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Air pollution health burden in Canada

Updated national estimates & focus on Southern Ontario

Clean Air Hamilton Meeting, September 9, 2024

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Acknowledgments and general notes

- Presentation based on Health Canada publications & ongoing work
- Content from collaborations between:
 - Health Canada
 - Environment and Climate Change Canada
 - Academia
- Publications mentioned are publicly available
 - Please contact mathieu.rouleau@hc-sc.gc.ca or air@hc-sc.gc.ca

Presentation Outline

Air pollution health burden assessment – 2024 report

- objectives
- methods
- results
 - national, provincial and territorial
 - Southern Ontario
- Take away

Complementary analyses

- Sector air pollution contributions
- Transboundary air pollution

Health impacts of air pollution in Canada in 2018

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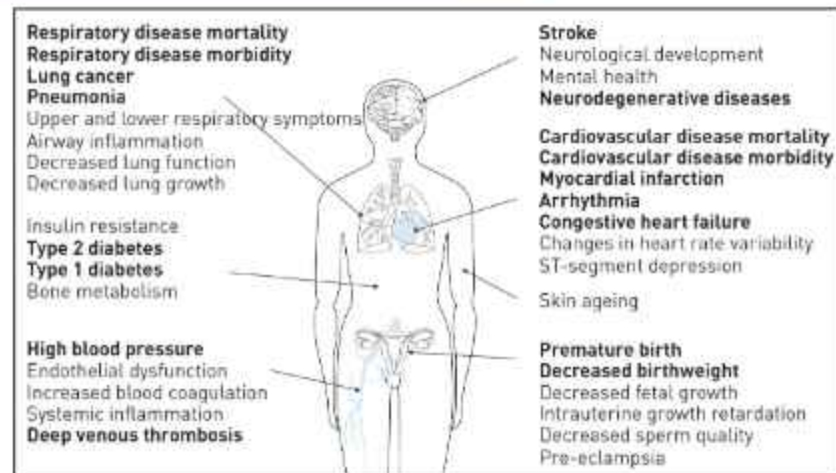
ISBN: 978-0-660-69855-7

Pub.: 230734

www.canada.ca/en/health-canada/services/publications/healthy-living/health-impacts-air-pollution-2018.html

Air pollution and health – What we know

- Exposure to air pollution is associated with several fatal and non-fatal health effects, including:
 - Respiratory
 - Cardiovascular
 - Reproductive & developmental
 - Neurological & mental health
 - Metabolic (e.g. diabetes)
- Some individuals/populations are at higher risk of adverse health effects from exposure to air pollution
- For many air pollutants, there is no safe level of exposure
 - ↓ exposure → ↓ health risks
 - ↑ exposure → ↑ health risks



ERJ, 2016

www.gov.uk/government/publications/health-matters-air-pollution/health-matters-air-pollution

Air pollution and health – Global burden & Canadian perspective

Air Pollution Worldwide

- Largest **environmental** cause of illness & death
- 5.2 million deaths attributable to **ambient** air pollution in 2021
 - 4.7M from PM_{2.5}
 - 0.5M from O₃



Deaths, 2021 ranking

Global	Canada
1 High blood pressure	1 High blood pressure
2 Air pollution	2 Tobacco
3 Tobacco	3 Dietary risks
4 Dietary risks	4 High fasting plasma glucose
5 High fasting plasma glucose	5 High body-mass index
6 High body-mass index	6 Kidney dysfunction
7 High LDL	7 High LDL
8 Kidney dysfunction	8 High alcohol use
9 Malnutrition	9 Occupational risks
10 Non-optimal temperature	10 Non-optimal temperature
11 High alcohol use	11 Drug use
12 Other environmental	12 Low bone mineral density
13 Occupational risks	13 Air pollution
14 WaSH	14 Other environmental
15 Unsafe sex	15 Low physical activity

Metabolic risks
Environmental/occupational risks
Behavioral risks



Air pollution in Canada

- Some of the lowest PM_{2.5} levels globally
- Low NO₂ and O₃ levels compared to other developed countries
- **Still represents a considerable health burden**



Source: All risk, level 2, <https://vizhub.healthdata.org/gbd-compare/#>

Air pollution health burden in Canada – reports



Air pollution health burden in Canada – objectives of the 2024 report

- Quantify the air pollution health burden in Canada in 2018
 - Mortality and morbidity outcomes
 - Monetization of impacts
- Update estimates using more recent:
 - Air quality modelling estimates
 - PM_{2.5}
 - NO₂
 - O₃
 - Health data
- Explore new metrics and address uncertainties
- Inform air quality management strategies

Air pollution health burden in Canada – methodology

➤ Method outline:

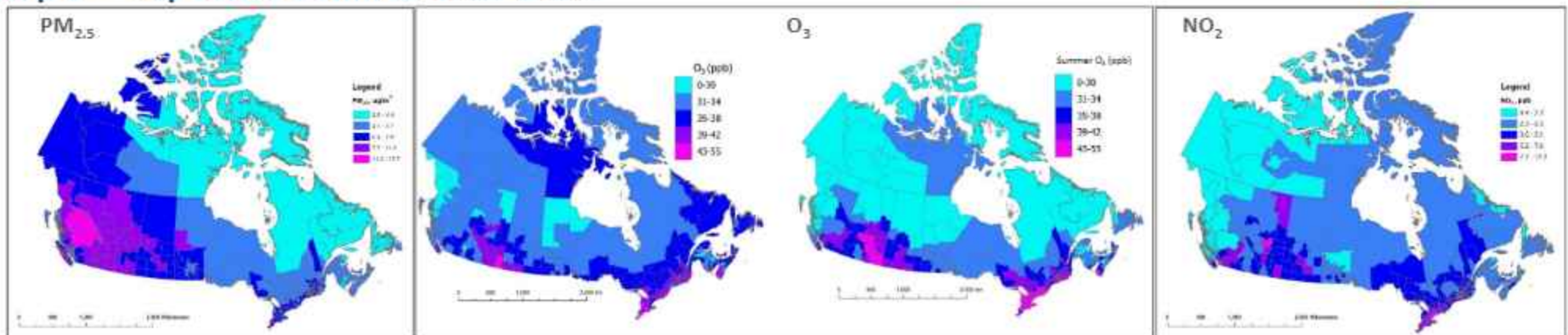
- Estimate **exposure** to ambient concentrations of PM_{2.5}, NO₂ and O₃
 - Air quality modelling
 - Background concentrations
- Estimate air pollution **health impacts** from exposure to PM_{2.5}, NO₂ and O₃
 - HC's Air Quality Benefits Assessment Tool (AQBAT)

