

Health Impacts of Air Pollution in Canada:

Recent findings on mortality, morbidity, and monetized costs by transportation, industry, and residential sectors

NCCEH Webinar

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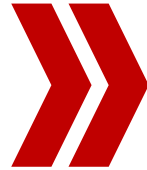
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→ link in chat !!

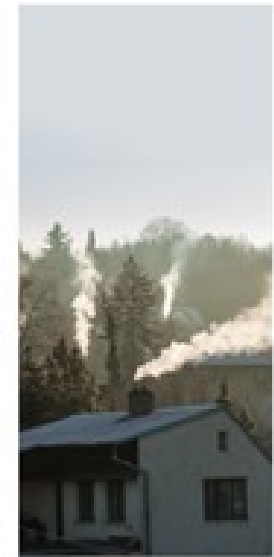
PROJECT TEAM

Health Canada

- Air Sectors Assessment and Exposure Science Division
- Economic Health and Analysis Division

**Environment & Climate Change
Canada**

- Air Quality Policy-Issue Response Section, Meteorological Service of Canada



**HEALTH IMPACTS OF AIR POLLUTION FROM
TRANSPORTATION, INDUSTRY AND
RESIDENTIAL SOURCES IN CANADA**

Estimates of premature mortality and morbidity outcomes
at national, provincial, territorial, and air zone levels



Outline

I. Project overview

- objectives
- methods

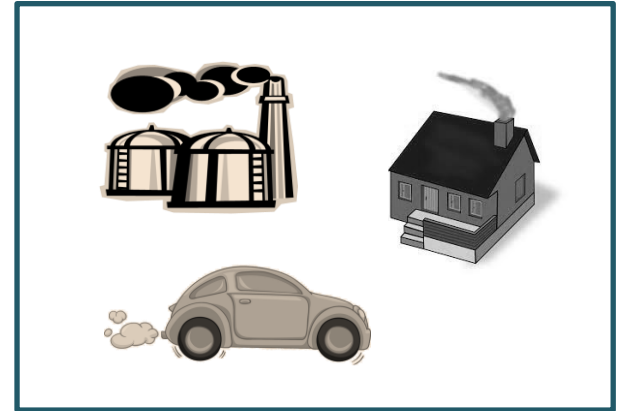
II. Sector health impact results

- national & prov/terr “top 3” sectors

III. Case studies (example results)

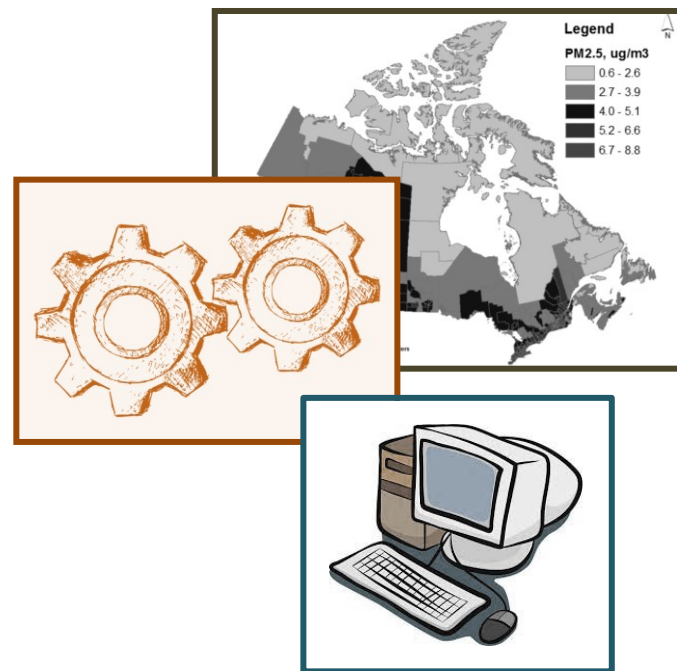
- sectors of interest: residential wood combustion, on-road vehicles
- example air zone: Southern Ontario

IV. Key findings & next steps



Project objectives

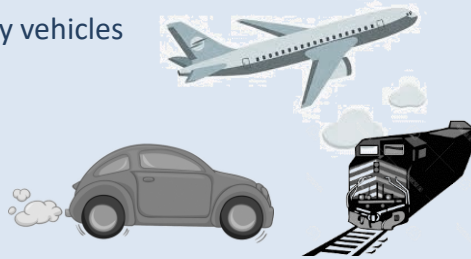
- quantify outdoor air quality and health impacts by sector
 - 21 sectors: industrial, residential and transportation
- compare health impacts
 - across sectors
 - by region: national, prov/terr, airzone
- inform policy, management strategies



