HEI

STATEMENT

Synopsis of Research Report 94 Part IV

HEALTH EFFECTS INSTITUTE

The National Morbidity, Mortality, and Air Pollution Study, Part IV: Combined Analysis of PM_{10} Effects on Hospitalization and Mortality

Over more than a decade, time-series epidemiologic studies have been conducted in many cities to evaluate the association between daily changes in concentrations of particulate matter in the air and daily counts of morbidity and mortality. The HEI-funded National Morbidity, Mortality, and Air Pollution Study (NMMAPS) was designed to address concerns about bias in the selection of cities in air pollution studies, to allow effects of PM to be estimated more precisely, and to explore heterogeneity of effects. NMMAPS investigators at Johns Hopkins University and Harvard University selected multiple cities only according to population size and availability of monitoring data for particulate matter less than 10 µm in aerodynamic diameter (PM_{10}).

Findings from NMMAPS support an association between short-term increases in the concentration of PM_{10} and mortality in the 90 largest cities in the United States. The NMMAPS investigators reported similar findings for hospitalizations for cardiovascular and respiratory diseases and mortality among residents 65 years of age and older in a smaller group of cities with daily PM_{10} monitoring. One of HEI's original objectives in funding NMMAPS was to contribute to an evaluation of coherence of epidemiologic findings by investigating whether associations of PM_{10} with deaths and with hospitalizations were related within each city. The parallel time series of mortality and hospitalizations allowed the NMMAPS investigators to pursue this objective while examining the effect of PM concentrations on two different, but presumably related, health outcomes.

Coherence is one of many criteria that have been applied in epidemiologic and other types of studies to assess whether the relation between an exposure and health outcomes is likely to be causal. As originally proposed, coherence implied that a causal basis for an association did not conflict with what is known about the natural history or biology of disease. In air pollution epidemiology, coherence has come to mean that causality implies similar responses to air pollution for a number of related health outcomes. Using this sense of coherence in support of causation would require that associations between short-term increases in air pollution concentrations and mortality be similar to those for hospitalizations, for example, as an indicator of morbidity. This is the sense of coherence that motivated HEI to support the work conducted in NMMAPS IV.

APPROACH

Several questions could be addressed by the combined analysis of air pollution effects on mortality and on hospital admissions. This study pursues one: Is the underlying true effect per unit PM_{10} on mortality (the mortality slope) of the same magnitude as the effect per unit PM_{10} on hospitalizations (the hospitalization slope) in a given city? (In other words, are the true mortality slopes and the true hospitalization slopes associated? The true slope is the slope that would be found in the absence of sampling error, for example, if each city's time series were extremely long.)

The investigators conducted this study by using data from 10 cities with daily PM_{10} monitoring and daily mortality and hospitalization data. They restricted analyses to deaths and hospitalizations due to cardiovascular diseases in residents 65 years of age and older. They used a standardized analytic approach, even though the previous NMMAPS used somewhat different approaches for the analyses of mortality and hospitalization in these cities. Any lack of correlation could not, then, be attributed to differences in analytic approach.

For each city, the investigators used methods they had developed earlier to evaluate the association between PM_{10} concentration with mortality and with hospitalizations, separately. They then

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This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Dr Francesca Dominici at Johns Hopkins Bloomberg School of Public Health, Baltimore MD. The complete report, *The National Morbidity, Mortality, and Air Pollution Study, Part IV: Hierarchical Bivariate Time-Series Models—A Combined Analysis of PM_{10} Effects on Hospitalization and Mortality*, can be obtained from HEI or our website (see reverse side).

developed and applied a new method to estimate the correlation between the associations of PM_{10} concentration with mortality and with hospitalization in each city, taking into account the cross-correlation between the mortality and hospitalization time series. In a second stage of analysis, the investigators applied previously developed Bayesian hierarchical methods to estimate the correlation between the associations of PM_{10} concentration with mortality and with hospitalization across all cities while accounting for variability due to sampling error.

RESULTS

There was little or no correlation between the time series of daily deaths and of daily hospitalizations within each city. The correlations between estimated effects (associations) of PM_{10} on daily deaths and hospitalizations within each city were estimated to range from −0.05 to 0.34. The estimated between-city correlation between effect estimates for mortality and hospitalization was low (0.20) but was estimated with a large degree of uncertainty (95% posterior interval−0.89, 0.98).

For each city, Bayesian estimates that assumed no correlation between the mortality and hospitalization PM_{10} effect estimates were similar to Bayesian estimates from a joint analysis in which these correlations were taken into account. The similarity of the results reflects weak correlation. The investigators attempted to use mortality data from a city for which no hospitalization data were available, in this case New York, in order to estimate a PM_{10} effect on hospitalizations in this city. They found that including these additional data did not much improve the precision of the estimated PM_{10} effect on New York hospitalizations compared with using only mortality and hospitalization data from other cities to calculate this estimate.

CONCLUSIONS

The Special Panel of the Health Review Committee that was convened to review results from NMMAPS research reached the following conclusions:

1. The main contribution of NMMAPS Part IV is methodologic.
2. The Investigators' Report describes, for the first time, a method for estimating correlation between effects of a covariate (PM_{10}) on two parallel time series of counts of population health outcomes over multiple cities. The ability to conduct a joint inference on two separate but related outcomes aids quantification of the extent of coherence of the data.
3. The mortality and hospitalization estimates of effect were only weakly correlated, providing no support for coherence when assessed in this way. Because of the imprecise estimate of the correlation, however, the question of coherence in the context of observational studies could not be adequately assessed. The broader question of coherence within the complete body of work on PM_{10} (including toxicologic and other experimental findings) is not addressed by these methods.
4. Although the methods could be used to predict hospitalization effect estimates from mortality effect estimates, their utility remains to be demonstrated, given the low correlation between the mortality and hospitalization effect estimates in this study.
5. The finding of low correlations between daily counts of deaths and daily counts of hospitalizations is noteworthy. It suggests that most mechanisms causing fluctuations in these counts over time—whether due to PM_{10} or other factors—differ for the two outcomes.

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