Methodology – ambient & exposure concentrations

Step 1 – Air quality modelling for 2017 to 2019

- PM_{2.5}** : hybrid model combining satellite measurements, ground-based observations and modelling using the Goddard Earth Observing System chemical transport model (GEOS-Chem)
- NO₂** : national land-use regression (LUR) model using satellite, land use and meteorological predictors
- O₃** : objective analysis combining ground-based observations and modelling using the Global Environmental Multiscale - Modelling Air quality and Chemistry model (GEM-MACH)

Step 2 – Exposure estimates for 2018



- 3-year average concentrations to represent ambient conditions in 2018
- Population-weighted concentrations at the census division level
- $\text{Exposure}_{\text{poll A}} = \text{Modelled concentration}_{\text{poll A}} - \text{Background concentration}_{\text{poll A}}$

Methodology – exposure

$$\text{Exposure}_{\text{poll A}} = \text{Modelled concentration}_{\text{poll A}} - \text{Background concentration}_{\text{poll A}}$$

- **Background concentrations**
 - minimum ambient air pollution levels; levels typically observed in remote areas
 - not influenced by North American human-made emissions or polluted air masses
- **Exposure = Above-background concentrations**
 - Mainly human-made emissions as well as emissions from natural events, such as wildfires

National average Concentrations	PM_{2.5}	NO₂	O₃	Summer O₃
Ambient (modelled)	7.12 µg/m ³	7.26 ppb	37.16 ppb	40.39 ppb
Background	1.8 µg/m ³	0.15 ppb	26 ppb	28 ppb
Above-background	5.32 µg/m ³	7.11 ppb	11.16 ppb	12.39 ppb

Health burden assessment methodology – AQBAT (1/2)

Modelled and background concentrations are used in **AQBAT**

- Health Canada model to estimate air pollution health impacts
- Accounts for **exposures**, air pollutant **risks**, **population** size & health
- Includes multiple mortality and morbidity effects (i.e. air pollutant-endpoint pairs)

Air Pollutant–Endpoint Pairs in AQBAT	
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

* Health Canada considers there is sufficient evidence for an association between exposure to a pollutant and a health effect for all AQBAT pairs.

Air pollution health burden in Canada – National mortality results

Air pollution attributable deaths in Canada, by pollutant, in 2018		
Pollutant	Deaths	Monetization (2020 CAD)
All	17,400	\$139B
NO ₂	1,300	\$10.3B
PM _{2.5}	12,500	\$99.8B
O ₃	2,400	\$19.5B
O ₃ summer	1,200	\$9.5B

- Exposure to **PM_{2.5}** contributes **72%** of the air pollution attributable deaths
- Deaths represent **95% of the air pollution health burden**
 - \$139B out of \$146B for all endpoints

Air pollution health burden in Canada – P/T mortality results

Air pollution attributable deaths in 2018			
Region	Counts	per 100k population	Monetized value, \$M (2020 CAD)
Canada	17,400	47	139,000
Ontario	6,500	46	52,200
Quebec	4,300	50	34,200
British Columbia	2,400	51	19,300
Alberta	2,100	48	17,100
Manitoba	570	43	4,600
Saskatchewan	540	48	4,300
Nova Scotia	390	41	3,100
New Brunswick	270	35	2,100
Newfoundland & Labrador	170	34	1,400
Prince Edward Island	59	39	470
Yukon	11	28	84
Northwest Territories	8	18	65
Nunavut	3	7	22

2018 results – Deaths per 100,000 pop, by census division

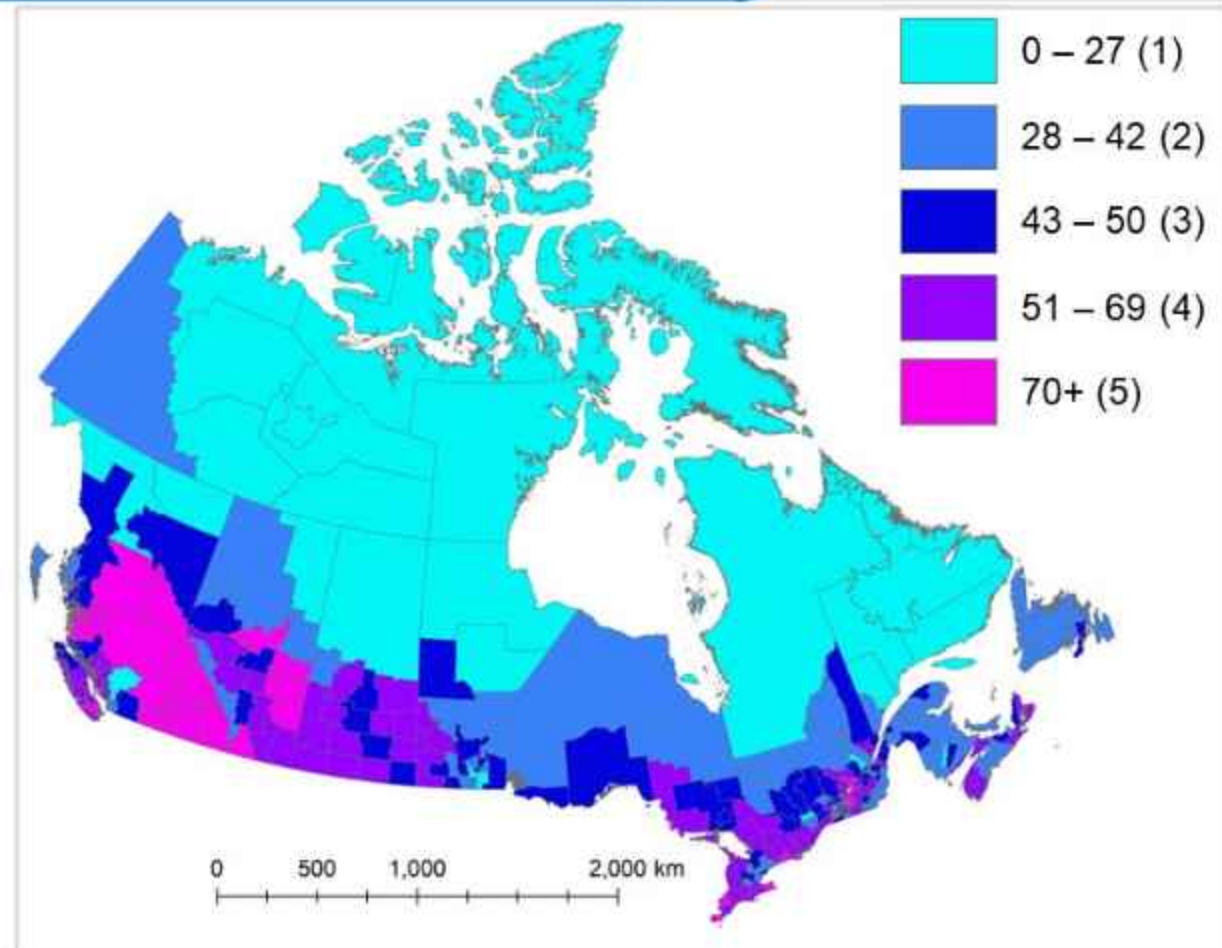
- National average = 47
- Values reflect variations in:
 - exposures
 - health status

