



Question for Consideration:  
*Should the Search Continue?*

HEI Annual Conference (webinar)  
Session on Particle Components and Associated  
Health Effects

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Bruce Copley, PhD, MPH  
Independent Consultant  
Philadelphia, USA

“We know they’re out there and continue to search for evidence, but . . . ”



**RESEARCH REPORT**

**National Particle Component Toxicity (NPACT) Initiative: Integrated Epidemiologic and Toxicologic Studies of the Health Effects of Particulate Matter Components**

Morton Lippmann, Lung-Chi Chen, Terry Gordon, Kazuhiko Ito, and George D. Thurston

Number 177  
October 2013

**Chronic Inhalation Exposure of Mice to Ambient PM<sub>2.5</sub> from Five Airsheds and Its Effects on Lung Function and In Vivo Toxicity of Exposure to Coarse, Suspended Particulate Matter from Five Airsheds**  
Lippmann, Arthur Nádas, and Christina Hickey

**Time-Series Analysis of Mortality, Hospitalizations, and Its Components**  
Chen, Jiang Zhou, Arthur Nádas, Morton Lippmann, and George D. Thurston

**Mortality and Long-Term Exposure to PM<sub>2.5</sub> and Ultrafine Particles in the American Cancer Society's Cancer Prevention Study II Cohort**  
Thurston, Kazuhiko Ito, Ramona Lall, Richard T. Burnett, Daniel Krewski, Yuanli Shi, Michael Brauer, W. Ryan Diver, and C. Arden Pope

EPA600/R-19/188 | December 2019 | www.epa.gov/isa

## Integrated Science Assessment for Particulate Matter

All EHP content is accessible to individuals with disabilities. A fully accessible (Section 508-compliant) HTML version of this article is available at <http://dx.doi.org/10.1289/ehp.1307568>.

### Associations of Fine Particulate Matter Species with Mortality in the United States: A Multicity Time-Series Analysis

*Lingzhen Dai, Antonella Zanobetti, Petros Koutrakis, and Joel D. Schwartz*

Department of Environmental Health, Harvard School of Public Health, Boston, Massachusetts, USA

**BACKGROUND:** Epidemiological studies have examined the association between PM<sub>2.5</sub> and mortality, but uncertainty remains about the seasonal variations in PM<sub>2.5</sub>-related effects and the relative importance of species.

**OBJECTIVES:** We estimated the effects of PM<sub>2.5</sub> species on mortality and how infiltration rates may modify the association.

**METHODS:** Using city-season specific Poisson regression, we estimated PM<sub>2.5</sub> effects on approximately 4.5 million deaths for all causes, cardiovascular disease (CVD), myocardial infarction (MI), stroke, and respiratory diseases in 75 U.S. cities for 2000–2006. We added interaction terms between PM<sub>2.5</sub> and monthly average species-to-PM<sub>2.5</sub> proportions of individual species to determine the relative toxicity of each species. We combined results across cities using multivariate meta-regression, and controlled for infiltration.

**RESULTS:** We estimated a 1.18% (95% CI: 0.93, 1.44%) increase in all-cause mortality, a 1.03% (95% CI: 0.65, 1.41%) increase in CVD, a 1.22% (95% CI: 0.62, 1.82%) increase in MI, a 1.76% (95% CI: 1.01, 2.52%) increase in stroke, and a 1.71% (95% CI: 1.06, 2.35%) increase in respiratory deaths in association with a 10-µg/m<sup>3</sup> increase in 2-day averaged PM<sub>2.5</sub> concentration. The associations were largest in the spring. Silicon, calcium, and sulfur were associated with more all-cause mortality, whereas sulfur was related to more respiratory deaths. County-level smoking and alcohol were associated with larger estimated PM<sub>2.5</sub> effects.

**CONCLUSIONS:** Our study showed an increased risk of mortality associated with PM<sub>2.5</sub>, which varied with seasons and species. The results suggest that mass alone might not be sufficient to evaluate the health effects of particles.

**CITATION:** Dai L, Zanobetti A, Koutrakis P, Schwartz JD. 2014. Associations of fine particulate matter species with mortality in the United States: a multicity time-series analysis. *Environ Health Perspect* 122:837–842; <http://dx.doi.org/10.1289/ehp.1307568>

Research

> 1 day. Thus, when one uses separate time series for components that are measured only 1 day in 6 or 1 day in 3, this will bias downward estimates, possibly more for some components than others. In addition, the loss of two-thirds to five-sixths of the data substantially reduces power.

