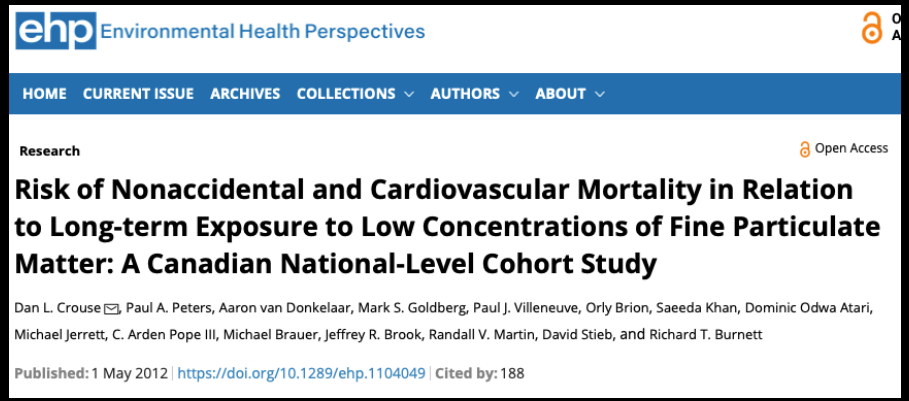
MAPLE: Mortality–Air Pollution Associations in Low Exposure Environments in Canada

Dan L. Crouse
University of New Brunswick

non-accidental mortality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Risk of Nonaccidental and Cardiovascular Mortality in Relation to Long-term Exposure to Low Concentrations of Fine Particulate Matter: A Canadian National-Level Cohort Study

Dan L. Crouse, Paul A. Peters, Aaron van Donkelaar, Mark S. Goldberg, Paul J. Villeneuve, Orly Brion, Saeeda Khan, Dominic Odwa Atari, Michael Jerrett, C. Arden Pope III, Michael Brauer, Jeffrey R. Brook, Randall V. Martin, David Stieb, and Richard T. Burnett

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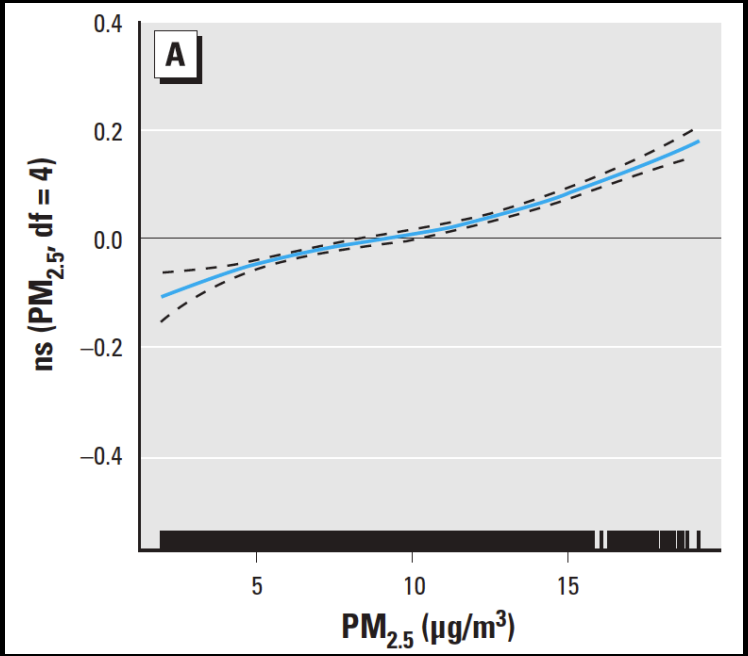

$PM_{2.5}$ = fine particulate matter

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Ambient $PM_{2.5}$, O_3, and NO_2 Exposures and Associations with Mortality over 16 Years of Follow-Up in the Canadian Census Health and Environment Cohort (CanCHEC)

Dan L. Crouse, Paul A. Peters, Perry Hystad, Jeffrey R. Brook, Aaron van Donkelaar, Randall V. Martin, Paul J. Villeneuve, Michael Jerrett, Mark S. Goldberg, C. Arden Pope III, Michael Brauer, Robert D. Brook, Alain Robichaud, Richard Menard, and Richard T. Burnett

Published: 1 November 2015 | https://doi.org/10.1289/ehp.1409276 | Cited by: 66

Pinault et al. Environmental Health (2016) 15:18
DOI 10.1186/s12940-016-0111-6

Environmental Health

RESEARCH Open Access

Risk estimates of mortality attributed to low concentrations of ambient fine particulate matter in the Canadian community health survey cohort

Lauren Pinault[1*], Michael Tjepkema[1], Daniel L. Crouse[2], Scott Weichenthal[3], Aaron van Donkelaar[4], Randall V. Martin[4,5], Michael Brauer[6], Hong Chen[7] and Richard T. Burnett[8]

Longer follow-up, residential mobility, multi-pollutant models

New, smaller cohort, with information on smoking, diet, alcohol, and body mass index (BMI).

