Particulate Matter Reproducibility and Air Pollution Epidemiology

Richard T. Burnett, Ph.D.
Health Canada
Health Effects Institute 2018 Annual Conference, Chicago, USA

Lave, L. B., and Seskin, E. P. Air Pollution and Human Health. Johns Hopkins University Press, Baltimore, 1977.

Air Pollution and Human Health: A Review and Reanalysis

by L. A. Thibodeau,* R. B. Reed,* Yvonne M. M. Bishop,* and L. A. Kammerman*

Since 1970, Lave and Seskin have published a series of articles dealing with the question, "Does air pollution shorten lives?" Their recent book reports revised and extended analyses of their previous studies emphasizing policy implications. We have undertaken a review of Lave and Seskin's book to evaluate the methodology used and hence gain some insight into the strength of the conclusions reached. This review concentrates on methodology and its application to establishing and quantifying the association between air quality and health. Beyond simply reviewing the analyses reported in Lave and Seskin's book, we have duplicated and expanded two of the reported analyses. Our detailed reanalysis is presented both to verify reported results, and to illustrate the difficulties encountered in such an analysis.

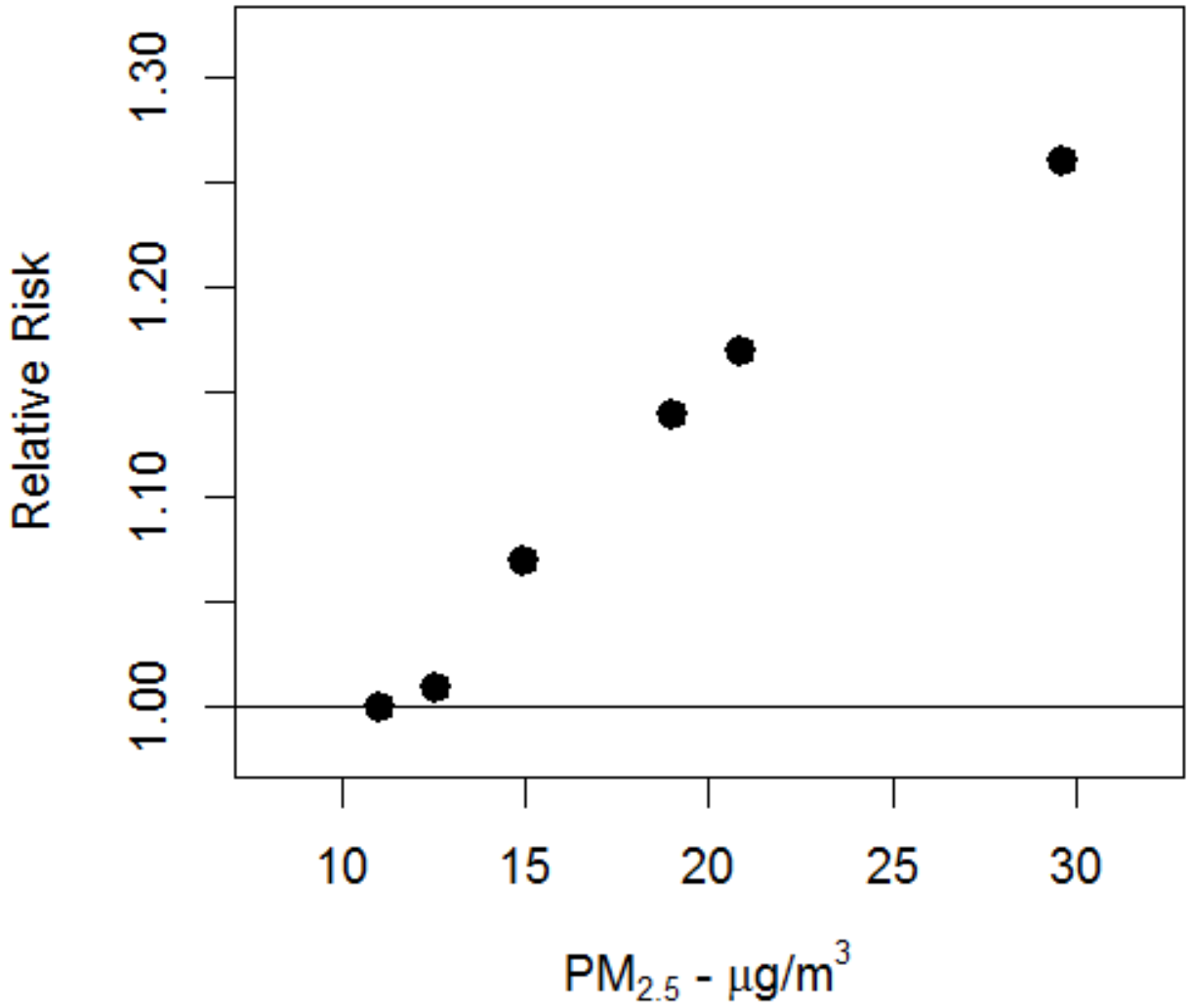
Our overall conclusion is that Lave and Seskin have done a thorough job of reporting and interpreting the various analyses that they performed. Lave and Seskin have made a pioneering effort in showing an association between mortality rates and air pollution. We do not disagree with the conclusion of the existence of an association but have some reservations about their methods of estimating its magnitude.

