/20998

25 Webpage: Natural Resources Canada. 2022. *Fuel consumption ratings search tool*. https://fcr-ccc.nrcan-rncan.gc.ca/en

26 Webpage: Natural Resources Canada. 2022. *2022 fuel consumption guide*. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/fuel-consumption-guide/21002

27 Webpage: Natural Resources Canada. 2022. *Buying an electric vehicle*. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/personal-vehicles/choosing-right-vehicle/buying-electric-vehicle/21034

28 Webpage: Canadian Automobile Association. 2022. *Electric vehicles*. https://www.caa.ca/sustainability/electric-vehicles/

29 Webpage: Natural Resources Canada. 2021. *Tips for buying a fuel-efficient vehicle*. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/personal-vehicles/choosing-right-vehicle/tips-buying-fuel-efficient-vehicle/21000

30 Webpage: Natural Resources Canada. 2019. *EnerGuide for vehicles*. https://www.nrcan.gc.ca/energy-efficiency/energuide-canada/energuide-vehicles/21010

31 Webpage: Alberta Motor Association. 2022. *Road reports*. https://roadreports.ama.ab.ca/

32 Webpage: Natural Resources Canada. 2014. Idling quiz. https://www.nrcan.gc.ca/energy/efficiency/communities-infrastructure/transportation/idling/4417

33 Webpage: Alberta Motor Association. 2022. *Protecting the environment*. https://ama.ab.ca/community/care/protecting-environment

34 Webpage: Canadian Automobile Association. 2022. *Fuel-efficient driving tips*. https://www.caa.ca/sustainability/fuel-efficient-driving-tips/

CASA Recommendations

CASA made recommendations informed by the goals of the Communications Plan along with performance measures to confirm achievement of those goals.

Generally, this project highlights the value and fully supports implementation of the 2018 CASA recommendations to reduce non-point source air emissions related to transportation in Alberta[35] and encourages the CASA Roadside Optical Vehicle Emissions Reporter (ROVER) III Project[36] to take into consideration the findings from this project and the recommendations from past CASA projects on transportation emissions. In particular, this project may help inform implementation of the CASA non-point source recommendation no. 1.[37] Furthermore, the CASA ROVER III project is expected to inform management actions and next steps for transportation emissions management to help achieve the Canadian Ambient Air Quality Standards (CAAQS) in Alberta.

CASA's recommendations are as follows:

1. For CASA to provide the final key messages, and guidance on delivering those messages, to its stakeholders and partners.
2. For stakeholders and partners to deliver the key messages to audiences through their networks.
3. For Alberta Environment and Parks to prepare the air quality and vehicle count analysis for peer-reviewed publication.
4. For monitoring organizations in Alberta to investigate air quality near major roadways through roadside ambient air monitoring and compare measured values to nearby neighbourhood scale stations.

35 Webpage: Clean Air Strategic Alliance. 2022. *Non-Point Source Project Team.* https://www.casahome.org/past-projects/non-point-source-project-team-37/

36 Webpage: Clean Air Strategic Alliance. 2022. *Roadside Optical Vehicle Emissions Reporter III Project Team.* https://www.casahome.org/current-initiatives/roadside-optical-vehicle-emissions-reporter-iii-project-team-53/

37 Recommendation 1: Reduce emissions from in-use on-road light-duty vehicles.
That Alberta Environment and Parks and Alberta Transportation collaborate with municipalities, Airshed Organizations, and other appropriate stakeholders to develop and implement a strategy to:
i. increase the public's understanding of emissions resulting from vehicle use and their impact on air quality
ii. increase the public's awareness of the practical actions they can take to reduce emissions from vehicle use
iii. encourage individuals to reduce emissions from vehicle use

Performance Measures

CASA supports several performance measures to evaluate and gauge success of the project. The measures are:

1. CASA has delivered the key messages and guidance to stakeholders and partners within one month of the final report public release.
2. The number of partners who delivered the key messages to audiences through their networks within one year of the final report public release.
3. Information on how, and to whom, the partners delivered key messages (e.g., type of media and which audiences) within one year of the final report public release, where available.
4. Information on key message uptake (e.g., number of views on social media, number of groups/classes presented to, number of recipients of newsletter articles) within one year of the final report public release, where available.
5. Submission of a manuscript on the air quality and vehicle count analysis to a peer-reviewed journal within one year of the final report public release.
6. Monitoring organizations in Alberta initiate a roadside air quality monitoring study and compare measured values to nearby neighbourhood scale stations within three years of the final report public release.

Performance Indicators

In addition to performance measures, CASA projects typically provide performance indicators (areas where CASA has a lower degree of control over results). However, this project's recommendations are unusual in that they are not intended to inform policy, and instead relate to CASA and its stakeholders and partners delivering messages. The team decided that it would not be possible to measure the indirect impacts of the messages beyond their delivery and uptake, or if there were a way to measure the impact, it would not be possible to relate in a meaningful way to the project messages. For example, vehicle emissions may decline over time, which could be an outcome from individuals acting on the project messages, but there are too many confounding factors to conclude that reduced emissions were directly related to the messages. Therefore, the team has opted not to include performance indicators.

Process Evaluation and Lessons Learned

The project team discussed the CASA process, project team, and the effectiveness of virtual meetings and resources.

Successes

- The team was able to clarify their understanding and views on the topic.
- Multi-stakeholder representation allowed the team to contribute, hear, and understand varied perspectives.
- Completing the project through CASA helped enable NGOs to participate (funding provided where appropriate).
- The workshop provided an opportunity to engage with external (communications) experts.
- Shorter, remote meetings had several advantages over in-person:
  - Less travel (meaning less cost, less time needed, no weather/road safety concerns, attendance from any location, fewer vehicle emissions, etc.) and potentially increased meeting attendance
  - Allowed for more frequent team meetings than potentially otherwise
  - Enabled the team to walk-the-talk on actions that can be taken to reduce vehicle emissions
  - Enabled team members to attend while incorporating ergonomic considerations that work best for them (e.g., sit/stand station, special desk/chair)
  - Enabled team members to conveniently manage any dietary restrictions
  - Potentially reduced out of scope conversations due to shorter meeting time
  - Increased individual work completion offline, which was useful for tasks that did not require team input until they were complete
- Using virtual meeting tools provided transferable skills for other remote meetings in the workplace and/or personal life.
- Having participants who had familiarity with interest-based negotiations expedited the team's work.

Challenges

- Remote meetings for a collaborative process are challenging (some of these challenges also apply to the virtual workshop):
  - Not the same depth of discussion as possible with in-person meetings, due to both the lack of face-to-face interaction (for meeting discussions and in-person meeting breaks) and shorter virtual meeting times to avoid fatigue
  - Limited social interaction that may otherwise assist with relationship-building among the team
  - Level of team member engagement is less clear
  - More difficulty building energy and momentum in discussions
  - Shorter meetings necessitated briefer, more structured discussions of issues and paths forward. This pressure reduced creative thinking and awareness of creative opportunities.
  - Some project tasks required more work be completed individually offline, rather than together with the team. This work then had to be evaluated and approved by the team later which was less efficient and lengthened the process.
  - Challenges for some team members in the use of technology for editing and adding suggestions
- There were some limitations to the data and analysis conducted for the summary report; these limitations are noted in the Technical Memorandum Appendix 2b in the "Study Limitations" section.

- The project was intended to be expedited; an ad hoc group was formed to assist with initial scoping discussions which would ideally have brought the project to faster completion, but that was not the result. At the project team stage, time is still required to gather diverse perspectives and reach consensus.
    - As a result, the project was delayed (the timeline in the terms of reference was revised in September 2021 from July–September 2021 to August 2021–April 2022)
        - Availability of project team members for expedited process (e.g., involvement in multiple CASA teams, other priorities)
        - Delay in when the project could start from lack of timely submission of names during call for members period
        - More discussion than expected to determine the scope of data analysis. Some subsequent project tasks (e.g., drafting of key messages) could not begin until the analysis was complete.
- Not having available communication engagement specialists who could directly participate on the project team made the work more challenging.

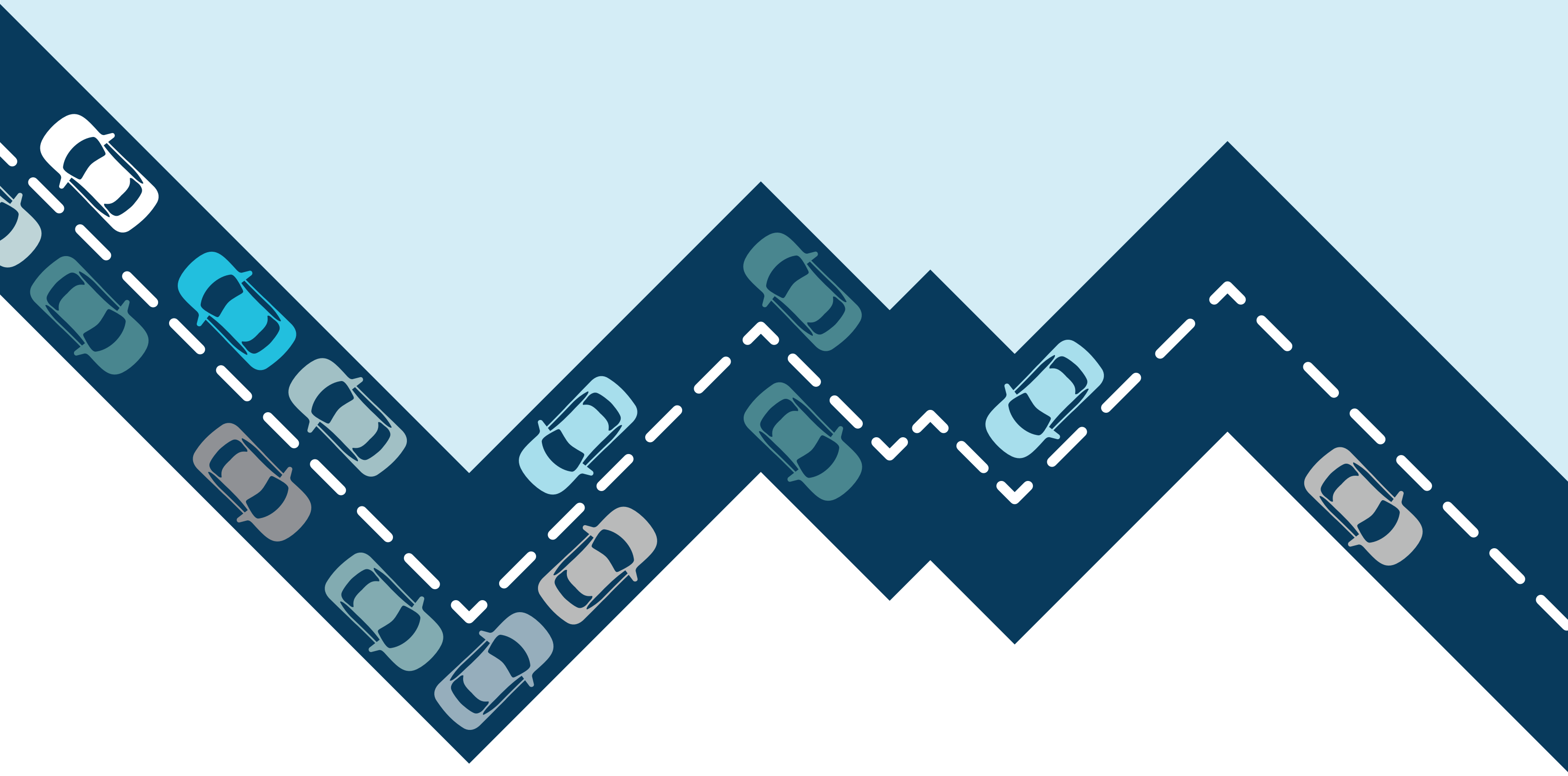
Conclusion

Air pollution has health implications for all Albertans. Some of the COVID-19 response measures resulted in notable reductions in vehicle traffic counts and these reductions translated to measurable reductions in air pollutant levels and an improvement to the calculated AQHI.

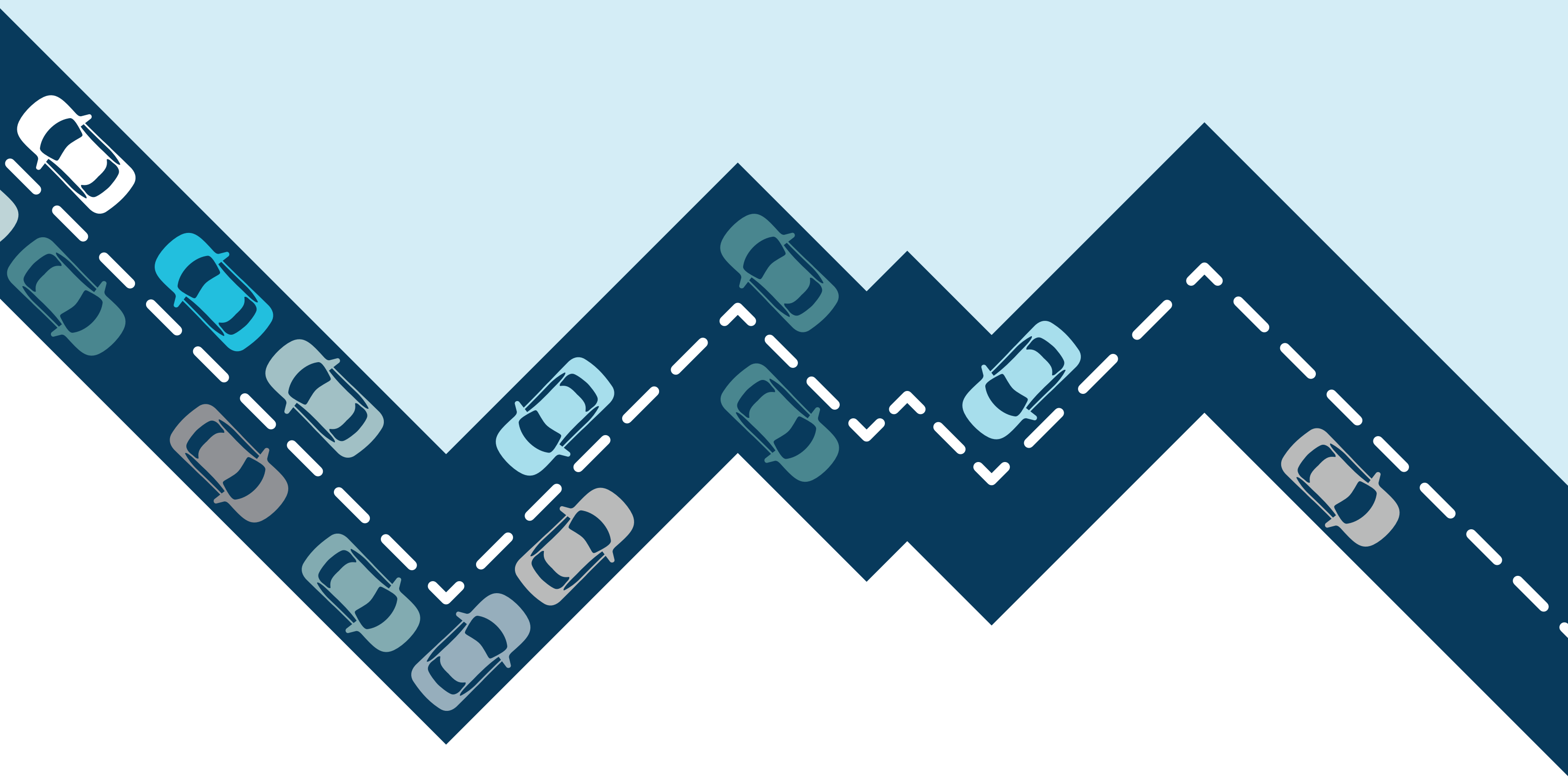
The project team collaboratively developed messaging to help generate provincial awareness of the impacts that reductions in motor vehicle transportation can have on air quality, and how individuals, governments, businesses, and other Albertans can act to improve it.

CASA's multi-stakeholder process and forum allowed participants to share information related to the issue. This project took place during the second year of the pandemic exclusively through remote meetings, which had its own set of benefits and challenges. However, the project team hopes the information from this project can support continued communication and engagement on the effects of transportation on air quality, and associated impacts on human health, through existing or ongoing CASA projects, or on a broader scale.

Appendices



Appendix 1:
Project Team Terms of Reference



Impacts of Reduced Transportation on Air Quality in Alberta Associated with COVID-19 Project Team

Terms of Reference

Approved by the Clean Air Strategic Alliance on July 2021

Context[38]

The Clean Air Strategic Alliance (CASA) formed an ad hoc group to explore how anticipated COVID-19-related trends in emissions due to reduced transportation could inform future air quality management policy. Members noted that CASA is an ideal forum to both gather interested parties to explore this issue and share the findings with Albertans[39] to improve air quality management and stewardship.

The discussions of the ad hoc group resulted in a statement of opportunity related to messaging on vehicle emissions and air quality. Team members will collaboratively provide or resource supporting information through subject-matter experts and available reference material for the project.

The project team will operate in a manner that is consistent with the rules, policies and procedures adopted by CASA, including the use of consensus to make decisions in a multi-stakeholder process.

Strategic intent (goal)

Collaboratively develop messaging that links changes in air quality associated with measures undertaken to reduce the spread of COVID-19. The messaging would aim to generate provincial awareness of the impacts that reductions in motor vehicle transportation can have on air quality, and how individuals, governments, businesses, and other Albertans can act to improve air quality.

Objectives

The project would achieve the following four objectives:

1. Summarize existing information on Alberta's ambient air quality and traffic counts before and during the implementation of measures taken to reduce the spread of COVID-19.
2. Link observed air quality changes associated with measures taken to reduce the spread of COVID-19 to outcomes that are relatable to Albertans.
3. Write a project final report including performance measures and recommendations.
4. Develop a plan for communicating the work of the project team on transportation reductions due to COVID-19 and the impacts on air quality.

Key Tasks[40]

1. Summarize existing information on Alberta's ambient air quality and traffic counts before (2019) and during (Spring 2020) the implementation of measures taken to reduce the spread of COVID-19.
   a. Gather information and data related to provincial ambient air quality and motor vehicle transportation.
   b. Compile and summarize relevant data and information from Alberta and other jurisdictions.
   c. Identify possible reasons for any changes in traffic counts and air quality.
   d. Conduct an inventory of existing communication to leverage or build on existing initiatives.
   e. Identify any data sources, gaps, or additional analyses required for the CASA project.

---

38 Additional project context can be found in the statement of opportunity approved by the CASA board, March 11, 2021.

39 Throughout this document, "Albertans" refers to individuals and all elements of our society (i.e., governments, industries, businesses, and other organizations and institutions).

40 An initial list of sources relevant to the key tasks can be found in the Statement of Opportunity. The working group identified additional resources for the tasks which are captured in the group's meeting minutes.

2. Link observed air quality changes associated with measures taken to reduce the spread of COVID-19 to outcomes that are relatable to Albertans.
   a. Use the AQHI (or other metrics as appropriate) and Health Canada's 2019 report, *Health impacts of air pollution in Canada: estimates of morbidity and premature mortality outcomes,*[41] where suitable, to communicate the data findings from key task 1 to those less familiar with air science.
3. Complete a project summary report.
   a. Compile all information and prepare a summary report based on key tasks 1 and 2.
4. Write a final report.
   a. Assemble a draft final report progressively throughout the project and present to the CASA board for feedback.
   b. Incorporate feedback on the draft final report and present the final report to the CASA board.
5. Develop a communications plan.
   a. Create a list of potential channels through which key messages could be distributed and select a subset of channels appropriate for the known or expected messaging.
   b. Create a set of key messages for each of the selected channels. Key messages will be aimed at Albertans regarding ambient air quality during the public health emergency relative to past conditions, the potential contribution of reduced transportation to improved air quality, and actions Albertans can undertake to help improve air quality.

Timelines and Deliverables

The project team will provide the following deliverables to CASA:

- Summary report: Aug 2021 - Dec 2021
  - including project methodology, findings, outcomes
- Final report: Dec 2021 - Apr 2022
  - including the summary report, key messages, any recommendations, next steps, and performance measures
- Communications Plan: Dec 2021 – Apr 2022
  - for dissemination of the findings and results on reduced transportation emissions due to COVID-19 and their impact on air quality

It should be noted that CASA's *Performance Measures Strategy: A "how-to" guide to performance measurement* at CASA, indicates that each project team is required to generate one specific metric that will allow the success of the team to be evaluated five (5) years in the future.

It is expected that the project team will also provide brief monthly status updates to the CASA board.

Membership

The project team is expected to encompass membership from Industry, Government, and Non-Government Organizations. A list of potential project participants identified by the working group can be found in Appendix 3a, which includes organizations not part of the CASA board membership. The working group membership is listed in Appendix 3b.

Budget

The working group anticipates the project can be completed within an estimated $13,500 of CASA core funds to support the project team's work as shown in Table 1. No additional project-specific funding is required.

Table 1: Core funding costs (covered by CASA)

Type	Amount
Stakeholder support	$7,000
Hosting	$1,500
Communications	$5,000

41 Report: Health Canada. 2019. *Health impacts of air pollution in Canada: estimates of morbidity and premature mortality outcomes, 2019 report.* Available online: http://publications.gc.ca/site/eng/9.874080/publication.html

Appendix 1a – Potential Participants for the Project

- Provincial Ministries and Agencies (e.g., Agriculture, Forestry and Rural Economic Development, Environment and Parks, Alberta Energy Regulator, Transportation, Alberta Health, Municipal Affairs, Education)
- Federal Government (e.g., Environment and Climate Change Canada, Natural Resources Canada, Health Canada)
- Municipalities (Large Urban, Small Urban, Rural)
- First Nation and Metis organizations
- Airshed Organizations
- Industry (e.g., agriculture, electricity, mining, construction, forestry)
- Transportation (e.g., Alberta Motor Association, Alberta Motor Transport Association, Alberta Motor Vehicle Industry Council, commercial operators, fleet operators)
- Health and Environmental Non-Government Organizations (e.g., Alberta Lung Association)
- Research Institutions (e.g., University of Alberta Centre for Smart Transportation)
- Education Bodies (e.g., Alberta Council for Environmental Education)

Appendix 1b – Working Group Membership

Name	Stakeholder Group
Andria Panidisz	Canadian Association of Petroleum Producers
Ann Baran	Southern Alberta Group for the Environment
Anne Vigneau	Heartland Generation Ltd.
Dave Reid	ENMAX Corporation
David Spink	Prairie Acid Rain Coalition
Kamran Faisal	City of Calgary
Kevin McCullum	Alberta Airsheds Council
Kevin Warren	Alberta Airsheds Council
Mike Bisaga	Alberta Airsheds Council
Scott Blurton	Environment and Climate Change Canada
Sean Mercer	Imperial Oil Limited/Canadian Fuels Association
Rhonda Lee Curran	Alberta Environment and Parks
Ruth Yanor	Mewassin Community Council
Yayne-Abeba Aklilu	Alberta Environment and Parks

Appendix 2:

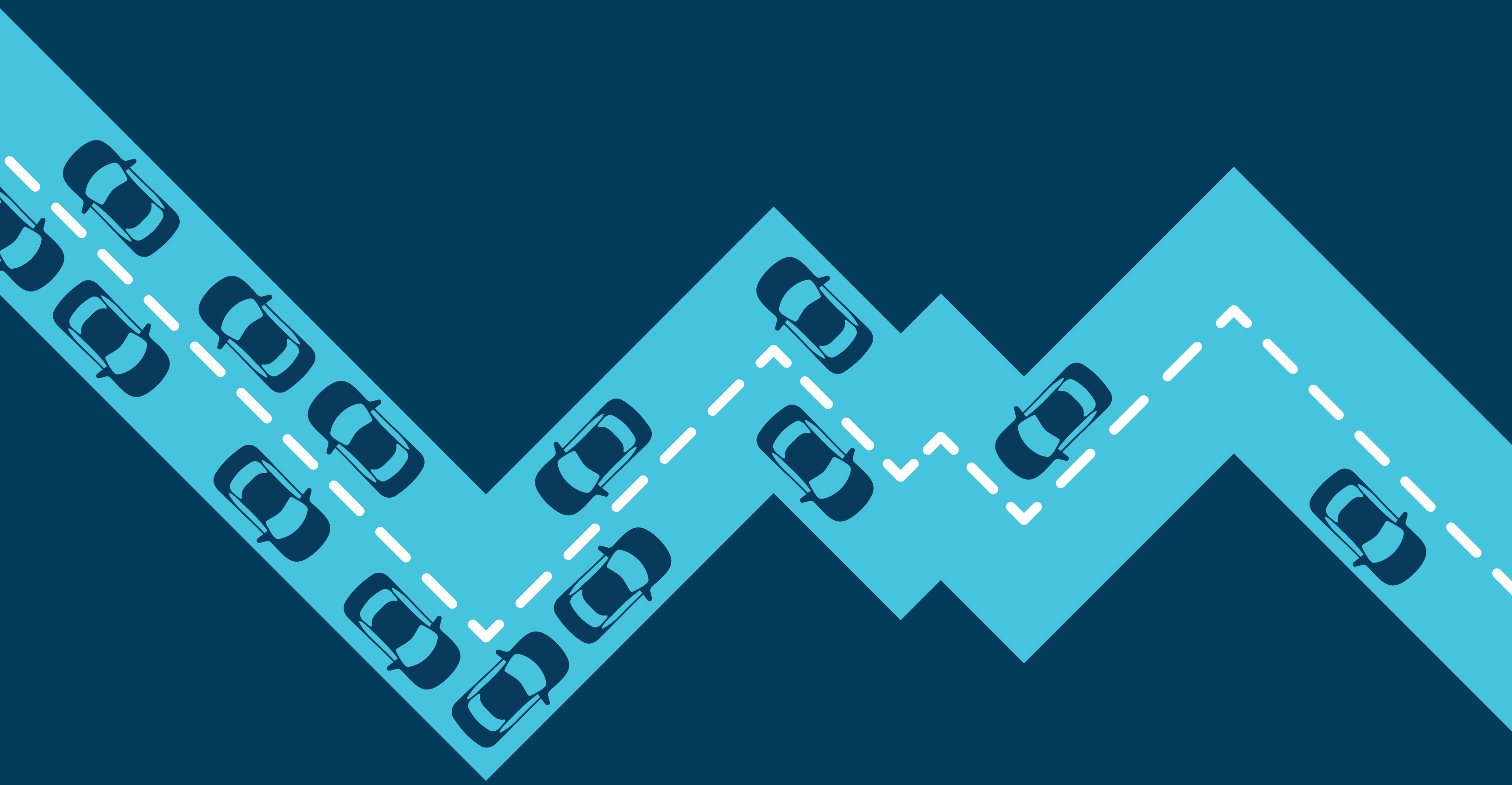
Impacts of Reduced Transportation on Air Quality in Alberta Associated with COVID-19 Summary Report

Impacts of Reduced Transportation on Air Quality in Alberta Associated with Covid-19

Summary Report

Clean Air Strategic Alliance

April 2022



Contents

Motivation for Undertaking the Project

Transportation plays an important role in bringing people and goods together in our society but is also a major source of air pollution in Canada.[42] Emissions from motor vehicles include, but are not limited to: nitrogen oxides, carbon monoxide, fine particulate matter, and volatile organic compounds. While stricter regulations and technological advancements have reduced emissions from new vehicles, vehicle numbers in Canada remain high, older models are still on roadways, and the total kilometres travelled by vehicles continues to increase.[43]

Scientific research has shown negative impacts of air pollution on human health and the environment.[44] Exposure to vehicle-related air pollutants has a range of human health effects, from minor respiratory symptoms to premature mortality.[45] Approximately a third of all Canadians live within 250 metres of a major roadway or thoroughfare and therefore transportation emissions represent a significant potential health risk to a large segment of the population.[46]

The risks are greater for children and those with existing heart and lung conditions. Along with human health impacts, air pollution can have environmental impacts including acid rain, eutrophication, and wildlife impacts (e.g., disease, birth defects).[47] In this report, the focus is on human health, and any reference to "health" should be taken to mean human health.

Alberta declared a COVID-19 public health emergency on March 17, 2020. The province implemented several measures to curb the spread of COVID-19 and protect the health care system, including closures of schools and requirements to work from home, where possible. These stay-at-home measures resulted in measurable reductions in motor vehicle traffic and provided an unprecedented real-world opportunity to examine the impact of motor vehicle traffic volume on air quality, and in turn, human health.

The purpose of this report is twofold: 1) to summarize existing information on Alberta's ambient air quality and traffic counts before and during the implementation of measures taken to reduce the spread of COVID-19, and 2) to link observed air quality changes associated with the measures taken and provide a health benefit perspective to these air quality changes.

This report is part of a broader "Impacts of Reduced Transportation on Air Quality in Alberta Associated with COVID-19" (IRTAQ) project. Additional information regarding this project, including the scope, goal, and objectives, can be found on the IRTAQ project page of the CASA website,[48] as well as the project team's terms of reference.[49]

---

42 Webpage: Government of Canada. 2017. *Sources of air pollution: transportation*. https://www.canada.ca/en/environment-climate-change/services/air-pollution/sources/transportation.html.

43 Webpage: Government of Canada. 2022. *Outdoor air pollution and health: overview*. https://www.canada.ca/en/health-canada/services/air-quality/outdoor-pollution-health.html.

44 Article: Manisalidis I et al. 2020. *Environmental and health impacts of air pollution: a review*. Frontiers in Public Health, 8:14. Available online: https://www.frontiersin.org/articles/10.3389/fpubh.2020.00014/full

45 Report: Health Canada. 2021. *Health impacts of air pollution in Canada - estimates of premature deaths and nonfatal outcomes*. Available online: https://www.canada.ca/en/health-canada/services/publications/healthy-living/2021-health-effects-indoor-air-pollution.html#a3.3

46 Report: Southern Ontario Centre for Atmospheric Aerosol Research. 2019. *Near-road air pollution pilot study*. Available online: https://www.socaar.utoronto.ca/wp-content/uploads/2019/10/SOCAAR-Near-Road-Air-Pollution-Pilot-Study-Summary-Report-Fall-2019-web-Final.pdf

47 Webpage: U.S. EPA. 2022. *Ecosystems and air quality*. https://www.epa.gov/eco-research/ecosystems-and-air-quality

48 Webpage: Clean Air Strategic Alliance. 2022. *Impacts of reduced transportation on air quality in Alberta associated with COVID-19 Project Team*. https://www.casahome.org/current-initiatives/impacts-reduced-transportation-air-quality-alberta-associated-covid-19-project-team-60/

49 Report: Clean Air Strategic Alliance. 2021. *Impacts of reduced transportation on air quality in Alberta associated with COVID-19 Project Team Terms of Reference*. Available online: https://www.casahome.org/uploads/source/IRTAQ_Project_Team_ToR_final.pdf

Air Quality, Health, and the Impact of Transportation

The following is a high-level summary of the health impact of air pollution with a focus on transportation emission impacts. This summary is based on the more detailed documentation in Appendix 2a. The references used to help formulate this summary are cited in Appendix 2a.

Numerous assessments show the significant health impact of air pollution. In Canada, the number of deaths attributable to air pollution were 14,600 in 2015 and 15,300 in 2016.

Air pollutants of relevance to health include:

- particulate matter (PM),
- nitrogen dioxide (NO_2), ozone (O_3),
- sulphur dioxide (SO_2), carbon monoxide (CO),
- polycyclic aromatic hydrocarbons (PAHs),
- certain metals, and
- black carbon (BC).

Transportation emissions can notably contribute to the ambient air levels of these pollutants.

In this study, the focus was on relating changes in traffic volume to changes in ambient air quality levels of $PM_{2.5}$, O_3, and NO_2, all of which are air quality parameters that can be significantly impacted by transportation emissions.

The health impacts of transportation emissions are particularly relevant for populations living near major thoroughfares. In Canada, approximately 33% of the population lives within 250 metres of a major thoroughfare. In Alberta, it is estimated that approximately 12% of the population lives near major thoroughfares.

The acute and chronic health impacts associated with transportation-related air pollutants are many and varied. Assessments generally consider health impacts of premature mortality, hospital admissions, and emergency department visits related to asthma, cardiac, and respiratory symptoms. There is also growing evidence that air pollution can have mental and central nervous system health effects.

Certain individuals such as the elderly; people with asthma, pneumonia, diabetes, obesity, and respiratory and cardiovascular diseases; and children and newborns are more susceptible to impact from exposure to air pollution.

Detailed mortality and hospital/emergency room data that could be used to quantify the health implications of pandemic-related traffic volume changes do not exist in Alberta. The AQHI was therefore used as a general indicator to link the observed air quality changes during reduced traffic volume to potential health implications.

The AQHI uses ambient levels of NO_2, $PM_{2.5}$ and O_3 to determine a health-based air quality index. The index is scaled to provide an indication of the potential health impacts associated with short-term exposure to these three air pollutants and is an air quality index which people can use to adjust their level of activity during periods of elevated air pollution.[50]

A study examining emergency department (ED) visits in Edmonton in relation to AQHI levels concluded that the AQHI was a valid indicator of air pollution-related ischemic health effects. A similar study in Ontario looked at asthma-related ED visits in relation to AQHI and reached the same conclusion regarding the use of the AQHI as a health impact indicator. These types of studies confirm the relevance of the use of changes in the AQHI as a general health impact metric in this CASA study. The changes or trends in AQHI levels at the locations used in this CASA project can therefore be used as a general indicator of increases or decreases in air pollution risk to health.

The AQHI is based on a scale from 1 to 10+, with health messages displayed graphically for each AQHI level. Regional AQHI index values are published every hour on Environment Canada's Air Quality Health Index website.[51] Figure 1 is a depiction of the AQHI scale and associated health messaging; more detail on the health messaging is available from Environment and Climate Change Canada.[52] Figure 2 is an example of how information on hourly AQHI values for communities in the Regional Municipality of Wood Buffalo are reported.[53]

50 The latest AQHI data for Alberta can be viewed on this map:
Government of Alberta. 2022. *Air Quality Health Index map*. https://airquality.alberta.ca/map/

51 Webpage: Government of Canada. 2022. *Air Quality Health Index*. https://weather.gc.ca/airquality/pages/index_e.html

52 Webpage: Government of Canada. 2015. *Understanding Air Quality Health Index messages*. https://www.canada.ca/en/environment-climate-change/services/air-quality-health-index/understanding-messages.html

53 Webpage: Wood Buffalo Environmental Association. 2022. *Homepage*. https://wbea.org/

Figure 1: The AQHI colour coding and health risk levels

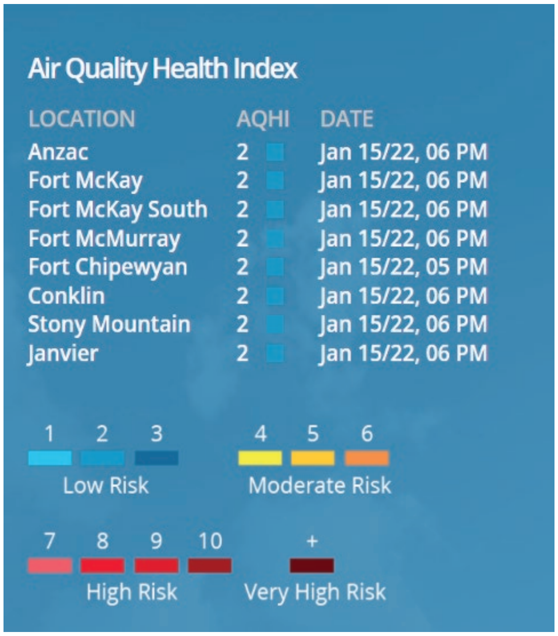


Figure 2: AQHI values for communities in the Regional Municipality of Wood Buffalo on January 15, 2022, at 6 p.m.

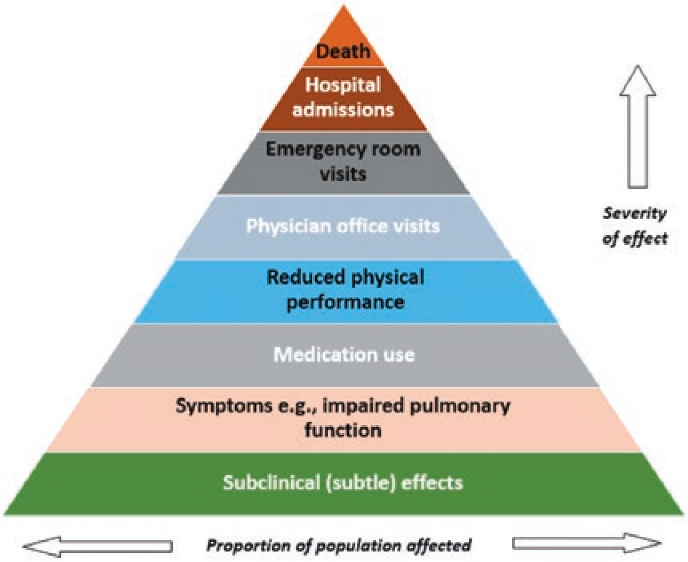


Figure 3: A pyramid of the health impacts associated with air pollution and relative proportion of the population affected by the impact

Figure 3 is a simplified pyramid depiction of the health effects associated with air pollution. It shows that the proportion of the population affected by air pollution is a function of the severity of the health impact, with a larger proportion of the population suffering lesser effects, and a smaller proportion suffering the severe effects (e.g., hospital admissions and premature mortality).

Most of the health impacts associated with air pollution involve less severe health outcomes but represent a significant health-effects burden on a large fraction of the population. Air pollution is therefore a significant quality of life determinant.

Many specific assessments of the health impacts associated with transportation-related emissions and specific vehicle type emissions (e.g., gasoline engine and diesel exhaust emissions) have been conducted. Transportation emission-related health impact assessments for Canada and Alberta have been conducted by Health Canada. Key results from these assessments relevant to this project are summarized below.

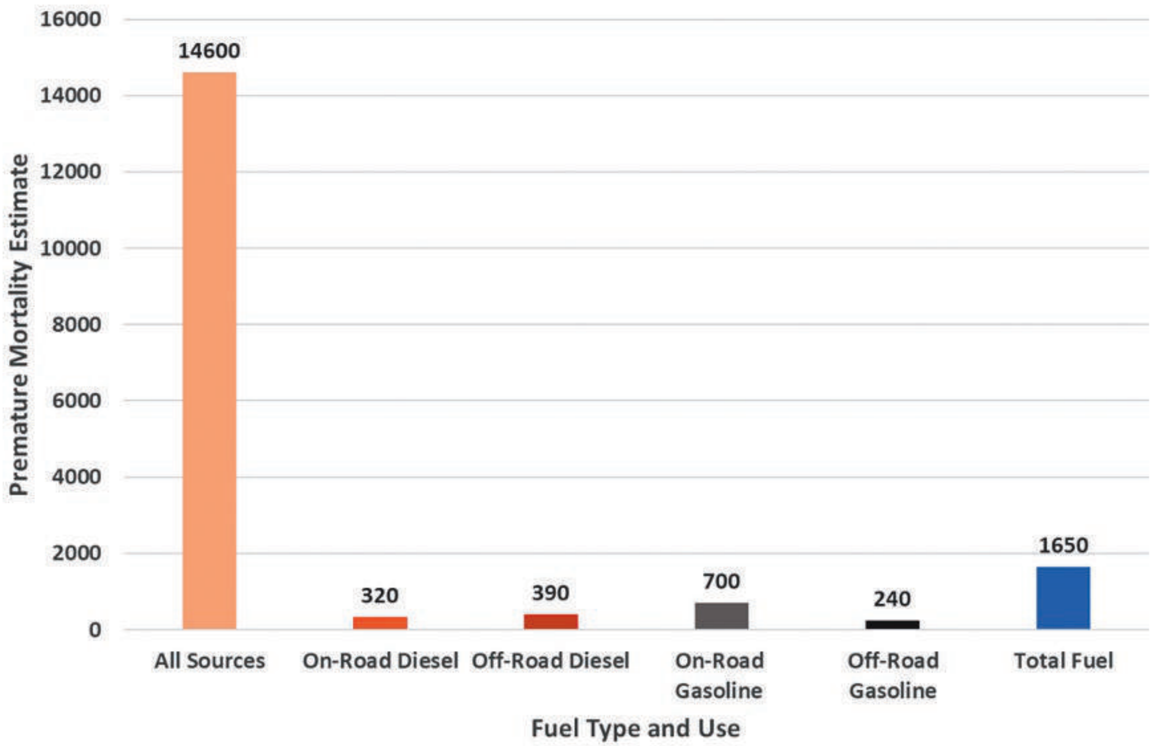


Figure 4: Number of premature mortalities in Canada in 2015 attributed to all population sources and to on- and off-road gasoline and diesel engine emissions

Figure 4 is from a Health Canada study which summarizes the number of estimated premature mortalities in Canada associated with on- and off-road gasoline and diesel emissions.

These data indicate that:

- In Canada, on-road gasoline vehicles/engines are the transportation-related emission sources that contribute to the highest number of emissions-related mortalities (700).
- Off-road diesel engine emissions are the second highest contributor to mortality (390) followed by on-road diesel exhaust emissions (320). Off-road gasoline engine emissions are the lowest contributor to transportation emission-related mortalities (240).
- The total mortality-related cost implications of all on- and off-road diesel and gasoline emissions is greater than $1 billion per year.
- The total transportation emission-related premature mortalities in Canada in 2015 was 1,650.
- On- and off-road diesel emission related mortalities (710), account for approximately 5% of total air pollution related mortalities in Canada.
- On- and off-road gasoline engine emission related mortalities (940), account for approximately 6% of total air pollution-related mortalities in Alberta.

Health Canada, in all its air pollution related-health impact assessments, notes that its analyses likely represent an underestimate of the full impacts of air pollution in Canada.

In summary, air pollution has a wide range of health impacts, and these impacts are significant. These impacts have been both quantified and monetized by Health Canada for each of the provinces and territories.

Changes in Traffic Volume and Ambient Air Quality During Periods When Measures were Taken to Reduce Spread of COVID-19

Several studies have examined changes in the ambient air concentration of pollutants as a secondary effect of measures taken to reduce the spread of COVID-19. For example, Griffin et al. used satellite data and ambient air modelling to estimate a 60% reduction in NO_x emissions from vehicle traffic over southern Ontario.[54] Mashayekhi et al. used ambient air modelling to predict, on average, a 31–35% decrease in NO_2 for four Canadian cities.[55] While reductions in NO_x have been noted by many, results for ozone concentration have been mixed.[56,57] Higher concentrations of ozone were observed during typical periods of NOx titration, lowering of ozone levels (at night and early morning) and marginally lower concentrations during periods of photochemical ozone production (midafternoon).[55,56]

To examine the impact of reduced transportation on air quality during Alberta's first COVID-19 public health emergency, ambient concentrations from long-term monitoring stations and traffic counts from Alberta Transportation were used.