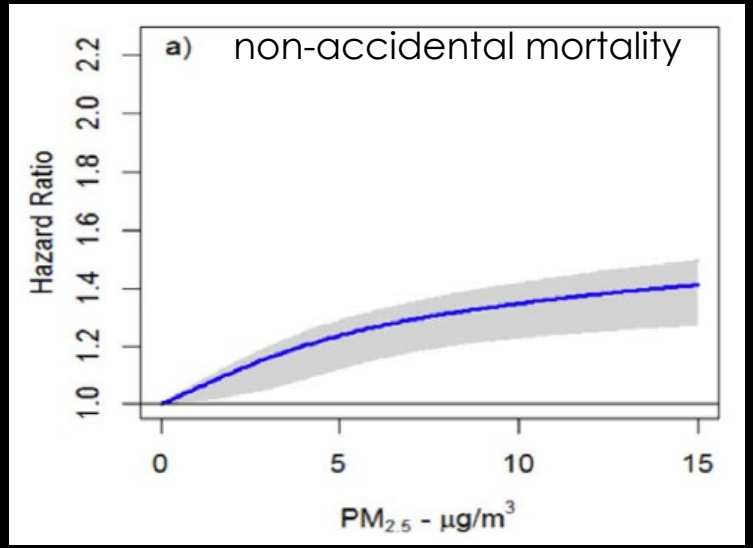
$PM_{2.5}$ = fine particulate matter; O_3 = ozone; NO_2 = nitrogen dioxide

ELSEVIER

Environmental Research
Volume 159, November 2017, Pages 406-415

Associations between fine particulate matter and mortality in the 2001 Canadian Census Health and Environment Cohort

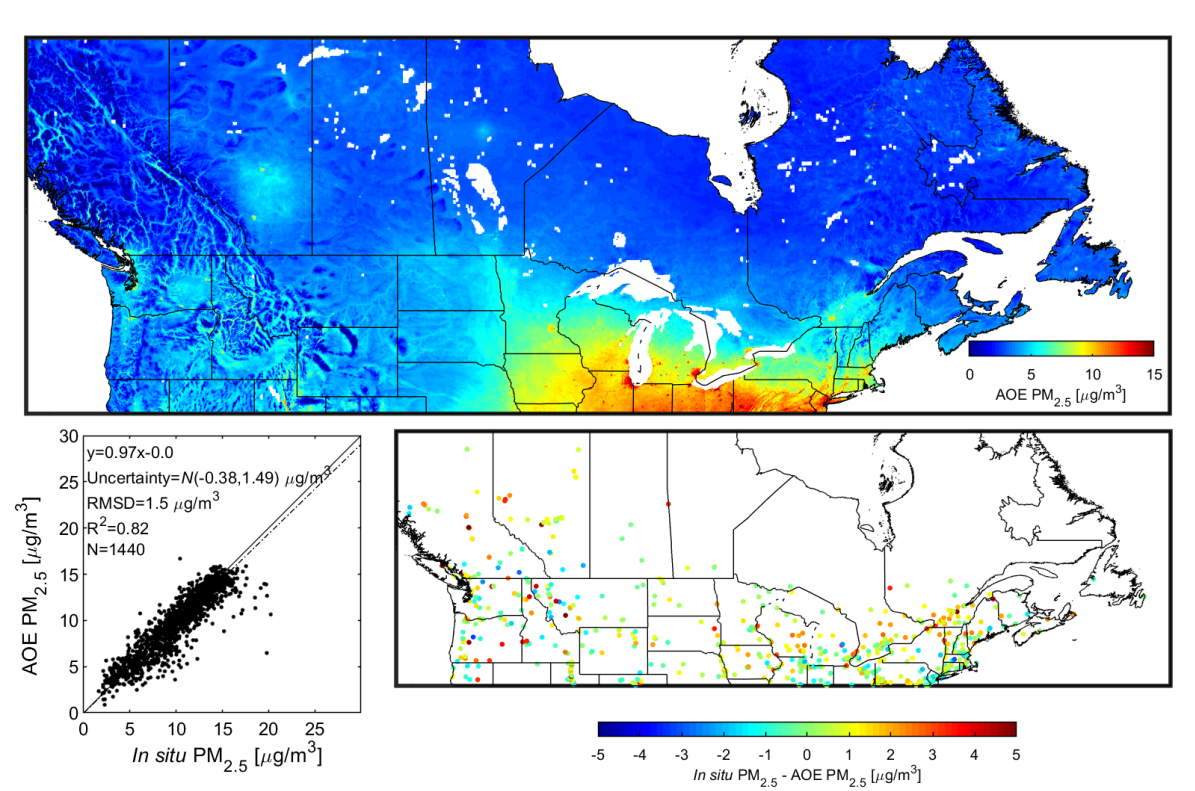
Lauren L. Pinault [a], Scott Weichenthal [b, c], Daniel L. Crouse [d], Michael Brauer [e], Anders Erickson [e], Aaron van Donkelaar [f], Randall V. Martin [f, g], Perry Hystad [h], Hong Chen [i, j], Philippe Finès [a], Jeffrey R. Brook [k], Michael Tjepkema [a], Richard T. Burnett [l]