We were particularly concerned that Lave and Seskin did not fully investigate how well their models fit these data. Our reanalysis results in estimated effects which differ considerably from the values reported by Lave and Seskin. Thus, we conclude that the regression coefficients are quite unstable and so must be used with care. Assessing the relative costs and benefits of reducing air pollution without extensive sensitivity analysis could, therefore, be misleading.

Limitations of Spatially Aggregate Data

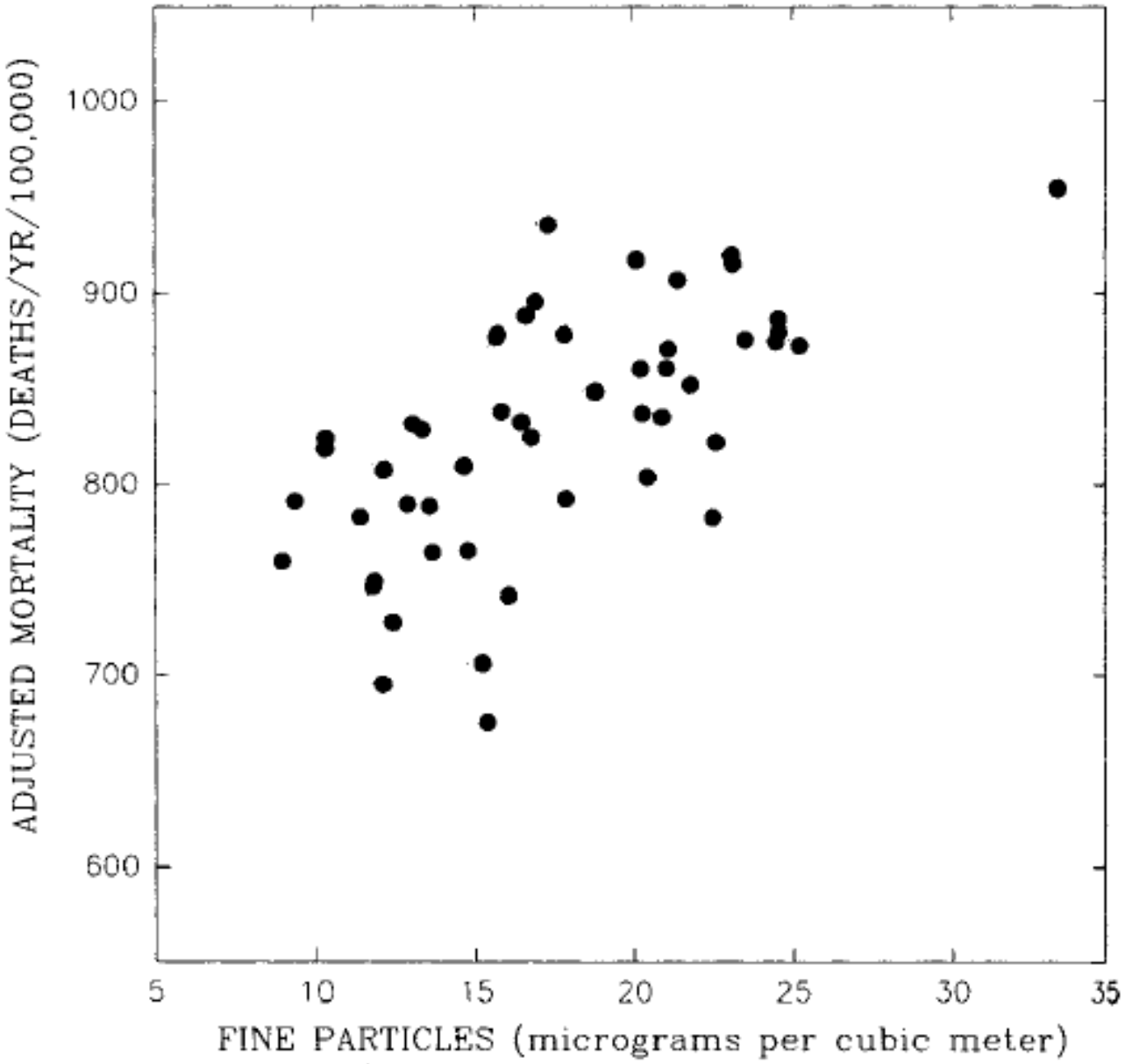
- No subject level risk factor information (smoking, diet, BMI)
- Spatial resolution of exposure assignment too coarse

Six Cities Study



NEJM 1993

American Cancer Society Cancer Prevention II Cohort (Pope et al AJRCC 1995)



SPECIAL REPORT

HEALTH EFFECTS INSTITUTE

July 2000

Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality

A Special Report of the Institute's Particle Epidemiology Reanalysis Project

HEALTH EFFECTS INSTITUTE

Part I: Replication and Validation

Daniel Krewski, Richard T Burnett, Mark S Goldberg, Kristin Hoover, Jack Siemiatycki, Michal Abrahamowicz, Warren H White, and Others

Part 1: Replication and Validation

Daniel Krewski, Richard T Burnett, Mark S Goldberg, Kristin Hoover,
Jack Siemiatycki, Michal Abrahamowicz, Warren H White, and Others

- The Reanalysis Team was able to replicate the original results in both studies using the same data and statistical methods as used by the Original Investigators. The Reanalysis Team confirmed the original point estimates: For the Six Cities Study, they reported the relative risk of mortality from all causes associated with an increase in fine particles of 18.6 $\mu g/m^3$ as 1.28, close to the 1.26 reported by the Original Investigators. For the ACS Study, the relative risk of mortality from all causes associated with an increase in fine particles of 24.5 $\mu g/m^3$ was 1.18 in the reanalysis, close to the 1.17 reported by the Original Investigators.