This work focused on identifying what changes were observed and provides general conclusions and observations. In the future, we anticipate that research communities will provide more comprehensive exploration of air quality changes associated with measures taken to reduce the spread of COVID-19.

Method of assessment

The study period, March 16– June 12, 2020, was selected based on data availability and the most notable change in vehicle traffic volume. Changes in air quality and traffic counts were examined by comparing data collected during the study period in 2020 to previously observed concentrations (hereafter referred to as historical data).

Historical data included data collected between 2015 and 2019. Informed by changes in spring 2020 traffic volume within Edmonton and Calgary, the study period is divided into Period A (March 16–April 24) and B (April 27–June 12). The analysis referred to in this section focuses on Period A. Period B includes Stage 1 reopening, after which some businesses and facilities resumed operations and some measures were eased; these results are included in Appendix 2b. The presence of historical trends is evaluated and detected at some locations (see Appendix 3b), however the extent to which this trend impacts the changes observed in 2020 was not examined.

Actions taken to stop the spread of COVID-19 were expected to temporarily decrease emissions from sectors such as transportation and, in turn, reduce the ambient concentrations of select air pollutants. These temporary changes were expected to be the most significant on weekdays (the heaviest commuter traffic days). To focus the analysis on the most impacted days, weekends and holidays (Easter and Victoria Day) were removed. Wildfire season in Alberta starts in March, and wildfire smoke also contributes pollutants to the atmosphere. Therefore, in addition to weekends and statutory holidays, days unduly affected by events such as wildfire smoke were removed from the historical data. There were no known wildfire smoke events during the study period in 2020, thus wildfire smoke-impacted day removal was only needed for the historical data.

---

54 Article: Griffin D et al. 2020. *Assessing the impact of corona-virus-19 on nitrogen dioxide levels over southern Ontario, Canada*. Remote Sensing, 12(24):1–13.

55 Article: Mashayekhi R et al. 2021. *Isolating the impact of COVID-19 lockdown measures on urban air quality in Canada*. Air Quality, Atmosphere, and Health, 14:1549–1570. Available online: http://www.ncbi.nlm.nih.gov/pubmed/34025821%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC8130219

56 Article: Keller C et al. 2021. *Global impact of COVID-19 restrictions on the surface concentrations of nitrogen dioxide and ozone*. Atmospheric Chemistry and Physics, 21(5):3555–92. Available online: https://acp.copernicus.org/articles/21/3555/2021/

57 Article: Venter Z et al. 2020. *COVID-19 lockdowns cause global air pollution declines*. PNAS. 117(32):18984–90. Available online: https://www.pnas.org/doi/10.1073/pnas.2006853117#:~:text=We%20find%20that%2C%20after%20accounting,with%20mixed%20effects%20on%20ozone.

In Alberta, air quality data collection and reporting are delivered through a system that includes airshed organizations, industry, and the provincial and federal governments. Community and regional monitoring are the backbone of the core long-term air quality network in the province. Many of these stations are operated by airshed organizations. Air quality data distributed throughout Alberta from select stations in urban settings were downloaded from the Air Data Warehouse.[58] This CASA project focuses on changes in nitrogen dioxide (NO_2), ozone, and fine particulate matter ($PM_{2.5}$) for stations in Edmonton and Calgary. A discussion of the results is in Appendix 2b.

Air quality monitoring stations in Alberta are intentionally located away from thoroughfares. The Alberta Ambient Air Monitoring Directive specifies a minimum distance between monitoring stations and roadways, and distance increases with higher estimated traffic counts.[59] Monitoring programs are evolving in other jurisdictions, particularly large urban areas, where pilot studies are being used to establish protocols for near-road monitoring programs.[60] The core long-term air quality monitoring stations in Edmonton and Calgary typically monitor at what might be considered a neighbourhood-level resolution. These stations detect concentrations of pollutants that are representative of an urban area with relatively uniform land use over several city blocks. While vehicles may be the dominant source of certain pollutants in Alberta's cities, neighbourhood-level monitoring stations detect pollutants from vehicles, residential heating, and many other urban area emission sources.

Automated Traffic Recorders are deployed by Alberta Transportation to count vehicles on major thoroughfares. Hourly vehicle counts were downloaded from the Alberta Transportation Traffic Data Map.[61] Traffic counters are located within each urban centre included in this study, with more located in the large communities. A traffic counter with valid data during the 2015–2020 study period was selected to represent traffic near the monitoring station. The data used consisted of hourly weekday vehicle counts. The study examined traffic volume in urban thoroughfares which may not be representative of all activities on neighbourhood roads or near the air quality monitoring sites.

For air quality and traffic counts, 2020 data are compared to historical data for each hour of the day. This comparison provided the magnitude of average change for each hour of the day.

Commuter periods were expected to be affected most. Further details on the analysis methods are in Appendix 2b.

58 Webpage: Government of Alberta. 2022. *Air quality reports and data*. https://www.alberta.ca/air-quality-reports-and-data.aspx

59 Report: Alberta Environment and Parks. 2016. *Air Monitoring Directive Chapter 3: Ambient monitoring site selection, siting criteria and sampling system requirements*. Available online: https://open.alberta.ca/dataset/9f75b54e-641a-4d9d-885f-e87e973321b4/resource/6a854f22-d133-42f8-8a29-1bb33587827f/download/amd-chapter3-siteselection-dec16-2016a.pdf

60 Report: Metro Vancouver Regional District. 2020. *Metro Vancouver near-road air quality monitoring study*. Available online: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/MV_Near-Road_Air_Quality_Monitoring_Study-Technical_Report.pdf

61 Webpage: Alberta Transportation. 2022. *Traffic data mapping*. http://www.transportation.alberta.ca/mapping/

How air quality changed during periods when measures were taken to reduce spread of COVID-19

Motor vehicle emissions can contribute to ambient NO_2 and primary $PM_{2.5}$ concentrations in urban centres like Edmonton and Calgary. Gases in vehicle emissions such as NO, NO_2, and volatile organic compounds (VOCs) can also react in the atmosphere to form ozone and secondary $PM_{2.5}$. In this study, traffic volume was used as an indicator of traffic emissions, but a direct link between traffic volume and ambient air concentrations has not been made.

In larger urban centres, traffic counts peak in the morning, afternoon and, to some extent, during the middle of the day. At the start of the first COVID-19 public health emergency, the largest decrease in traffic volume was observed during the parts of the day with higher traffic (i.e., the morning and afternoon commuter period, Figure 5).

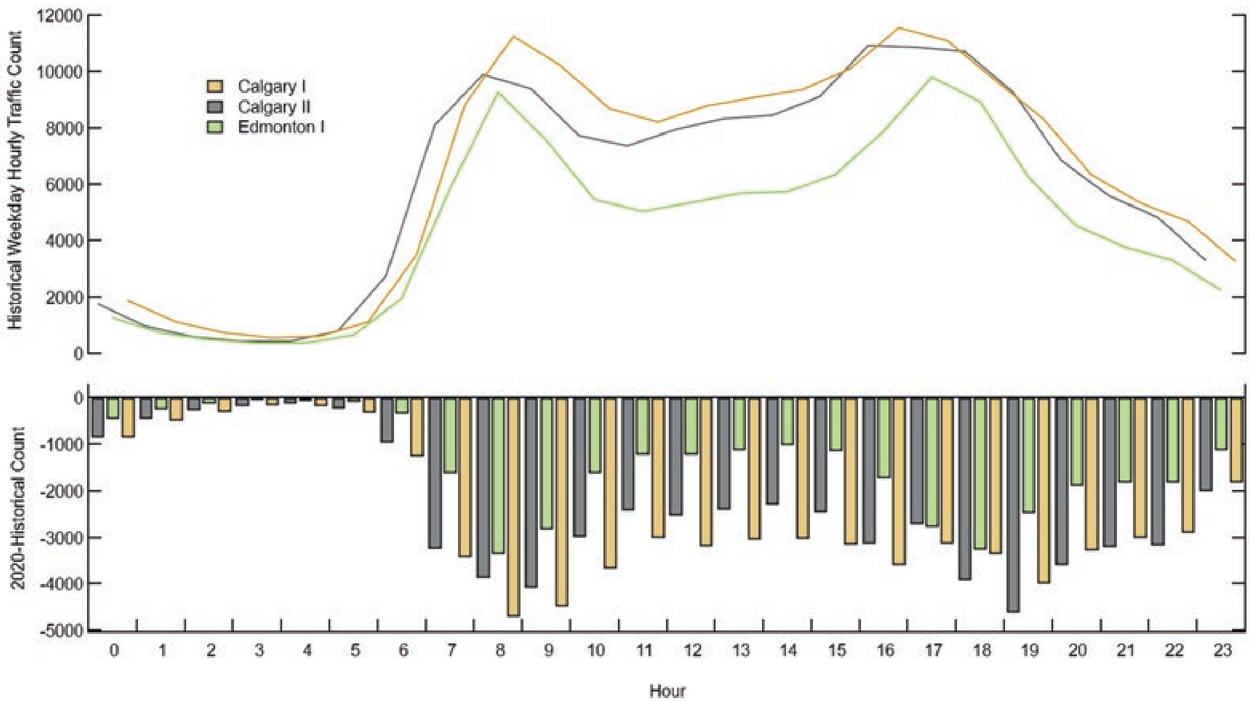


Figure 5: Historical traffic counts and change in traffic counts for the period of March 16–April 24 for historical years (2015–19) vs. 2020

Historically in Edmonton and Calgary, NO_2 concentrations peak during the morning commuter hours. Emissions at this time of day occur when atmospheric conditions typically do not promote the dispersion of emitted pollutants (more stagnant conditions). A similar peak was not observed for the afternoon commuter period, as atmospheric conditions are more likely to disperse emitted pollutants. Figure 6 illustrates the diurnal variability of historical and 2020 NO_2 concentrations. Between March 16–April 24, the greatest reductions in NO_2 concentrations were observed between the hours of 6–8 a.m. MST. Reductions during these hours at the Edmonton and Calgary stations ranged from 5 to 9 ppbv.

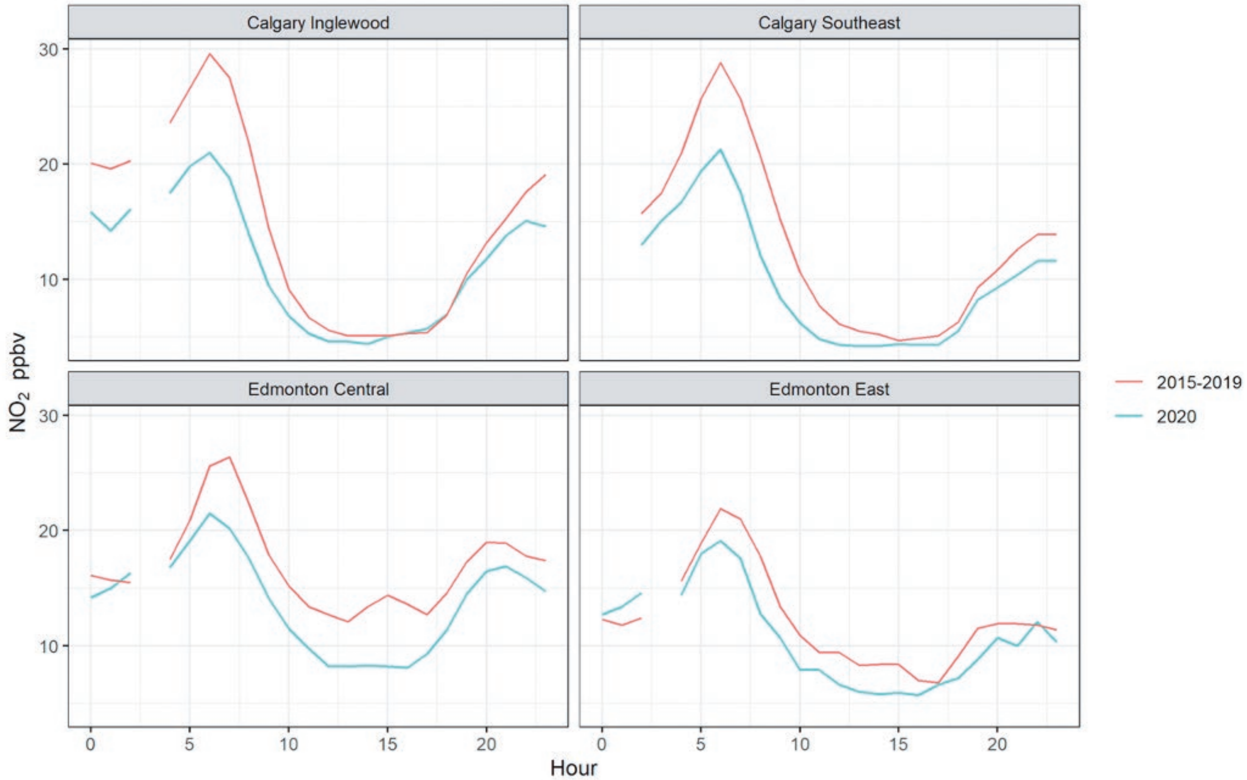


Figure 6: Average diurnal historical and 2020 NO_2 concentrations between March 16–April 24 of the indicated years; hours with less than 75% of valid data are not included

Ozone, and to some extent $PM_{2.5}$, is formed in the air through chemical reactions and thus are known as secondary pollutants. Changes in the measured concentrations of secondary pollutants can be due to processes affecting atmospheric chemistry (e.g., sunlight and temperature, and dispersion, as well as availability of pollutants that react to form secondary pollutants, also known as precursors).

Historically, ozone concentrations are the lowest during the morning commuter hours due to the abundance of oxides of nitrogen (NO, NO_2) at these times. Ozone can be lost as it reacts with emitted oxides of nitrogen. Ozone concentrations tend to peak in the afternoon due to several factors affecting the formation of this secondary pollutant, including availability of solar radiation that promotes photochemistry and meteorological conditions such as temperature and wind speed. Between March 16–April 24, 2020, ozone concentrations in Edmonton and Calgary were higher for most hours of the day, but the largest increases in ozone were observed during the morning commuter hours (Figure 7).

Increases in ozone concentration during the morning commuter hours in Edmonton and Calgary ranged from 6 to 12 ppb. The observed increase in ozone concentration is likely due to fewer than typically observed vehicles at this time of day. Fewer vehicles result in lower emissions and ambient levels of oxides of nitrogen, and thus less ozone loss as it reacts with oxides of nitrogen.

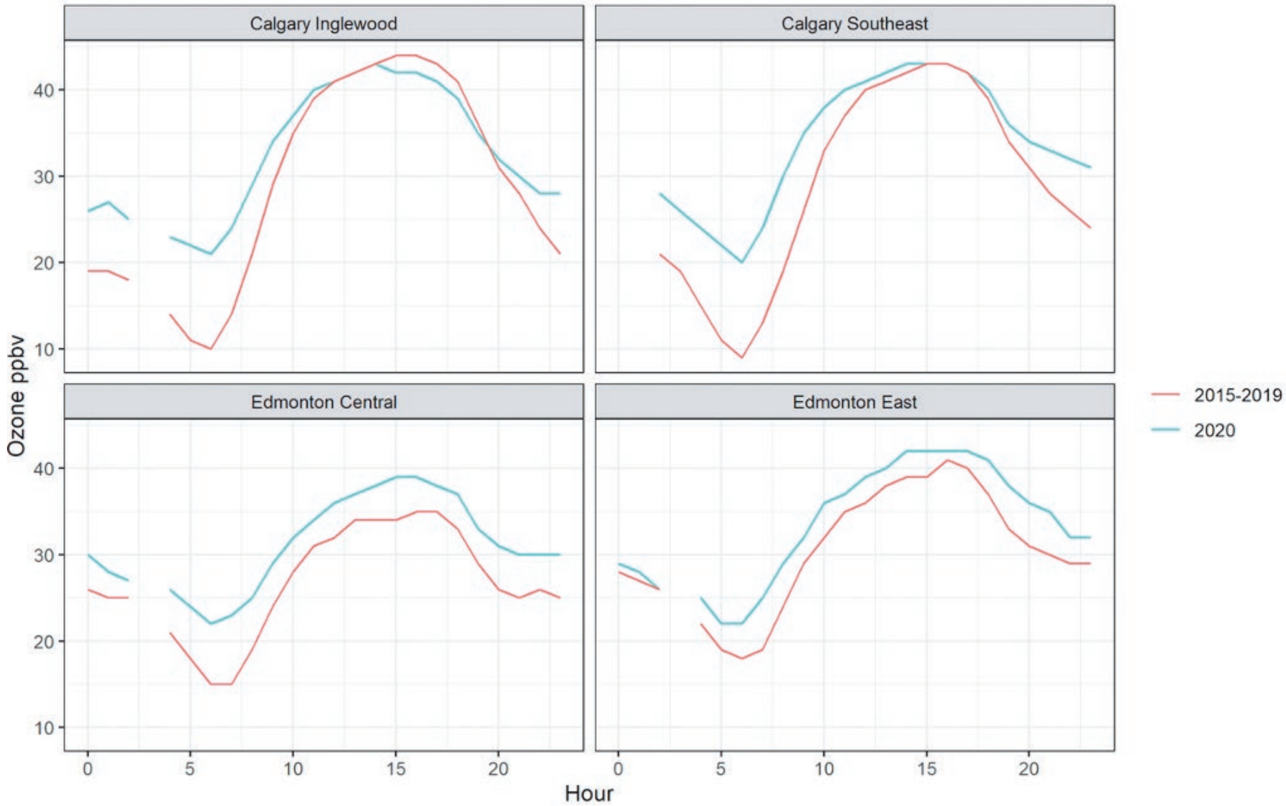


Figure 7: Average diurnal historical and 2020 ozone concentrations between March 16–April 24 of the indicated years; hours with less than 75% of valid data are not included

Results for $PM_{2.5}$ concentrations measured between March 16–April 24 were mixed (Figure 8). A 1–5 µg/m³ decrease in 2020 $PM_{2.5}$ concentrations were observed for parts of the day in Edmonton and Calgary. In addition, increased 2020 concentrations of 1–2 µg/m³ were also observed for mid- to late-afternoon in Calgary.

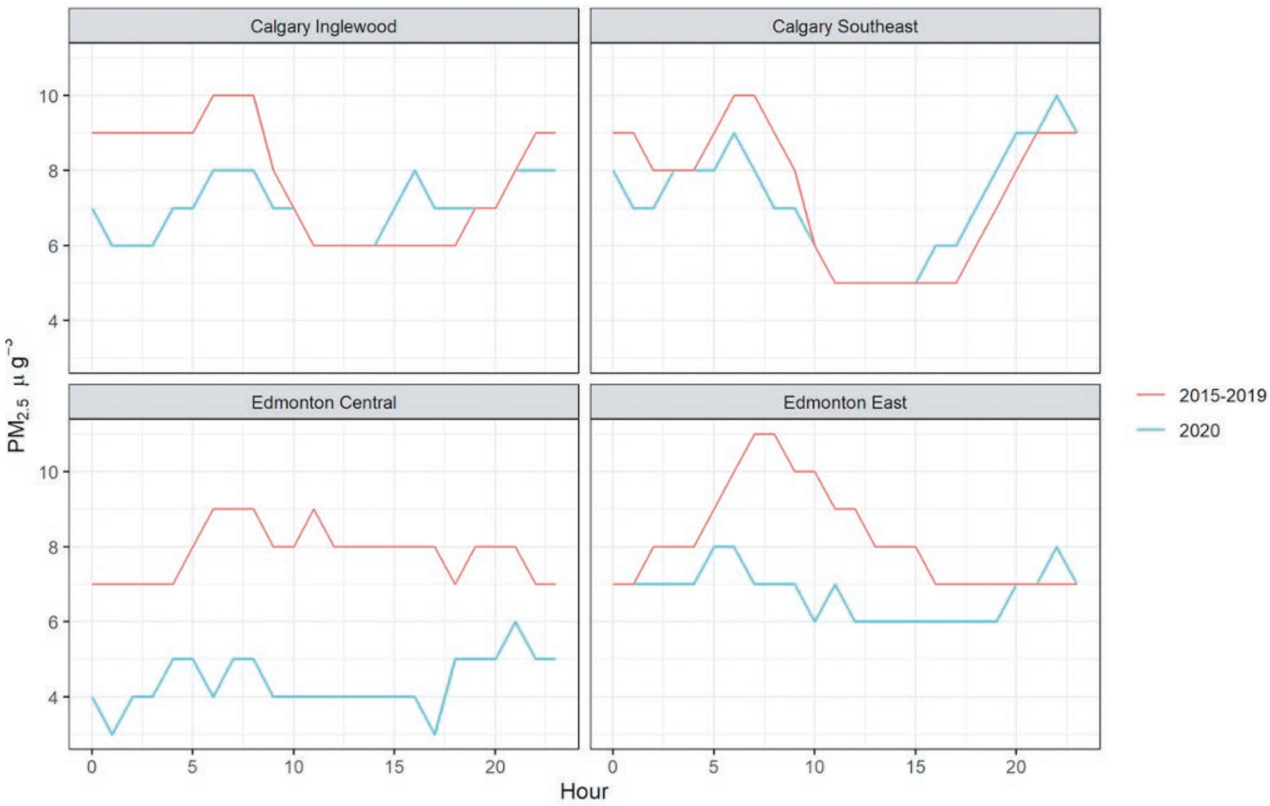


Figure 8: Average diurnal historical and 2020 $PM_{2.5}$ concentrations between March 16–April 24 of the indicated years; hours with less than 75% of valid data are not included

The relative contributions of motor vehicle emissions to ambient concentrations measured can depend on the presence and magnitude of other nearby sources such as commercial/home heating and off-road equipment; on the composition of vehicles on the road including the age, maintenance/tampering[62], and type of vehicles[63,64]; and atmospheric conditions that affect dispersion and chemistry[65],[66]. Note that the study was not designed to look at impact of different types of vehicles (e.g., cars versus heavy-duty trucks), type of fuel used, or age of vehicle; these can have different emission profiles and intensity. It is likely that the relative impact of the COVID-19 restrictions in Alberta on vehicle emissions varied between different types of vehicles.

Furthermore, while cold climate impacts were not investigated as part of this study, motor vehicle emissions of NO_x, PM, HC, and CO have been reported in literature as seasonally increasing up to 10 times higher in cold climates, depending on ambient temperature, vehicle technology, cold climate vehicle calibration, and trip duration. Emissions from

62 A definition of tampering is provided here:
Canadian Council of Ministers of the Environment. 2016. *Vehicle and engine tampering description and examples of acceptable practices.* Available online: https://ccme.ca/en/res/tamperingdescription_e.pdf

63 Article: Bishop G and Haugen M. 2018. *The story of ever diminishing vehicle tailpipe emissions as observed in the Chicago, Illinois area.* Environmental Science and Technology, 52(13):7587–93. Available online: https://pubs.acs.org/doi/10.1021/acs.est.8b00926

64 Article: Clark N et al. 2002. *Factors affecting heavy-duty diesel vehicle emissions.* Journal of the Air and Waste Management Association, 52(1):84–94. Available online: https://www.tandfonline.com/doi/pdf/10.1080/10473289.2002.10470755?msclkid=fdce3141c7da11ec997745579b4a19ad

65 Article: Jeong C et al. 2006. *Influence of atmospheric dispersion and new particle formation events on ambient particle number concentration in Rochester, United States, and Toronto, Canada.* Journal of the Air and Waste Management Association, 56(4):431–43. Available online: https://www.tandfonline.com/doi/pdf/10.1080/10473289.2006.10464519?msclkid=1b3ee86fc7db11ecb99dc65c8c3710d1

66 Article: Park S et al. 2004. *Dispersion characteristics of vehicle emission in an urban street canyon.* Science of the Total Environment, 323(1–3):263–71.

vehicles are seasonally higher in cold climate cities due to several factors including:

a. vehicle technology (impacts of cold temperatures on engine, fuel, and exhaust filters), and

b. vehicle use and driving behaviour (change of human behaviour such as more idling, less use of public transit, and less active transportation during cold weather).

Regarding vehicle technology, higher air emissions can result from compromised performance of the vehicle exhaust filtration system due to cold temperatures of typical Canadian winters, poor fuel vaporization and mixing, increased engine friction, lube oil degradation, and low conversion efficiency of not sufficiently warm exhaust after-treatment systems of vehicles. Reaching the proper operating temperature after a cold start and in a cold climate takes longer and depends on the engine load (if idling rather than driving, it may take several minutes).[67,68]

Vehicle idling increases air emissions, fuel consumption, and maintenance intervals. Idling effects greatly depend on the vehicle (diesel vs. gasoline vehicle, exhaust filtration, vehicle age) and the climate (cold vs. warm). Generally, modern technology vehicles are impacted more by idling; they have exhaust filtration systems that are highly sensitive to low exhaust temperatures caused by idling. Increased exhaust backpressure caused by idling in a modern diesel vehicle degrades engine lube oil faster. That is why modern diesel vehicles benefit from automatic start-stop technology that will significantly reduce idling.[69,70,71,72,73,74,75] While the idling impact on gasoline vehicles is less than on diesel vehicles as the exhaust systems are less complex, gasoline engines are significantly less efficient at idling mode. However, hybrid electric technology has improved gasoline vehicles' low-speed and idling conditions substantially by switching to electric mode.

The average diurnal 2015–2019 and 2020 concentrations were used to calculate a three-parameter AQHI value using a published method.[76] For the purposes of this work, the AQHI is calculated using hourly averages of NO_2, ozone, and $PM_{2.5}$, presented in Figures 6 through 8 as a surrogate measure of the relative health risk associated with reduced transportation emissions. The relative difference from 2015–2019 and 2020 diurnal AQHI values were calculated to infer impact of reduced transportation between March 16–April 24 on AQHI values.

Figures 9–12 show the AQHI calculated in Edmonton and Calgary using a three-hour rolling average of concentrations and the relative differences. In Calgary, the largest change in AQHI was a decrease of 9% observed at Calgary Inglewood during the morning commuter period (Figure 9). In Edmonton, the largest relative change in AQHI of 13% was observed during midafternoon at Edmonton Central (Figure 10).

67 Article: Wine O et al. 2022. *Cold climate impact on air-pollution-related health outcomes: a scoping review*. International Journal of Environmental Research and Public Health, 19(3):1473. Available online: https://pdfs.semanticscholar.org/210e/bf92bf7492f1061172647ad06e203f9c9cba.pdf?_ga=2.200088750.1490297358.1651250563-1554188667.1651250563

68 Webpage: Social Sciences and Humanities Research Council. 2022. *Knowledge gap on the health impact of transportation-related emissions in cold climate cities*. https://www.sshrc-crsh.gc.ca/society-societe/community-communite/ifca-iac/evidence_briefs-donnees_probantes/earth_carrying_capacity-capacite_limite_terre/shahbakhti_osornio-vargas_hosseini-eng.aspx

69 Article: Rahman S et al. 2013. *Impact of idling on fuel consumption and exhaust emissions and available idle-reduction technologies for diesel vehicles – a review*. Energy Conversion and Management, 74:171–182. Available online: https://doi.org/10.1016/j.enconman.2013.05.019.

70 Article: Shancita I et al. 2014. *A review on idling reduction strategies to improve fuel economy and reduce exhaust emissions of transport vehicles*. Energy Conversion and Management, 88:794–807.

71 Article: Taylor G and Stewart S. 2001. *Cold start impact on vehicle energy use*. Available online: https://doi.org/10.4271/2001-01-0221.

72 Article: Adamiak B et al. 2020. *An analysis of emissions at low ambient temperature from diesel passenger cars using the WLTP test procedure*. Available online: https://doi.org/10.4271/2020-01-2186.

73 Article: Lee J et al. 2020. *Development of advanced idle stop-and-go control utilizing V2I*. Available online: https://doi.org/10.4271/2020-01-0581.

74 Article: Wellmann T, Govindswamy K, and Tomazic D. 2013. *Integration of engine start/stop systems with emphasis on NVH and launch behavior*. SAE International Journal of Engines, 6(2):1368–1378. Available online: https://doi.org/10.4271/2013-01-1899.

75 Article: Romano M et al. 2022. *Application of engine intelligent start-stop system technology for heavy vehicle fuel saving*. In Product Lifecycle Management. Green and Blue Technologies to Support Smart and Sustainable Organizations; Canciglieri Junior, O., Noël, F., Rivest, L., Bouras, A., Eds.; Springer International Publishing: Cham; pp 200–214.

76 Article: Stieb D et al. 2008. *A new multipollutant, no-threshold air quality health index based on short-term associations observed in daily time-series analyses*. Journal of the Air and Waste Management Association, 58(3):435–50. Available online: https://www.tandfonline.com/doi/pdf/10.3155/1047-3289.58.3.435?msclkid=6a82867fc7dd11eca46bf09dfdc80522

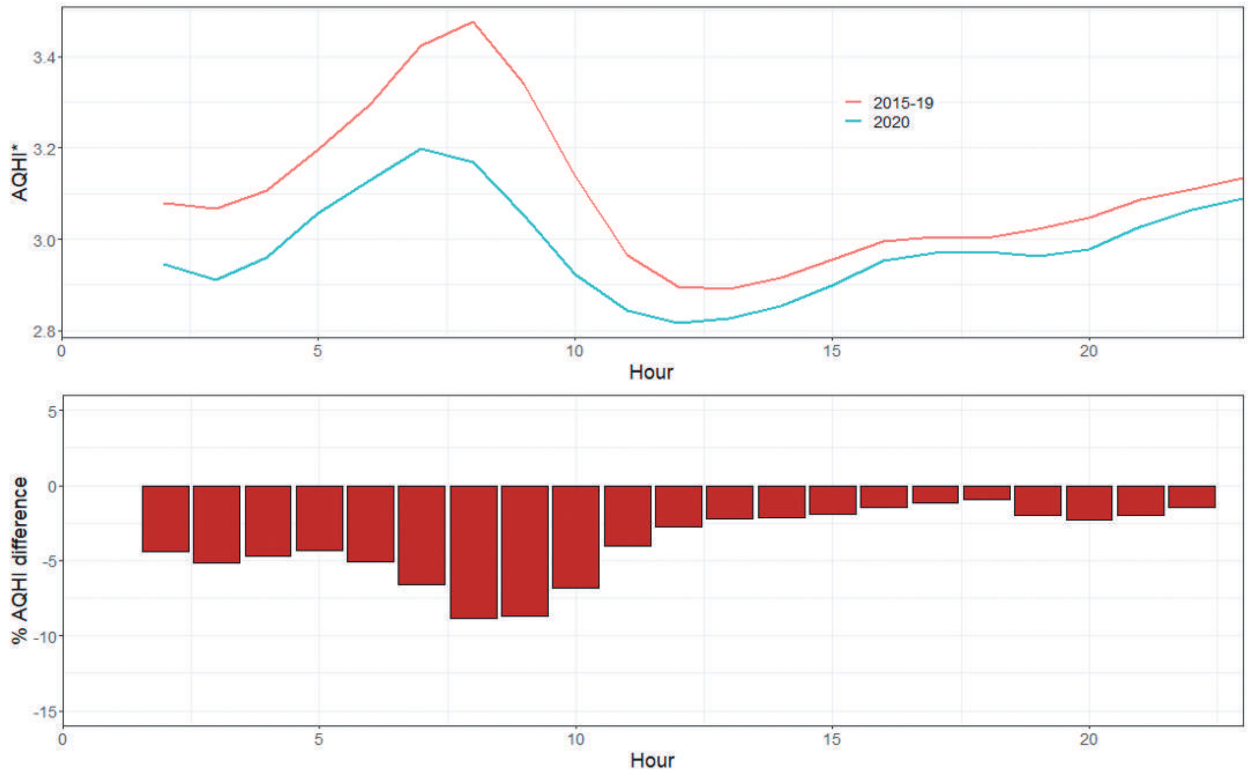


Figure 9: Calgary Inglewood AQHI values calculated using average diurnal concentrations between March 16–April 24 of the indicated years; AQHI values were calculated using rolling three-hour averages

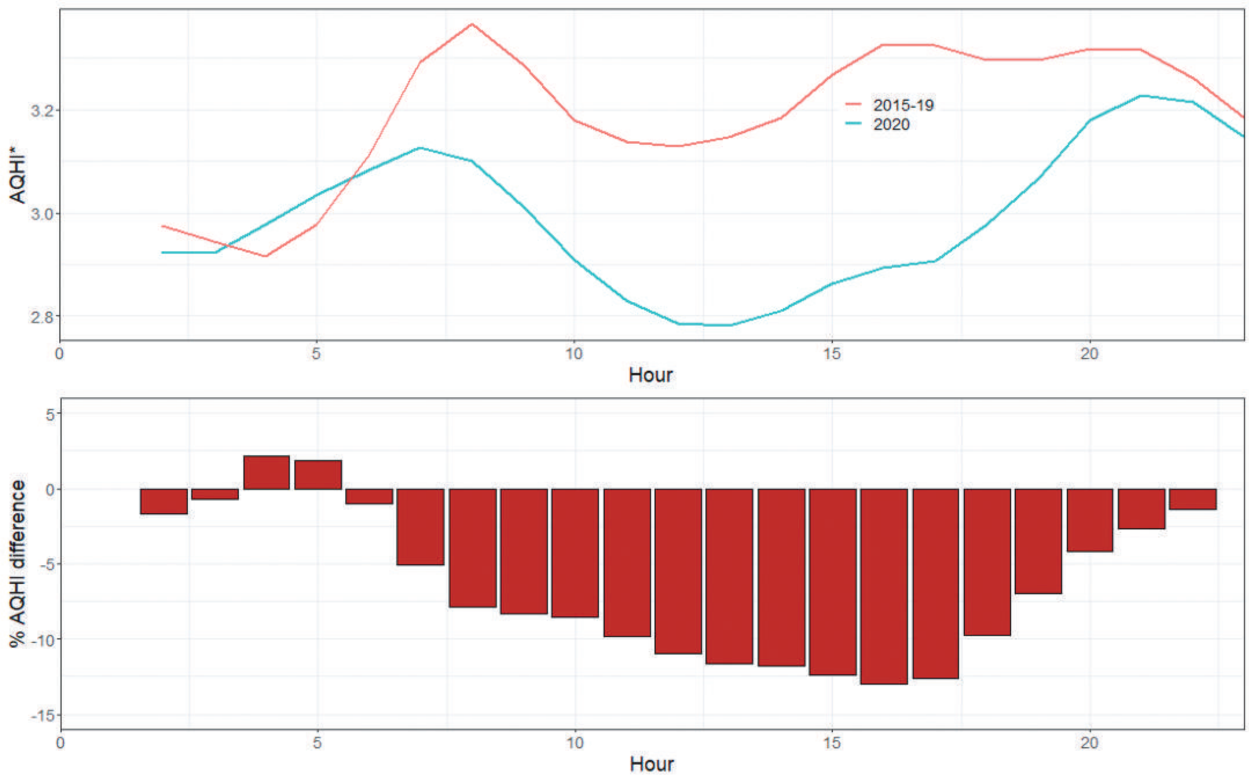


Figure 10: Edmonton Central AQHI values calculated using average diurnal concentrations between March 16–April 24 of the indicated years; AQHI values were calculated using rolling three-hour averages

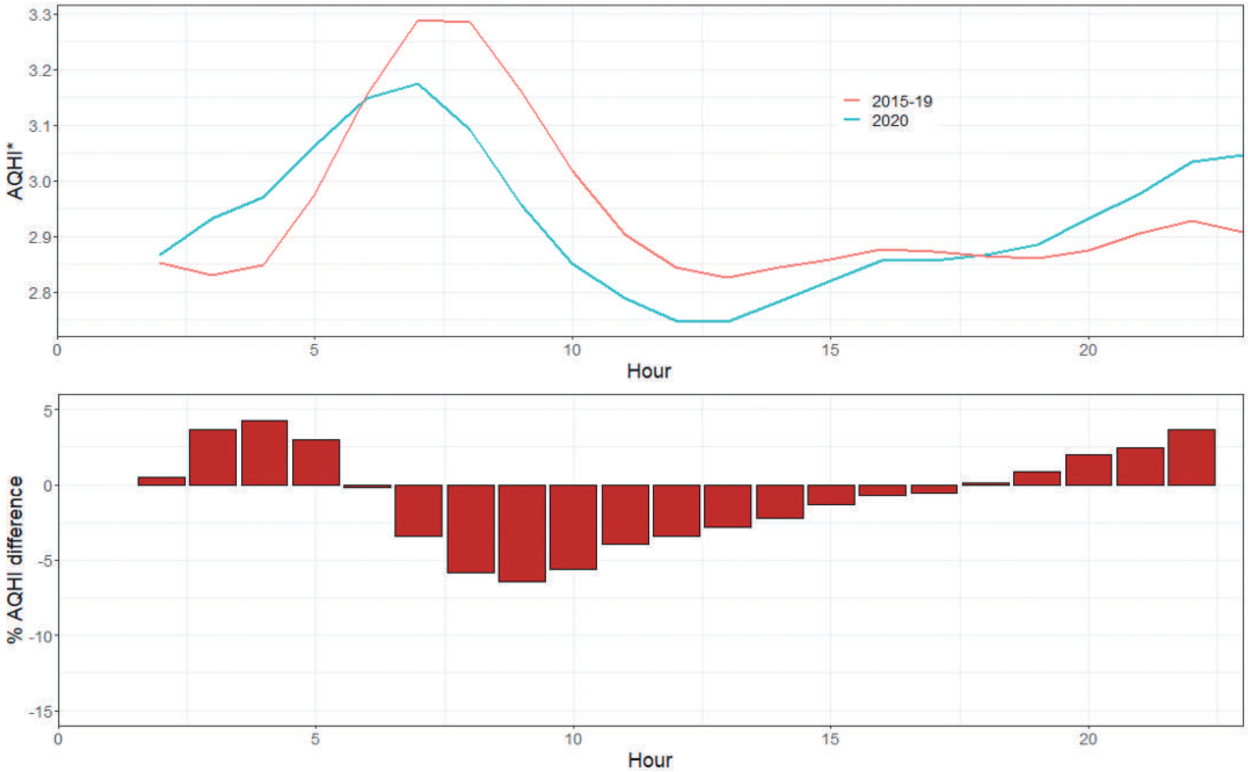


Figure 11: Calgary East AQHI values calculated using average diurnal concentrations between March 16–April 24 of the indicated years; AQHI values were calculated using rolling three-hour averages

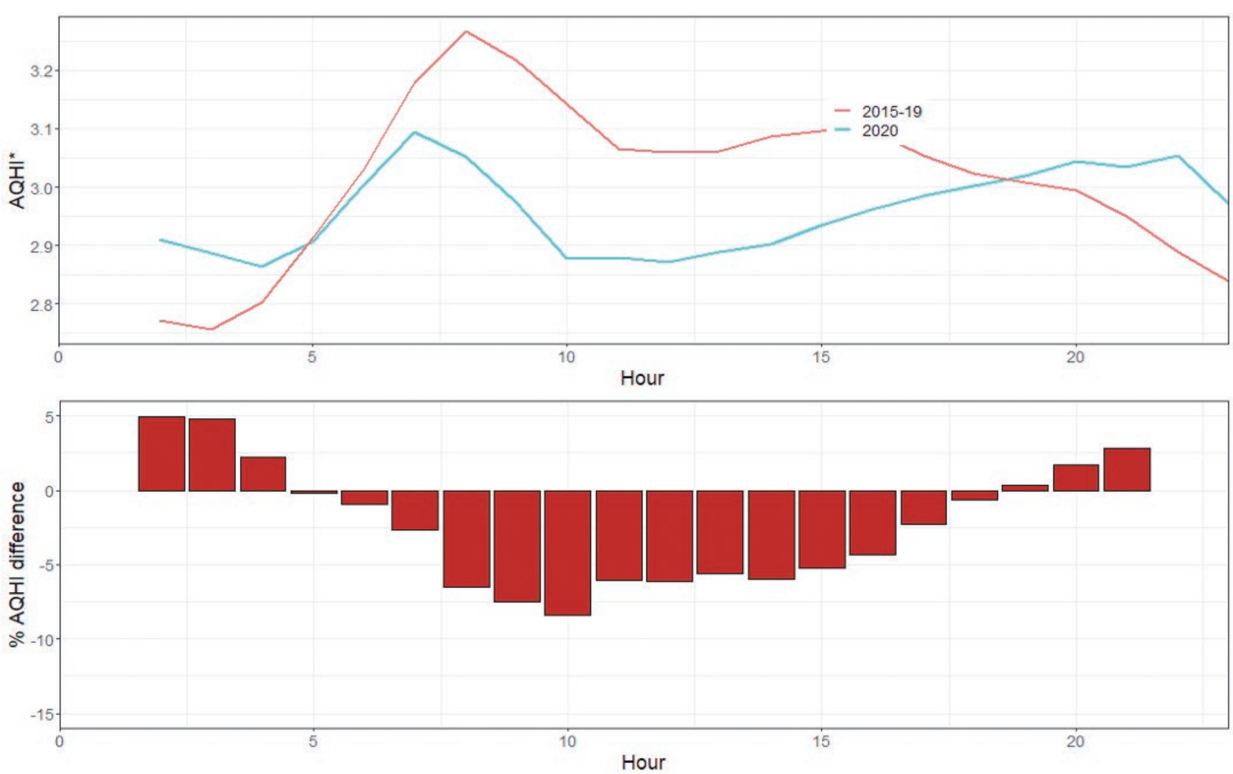


Figure 12: Edmonton East AQHI values calculated using average diurnal concentrations between March 16–April 24 of the indicated years; AQHI values were calculated using rolling three-hour averages

Summary

Transportation-related emissions are a known contributor to significant adverse health outcomes, particularly in urban areas where many people live or work near busy roadways and major thoroughfares. Therefore, reductions in transportation-related emissions can have significant population health benefits.

The COVID-19 public health emergency presented an opportunity to consider air quality changes associated with reduced traffic volumes due to the emergency measures implemented. Some emergency measures put in place to reduce the spread of COVID-19 resulted in a decrease in vehicular traffic volume in urban thoroughfares in Alberta relative to previous years during the same period.

