Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults

C. ARDEN POPE, III, MICHAEL J. THUN, MOHAN M. NAMBOODIRI, DOUGLAS W. DOCKERY, JOHN S. EVANS, FRANK E. SPEIZER, and CLARK W. HEATH, JR.

Environmental Epidemiology Program and Interdisciplinary Program in Health, Department of Environmental Health, Harvard School of Public Health, Boston, Massachusetts; Department of Epidemiology and Statistics, American Cancer Society, Atlanta, Georgia; and The Channing Laboratory, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts

Time-series, cross-sectional, and prospective cohort studies have observed associations between mortality and particulate air pollution but have been limited by ecologic design or small number of subjects or study areas. The present study evaluates effects of particulate air pollution on mortality using data from a large cohort drawn from many study areas. We linked ambient air pollution data from 151 U.S. metropolitan areas in 1980 with individual risk factor on 552,138 adults who resided in these areas when enrolled in a prospective study in 1982. Deaths were ascertained through December, 1989. Exposure to sulfate and fine particulate air pollution, which is primarily from fossil fuel combustion, was estimated from national data bases. The relationships of air pollution to all-cause, lung cancer, and cardiopulmonary mortality was examined using multivariate analysis which controlled for smoking, education, and other risk factors. Although small compared with cigarette smoking, an association between mortality and particulate air pollution was observed. Adjusted relative risk ratios (and 95% confidence intervals) of all-cause mortality for the most polluted areas compared with the least polluted equaled 1.15 (1.09 to 1.22) and 1.17 (1.09 to 1.26) when using sulfate and fine particulate measures respectively. Particulate air pollution was associated with cardiopulmonary and lung cancer mortality but not with mortality due to other causes. Increased mortality is associated with sulfate and fine particulate air pollution at levels commonly found in U.S. cities. The increase in risk is not attributable to tobacco smoking, although other unmeasured correlates of pollution cannot be excluded with certainty. **Pope CA III, Thun MJ, Namboodiri MM, Dockery DW, Evans JS, Speizer FE, Heath Jr CW. Particulate air pollution as a predictor of mortality in a prospective study of U.S. adults. Am J Respir Crit Care Med 1995;151:669–74.**

Many studies have observed associations between particulate air pollution and human health (1). Increases in sickness and death associated with severe air pollution episodes have been well documented. Recent daily time-series studies have observed associations between daily mortality and changes in particulate air pollution (2–6) at levels below U.S. air quality standards. Elevated particulate air pollution has been associated with declines in lung function (6–9), increases in respiratory symptoms (6, 8–11), increases in respiratory hospitalizations (6, 12–13), and restricted activity (14, 15).

Ecologic cross-sectional studies have reported associations between mortality rates and sulfate or fine particulate pollution levels across metropolitan areas (16–19). Mortality risks of air pollution have also been estimated using data from a 14 to 16 year prospective follow-up of over 8,000 adults living in six U.S. cities (20) which controlled for individual differences in age, sex, cigarette smoking, and other factors. In both the ecologic studies and the recent prospective cohort study, mortality was more strongly associated with sulfate or fine particulate air pollution than with other measures of air pollution.

Particulate air pollution is a mixture of particles that vary in size, composition, and origin. Fine particles (those with aerodynamic diameters equal to or less than 2.5 μm) are the largest health concern because they can be breathed most deeply into the lung. This size range includes most sulfate particles (which generally make up the largest fraction of fine particles by mass). Unlike larger particles which are derived primarily from soil and other crustal materials, fine particles (including sulfates) are derived chiefly from combustion of fossil fuels in processes such as transportation, manufacturing, and power generation. Sulfate particles are commonly generated by conversion from primary sulfur emissions and a varying portion of sulfate particles may be acidic.

Previous studies of particulate pollution and mortality have been limited by ecologic design or small number of subjects or study areas. In the present study, a large cohort of adults living in 151 U.S. metropolitan areas was followed prospectively between 1982 and 1989. Ambient concentrations of sulfates and fine particles were used as indices of exposure to combustion source ambient particulate air pollution. Exposure to ambient air pollution was estimated from national data bases. Associations between

(Received in original form June 3, 1994 and in revised form October 5, 1994)

Supported in part by National Institute of Environmental Health Sciences Grants ES-00002 and ES-01108 and by Environmental Protection Agency Cooperative Agreements CR-811650 and CR-818090.

Correspondence and requests for reprints should be addressed to C. Arden Pope, III, Department of Economics, Brigham Young University, 130 FOB, Provo, UT 84602.

Spatiotemporal Analysis of Air Pollution and Mortality in California Based on the American Cancer Society Cohort

Principal Investigator:
Michael Jerrett, PhD

Co-Investigators:
Richard T. Burnett, PhD
Daniel Krewski, PhD
Arden Pope III, PhD
George Thurston, DSc
George Christakos, PhD, DSc
Edward Hughes, PhD
Eugenna Calle, PhD
Michael Thun, MD

Official Authorized to Bind this Proposal:

Jyl Baldwin
Assistant Director, Sponsored Projects Office
University of California, Berkeley

Prepared for:

Bart Croes
Chief, Research Division
State of California Air Resources Board
PO Box 2815
Sacramento CA 95812

Prepared by:

Center for Occupational and Environmental Health
Division of Environmental Health Sciences
School of Public Health
University of California, Berkeley

Project Duration: 36 Months