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Part II: Sensitivity Analyses

Daniel Krewski, Richard T Burnett, Mark S Goldberg, Kristin Hoover, Jack Siemiatycki, Michael Jerrett, Michal Abrahamowicz, Warren H W and Others

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Part II: Sensitivity Analyses

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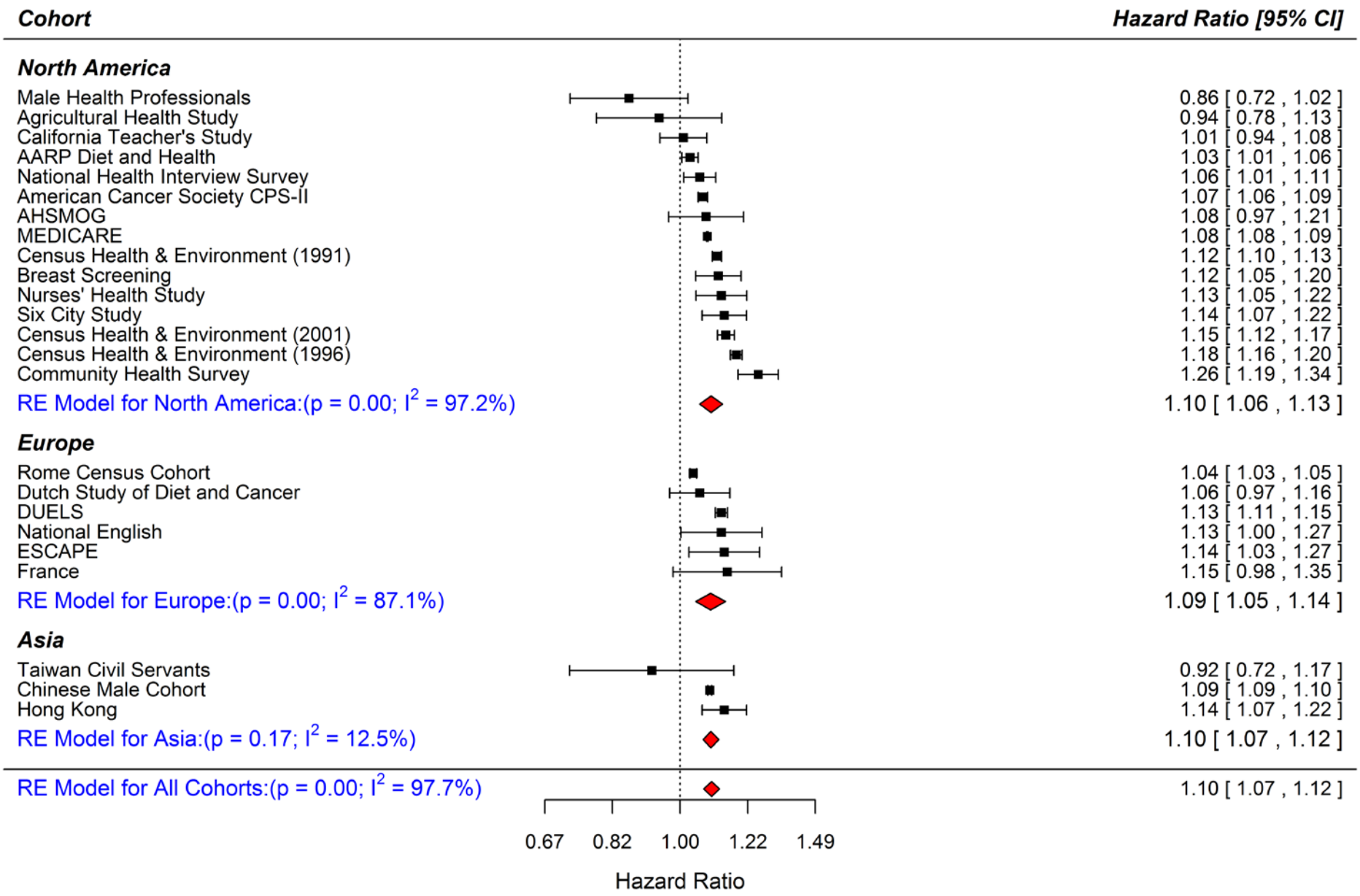
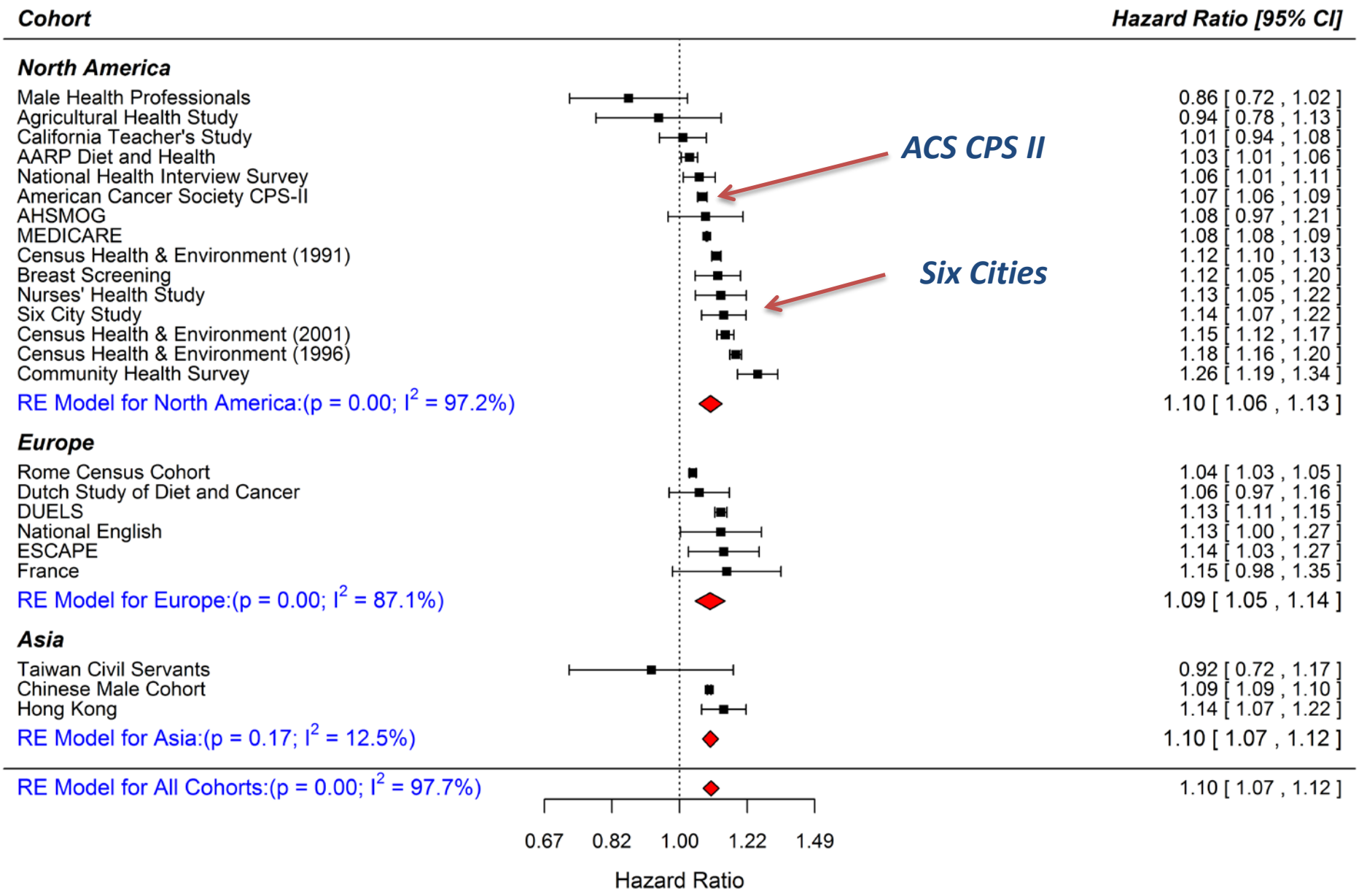
- No single epidemiologic study can be the basis for determining a causal relation between air pollution and mortality.