Highs:

- Large urban centres
- Wildfire areas
- Transboundary

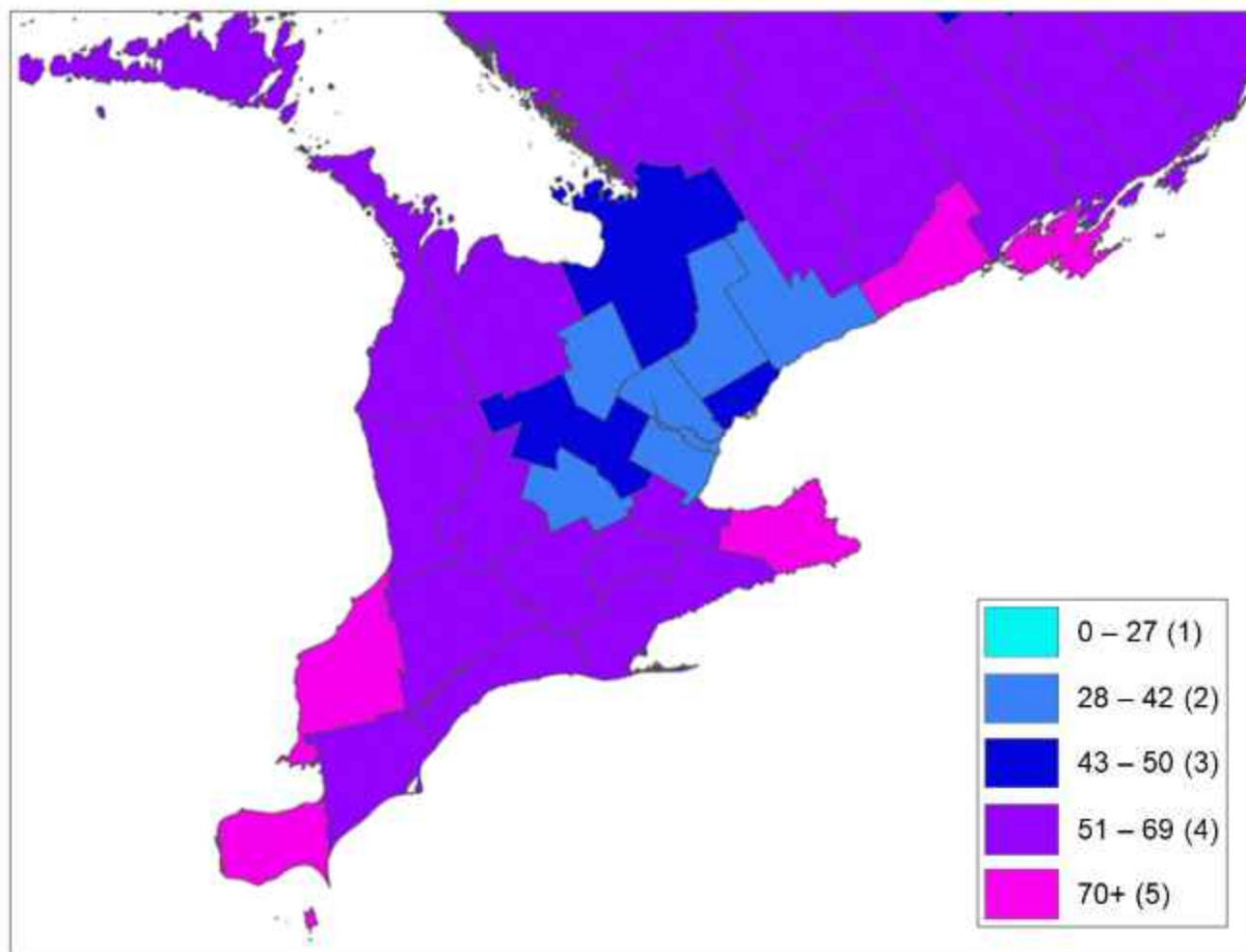
Lows:

- Northern & remote
- Atlantic



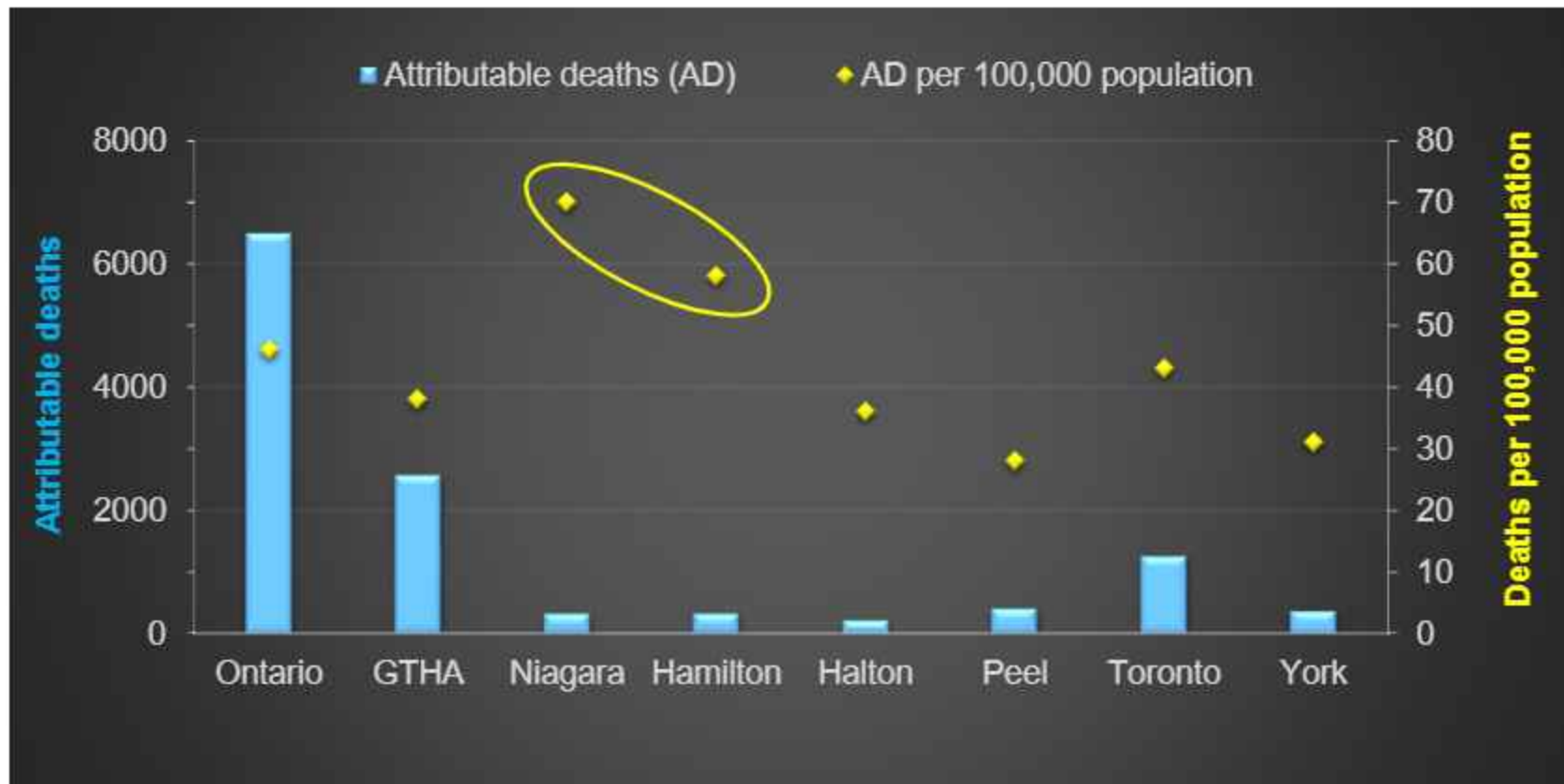
Air pollution health burden in Southern Ontario in 2018

