northern health
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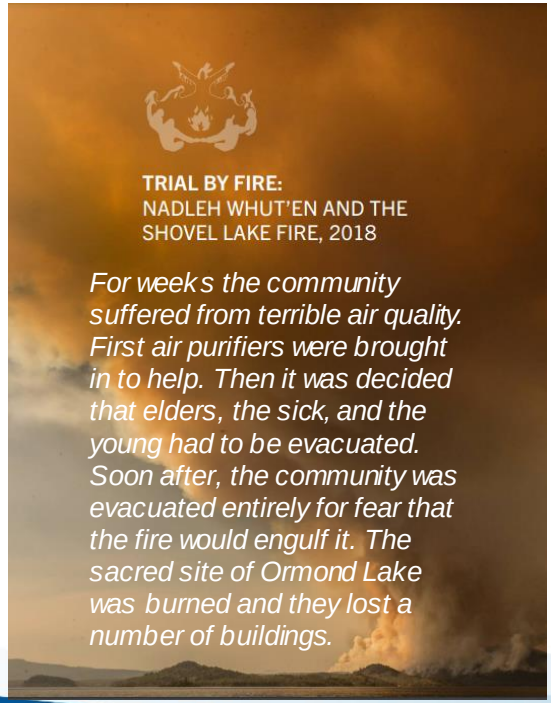
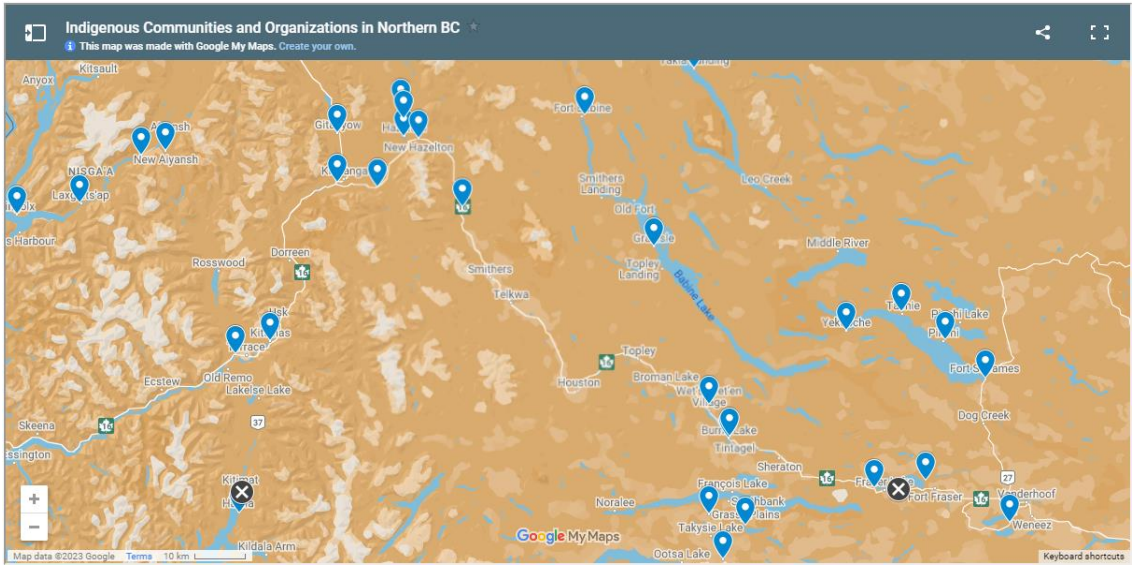
Outdoor Air Quality and Health

Paula Tait – Regional Outdoor Air Quality Lead (updated October 2023)

Land Acknowledgement

I acknowledge, with gratitude and respect, that my work takes place on the territories of the Tlingit, Tahltan, Nisga'a, Gitxsan, Tsimshian, Haisla, Haida, Wet'suwet'en, Dakelh (Carrier), Tse'khene (Sekani), Dane-zaa, Nihew (Cree), Saulteau, and Dene Peoples.





Interactive map | Indigenous Health (indigenoushealthnh.ca)

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Outline

- Air pollution and health effects
- Who is sensitive and who is exposed?
- Sources and contaminants
- Air quality risk seasons in the north
- Monitoring and mitigation

Air Pollution and Health Snapshot

Air Pollution→

By way of:

- Low concentrations
- High concentrations
- Short-term exposure
- Long-term exposure

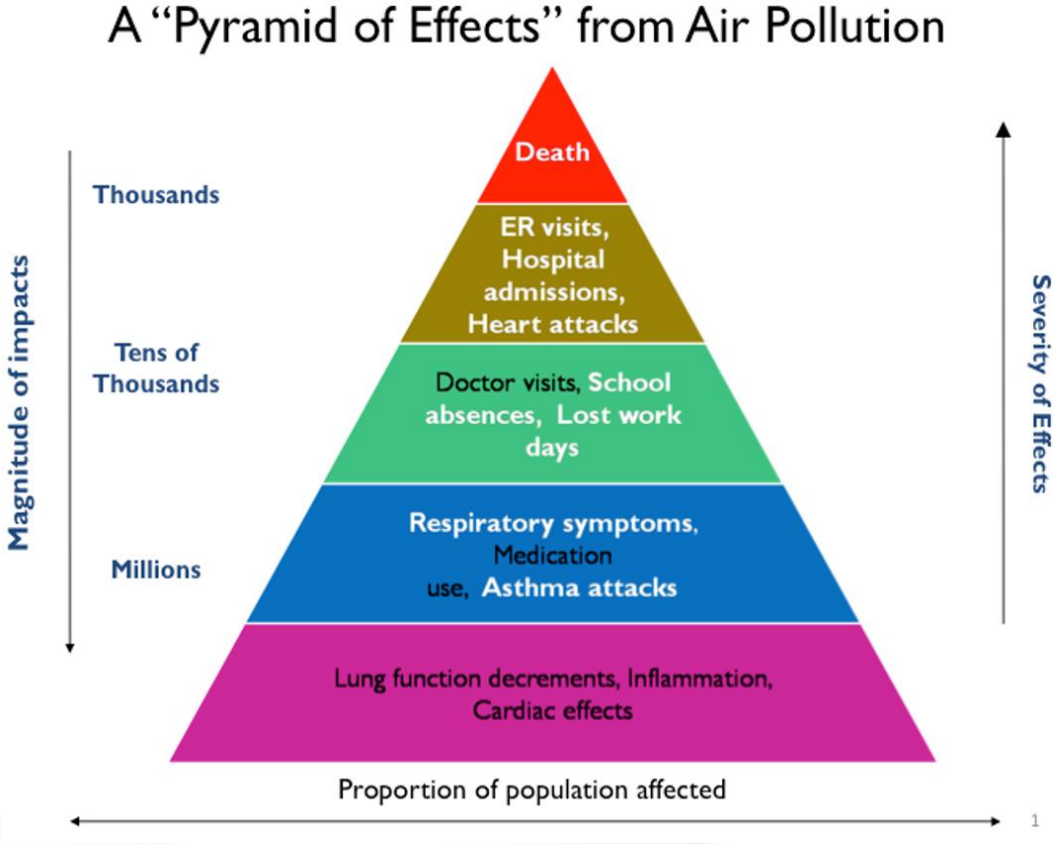
Causes:

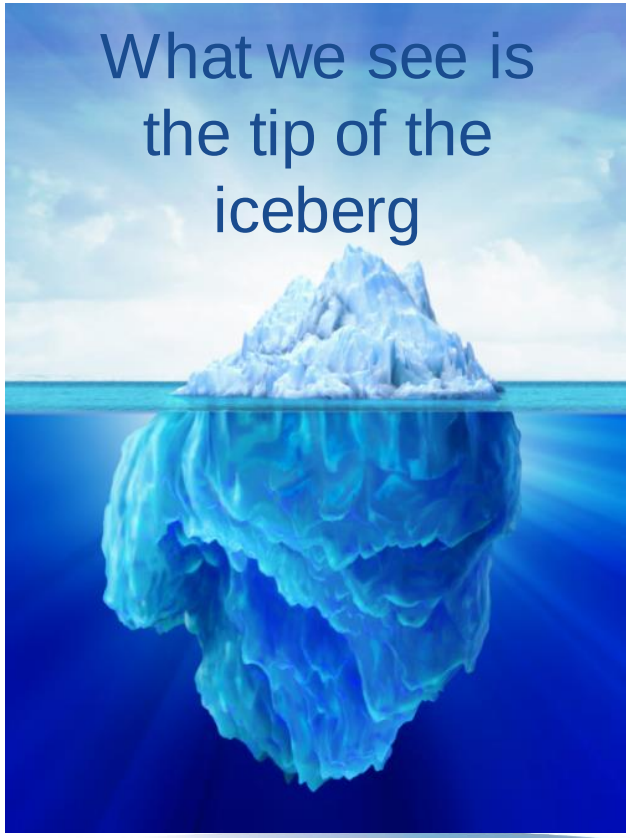
- Illness and worsens chronic conditions like asthma & COPD
- Death

Affects:

