Air Quality and Health Outcomes (AQHO) in Ontario

Outreach & Communication of AQHI

File No. AQHO-16/17-017

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Final Report

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Table of Contents

1. EXECUTIVE SUMMARY

Background

Health Canada proposed the national AQHI formulation in 2006 to measure the impact of air pollutants on human health, an index that derives a value based on the cumulative effect of three pollutants (i.e., O_3, $PM_{2.5}$ and NO_2). The AQHI is designed to help people understand what the air quality means to their health and how they can make decisions or alter their behaviour to protect their health. Ontario developed the AQHI Plus, a modified version of the national AQHI, in coordination with the federal government. The AQHI Plus takes into account cumulative health effects and Ontario's ambient air quality criteria, and provides consistent air quality messaging to the public.

Ontario's AQHI Plus public reporting was launched on June 24, 2015. Hourly AQHI readings are reported to the public in near real-time on the Ontario Ministry of the Environment, Conservation and Parks (MOECP)'s website www.airqualityontario.com and other websites (e.g., Environment and Climate Change Canada's website). Air quality information is disseminated on a timely basis to the public (especially the high-risk population) for self-calibration and taking precautionary measures to mitigate risks associated with air pollution.

A previous study showed that air pollution (measured using the AQHI) can exacerbate respiratory conditions like asthma,[1] emphysema and chronic obstructive pulmonary disease (COPD) and may also contribute to a long-term prevalence risk of other chronic disease such as diabetes, hypertension and stroke.[2,3] It is important to increase public awareness of the health impact of air pollution and the availability of the AQHI information so that the public (especially the high-risk population) can make good use of such valuable information for self-calibration and taking precautionary measures to mitigate risks associated with air pollution.

Methods

In this Project entitled "AQHO (Air Quality and Health Outcomes) in Ontario", air quality and health outcomes surveillance were integrated. Anonymized and aggregated results including summary tables, graphs and maps were generated and posted on the OASIS website and accessible by the public (http://lab.research.sickkids.ca/oasis/data-tables/). The following were conducted:

- Annual statistics and summary tables of AQHI values and individual pollutants (i.e., O_3, $PM_{2.5}$ and NO_2) for Ontario from 2003 to 2014 were generated.
- Maps of AQHI and each of the 3 major pollutants (O_3, $PM_{2.5}$ and NO_2) were generated. The most recent available data (2014) were mapped by cut-points (based on standard deviations from the mean) across public health units (PHU) in Ontario.
- The maps show the mean distribution of air quality and pollutants in Ontario by PHU for seasonal and annual time frames. These maps were generated on ArcGIS Pro using a two-step process. Firstly, the Empirical Bayesian Kriging (EBK) Regression Prediction tool was used to generate a spatial prediction surface of air pollution distribution across Ontario while taking elevation into

account. This spatial prediction surface helped determine air pollution levels in areas where there was no available data due to the absence of air monitoring stations. Secondly, the Zonal Statistics tool was used to calculate the mean statistics of the air pollution prediction surface within each PHU zone (i.e. boundary) of Ontario.

- To confidently predict the mean distribution of air pollution in Ontario using EBK Regression Prediction, fixed-distance buffer zones of 100km were sampled around the air monitoring stations within the provincial boundary. We do not have sufficient data to confidently predict the mean distribution of air pollution outside the buffer zones, such as in Northern Ontario because there are no air monitoring stations in the region. Those areas were marked in grey in the maps in this report.
- Maps of health outcomes by each of the primary surveillance outcome measures (i.e. incidence, prevalence, health services use (hospital admissions, emergency department (ED) visits and physician visits) and by major respiratory chronic diseases and conditions (asthma, chronic COPD, diabetes, hypertension and congestive heart failure (CHF)) were generated.
- Joint maps of AQHI and health outcomes were produced.
- Trend of AQHI and health outcomes were plotted from 2003 to 2014 (most recent data available). A logarithm trend is further fitted to generate modelled values for 2015 through to 2025. Each of the trend and forecasting was conducted for Ontario as a whole and by PHU regions.

Key Results

Air Pollution Maps in Ontario

- The annual mean distributions of air pollution measures varied across Ontario. Overall, average values of AQHI, NO_2, and $PM_{2.5}$ were highest in the Southwest and Northeast regions of the province (Figures 4.1.1-4.1.3), whereas average values of O_3 were highest along the Western provincial border (4.1.4).
- Some variations in annual mean distributions of air pollution measures were observed across seasons. For example, average seasonal highs of AQHI ranged from ≤ 2.88 in the fall to ≤ 3.16 in the spring (Figure 4.2.1). For examples on other pollutants, see Figures 4.2.2-4.2.4.

Health Outcomes

- The highest incidence and prevalence rates for asthma (incidence: 5 per 1000, prevalence: 19 per 100), diabetes (incidence: 9 per 1000, prevalence: 13 per 1000) and hypertension (incidence: 14 per 1000, prevalence: 32 per 1000) were in the PHUs located in Southern Ontario. Incidence and prevalence rates also remained relatively high across the middle of the province, where the highest rates for COPD (incidence: 9 per 1000, prevalence: 7 per 100) and CHF (incidence: 8 per 1000, prevalence: 5 per 100) were observed.
- For all health conditions, hospitalization and ED visit rates were high in Northern Ontario, whereas rates for outpatient physician office visits were generally highest across Southern PHUs.

Distribution of AQHI and Chronic Disease Outcomes

- In general, there appears to be a correlation between air pollution and chronic disease outcomes, whereby prevalence, incidence and health service use rates were higher in areas that had higher mean annual AQHI values.
- There were some exceptions to the pattern of observed correlations between air pollution and health outcomes. Across several chronic diseases, hospitalization and ED visit rates remained relatively high in areas with low AQHI values. For example, asthma hospitalization rates were high in the Northwestern and Timiskaming Health Units (Figure 6.1.3).

Trends and Forecasting By Regions

- Overall, there were minor variations between Public Health Regions.
- From 2003 to 2016, incidence rates for asthma (-59.9%) and hypertension (-39.3%) have been on the decline in Ontario and will continue to decrease, whereas the incidence of COPD, diabetes and CHF has remained relatively unchanged. Prevalence rates for all health conditions will continue to increase.
- Hospitalization and outpatient physician office visit rates for all health conditions have been decreasing across the province. Although ED visit rates for asthma (-61.4%) and diabetes (-18.8%) have decreased, they are increasing for COPD (+47.6%), hypertension (+43.0%) and CHF (+12.1%), most notably in the Northern Region of Ontario.
- There is a correlation between the trends in health conditions and trend in annual mean AQHI values, whereby both have been gradually decreasing and are projected to continue decreasing through 2025. However, causal associations between AQHI and health outcomes cannot be inferred from these crude projections.

Strengths & Limitations

To the best of our knowledge, this is the first comprehensive report examining the possible relationship between air pollution and health outcomes in Ontario. This report leveraged the use of population-based data, including air pollution data obtained from the MOECP and administrative data housed at ICES for five major chronic conditions. However, this report is based on cross-sectional rather than longitudinal data. We have estimated the correlations between measures of air pollution and health outcomes using a crude methodology, from which no inferences regarding causal associations should or can be made. There may be additional variables that contribute to the observed correlations, and more sophisticated analyses would be required to account for this unmeasured confounding.

Acknowledgement

Data were provided by ICES and funding support from the Ontario Ministry of the Environment, Conservation and Parks. Anonymized and aggregated results including graphs and maps were generated and posted on the OASIS website and accessible by the public. Public image is obtained from Environment Canada.