Traffic volumes were used as a general indicator of actual traffic-related emissions levels. The finding that air quality improved during the reduced traffic volume period is consistent with pandemic-related air quality observations in many jurisdictions across the world.

Changes in the AQHI associated with the air quality changes related to reduced traffic volumes were used as a general indicator of the reduction in health risk associated with these traffic volume reductions.

The improved air quality associated with certain COVID-19 public health measures provided an opportunity to link improvements with the societal changes associated with these measures. This helped identify possible behaviour and employment-related changes that could be encouraged to reduce air pollution and improve air quality and human health.

This CASA project, while not quantifying the specific health implications or benefits associated with reduced transportation volumes during periods of the pandemic, shows that reduced traffic volumes reduce air pollution. Based on health-based air quality metrics like the AQHI, reduced traffic-related air pollution levels translate to reductions in their related health impacts with associated quality of life and economic benefits.

This work is based on opportunistic analysis of data collected at Alberta's air monitoring stations. Air quality monitoring stations in Alberta are intentionally located away from thoroughfares and thus are likely not representative of near-road experience. Near-road air monitoring studies are being conducted in a few Canadian cities; such monitoring would clarify the relationship between the impact of transportation emissions on ambient air quality.

Next Steps

There are several opportunities for future work to examine the inter-relatedness of reduced transportation, improved air quality, and human health outcomes. Such assessments could consider or examine:

- any new information since the writing of this report
- direct linkages between traffic volume and atmospheric conditions
- additional traffic information (e.g., type, age, and condition of vehicles)
- roadways in other cities or other areas within the examined cities
- the impacts of meteorology on observed changes in air quality
- a comparison of concentrations measured at a strategically based roadside monitoring station with neighbourhood scale monitoring within large urban centres

Appendix 2a: Air Quality, Health, and the Impact of Transportation

Introduction

Air pollution is recognized as a significant determinant of health with an estimated worldwide annual mortality rate of more than 3 million attributable to poor outdoor air quality.[77] On a global basis, the estimated contribution of transportation emission-related mortalities to total emission-related mortalities is 11%; in Canada, the estimate is 13%.[78] Since the average person takes thousands of breaths and breathes in approximately 15,000 litres of air each day, air can represent a significant source of exposure to air contaminants even at what may seem to be low pollutant concentrations.[79,80]

The sources of air pollutants which lead to health impacts can be from natural sources (e.g., wildfires, volcanoes, and lightning) or human activities (e.g., industrial and agricultural activity and transportation), with fossil fuel usage representing a large source of air pollutants from human activities.[81] While the focus of this summary is on transportation-related air pollution and its health impacts, the analyses approaches used to estimate them applies to any emission source. In most cases, an individual's exposure to air pollutants reflects multiple sources.

The effects of air pollution on health depends on several factors which include:[82,83]

- the specific air contaminant(s) present
- the background (normal) levels of the air contaminant(s)
- the specific health effects associated with the contaminant(s)
- the exposure pathways and level, duration, and frequency of the exposure to the contaminant(s)
- the susceptibility of the individual or population to effects of the air contaminant(s)

The population health impacts of vehicle emissions, relative to other air pollutant emissions sources, can be magnified because elevated transportation-related pollutant levels generally occur in concentrated traffic areas, which are usually concentrated population areas (e.g., cities).

77 Report: World Health Organization. 2016. *Health risk assessment of air pollution – general principles*. Available online: https://www.euro.who.int/en/publications/abstracts/health-risk-assessment-of-air-pollution.-general-principles-2016#:~:text=An%20air%20pollution%20health%20risk,for%20informing%20public%20policy%20decisions

78 Article: Anenburg S et al. 2019. *The global burden of transportation tailpipe emissions on air pollution-related mortality in 2010 and 2015*. Environmental Research Letters, 14(9). Available online: https://iopscience.iop.org/article/10.1088/1748-9326/ab35fc

79 Report: International Agency for Research on Cancer. 2016. *Air pollution and cancer*. Available online: https://www.iarc.who.int/wp-content/uploads/2018/07/AirPollutionandCancer161.pdf

80 Report: U.S. EPA. 2011. *Exposure factors handbook 2011 edition (final report)*. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-09052F.

81 Book: Wallace J and Hobbs P. 2006. *Atmospheric science: an introductory survey*. San Diego: Elsevier Inc.

82 Report: Health Canada. 2019. *Guidance for evaluating human health impacts in environmental assessment: human health risk assessment*. Available online: https://publications.gc.ca/site/eng/9.870475/publication.html

83 Report: World Health Organization. 2014. *Health in impact assessments: opportunities not to be missed*. Available online: https://www.euro.who.int/en/health-topics/environment-and-health/health-impact-assessment/publications/2014/health-in-impact-assessments-opportunities-not-to-be-missed#:~:text=Prospective%20impact%20assessment%20is%20a,%2Dmaking%2C%20systematically%20deployed%20worldwide

Transportation-Related Pollutants

Transportation-related emissions from both gasoline and diesel engines include directly emitted pollutants (primary pollutants) and pollutants that form in the atmosphere from the exhaust emissions (secondary pollutants). Transportation-related primary and/or secondary air pollutants include:[84,85,86,87,88]

- ammonia (NH_3)
- heavy metals
- carbon monoxide (CO)
- nitrogen oxides (NO_x)
- particulate matter (PM) including black carbon (BC) and organic carbon (OC) (primary and secondary pollutants)
- sulphur oxides (SO_x)
- ground-level ozone (O_3) (secondary pollutant)
- volatile organic compounds (VOCs) and hydrocarbons (HCs)
- aldehydes
- benzene
- polycyclic aromatic hydrocarbons (PAHs)
- persistent organic pollutants (POPs)

There are also other air contaminant emission sources associated with transportation that are not exhaust emissions-related. These include:[89,90,91,92]

- evaporative emissions from refuelling
- fuel use related spills
- brake wear
- road surface wear
- resuspension of road dust

In terms of the health impacts associated with air pollutants, the focus has been on PM, NO_2 and O_3. These air pollutants are often present at elevated levels relative to background, and there is considerable air quality and health-effect information on these common air pollutants.[93] These pollutants are also associated with vehicle emissions. PM and NO_2 are usually assessed in transportation-related health impact studies with ozone and are often, but not always, also considered.[94,95,96,97]

Of note is that PM, NO_2 and O_3 are the three air quality parameters used to determine the AQHI. The AQHI is the metric used in the IRTAQ Project as a general indicator of the health benefits associated with the reduced transportation-related emissions and resultant improvement in ambient air quality during the COVID-19 pandemic. The AQHI was developed

84 Article: Westerholm R and Egeback K. 1994. *Exhaust emissions from light- and heavy-duty vehicles: chemical composition, impact of exhaust after treatment, and fuel parameters.* Environmental Health Perspectives 102:13-23.

85 Article: Sharaf J. 2013. *Exhaust emissions and its control technology for an internal combustion engine.* pp. 947-960. Available online: https://www.ijera.com/papers/Vol3_issue4/FC34947960.pdf

86 Report: European Monitoring and Evaluation Programme/ European Environment Agency. 2019. *Air pollutant emission inventory guidebook.* Available online: https://www.eea.europa.eu/themes/air/air-pollution-sources-1/emep-eea-air-pollutant-emission-inventory-guidebook

87 Report: Health Canada. 2016. *Human health risk assessment for diesel exhaust.* Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2016/sc-hc/H129-60-2016-eng.pdf

88 Report: Health Canada. 2017. *Human health risk assessment for gasoline exhaust.* Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2017/sc-hc/H144-52-2017-eng.pdf

89 Report: European Monitoring and Evaluation Programme/ European Environment Agency. 2019. *Air pollutant emission inventory guidebook.* Available online: https://www.eea.europa.eu/themes/air/air-pollution-sources-1/emep-eea-air-pollutant-emission-inventory-guidebook

90 Report: Health Canada. 2016. *Human health risk assessment for diesel exhaust.* Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2016/sc-hc/H129-60-2016-eng.pdf

91 Report: Health Canada. 2017. *Human health risk assessment for gasoline exhaust.* Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2017/sc-hc/H144-52-2017-eng.pdf

92 Report: Southern Ontario Centre for Atmospheric Aerosol Research. 2019. *Near-road air pollution pilot study.* Available online: https://www.socaar.utoronto.ca/wp-content/uploads/2019/10/SOCAAR-Near-Road-Air-Pollution-Pilot-Study-Summary-Report-Fall-2019-web-Final.pdf

93 Report: Health Canada. 2019. *Health impacts of air pollution in Canada: estimates of morbidity and premature mortality outcomes, 2019 report.* Available online: http://publications.gc.ca/site/eng/9.874080/publication.html

94 Report: Health Canada. 2019. *Health impacts of air pollution in Canada: estimates of morbidity and premature mortality outcomes, 2019 report.* Available online: http://publications.gc.ca/site/eng/9.874080/publication.html

95 Report: CE Delft. 2018. *Health impacts and costs of diesel emissions in the EU.* Available online: https://cedelft.eu/wp-content/uploads/sites/2/2021/03/CE_Delft_4R30_Health_impacts_costs_diesel_emissions_EU_Def.pdf

96 Report: Gower S et al. 2014. *Path to healthier air: Toronto air pollution burden of illness update.* Technical Report. Toronto Public Health. Available online: https://www.toronto.ca/wp-content/uploads/2017/11/9190-tph-Air-Pollution-Burden-of-Illness-2014.pdf

97 Article: Jerrett M et al. 2009. *A cohort study of traffic-related air pollution and mortality in Toronto, Ontario, Canada.* Environmental Health Perspectives 117(5): 772-777.

by Stieb et al.[98] and is a health-based air quality index based on pollutant mortality effects determined from epidemiological studies in Canadian cities.

The AQHI is based on a scale from 1 to 10+, with health messages (provided by the federal government[99]) displayed graphically for each AQHI level. Regional AQHI index values are published every hour on Environment Canada's Air Quality Health Index website.[100] Under an assumption of additive health effects of $PM_{2.5}$, NO_2, and O_3, the equation of AQHI is constructed as the sum of excess daily mortality risk associated with these three pollutants, adjusted to a 0–10+ scale. The AQHI formula is as follows:

$$AQHI=\frac{10}{10.4} * (100 * e^{(0.000871*NO_2)^{-1}} + e^{(0.000537*O\_3)^{-1}} + e^{(0.000487* PM_{2.5})^{-1}})$$

Figure 13 is a depiction of the AQHI scale and associated health messaging.

Figure 13: The AQHI colour coding and health risk levels

The index is based on a 3-hour rolling average of continuously measured NO_2 (in ppb), O_3 (in ppb) and $PM_{2.5}$ (in $\mu g/m^3$) concentrations. This average period was considered responsive to health impacts associated with shorter-term peaks and not unduly influenced by very short-term peaks which are not as relevant from a health impact standpoint. Current and forecasted (2-day) AQHI values for locations across Canada are provided by the federal government.[101] Since the pollutants used in the AQHI are considered non-threshold pollutants, there is no level below which adverse effects may occur.

A study examining emergency department (ED) visits in Edmonton in relation to AQHI levels concluded that: "*Our finding that ED visits for stroke were significantly associated with the AQHI suggests that the AQHI may be a valid communication tool for air pollution morbidity-effects related to stroke.*"[102] A similar study in Ontario that examined asthma-attributed hospitalizations, ED visits, and outpatient visits to AQHI levels came to a similar conclusion.[103]

This CASA project used the estimated changes (reductions) in AQHI levels associated with pandemic measures linked to reduced transportation volumes as its health impact (benefit) metric. The idea is that changes or trends in AQHI levels at a location can be used as a general indicator of increases or decreases in air pollution health impacts.

98 Article: Stieb D et al. 2008. *A new multipollutant, no-threshold air quality health index based on short-term associations observed in daily time-series analyses.* Journal of the Air and Waste Management Association 58(3):435–50. Available online: https://www.tandfonline.com/doi/pdf/10.3155/1047-3289.58.3.435

99 Webpage: Government of Canada. 2015. *Understanding Air Quality Health Index messages.* https://www.canada.ca/en/environment-climate-change/services/air-quality-health-index/understanding-messages.html

100 Webpage: Government of Canada. 2022. *Alberta Air Quality Health Index provincial summary.* Available online: https://weather.gc.ca/airquality/pages/provincial_summary/ab_e.html

101 Webpage: Government of Canada. 2022. *Alberta Air Quality Health Index provincial summary.* https://weather.gc.ca/airquality/pages/provincial_summary/ab_e.html

102 Article: Chen L et al. 2014. *The Air Quality Health Index as a predictor of emergency department visits for ischemic stroke in Edmonton, Canada.* 2014, Journal of Exposure Science and Environmental Epidemiology, 24(4): 358-364.

103 Article: Bhat T, Jiawen G, and Farzaneh, H. 2021. *Air Pollution Health Risk Assessment (AP-HRA), principles and applications.* International Journal of Environmental Research and Public Health, 18(4): 1935. Available online: https://www.mdpi.com/1660-4601/18/4/1935#:~:text=The%20Air%20Pollution%20Health%20Risk%20Assessment%20%28AP-HRA%29%20forecasts,a%20key%20tool%20for%20guiding%20public%20policy%20decisions.

Health Effects of Transportation-Related Emissions

Introduction

The health effects of the air contaminants associated with gasoline and/or diesel exhaust, and other transportation-related air contaminant emissions (e.g., non-tailpipe primary particulate emissions can exceed tailpipe particulate emissions[104]), are extensive and varied. These effects can be grouped into the following general categories:[105,106,107,108,109,110,111,112,113,114]

- carcinogenicity
- respiratory effects
- cardiovascular effects and diabetes
- immunological effects
- reproductive and developmental effects
- central nervous system effects

The health effects associated with air pollution can take the form of morbidity effects and/or premature mortality. Morbidity refers to acute (short) or chronic (long-term) health conditions. Examples of morbidity effects related to vehicle emissions include acute respiratory symptom days, restricted activity days, and asthma symptom days; all have quality of life and economic implications. Premature mortality is measured as lost years of life linked to the exposure to the air pollutant. Several agencies (e.g., the World Health Organization, Health Canada, and the U.S. Environmental Protection Agency [US EPA]) undertake detailed health assessments of these air contaminants. These assessments are periodically updated to reflect new health-effects information.

There are numerous health impacts associated with air pollution which, although difficult to quantify and monetize, can have significant quality of life implications. Examples include:

- mental health effects[115]

104 Report: Southern Ontario Centre for Atmospheric Aerosol Research. 2019. *Near-road air pollution pilot study*. Available online: https://www.socaar.utoronto.ca/wp-content/uploads/2019/10/SOCAAR-Near-Road-Air-Pollution-Pilot-Study-Summary-Report-Fall-2019-web-Final.pdf

105 Article: Bhat, T, Jiawen, G, and Farzaneh H. 2021. *Air Pollution Health Risk Assessment (AP-HRA), principles and applications*. International Journal of Environmental Research and Public Health, 18(4): 1935. Available online: https://www.mdpi.com/1660-4601/18/4/1935#:~:text=The%20Air%20Pollution%20Health%20Risk%20Assessment%20%28AP-HRA%29%20forecasts,a%20key%20tool%20for%20guiding%20public%20policy%20decisions

106 Health Canada. 2016. *Health risk assessment for ambient nitrogen dioxide (NO_2)*. Available online: https://www.canada.ca/en/health-canada/services/publications/healthy-living/human-health-risk-assessment-ambient-nitrogen-dioxide.html

107 Article: Lelieveld, et al. 2015. *The contribution of outdoor air pollution sources to premature mortality on a global scale*. Nature, 525:367-371.

108 Report: World Health Organization. 2004. *Health Aspects of Air Pollution: Results from the WHO Project "Systematic Review of Health Aspects of Air Pollution in Europe"*. Available online: https://apps.who.int/iris/handle/10665/107571

109 Report: U.S. EPA. 2016. *Integrated Science Assessment for oxides of nitrogen – health criteria*. Research Triangle Park, North Carolina: United States Environmental Protection Agency. Available online: https://www.epa.gov/isa/integrated-science-assessment-isa-nitrogen-dioxide-health-criteria

110 Report: U.S. EPA. 2013. *Integrated Science Assessment for ozone and related photochemical oxidants*. Available online: https://www.epa.gov/isa/integrated-science-assessment-isa-ozone-and-related-photochemical-oxidants

111 Article: Anderson J, Thundiyil J, and Stolback A. 2012. *Clearing the air: a review of the effects of particulate matter air pollution on human health*. Journal Medical Toxicology, 8(2):166-175. Available online: https://link.springer.com/article/10.1007/s13181-011-0203-1

112 Report: International Agency for Research on Cancer. 2013. *The carcinogenicity of outdoor air pollution*. Lancet.

113 Article: Bernstein, J. 2004. *Health effects of air pollution*. Journal of Allergy and Clinical Immunology, 121(3):1116-1123. Available online: https://www.jacionline.org/article/S0091-6749(07)02209-9/fulltext

114 Report: World Health Organization. 2013. *Review of evidence on health aspects of air pollution REVIHAAP project - technical report*. Available online: https://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report

115 Article: Xue T et al. 2019. *Declines in mental health associated with air pollution and temperature variability in China*. Nature Communications, 10(1) 2165. Available online: https://www.nature.com/articles/s41467-019-10196-y

- central nervous system effects such as cognitive decline and dementia,[116],[117],[118] autism, multiple sclerosis, reduced IQ, and neurodegenerative diseases[119],[120]
- glaucoma[121]
- vascular disease[122]
- diabetes[123],[124]
- hypertensive disorders of pregnancy[125]

Figure 14 is a simplified pyramid depiction of the health effects associated with air pollution from Craig et al.[126] and from the US EPA[127]. As indicated in Figure 14, the proportion of the population affected by air pollution is a function of the severity of the health impact, with a larger proportion of the population suffering lesser effects and a smaller proportion suffering severe effects (e.g., hospital emissions and premature mortality).

116 Article: Delgado-Saborit, J et al. 2021. *A critical review of the epidemiological evidence of effects of air pollution on dementia, cognitive function, and cognitive decline in adult population*. Science of the Total Environment, 757. Available online: https://www.sciencedirect.com/science/article/pii/S004896972037265X?via%3Dihub

117 Article: Zhang X, Chen X, and Zhang X. 2018. *The impact of exposure to air pollution on cognitive performance*. PNAS, 115(37): 9193-9197. Available online: https://www.pnas.org/doi/10.1073/pnas.1809474115

118 Article: Esnaola S et al. 2015. *Association between traffic-related air pollution in schools and cognitive development in primary school children: a prospective cohort study*. PLOS Medicine, 12(3): e10011792. Available online: https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1001792

119 Article: Block M et al. 2012. *The outdoor air pollution and brain health workshop*. NeuroToxicology, 33(5):972-984. Available online: https://www.sciencedirect.com/science/article/abs/pii/S0161813X12002100?via%3Dihub

120 Article: Raz R et al. 2014. *Autism spectrum disorder and particulate matter air pollution before, during, and after pregnancy: a nested case–control*. Environmental Health Perspectives, 123(3): 264-270. Available online: https://ehp.niehs.nih.gov/doi/10.1289/ehp.1408133?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%20%200pubmed

121 Article: Nwanaji-Enwerem J et al. 2019. *Association of long-term ambient black carbon exposure and oxidative stress allelic variants with intraocular pressure in older men*. JAMA Opthalmology, 137(2): 129-137. Available online: https://pubmed.ncbi.nlm.nih.gov/30419128/

122 Article: Lund A et al. 2007. *Gasoline exhaust emissions induce vascular remodeling pathways involved in atherosclerosis*. Toxicological Sciences, 95(2): 485-494. Available online: https://academic.oup.com/toxsci/article/95/2/485/1698977?login=false

123 Article: Eze I et al. 2015. *Association between ambient air pollution and diabetes mellitus in Europe and North America: systematic review and meta-analysis*. Environmental Health Perspectives, 123(5):381-389. Available online: https://ehp.niehs.nih.gov/doi/10.1289/ehp.1307823?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%20%200pubmed

124 Article: Yang B et al. 2020. *Ambient air pollution and diabetes: a systematic review and meta-analysis*. Environmental Research, 180:108817. Available online: https://www.sciencedirect.com/science/article/abs/pii/S0013935119306140

125 Report: National Toxicology Department. 2019. *NTP monograph on the systematic review of traffic-related air pollution and hypertensive disorders of pregnancy*. Research Triangle Park, North Carolina: U.S. Department of Health and Human Services.

126 Article: Craig L et al. 2008. *Air pollution and public health: A guidance document for risk managers*. Journal of Toxicology and Environmental Health, 71(9-10): 588-698.

127 Webpage: U.S. EPA. 2021. *How BenMAP-CE estimates the health and economic effects of air pollution*. https://www.epa.gov/benmap/how-benmap-ce-estimates-health-and-economic-effects-air-pollution

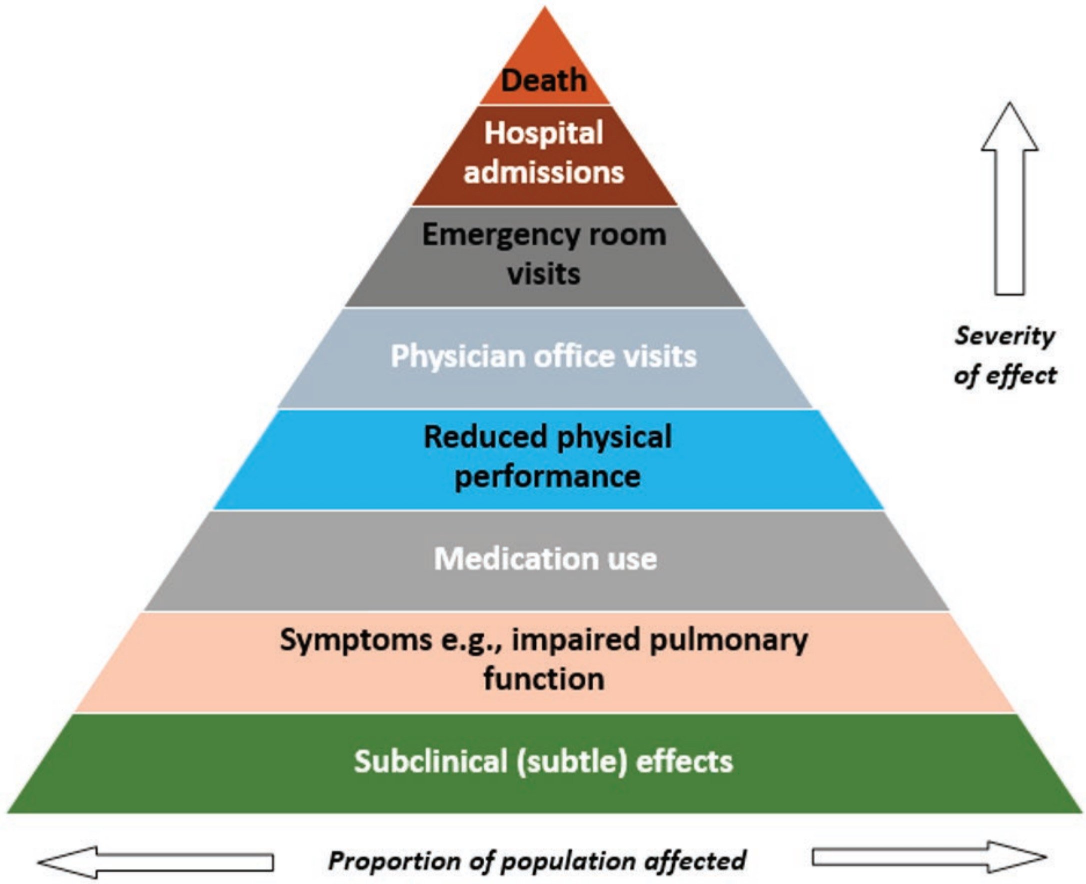


Figure 14: A pyramid of the health impacts associated with air pollution and relative proportion of the population affected by the impact

Gradient studies have indicated that exposure zones for traffic-related air pollution range from 50 to 1,500 m from highways and major roads.[128] The health impacts of transportation-related emissions are therefore particularly relevant in Canada since approximately 33% of the population lives within 250 m of a major thoroughfare (the estimate for Alberta is approximately 12%).[129,130] In the United States, an estimated 45 million people live within approximately 100 m of a major road, airport, or railroad, with the health impacts of roadway traffic of particular concern.[131]

Health Impact Functions

Relationships have been developed to estimate the health-related impacts associated with ambient air quality levels of certain air contaminants. These relationships are generally referred to as "health impact functions" (also referred to as "dose-response" or "concentration-response" functions).

128 Report: Health Effects Institute. 2010. *Traffic-related air pollution: a critical review of the literature on emissions, exposure, and health effects*. Available online: https://www.healtheffects.org/publication/traffic-related-air-pollution-critical-review-literature-emissions-exposure-and-health

129 Report: Southern Ontario Centre for Atmospheric Aerosol Research. 2019. *Near-road air pollution pilot study*. Available online: https://www.socaar.utoronto.ca/wp-content/uploads/2019/10/SOCAAR-Near-Road-Air-Pollution-Pilot-Study-Summary-Report-Fall-2019-web-Final.pdf

130 Report: Health Canada. 2022. *Exposure to traffic-related air pollution in Canada: an assessment of population proximity to roadways*. Available online: https://publications.gc.ca/collections/collection_2022/sc-hc/H144-99-2022-eng.pdf

131 Report: U.S. EPA. 2014. *Near Roadway Air Pollution and Health: Frequently Asked Questions*. Available online: https://www.epa.gov/sites/default/files/2015-11/documents/420f14044_0.pdf

These functions typically take forms similar to the following:[132,133,134]

$$\Delta Y = y_0(1 - e^{-ß\Delta x})P$$

Where:

ΔY = incremental change in the number of cases

y_0 = baseline incidence rate (cases person^{-1} year^{1})

ß = concentration-response estimate (log relative risk)

Δx = predicted change in the pollutant concentration

P = exposed population

Or

$$PAF = \frac{Pe * (RR\text{-}1)}{Pe * (RR\text{-}1)+1}$$

Where:

PAF = fraction of risk for an outcome attributable to a specific pollutant exposure

RR = relative risk for the outcome which generally has the form noted above i.e., ßΔx

Pe = the probability of exposure (i.e., the fraction of the population that is exposed)

These relationships, which are based principally on epidemiological health-effect data, also consider toxicological and clinical health effects for the pollutant.[135] These functions allow ambient air quality and population data to be used to quantitatively estimate the population health impacts (e.g., increased emergency room visits, lost workdays, premature mortality rates, etc.) associated with current air pollution levels, and predict the impacts of changes in health impacts associated with increases or decreases in these ambient levels.[136,137,138] *RR* and ß values for various air pollutants and for specific health outcomes associated with these pollutants have been determined and continue to evolve as more information on air pollutant concentration and health impact relationships becomes available.[137,139,140] Estimated economic costs associated with each health impact can be used to give an estimate of the overall societal costs associated with exposure to specific air contaminants.[141],[142] Health Canada has developed such a model called the Air Quality Benefit Assessment Tool. This model is used to "…estimate the human health and welfare benefits or damages associated with changes in Canada's ambient air quality."[143]

Figure 15 is a flow diagram that demonstrates the elements of, and inputs to, this type of air pollution-health impact model.[144]

---

132 Article: Martenies S, Wilkens D, and Batterman S. 2015. *Health impact metrics for air pollution management strategies*. Environmental International, 85:84-95.

133 Article: Rittner R et al. 2020. *Health Impacts from Ambient Particle Exposure in Southern Sweden*. International Journal of Environmental Research and Public Health, 17(14):5064. Available online: https://www.mdpi.com/1660-4601/17/14/5064

134 Report: Pruss-Ustan A et al. 2003. *Assessing the environmental burden of disease at national and local levels*. World Health Organization. Available online: https://apps.who.int/iris/bitstream/handle/10665/42750/9241546204.pdf?sequence=1&isAllowed=y

135 Article: Craig L et al. 2008. *Air pollution and public health: a guidance document for risk managers*. Journal of Toxicology and Environmental Health, 71(9-10):588-698.

136 Article: Strasut B, Teh S, and Cohan D. 2019. *Air quality and health benefits from potential coal power plant closures in Texas*. Journal of the Air and Waste Management Association, 69(3):333-350. Available online: https://www.tandfonline.com/doi/full/10.1080/10962247.2018.1537984

137 Article: Faustini A, Rapp R, and Forastiere F. 2014. *Nitrogen dioxide and mortality: review and meta-analysis of long-term studies*. European Respiratory Journal, 44:744–753. Available online: https://erj.ersjournals.com/content/44/3/744

138 Article: Burnett R et al. 2018. *Global estimates of mortality associated with longterm exposure to outdoor fine particulate matter*. PNAS, 115(38):9592-9597. Available online: https://www.pnas.org/doi/10.1073/pnas.1803222115

139 Report: World Health Organization. 2013. *Review of evidence on health aspects of air pollution REVIHAAP project - technical report*. Copenhagen: WHO Regional Office for Europe, 2013. Available online: https://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report

140 Report: World Health Organization. 2021. *WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. World Health Organization. Available online: https://apps.who.int/iris/handle/10665/345329

141 Article: Sacks J et al. 2020. *Quantifying the public health benefits of reducing air pollution: critically assessing the features and capabilities of WHO's AirQ+ and U.S. EPA's Environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP—CE)*. Atmosphere, 11(5): 516. Available online: https://www.mdpi.com/2073-4433/11/5/516/htm

142 Article: Paulot F and Jacob D. 2014. *Hidden cost of U.S. agricultural exports: particulate matter from ammonia emissions*. Environmental Science & Technology Policy, 48(2):903-908.

143 Report: Judek S et al. *Air Quality Benefits Assessment Tool (AQBAT) user guide version 3*. Ottawa: Health Canada, 2019.

144 Article: Bhat T, Jiawen G, and Farzaneh H. 2021. *Air Pollution Health Risk Assessment (AP-HRA), principles and applications*. International Journal of Environmental Research and Public Health 18(4): 1935. Available online: https://www.mdpi.com/1660-4601/18/4/1935#:~:text=The%20Air%20Pollution%20Health%20Risk%20Assessment%20%28AP-HRA%29%20forecasts,a%20key%20tool%20for%20guiding%20public%20policy%20decisions.

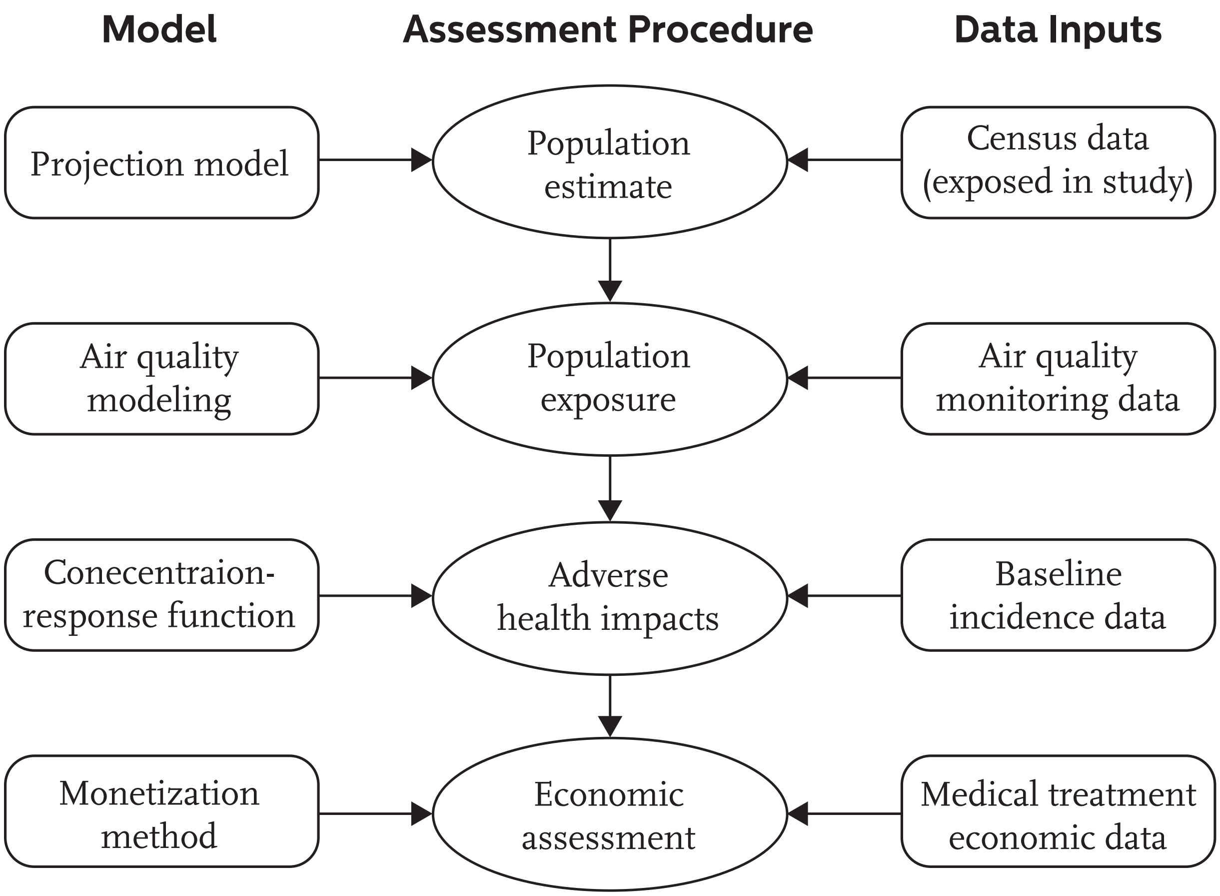


Figure 15: A flow diagram of Air Pollution Health Risk Assessment (AP-HRA) methods, typical models, and data inputs

Air pollution and health impact cost models can be combined with emission source dispersion models and pollution control cost and economic models. These types of integrated models are referred to as Integrated Assessment Models (IAM) and are used to assess the total health and general economic costs associated with different air pollution management interventions to help identify and prioritize different interventions based on cost-effectiveness. Examples of IAM models include the Greenhouse Gas-Air pollution Interactions and Synergies (GAINS) model and the Global change assessment model Long-term Interactive Multi-Pollutant Scenario Evaluator (GLIMPSE).[145,146]

145 Webpage: International Institute for Applied Systems Analysis. *The GAINS model*. https://iiasa.ac.at/web/home/research/researchPrograms/air/GAINS.html

146 Webpage: U.S. EPA. 2022. GLIMPSE – A computational framework for supporting state-level environmental and energy planning. https://www.epa.gov/air-research/glimpse-computational-framework-supporting-state-level-environmental-and-energy

Figure 16 shows the elements of IAMs.[147] In the context of transportation, the application of the framework in this figure is that:

- Transportation is a driving force (i.e., a human activity that has health and environmental impacts).
- Transportation has emissions that represent a pressure on health and the environment. The magnitude of these pressures is a function of both the transportation activity level and the emissions from this activity, which depends on factors such as fuel type and vehicle characteristics (type, size, use, age, etc.).
- Transportation has an influence of the state of air quality in a location. (Note: The state of air quality can be based on air quality measurements or based on emissions modelling with the impact of transportation emissions on air quality predicted based on this type of modelling.)
- The effects of transportation emissions on the overall state of air quality determine the nature and magnitude of the health and/or environmental impact of these emissions.
- Responses refers to measures that can be taken to reduce the air pollution pressures associated with transportation (e.g., reducing transportation activity, encouraging the use of lower-emitting transportation methods or forms with less emissions, implementing more stringent emission controls, mandatory and/or voluntary vehicle inspection and maintenance programs, anti-tampering legislation, anti-idling bylaws, incenting the scrappage of older high-emitting vehicles, incenting the transition to non-fossil fuel-based transportation vehicle and methods, etc.). This element includes an assessment of the effectiveness and/or benefits associated with different responses in relation to costs and/or specific air quality goals.

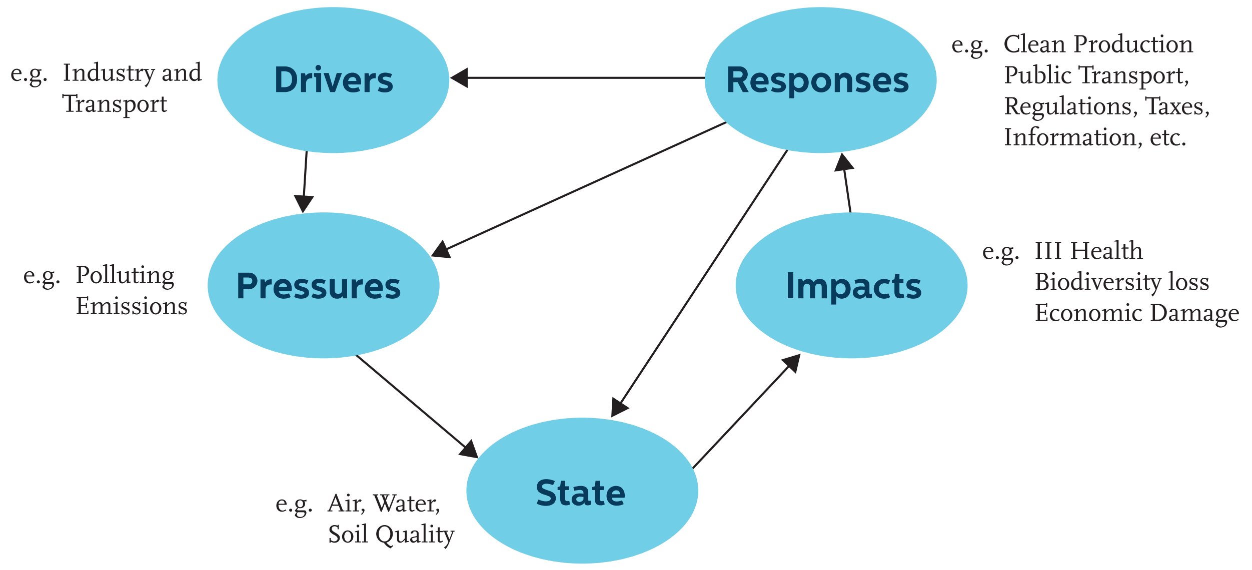


Figure 16: A general schematic of the elements of IAMs

Figure 16 has relevance to the IRTAQ Project because reduced transportation activity during the COVID-19 pandemic provided an opportunity to examine how this reduction changed the magnitude of the pressures on the state of air quality and the impact of these changes as measured by the AQHI.

As noted in Figure 17, there was an improvement (i.e., decrease) in the AQHI levels at an air monitoring station near downtown Calgary that can be related to reduced traffic volumes due to the 2020 COVID-19 restriction measures.

147 Book: Blond N et al. 2017. *Chapter 2: A framework for integrated assessment*. Guariso G and Volta M (eds). Air Quality Integrated Assessment: A European Perspective. Springer Brief, 9-35.

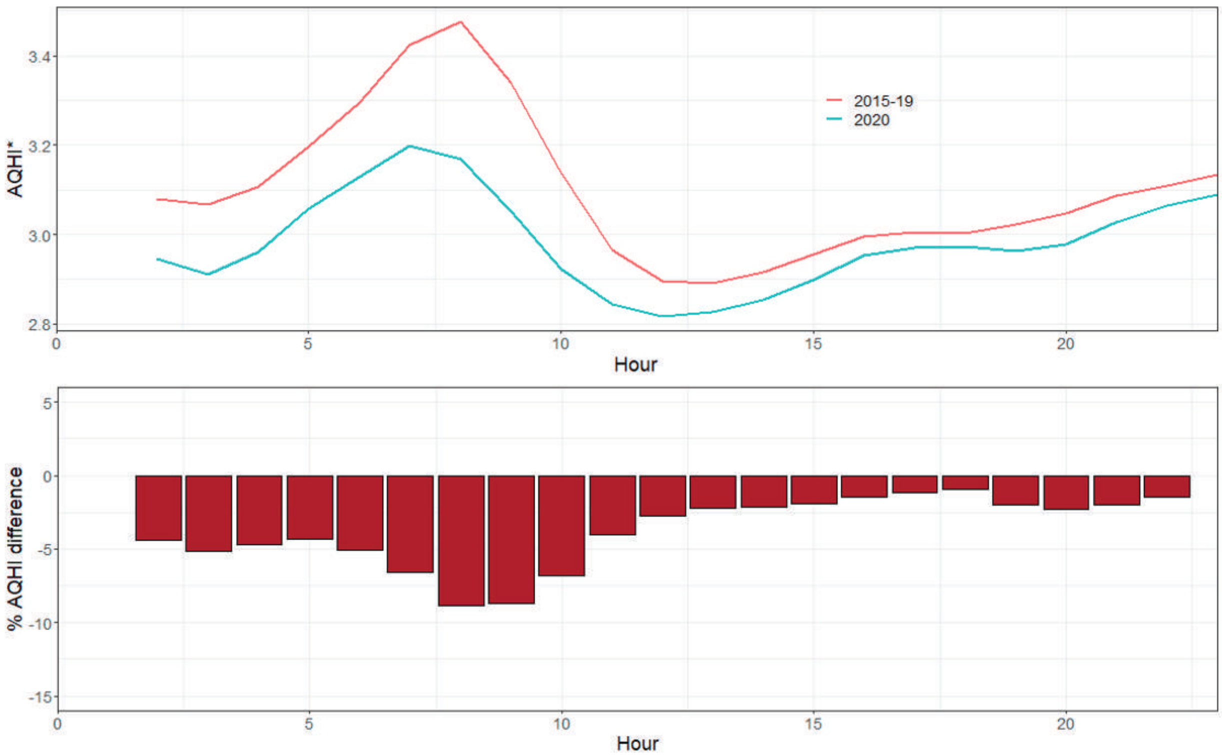


Figure 17: Calgary Inglewood AQHI values calculated using average diurnal concentrations between March 16–April 24 of the indicated years

This information and other transportation-related air quality information was used to identify possible response options for reducing transportation-related impacts on air quality emissions in Alberta.

Air Pollution-Related Health Impacts and Costs in Canada

In 2019, Health Canada released a report that assessed the health impacts and costs of air pollution on Canadians based on 2015 population census data and air quality in the 2014–2016 period.[148]

The assessment linked ambient air exposure of the population from 293 population census divisions to NO_2, O_3 and $PM_{2.5}$ (the three national AQHI pollutants). The ambient air concentrations of NO_2, O_3 and $PM_{2.5}$ were estimated based on satellite, ground-based and/or modelling data.