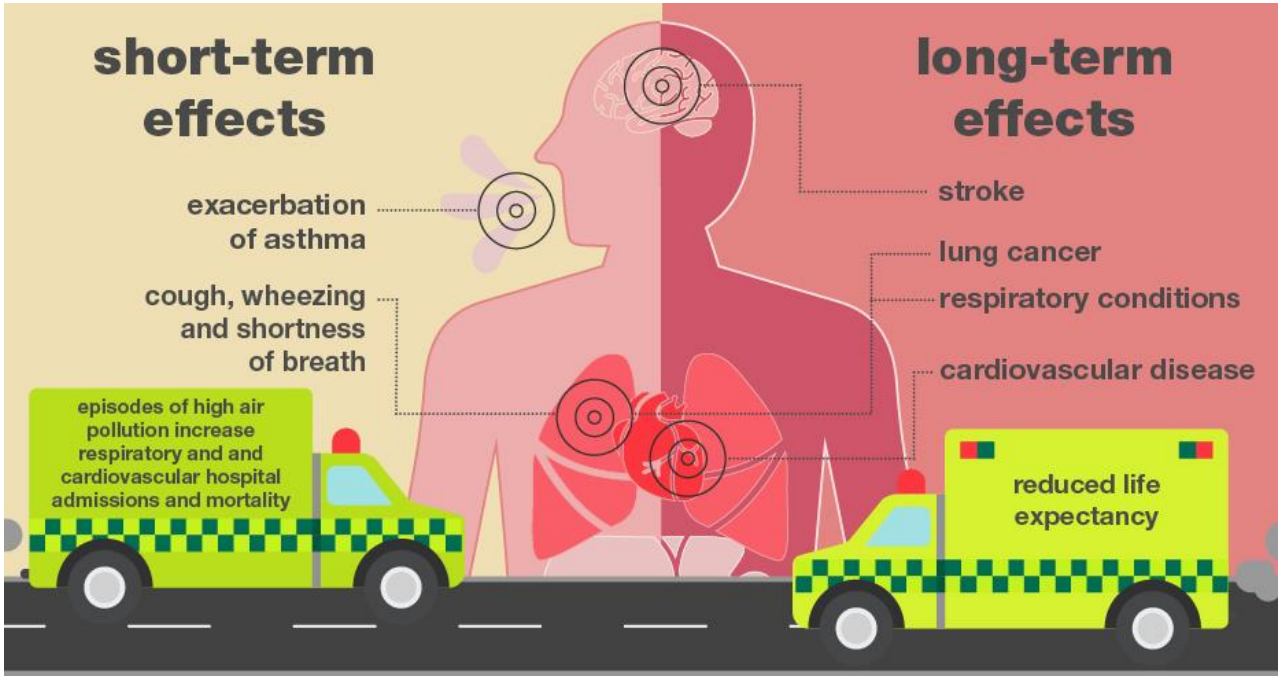
- Everyone
- Entire body
- Entire life course

Health Effects





Health Effects – Full Body Pollutant



high blood pressure
endothelial dysfunction
increased blood coagulation
systemic inflammation
deep venous thrombosis

cardiovascular morbidity/mortality
myocardial infarction
arrhythmia
congestive heart failure
heart rate variability
ST-segment depression

premature birth
decreased birthweight
decreased fetal growth
intrauterine growth retardation
decreased sperm quality
pre-eclampsia

respiratory morbidity/mortality
pneumonia
airway inflammation
decreased lung function/growth

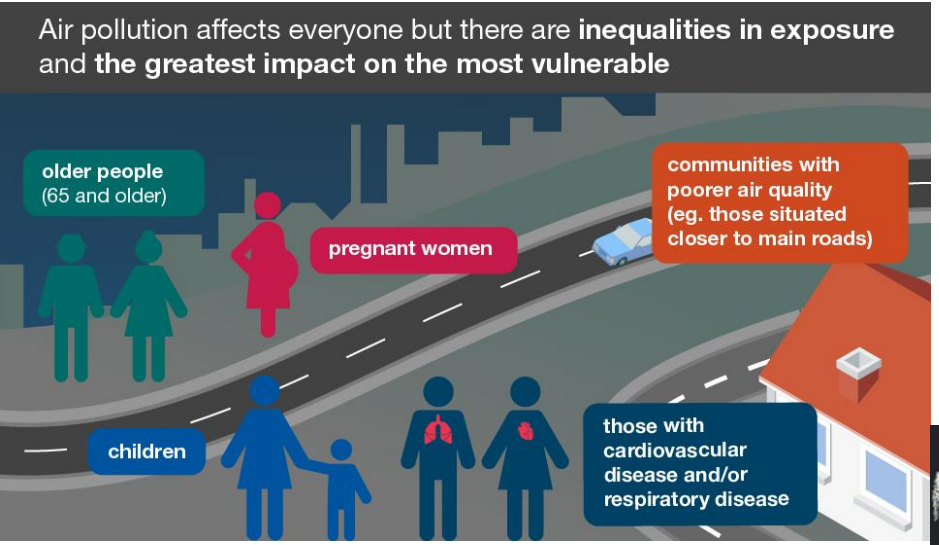
insulin resistance
type 1 and 2 diabetes
bone metabolism

neurodegenerative diseases
neurological development
mental health

skin aging

2016 Joint ERS/ATS Policy Statement: what constitutes an adverse effect of air pollution?

Who is most sensitive and who is exposed?

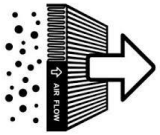


Source: Health Matters: Air pollution – sources, impacts and actions - UK Health Security Agency (blog.gov.uk)

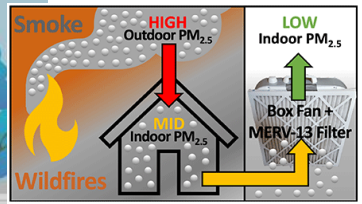
- People who work or exercise outdoors
- People who smoke (first-hand or second-hand)
- People who work in job sites where air is polluted
- People experiencing poverty
- People who lack access to health care

Source: 86% of Canadians live in areas where air pollution exceeds WHO guidelines: researchers - National | Globalnews.ca

What is an equity or environmental justice approach?



PREVENTION VS MITIGATION VS ADAPTATION



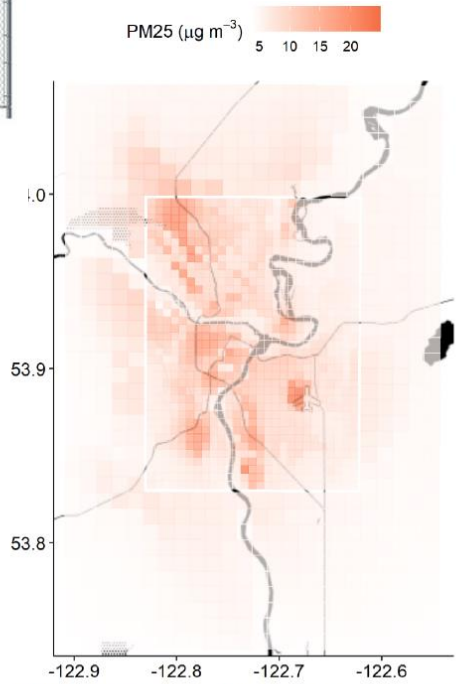


Figure 6. 3-year annual average modelled $PM_{2.5}$ concentration (µg m^{-3}) for the Prince George airshed. There is a fine, 0.5 km resolution, grid over the urban center and a coarser, 1 km resolution, grid surrounding that.

Health Effects in the Bigger Picture

Good air quality will make us more resilient to health stressors – and poor air quality will increase our sensitivity to other health stressors

