Sources of uncertainty in calculating mortality and morbidity attributable to air pollution

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AIRNET
A Thematic Network on Air Pollution and Health

NERAM
Network for Environmental Risk Assessment and Management

Introduction

This work evolved from a request from Clean Air Hamilton, a multi-stakeholder group tasked with advising Hamilton City Council on air pollution policy. We were asked to update the estimated mortality and morbidity attributable to air pollution in the City.

By conducting an in-depth study in one location, our aims were:

- to illustrate the sensitivity of health effect estimates to a wide range of possible underlying assumptions.
- to give policymakers a better sense of the assumptions and estimations that underlie estimates of mortality and morbidity attributable to ambient air pollution exposure.
- to highlight some of the differences in expectations between policymakers and scientific research.

Methods

- Dose-response relationships were derived based on pooled and averages estimates published in the scientific literature from 1997 to 2001. Estimates were applied to local air pollution and hospital admissions for the years 1995-1999, and mortality for 1995-1997.
- A programming limitation in the generalized additive models (GAM) revealed that risk estimates may have been overestimated by as much as 42%. Adjustments were applied to study data to account for this overestimation.
- Health effect estimates are normally compared to a zero pollution level, considered by many to be practically unattainable. Estimates were thus calculated using a baseline of the lowest quintile of measured pollution values, as mean-min 20%.
- Local estimates derived from Hamilton-specific models were also conducted. Additional sensitivity analyses were based on pooled random effects models and from chronic studies from other jurisdictions.

Figure 1. Location map of Hamilton, Canada

Equations used for calculations

$$H = B * \Delta H\% * P$$

where:
H = annual health outcome
B = base number of outcomes per year
ΔH% = percent change in health outcome per unit increase of pollutant
P = annual pollution average

Sample Calculation

$$HO = 3730 \frac{\text{deaths}}{\text{year}} \times 0.076 \frac{\text{deaths}}{\mu g/m3} \text{ per } 100 \text{ deaths} \times 27.9 \ \mu g/m3 = 79.09 \frac{\text{deaths}}{\text{year}}$$

Results and Discussion

- Sensitivity of estimates to choice of model can be seen as mortality and morbidity estimates can range by 278 annual deaths, 563 respiratory admissions and over 1600 cardiovascular admissions in one year.
- Mortality increased from 298 to 374 annual deaths, respiratory admissions increased from 144 to 607, while cardiovascular admissions increased from 257 to 2000, using more recent literature findings and local health and pollution averages.
- Combining both the 42% GAM adjustment and 20% baseline adjustment decreased the mortality estimate to **96** deaths, and morbidity estimates to **139** respiratory deaths and **479** cardiovascular admissions (Figure 2).
- Estimates based solely on Hamilton-specific data resulted in higher mortality counts than pooled data (**96** vs. **90**). Chronic exposure calculations resulted in **232** annual deaths due to fine particulate pollution (Table 1).

Figure 2. Differences in mortality and morbidity estimates according to model utilized

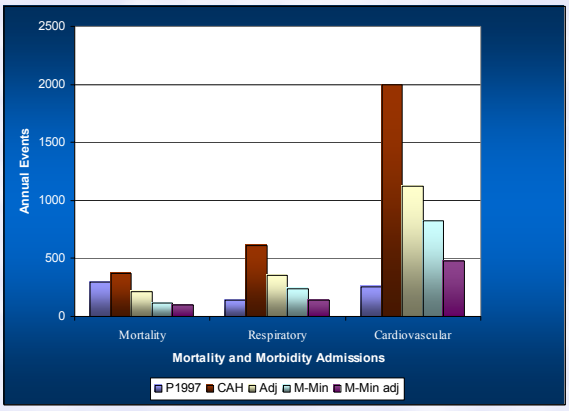

Table 1. Summary and Comparison of Mortality Counts Estimated for Different Models, Based on 1997 Hamilton Pollution Values

Pollutant	NT mortality (average incidences/year) average of estimates							
	P1997	CAH	Adj	M-min	M-min adj	Pooled	Hamilton	Chronic
PM_{10}	97	73	43	24	14	31		
$PM_{2.5}$		110	64					232
CoH							256	
SO_2	16	53	31	27	16	22	73	
NO_2	81	134	78	46	27	14	108	
CO	3	10	6	6	3	0	5	
O_3	102	105	61	62	36	23	122	
Total	298	374	217	119	96	90		232
Total **		411	238				564	

P1997 = HAQI report, Pengelly 1997
CAH = Current reanalysis for City of Hamilton
Adj = Adjusted value of CAH, for overestimate of 42%
M-min = Estimate calculated for pollution values of mean – min (lower quintile) for 1997
Total ** = Totals calculated with CoH as particulate measure instead of PM_{10}

Conclusions

- The wide range of estimates resulting from the different models substantiates our aim of highlighting the impact of scientific uncertainties and model assumptions.
- Contrary to advice from the academic literature, policymakers were interested in total numbers of deaths and admissions from all pollutants.
- While we compensated for potential overestimates by using only multi-pollutant models, we still believe that the summation of all air pollutants inflates mortality and morbidity admissions.
- Conversely, the total burden of illness due to air pollution includes other important health effects that were not into account in these analyses, such as asthma exacerbation, that may lead to underestimates of morbidity.

Future directions

Based on our analysis and experience with advising policymakers, we conclude with three suggestions for future research.
1. An effort should be made to reach a consensus on standardized reporting methods
2. An immediate need exists for widely accepted health accounting conventions.
3. Many areas of air pollution research require considerable work before complete estimates can be ascribed. Priority areas include studies on the chronic health effects of air pollution , multi-pollutant studies, and on health outcomes such as asthma

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