➤ *so how did we do this? let's talk a bit about methodology...*

TRANSPORTATION SOURCES (8)

- on-road
 - light duty vehicles
 - heavy duty vehicles
- off-road
- air
- marine
- rail



RESIDENTIAL SOURCES (2)

- residential fuel combustion
- residential wood combustion (RWC)
aka “home firewood burning”



INDUSTRY SOURCES (11)

- ore and mineral
 - cement
 - non-ferrous refining/smelting
- oil and gas – upstream
- oil and gas – downstream
- electric power generation
 - coal-fired
- manufacturing
 - chemicals
 - pulp and paper



EXCLUDED

- wildfires
- agriculture
- open sources (e.g., construction dust)
- Transboundary pollution

METHODS | MODELLING FRAMEWORK

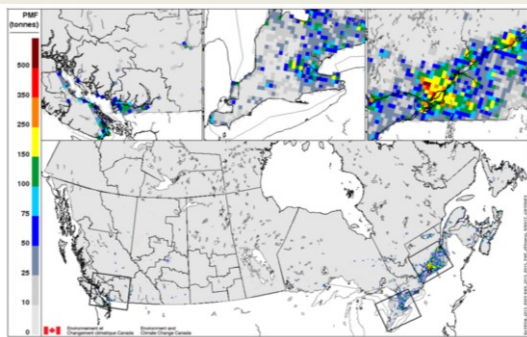
Step 1 Air pollutant emissions

PM_{2.5}, PM₁₀, NO_x, CO, SO_x, VOC,
NH₃

Inventory development

Source	1990	2000	2005	2
ORE AND MINERAL INDUSTRIES	54 000	51 000	41 000	
Aluminium Industry	5 400	4 600	5 200	
Asphalt Paving Industry	1 900	1 700	1 500	
Cement and Concrete Industry	11 000	9 700	12 000	
Foundries	4 600	4 300	4 500	
Iron and Steel Industry	11 000	9 700	5 200	
Iron Ore Pelletizing	650	3 900	1 200	
Mineral Products Industry	1 300	1 200	960	
Mining and Rock Quarrying	9 600	10 000	6 900	
Non-Ferrous Refining and Smelting Industry	8 600	5 600	4 100	
OIL AND GAS INDUSTRY	12 000	14 000	12 000	
Downstream Oil and Gas Industry	5 100	4 900	4 600	
Upstream Oil and Gas Industry	6 800	8 800	7 900	
ELECTRIC POWER GENERATION (UTILITIES)	49 000	23 000	9 100	
Coal	46 000	20 000	5 000	
Landfill Gas	0.41	1.6	5.3	
Natural Gas	1 300	2 100	1 900	
Diesel	280	410	400	
Other (Electric Power Generation)	1 300	720	1 800	
MANUFACTURING	110 000	75 000	45 000	
Abrasives Manufacturing	390	210	200	
Bakeries	0.54	0.54	0.43	
Biofuel Production	-	-	-	
Chemicals Industry	4 800	4 500	4 100	
Electronics	130	39	5.7	
Food Preparation	1 400	2 100	1 700	
Glass Manufacturing	950	1 300	1 100	
Grain Industry	2 200	2 900	2 000	
Metal Fabrication	180	270	360	
Plastics Manufacturing	150	170	120	
Pulp and Paper Industry	61 000	25 000	18 000	
Textiles	16	23	18	
Vehicle Manufacturing (Engines, Parts, Assembly, Painting)	1 700	1 600	650	
Wood Products	35 000	28 000	14 000	
Other (Manufacturing)	6 300	8 900	3 000	
TRANSPORTATION AND MORILE EQUIPMENT	70 000	72 000	65 000	