Health of Canadians in a Changing Climate: Advancing our Knowledge for Action

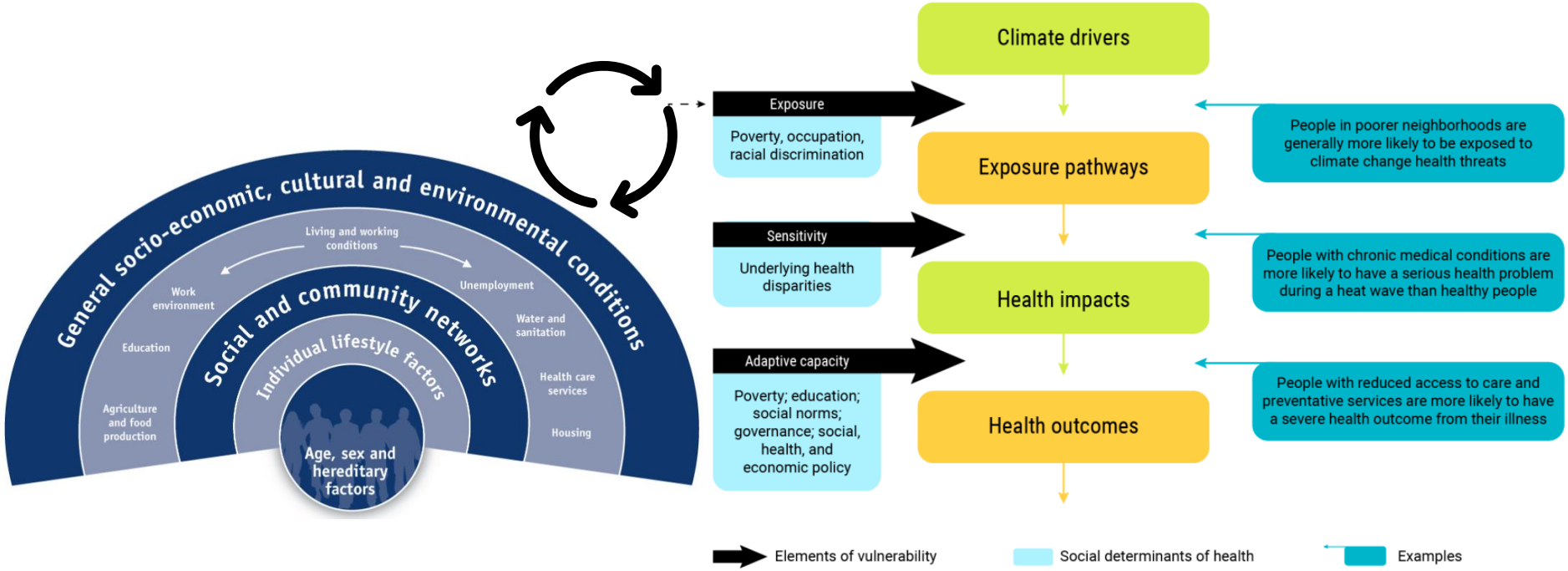
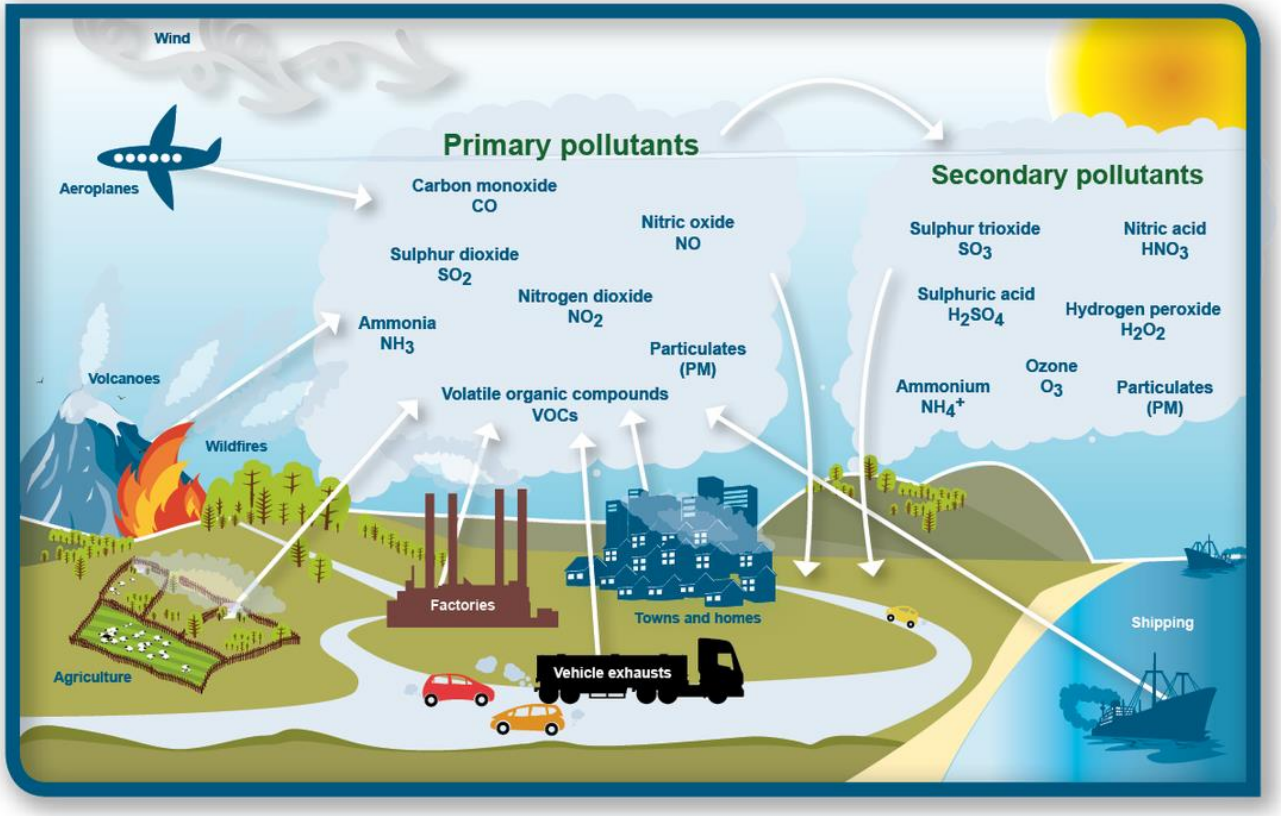
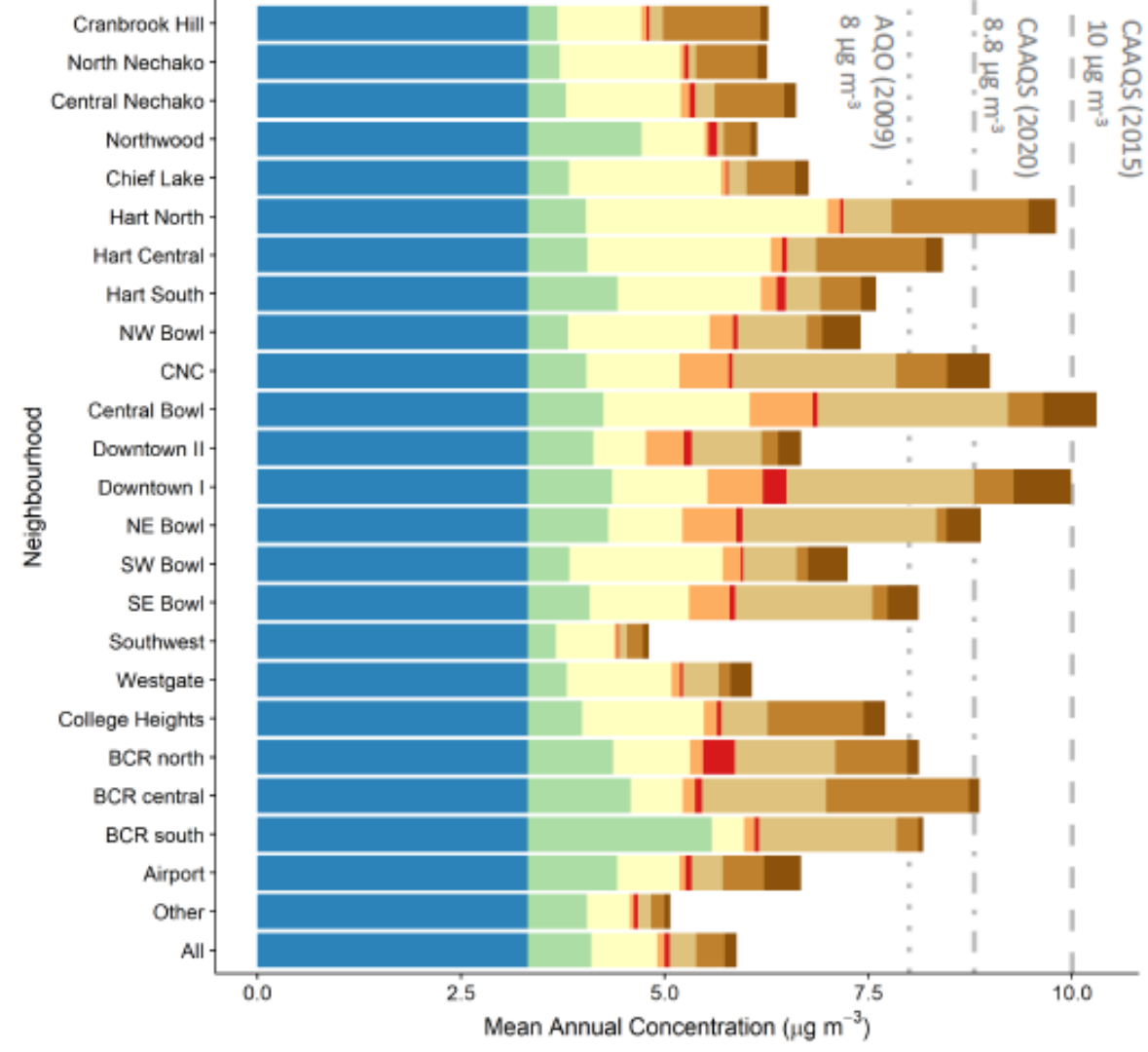


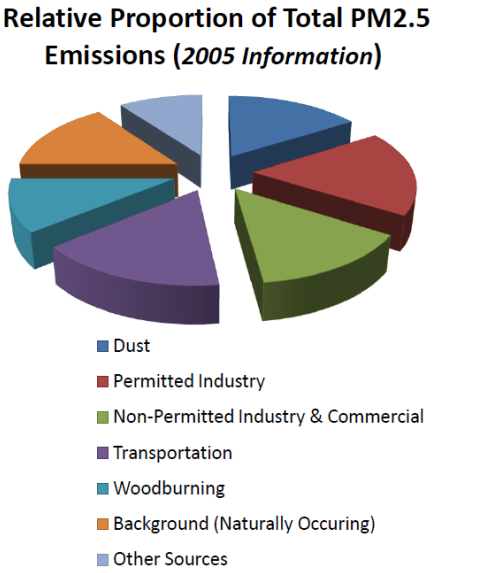
Figure 9.2 Social determinants of health interact with the three elements of vulnerability. Source: Gamble et al., 2016.

Sources of Air Pollutants



Varied Sources



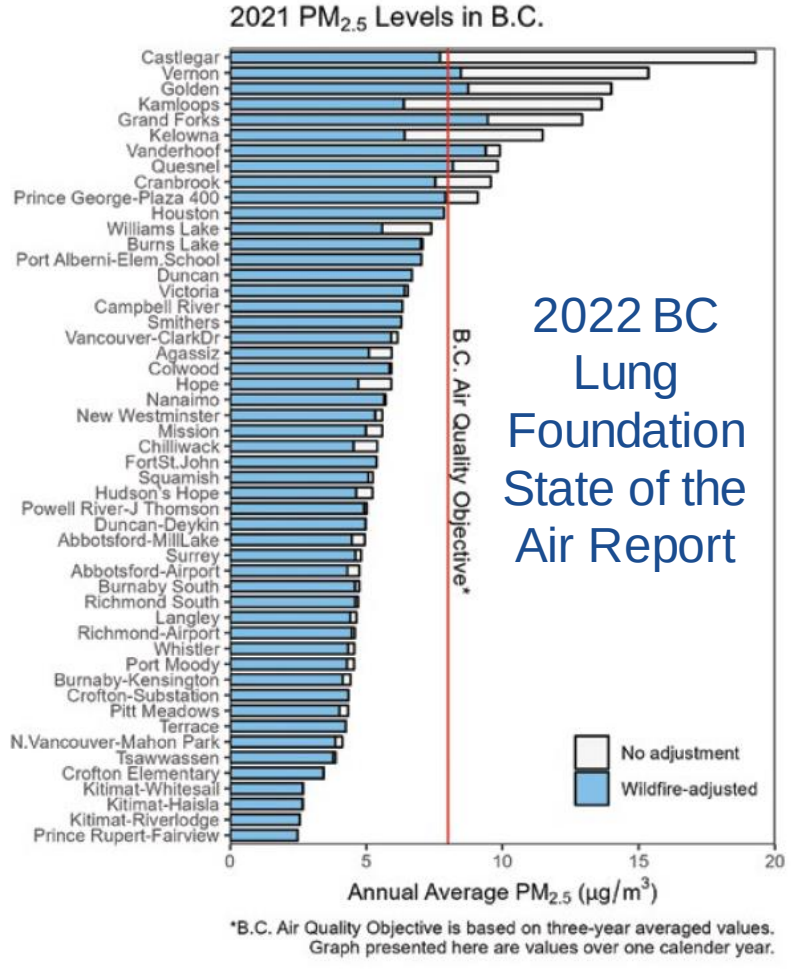


Natural Sources of Contaminants, Allergens and Irritants

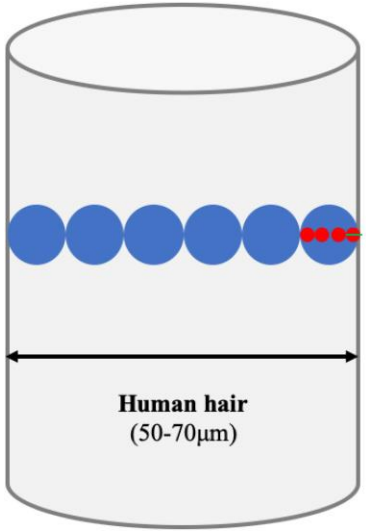
- Pollen
- Mould
- Wind blown dust
- Wildfires
- Volcanos
- Sea salt spray
- Fog/Mist (visibility)
- VOCs from plants
- Radon
- Ozone
- Cold (irritant)

