HEALTH EFFECTS INSTITUTE

Time-Series Analysis of Air Pollution and Mortality: A Statistical Review

BACKGROUND

In 1998, HEI issued the first Request for Applications (98-5) for the Walter A Rosenblith New Investigator Award, which had been established to provide funding for independent research by outstanding investigators at the beginning of their careers. Throughout his life, Professor Rosenblith had committed himself to developing young scientists. As the first Chair of the HEI Research Committee, he was instrumental in establishing HEI's scientific program and sought to attract basic scientists to air pollution research so the field may benefit from their new ideas and fresh approaches.

Dr Francesca Dominici was the first recipient of the Rosenblith Award in 2000. This Report reviews her collaboration with colleagues to develop innovative analytic methods for epidemiologic time-series studies.

Since the 1980s, many epidemiologic time-series studies have found associations between short-term increases of fairly low concentrations of ambient particulate matter (PM) and short-term increases in mortality and morbidity (eg, emergency room visits, hospitalizations). These studies were generally conducted in single locations chosen for a variety of reasons and were analyzed with a variety of different statistical approaches. Many people noted two fundamental questions about these studies: Could pollutants other than PM be responsible for these effects? and Would a study of many locations chosen on the basis of specific criteria and analyzed with uniform methods find similar associations? The National Morbidity, Mortality, and Air Pollution Study (NMMAPS), initiated in 1996 by HEI, was designed to address these and other questions raised about earlier studies.

Investigators at Johns Hopkins University and Harvard University selected 90 US cities on the basis of population size and the availability of two types of data: PM_{10} mass concentrations and daily records of cause-specific deaths. The investigators developed new methods to evaluate the association between PM_{10} concentrations and mortality in the extensive data base and in subsets, depending on the type and quantity of data available for certain cities. They also evaluated other issues raised by earlier studies: (1) whether pollution data gathered by central monitors are an adequate surrogate for personal exposure (an assumption generally applied in such studies) and the degree to which measurement error affects the results obtained under such assumptions; (2) whether mortality was advanced by just a few days for frail, near-death individuals (mortality displacement) or by a longer time for other susceptible individuals; and (3) whether, in the PM concentration–mortality relation, a threshold could be found beneath which adverse events were not observed.

APPROACH

As one of the NMMAPS investigators, Dominici proposed to use funds from the New Investigator Award to develop and validate more flexible methods and statistical models to apply to the NMMAPS database to:

1. obtain national estimates of air pollution that would be resistant to mortality displacement and to biases from modeling long-term trends inappropriately;

2. determine the time course of health events after high concentrations of air pollutants (lagged effects) by assessing the short-, medium-, and long-term adverse health effects and testing the variability of these effects across locations and on different time scales;

3. establish how the components of measurement error in exposure variables might influence risk assessment; and

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4. evaluate the effects of air pollution on morbidity and mortality concurrently and on hospitalization rates for elderly residents of the 10 largest cities.

An important aspect of Dominici's work was her extensive investigation into the effects of model choices and assumptions on the results of data analysis. This led to discovering that part of a statistical software program that had been used extensively by many researchers in the field at that time was not, in its generally marketed format, entirely appropriate to analyze data in air pollution time-series studies. This discovery prompted Dominici to develop programming that would overcome the software's limitations.

COMMENT

The research conducted under this Award not only has advanced methods used to analyze complex time-series data, but also has highlighted the importance of undertaking in-depth sensitivity analyses, even when validated methods have been applied to the data. Fulfilling the goal of the Rosenblith Award, Dominici has developed from a promising researcher into a leader in the field of statistical methods for research on the health effects of air pollution.

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Francesca Dominici

PREFACE

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