Global Cohorts of Ambient Fine Particulate Matter and Non-Accidental Mortality



Global Cohorts of Ambient Fine Particulate Matter and Non-Accidental Mortality



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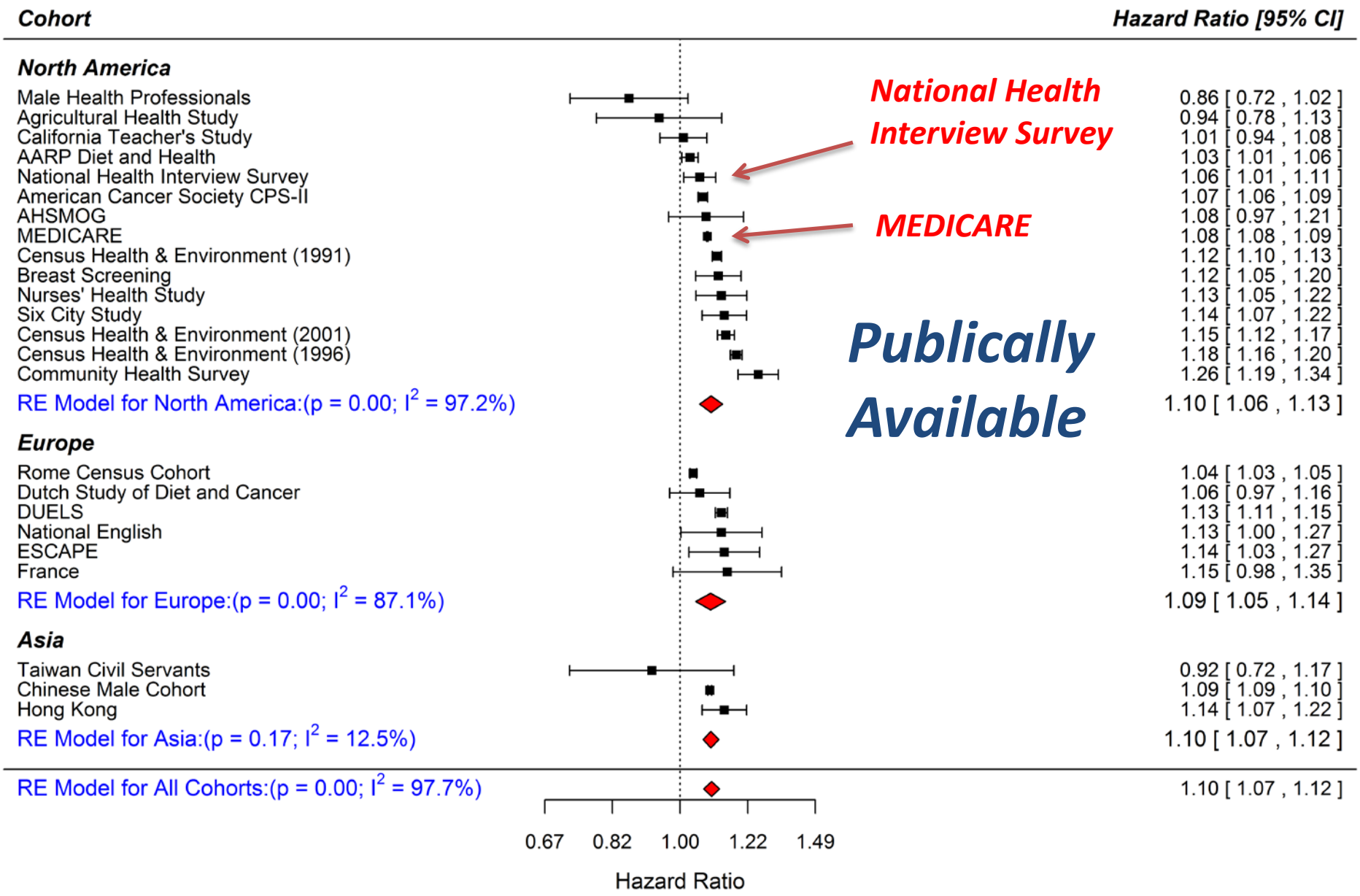
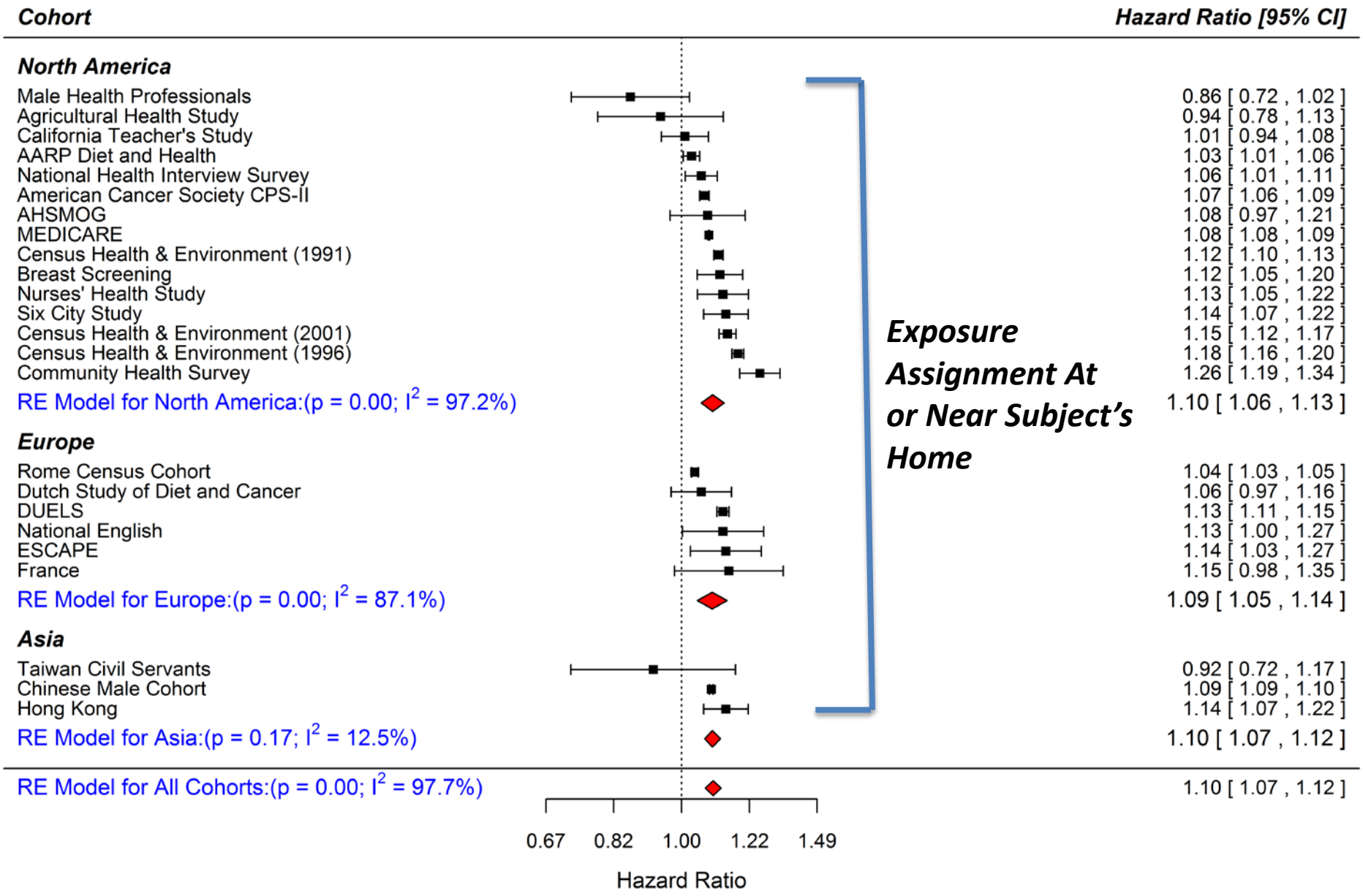
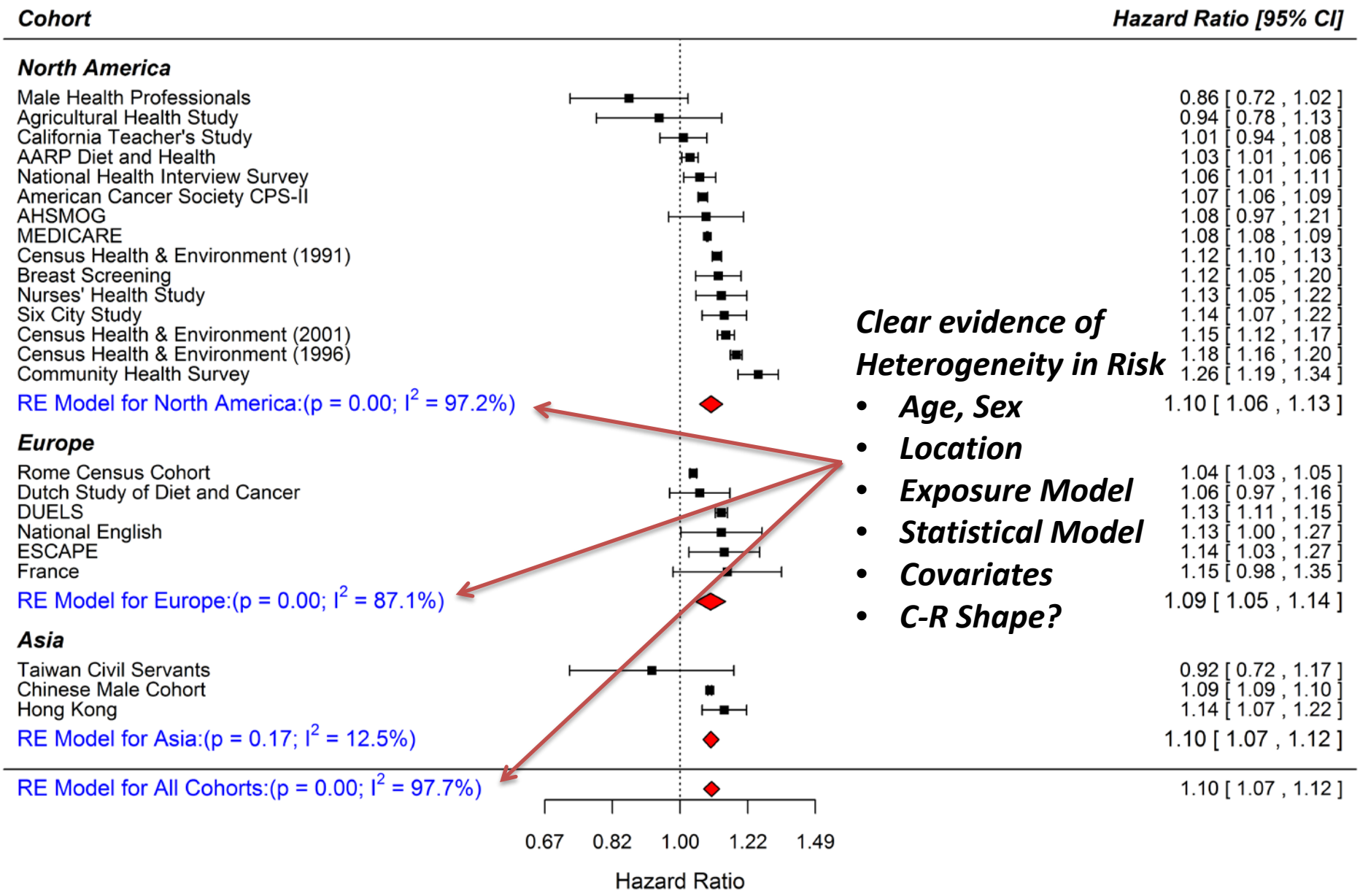