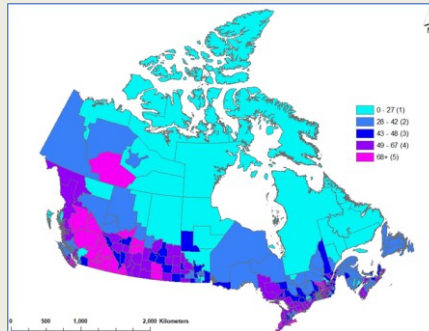
Spatial Allocation



Step 2 Air quality modelling

PM_{2.5}, NO₂, O₃, SO₂

Chemical transport modelling



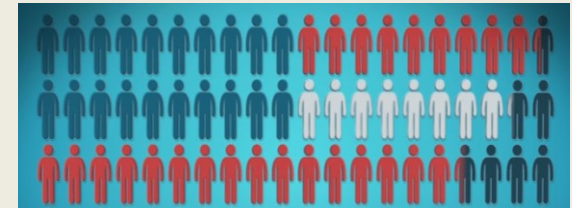
Exposure estimates



Step 3 Health impact modelling

Morbidity and mortality endpoints

Number of outcomes



Monetized impacts



SECTOR APPORTIONMENT – ZERO-OUT MODELLING

ITERATIVE AIR QUALITY MODEL SIMULATIONS

BASE CASE

Best estimate of real-world ambient (outdoor) pollution.
Includes all North American sources, excludes wildfires

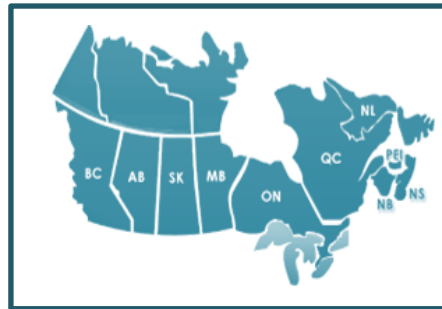


SECTOR SCENARIO

Emissions excluded for one Canadian sector at a time, for all pollutants



Δ concentrations



Sector contribution to ambient concentrations
=
Sector population exposure estimate

- Air Quality Benefits Assessment Tool (**AQBAT**)

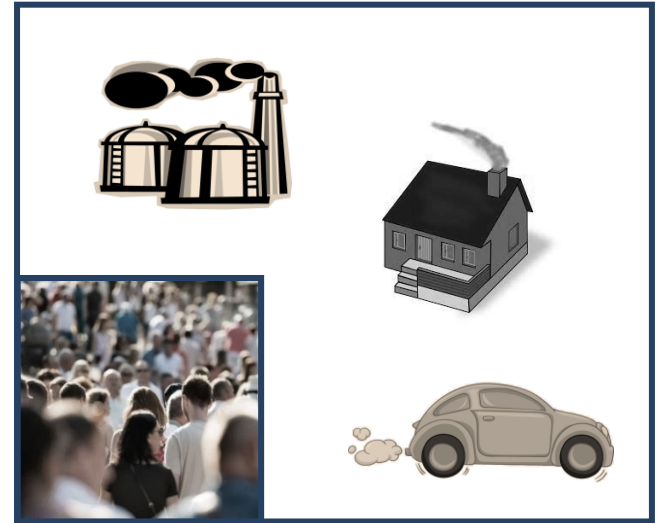
$$HI_i = Exposure_i \times Risk \times Pop \times State\ of\ health$$

- **HI_i**: sector *i* health impacts; **Exposure_i**: air pollutant concentration attributable to sector *i*; **Risk**: concentration-response function for a pollutant-endpoint pair; **Pop**: target population for an endpoint; **State of health**: baseline incidence rate for an endpoint

$$\text{Monetized impacts for sector } i = HI_i \times \text{Willingness to Pay}$$