Both acute and chronic exposures to these three pollutants were assessed, with three mortality endpoints: acute exposure mortality, chronic exposure respiratory mortality, and chronic exposure mortality.

Morbidity endpoints were also assessed and based on:

- minor restricted activity days
- acute respiratory symptom days
- adult chronic bronchitis cases
- asthma symptom days
- cardiac emergency room visits
- cardiac hospital admissions
- child acute bronchitis episodes
- respiratory emergency room visits
- respiratory hospital admissions
- restricted activity days

Economic impact estimates of exposure to these pollutants were based on "...the potential social, economic, and public welfare consequences of the health outcomes, including medical costs, reduced workplace productivity, pain and suffering, and the effects of increased mortality risk."

148 Report: Health Canada. 2019. *Guidance for evaluating human health impacts in environmental assessment: human health risk assessment*. Available online: https://publications.gc.ca/site/eng/9.870475/publication.html

While the general methodology used by Health Canada follows a standard and widely-used approach, there are several assumptions, simplifications, and scaling issues that are an inherent part of conducting air pollution-health impact assessments like the one noted above. Collectively these issues introduce a high degree of uncertainty around the exact magnitude of estimated health outcomes. Therefore, while there is a high degree of certainty that air pollution results in premature mortalities and non-fatal health effects, the magnitude of the estimated impacts must be considered approximations.

The Figures and Tables throughout section 3.4 summarize data from Health Canada air pollution and health impact assessments. However, because of the uncertainties associated with the estimated health impacts, the data presentation is focused on providing an indication of the general scale of the impacts associated with air pollution in Canada and how Alberta's transportation-related air emissions compare to other provinces and total Canadian emissions. More specific estimates on air pollution health impacts in Alberta can be obtained from the individual assessments, but these estimates require careful interpretation due to the uncertainties identified above.

Figure 18 shows the number of estimated premature mortalities in Canada that can be attributed to ambient air concentrations of NO_2, O_3, and $PM_{2.5}$, and the type and count of morbidity effects associated with $PM_{2.5}$ and O_3 for Canada.[149] It should be noted that possible morbidity effects associated with NO_2 were not assessed and morbidity data for the individual provinces was not provided.

The estimated number of days of air-pollution-related morbidity in Canada are shown in Table 2. Health Canada's estimated economic impact to Canada associated with the estimated premature mortalities is $108 billion. The estimated economic impact associated with the estimated premature morbidities for Canada is $5.5 billion.

In the summary of its air pollution and health and economic impact assessment results Health Canada noted:[150]

- "...that premature death associated with air pollution affected 41 per 100,000 Canadians."
- "On a provincial and territorial basis, health impact estimates are generally proportional to population counts. For example, the premature mortality count is 6,700 in Ontario, 3,800 in Québec, 1,600 in British Columbia and 1,200 in Alberta."
- "...the quantitative estimates of population health outcomes provided in this analysis are assumed to represent an underestimate of the full impacts of air pollution in Canada."
    - This conclusion is based on the following:
        - The analysis was based exclusively on $PM_{2.5}$, NO_2, and O_3 exposures and the effects of other air pollutants were not assessed. Not all endpoints associated with $PM_{2.5}$, NO_2, and O_3 were considered due to data limitations and knowledge gaps.
- "...despite improvements in air quality and the relatively low levels of air contaminants in Canada compared to other regions of the world, air pollution continues to have impacts on population health in Canada."

149 Report: Health Canada. 2019. *Health impacts of air pollution in Canada.* Ottawa: Health Canada.

150 Report: Health Canada. 2019. *Guidance for evaluating human health impacts in environmental assessment: human health risk assessment.* Available online: https://publications.gc.ca/site/eng/9.870475/publication.html

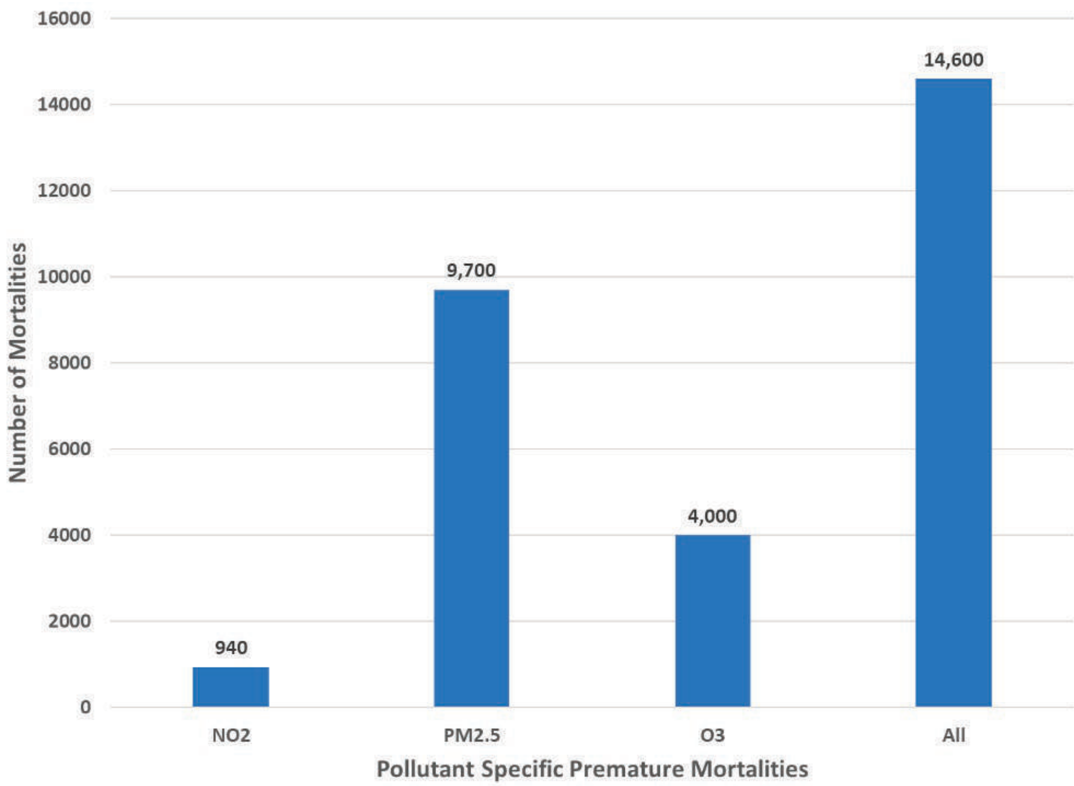


Figure 18: Pollutant specific premature mortalities in Canada in 2015

Table 2: Estimated number of days of specific air pollution-related morbidity impacts in Canada in 2015 and the air pollutants and seasonal considerations associated with the morbidity estimate

Morbidity	Pollutant(s)	# of Days
Acute respiratory symptom days	O_3 summer, $PM_{2.5}$	35,000,000
Adult chronic bronchitis cases	$PM_{2.5}$	9,100
Asthma symptom days	O_3 summer, $PM_{2.5}$	2,690,000
Cardiac emergency room visits	$PM_{2.5}$	1,000
Cardiac hospital admissions	$PM_{2.5}$	790
Child acute bronchitis episodes	$PM_{2.5}$	42,500
Minor restricted activity days	O_3 summer	2,340,000
Respiratory emergency room visits	O_3 summer, $PM_{2.5}$	7,000
Respiratory hospital admissions	O_3 summer, $PM_{2.5}$	1,400
Restricted activity days	$PM_{2.5}$	13,000,000

Transportation-Related Air Pollution and Associated Related Health Impacts and Costs

Health Canada has conducted studies that focus on vehicle emission-related health and cost impacts. These studies are:

- Human Health Risk Assessment for Diesel Exhaust[151]
- Human Health Risk Assessment for Gasoline Exhaust[152]
- Human Health Risk Assessment for Biodiesel Production, Distribution and Use in Canada[153]
- Health Risks and Benefits Associated with the Use of 10% Ethanol-blended Gasoline in Canada.[154]

The health risk assessments for diesel exhaust (DE) and for gasoline exhaust emissions were used to approximate the transportation-related contributions to the total air pollution health and cost impacts in the following subsections.

Diesel Vehicle Emissions and Health and Cost Implications

Health Canada's study, *Human Health Risk Assessment for Diesel Exhaust*[151] followed the same health impact and cost estimation approach as outlined in section 3.3 for the Health Canada report Guidance for Evaluating Human Health Impacts in Environmental Assessments: Human Health Risk Assessment.[155]

The Health Canada report focused on DE emissions from on- and off-road vehicles and excluded rail and marine diesel vehicles.

The study noted that: "*Only studies pertaining to DE or DEP (diesel exhaust particles) were reviewed, and studies on the health effects of individual DE constituents, traffic pollution in general, or ambient $PM_{2.5}$ were not considered for review.*"

Health Canada's causal determination for different potential health impacts associated with exposure to DE emissions are presented in Table 3. This determination indicates that there is a causal relationship between exposure to DE emissions and lung cancer, acute respiratory effects, and a likely or suggestive impact on other health outcomes.

The report also provides a summary of the emission volumes over time for common air pollutants associated with on- and off-road diesel exhaust for each of the provinces and territories and overall data for Canada in 2015. Figure 19 summarizes this diesel emission data for Alberta, Ontario, and Canada in total. Alberta, followed by Ontario, has the largest diesel exhaust emissions of any of the jurisdictions in Canada. Diesel emissions in Alberta would therefore be expected to be a contributor to the overall air pollution health impacts outlined in section 3.3.

151 Report: Health Canada. 2016. *Human health risk assessment for diesel exhaust*. Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2016/sc-hc/H129-60-2016-eng.pdf

152 Report: Health Canada. 2017. *Human health risk assessment for gasoline exhaust*. Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2017/sc-hc/H144-52-2017-eng.pdf

153 Report: Health Canada. 2012. *Human health risk assessment for biodiesel production, distribution and use in Canada*. Available online: https://publications.gc.ca/site/eng/9.696274/publication.html

154 Report: Health Canada. 2010. *Health risks and benefits associated with the use of 10% ethanol-blended gasoline in Canada*. Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2013/sc-hc/H128-1-10-597-eng.pdf

155 Report: Health Canada. 2019. *Guidance for evaluating human health impacts in environmental assessment: human health risk assessment*. Available online: https://publications.gc.ca/site/eng/9.870475/publication.html

Table 3: Causality determinations for possible diesel exhaust emission health impacts

Outcome	Acute/chronic DE exposure	Causality determination
Carcinogenicity	Chronic	Causal (lung cancer)
		Suggestive (bladder cancer)
		Inadeauate (other cancers)
Respiratory effects	Acute	Causal
	Chronic	Likely
Cardiovascular effects	Acute	Likely
	Chronic	Suggestive
Immunological effects	—	Likely
Reproductive and developmental effects	—	Suggestive
Central nervous system effects	Acute	Suggestive
	Chronic	Inadequate

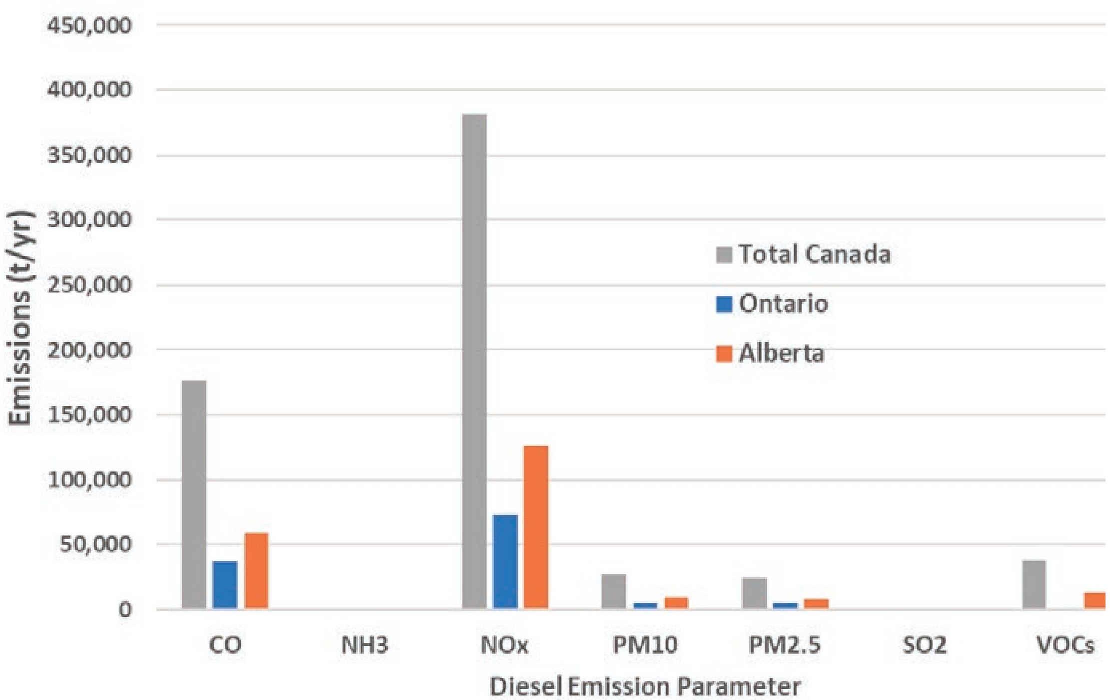


Figure 19: On- and off-road diesel emissions (t/yr) in Canada (total), Alberta, and Ontario in 2015 (Note: does not include rail or marine diesel emissions)

Figure 20 shows the estimated contribution of the specific on- and off-road DE emission-related air pollutants to air pollution-related mortalities in Canada in 2015 and the total estimated DE-related premature mortalities. Figure 20 shows that in Canada on- and off-road diesel emissions are estimated to contribute equally to DE emission-related premature mortalities. This may not be the case for Alberta as noted in the summary of the Health Canada report.[156]

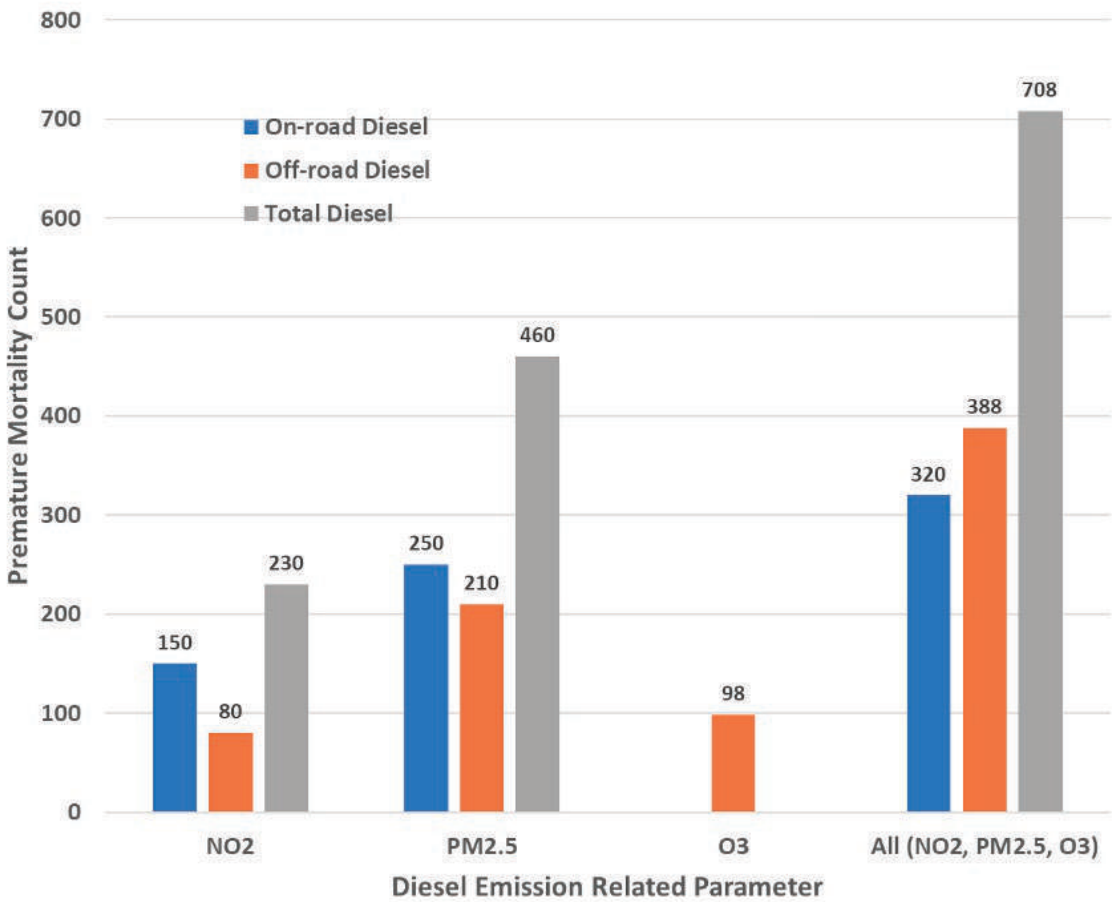


Figure 20: Number of premature mortalities in Canada in 2015 attributable to on- and off-road diesel emission sources by pollutant

Health Canada provided the following comments and assessments that are particularly relevant in an Alberta context:[157]

- "The total economic value of the health outcomes for on-road and off-road diesel emissions is approximately $5.5 billion…largely due to premature mortalities (valued at $5.1 billion)."
- "Off-road diesel emissions have a greater influence on health outcomes relative to on-road diesel emissions in Alberta and Saskatchewan… This concurs with the higher off-road vehicle populations in Alberta and Saskatchewan."
- "The large apparent impacts of off-road emissions are in large urban centres, owing to the confluence of high emissions and high population density…Off-road diesel emissions have relatively more influence in Calgary and Edmonton than in other urban centres, highlighting the importance of the off-road diesel fleet in those areas."

156 Report: Health Canada. 2016. *Human health risk assessment for diesel exhaust*. Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2016/sc-hc/H129-60-2016-eng.pdf

157 Report: Health Canada. 2016. *Human health risk assessment for diesel exhaust*. Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2016/sc-hc/H129-60-2016-eng.pdf

- "…the populations exposed to off-road emissions are likely smaller (a large fraction of off-road emissions being allocated to rural and less populated areas) than those exposed to on-road diesel emissions (mainly in urban centres), which decreases the magnitude of the effect on population health on a per emission basis."
- "In all provinces and territories, on-road and off-road diesel emissions are associated with higher O_3-related premature mortalities or lower avoided premature mortalities than on-road diesel emissions alone. Differences in the O_3-related effects between the scenarios are concentrated and highest in urban centres, such as Montréal, Toronto, Calgary, and Edmonton."
- "Diesel emissions are also important along major trucking routes and roadways connecting major cities (e.g., Windsor–Québec corridor), as well as in agricultural and mining areas (e.g., Alberta)."
- "The combination of on-road and off-road emissions leads to greater air quality impacts in the largest Canadian urban centres, notably Greater Vancouver, Edmonton, Calgary, Winnipeg, Toronto, and Montréal. Off-road diesel emissions also have a relatively large impact in less developed areas characterized by few other sources of pollutant emissions (e.g., remote mining communities)."

Gasoline Vehicle Emissions and Health and Cost Implications

The Health Canada *Human Health Risk Assessment for Gasoline Exhaust* report[158] followed the same health impact and cost estimation approach as outlined in Section 3.3 for the Health Canada *Guidance for Evaluating Human Health Impacts in Environmental Assessments: Human Health Risk Assessment* report and outlined in Section 3.4.1 for Health Canada *Human Health Risk Assessment for Diesel Exhaust*.

This Health Canada report notes that gasoline (spark ignition) engines represent 92% (22.2 million) of on-road vehicles and 87% (13.6 million) of off-road engines or equipment.

The report provides a summary of the emissions of the common air pollutants associated with on- and off-road gasoline engines based on a 2012–2013 inventory. Figure 21 summarizes the gasoline emission data for Alberta, Ontario, Quebec, and Canada in total. Ontario has the largest gasoline exhaust emissions of any jurisdiction in Canada, followed by Quebec then Alberta. However, on a per capita basis, Alberta has the highest gasoline-related emissions (Figure 22).

158 Report: Health Canada. 2017. *Human health risk assessment for gasoline exhaust*. Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2017/sc-hc/H144-52-2017-eng.pdf

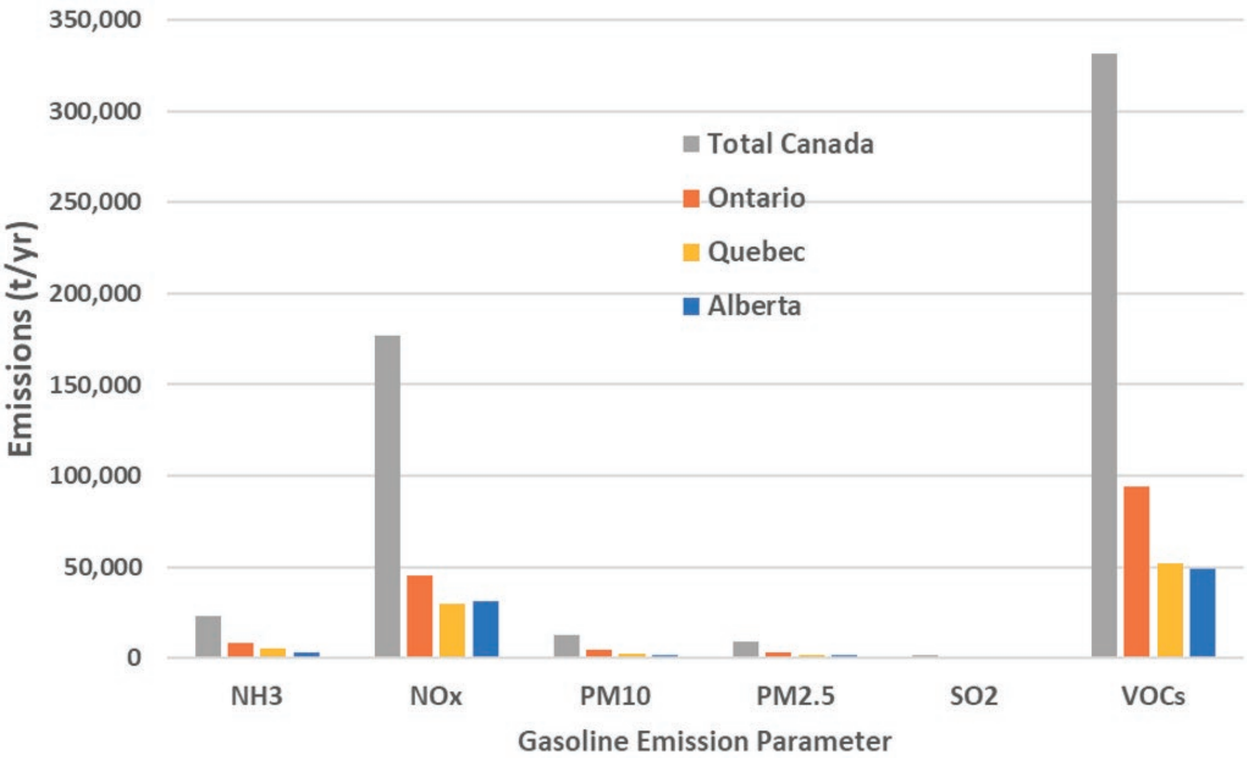


Figure 21: On- and off-road gasoline emissions (t/yr) in Canada (total), Ontario, Quebec, and Alberta (2012–13 data)

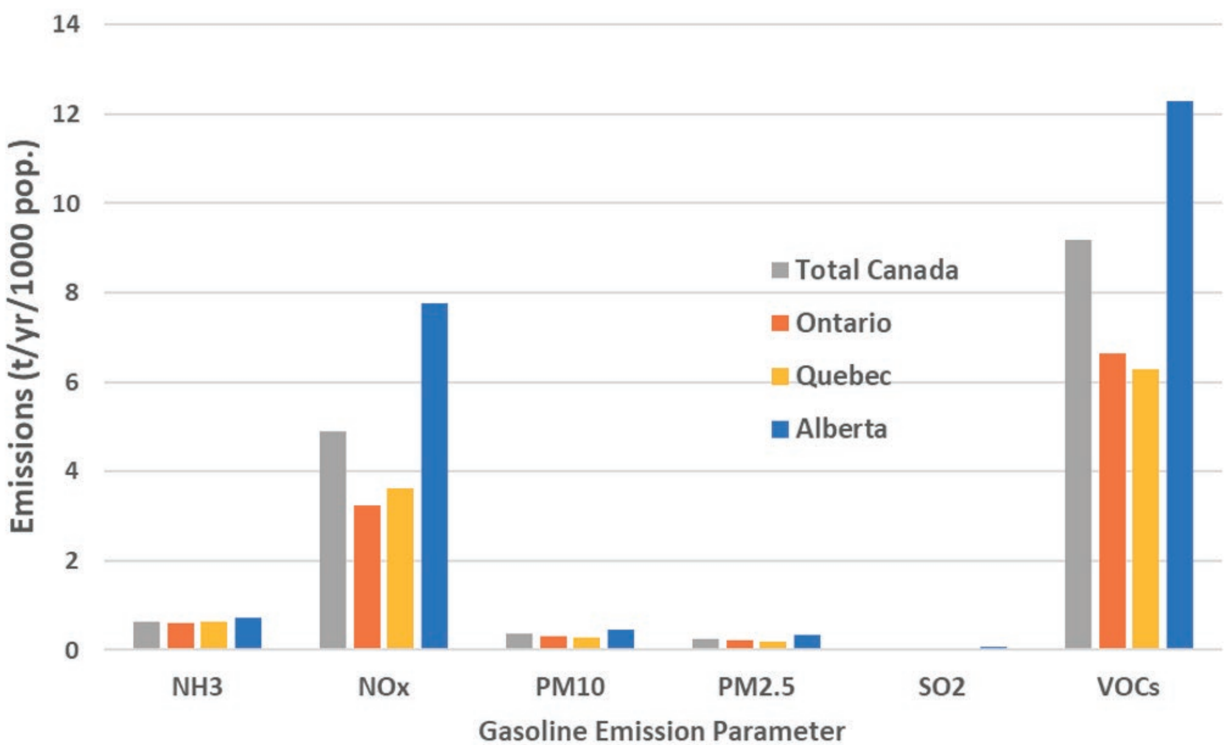


Figure 22: On- and off-road gasoline emissions per 1000 population (t/yr/1000 pop.) in Canada (total), Ontario, Quebec, and Alberta (2012–13 emission data and 2015 census data)

Figure 23 shows the contribution of on- and off-road gasoline engine (GE) emissions-related premature mortalities in Canada in 2015 compared to the premature mortalities from all pollution sources. On-road GE emissions are estimated to contribute approximately three times the premature mortalities compared to off-road GE emissions. In total, on- and off-road GE emissions contribute to 6.4% (940) of the premature mortalities in Canada from all pollution sources (14,600).

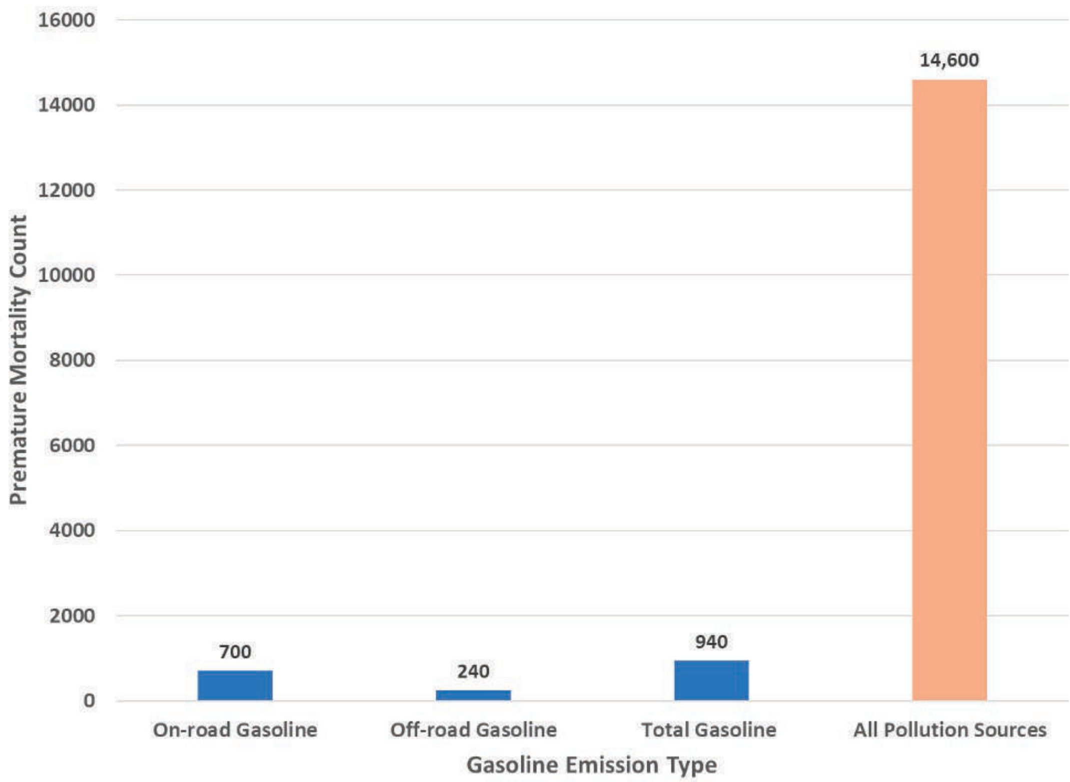


Figure 23: Number of premature mortalities in Canada in 2015 attributed to all pollution sources and to on- and off-road gasoline engine emissions

In Health Canada's summary of the results of its health assessment of GE emissions in Canada, the following comments and assessments are particularly relevant in an Alberta context:[159]

- "… given the number of vehicles and engines in use, the age structure of the in-use fleets, and the vehicle kilometres travelled by Canadians, gasoline engines remain a key source of air pollution."
- "It is inherently difficult to examine the health effects of GE as a mixture in epidemiological studies, given that most populations are co-exposed to GE and diesel exhaust (DE), and that a unique surrogate for GE exposure has not been identified."
- "On-road gasoline emissions contribute to air pollutant concentrations in urban areas (e.g., Greater Vancouver, Calgary, Winnipeg, Toronto, and Montréal) and along major transportation routes."
- "On-road and off-road gasoline emissions are associated with 940 premature mortalities (valued at $6.8 billion), where 66%, 17%, 11%, and 6% of the estimated mortalities are attributable to ambient $PM_{2.5}$, NO_2, and O_3, and CO, respectively.
- "Gasoline emissions are also associated with acute respiratory symptom days, restricted activity days, asthma symptom days, hospital admissions, emergency room visits, child acute bronchitis episodes and adult chronic bronchitis cases across Canada."[160]

159 Report: Health Canada. 2017. *Human health risk assessment for gasoline exhaust*. Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2017/sc-hc/H144-52-2017-eng.pdf

160 The societal cost for calendar year 2015 associated with these health impacts was estimated to be approximately $0.5 billion.

- "…the population health impacts from gasoline emissions are estimated to be greater than those from diesel emissions, based on these model-based analyses."[161]
- "It is intended that the report be used to inform further efforts to mitigate emissions and population health impacts associated with this key source of air pollution in Canada. Overall, it is concluded that air pollutants from gasoline sources continue to pose a risk to human health in Canada."
- "Contributions to ambient air toxic levels from on-road gasoline emissions or on-road and off-road gasoline emissions combined are associated with individual and cumulative lifetime cancer risks lower than 1 × 10-5. Thus, on average across Canada, gasoline emissions are considered to contribute negligibly to lifetime exposure cancer risks for ambient levels of acetaldehyde, benzene, and formaldehyde (individually and cumulatively)."
- "The majority of the premature mortalities attributed to gasoline emissions were associated with $PM_{2.5}$ and NO_2 concentrations, with lower contributions from O_3 and CO. Cardiovascular mortalities accounted for more than half of the total mortalities, followed by lung cancer and respiratory mortalities. Gasoline emissions, through their influence on ambient $PM_{2.5}$ and O_3 concentrations, were also associated with acute respiratory symptom days, restricted activity days, asthma symptom days, hospital admissions, emergency room visits, child acute bronchitis episodes and adult chronic bronchitis cases across Canada."
- "…the quantitative estimates of population health impacts provided in this analysis are assumed to represent an underestimate of the full effects of gasoline emissions-related air pollution."
- "…populations residing in urban centres are exposed to higher pollutant concentrations than populations residing in rural areas, and that proximity to GE traffic sources is associated with elevated exposure to multiple pollutants."

10% Ethanol-blended Gasoline – Health Impacts and Associated Cost Implications

Health Canada conducted a Health Risks and Benefits Associated with the Use of 10% Ethanol-blended Gasoline in Canada study which examined and evaluated the health impacts of vehicle emissions associated with 10% ethanol (E10) gasoline blends relative to conventional gasoline.[162]

The conclusion from the study was that: "…increasing the use of E10 fuel in Canada would result in a possibly negligible decrease in the number of adverse health effect incidents."

Ethanol-blended gasoline would therefore not appear to have significant use or benefit in terms of reducing the health impacts of gasoline engine emissions.

Biodiesel Production, Distribution and Use – Health Impacts and Associated Cost Implications

Health Canada conducted a Human Health Risk Assessment for Biodiesel Production, Distribution and Use in Canada study which examined and evaluated the impacts of biodiesel use on Canadian fleet-wide mobile source (on-road heavy duty diesel vehicles) emissions.[163]

The health impacts of biodiesel use were compared to the use of ultra-low sulphur diesel. Biodiesel use included two biodiesel types: 5% biodiesel (B5) and 20% biodiesel (B20), in three time periods (2006, 2010, and 2020).

The general conclusion from this study was that the use of B5 or B20 across Canada was expected to result in minimal impacts to air quality and health, and those impacts would likely diminish over time. The possible benefits of biodiesel use in reducing greenhouse gas emissions were not considered in this study.

Increased use or percentage of biodiesel in on-road heavy-duty diesel vehicles would therefore not appear to significantly reduce the health impacts of on-road heavy-duty diesel emissions.

161 For Alberta, the model-based analyses showed that DE have approximately twice the population health impacts compared to GE.

162 Report: Health Canada. 2010. Health risks and benefits associated with the use of 10% ethanol-blended gasoline in Canada. Available online: https://publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2013/sc-hc/H128-1-10-597-eng.pdf

163 Report: Health Canada. 2012. *Human health risk assessment for biodiesel production, distribution and use in Canada*. Available online: https://publications.gc.ca/site/eng/9.696274/publication.html

Air Pollution, Health Impacts, and Ambient Air Quality Guidelines/Objectives/Standards

Several agencies undertake detailed health assessments of $PM_{2.5}$, NO_2, and O_3 and other air contaminants, and these assessments are periodically updated to reflect new health-effects information. These health assessments are used by regulatory agencies to develop ambient air quality guidelines, objectives, criteria, and/or standards. Examples of such ambient air quality limits include:

- Alberta's Ambient Air Quality Objectives and Guidelines (AAAQO/G)[164]
- the Canadian Ambient Air Quality Standards[165]
- the WHO Air Quality Guidelines[166]
- the U.S. Environmental Protection Agency National Ambient Air Quality Standards[167]
- the European Union Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe[168]

For the same air contaminant, air quality limits established by different jurisdictions often vary significantly. These differences generally reflect the intended use of or for the limits (e.g., the AAAQO/Gs indicate that they are based on scientific, social, technical, and economic factors, with an objective to ensure emission sources are effectively managed). Of the limits listed above, only the WHO Air Quality Guidelines are entirely health effect-based. The WHO also notes that:

> "The overall objective of the updated global guidelines is to offer quantitative health-based recommendations for air quality management, expressed as long- or short-term concentrations for a number of key air pollutants. Exceedance of the air quality guideline (AQG) levels is associated with important risks to public health."

Therefore, if ambient air quality in a location exceeds the WHO Air Quality Guideline for an air contaminant, there are potential health impacts on individuals at that location.

164 Report: Government of Alberta, Ministry of Environment and Parks. 2019. *Alberta Ambient Air Quality Objectives and Guidelines summary*. Available online: https://open.alberta.ca/publications/9781460134856

165 Report: Canadian Council of Ministers of the Environment. 2019. *Guidance document on Air Zone management*. Available online: https://ccme.ca/en/res/guidancedocumentonairzonemanagement_secured.pdf

166 Report: World Health Organization. 2021. *WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide, and carbon monoxide*. Available online: https://apps.who.int/iris/handle/10665/345329

167 Webpage: U.S. EPA. 2021. *NAAQS*. Available online: https://www.epa.gov/criteria-air-pollutants/naaqs-table

168 Report: European Union. 2008. *Directive 2008/50/EC on ambient air quality and cleaner air for Europe*. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0050-20150918

Summary

Air pollution is recognized as having significant health and quality of life impacts. Understanding of the health effects associated with air pollution, and the biological mechanisms through which these effects occur, is still evolving.

Estimating the exact magnitude and economic implications of health and quality of life impacts and the specific contribution of different air pollutants to these impacts is challenging. The current state of knowledge with respect to air pollution, and the contribution of transportation-related emissions to air pollution, indicates that reduction in transportation emissions in Canada, and by extension Alberta, would have health and economic benefits.

The COVID-19 pandemic measures that resulted in reduced transportation volumes and associated overall traffic-related emission reductions resulted in improved air quality compared to estimated normal (i.e., non-COVID-19) air quality. This study used the AQHI as a general indicator of the potential health impacts associated with these air quality improvements.

As this review of air pollution and health shows, the AQHI, which considers three of the general overall and transportation-related air pollutants (i.e., $PM_{2.5}$, NO_2, and O_3) can be used as a predictor of health impacts.

Appendix 2b: Air Quality During Periods when Measures were Taken to Reduce Spread of COVID-19: Examining a Secondary Effect

Contents

Objective of the Study

Alberta declared a COVID-19 public health emergency on March 17, 2020, and implemented a staggered set of measures, including closure of schools and requirements to work from home when possible. These measures had the potential to reduce air emissions, most notably from motor vehicles. Therefore, the public health emergency provided an unprecedented real-world opportunity to examine the impact of traffic volume on air quality.

Several studies have examined changes in atmospheric concentration of pollutants as a secondary effect of measures taken to reduce the spread of COVID-19. Evaluations have ranged from a comparison of statistical measures, to the use of linear regression, machine learning, satellite, and modelling data. The use of different methodologies, data spans, and treatment of data may result in slightly different conclusions. For example, Griffin et al. used satellite data and atmospheric modelling to estimate 80, 60 and 30% reduction in NOx emissions from aircraft, vehicle traffic, and industry over southern Ontario, respectively.[169] Keller et al.[170] (11) used weather-normalization and chemical composition of key hydrocarbons and particulate matter to estimate monthly reduction in NO_2 concentrations ranging from 15–35% in Edmonton during the months of March–June 2020 and Mashayekhi et al. used atmospheric modelling to predict, on average, a 31–35% decrease in NO_2 for four Canadian cities.[171] While reductions in NOx have been noted by many, results for ozone concentration have been mixed.[170,172] Higher concentrations were observed during typical periods of titration (at night and early morning) and marginally lower concentrations during periods of photochemistry (midafternoon).[170,171]

Many of the studies to date have focused on large urban centres, sometimes from various jurisdictions, which can make narrowing impacted dates difficult. Alberta Environment and Parks (AEP) initiated a study in April 2020 to examine the impact of measures taken to reduce the spread of COVID-19 on air quality. Stations located within urban centres of various sizes were included in the study. Similar to many of the published works, the study examined historically typical observations and compared these to concentrations measured in spring 2020.

This document provides a technical briefing on the work completed to date by staff in Alberta Environment and Parks and is intended only for the use of the Clean Air Strategic Alliance's Impacts of Reduced Transportation on Air Quality in Alberta Associated with COVID-19 Project Team. The document includes a summary of findings in section 2, a list of study limitations (including assumptions and initiated and planned work items) in section 3, and additional information and discussions in the Appendices.

169 Article: Griffin D et al. 2020. *Assessing the impact of corona-virus-19 on nitrogen dioxide levels over southern Ontario, Canada*. Remote Sensing. 12(24):1–13.

170 Article: Keller C et al. 2021. *Global impact of COVID-19 restrictions on the surface concentrations of nitrogen dioxide and ozone*. Atmospheric Chemistry and Physics. 21(5):3555–92. Available online: https://acp.copernicus.org/articles/21/3555/2021/

171 Article: Mashayekhi R et al. 2021. *Isolating the impact of COVID-19 lockdown measures on urban air quality in Canada*. Air Quality, Atmosphere, and Health. 14:1549–70. Available online: http://www.ncbi.nlm.nih.gov/pubmed/34025821%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC8130219

172 Article: Venter Z et al. 2020. COVID-19 lockdowns cause global air pollution declines. PNAS. 117(32):18984–90. Available online: https://www.pnas.org/doi/10.1073/pnas.2006853117#:~:text=We%20find%20that%2C%20after%20accounting,with%20mixed%20effects%20on%20ozone.

Summary

On March 17, 2020, Alberta declared a public health emergency to prevent the spread of COVID-19. Additionally, some municipal plans were activated (e.g., the Calgary municipal plan was activated on March 12, 2020). The public health emergency and municipal plans included measures such as the closure of schools and daycares, the restriction of gatherings to 15 or fewer people, and mandated physical distancing. These actions were expected to temporarily decrease emissions from sectors such as transportation and in turn reduce the concentration of select air pollutants. On May 14, 2020, Alberta entered Stage 1 reopening of the first public health emergency, which was accompanied by the lifting of some restrictions. Further lifting of measures followed on June 12, 2020, as the province entered Stage 2 reopening. As restrictions were lifted, the impact of measures taken were expected to decrease.

This study included sample days from March 16–June 12, 2020. Atmospheric concentrations and vehicle counts for the same dates between 2015 and 2019 are used as previous observations (hereafter referred to as historical data) for comparison to 2020 observations. Informed by changes in spring 2020 traffic volume within Edmonton and Calgary, the study period is divided into Period A (March 16–April 24) and Period B (April 27–June 12). Period B includes Stage 1 reopening. Weekends and holidays (including Easter and Victoria Day) were removed because traffic volumes, and thus the impact of COVID-19 measures, were lower than on weekdays.

The effect of wildfire smoke and transport of springtime ozone greatly vary from year to year and in the case of ozone may be affected by synoptic scale weather. Days that were unduly affected by such events were removed from the historical atmospheric and vehicle count data.