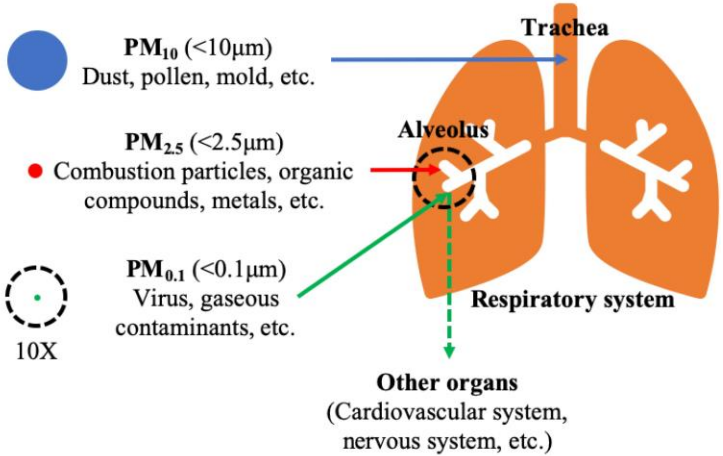
Meteorology and Topography

Fine Particulate Matter ($PM_{2.5}$)

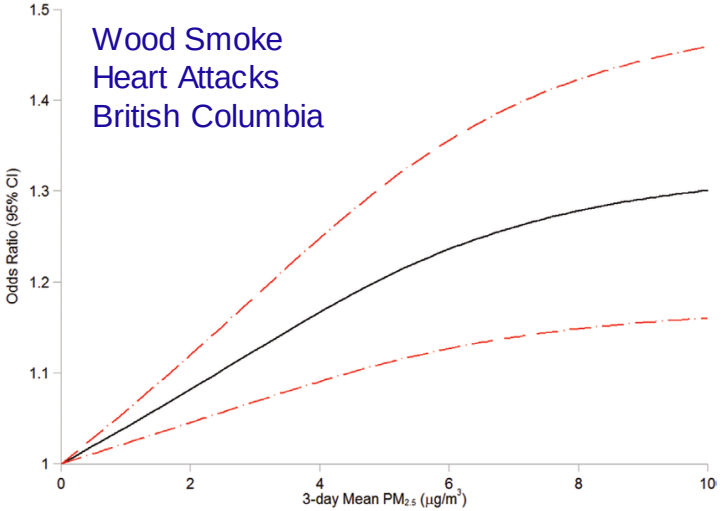


2022 BC Lung Foundation State of the Air Report

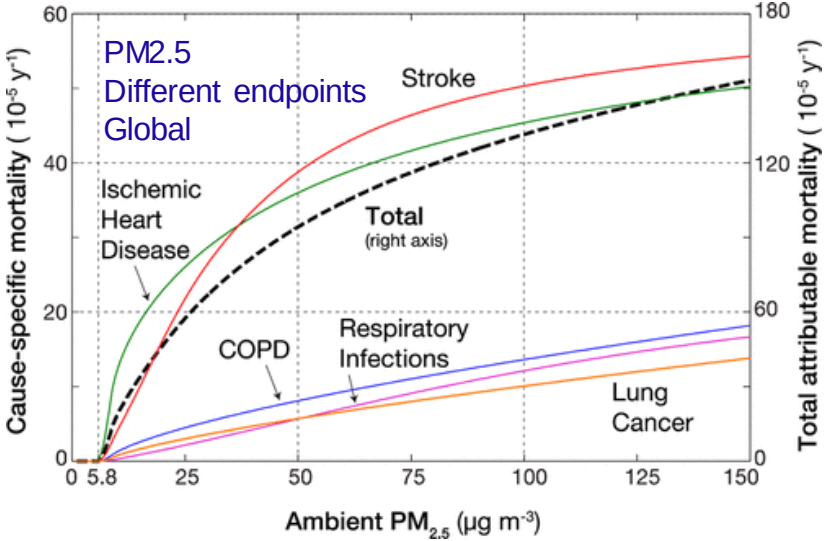




The steep exposure-response relationships down to near-background levels imply **continued benefits of further improving air quality**



'The dose makes the poison'



Concentration-response relationship between PM 2.5 concentrations and hospital admissions for MI among elderly subjects (≥65 years) – biomass burning in BC

Source: Weichenthal et al, https://journals.lww.com/epidem/Fulltext/2017/05000/Biomass_Burning_as_a_Source_of_Ambient_Fine.5.aspx

Adult ischemic heart disease (IHD) and stroke account for ~70% of combined $PM_{2.5}$-attributable mortality for all five causes. Other causes are chronic obstructive pulmonary disease (COPD) and lung cancer (LC) in adults, and acute lower respiratory infections (ALRI) in children – global population.

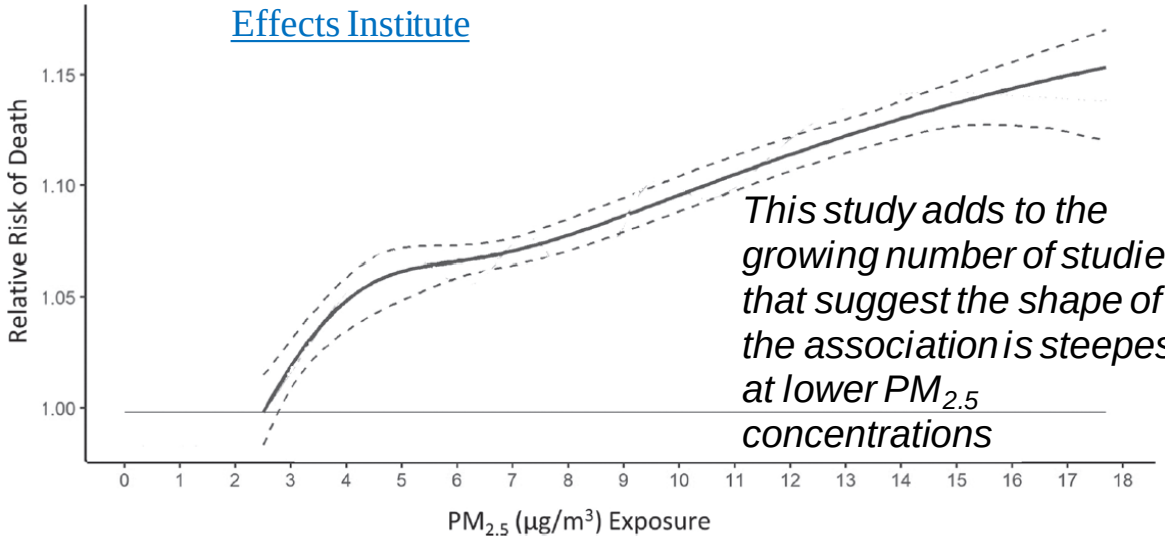
Source: Addressing Global Mortality from Ambient PM2.5 | Environmental Science & Technology (acs.org)

New research: Low Levels and Exposure Response Curves

2022 - Assessing Adverse Health Effects of Long-Term Exposure to Low Levels of Ambient Air Pollution: Implementation of Causal Inference Methods | Health Effects Institute

increased risks of all-cause mortality of 6% to 8% per 10-µg/m³ increase in $PM_{2.5}$, with larger effect estimates in a low exposure subcohort

2022 - Mortality–Air Pollution Associations in Low-Exposure Environments (MAPLE): Phase 2 | Health Effects Institute



This study adds to the growing number of studies that suggest the shape of the association is steepest at lower $PM_{2.5}$ concentrations

Statement Figure. Shape of the association between outdoor $PM_{2.5}$ exposure and nonaccidental death. This plot shows how the risk of death changes over different $PM_{2.5}$ exposure concentrations. The relative risk of death compares the lowest observed $PM_{2.5}$ concentration (2.5 µg/m³) to all higher concentrations. (Adapted from Investigators' Report Figure 29.)

Non-threshold pollutant:
No safe level of exposure

Different Pollutants and Effects

PM_x — **Particulate matter** are particulates that are suspended in the air. Sea salt, black carbon, dust and condensed particles from certain chemicals can be classed as PM pollutants.

NO_2 — **Nitrogen dioxide** is formed mainly by combustion processes such as those occurring in car engines and power plants.