- willingness to pay for a reduction in risk, by endpoint

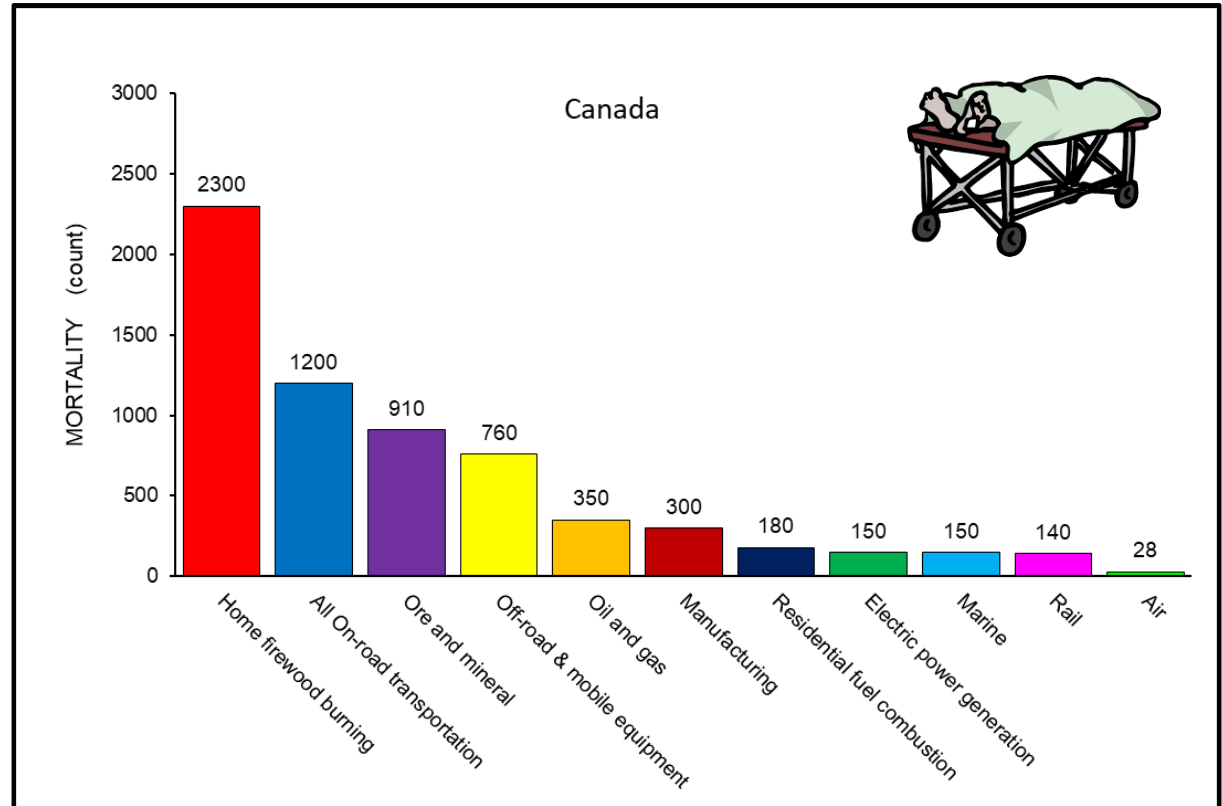
Pollutant–Endpoint Pairs	
NO₂	Acute exposure mortality
O₃	Acute exposure mortality
Summer O₃	Chronic exposure respiratory mortality Acute respiratory symptom days; Asthma symptom days; Minor restricted activity days; Respiratory emergency room visits; Respiratory hospital admissions
PM_{2.5}	Chronic exposure mortality 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