Deaths per 100,000 pop attributable to PM_{2.5}, O₃ and NO₂



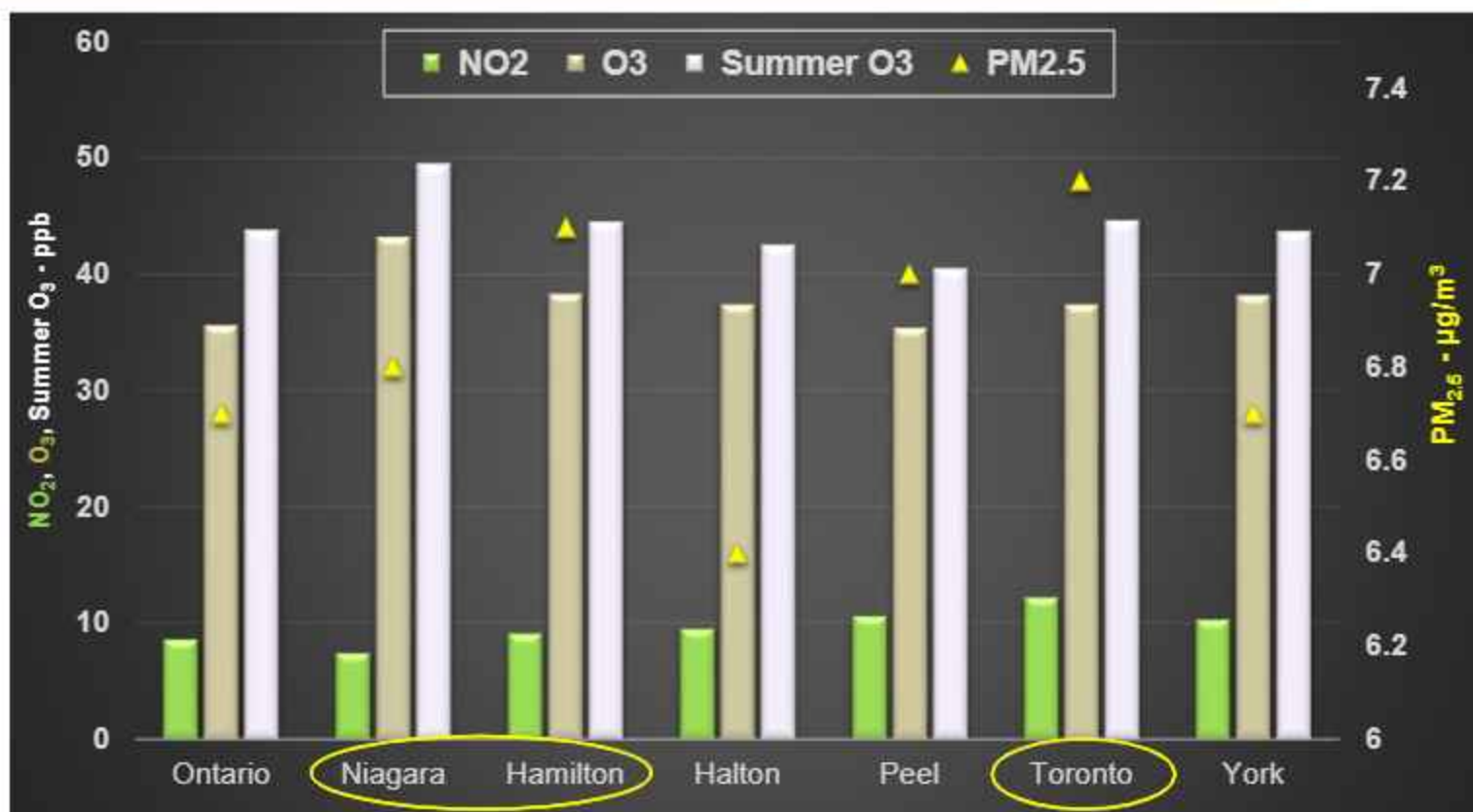
What could explain regional differences in Southern ON and the GTHA?