For both atmospheric concentrations and vehicle count, the 2020 data was compared to the historical data using two methods: 1) period differential, where 2020 Period A or B is compared to historical data of the same period, and 2) diurnal comparison, where 2020 data are compared to historical data for each hour of the day.

Each of these comparisons was tested for statistical significance ($p \leq 0.05$) using the Wilcoxon Rank sum test. However, the sample size difference between historical and 2020 data (5:1) resulted in issues with statistical power which might have increased type II error rate. In some cases, the difference between 2020 and historical data was found to be statistically insignificant even though there was strong evidence of a difference.

In this document, only the mean period differences, using minimum reporting limits to illustrate negligible differences, are presented. If the difference between the mean value for a period in 2020 and historical data (e.g., mean Period A 2020 – mean Period A historical) is less than the lowest reported concentration (e.g., 0.0001 ppb for NO_2), the difference was deemed negligible.

For all but one automated counter, 2020 vehicle counts during both Period A and B were lower than historical counts for the same period (Figure 24). Decreases in average hourly weekday traffic count ranged from -41% to -8%. Historical vehicle count at the Edmonton East Automated Traffic Recorder (Edmonton II) is lower than expected due to construction of the northeast section of the Anthony Henday Drive freeway (Table 5). As a result, vehicle counts at Edmonton II were only 8% lower in 2020 during Period A and 2020 counts were higher than historical during Period B. Smaller urban centres had a notably lower traffic count, and thus the decrease in the number of vehicles in 2020 was also lower (100s). The decrease in Calgary and Edmonton was an order of magnitude higher. During the latter part of the health emergency (Period B), when Alberta entered Stage 1 reopening, some measures put in place to reduce the spread of COVID-19 were lifted. During this time the decrease in weekday traffic count in 2020 was much smaller at all locations (Figure 24).

In general, the largest decrease in traffic volume was observed during the part of the day with typically higher traffic (morning and/or afternoon commuter period). This study does not distinguish between types of vehicles (e.g., cars vs. heavy trucks), type of fuel used, or age of vehicle; these can have different emission profiles and intensity. It is likely that the COVID-19 restrictions in Alberta had different relative impacts on different types of vehicles.

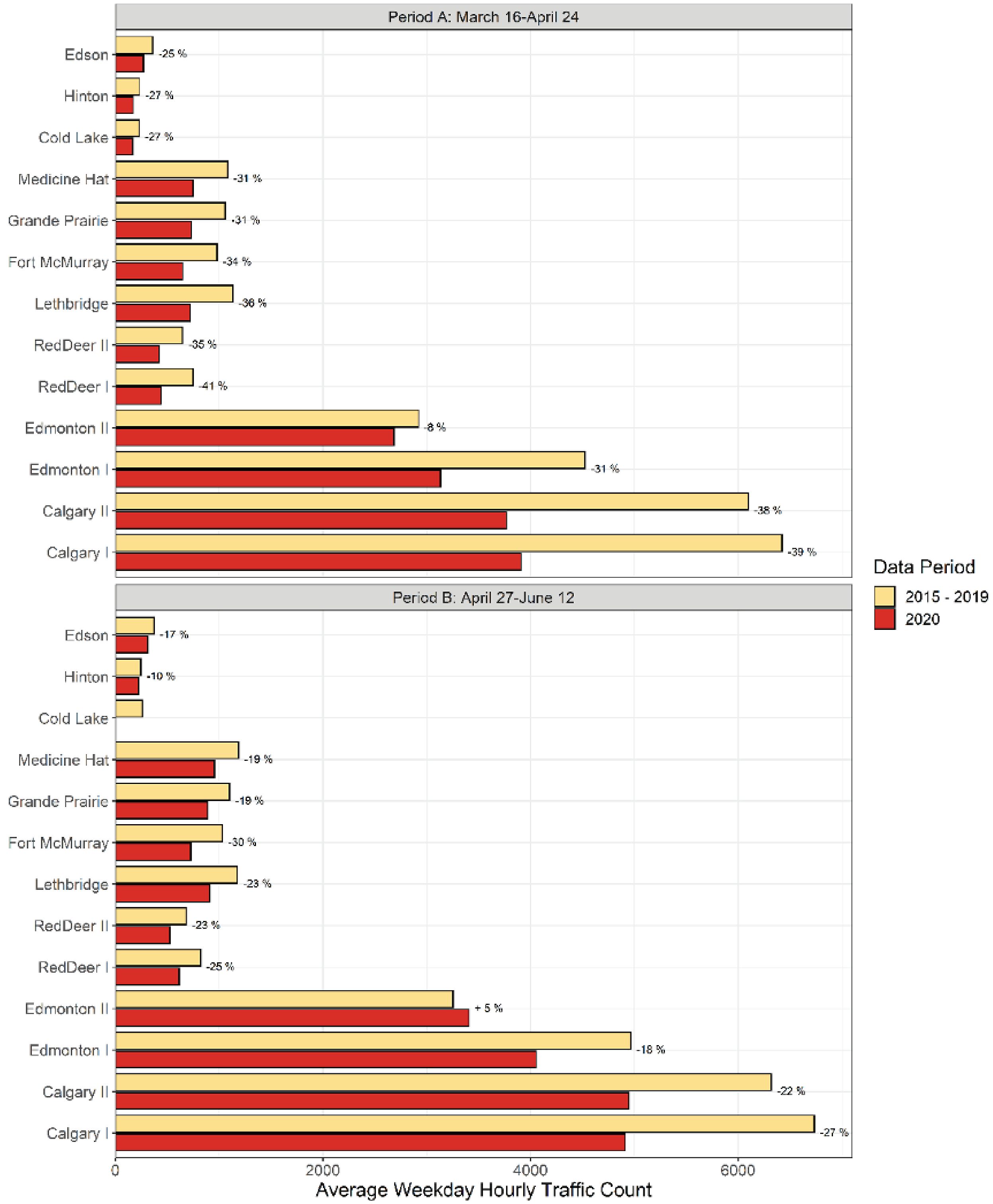


Figure 24: Average weekday hourly traffic count on select roads in Alberta. Two roads were selected for larger urban centres indicated as I and II. Relative change in traffic count is expressed in percentage. Locations of automated traffic counters are listed in Table 5. Comparisons were not possible for counts from automated traffic counters located in Cold Lake (Period B) and Fort Saskatchewan (Period A and B) because there were insufficient data (available data <50%).

Within urban centres, motor vehicle emissions can contribute to ambient NO, NO_2, CO, and primary $PM_{2.5}$ concentrations. Gases in vehicle emissions such as NO, NO_2, and volatile organic compounds can also react in the atmosphere to form ozone and secondary $PM_{2.5}$. The relative contributions of motor vehicles emissions to concentrations measured can depend on the presence and magnitude of other nearby sources, and on the composition of vehicles on the road including the age, maintenance, and type of vehicles, and on atmospheric conditions that affect dispersion and chemistry.

For most stations and air quality parameters, the comparison results for Period A were notably different from the comparison results for Period B. These differences from historical concentrations are likely only partially explained by changes in weekday traffic counts. March to June is a period of rapid change in planetary boundary layer height for the northern part of the North American continent.[173] The earlier period of the study (Period A) was expected to have a lower planetary boundary layer (limited dispersion, thus higher atmospheric concentrations) than later in the study (Period B). The effect of emission reduction for some atmospheric concentrations is expected to be greater during the earlier period of study. However, this is complicated for secondary pollutants where photochemistry may be involved. The abundance of solar radiation is higher during Period B, promoting atmospheric chemistry. Work is underway to understand these relationships (section 3).

Figure 25 shows the mean changes in NO and NO_2 concentrations between 2020 and the historical data for Period A and B. NO and NO_2 primarily enter the air as a result of fuel combustion, including motor vehicles, power plants, and industrial activities. Mean NO decreased by 32–46% or 2–3 ppb in Edmonton and Calgary. In smaller population centres, the results varied. The decreases ranged from 15%–72% or 3–4 ppb at some stations, while concentrations at Fort McMurray-Patricia McInnes and Lethbridge increased.

The mean NO_2 concentration decreased by 19–25% or approximately 3 ppb in central Edmonton and Calgary. In smaller population centres, as with NO, NO_2 results were mixed: the decrease in Lethbridge and Medicine Hat was less than 1 ppb and NO_2 concentrations increased at Fort McMurray-Patricia McInnes.

Figure 26 shows changes in NO and NO_2 concentrations across different times of day for Period A. Historically, NO and NO_2 concentrations peak during the morning commuter hours. Emissions at this time of day occur under the nocturnal boundary layer when atmospheric conditions typically do not promote dispersion. A similar peak is not observed for the afternoon commuter period as atmospheric mixing height during the afternoon is typically higher, thus more conducive to dispersion.

During the public health emergency, NO concentrations were reduced during Period A at several stations, particularly during the morning commuter hours; these reductions were statistically significant at nine stations. The provincial average reduction in 2020 NO concentrations during Period A reached 7.0 ppb at 7 a.m. MST. Edmonton Central saw the largest decrease but the observed change likely has contribution from long-term changes of NO at the station (section C). Work is ongoing to understand the impact of historical trends and meteorology on these results.

For NO_2, the greatest reductions in magnitude and the number of stations affected were observed between the hours of 6–8 a.m. MST. The maximum provincial average reduction in 2020 during Period A was 5.3 ppb and observed at 8 a.m. MST, albeit neighbouring hours also saw comparable reductions. Seven stations saw a statistically significant change in 2020 during this hour.

While 2020 reductions in NO_2 and to some extent NO were comparable for the two periods at some sites (e.g., Edmonton Central for NO_2 and Edmonton East for NO), others such as Calgary, Hinton, and Edson, observed larger reductions during Period A than Period B. NO and NO_2 concentrations for 2020 were lower at some sites for both Period A and B.

Ozone and to some extent $PM_{2.5}$ are secondary pollutants. Changes in the measured concentrations of secondary pollutants can be due to processes affecting atmospheric chemistry and dispersion, as well as availability of precursors. Peak ozone and

173 Article: Chan K and Wood R. 2013. *The seasonal cycle of planetary boundary layer depth determined using COSMIC radio occultation data*. Journal of Geophysical Research: Atmospheres.118(12):422-34. Available online: http://doi.wiley.com/10.1002/2013JD020147

$PM_{2.5}$ concentrations are often observed downwind from precursor sources, such as large urban centres.

Figure 27 shows the change in mean ozone concentrations for 2020 versus historical data in Period A. On average, 2020 ozone concentrations were higher in Period A for all stations except Medicine Hat, where concentrations increased by less than 1 ppb. Observations at Medicine Hat are likely complicated by an increasing trend in the historical ozone data. Mean 2020 ozone concentration increased by 5–36% or 2–11 ppb. Period A is markedly different than Period B, during which concentrations of ozone decreased in 2020 compared to historical data.

Figure 27 also shows the change in mean $PM_{2.5}$ concentrations for 2020 versus historical data in Period A. 2020 $PM_{2.5}$ concentrations were lower than historical data at all stations for at least one of the two periods, but more consistently for Period B. For data collected in Period A, $PM_{2.5}$ concentrations were 10–63% (1–3 $\mu g/m^3$) lower in 2020 at some stations. At Red Deer-Lancaster, Lethbridge, and Calgary SE this difference was negligible (<1 $\mu g/m^3$), and at other stations mean 2020 concentrations were higher.

Figure 28 shows ozone concentration changes throughout the day. Historically, ozone concentrations are the lowest during the morning commuter hours due to the abundance of NO_x at this time of day under the nocturnal boundary layer. Ozone concentrations tend to peak in the afternoon because of several factors, including availability of solar radiation that promotes photochemistry and meteorological conditions such as temperature and wind speed. Ozone concentrations in 2020 during Period A were on average higher for each hour of the day, but the largest increase in ozone was observed during the morning commuter hours (Figure 5). The provincial average increase in 2020 ozone concentrations was greater than 8.0 ppb between 4–7 a.m. MST.

Figure 28 also shows $PM_{2.5}$ concentrations across different times of day. Historical $PM_{2.5}$ is variable between stations. The highest concentrations were measured for Hinton and some hours in Edmonton East and Calgary Southeast. These stations are thought to be impacted by industrial activities. On average, a 1–3 $\mu g/m^3$ decrease in 2020 $PM_{2.5}$ concentrations are observed for many of the hours in Period A.

CO concentrations were evaluated; however, the interpretation of results is difficult due to the detection limit and a statistically significant historical trend at several sites. Diurnal evaluation resulted in statistically significant change (decrease of 100 ppb in 2020) at some stations during the morning commuter hours.

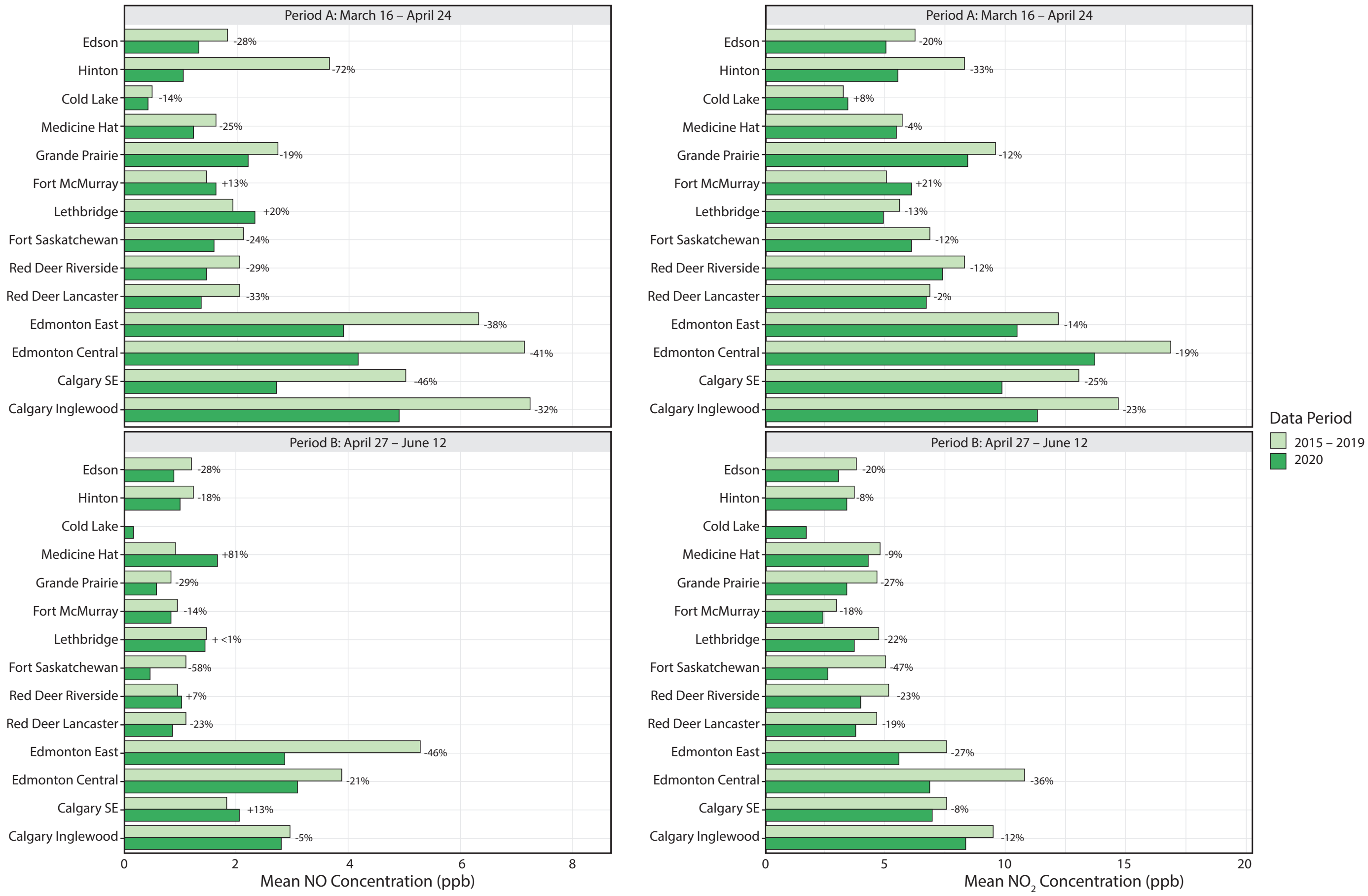


Figure 25: Change in mean NO and NO_2 concentrations during Period A

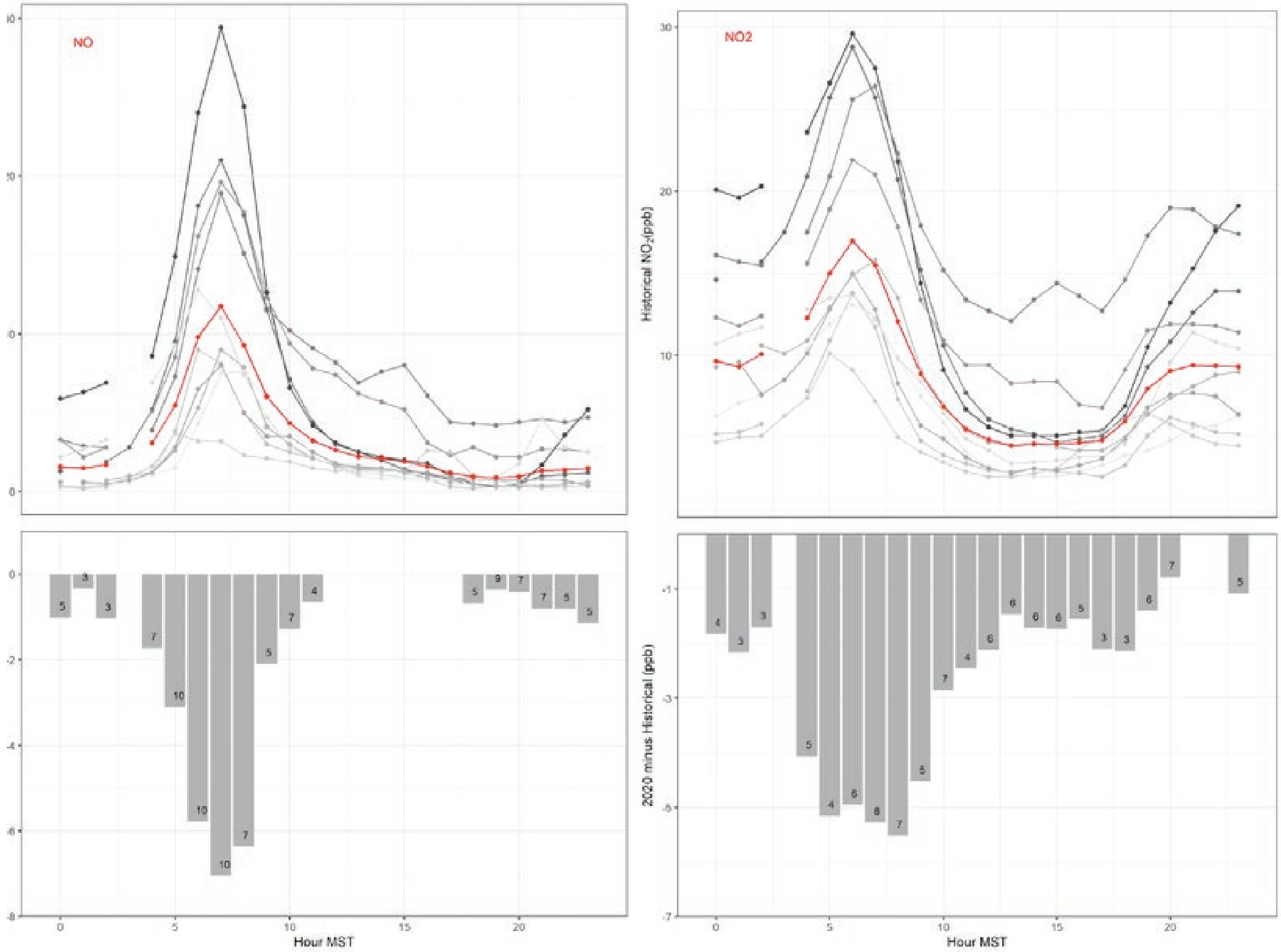


Figure 26: NO and NO_2 concentrations across different parts of the day during Period A. The red line represents the provincial average for historical concentrations. The bar chart indicates the provincial average decrease for each hour, determined using statistically significant changes. The numbers on the bar chart indicate the number of stations with 2020 data that were statistically different. The average changes (2020- Historical) are calculated when three or more stations reported statistically significant 2020 concentrations to illustrate broader scale observations.

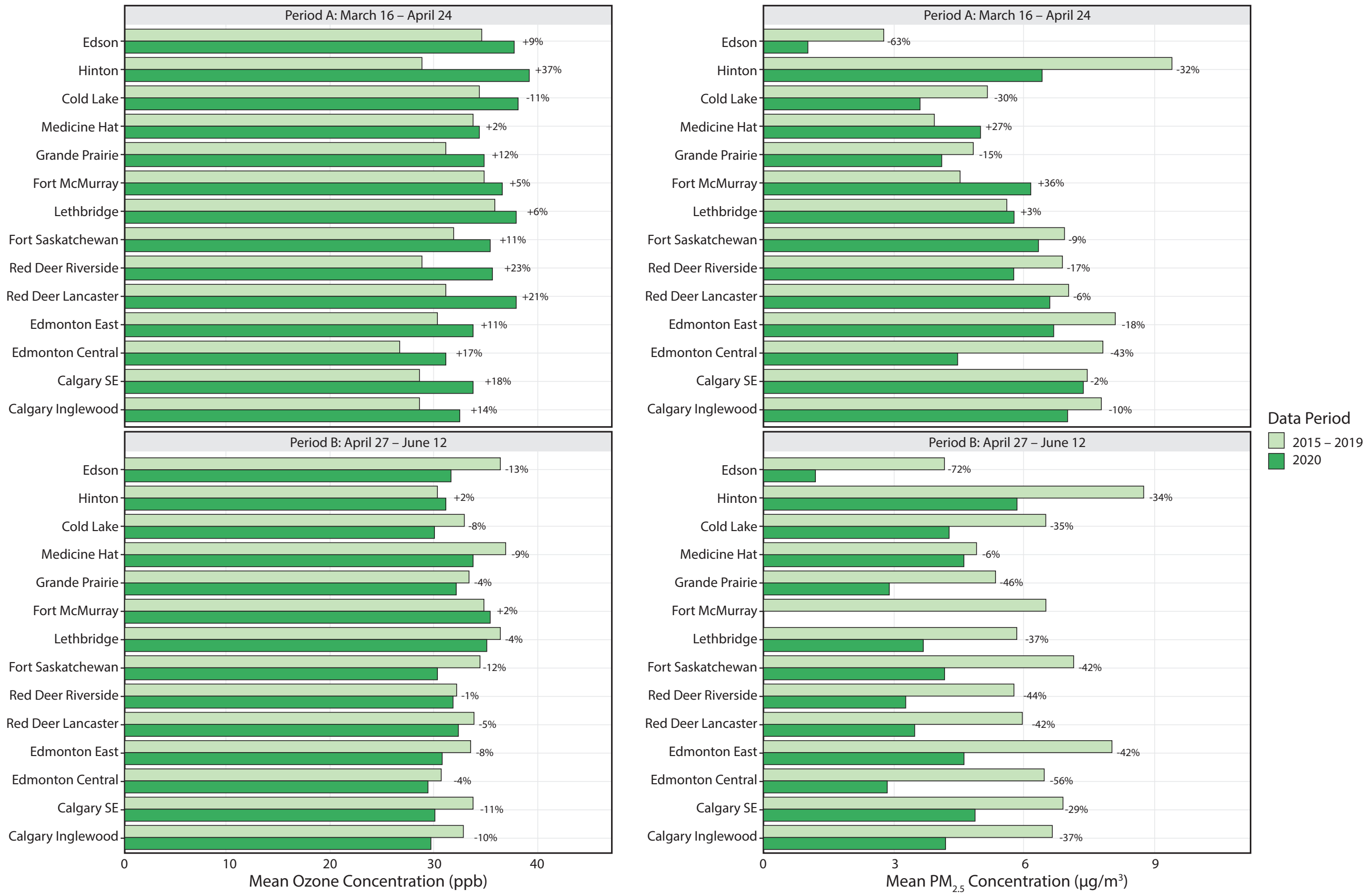


Figure 27: Change in mean ozone and $PM_{2.5}$ concentrations during Period A

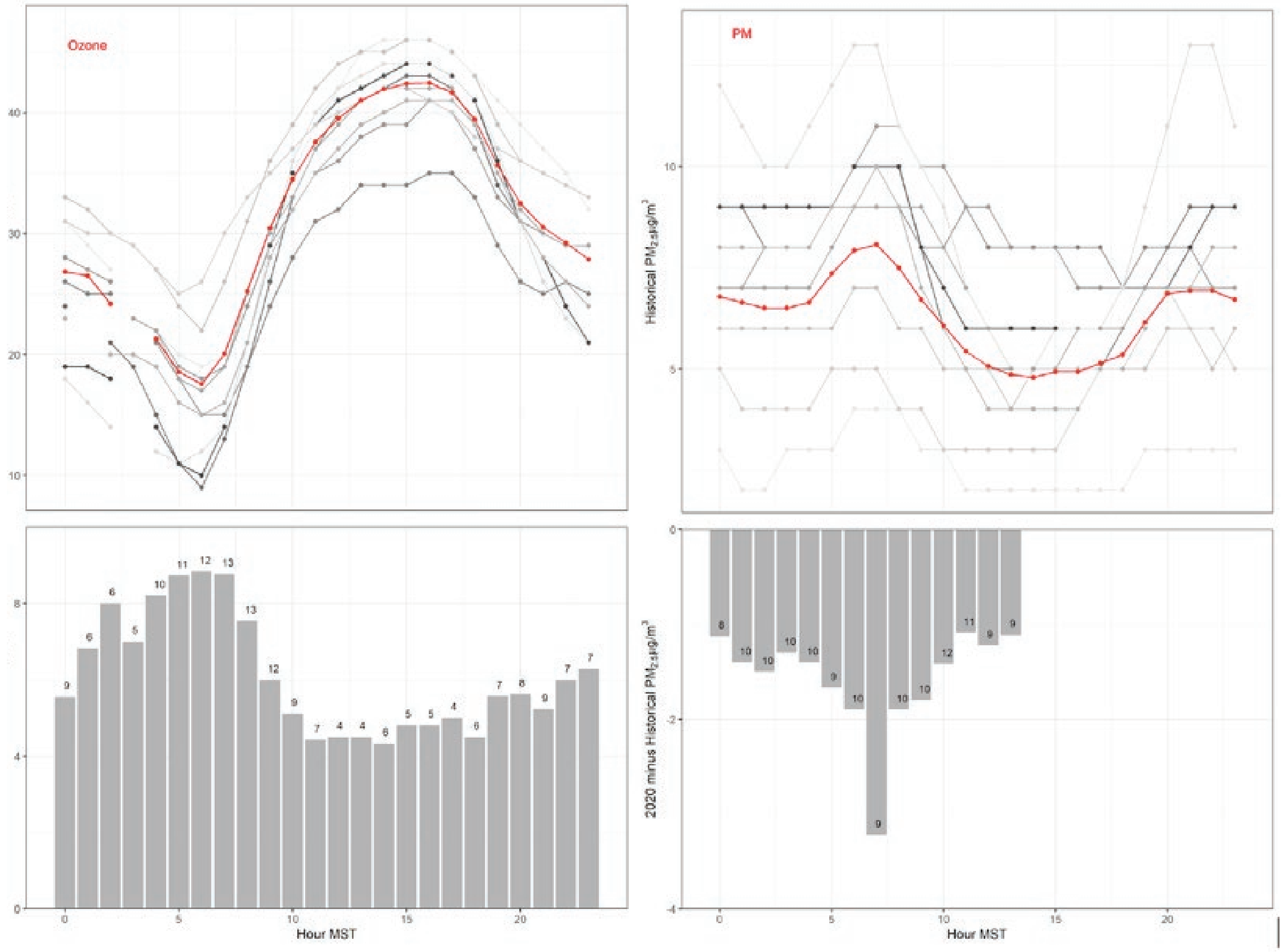


Figure 28: Ozone and $PM_{2.5}$ concentrations across different parts of the day during Period A. The red line represents the provincial average for historical concentrations. The bar chart indicates the provincial average increase (O_3) or decrease ($PM_{2.5}$) for each hour determined using statistically significant changes. The number on the bar chart indicates the number of stations with 2020 data that were statistically different. The average changes (2020-Historical) are calculated when three or more stations reported statistically significant 2020 concentrations to illustrate broader scale observations.

Study Limitations

Below is a list of limitations of the data and analysis conducted:

- The study examined traffic volume in urban thoroughfares which may not be representative of all activities on neighbourhood roads.
- The study examined traffic volume and did not account for type, age, or maintenance of vehicle, all of which can affect emissions.
- The study assumes that five years of data represents historically observed data. This is based on the need to include general year-to-year variability without the impact of long-term changes in emissions and monitoring technology or highly anomalous years.
- Period differential could not adequately be tested for significance. The study is instead relying on the reporting limit (the number of decimal places used when submitting data to Air Data Warehouse) to identify negligible differences.
- Although the presence of historical trends is evaluated, the extent to which these trends impact the changes observed in 2020 are still being examined.
- In this document, changes in atmospheric concentrations have been inferred to co-vary with change in traffic volume but a direct link between traffic and atmospheric concentrations has not been made.
- The impacts of meteorology on observed changes are still being evaluated and thus have not been reported.
- Analysis using predictive models to further help our understanding of how changes in traffic volume, meteorology, and historical trends have impacted the 2020 measured concentration is planned.

Data and Methods

Ambient air concentrations data

Hourly concentrations for select parameters from stations in urban settings throughout Alberta were downloaded from the Air Data Warehouse[174] between August 8–October 9, 2020. Table 4 lists the stations selected and parameters of interest available at the station. Parameters of interest were those thought to have contributions from or be affected by motor vehicle emissions including carbon monoxide (CO), oxides of nitrogen (NO, NO_2), ozone (O_3), and fine particulate matter ($PM_{2.5}$).

The study period included sample days between March 16–June 12, 2020. Data collected for the same dates between 2015–2019 were used as previously observed concentrations (hereafter referred to as historical data) for comparison. Informed by changes in spring 2020 traffic volume within Edmonton and Calgary, the study period is divided in two: Period A (March 16–April 24) and B (April 27–June 12). Weekends and holidays (Easter and Victoria Day) were removed from the sample. In addition, days where ambient concentrations were affected by events such as wildfire smoke and springtime ozone transport were removed from the historical data. The transboundary flow and exceptional event (TF/EE) days identified in previous CAAQS annual assessments were used to identify event days for removal.[175,176] All TF/EE days were removed from the study (all historical ambient air and traffic count data). There were no known wildfire smoke events during the study period in 2020. For any of the analysis outlined below, data were considered complete and included in the analysis if 75% of the possible data were valid and available.

Ambient air concentrations – comparison to historical data

The 2020 dataset was compared to the historical data using two methods: 1) period differential, where 2020 Period A or B is compared to historical data of the same period, and 2) diurnal comparison, where 2020 data is compared to historical data for each hour of the day. The period differential evaluation compared the mean, 25th, 50th, and 75th percentile measures for the 2020 data at each station to similar measures in the historical data. This comparison was conducted separately for Period A and B. For each evaluation, a two-tailed Mann Whitney Wilcoxon Test using the Wilcox.test function in R was used to determine whether the concentrations measured in 2020 had the same distribution as the historical data (i.e., from the same population).[177] The 2020 data were considered to be significantly different from historical data when $p \leq 0.05$. However, the sample size difference between historical and 2020 data (5:1) resulted in issues with statistical power which might have increased the type II error rate. In some cases, the difference between 2020 and historical data was found to be statistically insignificant even though there was strong evidence of a difference. This appendix presents period differences, using minimum reporting limits to illustrate negligible differences.

The diurnal evaluation compared the average 2020 concentration of each hour of the day with the corresponding average concentration determined using historical data. The historical dataset covers five years (2015–2019) and therefore has more data than the 2020 dataset. This creates an imbalance in the sample sizes if all the historical data are used for determining the hourly averages. Therefore, the historical average for each hour of the day was determined by first establishing the number of valid samples for each hour in the 2020 data. The historical

174 Webpage: Government of Alberta. 2022. *Air quality reports and data*. https://www.alberta.ca/air-quality-reports-and-data.aspx

175 Report: Brown C. 2018. *Alberta: Air Zones Report 2014-2016*. Government of Alberta, Ministry of Environment and Parks, ISBN 978-1-4601-4047-5. Available from: https://open.alberta.ca/dataset/684c673a-14a3-45b9-b5df-a158c8e83234/resource/0929eb23-9655-4046-b8df-0c0fc4e195fd/download/alberta-air-zones-report-2014-2016.pdf

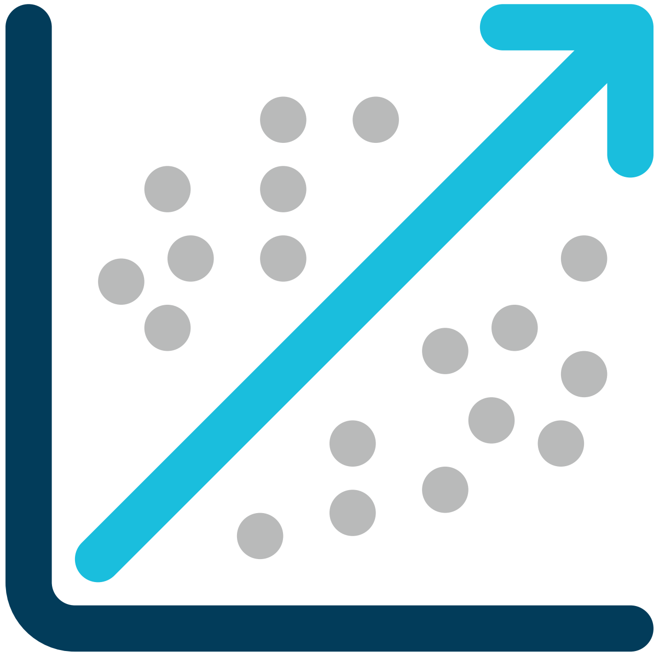
176 Report: Brown C. 2019. *Alberta: Air Zones Report 2015-2017*. Government of Alberta, Ministry of Environment and Parks, ISBN 978-1-4601-4569-2; 2019. Available from: https://open.alberta.ca/dataset/f7fc0a13-02e4-4d2b-818a-357154868bee/resource/1141144a-c7a5-4a93-8c32-5dca3f195054/download/aep-alberta-air-zones-report-2015-2017.pdf

177 Webpage: Core Development Team R. 2021. *A Language and Environment for Statistical Computing*. Vol. 2, R Foundation for Statistical Computing. Available online: http://www.r-project.org

data were sampled so the number of samples for each hour in the historical subsample was the same as the number of valid samples in the 2020 data. A return bootstrap resampling technique was used to sample the historical data 1,000 times and the average concentration of each hour of subsample was determined. This resulted in 1,000 diurnal concentration distribution. The overall average concentration and 95% confidence interval (CI) for each hour were determined and compared to 2020 data values. 2020 values that were outside the 95% (CI) were deemed significantly different from historical data.

Ambient air concentrations – historical trend analysis

To determine whether observations in the spring 2020 were affected by a trend in the historical springtime concentrations at a particular station, trend analysis was conducted. The Mann Kendall-TheilSen approach with the TheilSen function in the R openair package was used to estimate and test the springtime trend in the historical data.[178] This evaluation provided the slope (% change/year) and 95% CI. Monthly average concentrations for March–June for each year between 2015–2019 (n=20) were used to conduct trend analysis. This method determined the average historical trend for the months of March–June (Period A and B combined). Only months with valid data for at least 75% of sample hours were used in the trend analysis. The stations and parameters included in the analysis are shown in Table 4.



178 Webpage: Core Development Team R. *openair: Tools for the analysis of air pollution data.* https://cran.r-project.org/package=openair

Table 4: Stations and parameters included in the analysis

Station	CO	NOx	$PM_{2.5}$	O_3	Urban centre1	Date downloaded
Calgary Southeast	✔	✔	✔	✔	Large2	2020-09-15
Calgary Central-Inglewood	✔	✔	✔	✔	Large	2020-08-28
Cold Lake South	✘	✔	✔	✔	Small	2020-08-28
Edmonton Central	✘	✔	✔	✔	Large	2020-09-08
Edmonton East	✔	✔	✔	✔	Large2	2020-09-08
Edson	✘	✔	✔	✔	Small	2020-09-08
Fort Saskatchewan	✔	✔	✔	✔	Medium	2020-09-08
Grande Prairie-Henry Pirker	✔	✔	✔	✔	Medium	2020-09-08
Hinton	✘	✔	✔	✔	Small	2020-09-15
Lethbridge	✔	✔	✔	✔	Medium	2020-09-08
Medicine Hat-Crescent Heights	✔	✔	✔	✔	Medium	2020-09-08
Fort McMurray-Patricia McInnes	✔	✔	✔	✔	Medium	2020-10-09
Red Deer-Lancaster	✔	✔	✔	✔	Medium	2020-09-21
Red Deer-Riverside	✔	✔	✔	✔	Medium	2020-09-08

1: Urban centre classification is informed by the Five-year Air Quality and Deposition Monitoring Evaluation and Reporting Plan (Large population>100,000; Medium population between20,000-100,000; small population <20,000).

2: Anticipated to have significant contribution from industrial emissions sources.

Vehicle count

Automated Traffic Recorders are deployed by Alberta Transportation to count vehicles on major thoroughfares. Hourly vehicle counts were downloaded from the Alberta Transportation Traffic Data Map[179] between August 31, 2020– February 18, 2021. There are several traffic counters located within each urban centre in this study, with more traffic counters in large communities. For each air monitoring station in Table 4, a traffic counter with valid data during the 2015–2020 study period was selected as representative of traffic near the monitoring station. The distance between the location of the traffic counter and the associated air monitoring station is given in Table 5. Traffic counters were selected based on the following criteria:

- the counter records some of the highest traffic volumes in the urban centre
- if possible, the counter is the closest to the air monitoring station
- if possible, the counter is on a road used to get in and out of the area housing the air quality monitoring station

179 Webpage: Alberta Transportation. 2022. *Traffic data mapping.* http://www.transportation.alberta.ca/mapping/

The data used consisted of one-hour weekday vehicle counts. Vehicle count data were analyzed using the same method used for ambient air concentrations. The data completeness threshold for vehicle count was lowered from 75% to 50% so that most sites could be included in the analysis; the vehicle counter at Fort Saskatchewan did not meet the 50% data completeness threshold and was excluded. A bootstrap analysis was used to examine the distribution of the traffic count data as well as the concentration of ambient air quality parameters. The results indicated that traffic count data were less variable (narrower 95% CI) than ambient air concentrations, and the possible reduced sample size of traffic count data due to the lower data completeness criterion should not affect the representativeness of the results at these locations.

Table 5: Stations and associated Automated Traffic Recorders (name used to label data in figures when different from station name)

Air Quality Stations	Automated Traffic Recorder (ATR Number)	Distance and direction of ATR from air quality station	Date downloaded
Calgary Southeast (Calgary II)	60021530	4.3 km W	2020-09-23
Calgary Central-Inglewood (Calgary I)	60021520	0.8 km E	2020-09-23
Cold Lake South	50551850	4.8 km N	2020-09-18
Edmonton Central (Edmonton I)	60160620	10.2 km W	2020-09-02
Edmonton East (Edmonton II)	61602068	1.6 km E	2021-02-18
Edson	50160650	11.0 km W	2020-09-18
Fort Saskatchewan	50150410	1.4 km NW	2020-09-18
Grande Prairie-Henry Pirker (Grande Prairie)	50430330	1.6 km SW	2020-09-02
Hinton	5016260	1.5 km SE	2021-02-18
Lethbridge	50030920	2.1 km S	2020-08-31
Medicine Hat-Crescent Heights (Medicine Hat)	50012140	2.5 km SW	2020-08-31
Fort McMurray-Patricia McInnes (Fort McMurray)	60631210	4.0 km NE	2020-08-31
Red Deer-Lancaster (Red Deer I)	50111220	9.4 km NW	2020-08-31
Red Deer-Riverside (Red Deer II)	60201818	3.5 km NW	2020-08-31

Results

Changes in vehicle count

Figure 29 shows the period differential in traffic count between 2020 and the historical data. At all but one traffic counter, 2020 vehicle counts during Period A and B were lower than historical counts for the same period. The exception was weekday vehicle counts in Edmonton II located in east Edmonton where 2020 weekday counts were higher than historical data during Period B. The traffic count on this road was affected by construction of the northeast section of the Anthony Henday Drive freeway pre-2017, making the historical traffic weekday count lower than expected. Edmonton II will be removed from the final discussions. Comparisons were not possible for counts from automated traffic counters located in Cold Lake (Period B) and Fort Saskatchewan (Period A and B) because there were insufficient data (available data was less than 50%).

The average 2020 weekday hourly traffic count for Period A was lower than the historical count by 61 (in Hinton) to more than 2,500 (at Calgary I), a 25–41% decrease. The decrease in 2020 weekday hourly traffic count was smaller in Period B and ranged from 24 (Hinton) to 1,820 (Calgary A), a 10–30% decrease. The 2020 decrease in average weekday hourly traffic vehicle count was notably larger for Edmonton and Calgary; at all other urban centres the difference was less than 500 vehicles (Figure 29).