II. Sector results | **comparisons of health impacts**

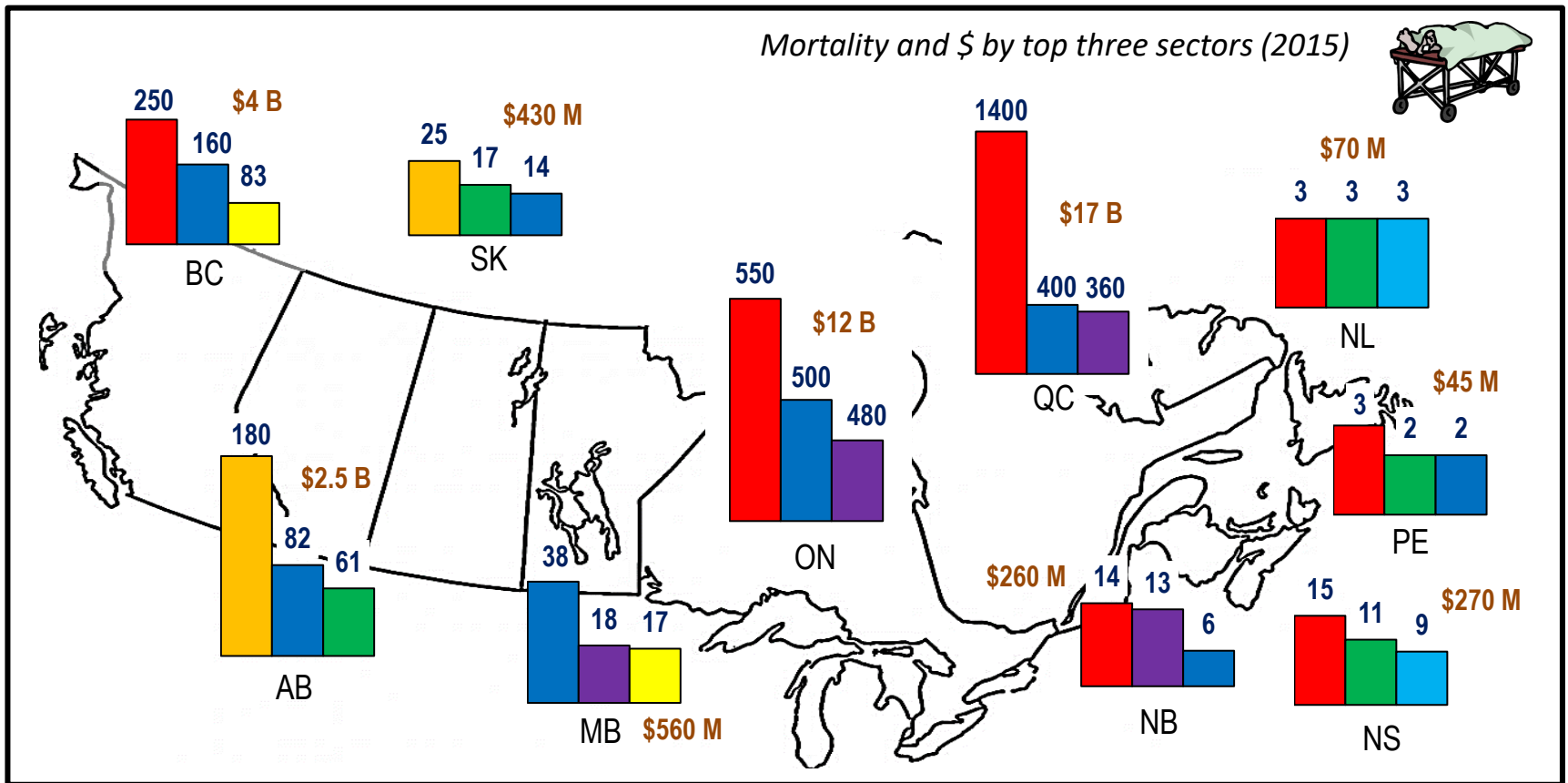
- national
- provincial

- nationally, **6,500 deaths** (2015) attribute to ambient air pollution from all modelled sectors
- total health burden (premature mortality + morbidity) equivalent to **\$51 B annually** in monetized costs
- **sectors with greatest health impacts**
 - residential wood combustion (home firewood burning)
 - on-road transportation
 - ore and mineral industry



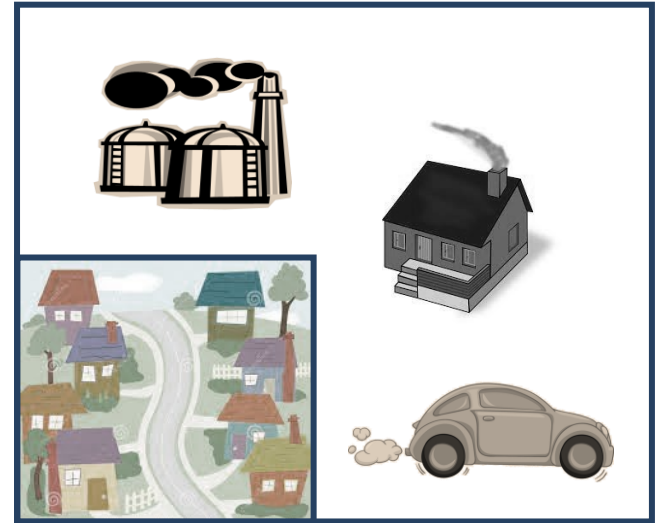
Air pollution-related mortality (PM_{2.5}, NO₂, O₃, summer-O₃ | national 2015 total).

HEALTH IMPACTS – PROVINCIAL



- some sectors rank high in nearly all provinces → RWC, on-road transportation
- other high-health impact sectors are highly regional (i.e., industry)
 - oil and gas → West (AB, SK)
 - ore and mineral → Central (ON, QB) + MB + NB
 - electric power gen → West (AB, SK) + Atlantic (NS, NL, PE)
 - marine transportation → Atlantic (NS, NL)
- provincial costs for top-3 are substantial





III. Sector results | **CASE STUDIES**

- sectors of interest (“sector dashboard”)
- example air zone

SECTOR DASHBOARD | Residential: home firewood burning (RWC)