Air pollution deaths (counts & rate per 100,000 pop) in Southern Ontario in 2018



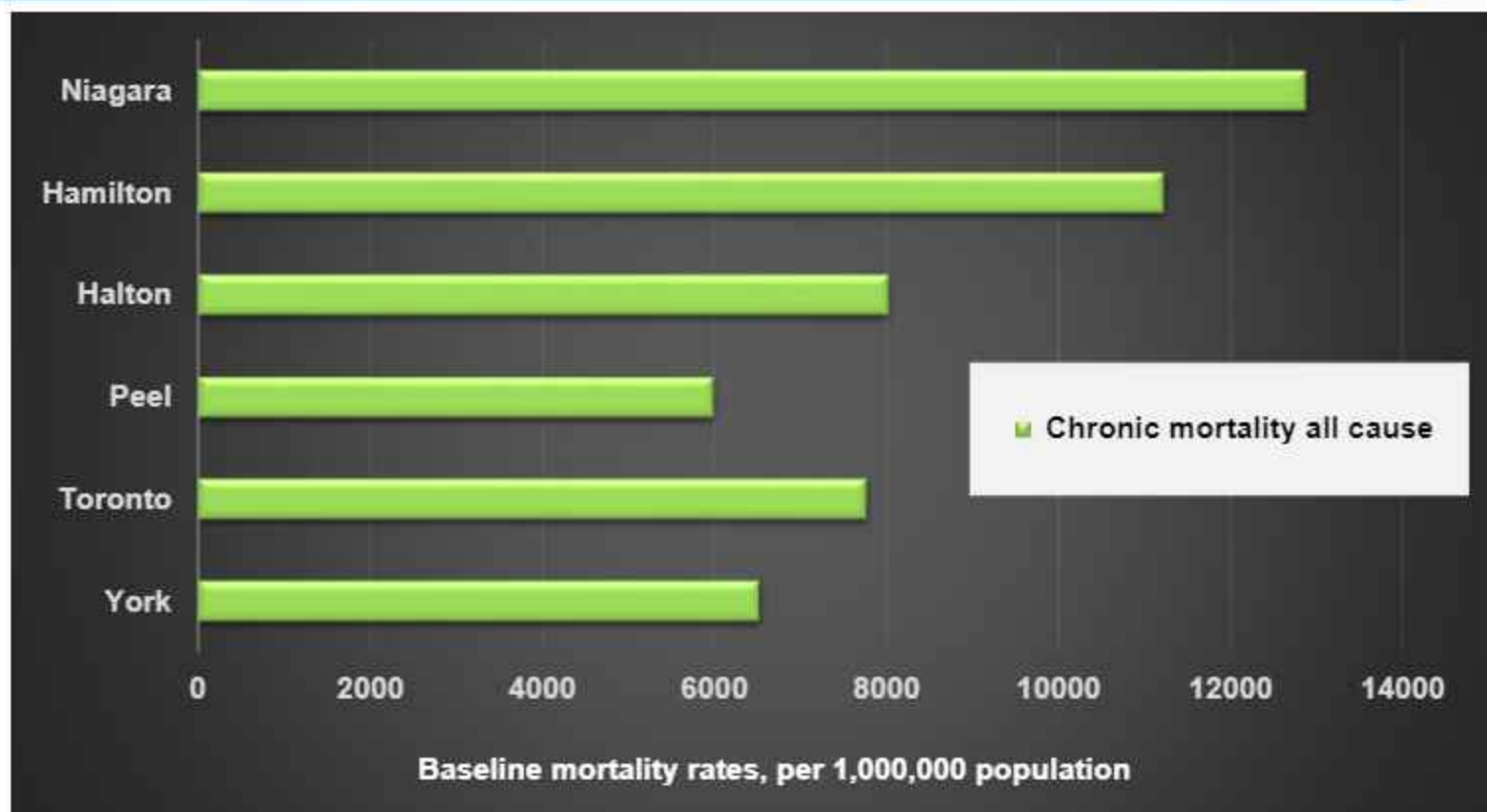
- While absolute counts are low in Hamilton and Niagara, air pollution appears to have a relatively larger impact

Modelled NO_2 , O_3 and $\text{PM}_{2.5}$ ambient air pollution in Southern Ontario in 2018



- Air pollution concentrations at the census division level are not strikingly different in Hamilton vs. Toronto.

Baseline mortality rates, all non-accidental causes, in Southern Ontario in 2018



- Health data show there are more deaths per capita in Niagara and Hamilton compared to other GTHA census divisions.

Air pollution health burden in Canada – Takeaways

- 17,400 deaths from air pollution in Canada annually, despite good air quality
- Health burden across regions depends on:
 - Exposure concentrations for each pollutant
 - Population size
 - Population health status (i.e. baseline incidence rates)
- As we move from national to more local results
 - Regional drivers of health burden can vary

Air pollution health burden – Additional Health Canada analyses



**Transportation, industry
and residential sectors**



Transboundary air pollution

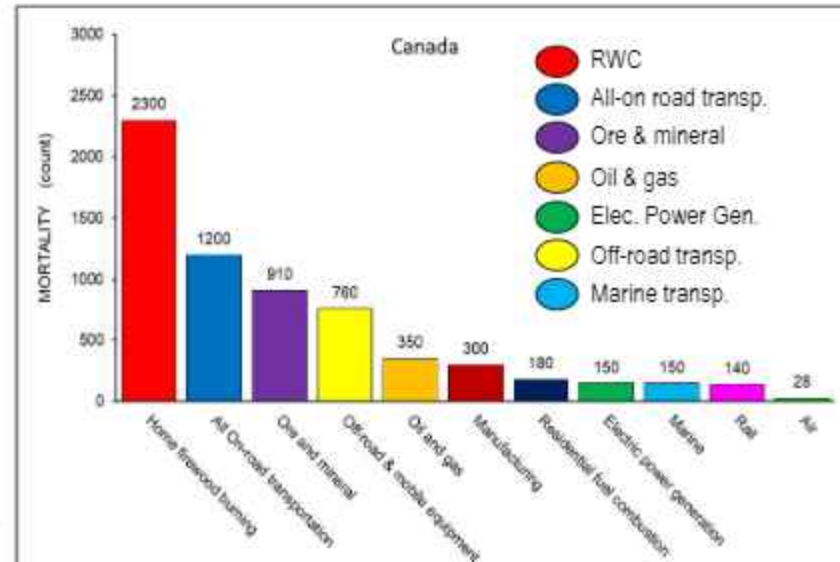
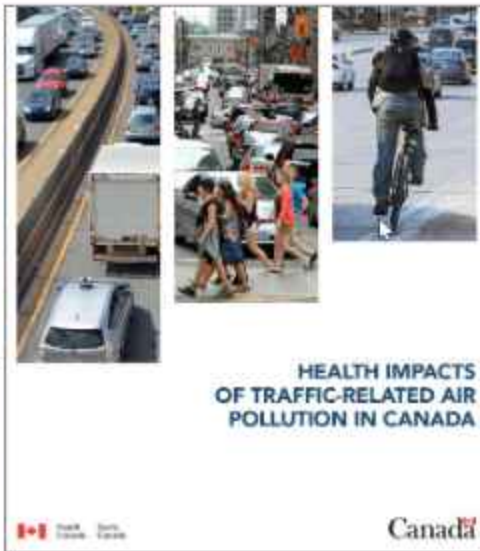
Air pollution health burden – Sector contributions