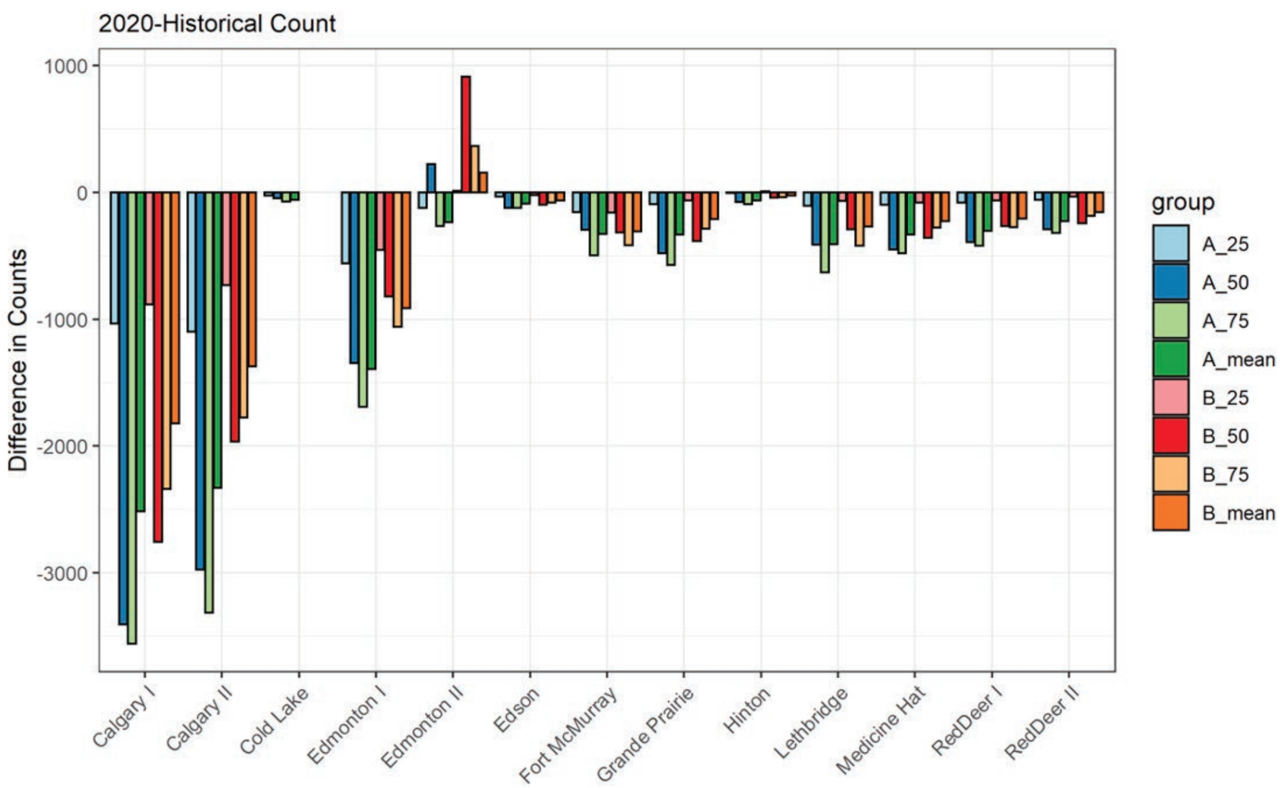


Figure 29: Traffic count difference between 2020 and historical data (2015–2019). The differences were calculated for 25th, 50th, and 75th percentile and mean (average) traffic counts, for Period A and B. Comparisons were not possible for automated traffic counts in Cold Lake South (Period B) and Fort Saskatchewan (Period A and B) due to insufficient data (available data <50%).

Historically, weekday traffic count during Period A did not noticeably differ from Period B. Within larger urban centres, traffic count peaked in the morning and afternoon and to some extent during the middle of the day. Roads in smaller centres had increasing counts throughout the morning, peaking in the late afternoon.

The historical diurnal breakdown of traffic count differences are shown in Figure 30, Figure 31, and Figure 32. The comparisons fall into two groups based on common patterns of traffic counts throughout the day in the historical data.

The first group had a noticeably higher weekday traffic count during the morning (7–9 a.m. MST) and afternoon (4–6 p.m MST) commuter hours. This group included weekday traffic counts in large urban centres like Edmonton and Calgary (Figure 30) and other urban centres of Lethbridge, Medicine Hat, Red Deer, Cold Lake, and Fort McMurray (Figure 31). The differences between historical and 2020 weekday traffic count for this first group were larger for the commuter hours, although vehicle counts throughout the day were lower in 2020. The decrease in 2020 weekday vehicle count was markedly larger during period A than B.

The second group included traffic counts at Edson, Grande Prairie, and Hinton, and had historical vehicle counts that gradually increased, starting in the early morning and peaking in the late afternoon (Figure 32). At these stations, the 2020 weekday traffic count was lower than historical, particularly for Period A, with the largest difference observed during late afternoon.

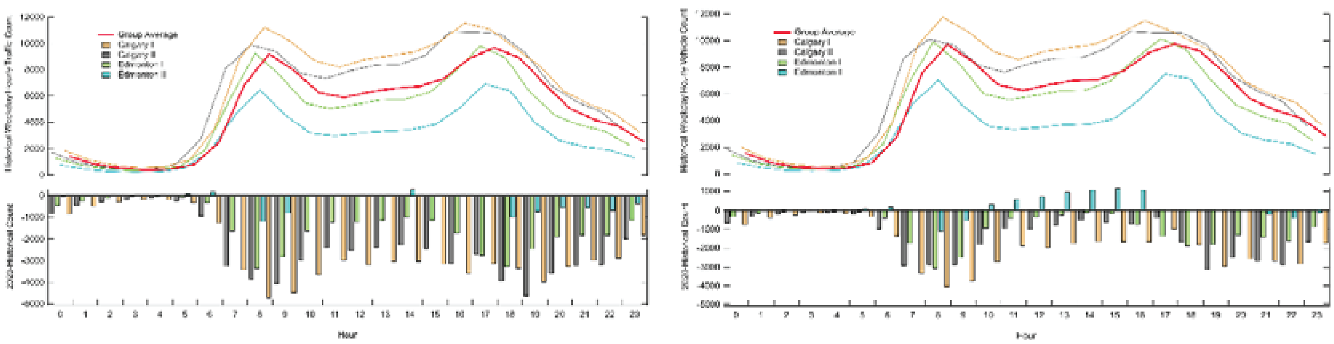


Figure 30: Historical diurnal traffic variation and difference from 2020 counts for Edmonton and Calgary during Period A (left) and B (right). Time indicated in MST. Historical data at Edmonton II is likely impacted by construction of northeast section of the Anthony Henday Drive freeway.

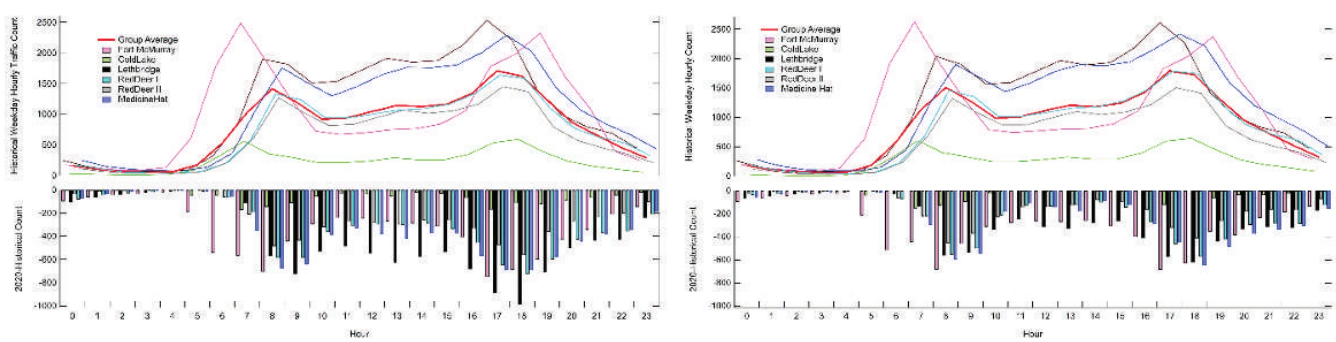


Figure 31: Historical diurnal traffic variation and difference from 2020 counts for smaller urban centres during Period A (left) and B (right); time indicated in MST

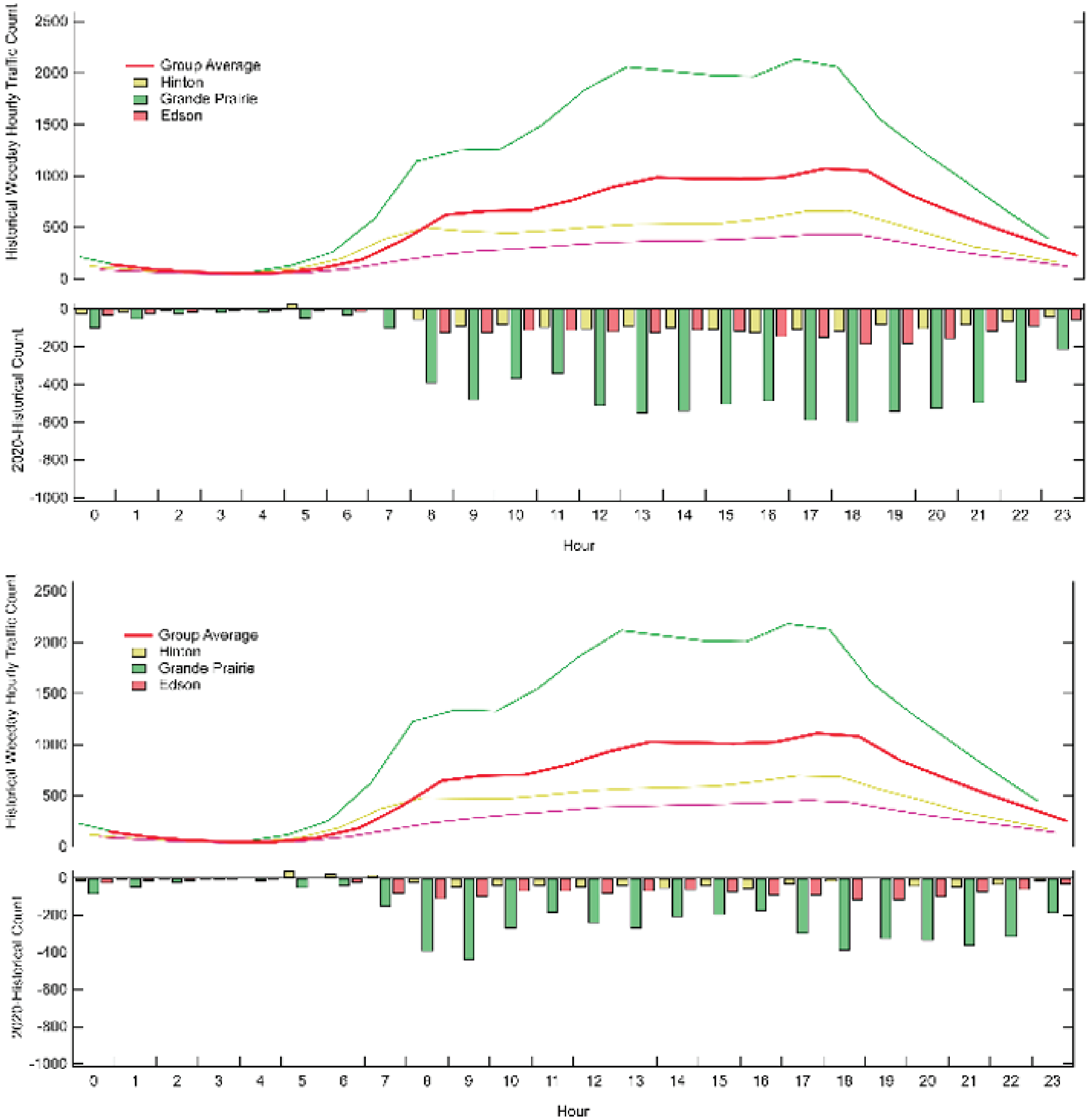


Figure 32: Historical diurnal traffic variation and difference from 2020 counts for Hinton, Grande Prairie, and Edson during Period A (top) and B (bottom); time indicated in MST

Changes in ambient air concentrations

Nitric oxide

Figure 33 illustrates the period differential comparison for NO. NO concentrations in 2020 were generally lower than historical data. A difference in at least one statistical measure was observed at all the stations. The largest differences in Period A were for the mean and 75th percentile concentrations. The Period A mean differential for stations in Edmonton, Calgary, and the Hinton station were greater than 2 ppb. Stations in Red Deer, Edson, Grande Prairie, and Fort Saskatchewan saw a Period A mean decrease of less than 1 ppb but greater than 0.5 ppb. Decreases in Medicine Hat and Cold Lake were negligible (<0.5 ppb) and increases in Period A mean differential were observed at Fort McMurray-Patricia McInnes and Lethbridge. A decreasing historical trend for NO concentrations was observed for data collected at Edmonton Central and Lethbridge. Therefore, the decrease in 2020 NO concentrations at Edmonton Central may partly be explained by this historical trend. The area near the station has undergone significant construction and development of high rises and a new arena since 2015; emissions in the area have likely changed as a result. For Period B, a 2020 decrease greater than 1 ppb in period mean differential is only observed in Edmonton. Some 2020 statistical measures for data collected during Period B at Calgary Southeast, Lethbridge, and Medicine Hat were higher than historical, but these differences were less than 1 ppb. This indicates that despite the traffic reduction on roads managed by Alberta Transportation, 2020 NO concentrations at some sites were (a) negligibly different from historical data or (b) marginally higher than historical data.

The diurnal comparison results for Period A and B were markedly different, as shown in Figure 34 and Figure 35. Historically, NO concentrations have an observed peak between 5–8 a.m. MST, likely due to morning commuter traffic. Historical peak concentrations are higher during Period A than B, due to lower boundary layer during the cooler evenings and mornings of March and April.

As illustrated in Figure 34, the largest differences between 2020 and historical data for Period A were for concentrations measured during the morning commuter period. There was no obvious clustering of comparison results between large urban and small urban sites. On average, at Calgary Southeast, Calgary Inglewood, Edmonton Central and Hinton, 2020 concentrations during the morning commuter hours were at least 10 ppb lower than observed historically.

The changes in Edmonton and Calgary are likely associated with changes in commuter traffic. Hinton is considered a smaller urban centre and did not seem to have notable morning commuter traffic. The peak concentration differences for larger urban centres were between 6–8 a.m. MST; for smaller urban centres the largest differences, when significant, were between 5–7 a.m. MST. Some sites like Lethbridge and Grande Prairie also saw a higher 2020 NO concentration (up to 3.8 ppb) at midday and afternoon hours relative to the historical data.

For Period B, daily differences between 2020 and historical data were lower compared to Period A or were not statistically significant (Figure 34). Higher Period B traffic in 2020, in conjunction with a higher mixing height for that time of year, likely contributed to the observations. Stations such as Edmonton Central continued to have lower 2020 concentrations of up to 8 ppb in the morning commuter period, while 2020 late morning and midday concentrations were higher at Lethbridge, Medicine Hat, and Edmonton Central. Stations that had no negligible period differential between 2020 and historical data either had a minimal diurnal difference (Cold Lake South) or had differences for a limited number of hours (Red Deer-Lancaster and Riverside).

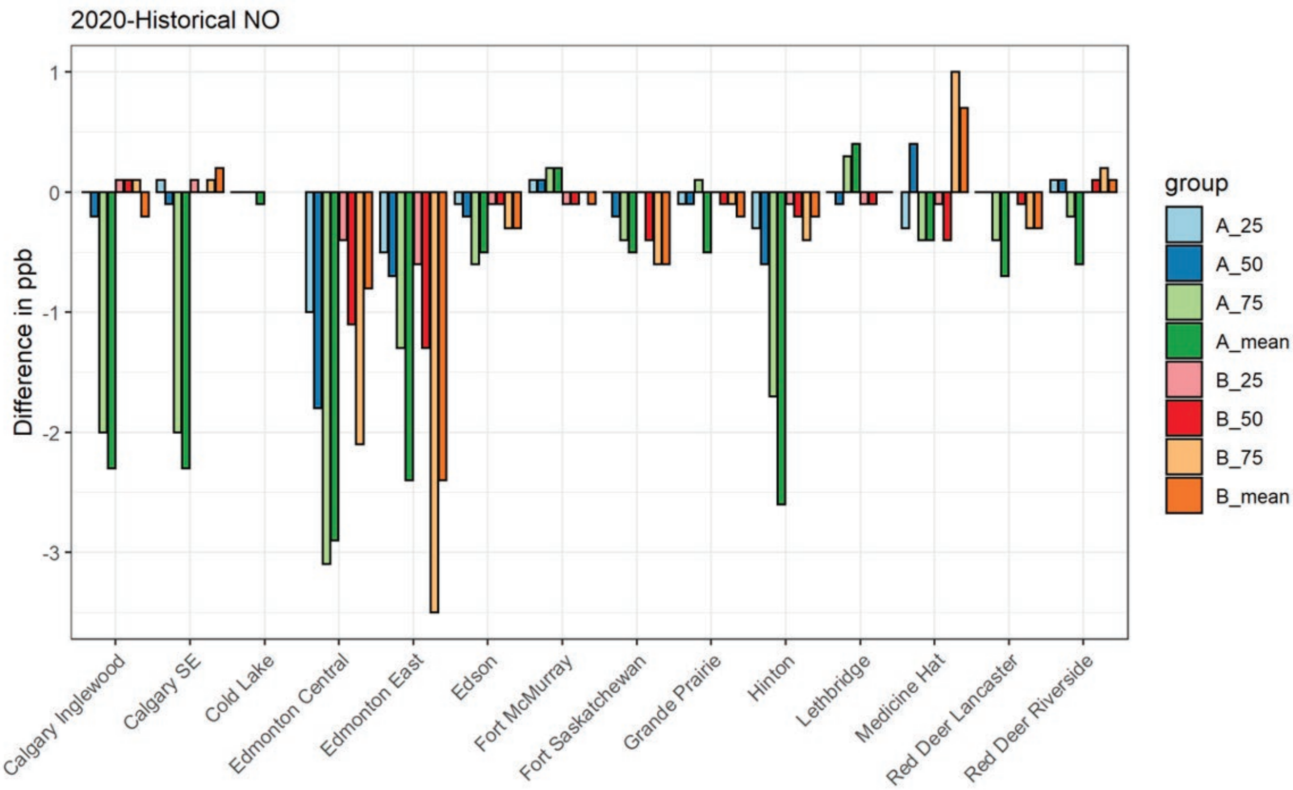
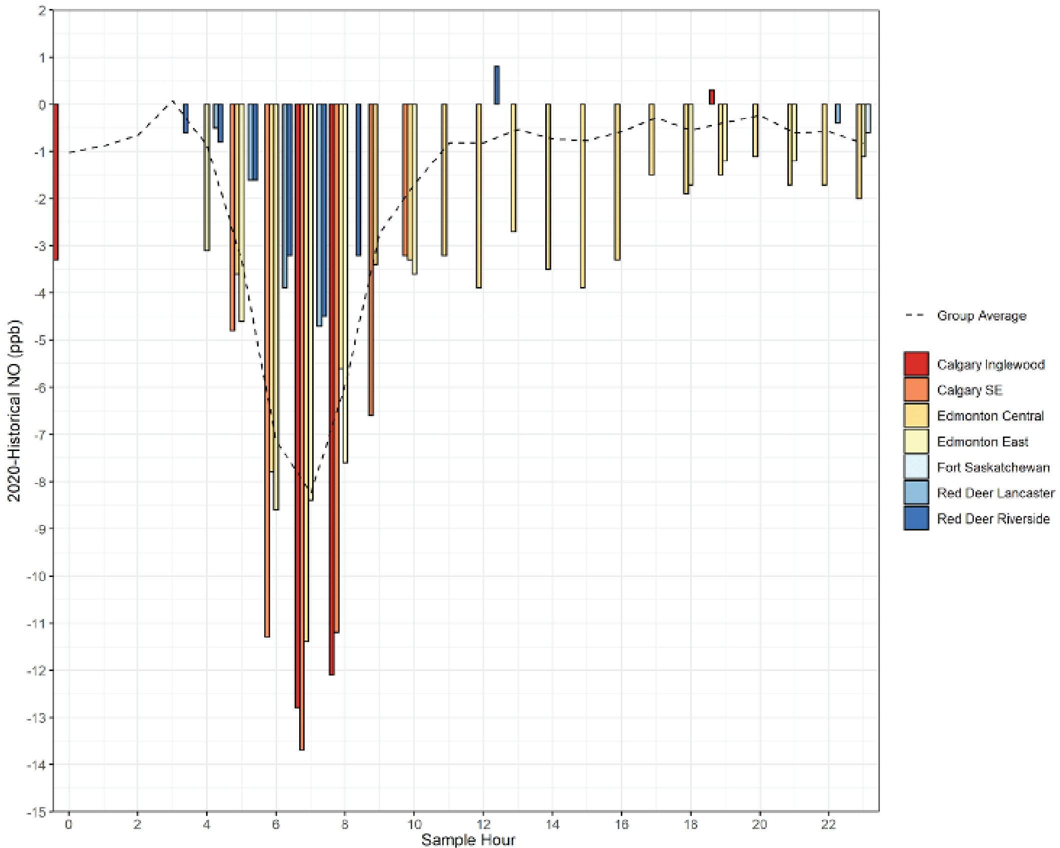


Figure 33: The difference for NO concentrations measured in 2020 and historical data (2015–2019). The differences were calculated for 25th, 50th, and 75th percentile and mean concentrations. These were done for Period A and B.



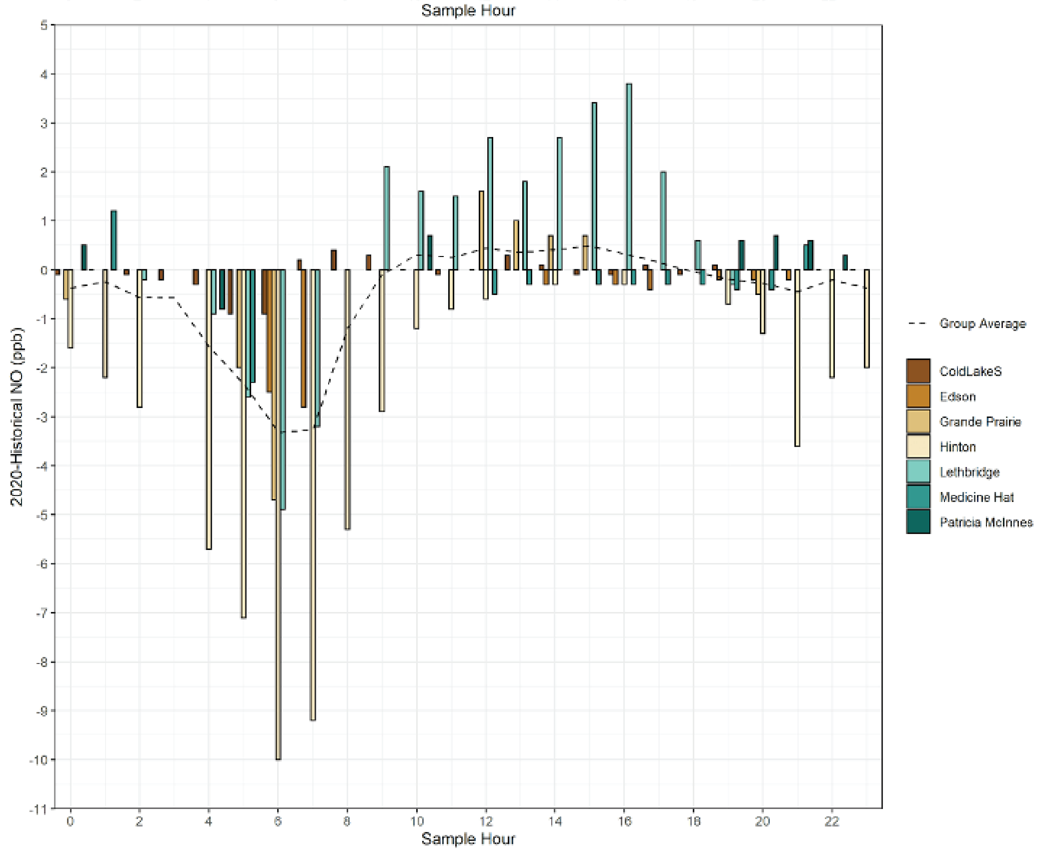
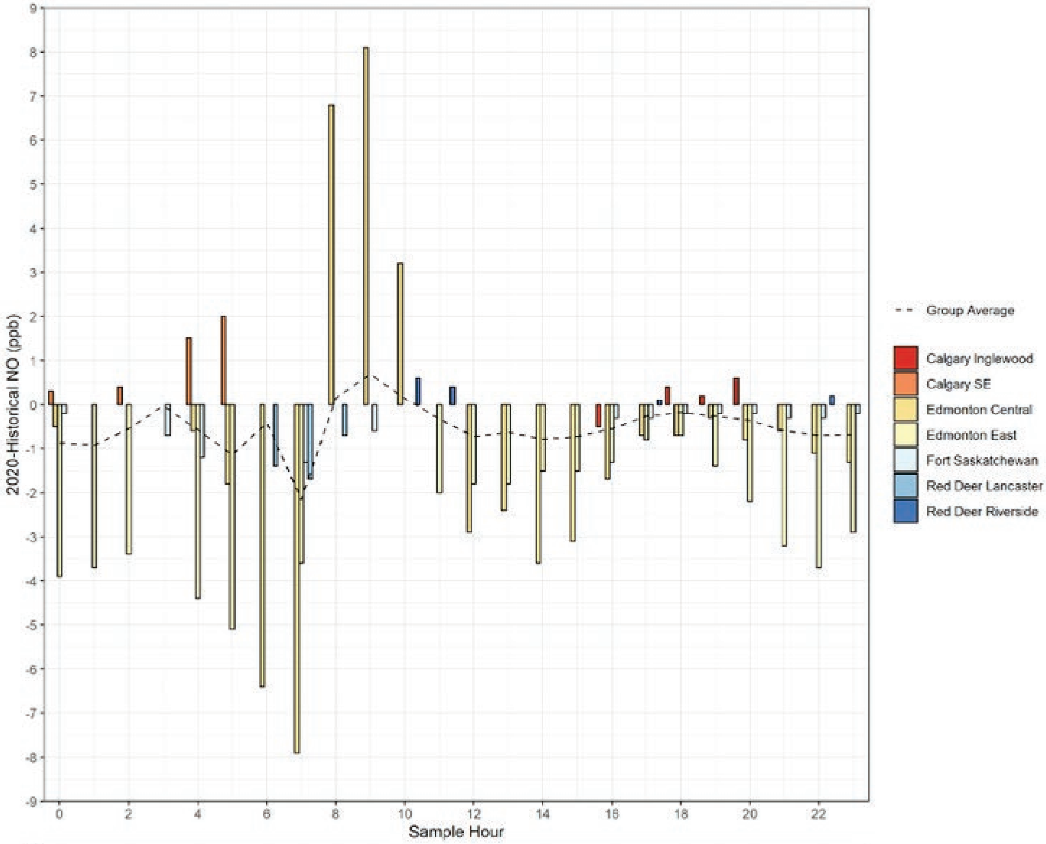


Figure 34: Comparison between 2020 and historical 24-hr variation of NO concentrations for Period A. For clarity, the stations were grouped in two. The bars included are for significant differences (2020 data is outside 95% CI of historical data). The dotted line is the mean of all observed differences for the group. Time is indicated in MST.



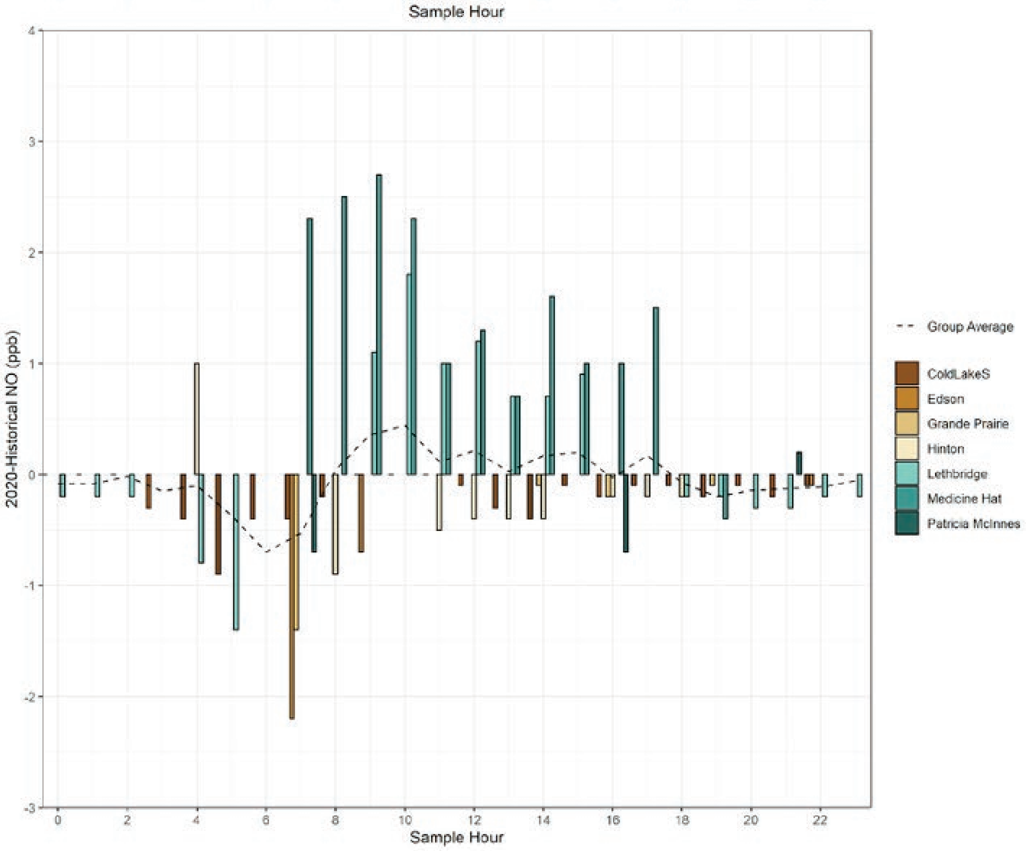


Figure 35: Comparison between 2020 and historical 24-hr variation of NO concentrations for Period B. For clarity the stations were grouped in two. The bars included are for differences that were significant (2020 data is outside 95% CI of historical data). The dotted line is the mean of all observed differences for the group. Time is indicated in MST.

Nitrogen Dioxide

Figure 36 shows the period differential for NO_2. A period differential between 2020 and historical NO_2 concentrations was observed at 13 of the 14 stations. At select stations such as Calgary Inglewood, Calgary Southeast, and Hinton, the period differential showed a larger decrease in NO_2 during Period A than during Period B. At Edmonton Central, Edmonton East, Edson, and Grande Prairie, the difference between 2020 and historical concentrations were comparable between the two periods. The mean 2020 NO_2 concentrations were 3.4 ppb (Calgary Inglewood) to 0.1 ppb (Red Deer-Lancaster) lower than historical data in Period A for stations that showed a decrease. The mean 2020 concentrations at Patricia McInnes and Cold Lake South were slightly higher (≤1.0 ppb) than historical data in Period A. The mean 2020 NO_2 concentrations were 4.0 ppb (Edmonton Central) to 0.3 ppb (Hinton) lower than historical data in Period B. The differences in 75th percentile concentrations were larger (up to 9.4 ppb) or equivalent to the differences in the mean concentration, in both Period A and B. This indicates that elevated concentrations historically observed at some sites were absent or lower in 2020.

Figure 37 and Figure 38 show the diurnal comparison for Period A and B. Historically, NO_2 concentrations peak between 5–8 a.m. MST and as the nocturnal boundary layer forms. Much like NO, the largest differences between 2020 and historical data were during the morning commuter hours, and in some cases the evening and early morning hours. For Period A, all stations in large urban centres saw a decrease in 2020 concentrations during commuting hours. During Period B, more urban centres saw decreases in 2020 concentrations, although the magnitude of the differences were smaller. On average, the mean 2020 concentrations were 8.7 to 2.8 ppb lower than historical between the hours of 5–8 a.m. MST during Period A. During Period B, the difference ranged between 8.9 to 0.7 ppb.

Clear diurnal trends were evident where the largest period differentials were observed, with the greatest difference being observed during the morning commuter hours. For stations like Medicine Hat and Cold Lake South, where period differential was negligible, 2020 concentrations were marginally lower for several hours of the day, most notably during Period B.

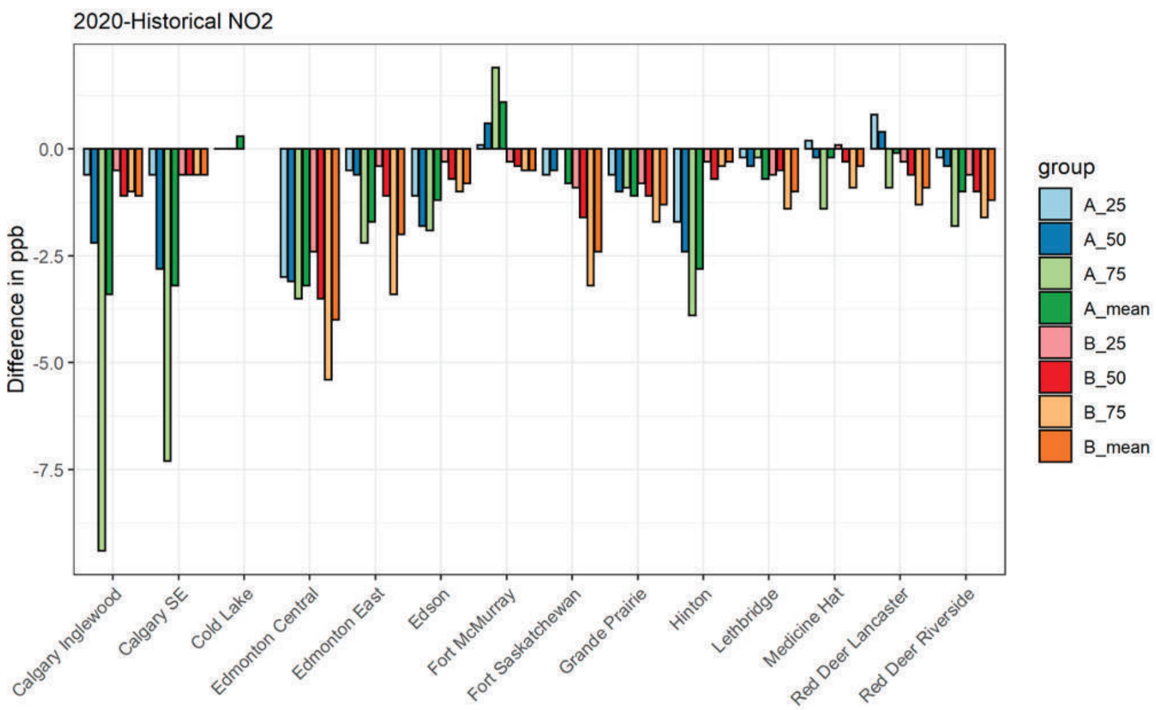


Figure 36: The difference between NO_2 concentrations measured in 2020 and historical data (2015–2019). The differences were calculated for 25th, 50th, and 75th percentile and mean concentrations for Period A and B.

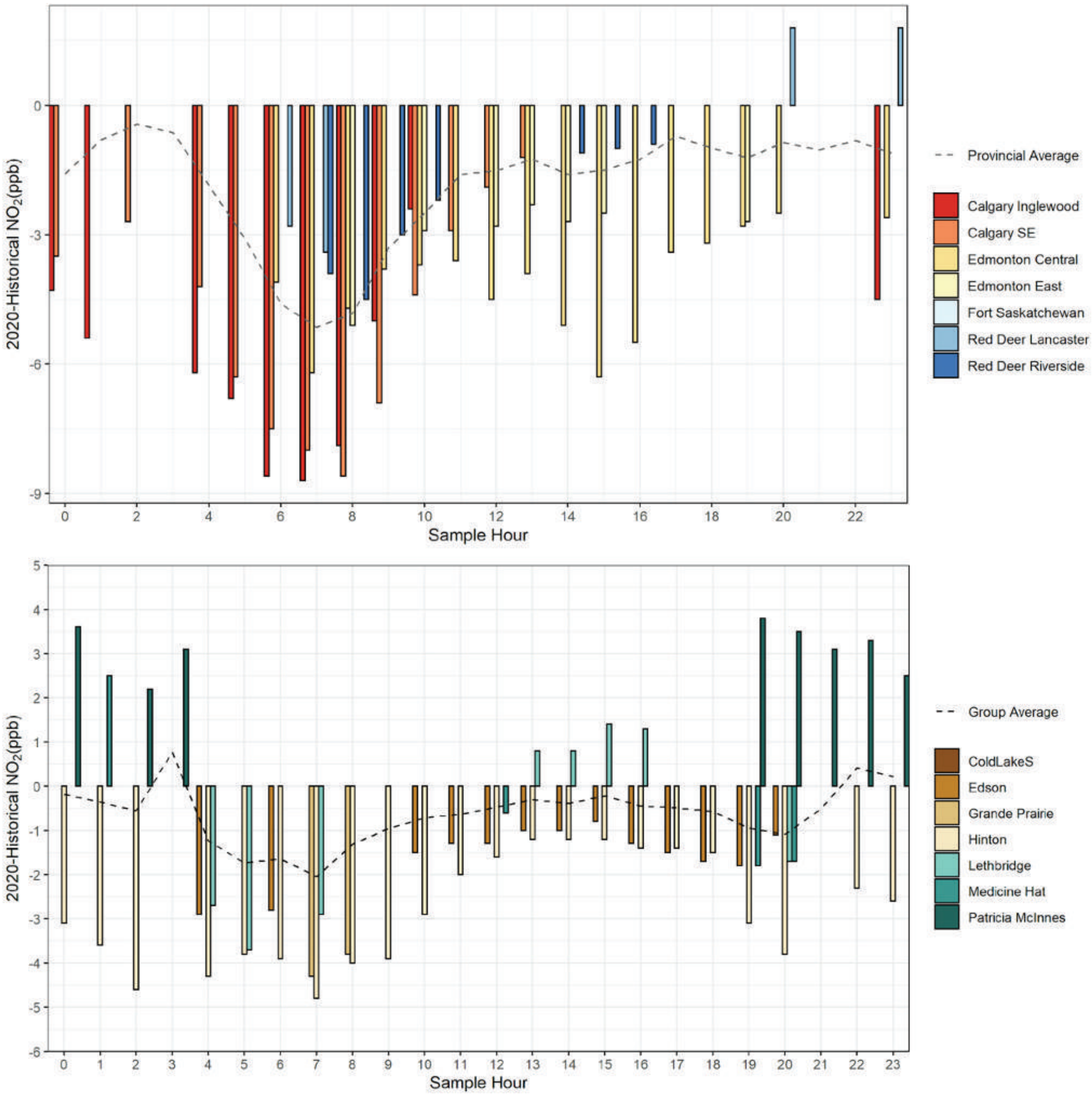


Figure 37: Comparison between 2020 and historical 24-hr variation of NO_2 concentrations for Period A. For clarity the stations were grouped in two panels. The bars included are for differences that were significant (2020 data is outside 95% CI of historical data). The dotted line is the mean of all observed differences for the group. Time is indicated in MST.

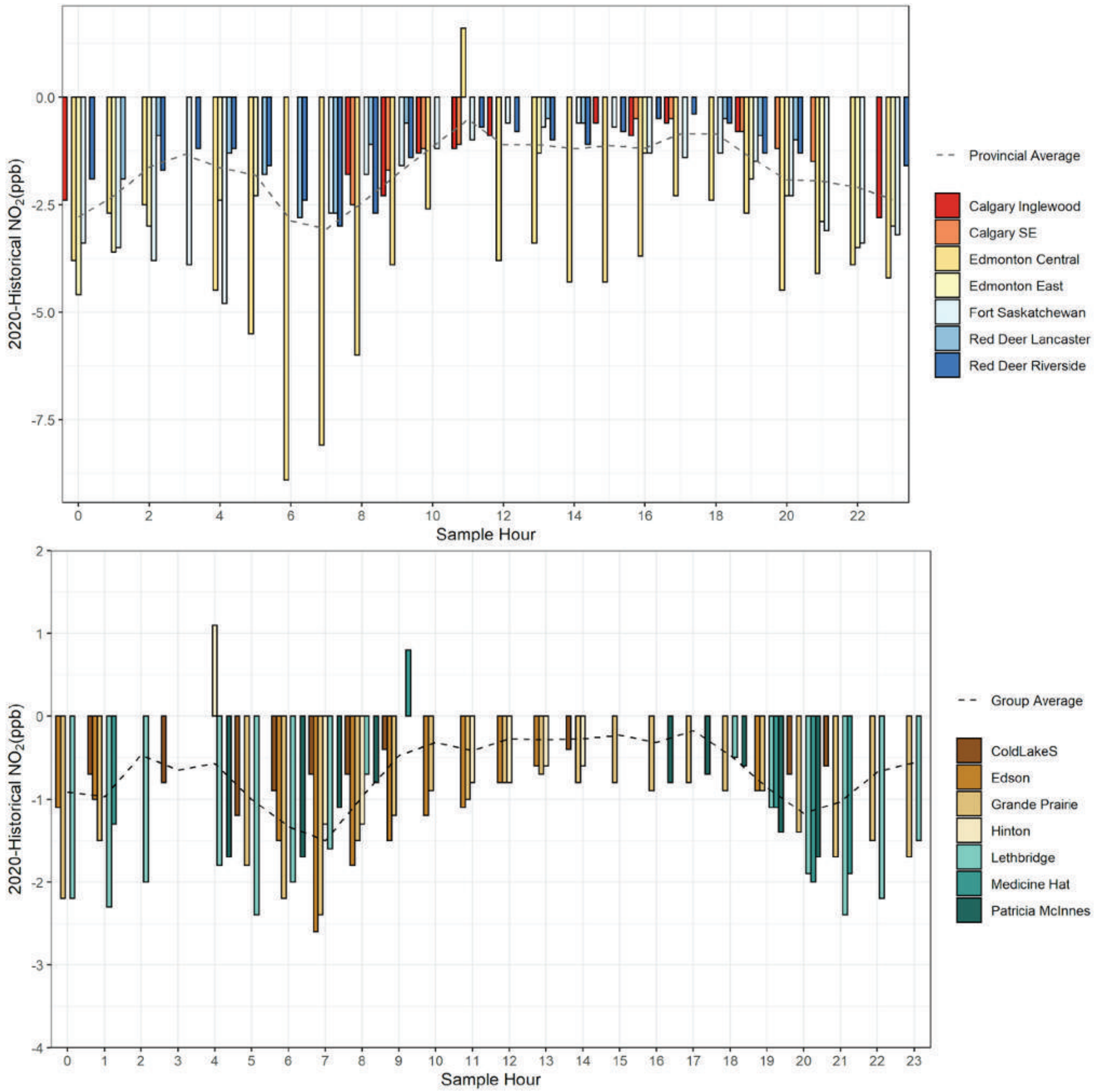


Figure 38: Comparison between 2020 and historical 24-hr variation of NO_2 concentrations for Period B. For clarity the stations were grouped in two. The bars included are for differences that were significant (2020 data is outside 95% CI of historical data). The dotted line is the mean of all observed differences for the group. Time is indicated in MST.