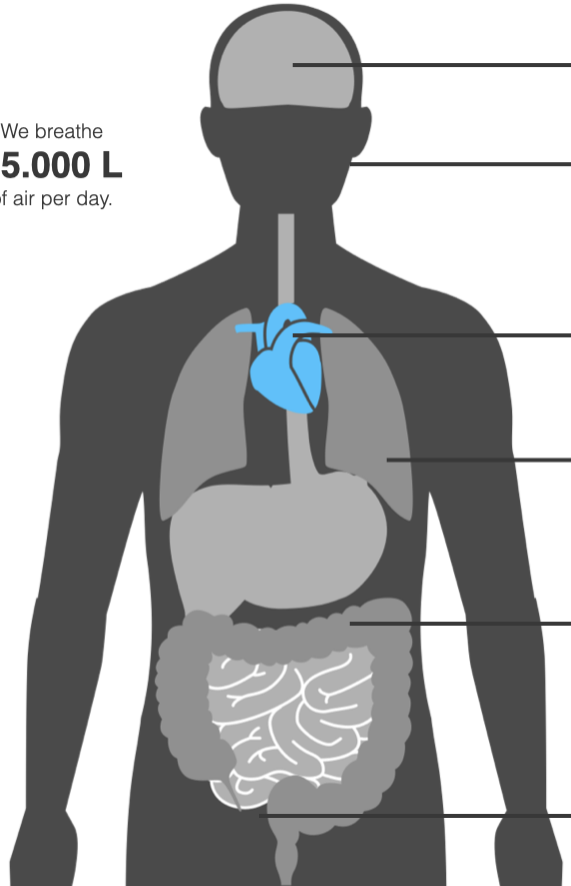
O_3 — Ground-level **ozone** is formed by chemical reactions (triggered by sunlight) involving airborne pollutants.

SO_2 — **Sulphur dioxide** is emitted when sulphur-containing fuels are burnt. As many regions have introduced sulphur reduction legislation, the marine industry remains a main source of SO_2.

CO — **Carbon monoxide** is formed during combustion of fuels (e.g. in heating, transportation). Poor combustion gives increased CO emissions.

Source: Breeze Technologies / European Environment Agency / UN

We breathe
15.000 L
of air per day.



Headache and anxiety (SO_2)
Impacts on the central nervous system (PM_x)

Irritation of eyes, nose and throat
Breathing problems
(O_3, PM_x, NO_2, SO_2)

Cardiovascular diseases
(O_3, PM_x, SO_2)

Irritation, inflammation and infection of the respiratory system
Asthma and reduced lung function
Chronic obstructive pulmonary disease
Lung cancer (PM_x)

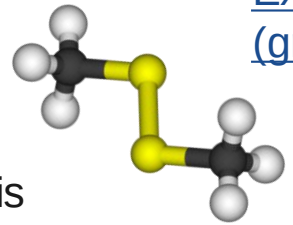
Impacts on liver, spleen and blood (NO_2)

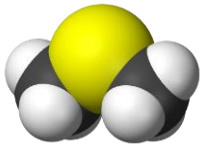
Impacts on the reproductive system (PM_x)

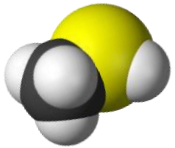
Odour

BC Lung State of the Air 2021: Unlike air pollutants such as fine particulate matter ($PM_{2.5}$) and ground-level ozone (O_3), there is no strong scientific evidence linking exposure to odours with specific health effects. Odours can definitely have an impact on how people feel and behave, and can affect their overall quality of life.

Metro Vancouver: physiological responses - watering eyes, headache, nausea, vomiting, loss of appetite, upset stomach, and throat irritation. Sleeplessness, stress and anxiety are also reported effects and, if experienced for prolonged periods, can result in chronic health impact.







Example: Total Reduced Sulphur (group of gases)

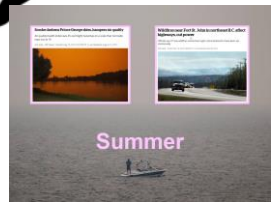
- Dimethyl disulphide,
- Dimethyl sulphide
- Methyl mercaptan (most odourous)
- Hydrogen sulphide (most common and toxic)

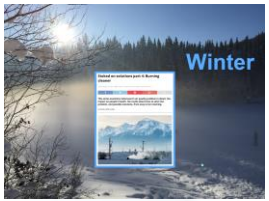
- Mostly from industrial sources
- Low odour threshold (0.2 $\mu g/m^3$)
- Health effects generally at much higher concentrations (~ 1000 $\mu g/m^3$)
  - Some studies also suggest increase in respiratory hospital admissions at lower concentrations
  - Complaints of headache and nausea are common and a quality of life issue at much lower concentrations

Northern Air Quality ‘Risk Seasons’

- Road Dust

- Wildfire Smoke

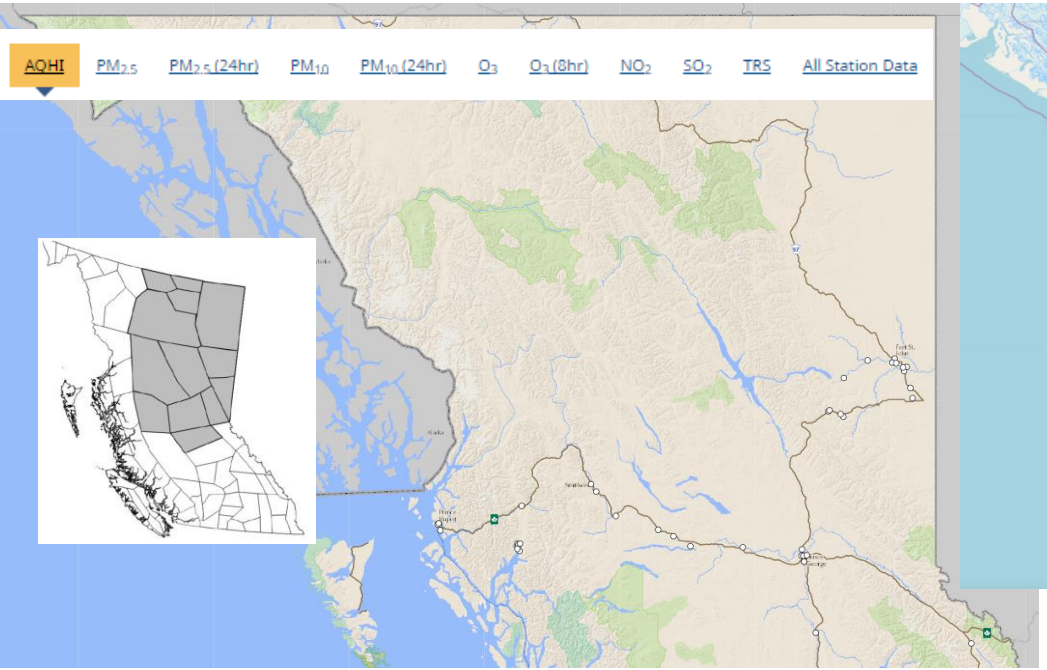


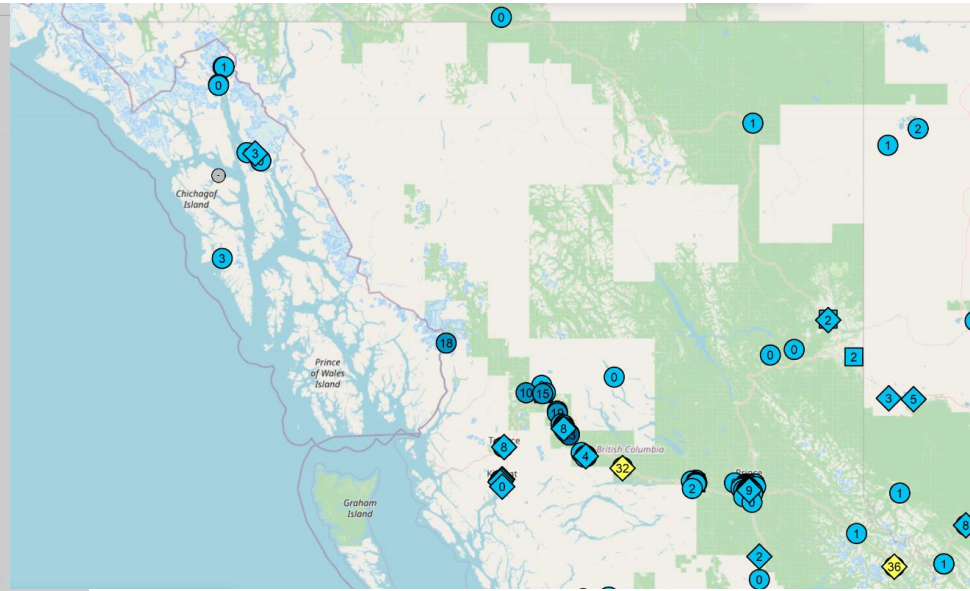


- Residential Wood Smoke

- Slash Burning Smoke

Monitored Communities in Northern Health





- Provincial high quality/cost monitors
- 6 can report the AQHI
- AQ Advisories and Smoky Skies Bulletins

- Low quality/cost monitors
- UNBC calibration
- Not used for decision making/alerts

Air Quality Health Index (AQHI):

Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population*	General Population
Low	1 - 3	**Enjoy** your usual outdoor activities.	**Ideal** air quality for outdoor activities.
Moderate	4 - 6	**Consider reducing** or rescheduling strenuous activities outdoors if you are experiencing symptoms.	**No need to modify** your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	7 - 10	**Reduce** or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	**Consider reducing** or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High	Above 10	**Avoid** strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	**Reduce** or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

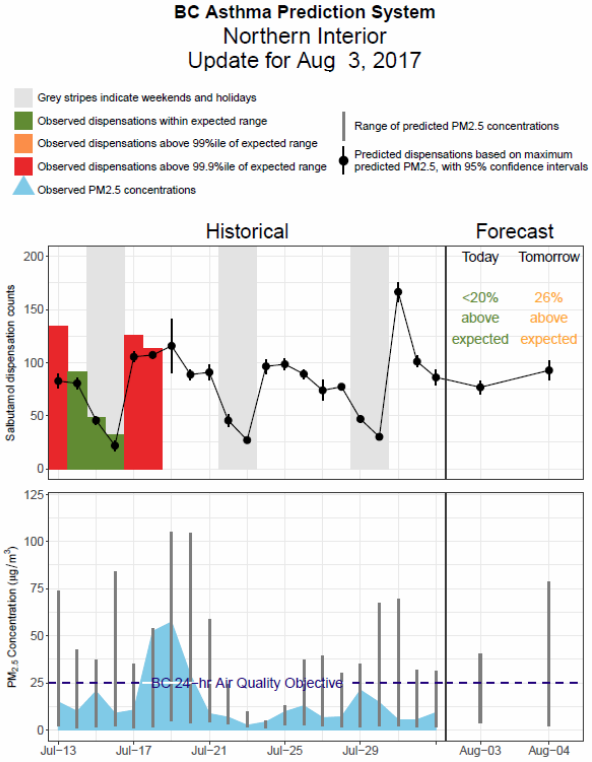
* People with heart or breathing problems are at greater risk. Follow your doctor's usual advice about exercising and managing your condition.