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

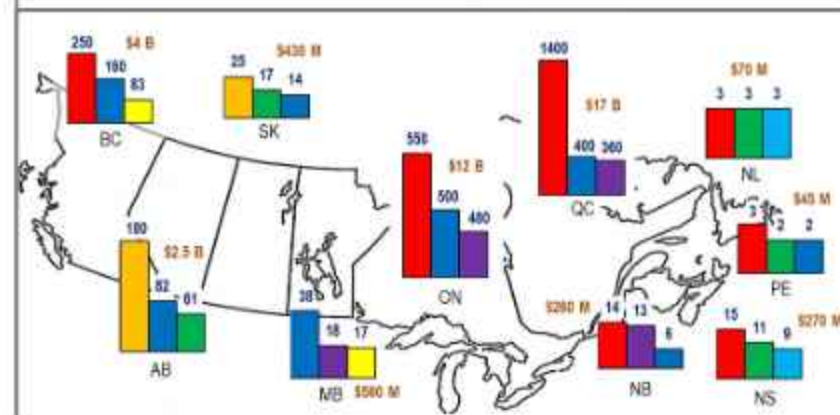
Estimates of premature mortality and morbidity outcomes at national, provincial, territorial, and air zone levels



https://publications.gc.ca/collections/collection_2023/sc-hc/H144-112-2022-eng.pdf
https://publications.gc.ca/collections/collection_2022/sc-hc/H144-91-2022-eng.pdf

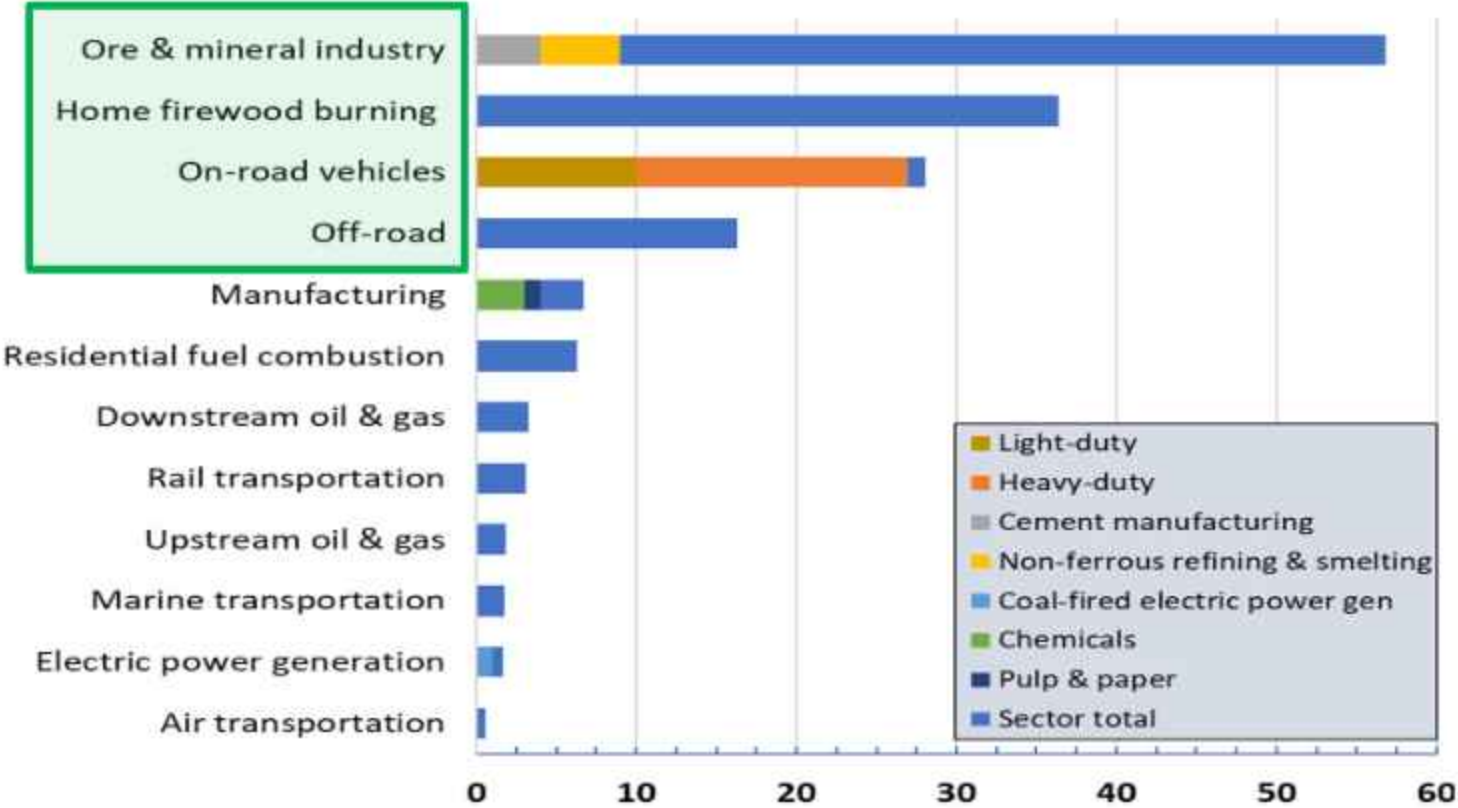


- 21 sectors (excludes wildfires & agriculture)
- 2015 model year (GEM-MACH)
 - Zero-out simulations
- 6,500 premature deaths (\$51B; 2015 CAD) for all sectors combined
 1. Residential wood combustion / RWC (2,300 deaths)
 2. On-road (1,200 deaths)
 3. Ore and minerals (910 deaths)



