Transportation, air pollution and human health @ Health Canada

Mathieu Rouleau
Fuels Assessment Section, Water & Air Quality Bureau

CARTEEH – Transportation, Air Quality, and Health Symposium
February 20, 2019
Presentation outline

1. Our organisation and mandate
2. Health impact assessments for transportation sectors
3. Literature reviews of transportation strategies
4. Exposure research initiatives on transportation
5. Closing remarks
1. Organisation and Mandate – Health Canada

- Federal department
- Responsible for helping Canadians
  - Maintain and improve their health
  - Prevent and reduce risks

- Water and Air Quality Bureau
  - Air Division
    - Evidence-based decisions to address the health impacts of air pollution
    - Support policy development & regulatory actions
    - Inform the public on action they can take to protect their health

➤ Transportation activities: HIAs, CBAs, RAs, RIAS and exposure research
2. Health Impact Assessments

Transportation sectors
2. Health Impacts Assessments

Step 1

- Canadian and US emission inventories for all sources
- Policy or Sector scenarios

Step 2

- Air Quality Modeling System
  - Meteorological model
  - Emissions processing system
  - AQ MODEL (AURAMS, GEM-MACH)

Step 3

- Ambient Concentrations
  - $O_3$, $PM_{2.5}$, $NO_2$, etc.
- AQBAT
- Human health benefit estimates
- Morbidity & mortality

AQ modeling system allows to investigate different “what if” emission scenarios & compare them with a reference scenario.

Output:

- Magnitude and location of proposed changes in emissions and air quality
- Health benefit estimates & cost estimates
2. HIAs associated with transportation emissions

- Air quality benefits assessments tool (AQBAT) to quantify adverse health outcomes
  - Concentration response functions (CRFs)
  - $\text{PM}_{2.5}$, NO$_2$, CO, SO$_2$ and O$_3$
  - Willingness to pay values

- Example: All on-road vehicle emissions *

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>outcomes/ year</th>
<th>Costs (CAN)</th>
<th>Model year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature deaths</td>
<td>1700</td>
<td>$12.7B</td>
<td>2014</td>
</tr>
<tr>
<td>Asthma symptom days</td>
<td>25,000,000</td>
<td>$25M</td>
<td></td>
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</table>

* Preliminary results; please do not cite
3. Reviews

Transportation strategies
3. Reviews of transportation management strategies

• Evaluate the impact of transportation options on emissions, air quality, exposure and population health:
  
  i. Traffic management strategies (lead: A. Bigazzi, UBC)
  ii. Freight modal shift (lead: T. Ramani, TTI)
  iii. Personal travel modal shift (lead: D. Scott, McMaster U)

• The reviews highlighted:
  - Lack of Canadian data
  - Need for greater monitoring and accountability
  - Transportation-related improvements in air quality and population health require coordinated and concerted interventions.

• Publications are available
4. Exposure research initiatives

Transportation modes
Canadian Atlantic Marine Air Pollution Study (CAMAPS)

- In 2012, regulations implemented to reduce air pollution from marine vessels in Canada & to define a North American Emission Control Area (ECA).
- Pre- and post-ECA air quality monitoring in the port city of Halifax, NS
- Data sources:
  - National Air Pollution Surveillance (NAPS) site
  - Field campaigns in 2011-12 and 2016-17

How did the large vessel marine fuel sulfur Regulations influence ambient air pollutant exposures in a Canadian port city?

Project lead: Angelos.Anastassopoulos@canada.ca
CAMAPS – Did the ECA improve air quality?

- Mean decrease of 73% in ambient SO₂
  - ↓ 2 ppb all directions
  - ↓ 4–7 ppb harbour inlet
  - Current SO₂ levels show little directionality
  - Suggests marine ships no longer dominant SO₂ source in Halifax

- Mean decrease of 26% in ambient PM₂.₅
  - ↓ 1.7 µg/m³ all directions
  - Slightly greater ↓ for harbour inlet
  - Suggests less effective for ship PM₂.₅
    - OR
  - Marine & local sources don’t dominate
  - Ongoing PM₂.₅ source apportionment
5. Closing remarks

Road work ahead
Closing remarks

• Promote HC initiatives and research on transportation

• Improve estimates of health impacts attributable to air pollution, specifically from transportation

• Ongoing work associated with multiple modes

• Addressing knowledge gaps via research

• Always looking for opportunities to collaborate
  o Data analysis & interpretation
  o Communications and outreach
Acknowledgements

Health Canada colleagues

- Angelos.Anastassopoulos@canada.ca – Marine and Rail
- Keith.VanRyswyk@canada.ca – Bus, Metro & Car commuters
- Gary.Mallach@canada.ca – In-vehicle Ventilation
- Markey.Johnson@canada.ca – Integrated Urban Modelling

Collaborators for transportation literature reviews

- Alex Bigazzi, abigazzi@civil.ubc.ca
- Tara Ramani, T-Ramani@tti.tamu.edu
- Darren Scott, scottdm@mcmaster.ca
Thank you / Merci

Mathieu.Rouleau@canada.ca, senior evaluator
Fuels Assessment Section
Air Health Effects Assessment Division
Health Canada
hc.air.sc@canada.ca
References