Global Cohorts of Ambient Fine Particulate Matter and Non-Accidental Mortality



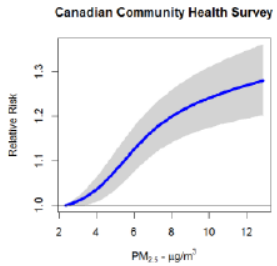
Global Cohorts of Ambient Fine Particulate Matter and Non-Accidental Mortality

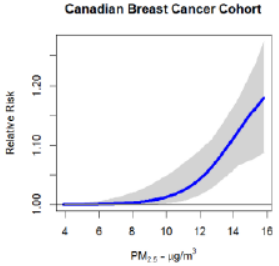


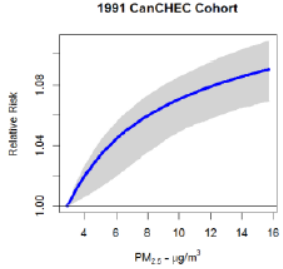
C-R = concentration - response

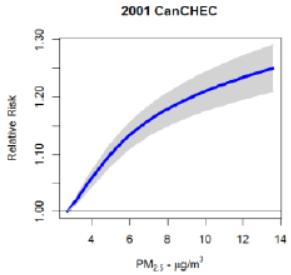
Global Mortality and Long-Term Ambient Exposure to Fine Particulate Matter: a New Relative Risk Estimator