Air pollution health burden – Sector contributions in Hamilton

Sector air pollution attributable deaths in Hamilton, in 2015

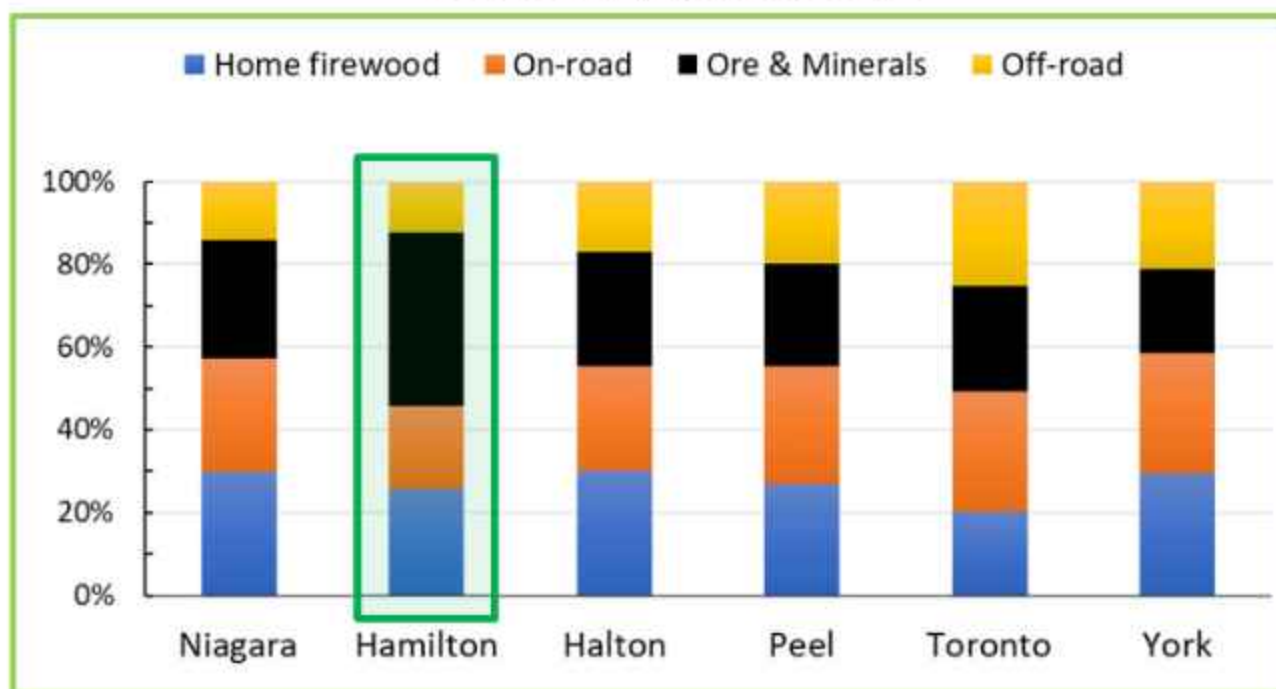


Air pollution health burden – Sector contributions in the GTHA

Relative contributions of top 4 sectors to deaths in GTHA census divisions, in 2015

Hamilton is distinct:

- Lower relative health burden attributed to on-road traffic
- Higher relative health burden attributed to Ore & Minerals industry

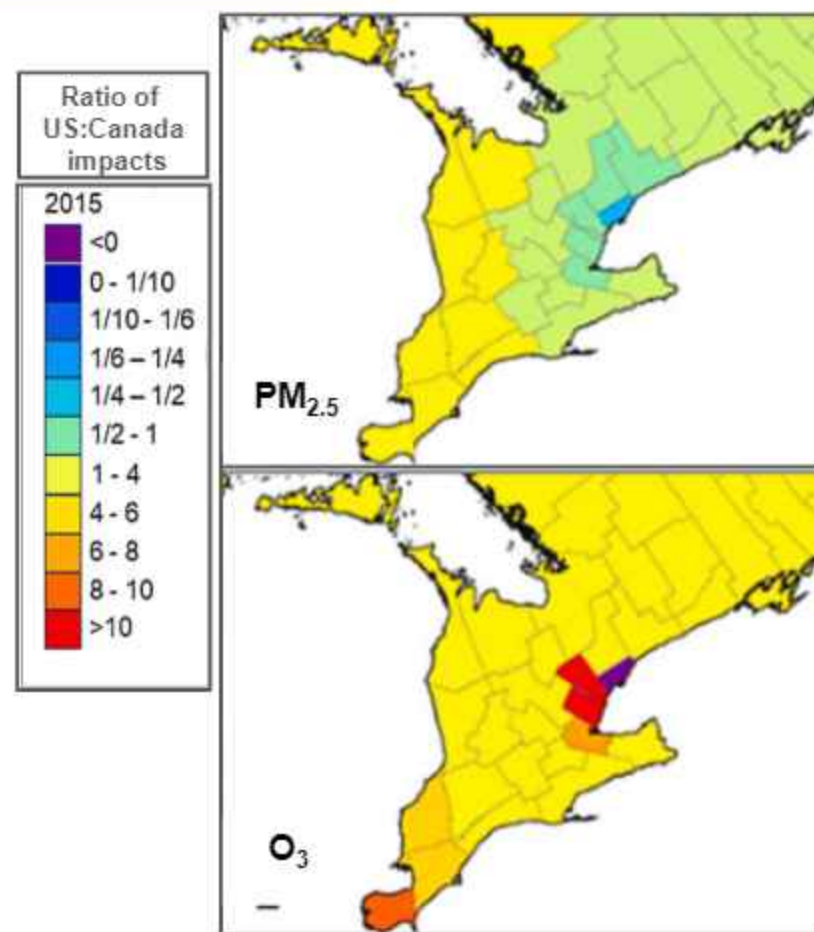


Air pollution health burden – Transboundary air pollution

Pappin et al. 2024. Attribution of fine particulate matter and ozone health impacts in Canada to domestic and US emission sources. Sci Tot Environ 909: 168529.

- Quantify the health impacts in Canada from **20%** of US and Canadian emissions
- Overall:
 - 80% of impacts in ON and QC
 - Most impacts < 200-300 km of the Canada-US border

Pollutant – mortality endpoint	CND emissions	US emissions
	Attributable deaths in Canada	
PM _{2.5} – chronic all-cause	1,600	390
O ₃ – acute all-cause	29	83



Thank you / Merci

Questions?

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Air pollution health burden in Canada – Deaths by age groups

National deaths by age group attributable to PM_{2.5}, O₃ and NO₂ air pollution, in 2018

Age group years	Population	Counts	% of attributable deaths
25 to 29	2,559,417	34	0.2
30 to 39	5,052,394	120	0.7
40 to 49	4,811,582	340	1.9
50 to 59	5,282,541	1,100	6.1
60 to 64	2,441,551	1,300	7.3
65 and older	6,389,283	14,600	83.8
All ages	36,940,652	17,400	100

- ~ 84% of deaths attributable to air pollution affect the 65 years and older population.
- Distribution of impacts is linked to age-specific baseline mortality rates
 - Air pollutant risks are applied uniformly for all age groups in AQBAT

Air pollution health burden – 2018 National results – Morbidity

National morbidity counts and monetized value			
Health endpoint	Pollutant	Count	Monetized value, \$M (2020 CAD)
Acute respiratory symptom days	Summer O ₃	8,850,000	160
	PM _{2.5}	30,600,000	280
Adult chronic bronchitis cases	PM _{2.5}	11,400	5,300
Asthma symptom days	Summer O ₃	938,000	74
	PM _{2.5}	2,650,000	210
Cardiac ER visits	PM _{2.5}	1,400	9
Cardiac hospital admissions	PM _{2.5}	1,100	n/a
Child acute bronchitis episodes	PM _{2.5}	51,800	25
Minor restricted activity days	O ₃ summer	741,000	25
Respiratory ER visits	O ₃ summer	3,800	12
	PM _{2.5}	3,900	12
Respiratory hospital admissions	O ₃ summer	760	n/a
	PM _{2.5}	760	n/a
Restricted activity days	PM _{2.5}	16,500,000	1,200
Total morbidity			7,300