U.S. adults—particularly the elderly, who dominate mortality statistics—spend approximately 90% of their time indoors (U.S. EPA 1989). Although particles penetrate indoors, the infiltration rates vary with the extent to which windows and doors are open, which in turn can vary with local temperature and may therefore modify the association. Previous studies have reported such modification (Franklin et al. 2008; Stafoggia et al. 2008; Zanobetti et al. 2009). In this paper we address these issues and also examine more species, add an additional year of observation, and look at specific causes of death.

**Materials and Methods**

**Study sites.** We included 75 U.S. cities in our study (see Supplemental Material, Table S1).

# HEI Perspectives 3

January 2013

*Insights from HEI's research*

## Understanding the Health Effects of Ambient Ultrafine Particles

HEI Review Panel on Ultrafine Particles

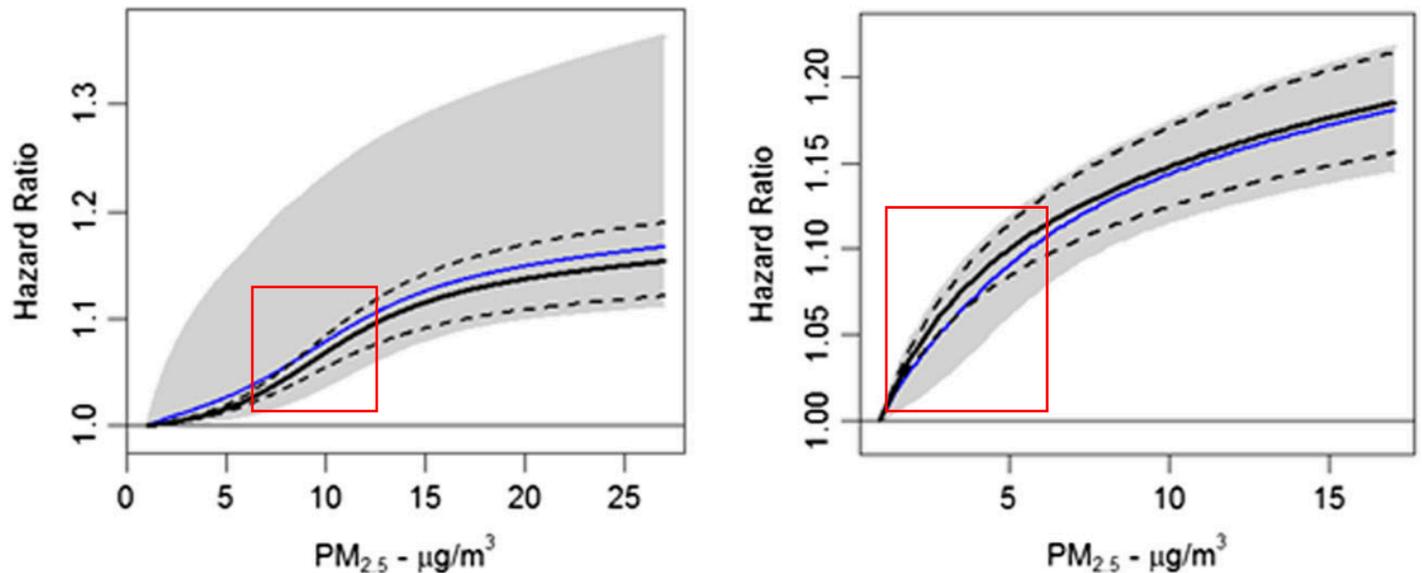
Signals?

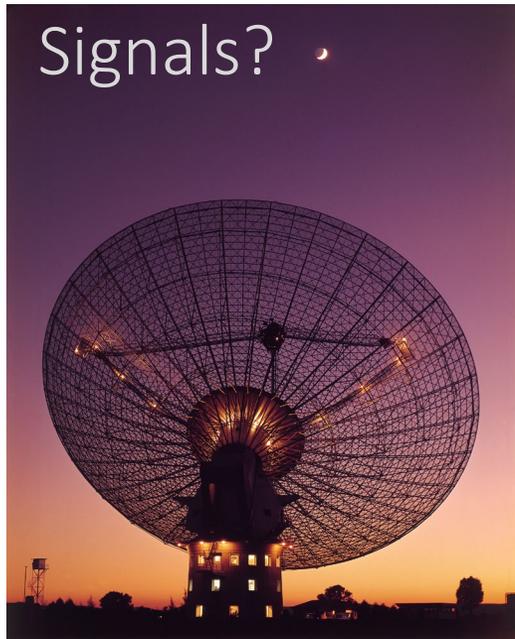


*Might the recent observations of supralinearity at low ambient concentrations be indicative of relatively more toxic species/types of PM that have been resistant to, or not targeted in, past and current pollution reduction policies and regulations?*

