Investigating Emergency Room Visits for Cardiorespiratory Diseases in Alberta and Ontario, Canada in Relation to Wildfires

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Motivation

Carbon monoxide (CO) is released through biomass burning events, remaining in the atmosphere on the order of weeks to months, and is a good atmospheric tracer to track the distribution and movement of smoke.

A new seasonal peak in CO has emerged in August when comparing satellite data from regions in North America from 2002-2011 and 2012-2018, coinciding with the Pacific-North-West wildfire season [1].

Smoke exposure from biomass burning events has been shown to result in an increase of hospitalizations and mortalities related to cardiovascular and respiratory diseases, through both local and long-range transport [2,3]

Climate change is expected to increase the frequency and magnitude of forest fires, making it important to evaluate their potential health impacts [4]. Here, we aim to link smoke from increasing wildfires with health impacts in Alberta and Ontario, Canada.

Datasets & Processing

XCO total columns from the Measurements of Pollution In the Troposphere (MOPITT) instrument on the Terra satellite [4]:

- L3 Joint NIR/TIR monthly product
- Converted to column-averaged dry-air mole fraction in parts per billion (XCO, ppb)
- Detrended using the Northern Hemisphere average change in CO (-0.57%/year) [1]

Burned Area (BA) from the Moderate Resolution Imager (MODIS) [7]:

- From Terra and Aqua satellites, MCD64CMQ / MCD64A1, 500m resolution
- Monthly BA summed for the three regions of Alaska, Canada and USA, in hectares

Canadian Institute for Health Information* monthly counts of Emergency Room admissions for respiratory and cardiovascular diseases in Alberta (2010-2019) and Ontario (2004-2019) separated by ICD-10 code listings:

- Hypertension, Ischemic Heart Disease, Arrhythmia, Heart Failure, Cerebrovascular Disease, Pneumonia, Acute Lower Respiratory Disease, Chronic Obstructive Pulmonary Disease, and Asthma
- Separated by health district (14 in Ontario, 5 in Alberta) normalized to admissions per 100,000 by annual population

References

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Acknowledgments

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Key Points

Atmospheric CO columns in Alberta and Ontario are influenced by biomass burning events in Canada, the Continental USA, and Alaska.

An increase in biomass burning events has changed the seasonal cycle of CO in North America; this has been observed in Alberta and Ontario.

People who experience cardiovascular and respiratory related health concerns are at an increased risk of adverse health effects from biomass burning events.

The link between health outcomes and wildfire smoke in Alberta and Ontario is unclear and requires further statistical analysis.

Wildfires, CO, and Canada

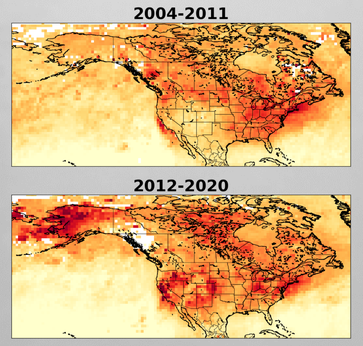

Figure 1 :
Mean August MOPITT XCO column (ppb) over North America. Top: 2004-2011, bottom: 2012-2020.

MOPITT XCO over Alberta and Ontario shows an increase in the summer months, pre- and post-2012, consistent with [1]. This trend was also observed (not shown) with the ground-based Fourier transform infrared spectrometer at the University of Toronto Atmospheric Observatory, a station in the Network for the Detection of Atmospheric Composition Change (NDACC).

MOPITT XCO over Alberta and Ontario demonstrates a positive correlation with the MODIS burned area product when summed over the regions of Canada, Alaska, and the Continental USA.

Outliers to this may be a result of lofted smoke being carried out of the area through an increased injection height, which has been linked to fire intensity in the boreal region [8].

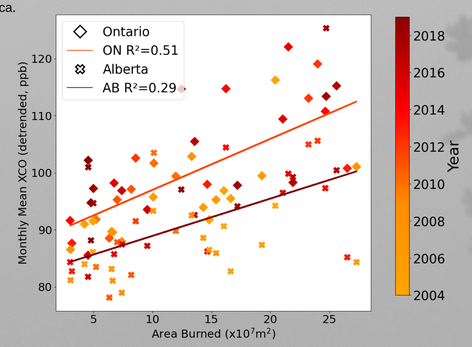

Figure 2 :
XCO columns in Alberta (x) and Ontario (◊), compared to MODIS burned area summed for Alaska, Canada, and the Continental USA, for July, August and September from 2004-2019.

Healthcare Utilization

Health care utilization as a result of wildfires may be impacted by:

- Smoke toxicity – variable by the age of smoke, fire temperature, ecoregion of the burn
- Local intervention measures – e.g., evacuation orders, distribution of protective equipment
- Human behavior – e.g., proximity and severity of burn, availability of medical treatment, ability to self-treat

Some diseases show distinct seasonal patterns, and/or trends over time, both of which confound the ability to compare the two time periods (see example of heart failure in Fig. 3).

Examining the monthly mean number of emergency room visits for the summer months (July-September, per 100,000 people) for each disease in the regions of Ontario and Alberta shows an increase in the latter time period for 9 of the 18 province-disease pairs (see Fig. 4).

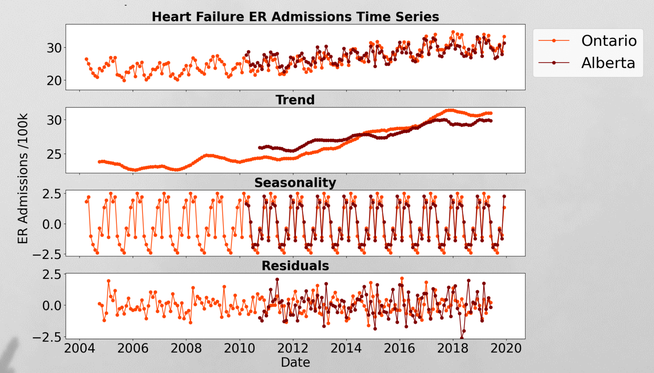

Figure 3 :
Decomposed time series of monthly emergency room visits for heart failure in Alberta (orange, 2010-2019) and Ontario (maroon, 2004-2019).

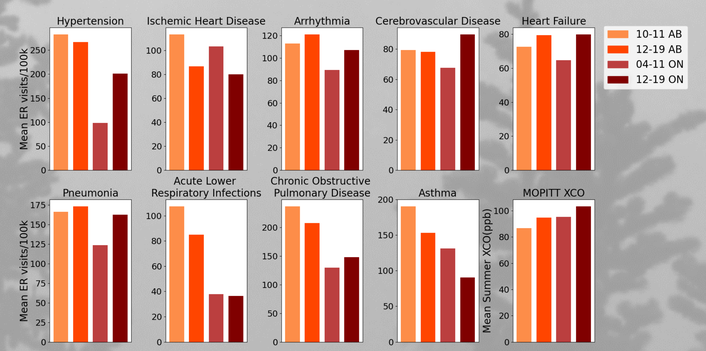

Figure 4 :
Mean sum of summer ER visits (July-September) by disease grouping, pre- and post-2012, for Alberta and Ontario per 100,000 people. Bottom right panel shows MOPITT mean summer XCO, for the same time period.

Next Steps

Implement a “difference in difference” approach which can account for influences such as health district, measured CO and month [e.g., 9].

Determine if the frequency and duration of the health care utilization data allows for significant resolution beyond any natural fluctuation to evaluate if there has been a change in ER visits corresponding to the increase in wildfires and XCO.