Air pollution health burden – National 2018 results

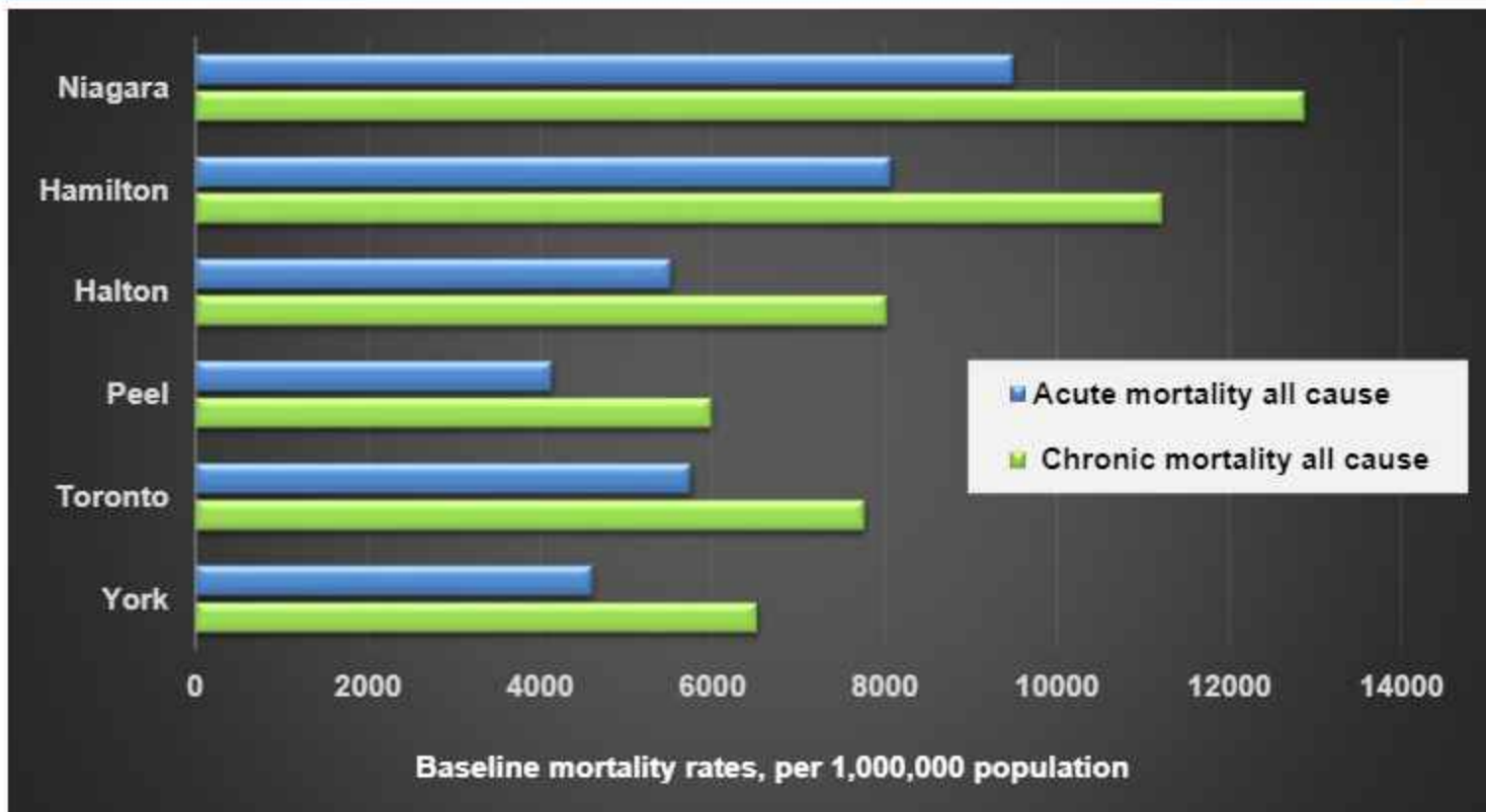
Annual counts of premature deaths by province and territory

	Pollutant					per 100,000	Monetization \$M (2020 CAD)
	NO ₂	PM _{2.5}	O ₃	O ₃ summer	All		
Canada	1,300	12,500	1,200	2,400	17,400	47	139,000
ON	570	4,300	560	1,100	6,500	46	52,200
QC	320	3,000	300	640	4,300	50	34,200
BC	170	1,900	120	230	2,400	51	19,300
AB	120	1,700	120	240	2,100	48	17,100
MB	37	470	15	53	570	43	4,600
SK	28	430	27	59	540	48	4,300
NS	21	270	23	77	390	41	3,100
NB	16	190	12	48	270	35	2,100
NFL	10	120	8	40	170	34	1,400
PEI	3	42	3	11	59	39	470
YK	0	9	0	1	11	28	84
NWT	0	7	0	1	8	18	65
NU	0	1	0	1	3	7	22

Air pollution health burden – 2018 results – Hamilton

Endpoint	Pollutant	Counts	Valuation (\$M, 2020CAD)	Counts per 100K
Acute Exposure Mortality	NO ₂	31	246.1	5
	O ₃	47	377.8	8
Chronic Exposure Mortality	PM _{2.5}	230	1,816.7	39
Chronic Exposure Respiratory Mortality	O ₃ summer	27	214.6	5
Acute Respiratory Symptom Days	O ₃ summer	184,000	3.3	
	PM _{2.5}	475,000	4.3	
Adult Chronic Bronchitis Cases	PM _{2.5}	180	82.0	
Asthma Symptom Days	O ₃ summer	19,200	1.5	
	PM _{2.5}	40,100	3.1	
Cardiac Emergency Room Visits	PM _{2.5}	23	0.2	
Cardiac Hospital Admissions	PM _{2.5}	18	0	
Child Acute Bronchitis Episodes	PM _{2.5}	780	0.4	
Minor Restricted Activity Days	O ₃ summer	15,400	0.5	
Respiratory Emergency Room Visits	O ₃ summer	78	0.2	
	PM _{2.5}	56	0.2	
Respiratory Hospital Admissions	O ₃ summer	15	0	
	PM _{2.5}	11	0	
Restricted Activity Days	PM _{2.5}	255,000	18.6	

Baseline mortality rates, by cause of death, in Southern Ontario in 2018



- Health data show there are more deaths per capita in Niagara and Hamilton compared to other GTHA census divisions.