Evaluating the Sensitivity of $PM_{2.5}$-Mortality Associations to the Spatial and Temporal Scale of Exposure Assessment and the Inclusion of Immigrant Populations

Anders C Erickson[1], **Scott Weichenthal**[2], Dan L Crouse[3], Tanya Christidis[4], Lauren Pinault[4], Amanda Pappin[4], Aaron van Donkelaar[5], Chi Li[5], Jun Meng[5], Randall V. Martin[5], Perry Hystad[6], Jeffery Brook[7], Michael Tjepkema[4], Rick Burnett[8], Michael Brauer[1]

Sensitivity to Spatial and Temporal Scale of Exposure Assessment

Background & Objectives

- The temporal and spatial scale of $PM_{2.5}$ exposure assignment may impact the magnitude of association with mortality at low mass concentrations.

Data

- 2001-2011 Canadian Census Health and Environment Cohort (N=2.4 million).
- $PM_{2.5}$: Satellite AOD/GEOS-CHEM/Geographically-weighted regression.
- NO_2: National land use regression model.
- O_3: National model (Environment Canada).

Methods

- Cox proportional hazards models.
- $PM_{2.5}$ exposures assigned at three spatial scales (1-km^2, 5-km^2, 10-km^2) and three temporal scales (1-year, 3-years, 8-years).
- Different spatial scales (i.e. 1-km^2 vs. 10-km^2) were examined based on age, employment status, and urban/rural location.
- Examined sensitivity of $PM_{2.5}$-mortality associations to inclusion of oxidant gases.

Results

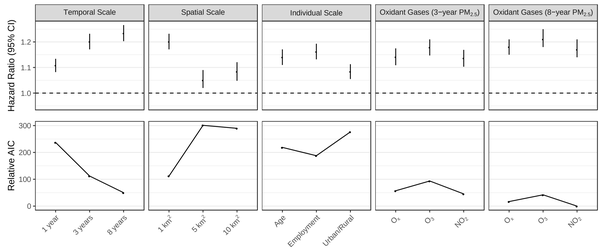
- Longer moving averages and smaller spatial scales generally resulted in stronger associations.
- Adjusting for oxidant gases attenuated associations between $PM_{2.5}$ and cardiovascular mortality and strengthened associations for lung cancer.
- $PM_{2.5}$ was associated with mortality in nearly all of the models examined at 1-km^2 spatial resolution.

Conclusions

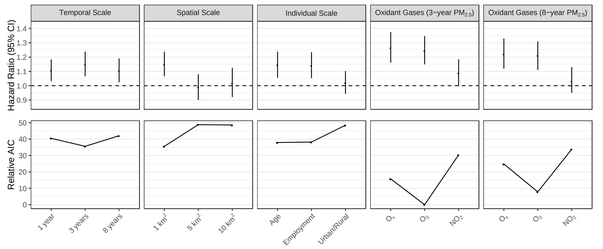
- $PM_{2.5}$-mortality associations are sensitive to the spatial and temporal scale of exposure assignment as well as oxidant gases.
- Respiratory outcomes were most sensitive to the spatial scale of exposure assessment.
- Overall, these results support a relationship between long-term exposure to $PM_{2.5}$ and mortality at low mass concentrations.

Results

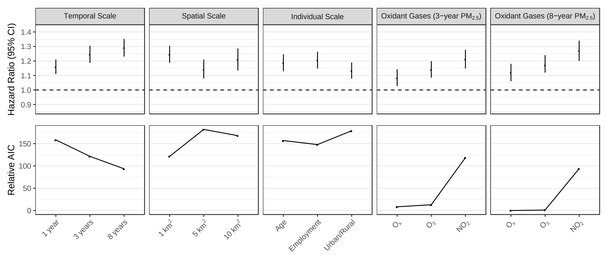
Nonaccidental Mortality



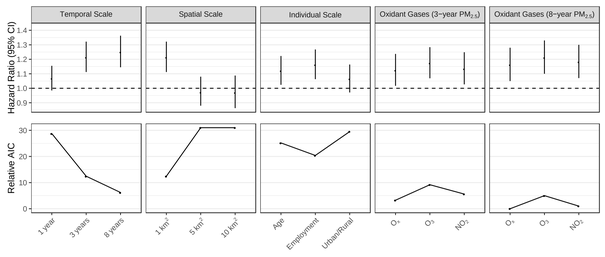
Lung Cancer Mortality



Cardiovascular Mortality



Respiratory Mortality



Assessment of Immigrant Populations

Background & Objectives

- Canadian immigrants have lower mortality risks than the native-born population, but little is known about the impact of ambient air pollution exposure on their long-term health.
- **Objective:** To assess the risk of non-accidental and cause-specific mortality to the Canadian immigrant population with exposure to $PM_{2.5}$ compared to the non-immigrant population.