Ozone

Figure 39 shows the period differential for ozone. During Period A, 2020 concentrations were higher than historical, with mean 2020 concentrations 1.8 to 10.5 ppb higher than the mean historical data. The larger differences were observed at Hinton and stations within Red Deer. Differences were observed for all statistical measures but most notably for the 25th percentile, where a difference of 18 ppb was noted at Hinton station; this station also saw a notable NOx reduction (for its population size) during Period A. Increase in the 25th percentile illustrates that sample hours with historically lower ozone concentrations (morning commuter hours) in 2020 had higher ozone concentrations than the historical data. During Period B, 2020 concentrations were lower than historical data, most notably for 75th percentile concentrations; in other words, when ozone concentrations were historically higher (i.e., midafternoon), concentrations in 2020 were not as high. Larger reductions are observed at smaller centres such as Edson and Fort Saskatchewan. The mean 2020 ozone concentrations were 4.6 to 1.2 ppb lower than historical. The difference in the 75th percentile was up to 8 ppb (Edson station).

The diurnal comparison is shown in Figure 40 for Period A. The larger differences between 2020 and historical data for O_3, much like NO and NO_2, were during the morning commuter period, with 2020 ozone concentrations 4 to 18 ppb higher between the hours of 6–8 a.m. MST. Typically, at this time of day, ozone concentrations are the lowest due to NOx titration. This is consistent with the observed decrease in the 25th percentile O_3 in the differential plots. The higher O_3 concentrations observed in 2020 are likely due to lower NO and/or NO_2 and reduced titration during this period.

The diurnal comparison for Period B is different, as shown in Figure 41. Historically, afternoon concentrations are higher during Period B indicating higher photochemical O_3 production during this time than earlier in the spring. The largest differences were observed in the midafternoon with mean increases ranging from 3 to 8 ppb. This is consistent with the observed increase in 75th percentile O_3 in the period differential for Period B. Where a negligible (<1 ppb) period differential is observed in Period B (Hinton, Patricia McInnes, and Red Deer-Riverside), diurnal comparisons were largely insignificant. The exception is where 2020 concentrations were higher for a few hours in the morning (Patricia McInnes and Hinton) similar to observations during Period A. Lower 2020 concentrations during Period B may be due to a limiting factor in the photochemical process. For example, a change in the availability of NOx and/or volatile organic compounds, solar radiation, or differences in temperature and/or wind speed. Ozone formation typically peaks away from large urban centres and may explain the larger reductions at stations like Edson and Fort Saskatchewan.

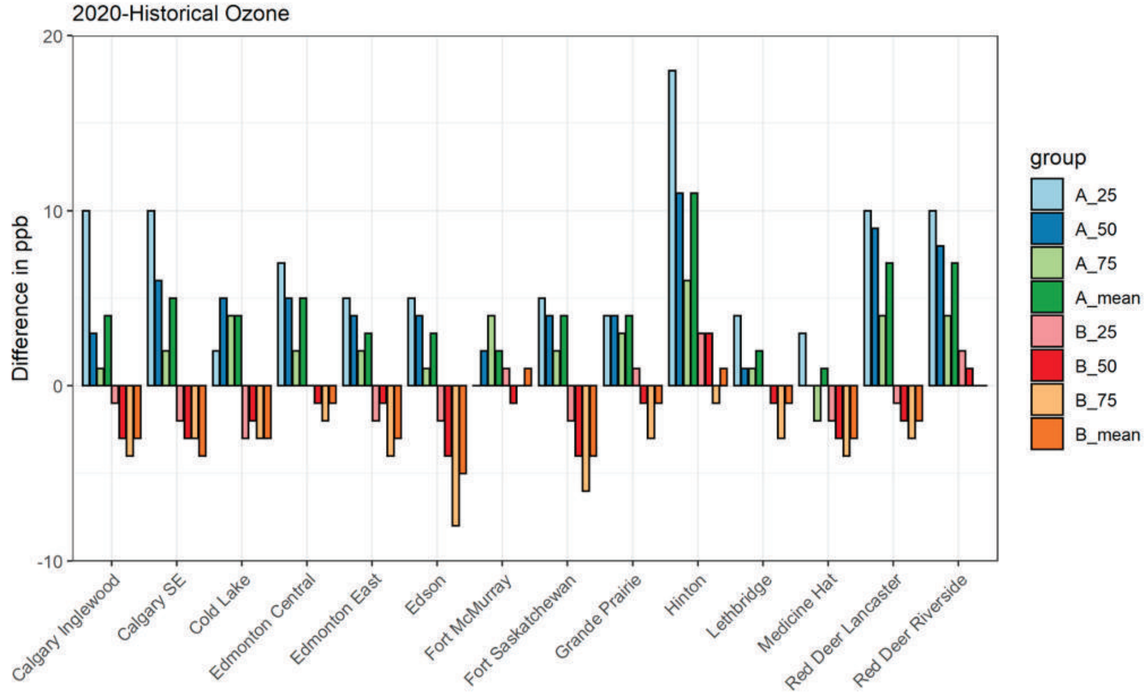
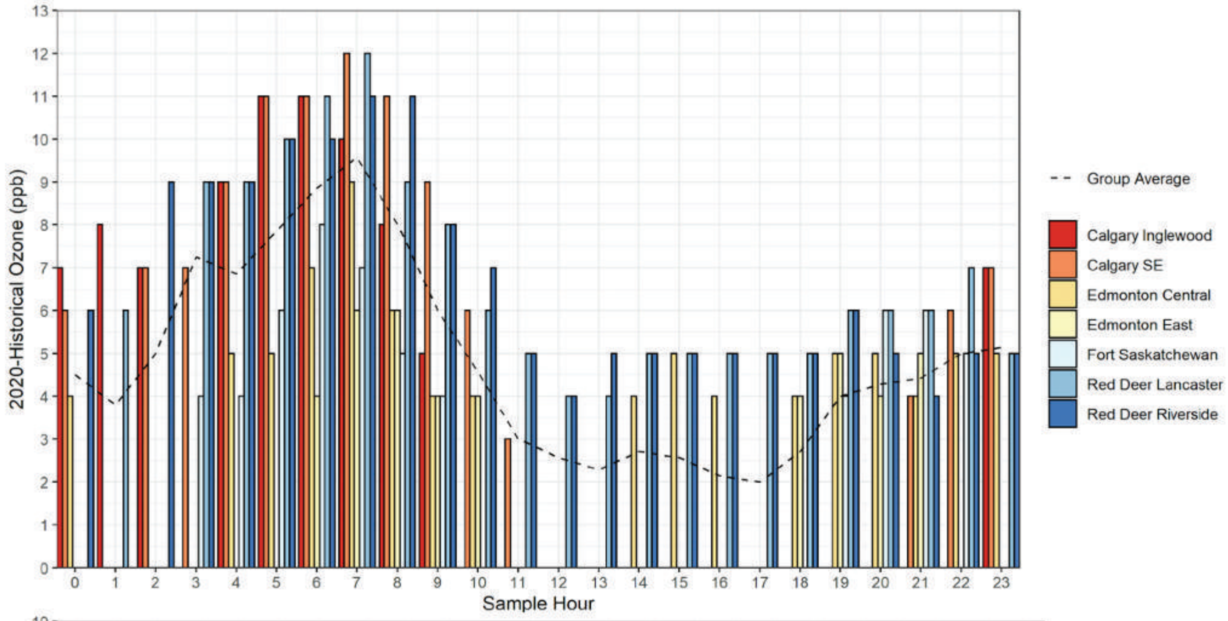


Figure 39: Difference in ozone concentrations measured in 2020 and historical data (2015–2019). The differences were calculated for 25th, 50th, and 75th percentile and mean concentrations for Period A and B.



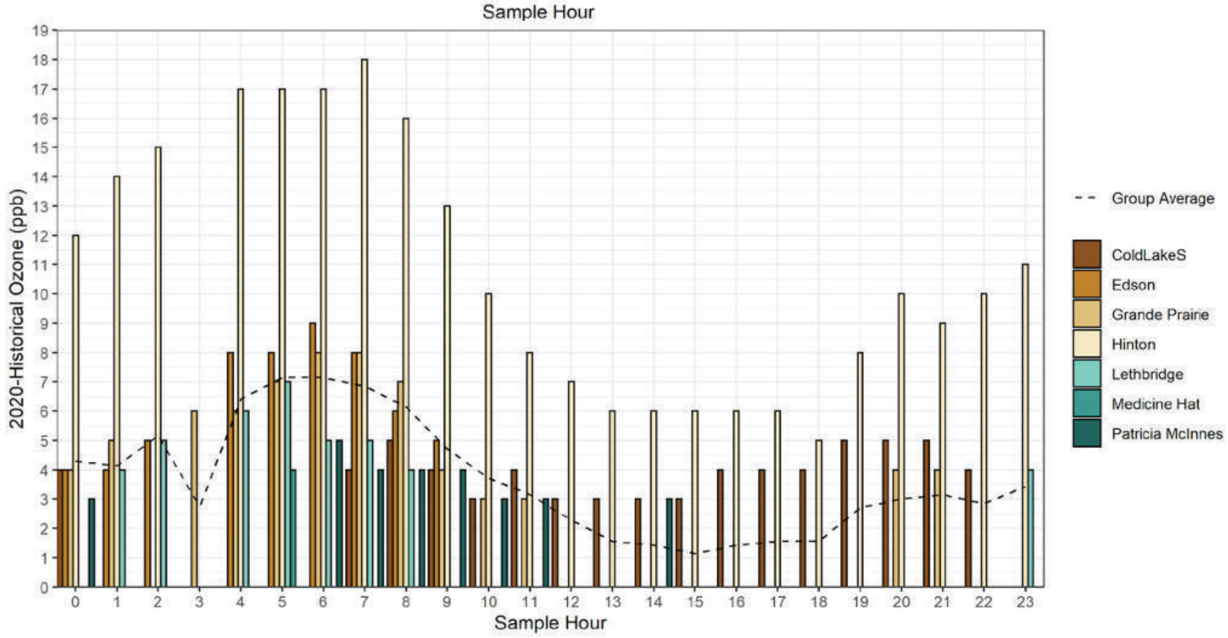


Figure 40: Comparison between 2020 and historical 24-hr variation of ozone concentrations for Period A. For clarity the stations were grouped in two. The bars included are for differences that were significant (2020 data is outside 95% CI of historical data). The dotted line is the mean of all observed differences for the group. Time is indicated in MST.

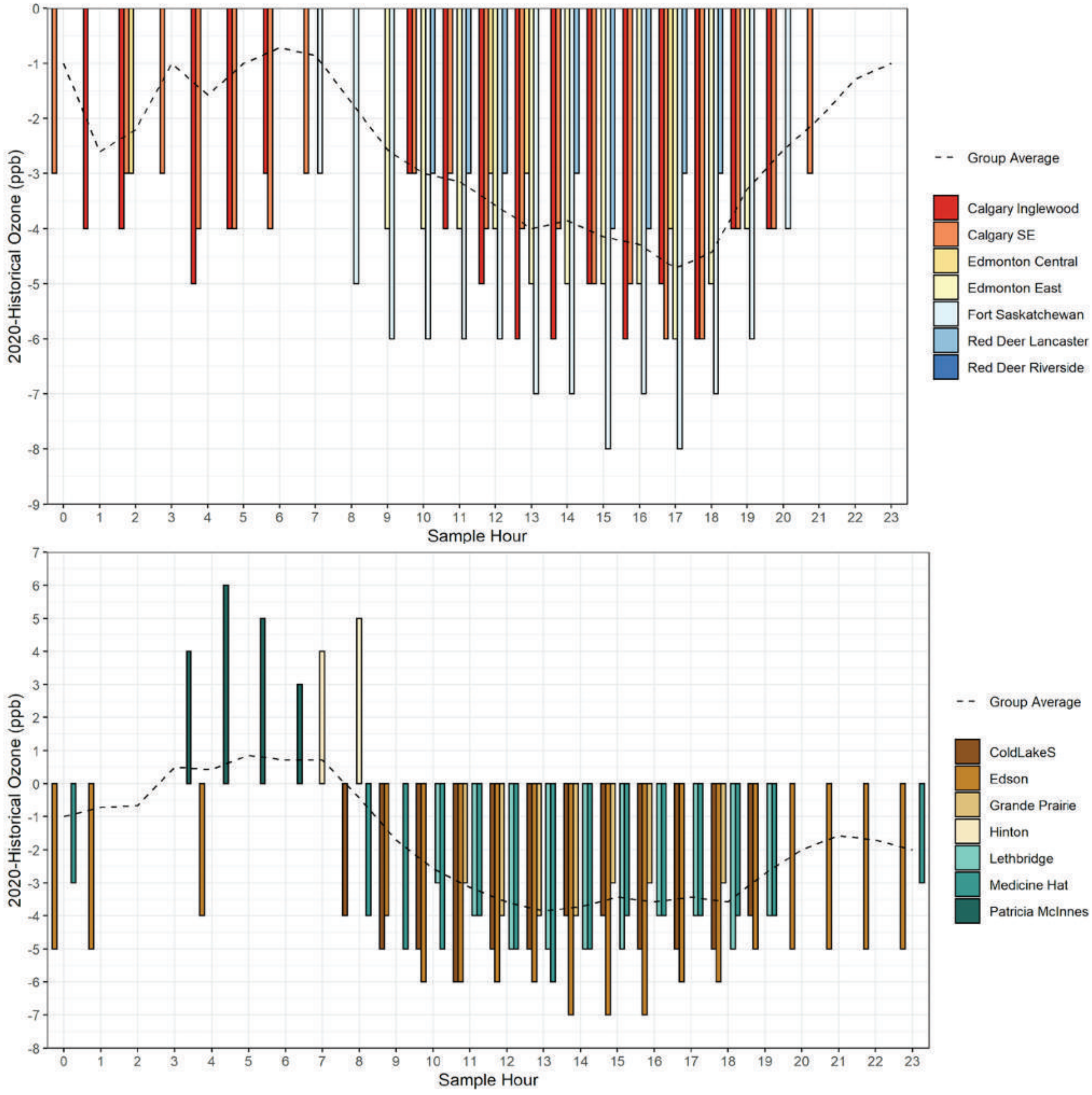


Figure 41: Comparison between 2020 and historical 24-hr variation of ozone concentrations for Period B. For clarity the stations were grouped in two. The bars included are for differences that were significant (2020 data is outside 95% CI of historical data). The dotted line is the mean of all observed differences for the group. Time is indicated in MST.

$PM_{2.5}$

Period differentials for $PM_{2.5}$ are shown in Figure 42. 2020 period concentrations were lower than historical concentrations at all stations for at least one of the two periods, but more consistently for Period B. For the stations that reported lower 2020 concentrations, the mean 2020 $PM_{2.5}$ concentrations were 1-3 µg/m³ lower than historical data during Period A and 1–4 µg/m³ lower during Period B. However, for Patricia McInnes and Medicine Hat stations, the 2020 concentrations were found to be 1–2 µg/m³ higher than historical during Period A. The observation at Fort McMurray-Patricia McInnes may be partially or fully explained by the historical trend for $PM_{2.5}$ at this site (section C). During Period B, 2020 $PM_{2.5}$ concentrations were, on average, lower than historical; the exception was Medicine Hat where, on average, concentration differences were negligible for Period B. At most stations, the Period B difference in the 75th percentile was higher, where differences of up to 5 µg/m³ were observed (Edmonton Central and Edson).

Figure 43 and Figure 44 show the diurnal comparison for $PM_{2.5}$ in Period A and B, respectively. Historically $PM_{2.5}$ concentrations are higher under the nocturnal boundary layer and, to a smaller extent, during the morning commuter hours. On average, concentrations in Period B were historically marginally higher than those measured in Period A. A distinct diurnal variability in the difference between historically observed concentrations and those measured in 2020 was not consistently evident in Period A. Concentrations at most stations in large urban centres were 1-3 µg/m³ lower in the early morning hours during Period A. For some sites (e.g., Edmonton Central and Fort Saskatchewan) 2020 concentrations were up to 5 µg/m³ lower on average by midmorning; lower concentrations continued to be measured well into the afternoon hours. Similar observations were made for smaller urban centres like Hinton and Edson. At Cold Lake, 2020 concentrations were on average up to 3 µg/m³ lower in the middle of the day. Outside of these observations, 2020 concentrations were either higher (Patricia McInnes, Medicine Hat, and Lethbridge) or insignificant. Much like NO_2, lower 2020 concentrations were consistently observed for most hours of the day at most stations during Period B. On average, 2020 concentrations were at least 1 µg/m³ lower for each hour of the day for data collected at almost all the stations during Period B. These differences were higher (up to 5 µg/m³) between 6–10 a.m. MST for stations in large urban centres.

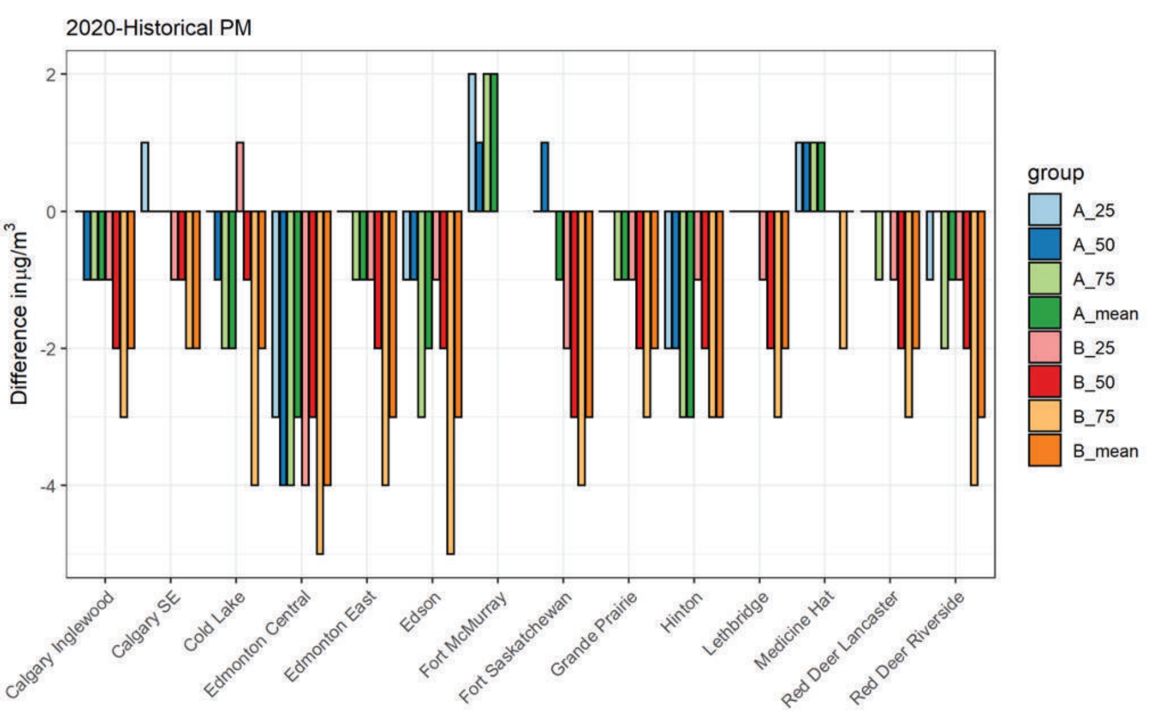


Figure 42: Difference in $PM_{2.5}$ concentrations measured in 2020 and historical data (2015–2019). The differences were calculated for 25th, 50th, and 75th percentile and mean concentrations for Period A and B.

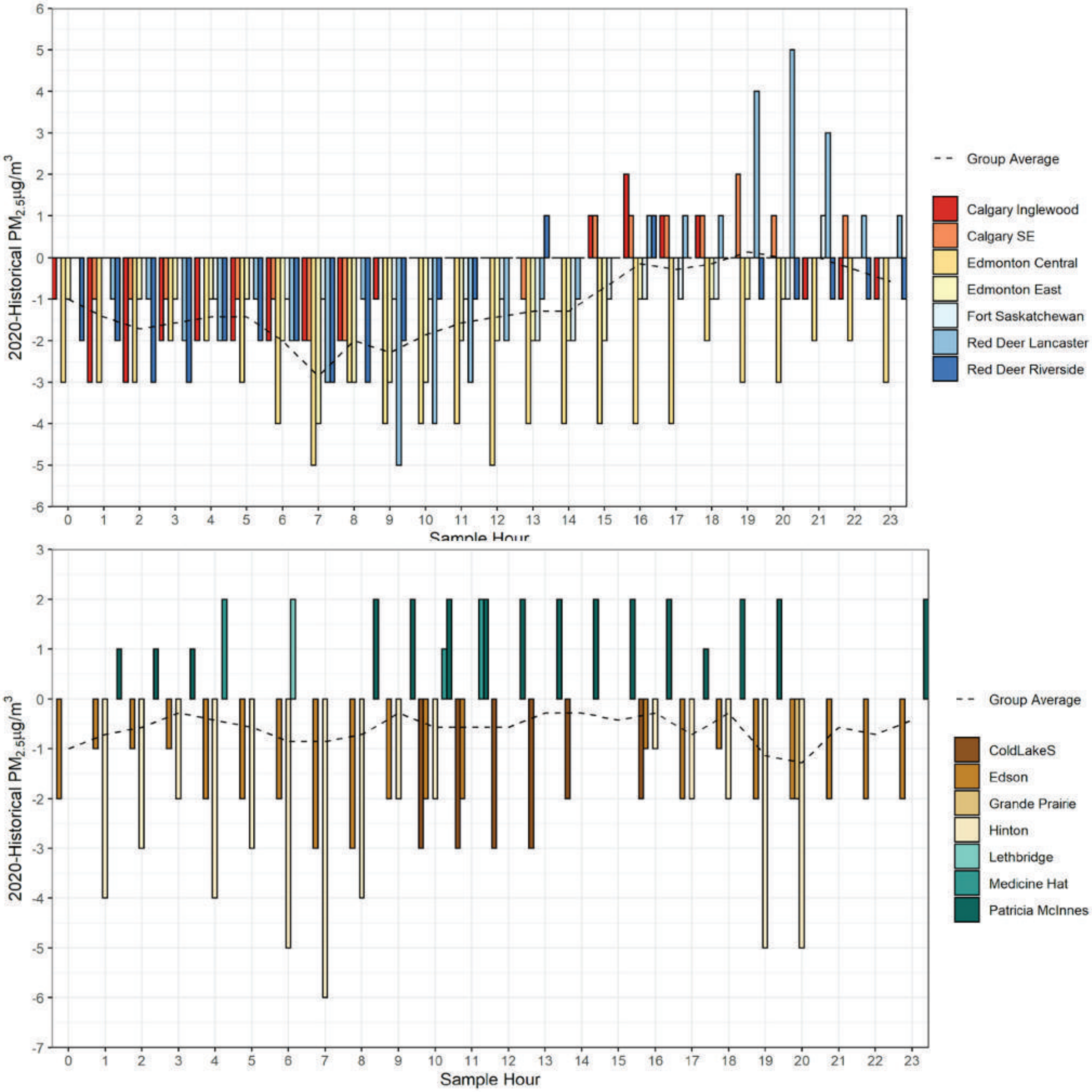


Figure 43: Comparison between 2020 and historical 24-hr variation of $PM_{2.5}$ concentrations for Period A. For clarity the stations were grouped in two. The bars included are for differences that were significant (2020 data is outside 95% CI of historical data). The dotted line is the mean of all observed differences for the group. Time is indicated in MST.

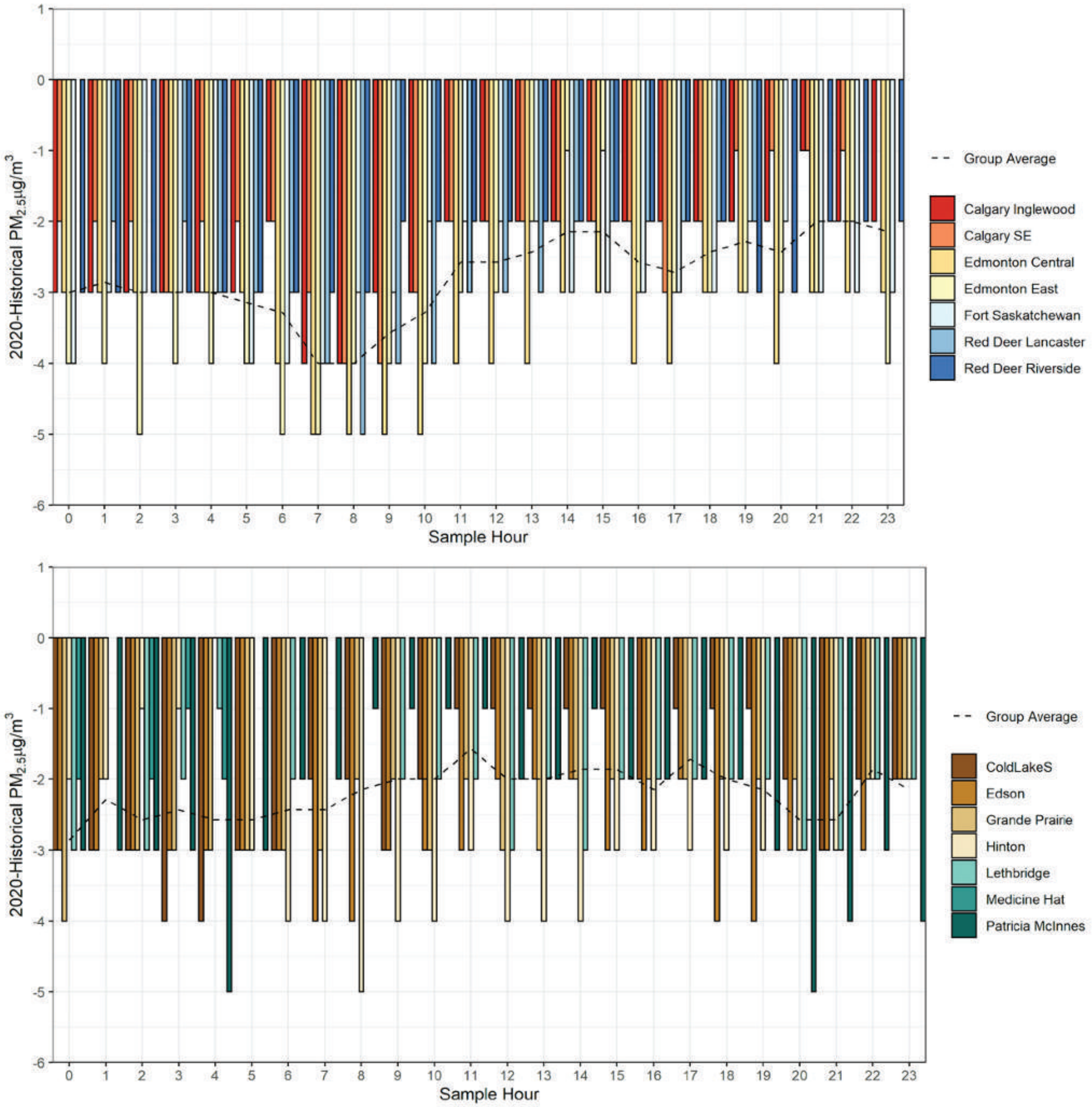


Figure 44: Comparison between 2020 and historical 24-hr variation of $PM_{2.5}$ concentrations for Period B. For clarity the stations were grouped in two. The bars included are for differences that were significant (2020 data is outside 95% CI of historical data). The dotted line is the mean of all observed differences for the group. Time is indicated in MST.

Carbon monoxide

Figure 45 shows the period differential for CO concentrations. CO concentration differences of 100 ppb were observed in at least one statistical measure at 5 of the 9 stations where the concentration is measured. However, the results were mixed. Some sites saw an increase (e.g., Fort Saskatchewan and Calgary Inglewood), some sites saw a decrease (e.g., Grande Prairie, Lethbridge, and Medicine Hat), while others saw no significant change (e.g., Red Deer). All statistically significant differences between 2020 and historical data were 100 ppb (the resolution of most CO data).

The diurnal comparison shows that during Period A, on average, 2020 concentrations were 100 ppb lower than historical concentrations during the morning commuter hours. This difference was observed for at least one hour between 6–8 a.m. MST for all but two stations that monitored CO (Fort Saskatchewan and Medicine Hat). Differences between 2020 and historical diurnal variability were not significant at most stations during Period B. Historical CO trends for several stations further complicate interpretation of observed 2020 changes (section C).

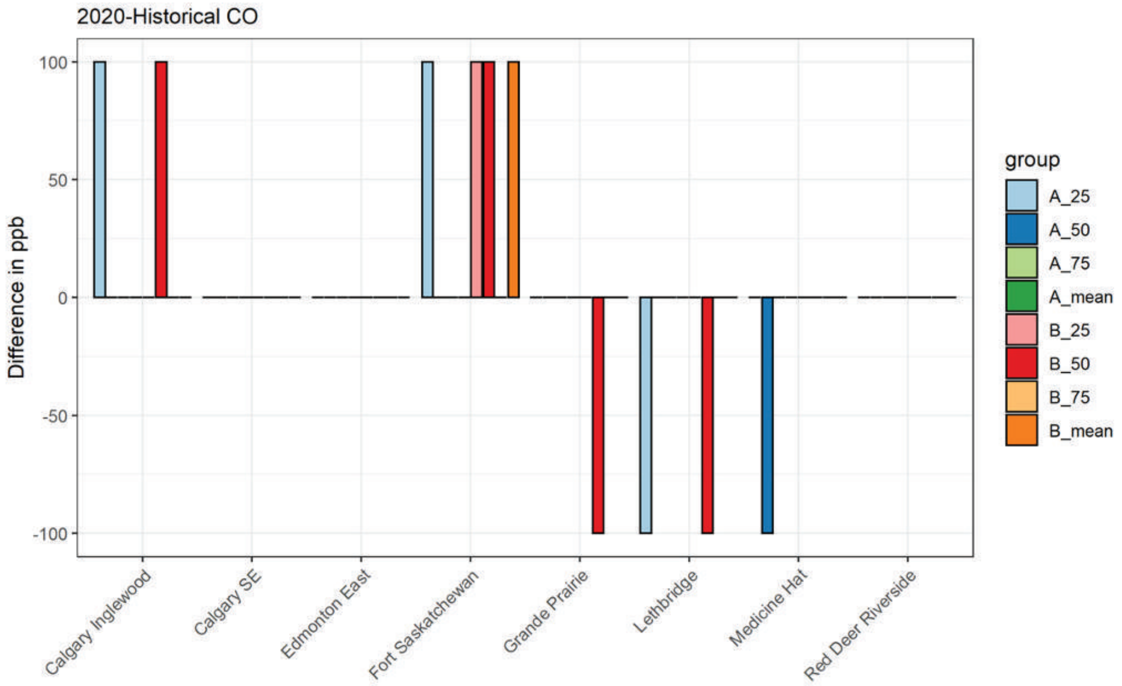


Figure 45: The differences in CO concentrations measured in 2020 and historical data (2015–2019). The differences were calculated for 25th, 50th, and 75th percentile and mean concentrations. These were done for Period A and B. CO concentrations were not monitored at Cold Lake S, Edmonton Central, Edson, and Hinton.

Evaluations for Historical Trends

The trend (% change/year) in historical data (2015–2019) was calculated to establish ongoing changes in air quality. This helps to determine whether any changes in air quality observed in 2020 are unique compared with ongoing trends over time. A comparison of expected concentrations based on historical trends and the observed concentrations was not conducted.

Table 6 lists the parameters at stations that had significant historical trends. Of the 52 station/parameter combinations examined, nine of the historical trends were found to be significant (p-value < 0.05). CO, NO, and O_3 were the most commonly affected parameters. For each statistically significant trend, the mean 2020 concentrations for Period A and B were compared if within 95% confidence interval of the predicted 2020 concentration. This is an initial evaluation to examine if the observed trend could at least partially explain the changes in 2020.

Changes that can be at least partially explained by historical trends include:

- Higher 2020 CO concentrations at Calgary Central-Inglewood (both periods)
- Lower 2020 NO concentrations at Edmonton Central (both periods)
- Lower 2020 $PM_{2.5}$ at Cold Lake South (both periods)
- Lower 2020 CO concentration in Period B at Grande Prairie
- Lower 2020 CO concentration in Period A at Medicine Hat
- Lower 2020 NO concentrations in Period B at Lethbridge
- Lower 2020 $PM_{2.5}$ concentrations in Period B at Patricia McInnes

In some cases, the historical trend was opposite to the changes observed in 2020. This may indicate that the COVID-19 prevention measures had a larger impact on concentrations than the observations in the period differential suggest. The following changes in 2020 could have been partially masked by historical trends:

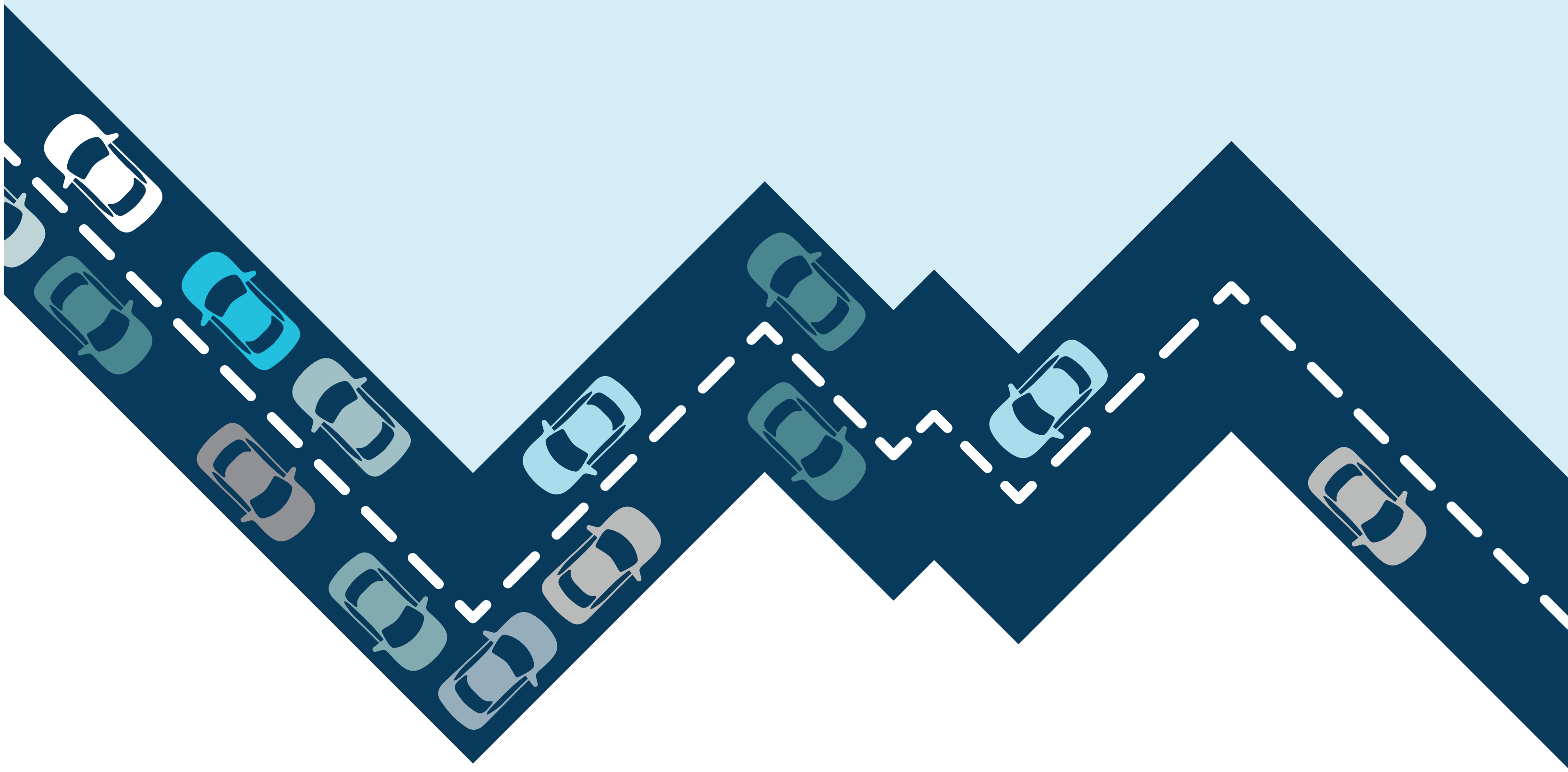
- Lower ozone concentrations in Period B at Medicine Hat
- Higher CO concentrations in Period B at Medicine Hat
- Higher CO concentrations in Period A at Grande Prairie

No statistically significant trends were observed for historical NO_2 concentrations that could impact comparison of these data with 2020.

Table 6: Results of historical trend analysis; the listed trends were statistically significant at $p \leq 0.05$

Parameter	Station	Slope (%/year)	Lower 95 CI (%/year)	Upper 95 CI (%/year)	p-value
CO	Calgary Central-Inglewood	11.1	0.3	33.8	0.05
	Grande Prairie-Henry Pirker	-11.0	-15.0	-3.2	0.03
	Medicine Hat-Crescent Heights	-8.8	-20.0	-1.5	0.02
NO	Cold Lake South	-14.6	-27.1	-1.1	0.05
	Edmonton Central	-11.9	-21.7	-4.1	0.02
	Lethbridge	-10.9	-14.5	-1.5	0.02
O_3	Fort McMurray-Patricia McInnes	3.7	0.1	9.0	0.04
	Medicine Hat-Crescent Heights	3.6	0.5	10.1	0.02
$PM_{2.5}$	Cold Lake South	-10.5	-17.7	-1.8	0.02

Appendix 3:
Communications Plan



Background

In July 2021, the CASA board approved the terms of reference to form the Impacts of Reduced Transportation on Air Quality in Alberta Associated with COVID-19 (IRTAQ) Project Team. The project team first met in August 2021.

The project has four objectives, to:

1. Summarize existing information on Alberta's ambient air quality and traffic counts before and during the implementation of measures taken to reduce the spread of COVID-19
2. Link observed air quality changes associated with measures taken to reduce the spread of COVID-19 to outcomes that are relatable to Albertans
3. Write a project final report including performance measures and recommendations
4. Develop a plan for communicating the work of the project team on transportation reductions due to COVID-19 and the impacts on air quality

Goals

The goals of the communications plan as part of the overall project are to:

1. identify target audiences (recipients of messages) and possible partners to deliver messages to those audiences
2. develop and provide key messages and guidance on delivering those messages

Audiences

As mentioned in the project team's terms of reference (Appendix 1), the overall audience for the key messages is all Albertans. It is recognized that messages may warrant tailoring for targeted audiences.

Table 7 outlines potential partners who could deliver the key messages. Between CASA's delivery of messages and the work of its partners and stakeholders, it is hoped that the messages reach a wide audience.

General guidance on how to effectively deliver the key messages is described in Appendix 3a.

Table 7: Potential partners involved in delivering key messages

Sectors	Example Organizations
Policy makers	Provincial Ministries and Agencies (e.g., Alberta Agriculture and Forestry, Environment and Parks, Alberta Energy Regulator, Transportation, Alberta Health, Municipal Affairs, Education, Indigenous Relations)
	Federal Government (e.g., Environment and Climate Change Canada, Natural Resources Canada, Health Canada)
	Municipalities (Large Urban, Small Urban, Rural)
Other health organizations	Alberta Health Services
Research and educational institutions	University of Alberta (e.g., Centre for Smart Transportation) Alberta Council for Environmental Education Simon Fraser University, School of Sustainable Energy Engineering
Industry	Industry associations (e.g., agriculture, electricity, mining, construction, forestry)
Employers	Professional associations Unions
Indigenous Communities and Métis	Samson Cree Nation Métis Settlements General Council
Airshed Organizations	Alberta Airsheds Council
Transportation Sector	Alberta Motor Association, Alberta Motor Transport Association, Alberta Motor Vehicle Industry Council, commercial operators, fleet operators
Health and Environmental Non-Government Organizations	Alberta Lung Association Alberta Environmental Network

Approach

The project team held a virtual workshop on February 11, 2022. The purpose of the workshop was to: 1) raise awareness of the project and draft key messages, 2) gather input on the draft key messages, and 3) identify potential partners to help distribute the messages and audiences to receive the messages.

The workshop was broken into two parts:

1. A project overview with technical presentations on the analyses conducted which were the basis for the key messages
2. An interactive facilitated discussion based on a series of targeted questions

In addition to project team members, 17 communications experts from a range of sectors and organizations attended the workshop. The virtual format allowed the participants to receive the messages and at the same time provide input remotely.

Electronic copies of webinar documents and a recording of the session were provided to participants following the workshop by request. An electronic survey was also distributed to gather any additional feedback not covered during the session.

The input from the session was used to revise this communications plan with a focus on the target audiences and key messages.

The proceedings of the workshop are included in Appendix 3b.

Budget

The communications plan and any related project documentation will be made available electronically. Hard copies of project documentation will be provided upon request to CASA. The number of requests is expected to be low, with minimal budget implications (likely under $500 for printing hard copies).

No other expenses are expected to be incurred by CASA in delivering the communications plan, as most of the effort toward spreading the messages will be taken on by stakeholders.

Key Messages

As seen in the IRTAQ Summary Report (Appendix 2), some of the COVID-19 response measures taken in Alberta resulted in reductions in vehicle traffic counts and these reductions translated to measurable reductions in ambient air pollutant levels. Air pollution from vehicular traffic (and other sources) has health implications for all Albertans, the details of which are in the Summary Report.

While vehicle use is an inherent part of our current society and our economy, air emissions significantly contribute to air pollution levels throughout the province, particularly in urban areas. Approximately 12% of Albertans live within 250 m of a major thoroughfare with associated higher vehicle emission-related air pollution levels.

Reducing air pollution levels associated with motor vehicle emissions is a complicated and challenging issue with many considerations, such as the ubiquitous presence of emitting vehicles, the variability in the types and condition of vehicles on the road (e.g., diesel trucks vs. small passenger cars), and the location of roadways relative to residents and commercial activities. In addition, air pollution that originates in one area often flows to other areas. This means that air emissions from motor vehicles are a shared issue because all Albertans are exposed to these pollutants. More importantly, the way individuals interact with transportation has consequences for both themselves and those around them.