MAPLE Objectives

Develop	Develop and apply more-refined, annual estimates of $PM_{2.5}$ exposure to several large population-based cohorts
Describe	Describe associations between exposure to low levels of $PM_{2.5}$ and mortality
Characterize	Characterize the shape of concentration-mortality associations

Creating refined estimates of exposure to $PM_{2.5}$



2004-2008

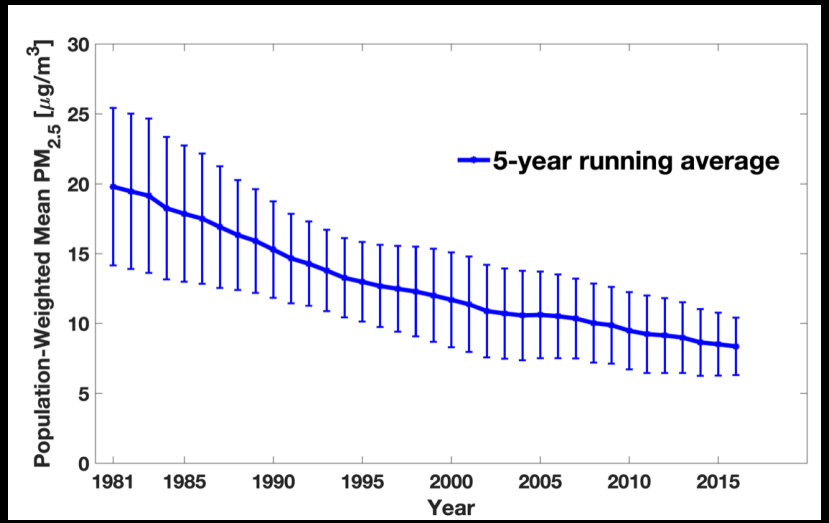
van Donkelaar et al. 2016

Developing annual, historical $PM_{2.5}$ surfaces 1981-2016

Estimates back-casted using historical ground-based measurements of $PM_{2.5}$, PM_{10}, and TSP, and remote sensing, chemical transport model, and elevation data

Captures temporal and spatial changes in pollutant concentrations over time

Estimates from nearest grid cell assigned to residential postal codes



$PM_{2.5}$ = fine particulate matter
PM_{10} = coarse particulate matter
TSP = total suspended particles

Meng et al., 2019

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

Canadian Community Health Surveys (CCHS)

Baseline = 2001-2012

n = 540,900

Depth:

Self-reported health behaviours (BMI, diet, physical activity, smoking, alcohol consumption)

Nationally-representative

Death registry and tax records (residential history) through 2016

Many socioeconomic covariates

20% mandatory response to long-form census:

1991: 2.5M 1996: 3.5M 2001: 3.5M

Size:

Nearly 10 million subjects with up to 25 years follow-up

Canadian Census Health & Environment Cohorts (CanCHEC)