Data

- 2001-2016 Canadian Census Health and Environment Cohort (CanCHEC, N=3.5 million) linked to longitudinal mortality and air pollution exposure via annual residential postal code histories.
- $PM_{2.5}$: Satellite AOD/GEOS-CHEM/Geographically-weighted regression.

Methods

- Cox proportional hazards models used to estimate $PM_{2.5}$ exposure and cause-specific mortality relationship.
- Immigrants grouped by year immigrated to Canada: >30 years, 21-30 years, 11-20 years, ≤10 years.
- Examined models comparing Canada-born (CB) non-immigrants to all foreign-born (FB) immigrants or stratified by year immigrated.
- Assessed mortality risk by year immigrated with increasing $PM_{2.5}$ exposure.

Results

Table 1

- On average, immigrants had 20% higher exposure to ambient $PM_{2.5}$ than non-immigrants.

Figure 1

- Notable cohort differences of characteristics between non-immigrants, established immigrants (pre-1971) and more recent immigrants (1971-2000), but particularly among recent immigrants (post-1980).

Figure 2

- Immigrants tend to show larger $PM_{2.5}$ hazard ratios compared to non-immigrants for cardiovascular related mortalities, largely driven by pre-1970 and 1981-1990 immigrants.

Figure 3

- Clear mortality trend at mean $PM_{2.5}$ levels (7.5µg/m^3), deteriorates with increasing exposure levels.

Conclusions

- Despite overall lower mortality risk, immigrants were more sensitive to $PM_{2.5}$ compared to non-immigrants for CVD-related causes of death.
- Trend in mortality advantage was not consistent across immigrant cohorts with increasing $PM_{2.5}$ exposure.
- Immigrant cohort differences over time presents challenges to disentangle the $PM_{2.5}$ health effects on mortality from other risk factors.

Results

Table 1: Cohort size and $PM_{2.5}$ exposure levels

TABLE 1		Year Immigrated			
Characteristic	**non-immigrants**	**Pre-1971**	**1971-1980**	**1981 – 1990**	**1991-2000**
Total N	2,417,175	255,985	138,260	125,780	164,405
Mean $PM_{2.5}$ (SE)	7.53 (2.7)	9.13 (2.5)	9.28 (2.3)	9.54 (2.1)	9.69 (2.0)

Figure 1: Cohort characteristics

Figure 2: $PM_{2.5}$ hazard ratios per 10µg/m^3 of Foreign-born (FB) immigrants and Canada-born (CB) non-immigrants

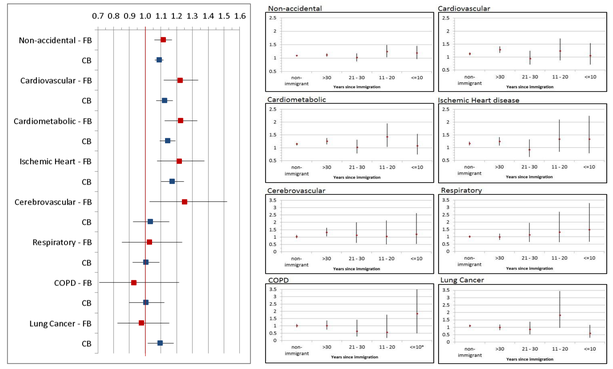
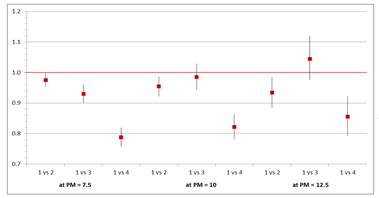


Figure 3: Non-accidental mortality hazard ratios by Year of Immigration with increasing $PM_{2.5}$



Year Immigrated
Group 1: pre-1970 (reference group)
Group 2: 1971-1980
Group 3: 1981-1990
Group 4: 1991-2000

Affiliations: 1: University of British Columbia, Vancouver, BC, Canada; 2: McGill University, Montreal, QC; 3: University of New Brunswick, Fredericton, NB, Canada; 4: Statistics Canada, Ottawa, ON, Canada; 5: Dalhousie University, Halifax, NS, Canada; 6: Oregon State University, Corvallis, OR, USA; 7: University of Toronto, Toronto, ON; 8: Health Canada, Ottawa, ON, Canada.

Funding: Research described in this article was conducted under contract to the Health Effects Institute (HEI), an organization jointly funded by the United States Environmental Protection Agency (EPA) (Assistance Award No. R-82811201) and certain motor vehicle and engine manufacturers. The contents of this article do not necessarily reflect the views of HEI, or its sponsors, nor do they necessarily reflect the views and policies of the EPA or motor vehicle and engine manufacturers.