How is the AQHI calculated?

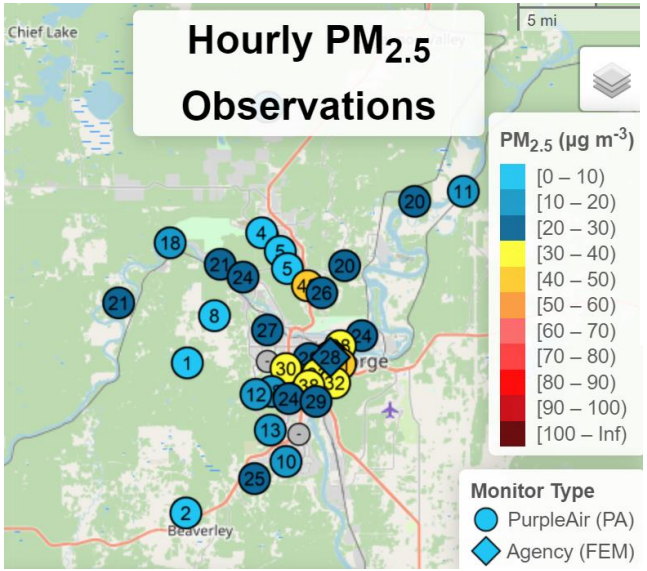
The AQHI is calculated based on the relative risks of a combination of common air pollutants that is known to harm human health. These pollutants are:

- **Ozone (O_3)** at ground level,
- **Particulate Matter ($PM_{2.5}$/PM_{10})** and
- **Nitrogen Dioxide (NO_2)**.

Predictions, Forecasts and Models

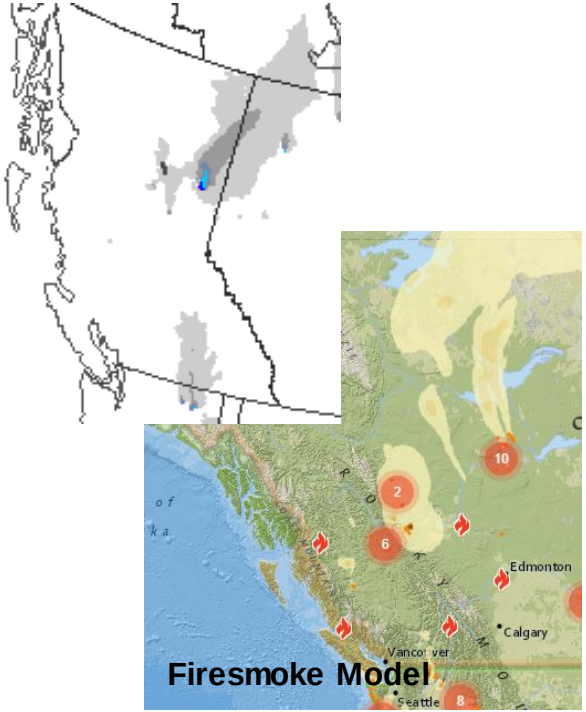


Air quality is variable in space and time

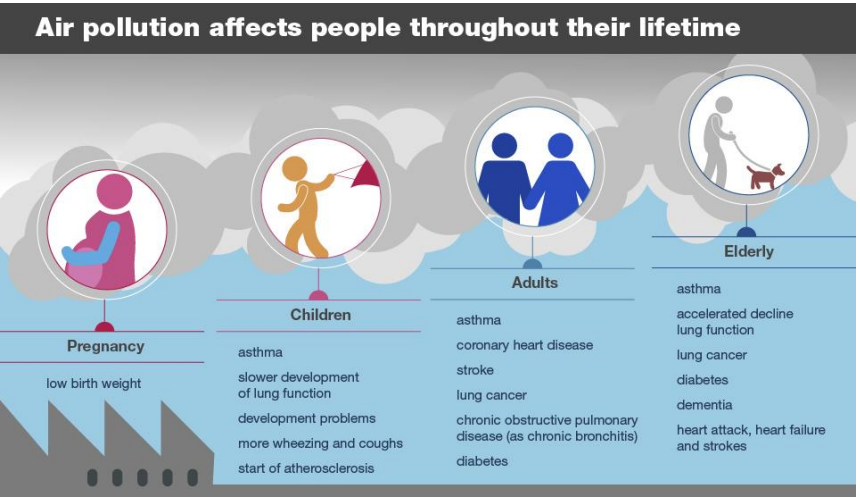


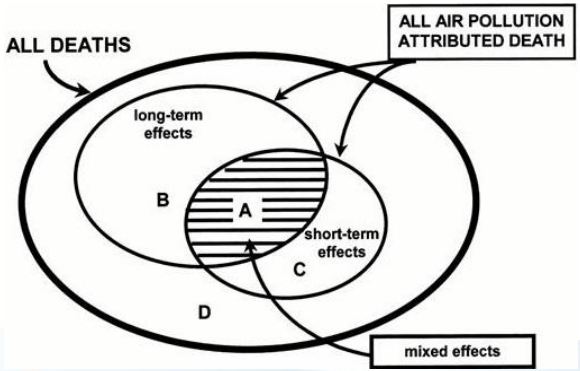
https://cyclone.unbc.ca/aqmap/#10/53.9451/-122.7757

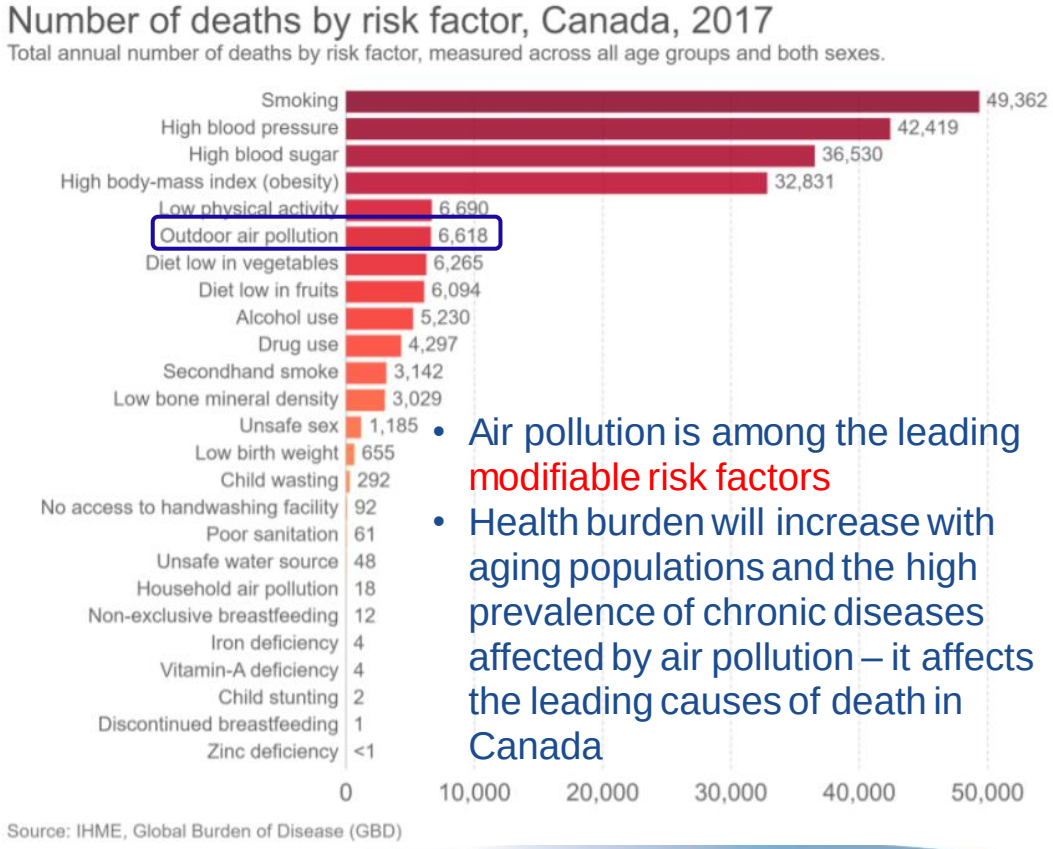
Canada's Firework Model



Policy Implications







- Air pollution is among the leading modifiable risk factors
- Health burden will increase with aging populations and the high prevalence of chronic diseases affected by air pollution – it affects the leading causes of death in Canada

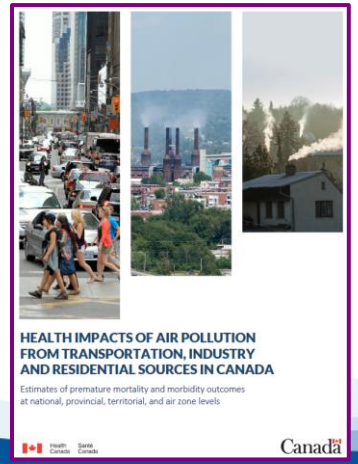
Healthcare costs of air pollution:

Canada

- $114 Billion
- 15,300 deaths (~5% of total)
- $PM_{2.5}$: 10,000
- NO_2: 1300
- Ozone: 4,100

British Columbia

- $13.9 Billion
- 1,900 deaths
- $PM_{2.5}$: 1,200
- NO_2: 170
- Ozone: 470



Central Interior Air Zone: In this lower population air zone (2015 pop. ~0.2M) the modelled sectors together contribute an estimated **9 air pollution-related premature deaths**, primarily due to sector contributions to annual mean **PM2.5 levels (4 deaths)**. Sector emissions contributing most to air pollution-related premature mortality in this air zone are those from **home firewood burning** (2 deaths), **on-road transportation** (2 deaths), and **manufacturing industry** (2 deaths).