- Perhaps these longstanding policies targeting industrial and vehicle exhaust emissions have been successful in lowering PM<sub>2.5</sub> ambient concentrations overall but not non-tailpipe emissions (e.g., tire wear, brake wear, domestic woodsmoke, new roadway surface components) or other novel components that persist after those 'traditional' PM sources are lowered.

**Fig. 2** Hazard functions for CPS II (left hand panel) and CanCHEC (right hand panel). Optimal hazard function (black solid line) with uncertainty bounds (dashed black lines). Ensemble hazard function (blue solid line) with uncertainty bounds (gray-shaded area)





*Are the persistent findings of regional heterogeneity in cross-sectional epidemiological studies also indicative of varying levels of toxicity among PM components?*



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**Original Contribution**

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**Long-Term PM<sub>2.5</sub> Exposure and Respiratory, Cancer, and Cardiovascular Mortality in Older US Adults**

**Vivian C. Pun, Fatemeh Kazemiparkouhi, Justin Manjourides, and Helen H. Suh\***

\* Correspondence to Dr. Helen H. Suh, Department of Civil and Environmental Engineering, School of Engineering, Tufts University, Medford, MA 02153 (e-mail: helen.suh@tufts.edu).

**Table 2.** Mortality Risk Associated With a 10- $\mu\text{g}/\text{m}^3$  Increase in 12-Month Moving Average PM<sub>2.5</sub> Concentration, Nationwide and by Region, United States, 2000–2008

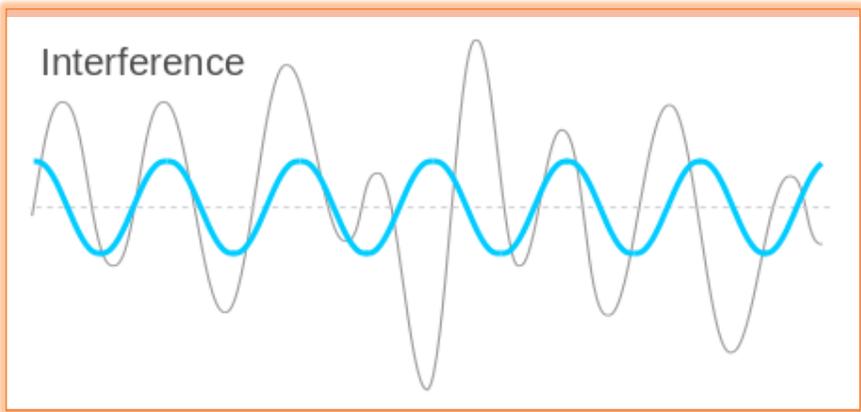
Cause of Death and Region	Nonadjusted Model		BRFSS-Adjusted Model <sup>a</sup>	
	RR	95% CI	RR	95% CI
All causes				
United States	1.223	1.215, 1.232	1.206	1.197, 1.214
West	1.163	1.152, 1.174	1.167	1.156, 1.178
Midwest	1.210	1.193, 1.228	1.172	1.155, 1.190
South	1.215	1.193, 1.239	1.151	1.129, 1.174
Northeast	1.471	1.447, 1.496	1.397	1.372, 1.422

*Are current data sources and statistical methods still too limited to process these signals within a multi-pollutant world?*



Analyses of time-activity patterns indicate that most people spend 85%-90% of their time indoors (even pre-COVID). In some areas/homes, concentrations of indoor-generated particles are higher than outdoor concentrations.

- *Might the signals from indoor PM be interfering with those from outdoor PM, thus partially obliterating potentially observable differences in particle species toxicity in epidemiology studies?*



# Path Forward

- Abandon the particle mass-based search?
- Search on other characteristics, e.g., particle number, morphology, sizes, sources?
- Focus search on 'new' sources mentioned previously?
- Account for and isolate signals from indoor PM in future searches?
- Are the appropriate data sources (now inadequate) and analytical tools required for non-mass PM epidemiologic research available or being developed?