EMISSIONS

- **dominant sector for multiple pollutants** (PM_{2.5}, PM₁₀, VOC; within top 3 for CO, NH₃)
- PM_{2.5} emissions ranking high in all prov/terr (except NU)
 - nationally, **~2.5x total of all transportation sectors**
- inherently greater EI uncertainty

AIR QUALITY IMPACTS

- nationally, **within top 3** contributing to ambient PM_{2.5}
- within top 3 in **most provinces** (West, Central, Atlantic)
- **substantial AQ impacts**
 - e.g., contribution to annual avg pop-wt levels of PM_{2.5}
 - QC, 2.4 ug/m³
 - BC, 0.9 ug/m³



HEALTH IMPACTS

- nationally in 2015, **2,300 deaths**
 - top-ranked in majority of provinces: Central, Atlantic, BC (not in West)
 - within these provinces, top-ranked in majority of air zones
 - including lower pop air zones
- **substantial morbidity**
 - 9,300 child acute bronchitis cases
 - 2,100 adult chronic bronchitis cases
 - 1,300 hospital admissions and emergency room visits (cardiac & respiratory)
 - 5.9 M symptom days (acute respiratory and asthma)
 - 2.9 M restricted activity days

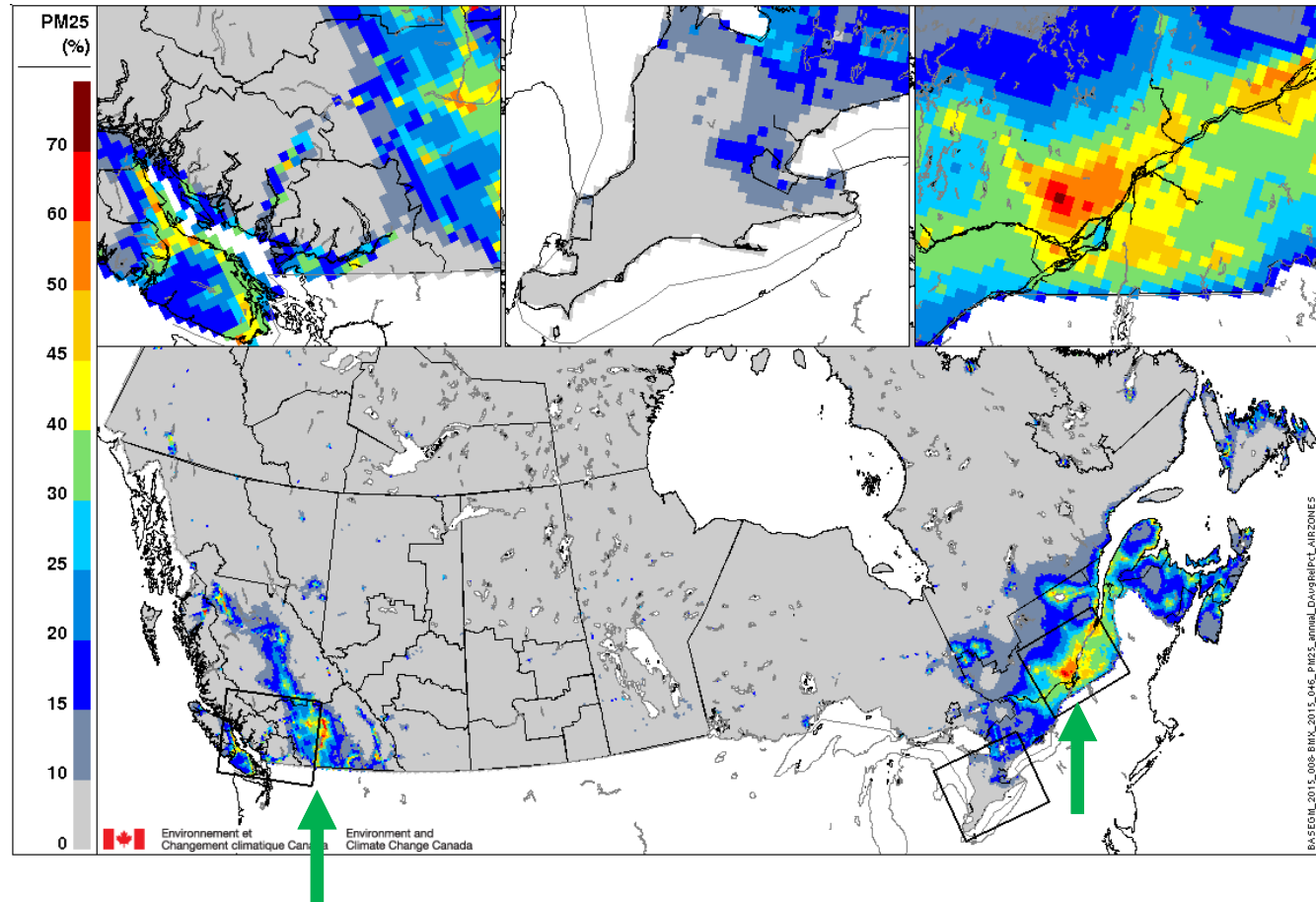


- **\$18 B monetized health costs** (2015 CAD, mortality + morbidity)
- **2x higher than All On-Road Transportation**



% RWC contribution to ambient $PM_{2.5}$
(annual average daily mean, 2015)

- in many locations (grid cells), RWC contributes **40-70%** of **$PM_{2.5}$ levels** (annual average daily mean)
 - QC
 - BC



SECTOR DASHBOARD | Transportation: On-Road Vehicles

EMISSIONS

- **highest in most populated/urban** provinces
- **ubiquitous source**: top 3 in most provinces for NO_x , CO, VOC, NH_3
- **LDV, HDV differ meaningfully**
 - LDV → CO, SO_x , VOC, NH_3
 - HDV → $\text{PM}_{2.5}$, PM_{10} , NO_x

AIR QUALITY IMPACTS

- nationally, **within top 3** sectors contributing to ambient $\text{PM}_{2.5}$, NO_2 , summer O_3
- within top 3 in most provinces, **espec. West, Central regions**
 - e.g., contribution to annual avg pop-wt levels in BC
 - 10% of $\text{PM}_{2.5}$ ($0.4 \mu\text{g}/\text{m}^3$)
 - 47% of NO_2 (2 ppb)



HEALTH IMPACTS

- nationally in 2015, **1,200 deaths**
 - within top 3 in nearly all provinces and majority of air zones
- **substantial morbidity**
 - 3,600 child acute bronchitis cases
 - 800 adult chronic bronchitis cases