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- Van Ryswyk K; Evans G; Kulka R; Sun L; Sabaliauskas K; Rouleau M; Anastasopolous A; Wallace L; Weichenthal S (submitted). Commuting exposures to particulate air pollution in three Canadian bus transit systems: The Urban Transportation Exposure Study.
- Van Ryswyk K; Anastasopolos A; Evans G; Sun L; Sabaliauskas K; Kulka R; Wallace L; Weichenthal S (2017). Metro commuter exposures to particulate air pollution and PM$_{2.5}$-associated elements in three Canadian cities: the Urban Transportation Exposure Study. Environ Sci Technol 51: 5713-5720.
- Weichenthal S; Shekarrizfard M; Kulka R; Lakey PSJ; Al-Rijleh K; Anowar S; Shiraiwa M; Hatzopoulou M (2018). Spatial variations in the estimated production of reactive oxygen species in the epithelial lung lining fluid by iron and copper in fine particulate air pollution. Environmental Epidemiology 2:e020
Extras
Canadian ECA Effects Study (CanECA)

- Impact of ECA on ambient air pollution in more major Canadian ports: Victoria & Vancouver, BC; Montreal & Quebec, QC; St. John, NB; St. John’s NL
- Similar results seen for Vancouver near-port NAPS data
  - 66–83% decrease in ambient SO\textsubscript{2} level post- vs. pre-ECA
  - PM\textsubscript{2.5} review ongoing

![Map of Canadian ECA Effects Study](image)

Hourly mean SO\textsubscript{2} (ppb)

<table>
<thead>
<tr>
<th>Period</th>
<th>Description</th>
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<tbody>
<tr>
<td>Pre</td>
<td>2010-2011</td>
</tr>
<tr>
<td>ECA1</td>
<td>Interim Regulations 2013-2014</td>
</tr>
<tr>
<td>ECA2</td>
<td>Post Regulations 2015-2016</td>
</tr>
</tbody>
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4. Transportation exposure research @ Health Canada

- Urban Transportation Exposure Study (UTES)
- Toronto Subway Air Quality Intervention (SAQI) study
  - Keith.VanRyswyk@canada.ca
- Commuter Air Pollution Intervention (CAPI) study
  - Gary.Mallach@canada.ca
- Integrated Urban Modelling SMARTPLANS (Simulation Model for Assessing the Ramifications of Transportation Policies and Land Use Scenarios)
  - Markey.Johnson@canada.ca
Urban Transportation Exposure Study – UTES

Project lead: Keith.VanRyswyk@canada.ca

Vancouver, BC 2013
Car, Bus & SkyTrain

Toronto, ON 2010-11
Car, Bus & Subway

Montréal, QC 2010-11
Car & Metro

Ottawa, ON 2010-11
Bus
Air pollution health impacts in Canada

- Ambient air pollution levels attributable to emissions from North American anthropogenic sources

- Exposure surfaces:
  - Current levels of PM$_{2.5}$, O$_3$ and NO$_2$
  - Reference or counterfactual exposure surfaces
    - All North American anthropogenic sources of air pollution removed

- 14,400 premature deaths annually in Canada.
  - All sectors combined
  - All-cause non-accidental deaths (cancer, IHD, COPD and CV)
  - ~6.6% of annual deaths in Canada

<table>
<thead>
<tr>
<th></th>
<th>PM$_{2.5}$</th>
<th>NO$_2$</th>
<th>O$_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg ambient concentration</td>
<td>6.5 µg/m$^3$</td>
<td>8.5 ppb</td>
<td>38.8 ppb (annual) 43.6 ppb (May-Sept)</td>
</tr>
<tr>
<td>Counterfactual</td>
<td>1.8 µg/m$^3$</td>
<td>0.2 ppb</td>
<td>25.8 ppb (annual) 28 ppb (May-Sept)</td>
</tr>
<tr>
<td>Nb of premature deaths</td>
<td>9,500 – chronic</td>
<td>1,300 – acute</td>
<td>2,400 – acute 1,200 – chronic</td>
</tr>
</tbody>
</table>
2. Recent HIAs associated with transportation emissions

- Air quality benefits assessments tool (AQBAT) to quantify adverse health outcomes
  - Concentration response functions (CRFs)
  - PM$_{2.5}$, NO$_2$, CO, SO$_2$ and O$_3$
  - Willingness to pay values

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<thead>
<tr>
<th>Sector / Regulations</th>
<th>Premature deaths</th>
<th>Costs (CAN)</th>
<th>Model year</th>
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<tbody>
<tr>
<td>All on-road</td>
<td>1700</td>
<td>$12.7B</td>
<td></td>
</tr>
<tr>
<td>HDVs</td>
<td>800</td>
<td>$6.0B</td>
<td>2014</td>
</tr>
<tr>
<td>LDVs</td>
<td>760</td>
<td>$5.7B</td>
<td></td>
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<tr>
<td>Air, marine, rail</td>
<td>310</td>
<td>$2.3B</td>
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<tr>
<td>On-road diesel *</td>
<td>320</td>
<td>$2.5B</td>
<td>2015</td>
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<tr>
<td>On-road gasoline *</td>
<td>700</td>
<td>$5.4B</td>
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<tr>
<td>Tier III regs *</td>
<td>1400</td>
<td>$7.2B</td>
<td>2017-2030</td>
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* Publications available