Motor vehicle emissions management involves the complementary roles of federal, provincial, local governments, and other stakeholders. The federal government sets air emission and fuel efficiency standards for new and imported vehicles which become more stringent over time; however, turnover of the overall vehicle fleet can be slow. The provincial government has jurisdiction over in-use vehicles e.g., maintenance and local governments may contribute through land-use planning and local bylaws e.g., anti-idling. For transportation fuels, there are accompanying federal and provincial standards. New and continued actions by governments, organizations, industry, and individual Albertans will continue to be important as reflected by the project key messages.

The following are key messages on a) overall takeaways from the study related to vehicle emissions, air quality, and health; and b) actions Albertans can undertake to reduce vehicle emissions and thereby help improve air quality. Guidance that may help stakeholders in the delivery of the key messages is in Appendix 3a.

General takeaways from the study

Alberta declared a COVID-19 public health emergency on March 17, 2020. The province implemented several measures to curb the spread of COVID-19 and protect the health care system, including closures of schools and requirements to work from home, where possible. These measures resulted in measurable reductions in motor vehicle traffic and provided an unprecedented real-world opportunity to examine the impact of motor vehicle traffic volume on air quality, and in turn, implications for human health.

The key messages below are related to an analysis of the potential changes in air quality and traffic counts by comparing data collected during the study period (March-June 2020) to previously observed pollutant concentrations (2015-2019), as well as qualitative information gathered related to the potential impacts of air quality improvements on human health.

Transportation-related emissions can notably contribute to the ambient air levels of various pollutants, including particulate matter (PM), NO and NO_2, CO, polycyclic aromatic hydrocarbons (PAHs), certain metals, and BC.

The key messages are divided into three categories as shown below.

Ambient air quality during the study period relative to past conditions

- Improvements in outdoor air quality were seen in many Alberta cities associated with the reduced traffic during the study period.
- During the COVID-19 public health emergency, the reduced levels of certain air pollutants resulted in decreases in the AQHI of up to 13% at some urban stations with an associated expected reduction in outdoor air pollutant related health impacts.

Contribution of reduced transportation to improved air quality

- During the COVID-19 public health emergency, the volume of morning commuters dropped approximately 45%, which resulted in improved outdoor air quality for many.
- Working from home helps reduce traffic volume and outdoor air pollutants and commuters' exposure to these pollutants.
- The findings from the project illustrate that taking certain actions can improve outdoor air quality.

Impacts of air quality on human health

- Even low levels of pollutant exposure can lead to negative short- and long-term health effects.
- Traffic-related air emissions have impacts on health for people in all areas of Alberta.
- Those most at risk from traffic pollutants are the elderly, the young, those with cardiovascular or pulmonary diseases, or with chronic illnesses.
- Reducing traffic pollutants is anticipated to reduce health impacts such as hospital admissions, emergency room visits, doctor visits, and lost work or school time.
- Alberta has the largest diesel exhaust emissions in Canada. There are negative health impacts from diesel emissions.

Actions Albertans can undertake to help improve air quality

Below there are examples of measures and actions that individuals, governments, industry, and organizations can take to reduce transportation-related emissions, followed by a longer list of actions that the three groups could share. Some of the measures and actions directly relate to the findings of the IRTAQ Summary Report, while others were borrowed and referenced from similar initiatives.

The intent of these example actions and measures is, at a minimum, to generate awareness of how actions and behaviours impact air quality and in turn, human health. These actions and measures vary significantly in potential impact in reducing emissions and in the ease and time needed to implement them. This is not a comprehensive list and there are many actions that are not captured. Individuals, government, and industry/organizations are encouraged to build upon or develop their own actions to reduce emissions where possible. If there was a clear target audience, it is included in brackets at the end of the message. The messaging to governments on expected policy-level actions are in the Project Team Recommendations section. In addition to air quality benefits, there may be other co-benefits to undertaking these actions such as saving fuel/money, saving time, improving the longevity of a vehicle, or reducing stress (e.g., reading on transit instead of driving).

Government (municipal, provincial, federal)

- Follow best practices in land use planning and sustainable communities to address transportation related issues.[180,181] Considerations such as 15-minute neighbourhoods,[182] accessible public transit, and active transportation corridors need priority.
- Build infrastructure to support active transportation (e.g., biking, walking).
- Consider modifying staff work schedules to allow working from home and attending meetings virtually where possible.
- Government agencies with internal or contracted fleets that provide services and have active operations in municipalities and on highways should take actions to reduce fleet emissions. Examples of fleet type activities are parks and roadway maintenance, waste collection, police, transit/bus, etc.
- Natural Resources Canada has information and resources related to improving fuel efficiency for commercial fleets (e.g., driver training in fuel efficiency, imposing maximum vehicle speed, advanced vehicle aerodynamics, automatic engine shut-off after set idling time).[183,184]

Individuals

- Where and when possible, choose an active mode of transportation (e.g., walk, bike) or use public transportation instead of driving a personal vehicle. (Commuters)
- Consider carpooling as it can help reduce traffic.
- Plan trips and choose an efficient route before you go so that you only have to travel once – saving time, money, and emissions ("trip chaining"). (Commuters)

Organizations (could include government, industry, or other groups)

Use the resources listed below for better management of fleet vehicles:

- Natural Resources Canada has information and resources related to improving fuel efficiency for commercial fleets (e.g., driver training in fuel efficiency, imposing maximum vehicle speed, advanced vehicle aerodynamics, automatic engine shut-off after set idling time).[5,6]
- The SmartWay Transport Partnership (SmartWay) is a free and voluntary program that helps businesses move goods efficiently while keeping fuel costs and environmental impact at a minimum. (Partners and affiliates:

---

180 Webpage: Alberta Health Services. 2022. *Alberta Healthy Communities Hub*. https://albertahealthycommunities.healthiertogether.ca/

181 Webpage: University of Alberta School of Public Health. 2022. *Centre for Healthy Communities*. https://www.ualberta.ca/public-health/research/centres/centre-for-healthy-communities/index.html

182 Webpage: Smart Transport. 2021. *What is a 15-minute neighbourhood?* https://www.smarttransport.org.uk/insight-and-policy/latest-insight-and-policy/what-is-a-15-minute-neighbourhood

183 Webpage: Natural Resources Canada. 2022. *Federal vehicles and fleets*. https://www.nrcan.gc.ca/energy-efficiency/buildings/nrcans-greening-government-services/federal-vehicles-and-fleets/20053

184 Webpage: Natural Resources Canada. 2019. *Fuel efficiency benchmarking in Canada's trucking industry*. https://www.nrcan.gc.ca/energy/efficiency/transportation/commercial-vehicles/reports/7607

businesses, commercial trucking/carriers, logistics companies and shippers, non-profit organizations, truck/trailer leasing firms and dealerships.)

- Proven tips for commercial driving and equipment that help save money and reduce emissions through fuel efficiency are available from Natural Resources Canada.[185]
- SmartWay offers webinars on aerodynamic drag reduction and other topics for improved fuel efficiency.[186]
- SmartDriver provides free, practical training to help Canada's commercial and institutional fleets lower their fuel consumption, operating costs, and vehicle emissions. Fleet energy-management training that helps truckers, transit operators, school bus and other professional drivers improve fuel efficiency by up to 35%![187]
  - Explore available resources for setting up an idle-free zone, for example through Natural Resources Canada.[188,189]

Shared actions

Use these resources to improve fuel efficiency and reduce environmental impact

- Better fuel efficiency/fuel consumption results in fuel savings and less emissions.[190,191]
- Smooth acceleration and strategic coasting can help reduce fuel consumption and emissions. (Commuters, commercial trucking)[192]
- Learn driving techniques that can save you in fuel costs.[193]
- In the summer heat, your car's interior will cool down quicker by driving than by idling it with the air conditioner running.[192]
- Reduce use of air conditioning, as air conditioning can increase a vehicle's fuel consumption by as much as 20%.[14]
- To save money and minimize emissions, slow down and try to maintain a steady speed. At 120 km/h, a vehicle uses about 20% more fuel than at 100 km/h.[192]
- Use a block heater so you can plug in your vehicle during cold weather. Block heaters can reduce a vehicle's warm up time, increasing fuel efficiency and reducing emissions. It will also reduce wear on your engine components and help warm up your vehicle faster.[194]
- Reduce vehicle idling when warming up your vehicle or otherwise waiting.[195]
- Cut fuel consumption, reduce emissions, and save money by avoiding excessive

185 Webpage: Natural Resources Canada. 2018. *Tips for better driving and equipment*. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/greening-freight-programs/smartway-fuel-efficient-freight-transportation/tips-for-better-driving-and-equipment/tips-for-better-driving-and-equipment

186 Webpage: Natural Resources Canada. 2021. *Upcoming SmartWay webinars*. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/greening-freight-programs/smartway-fuel-efficient-freight-transportation/smartway-tools-and-resources/upcoming-smartway-webinars/21080

187 Webpage: Natural Resources Canada. 2019. *SmartDriver training series*. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/greening-freight-programs/smartdriver-training-series/21048

188 Webpage: Natural Resources Canada. 2017. *Welcome to the idle-free zone*. https://www.nrcan.gc.ca/energy/efficiency/communities-infrastructure/transportation/idling/4397

189 Webpage: Parkland Airshed Management Zone. 2022. I*dle free*. https://pamz.org/idle-free/

190 Webpage: Natural Resources Canada. 2018. *Understanding fuel consumption ratings*. http://www.nrcan.gc.ca/energy/efficiency/transportation/cars-light-trucks/buying/7489

191 Webpage: Natural Resources Canada. 2018. *Factors that affect fuel efficiency*. https://www.nrcan.gc.ca/energy/efficiency/transportation/cars-light-trucks/buying/16217

192 Webpage: Natural Resources Canada. 2021. *Fuel-efficient driving techniques*. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/personal-vehicles/fuel-efficient-driving-techniques/21038
Webpage: Alberta Motor Association. 2022. *Save money on gas by refining the way you drive*. https://amainsider.com/save-money-on-gas/

193 Webpage: Stantec. 2020. *ecoDriving online*. http://www.ecodrivingonline.ca/home.htm

194 Webpage: Alberta Motor Association. 2022. *Why your block heater is essential in winter*. https://amainsider.com/auto-expert-block-heaters/

195 Webpage: City of Edmonton. 2022. *Be idle free*. https://www.edmonton.ca/city_government/environmental_stewardship/be-idle-free#:~:text=Under%20the%20bylaw%2C%20drivers%20cannot,area%20designated%20as%20no%20idling.&text=Vehicles%20licensed%20to%20provide%20public,are%20exempt%20from%20the%20bylaw

idling.[196] Examples of excessive idling includes pick up/ drop off areas, train crossings, and warming up.[197,198]

Conduct proper vehicle maintenance

- Follow regular vehicle maintenance schedules to reduce emissions while benefiting the safety and life of your vehicle.[199] (Commuters)
- Maintain proper pressure in your tires to improve fuel efficiency (reduce emissions), reduce tire wear (save money), and improve safety by increasing traction.[200]
- Maintain your vehicle's emission control system in good working order. (Commuters, commercial trucking)
- Idling not only impacts emissions (air pollution) and fuel consumption (costs), but also vehicle wear (more costs and more frequent maintenance).

Considerations when purchasing a vehicle

- If upgrading to a newer vehicle, consider choosing a lower emission vehicle (i.e., hybrid, plug-in hybrid or ideally, a zero emissions vehicle) where possible. (Commuters, commercial fleets)
- Choosing the most fuel-efficient vehicle that meets your needs can reduce emissions and fuel costs.[201,202] (Individuals, commercial fleets)
- The Natural Resources Canada fuel consumption ratings search tool to helps identify the most fuel-efficient vehicle that meets your everyday needs by comparing the fuel consumption information of different models.[203]
- The 2022 Fuel Consumption Guide gives information about the fuel consumption of 2022 model year light-duty vehicles (passenger cars, vans, SUVs, pickup trucks) to compare vehicles as you shop for the most fuel-efficient vehicle that meets your everyday needs.[204]
- For a quick overview of battery electric vehicles and plug-in hybrid electric vehicles, check out resources from Natural Resources Canada and the Canadian Automobile Association for electric vehicles.[205,206]
- Natural Resources Canada has tips for choosing a fuel-efficient vehicle.[207]
- Natural Resources Canada has some tips for reading EnerGuide labels for vehicles if considering a new purchase.[208]

---

196 Webpage: Natural Resources Canada. 2017. *Idling – frequently asked questions.* https://www.nrcan.gc.ca/energy/efficiency/communities-infrastructure/transportation/idling/4463

197 Webpage: Natural Resources Canada. 2009. *Turn it off: reducing vehicle engine idling final report.* https://oee.nrcan.gc.ca/transportation/idling/material/reports-research/turn-it-off-exec-summary.cfm

198 Webpage: Argonne National Laboratory. *Reducing vehicle idling.* https://www.anl.gov/es/reducing-vehicle-idling

199 Report: South Carolina Department of Health and Environmental Control. *Vehicle maintenance and air quality fact sheet.* Available online: https://scdhec.gov/sites/default/files/Library/CR-010092.pdf

200 Webpage: Alberta Motor Association 2022. *The right tire pressure for your car.* https://ama.ab.ca/articles/how-to-check-tire-pressure

201 Webpage: U.S. Department of Energy Alternative Fuels Data Center. *Rightsizing your vehicle fleet to conserve fuel.* https://afdc.energy.gov/conserve/rightsizing.html

202 Webpage: Natural Resources Canada. 2020. *Choosing the right vehicle.* https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/personal-vehicles/choosing-right-vehicle/20998

203 Webpage: Natural Resources Canada. 2022. *Fuel consumption ratings search tool.* https://fcr-ccc.nrcan-rncan.gc.ca/en

204 Webpage: Natural Resources Canada. 2022. *2022 fuel consumption guide.* https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/fuel-consumption-guide/21002

205 Webpage: Natural Resources Canada. 2022. *Buying an electric vehicle.* https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/personal-vehicles/choosing-right-vehicle/buying-electric-vehicle/21034

206 Webpage: Canadian Automobile Association. 2022. *Electric vehicles.* https://www.caa.ca/sustainability/electric-vehicles/

207 Webpage: Natural Resources Canada. 2021. *Tips for buying a fuel-efficient vehicle.* https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/personal-vehicles/choosing-right-vehicle/tips-buying-fuel-efficient-vehicle/21000

208 Webpage: Natural Resources Canada. 2019. *EnerGuide for vehicles.* https://www.nrcan.gc.ca/energy-efficiency/energuide-canada/energuide-vehicles/21010

Remote work arrangements

- Encourage or implement a policy enabling employees to work from home when or where possible. (Employers)
- Consider modifying your work schedule to work from home or attend meetings virtually when or where possible. (Employees)
- Consider reviewing resources or taking part in training opportunities for conducting or participating in remote meetings, which could reduce the need for in-person meetings. (Individuals, employees, employers)

Refer to educational resources

- Use the Alberta Motor Association (AMA) Road Reporter app to avoid unnecessary travel delays and confirm road and travel conditions.[209]
- Natural Resources Canada has an interactive Idling Quiz - check out the truths or myths![210]
- AMA has several Tips for Green Driving such as avoiding hard braking and acceleration, using cruise control on highway drives where possible, considering reducing driving speed to lower fuel consumption, and opening windows instead of using A/C below 60 km/h to cool the vehicle interior.[211]
- The Canadian Auto Association provides easy fuel-efficient driving tips.[212]

---

209 Webpage: Alberta Motor Association. 2022. *Road reports*. https://roadreports.ama.ab.ca/

210 Webpage: Natural Resources Canada. 2014. *Idling quiz*. https://www.nrcan.gc.ca/energy/efficiency/communities-infrastructure/transportation/idling/4417

211 Webpage: Alberta Motor Association. 2022. *Protecting the environment*. https://ama.ab.ca/community/care/protecting-environment

212 Webpage: Canadian Automobile Association. 2022. *Fuel-efficient driving tips*. https://www.caa.ca/sustainability/fuel-efficient-driving-tips/

Appendix 3a: Guidance on Delivery of Project Messages

It is expected that the messages will be delivered through existing initiatives/channels or will help inform new initiatives for efficiency.

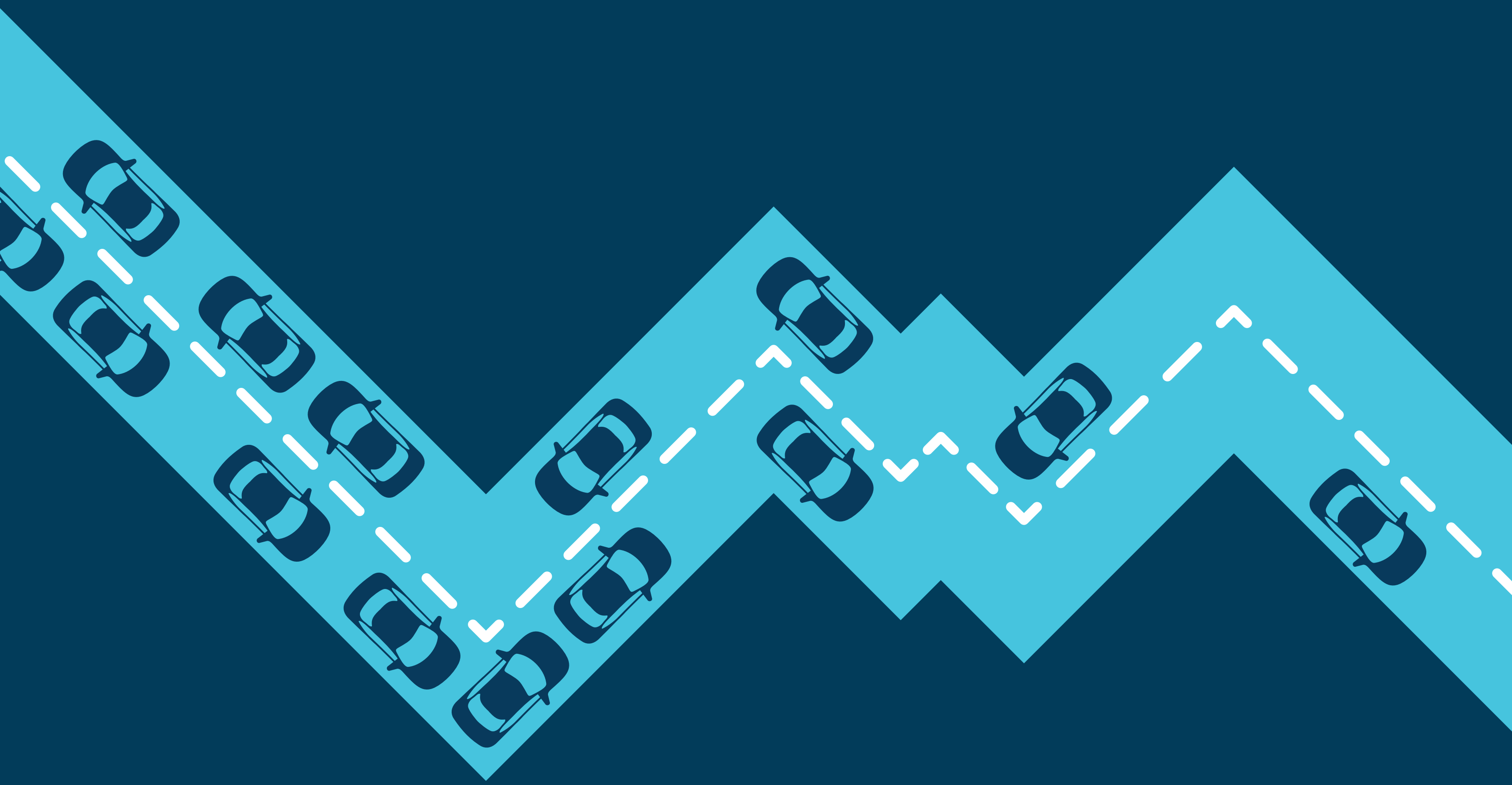
To help guide stakeholders in delivery of the project messages, some considerations are provided below.

- Highlighting co-benefits (e.g., saving fuel/money) may make the messages more impactful in relation to quality of life.
- Keep the audience in mind when relaying or tailoring these messages and be sensitive to issues such as privilege (ability to buy a new car), feasibility (geographic area where transit is available), and the overall impacts of the pandemic.
- This study is not to show that the start of the pandemic was a “good thing”, but rather a unique opportunity to examine changes in traffic volume and associated air quality.
- Although not the focus of this study, there is mention of the pandemic. Due to the sensitivity around the issue, stakeholders may wish to consider timing of release of the messages.
- Messages could coincide with air-related events such as Clean Air Day.

Medium	Notes on effective delivery of messages using that medium
Social media (Instagram, Facebook, Twitter, podcasts, etc.)	There are many online resources available for effective use of social media platforms. Links to the project webpage could be included in posts for further information.
Email	Links to project materials or key messages could be shared with colleagues or others (also see newsletter row).
Advertisement (radio, television, internet)	Advertisements could be created explaining how the study was done and how the pandemic reduced emissions from urban transportation. A link to the IRTAQ project page on the CASA website could be provided for more information. A quick sponsored ad on social media could be created to show up in an individual’s feed or their story feed with a link to the project materials.
Newsletter or organization’s website	Clean Air Day announcements, Commuter Challenges, or other environmental information could incorporate messages from the project.
Billboard	Billboards would have to be eye-catching and have a brief message (e.g., “Did you know that air pollutants cause X? Did you know that the pandemic reduced X amount of transportation emissions from the atmosphere? Find out why and more here: XXX)”. Could also consider billboard location; electronic billboards where cars are idling at traffic lights would be a good resource to use to reach urban city drivers.
Cross-promotion and partnership with existing environmental education and outreach programs at the provincial and municipal levels	Examples are Green Living Guide and Climate Adaptation guides published by the City of Edmonton. These outreach programs already have a dedicated marketing strategy and target audience that cares about the environment. These programs typically have a presence at various trade shows and environmentally-themed events.

Appendix 3b:
Workshop Proceedings

Impacts of Reduced Transportation on Air Quality in Alberta Associated with COVID-19 (IRTAQ) Project Team Workshop: Project Overview and Draft Key Messages



Contents

Workshop Description

A virtual workshop was held on February 11, 2022, with a multi-stakeholder group of 25 participants, 17 of whom were outside the project team.

The purpose of the workshop was to: 1) raise awareness of the project and draft key messages developed, 2) gather input on the draft key messages, and 3) identify potential partners to help distribute the messages and audiences to receive the messages.

The workshop was broken into two parts:

A project overview with technical presentations on the analyses conducted which were the basis for the key messages

An interactive facilitated discussion based on a series of targeted questions

Presentations

Participants heard three presentations on the project background and intent, findings related to observed changes in air quality during the study period in Alberta and elsewhere, and the relevance of these changes in terms of human health.

There was an opportunity for questions following the two technical presentations.

Project Intent

This presentation provided background information on the project idea, the steps involved in its implementation, project team membership, project timelines, project goals and outcomes, and the purpose of the workshop. The following is a synopsis of the information provided on the project.

The project arose from discussions at a CASA board meeting in June 2020, based on an interest in understanding the air quality impacts associated with the significant reduction in traffic volumes resulting from public health measures taken to reduce the spread of COVID-19. The goal was to communicate the findings to the public (all Albertans) and possibly provide messages to the public on actions that could be undertaken to improve air quality in the province.

Following the June 2020 CASA board meeting the project went through a series of stages of scoping, resulting Terms of Reference (ToR) for the Project, and the establishment of a project team to implement the ToR. The project team had their first meeting in August 2021. The project is in its final stages and through the workshop, the project team is seeking input on draft material before it is finalized and submitted to the CASA board for final approval in April 2022.

The goal of the project is to:

> **"Collaboratively develop messaging that links changes in air quality associated with measures undertaken to reduce the spread of COVID-19. The messaging would aim to generate provincial awareness of the impacts that reductions in motor vehicle transportation can have on air quality, and how individuals, governments, businesses, and other Albertans can act to improve air quality."**

The three objectives of the project that the team has worked on to date are:

1. Summarize existing information on Alberta's ambient air quality and traffic counts before and during the implementation of measures taken to reduce the spread of COVID-19
2. Link observed air quality changes associated with measures taken to reduce the spread of COVID-19 to outcomes that are relatable to Albertans
3. Develop a plan for communicating the work of the project team on transportation reductions due to COVID-19 and the impacts on air quality

It was noted that the next two presentations would be technical in nature and would provide a summary of the work relative to objectives 1, 2, and 3 and the elements of the work that the project team is seeking input on during the feedback session. These were:

- Draft key messages
- Identifying target audiences (recipients of messages) and possible partners to deliver those messages to audiences
- Guidance on delivering messages

Participants were informed of how their feedback will be used; materials will be updated based on the input by March. The project documentation will then be shared with and reviewed by sectors. Following these sector reviews, the project team will update the materials and submit them to the CASA board for final approval in April.

Changes in Air Quality During the Study Period

This presentation started with a background on air quality monitoring, including the distribution and management of monitoring stations, pollutants measured, and how the data are used.

On March 17, 2020, a public health emergency was declared because of the COVID-19 pandemic. As a result, schools and daycares were closed and people were advised to work from home if possible and avoid social gatherings. These actions are expected to result in a temporary decrease in air pollutants due to reduced road traffic in urban centres in Alberta (Calgary and Edmonton).

An analysis was conducted by the Government of Alberta to:

- Compare traffic volume in 2020 with historical data
- Compare ambient air pollutant levels in 2020 with historical data
- Determine metrics for communication to Albertans

The analysis found a complex relationship between emissions and pollutants in the air. Pollutants reported on in this study included NO_2, $PM_{2.5}$, and O_3. The main results for the ambient air quality analysis were:

Pollutant levels followed traffic levels (higher levels during the morning). Levels were usually higher during the morning relative to the afternoon due to limited dispersion at this time of day.

Relative to previous years (2015–2019), in 2020:

NO_2 concentrations decreased for most hours of the day at all stations, especially in the morning.

$PM_{2.5}$ concentrations were overall lower, but there were times at which concentrations were higher.

Ozone concentrations increased, due to photochemical reactions in the atmosphere involving ozone precursors.

These results were translated into a single index, the AQHI, to help understand the observed changes. The AQHI is a tool designed to help understand the health impacts of air quality. In 2020, the AQHI was up to 10% lower, relative to previous years.

Question & Answer

Q: *How does NO_x destroy ozone?*

A: NO_2 can destroy O_3, as well as create it. There is a balance between VOCs and NO_2 in the air, so it depends on what is in the air.

Q: *You used historical data during a timeframe that had significant wildfire smoke events that would have driven the AQHI in Alberta, compared to 2020 where there were not any significant events. What was the influence of the wildfire smoke events on the AQHI information presented?*

A: In addition to weekends and holidays, all days that were impacted by wildfire smoke were removed from the analysis. Anything that influenced the historical data to appear higher than usual was removed.

Potential Health Impacts Associated with Air Quality Changes

This presentation shared information about air pollution and associated human health impacts with the intent to highlight why the findings from the study on changes to air quality are meaningful and relevant to Albertans. Such information can help create awareness of the impacts of air quality and health and generate interest in reducing emissions from transportation sources.

Some examples of air pollutant emissions from transportation exhaust include:

- Particulate matter
- Nitrogen dioxide
- Ozone
- Sulphur dioxide
- Carbon monoxide
- Polycyclic aromatic hydrocarbons
- Certain metals
- Black Carbon
- Benzene

There are also non-exhaust transportation emissions (e.g., from tire wear).

Relative to the rest of Canada, Alberta has high per capita transportation emissions. Of particular note are carbon monoxide and NOx from diesel emissions, and NOx and VOCs from gasoline emissions.

The health-related impacts of air pollution range in severity and number of people affected. Specific health effects include, from least severe but most common to most severe and least common:

- lung function decrements, inflammation, and cardiac events
- respiratory symptoms, medication use, and asthma attacks
- doctor visits, school absences, and lost work days
- emergency room visits, hospital admissions, and heart attacks
- death

There are many challenges and uncertainties associated with estimating the impact of air pollution. In Canada, the estimated number of air pollution-related deaths in 2015 was 14,600 with 1,650 of these deaths related to on- and off-road vehicle emissions. The estimated economic impact to Canada associated with air pollution-related premature mortalities is $108 billion; for morbidities, the cost is estimated at $5.5 billion.

Reducing transportation-related emissions in Canada and Alberta would have significant air quality and associated health and economic benefits.

Question & Answer

Q: *It sounds like there are implications for the social determinants of health, do you have comments regarding Indigenous populations and what carryovers there might be?*

A: There is interest in the impacts specific to Indigenous communities. Reserves close to urban centres experience negative impacts that are not always measured. This topic warrants more focused work.

Facilitated Feedback Session

The second segment of the workshop focused on sharing and discussing the key messages developed by the IRTAQ Project Team. The information summarized in the presentations during the first half of the workshop was used, and participant input on the audience receiving key messages and identifying partners who might distribute the messages was gathered.

The session was structured around a series of targeted questions and feedback was entered using a Google document, allowing participants to be actively involved through both discussion and typing ideas in the document.

Key messages: General takeaways from the study

- Air quality trade-offs should be acknowledged, such as the economic benefits associated with transportation. Perhaps it could be framed as “ways to do better with existing economic factors.”
- There seems to be an urban/ rural divide. For example, the message for using public transportation is specific to urban dwellers. The rural experience seems to be missing. Perhaps what could be added is how urban actions impact the broader public.
- There could be messaging specifically for employers, related to developing ride-share and other programs to avoid single-commuter vehicles.
- Using the three headings (category of key messages) as overarching key messages would be more reader-friendly. The listed key messages could be sub-components.
- Each message should be supported with reference to a study to provide support for the action (e.g., traffic count differences between the study period and previous years, at different times of day).

- Working from home messages should be directed toward employers, not individuals, as individuals do not always have full control of where they work.
- Mention of COVID-19 could hinder the messages given the current sensitivity around the topic.
- A general statement should be added to why individuals should care. The study results were due to collective action among many people, but how individuals can act is a tough sell. There might be a sense of defeatism, where individuals may not feel like their actions matter.

Key messages: Actions Albertans can undertake to help improve air quality

- Some of the actions are mostly appropriate for a non-pandemic scenario (e.g., carpooling and using public transportation).
- Not all actions are appropriate for everyone. The actions generally tend to be for urban and middle-class people. For example, the message about investing in a new vehicle; perhaps it could be updated to "if upgrading to a new vehicle, consider buying..."
- There may be other ways to make actions possible that aren't necessarily done by individuals. For example, development of infrastructure to allow active transportation (e.g., bike lanes).
    - Individuals can pressure various levels of government to transition infrastructure toward an active transport model.
    - Healthy Communities by Design is an example of an Alberta initiative that could be supported by individuals or duplicated elsewhere.

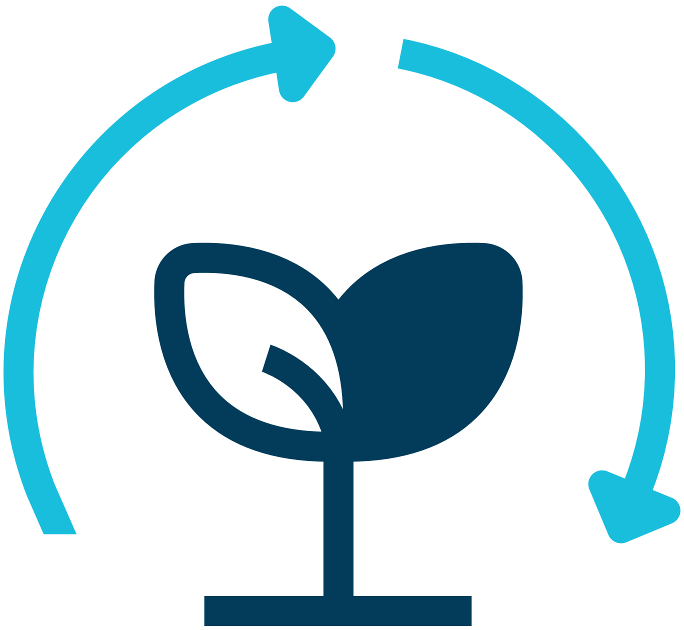
Distributing key messages

- Share with Alberta Airsheds and consider the communication approach the different airshed organizations use.
- For an urban population, post-secondary education institutions could be informed.
- Younger generations interact with and use transportation differently than older generations. It may be worthwhile to reach them.
- The actions should note that they are short-term sacrifices for long-term and collective benefit.
- Elected officials, policy makers, and decision makers are critical to reach.
- There is a lot going on in the world right now. The team and stakeholders distributing the messages might consider the timing of when to strategically release them, (i.e., at a time the messages won't get lost among other high-profile news).

Closing Remarks

Speakers and participants were thanked for taking the time to prepare and attend the workshop.

Final project materials will be sent to workshop participants once approved by the CASA board and will be publicly available on the CASA website.



Appendix 3bi: Workshop Participant List

Name	Affiliation
Amber Link	Rural Municipalities of Alberta
Andria Panidisz	Canadian Association of Petroleum Producers
Ann Baran	Southern Alberta Group for the Environment
Anne Vigneau	Heartland Generation
Brendan Schiewe	Alberta Health
Chandra Tomaras	City of Edmonton
Dominic Gniewek	Alberta Health Services
Dominic Schamuhn	Alberta Motor Association
David Spink	Prairie Acid Rain Coalition
Hayley Martin	Alberta Environment and Parks
Janine Legare	Alberta Health Services
Jocelyn Thrasher-Haug	Strathcona County
Karen Ritchie	Alberta Environment and Parks
Karla Reesor	Peace River Area Monitoring Program
Laurie Cheperdak	Alberta Health
Lynn Que	Alberta Health Services
Sean Mercer	Canadian Fuels Association
Michael Bisaga	Alberta Airsheds Council
Mike Iwanyshyn	Natural Resources Conservation Board
Michael Mooney	Alberta Motor Transport Association
Nicole Renaud	Alberta Environment and Parks
Opel Vuzi	Health Canada
Rhonda Lee Curran	Alberta Environment and Parks
Rita Stagman	Alberta Environment and Parks
Ruth Yanor	Mewassin Community Council
Yayne-abeba Aklilu	Alberta Environment and Parks
CASA Staff	
Alec Carrigy	Project Lead
Jacqueline Noga	Project Support

Appendix 3bii: Workshop Agenda

9 a.m.	**Welcome and Administration**	**Alec Carrigy**, CASA Project Manager
9:05 a.m.	**Project Intent**	**David Spink**, Project Team Co-Chair, Prairie Acid Rain Coalition
9:15 a.m.	**Observed changes in air quality during the study period in Alberta and elsewhere**	**Yayne-abeba Aklilu**, Project Team Co-Chair, Alberta Environment and Parks **Mike Bisaga**, Alberta Airsheds Council
9:35 a.m.	**Q&A**	**Alec Carrigy**
9:40 a.m.	**Potential health impacts associated with changes in air quality**	**Ann Baran**, Southern Alberta Group for the Environment **Ruth Yanor**, Mewassin Community Council **David Spink**
9:55 a.m.	**Q&A**	**Alec Carrigy**
10 a.m.	**Break**	
10:10 a.m.	**Feedback on key messages** **Presentation of project key messages** **Webinar participant input on key messages** **Missed opportunities (data, information, similar groups and initiatives)** **Channels available to distribute messages** **Webinar participant interest in spreading key messages**	**Rita Stagman**, Alberta Environment and Parks
11:20 a.m.	**Closing Remarks**	**Alec Carrigy**
11:30 a.m.	**Adjourn**	

Appendix 3biii: Facilitation Session Notes

Notes about key messages

Feedback on specific key messages

Key message	Feedback
Improvements in outdoor air quality were seen in many Alberta cities associated with the reduced traffic during the study period.	Do we know how much traffic was reduced by? Stats may be beneficial. The project found a 5% reduction in peak hour traffic was associated with a ~10% reduction in the AQHI.
Working from home helps reduce traffic volume, outdoor air pollutants, and commuters' exposure to these pollutants.	Working from home was not solely individual choices but employers facilitated a great deal. Meetings that were face-to-face were replaced with virtual meetings.
The findings from the project illustrate that individual choices/actions do impact outdoor air quality.	Oversimplifying? It was collective actions that impacted air quality.

What changes would you suggest to improve the proposed key messages? Are they too specific or general? Are they relevant to Albertans? How would you improve them?

- Is there a rural/urban audience to be focused on? The intent is clear, but the audience may drive more concise statements.
- Key messages could just be the main headings with sub-bullets removed.
- Connect messages back to the study - differences in time of day, etc.
  - How does the mention of COVID-19 hinder the messages because of other associations
- It may not hinder. The data were not from an experimental environment, these data are observations from the situation.
- Could be applied to not just to working from home; also to the use of public or active transportation.
- A statement could be added that acknowledges the balance between economic, social, environmental goals for transportation, etc.
- The general Albertan - why would they care about this? How can their own individual action have an effect? What was observed was due to collective action.

Notes about actions

How do these actions resonate with you?

- They may need to be clarified for a non-pandemic scenario.
- Like messages that focus on individuals and refer to actions within their own control; the broader messages may need refinement.
- Some actions were directly tied to the study. The actions have tried to draw out voluntary actions we can take.
- Where there is reference to "upgrade" (to a new vehicle, for example) – the wording could be changed to, "if upgrading".
- Need to connect to the study completed - what did we learn and how can we apply the learnings to the actions?
- Many are focused to middle class and urban. Perhaps focus on ways that take away the individual vehicles as populations continue to increase.
- Healthy communities by design and what is needed to make them possible (see links below).

Are there any actions you feel are missing?

- What about companies that have their own vehicles that their employees use to do service work, repairs, etc.?

Are there other studies or communication initiatives (ongoing or completed) you are aware of that could include similar types of actions individual Albertans could undertake to improve air quality?

- Ties in with some of the Healthy Communities by Design initiatives. There are some Alberta-specific resources.[213,214]

Sharing the messages

Who else might be interested in spreading these messages that did not attend today's session?

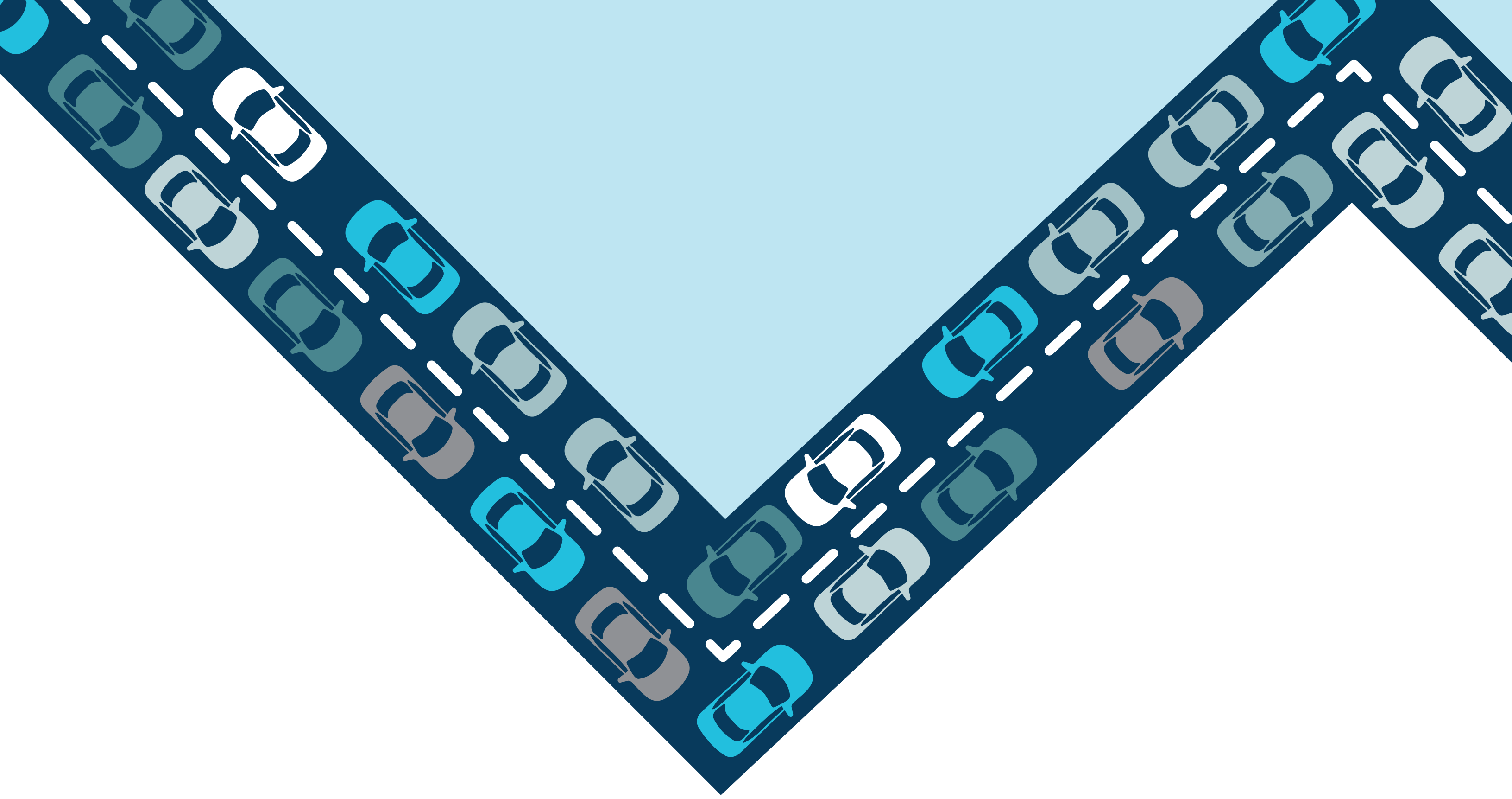
- Alberta Education.
- Need info on demographics - shift in demographics towards younger generation – there may be opportunities to engage with a younger crowd and connect with different perspectives.
- Alberta Medical Association - doctors, nurses etc.

Are there specific groups we might target as recipients of these key messages?

- Policy makers.
- Elected officials, decision makers, those that influence infrastructure transition.

213 Webpage: Alberta Health Services. 2022. *Alberta healthy communities, healthier together.* https://albertahealthycommunities.healthiertogether.ca/

214 Webpage: University of Alberta, School of Public Health. 2022. *Centre for Healthy Communities.* https://www.ualberta.ca/public-health/research/centres/centre-for-healthy-communities/index.html



CASA
Clean Air Strategic Alliance

1400, 9915 – 108 Street NW
Edmonton, AB T5K 2G8

T: 780-427-9793
E: info@awc-casa.ca

https://www.casahome.org/
@CleanAirSA