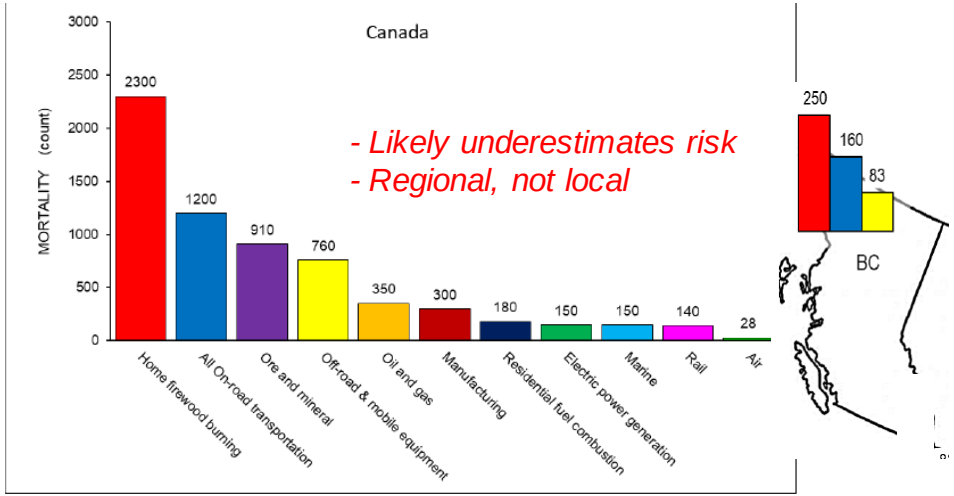


Figure 3-1 Sector-specific all-cause air pollution-related premature mortality ($PM_{2.5}$, NO_2, O_3, summer O_3) in Canada (2015).

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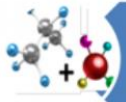
Cumulative Effects and Future Impacts

Sensitivity
- Standards based on sensitive life stages



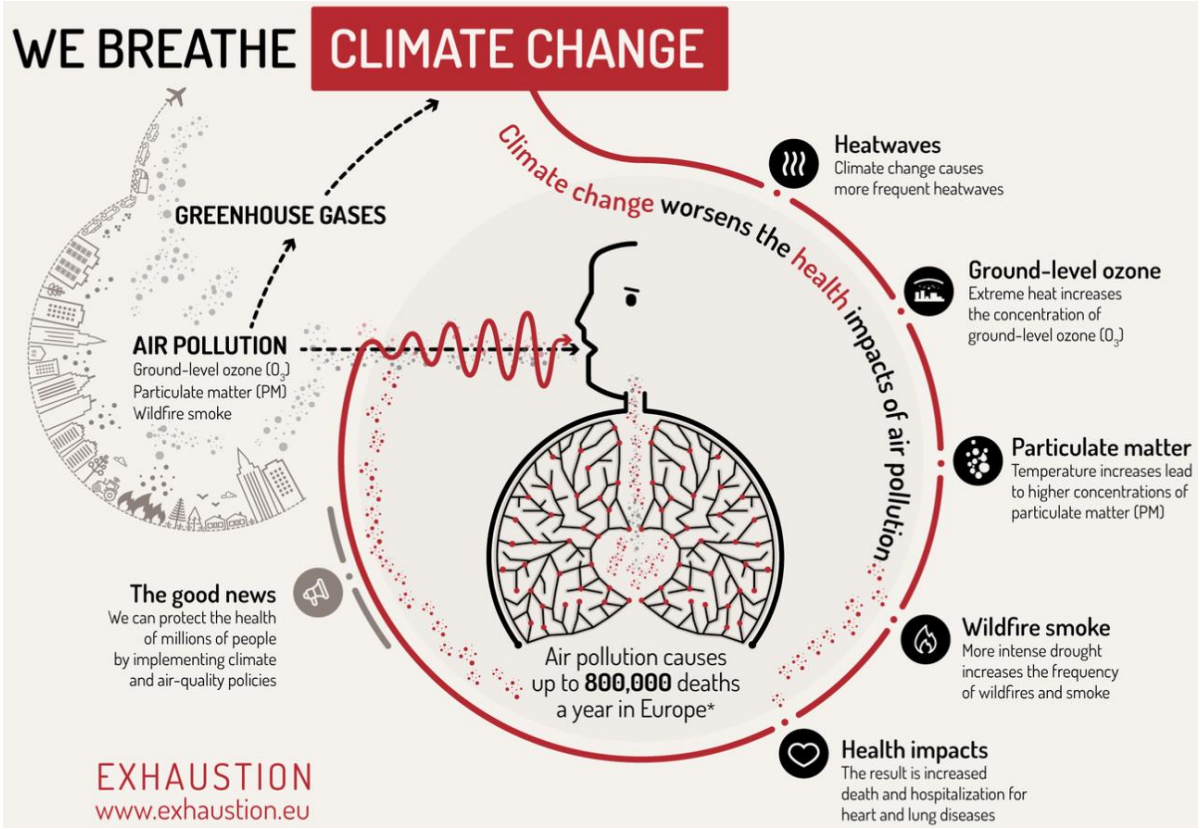
Additivity
- Multiple contaminants with similar effects

Multiple Pathways
- Total exposure via drinking, eating, swimming...

Multiple Sources
- Added effects of cars, factories, runoff...

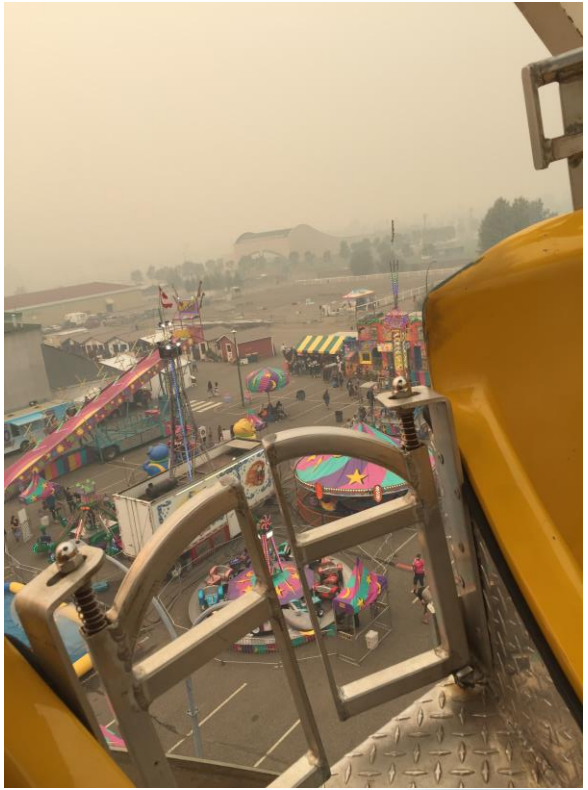
Non-Chemical Stressors
- Impacts from noise, traffic, aesthetics ...

Community Vulnerabilty
- Greater susceptibility to pollution due to health care, housing, other challenges

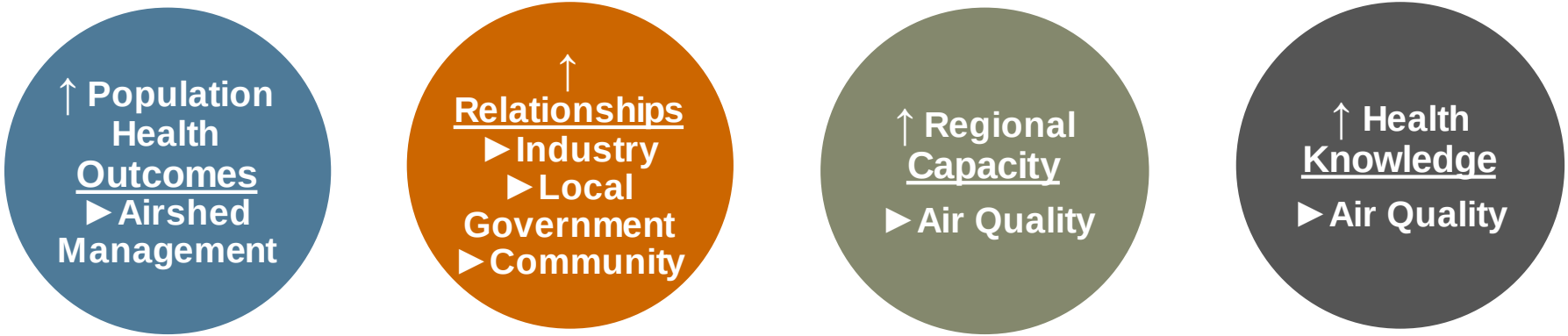


Emerging Issues

- Aging populations and chronic disease
- Climate Change
  - Wildfires
  - Drought and dust
  - Heat
- COVID-19 and other infectious diseases
- Increasing complex industrial development (e.g. LNG, proposed ethylene plant, “green” industries – CO_2 sequestration, ammonia and hydrogen)
- Socio-economic and mental wellbeing considerations



Protect and Improve the Health of the Population as it Relates to Air Quality



- Air Quality Roundtables
- Permitting and Environmental Assessment Process
- Policy, legislation and provincial initiatives
- Community and land use planning

- Support community, industry and stakeholder events and processes
- Provincial air quality groups

- NH air quality steering committee
- Support complaints and investigations
- Internal guidance and resources

- Information and knowledge management
- Health promotion and public awareness

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Building Relationships

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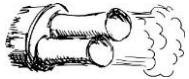
Air Quality Management Roundtables

- Kitimat Airshed Group (KAG)
- Bulkley Valley Lakes District Air Management Society (BVLD AMS)
- Prince George Air Improvement Roundtable (PGAIR)
- Quesnel Air Quality Roundtable (QAQR)
- Valemount Clean Air Task Force (VCATF)

Promote and support community, industry and public actions through bylaws, policy, best practices, legislation, and education

Prevent

- Wildfires
- Residential wood smoke
- Road dust and local traffic pollution



- Open burning
- Industrial emissions

Avoid

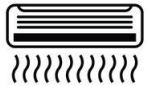
- Air quality maps and data sources
- Land use planning
- Notification systems

- Best available technologies

Protect

- Most sensitive populations
- Community support networks
- Built environment
- New and existing public infrastructure

- Face masks
- Indoor air cleaners



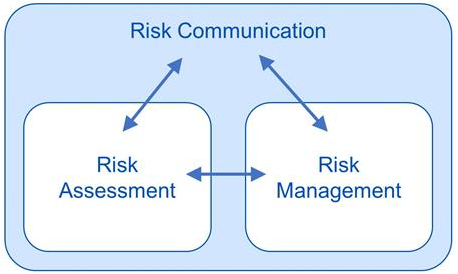
Planning for equity contributes to the development of sustainable, resilient and healthy communities by more effectively and systematically addressing community well-being.