 - 780 hospital admissions and emergency room visits (cardiac & respiratory)
 - 3 M symptom days (acute respiratory and asthma)
 - 1.3 M restricted activity days
- **\$9.5 B monetized health costs** (2015 CAD, mortality + morbidity)
- **HDV dominates impacts**
 - HDV ~ 2x LDV (mortality, \$)



- Central Canada
- high population air zone ~ 12.4 M
- **health impacts** from modelled sectors
 - 2,200 deaths (ON total = 2,400)
 - \$19 B (mortality + morbidity)
- **pollutants driving health impacts** are largely PM_{2.5} (1800 deaths), then NO₂
- **top sectors** contributing health impacts
 1. **Home firewood burning/RWC** (510 deaths → driven by sector-contributed PM_{2.5})
 2. **On-road transportation** (470 → O₃, PM_{2.5})
 3. **Ore and mineral industry** (400 → PM_{2.5})
 4. **Off-road & mobile equipment** (370 → PM_{2.5})
- **multiple sectors with similar impacts**



➤ *more info on air zones at:*
<https://ccme.ca/en/air-quality-report>

KEY FINDINGS

- ✓ **individual sector health impacts not always aligned with emissions inventory inference**
 - require quantification via air quality and health burden modelling
- ✓ **for key sectors, geographic scale is important**
 - national ≠ provincial/territorial ≠ air zone
- ✓ **sector-based health impact results can help air quality management better target most important/relevant sources**
 - Air Quality Management System (AQMS) air zones
- ✓ **sectors from all classes important to reduce air pollution health risk**
 - transportation sources, industry sources, residential sources



**Health Canada report
published at**

publications.gc.ca



NEXT STEPS



Air quality & health burden modelling

- **modelling Agriculture sector, including key subsectors (animal, crop)**
 - ✓ 2019 emissions data
 - ✓ first time HC leading health burden modelling on this sector
 - ✓ partnership with AAFC, ECCC

- **updated modelling of RWC sector**
 - ✓ 2019 emissions data
 - ✓ for comparison with 2015 RWC results
 - ✓ emissions inventory comparison suggests similar magnitude of results (i.e., remains top-ranked sector)



- **currently developing new interactive website of sector health burden data**

... stay tuned! 😊

Thank you!



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