Identifying the shape of the association between long-term exposure to low levels of ambient air pollution and the risk of mortality: An extension of the Canadian Census Health and Environment Cohort using innovative data linkage and exposure methodology

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Background
- Fine particulate matter (PM2.5) is a causal risk factor for mortality, even in Canada where most of the population lives in areas with relatively low ambient concentrations (<12 µg/m³).
- Canada is an ideal environment to study the relationship between mortality and exposure to low PM2.5 concentrations

Study objectives
- Apply novel satellite-based estimates of PM2.5 exposure to 4 large population-based cohorts in Canada
- Characterize shape of relationship between PM2.5 exposure with all cause and cause-specific mortality

Satellite-based PM2.5 Exposure estimates
- Annual estimates ~ 1km x 1km resolution for 1998-2016 across Canada
- Back-casted to 1981 using remote sensing, chemical transport model (GEOS-Chem), and historical ground monitoring data.
- Further refinements to estimates will incorporate new information on spatiotemporal relationship between aerosol optical depth (AOD) and PM2.5 based on measurements at 3 Canadian sites of the SPARTAN Network (Sriniv et al. Atmos Meas Tech 2015;8:905-21)

Epidemiologic analyses
- Characterized shape of concentration-mortality association using Shape Constrained Health Impact Function (SCHIF) model (Figure 4)
- Evaluated application of indirect adjustment methods using the Canadian Community Health Survey (CCHS) to control for unmeasured behavioural risk factors in census cohorts, and compared exposure profiles between the CCHS and 2001 census cohort (CanCHEC 2001) (Table 1)
- Internal validation: little difference in HRs, indicating suitability with survival models.
- External validation: some downward bias in HRs in indirectly adjusted models. Follow-up tests using sample weights will be run to assess performance differences. Evaluated use of contributing cause of death information in informing cause-specific mortality analyses by including all International Classification of Disease (ICD-10) codes listed on the death certificate in analysis of air-pollution-mortality association, (Figure 5)
- Co-mention of diabetes increased magnitude of air pollution-cardiovascular disease mortality association, suggesting that restricting analyses to primary cause of death underestimates role of co-morbidities.

Figure 1. Mean PM2.5 estimates in Canada from 1998-2010 derived from satellite imagery at 1km x 1km resolution. Pinault et al. Environ Health 2016;15:18.

Figure 2. Exposure estimation development process for PM2.5

Figure 3. Preliminary results. Measured relationships between AOD and PM2.5 indicate driving factor of PM2.5 relationship

Figure 4. SCHIF model model mortality predictions (blue solid line) and 95% confidence intervals (gray shaded area) by cause of death (Pinault et al. Environ Res 2017;159:406-15) (CanCHEC 2001)

Figure 5. Preliminary results. Fully adjusted Cox proportional survival model hazard ratios per increase of 10 µg/m³ increase in PM2.5 in CanCHEC 2001 cohort

Table 1. Preliminary results. Internal and external validation results of Indirect Adjustment. Cox proportional survival model hazard ratios for different causes of mortality per 10 µg/m³ increase in PM2.5 in CanCHEC 2001 cohort

For forthcoming analyses
- Evaluate impact on hazard ratios of spatial scale of PM2.5 exposure assessment: 1km vs 10km buffer vs variable buffer based on age (1 km buffer for older subjects, 10 km buffer for younger subjects)
- Sensitivity to oxidant gases (including PM2.5) and PM2.5 related
- Assessment of multiple exposure-time windows (3, 10, 20-year moving average)
- Restrict analysis to subjects whose average exposure did not exceed 12, 10, 8, or 6 µg/m³

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