Geographic Identifiers & Contextual Covariates

Regional airsheds

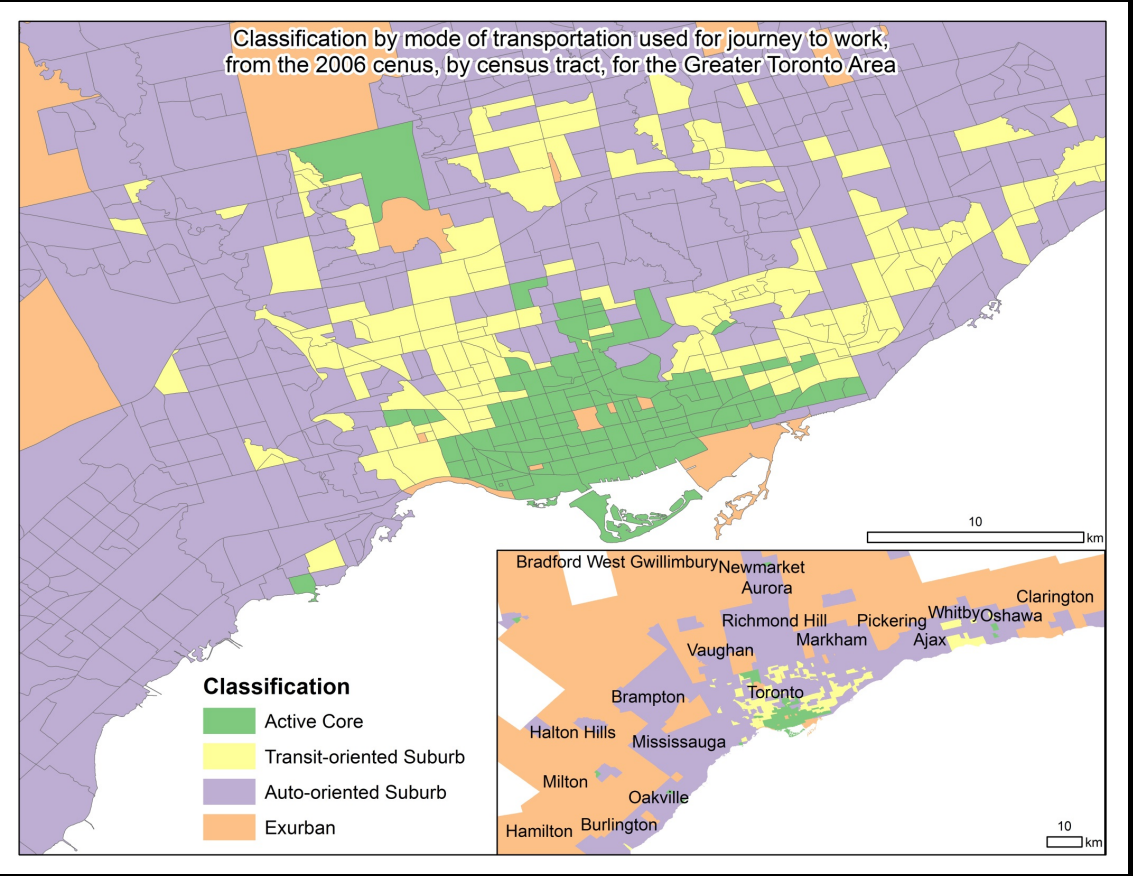
Neighbourhood-level marginalization:

- material deprivation
- residential instability
- dependency
- ethnic concentration

Geographic Identifiers & Contextual Covariates

Community size
(6 levels. small town → large city)

Urbanization
(4 levels. transit reliant suburb → urban core)