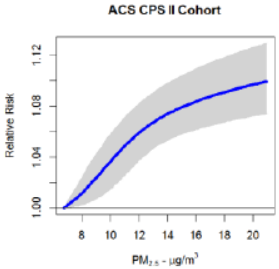
Richard Burnett[1], Hong Chen[2], Mieczyslaw Szyszkowicz[1] , Neal Fann[3], Bryan Hubbell[4], C. Arden Pope III[5], Joshua S. Apte[6], Michael Brauer[7], Aaron Cohen[8], Scott Weichenthal[9], Jay Coggins[10], Qian Di[11], Bert Brunekreef[12], Joey Frostad[13], Stephen S. Lim[13], Haidong Kan[14], Katherine D. Walker[8], George D. Thurston[15], Richard B. Hayes[16], Chris C. Lim[17], Michelle C. Turner[18], Michael Jerrett[19], Daniel Krewski[20], Susan Gapstur[21], W. Diver[21], Bart Ostro[22] , Debbie Goldberg[23], Daniel L. Crouse[24], Randall Martin[25], Paul Peters[26], Lauren Pinault[27], Michael Tjepkema[27], Aaron van Donkelaar[25], Paul J. Villeneuve[28], Anthony B. Miller[29], Peng Yin[30], Maigeng Zhou[30], Lijun Wang[30], Nicole A.H. Janssen[31], Marten Marra[31], Richard W. Atkinson[32], Hilda Tsang[33], Thuan Quoc Thach[33], John Cannon[5], Ryan Allen[5], Jaime Hart[34], Francine Laden[34], Giulia Cesaroni[35], Francesco Forastiere[35], Gudrun Weinmayr[36], Andrea Jaensch[36], Gabriele Nagel[36], Hans Concin[37] , Joseph V. Spadaro[38]

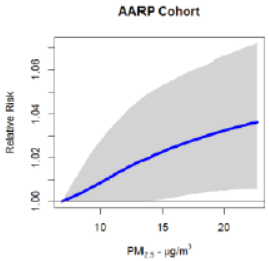

Canadian Community Health Survey
Relative Risk
1.0
1.1
1.2
1.3
2
4
6
8
10
12
PM2.5 - µg/m3

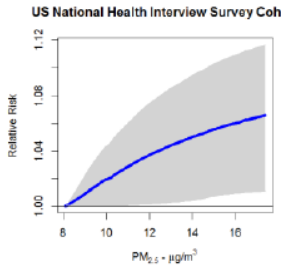

Canadian Breast Cancer Cohort
Relative Risk
1.00
1.10
1.20
4
6
8
10
12
14
16
PM2.5 - µg/m3

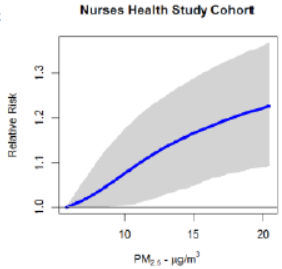

1991 CanCHEC Cohort
Relative Risk
1.00
1.04
1.08
4
6
8
10
12
14
16
PM2.5 - µg/m3

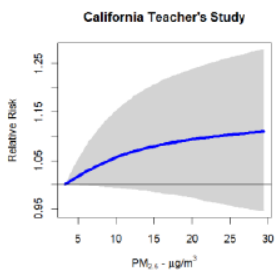

2001 CanCHEC
Relative Risk
1.00
1.10
1.20
1.30
4
6
8
10
12
14
PM2.5 - µg/m3

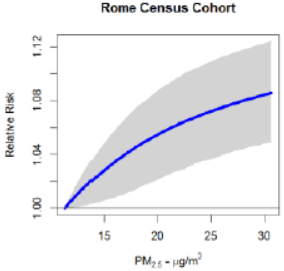

ACS CPS II Cohort
Relative Risk
1.00
1.04
1.08
1.12
8
10
12
14
16
18
20
PM2.5 - µg/m3

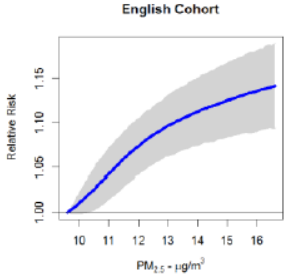

AARP Cohort
Relative Risk
1.00
1.02
1.04
1.06
10
15
20
PM2.5 - µg/m3

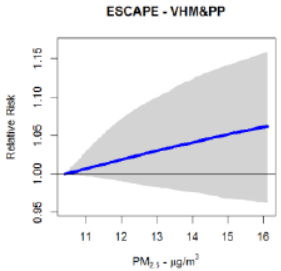

US National Health Interview Survey Cohort
Relative Risk
1.00
1.04
1.08
1.12
8
10
12
14
16
PM2.5 - µg/m3

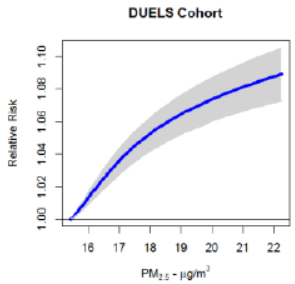

Nurses Health Study Cohort
Relative Risk
1.0
1.1
1.2
1.3
10
15
20
PM2.5 - µg/m3

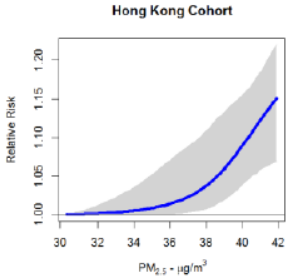

California Teacher's Study
Relative Risk
0.95
1.05
1.15
1.25
5
10
15
20
25
30
PM2.5 - µg/m3

