Carcinogens in traffic-related air pollution

Environmental Exposure Summary Package

This package serves as a summary of CAREX Canada’s results on priority exposures to known or suspected carcinogens in traffic-related air pollution (TRAP) in Canada. Assembling various CAREX Canada data, tools, and resources, it provides an overview of exposures to traffic-related air pollutants that are linked to cancer, including diesel engine exhaust, gasoline engine exhaust, particulate matter, 1,3-butadiene, benzene, and formaldehyde. Our aim is to provide a useful guide for those looking to better understand – and help reduce or eliminate – common carcinogenic exposures associated with traffic-related air pollution.

Figure 1: Priority known or suspected carcinogens in traffic-related air pollution

Traffic-related air pollution in Canada

Approximately one third of the Canadian population is exposed to traffic-related air pollution (TRAP) where they live (defined as areas located 500m from a highway or 100m from a major urban road), according to Brauer et al. (2012). Concentrations of air pollution can vary widely within a geographical area, but people living near major roads and traffic corridors can be exposed to higher levels of TRAP. The main route of exposure to TRAP carcinogens is inhalation via outdoor and indoor air (traffic emissions can infiltrate buildings and homes).

The International Agency for Research on Cancer (IARC) classifies outdoor air pollution as carcinogenic to humans, and exhaust from motor vehicles, or TRAP, is a major contributor to outdoor air pollution. Exhaust from gasoline and diesel engines is a complex mixture of substances that are formed as by-products of fuel combustion. This includes a number of known or suspected carcinogens, as well as substances such as nitrogen oxides, sulphur dioxide, carbon monoxide, and ozone, which are linked to other health effects. The focus of this package is carcinogens in TRAP, but non-cancer health effects, such as respiratory and cardiovascular diseases, are also important outcomes associated with TRAP exposure.
CAREX Canada offers various tools and resources to explore exposures across jurisdictions and gain a better understanding of how to interpret the information that CAREX provides. These include:

### Emissions Mapping Project

Uses a Google Earth interface to allow users to:
- See how watersheds, eco-zones, provinces, health regions, and major cities rank in terms of total toxicity of emissions to outdoor air
- Explore how much each source - including motor vehicles - contributes to total emissions by carcinogen
- Identify how different sources contribute to the rankings for 2011

For example, in Toronto the highest annual amounts of emissions from vehicle traffic included benzene (854,667 kg), formaldehyde (574,561 kg), and particulate matter (76,384 kg).

The Emissions Mapping Project (EMP) is available under the Tools tab on our website. Information on data sources and strengths and limitations can be found on page 6 of this package.

Figure 2: EMP results for emissions to outdoor air in Toronto

*Note: The method used to rank a substances’ toxicity in EMP requires a published human toxicity potential (HTP) factor, a numerical value that indicates the relative toxicity of various emissions with respect to potential cancer outcomes. The HTP factor is not available for all of our priority substances.*
eRISK Tool

Allows users to explore estimates of excess cancer risk associated with exposures to known and suspected carcinogens in the environment. Cancer risk is measured at a population level using Lifetime Excess Cancer Risk (LECR) or the expected number of additional cancer cases above the national average. Users can explore CAREX Canada’s data, or use local data (ex. air monitoring data from traffic corridors) to develop custom estimates and make comparisons. Note that these risk estimates capture exposures from total emissions in outdoor air, not just those from TRAP.

eRISK is available under the Tools tab on our website. Information on data sources and strengths and limitations can be found on page 6 of this package.

Figure 3: Sample of eRISK Online results for diesel engine exhaust and benzene in outdoor air, using cancer potency factors from the California Office of Environmental Health Hazard Assessment (CAOEHHA)

### eRISK Online

**Scenario 1 Substance Name**
- Diesel engine exhaust

**Scenario 1 Exposure Pathway**
- Outdoor Air

**Scenario 1 Agency Name**
- CAOEHHA

**Scenario 1 Detection Frequency**
- 1

**Scenario 1 Mean or Maximum Concentration**
- Mean

**Scenario 1 Input Custom Concentration**
- 0

**Environmental concentration:** 1.242 μg/m³

The lifetime excess cancer risk (LECR) associated with this exposure scenario is 31.613 per million people.

**Scenario 2 Substance Name**
- Benzene

**Scenario 2 Exposure Pathway**
- Outdoor Air

**Scenario 2 Agency Name**
- CAOEHHA

**Scenario 2 Detection Frequency**
- 1

**Scenario 2 Mean or Maximum Concentration**
- Mean

**Scenario 2 Input Custom Concentration**
- 0

**Environmental concentration:** 0.840 μg/m³

The lifetime excess cancer risk (LECR) associated with this exposure scenario is 1.944 per million people.

### Videos

Webinar and tutorial videos provide detailed background on estimates and methods, training on how to use CAREX resources and tools such as eRISK, and special topics such as outdoor air exposures.

Webinar and tutorial videos are available under the Videos tab and the schedule of upcoming webinars is available under the Training tab on our website.
The CAREX Canada website contains detailed information on use, production and trade, exposure routes, and health effects for priority carcinogens linked to TRAP. A sample of these is summarized below.