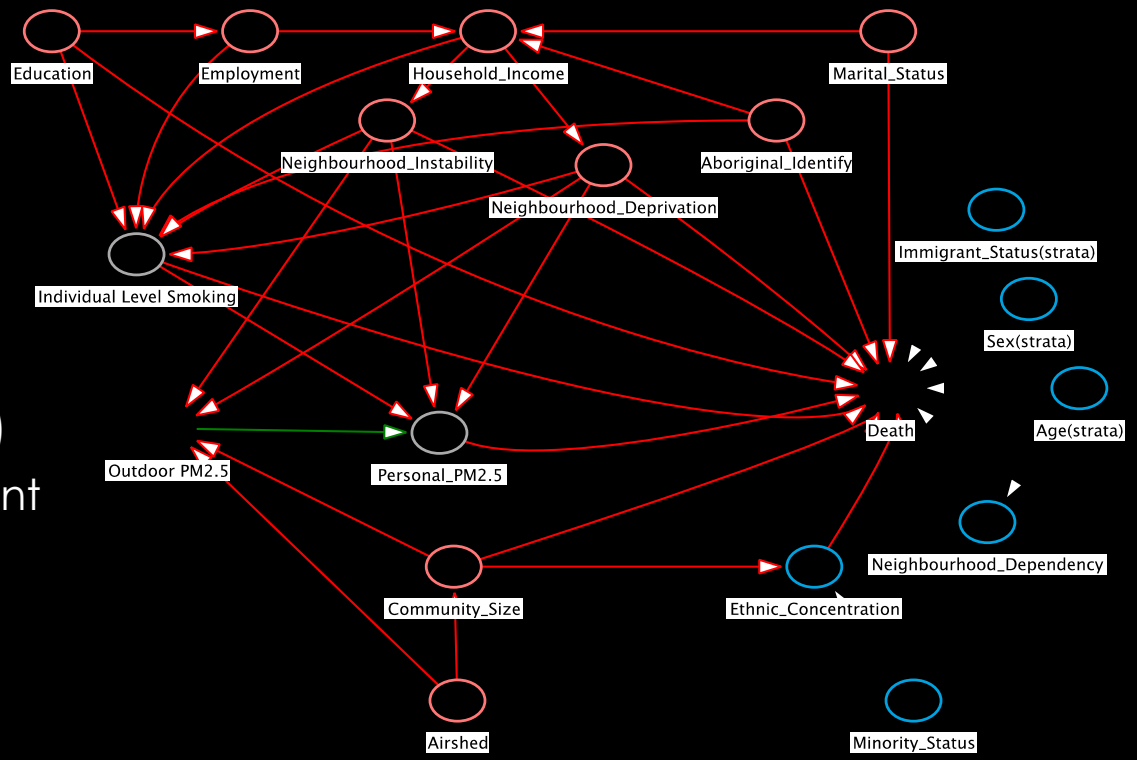


Epidemiological Approach

- Cox Proportional Hazards
- Non-accidental deaths
- Primary exposure time-window is a 3-year moving average with 1-year lag
  - (e.g., exposure for person-year in 2001 = mean of 1998, 1998, 2000)

Evaluating sensitivity of $PM_{2.5}$-mortality associations to model specification

- Combinations of covariate adjustment
- Exposure time-windows
- Spatial scales (1-km^2 vs 10-km^2)
- Sub-populations (e.g., immigrant status)
- Adjusting for co-pollutants



Crouse et al., forthcoming

Results: CCHS Analysis

- One of largest analyses of $PM_{2.5}$ and mortality including individual-level behavioural risk factors (4.4 million person-years)
- Over 50k deaths from non-accidental causes; up to 15 years follow-up
- Annual average $PM_{2.5}$ concentration: 5.9 μg/m^3 (standard deviation 2.0 μg/m^3)

Christidis et al., forthcoming

Results: CCHS Analysis

	Hazard Ratio / 10 μg/m^3 $PM_{2.5}$
Adjusted for personal-level socio-economic covariates and contextual covariates (airshed, city size, marginalization)	1.13 (1.06-1.21)
Adjusted additionally for behavioural covariates (fruit and vegetable consumption, leisure exercise frequency, alcohol consumption, and smoking behaviours)	1.11 (1.04-1.18)

Christidis et al., forthcoming

Results: Stacked CanCHEC cohorts

~8.5 million individuals (151 million person-years)

~1.5 million deaths; up to 25 years of follow-up

Annual average $PM_{2.5}$ concentration: 7.4 μg/m^3 (standard deviation 2.9 μg/m^3)

	Hazard Ratio / 10 μg/m^3 $PM_{2.5}$
Adjusted for personal-level socio-economic covariates & contextual covariates (airshed, city size, marginalization)	1.05 (1.04-1.05)

Pappin et al., forthcoming

Summary

- In both cohorts: associations between $PM_{2.5}$ and non-accidental mortality at concentrations as low as 5 μg/m^3 or lower
- Associations not affected substantially by adjustment for smoking or other health behaviours

What's next…

- Sub-analyses (by sex, age, immigrants)
- Specific causes of death
- Models restricted to subjects with long-term low-level exposures and additional exploration of the shape of the concentration-response function
- Refinement of exposure estimates based on AOD:$PM_{2.5}$ measurements

AOD = aerosol optical depth

MAPLE Team, Collaborators, & Supporters

Michael Brauer, University of British Columbia
Jeffrey Brook, University of Toronto
Rick Burnett, Health Canada
Tanya Christidis, Statistics Canada
Yen Chu, University of British Columbia
Anders Erickson, University of British Columbia
Perry Hystad, Oregon State University
Chi Li, Dalhousie University
Jun Meng, Dalhousie University
Amanda Pappin, Statistics Canada
Lauren Pinault, Statistics Canada
Randall Martin, Dalhousie University
Alain Robichaud, Environment and Climate Change Canada
Michael Tjepkema, Statistics Canada
Richard Ménard, Environment and Climate Change Canada
Aaron van Donkelaar, Dalhousie Univerisity
Scott Weichenthal, McGill University

MAPLE

CANUE

CRDCN Canadian Research Data Centre Network

HEI