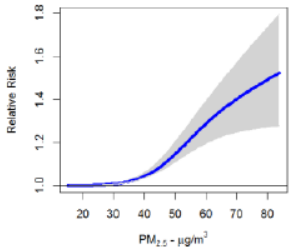

Rome Census Cohort
Relative Risk
1.00
1.04
1.08
1.12
15
20
25
30
PM2.5 - µg/m3

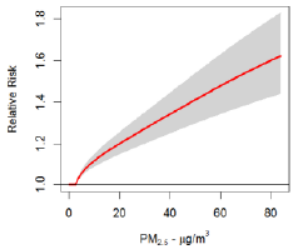

English Cohort
Relative Risk
1.00
1.05
1.10
1.15
10
11
12
13
14
15
16
PM2.5 - µg/m3


ESCAPE - VHM&PP
Relative Risk
0.95
1.00
1.05
1.10
1.15
11
12
13
14
15
16
PM2.5 - µg/m3


DUELS Cohort
Relative Risk
1.00
1.02
1.04
1.06
1.08
1.10
16
17
18
19
20
21
22
PM2.5 - µg/m3


Hong Kong Cohort
Relative Risk
1.00
1.05
1.10
1.15
1.20
30
32
34
36
38
40
42
PM2.5 - µg/m3


Chinese Male Cohort
Relative Risk
1.0
1.2
1.4
1.6
1.8
20
30
40
50
60
70
80
PM2.5 - µg/m3


Global Exposure Mortality Model
Relative Risk
1.0
1.2
1.4
1.6
1.8
0
20
40
60
80
PM2.5 - µg/m3

The Role of Publically Available Data

- ***Benefits***
  - ***Provides opportunities for innovative methods of design and analysis***
  - ***Help identify critical sources of uncertainty***
  - ***Value of innovations more convincing when applied to relevant data!***
- ***Limitations***
  - ***To have data made public one must "de-personalize" information***
    - ***"alter" age, date of death, cause of death, and location***
  - ***Need to understand influence of these "altered" data on effect estimates and uncertainty compared to un-altered information***
  - ***Access to personal data available under restrictive environments***
    - ***These restricted environments can impose limitations***
- ***Then these innovations will have to be applied to relevant global subject-level data to fully understand their influence***
  - ***Develop collaborative efforts among researchers with access to complete subject level information***

Ongoing Studies and Reports under Review and in Press 2016–2017

ACCOUNTABILITY

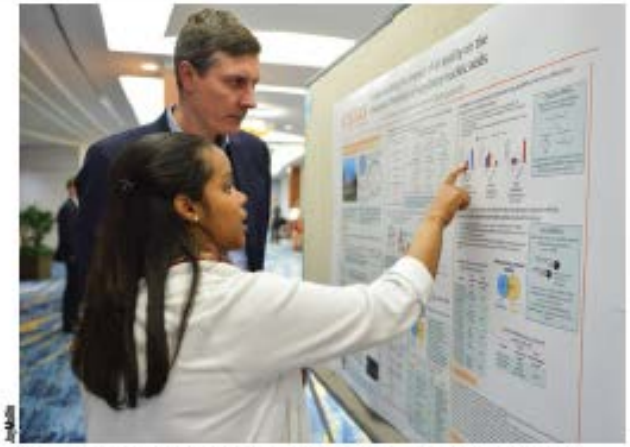
Improvements in air quality and health outcomes among California Medicaid enrollees due to goods movement actions — Phase 2. *Xing-Ying Meng, University of California–Los Angeles*

*Impact of emissions changes on air quality and acute health effects in the Southeast, 1993–2012. *Armistead Russell, Georgia Institute of Technology*

OZONE

Effects of ozone in human volunteers exposed to low levels of ozone in a laboratory, Part 2. *John Balmes, University of California–San Francisco; Philip Bromberg, University of North Carolina–Chapel Hill; Mark Frampton, University of Rochester*

Scavenger receptor B1 regulates oxidized lipid driven pulmonary and vascular inflammation after ozone exposure. *Kymberly Gowdy, East Carolina University*



Lydia Contreras, University of Texas-Austin; and Ivan Rusyn, Texas A&M University and HEI Research Committee.

AIR POLLUTION CONSTITUENTS AND MIXTURES

Epidemiology

*Particulate air pollutants, risk of cognitive disorders, and neuropathology in the elderly. *Jiu-Chiuan Chen, University of Southern California*

Air Pollution, Autism spectrum disorders, and brain imaging amongst CHildren in Europe — the APACHE project. *Mónica Guxens, ISGlobal, Barcelona Institute for Global Health*

Epidemiology at Low Exposures

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. *Michael Brauer, University of British Columbia*

Mortality and morbidity effects of long-term exposure to low-level $PM_{2.5}$, black carbon, NO_2, and O_3: an analysis of European cohorts. *Bert Brunekreef, Utrecht University*

Assessing adverse health effects of long-term exposure to low levels of ambient pollution. *Francesca Dominici, Harvard University*

Emissions and Exposure Assessment

*The Hong Kong D3D study: a dynamic three-dimensional exposure model for Hong Kong. *Benjamin Barratt, King's College London*

Enhancing models and measurements of traffic-related air pollutants for health studies using Bayesian melding. *Stuart Batterman, University of Michigan*

*Report in the HEI review process as of June 30, 2017

Ongoing Studies and Reports under Review and in Press 2016–2017

Epidemiology at Low Exposures

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Thank You