More information, including regulations and guidelines for each agent, methods for calculating exposure level estimates, and a list of references, is available under the Profiles and Estimates tab on our website.
Exposure reduction strategies

A number of strategies may help reduce environmental exposure to TRAP. A report prepared for Health Canada (Brauer et al., 2012) summarizes the main exposure reduction strategies from a Canadian perspective. These include:

1. Land-use planning and transportation management. For example:
   - Site new buildings that house susceptible populations away from busy roads
   - Develop low emission zones and anti-idling bylaws
   - Improve infrastructure for active commuting

2. Reduce vehicle emissions. For example:
   - Develop new vehicle emission regulations and improve fuel quality standards
   - Develop inspection and maintenance programs for existing vehicles
   - Reduce age of vehicle fleet

3. Modify existing structures. For example:
   - Create separated bicycle lanes
   - Install air filtration in indoor environments

4. Encourage behaviour change. For example:
   - Offer alternatives to private vehicles such as car sharing and improved public transport
   - Educate people on the impact of their transportation choices and exposure to TRAP

A compilation of exposure reduction resources, including the Canadian Partnership Against Cancer’s Prevention Policies Directory and the Canadian Cancer Society’s Cancer Information portal, is available on our website.

Methods

One of the main goals of the CAREX Canada project is to estimate Canadians’ potential exposures to the most common known or suspected carcinogens in community settings outside of work (“environmental exposures”), including exposures via outdoor air. Carcinogens are classified based on evaluations made by IARC. We have two indicators of environmental quality: risk-based (eRISK) and emissions-based (EMP). The population-level, risk-based screening approach produces estimates of potential lifetime excess cancer risk (LECR) (Figure 4). These estimates show the number of additional cases of cancer expected to occur in a group of people exposed to a specific known or suspected carcinogen through their entire life.

Figure 4: CAREX Canada’s risk-based approach to assessing environmental exposure to carcinogens
Methods continued...

The emissions-based approach provides geospatial data and regional indicators for environmental quality in Canada. The indicators developed are the sum of total emissions, in toxic equivalents, of known and suspected carcinogens within a region. The sums illustrate differences in Canadians’ potential exposure to these substances in outdoor air.

The highest priority substances we selected are outdoor air carcinogens found in TRAP that have a LECR of 1 in a million people or above (using maximum intake and the highest potency factor). These include diesel and gasoline engine exhaust, as well as individual components found within this exhaust such as particulate matter, 1,3-butadiene, benzene, and formaldehyde. Note that the risk estimates capture exposures from total emissions in outdoor air, not just those from TRAP. Risk estimates are not available for some of the substances on this list because data is lacking (i.e. particulate matter) or IARC has classified it recently so an estimate has not yet been developed (i.e. gasoline engine exhaust).

More information on our methods is available under the Environmental Approach tab on our website.

Data sources


More information on data sources is available under the Data tab for each carcinogen on our website and on the CAREX Emissions Mapping Project page.

Strengths and limitations

Our environmental exposure and emission estimates are indicators of environmental quality in Canada and support prioritization of known and suspected carcinogens for exposure reduction. They enable surveillance by establishing a benchmark, allowing users to identify trends over time and compare across substances and pathways. They are national in scope, while incorporating regional variation when appropriate. Users can also input their own local data to create custom exposure risk estimates and emissions maps.

The environmental exposure estimates on the CAREX Canada website and the eRISK tool are population level indicators of risk, meaning they do not represent an actual risk for any specific Canadian. We assume that exposure occurs at the same level, 24 hours per day for 70 years. Although this is not true for any single individual, using a standard set of assumptions allows us to provide a relative ranking across multiple substances and exposure pathways. Uncertainties may also exist around the cancer potency factors used, which are published by various agencies and make a variety of toxicological assumptions such as a linear dose response.

The Emissions Mapping Project is a visual and interactive display of major sources of emissions made available through national monitoring programs. Reported emissions may be over or underestimated for a number of reasons. Emission factors were not available for all substances of interest, and factors known to alter overall emission levels such as vehicle age, off-road emissions, and the most recent vehicle emission factors were not considered. Due to lack of data, the emissions are based on road length and not traffic volume, which may underestimate emissions in urban areas and overestimate emissions in rural areas. Emissions travel across boundaries and dissipate at various rates, which may also affect reported values. The EMP presents estimates of emissions from major sources, not estimates of concentration or individual exposures.

More information on strengths and limitations is available under the Environmental Approach tab on our website and on the CAREX Emissions Mapping Project page.
**Where can you learn more?**

- Visit our website at [www.carexcanada.ca](http://www.carexcanada.ca)
- Follow us on Twitter [@CAREXCanada](https://twitter.com/CAREXCanada)
- Email us at [info@carexcanada.ca](mailto:info@carexcanada.ca)

**Relevant publications and reports**

- **IARC Monographs Volume 109: Outdoor Air Pollution**

- **IARC Monographs Volume 105: Diesel and Gasoline Engine Exhausts and Some Nitroarenes**

- **IARC Monographs Volume 100F: Chemical Agents and Related Occupations**

- **Environmental Burden of Cancer in Ontario**
  Cancer Care Ontario, Public Health Ontario, 2016.

- **Air Pollution**
  Canadian Cancer Society, 2016.

- **Identifying potential exposure reduction priorities using regional rankings based on emissions of known and suspected carcinogens to outdoor air in Canada**

- **Traffic-Related Air Pollution and Health: A Canadian Perspective on Scientific Evidence and Potential Exposure-Mitigation Strategies**

- **Risk-based indicators of Canadians’ exposures to environmental carcinogens**

- **Spatiotemporal air pollution exposure assessment for a Canadian population-based lung cancer case-control study**

- **Creating National Air Pollution Models for Population Exposure Surveillance in Canada**

- **Reducing Exposure to Traffic Emissions**
  Metro Vancouver, 2013.

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