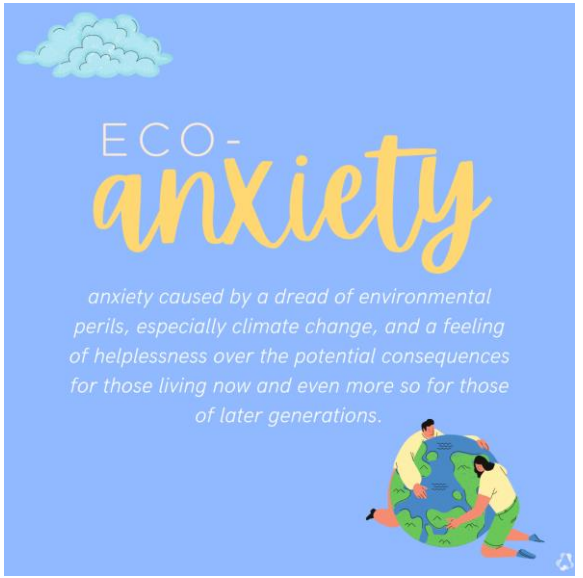
Industrial Development and Land Use Planning

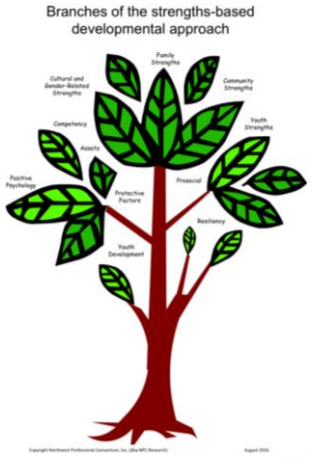
- How are emissions described? (contaminants and odours)
- Fugitive Dust Emissions and Management (road and parking lots)
- Set backs
- Sensitive receptors
- Best available technologies
- Local conditions
- Active transportation
- How best to characterize health impacts?

Build Trust and Resilience Together

- Build relationships
- Risk communication
- Strengths-based approaches
- Prepare and plan
- Take action and know what's within your control
- Limit media intake
- Use trustworthy news sources
- Connect with nature
- Self care
- Support others







Thanks - I’m happy to stay connected!

Paula Tait

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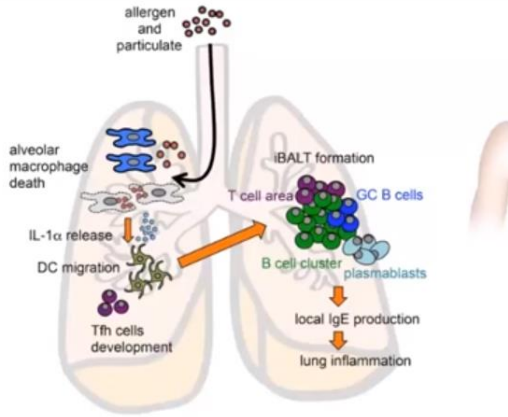
Extra slides…

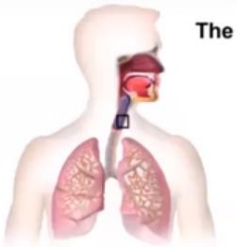
Extra slide (Michael Brauer, BC Lung webinar, December 1, 2021) :

Woodsmoke and respiratory infections



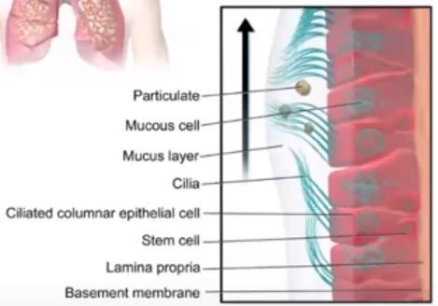
Kuroda e et al. Inhaled Fine Particles Induce Alveolar Macrophage Death and Interleukin-1α Release to Promote Inducible Bronchus-Associated Lymphoid Tissue Formation. Immunity. 2016;45(6):1299-1310. doi: 10.1016/j.immuni.2016.11.010.

Enhanced viral binding, Pro-inflammatory response following PM exposure



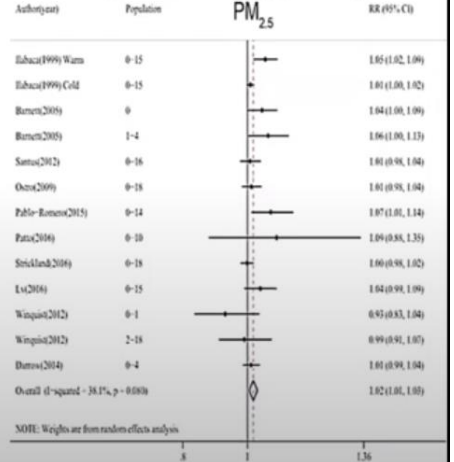
The Respiratory Epithelium

Movement of mucus to the pharynx



Blausen.com staff (2014). "Medical gallery of Blausen Medical 2014". WikiJournal of Medicine 1 (2). DOI:10.15347/wjm/2014.010

Pneumonia hospitalization in children under 18 years old per increase of 10 μg/m³ $PM_{2.5}$

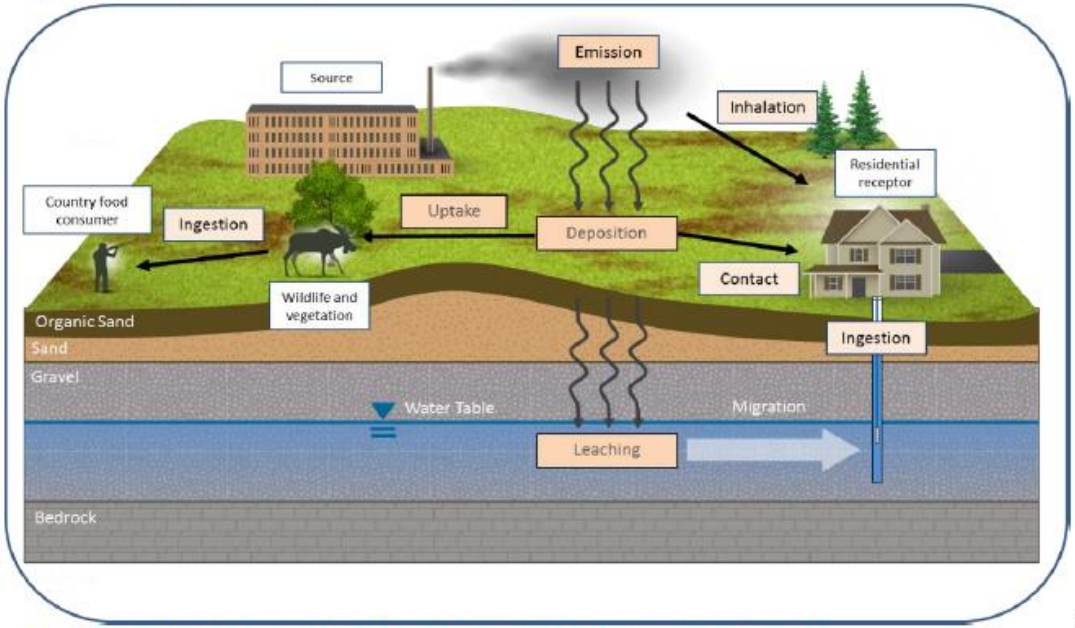


Nhung NTT et al. Short-term association between ambient **air pollution** and pneumonia in children: A systematic **review** and meta-analysis of time-series and case-crossover studies. Environ Pollut. 2017 Nov;230:1000-1008. doi: 10.1016/j.envpol.2017.07.063

Clearing the Smoke: Tackling the Issue of Residential Wood Smoke and Public Health - YouTube

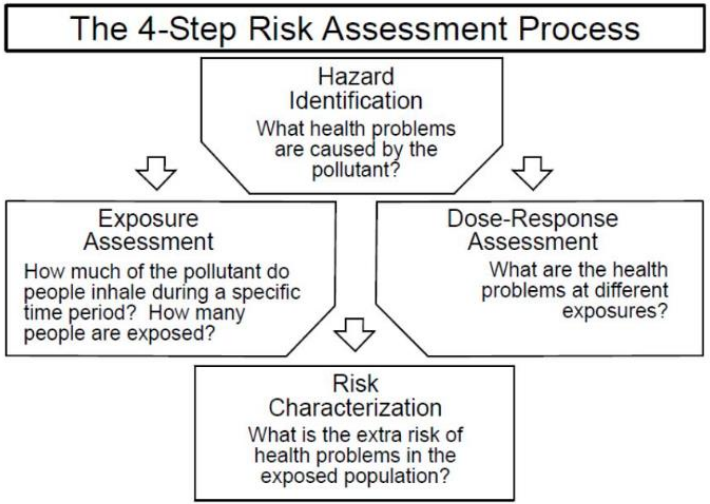
Human Health Risk Assessment

Figure 4: Example of conceptual site model in pictorial format



Created with Health Canada's CSM Builder Tool (eSolutionsGroup Ltd., 2015).

Health Risk Assessment Process



Source: USEPA, APTI 452, Principles and Practices of Air Pollution Control, Ch2

Industrial Sources in the North

- Aluminum smelter
- Forestry – slash burning
- Pellet plants
- Pulp mills

- Oil refineries
- Other oil and gas activity
- Mining and gravel quarries
- Marine, Rail, Truck - Traffic


Source: Rio Tinto


Source: Conuma