STATEMENT

Synopsis of Research Report 94, Part III

HEALTH EFFECTS INSTITUTE

The National Morbidity, Mortality, and Air Pollution Study: Concentration–Response Curves and Thresholds for the 20 Largest US Cities

Over more than a decade, time-series epidemiologic studies conducted in many cities evaluated the association between daily changes in concentrations of particulate matter in the air and daily 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. For this study, investigators at Johns Hopkins University and Harvard University selected multiple locations based on population size, particulate matter less than 10 µm in aerodynamic diameter (PM_{10}) monitoring at least every sixth day, and availability of daily cause-specific mortality data. For these extensive data, the investigators developed new methods to evaluate the association between PM_{10} concentrations and mortality. The associations between PM_{10} concentrations and morbidity/mortality were also evaluated in a subset of cities where PM_{10} was measured daily.

Results from most time-series studies have suggested a linear relation between concentration and daily mortality over the entire range of ambient PM_{10} concentrations observed in the continental US. That is, there appeared to be no concentration (or threshold) beneath which adverse events were not observed. Because of the possible public health implications of very low concentrations of particulate matter being associated with deleterious health outcomes, the NMMAPS investigators evaluated the concentration–mortality relation in the largest 20 US cities for this Part III report. The results in this Research Report were calculated using methods that address shortcomings in statistical software used for several years to fit generalized additive models in time-series data analyses.

APPROACH

The investigators evaluated the shape of the relation between PM_{10} concentrations measured at fixed monitoring sites and daily mortality among residents from all causes (excluding accidental causes), from all cardiovascular and respiratory causes combined, and from causes other than cardiovascular-respiratory disease. They developed new statistical methods to address the shape of this relation as well as to characterize the uncertainty of estimated threshold values for each city and for all 20 cities combined. Before estimating a summary measure, the investigators evaluated whether the concentration–response shapes differed across the cities using a statistical test for heterogeneity. They also tried to identify a possible threshold in PM_{10} concentration below which an effect of PM_{10} on daily mortality rate could not be detected.

The investigators evaluated three concentration–response models: *log-linear models*, in which the relation between PM_{10} and the (log) risk of mortality is assumed to be a straight line; *spline models*, in which the method estimates a concentration-response curve when little can be assumed about its shape; and *threshold models*, in which the method assumes no effect until a specified threshold level is exceeded (after which the relation is assumed to be log linear). All models controlled statistically for long-term fluctuations in mortality over time and accounted for possible confounding effects caused by other factors (in particular, weather). The investigators also examined time delays (lags) in the estimated effect of air pollution on mortality.

RESULTS

Based on statistical comparison of spline models with the log-linear model and of threshold models with the log-linear model, including comparison by

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This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Dr Michael J Daniels and others (Dr Jonathan Samet, Principal Investigator) of Johns Hopkins Bloomberg School of Public Health, Baltimore MD. The complete report, *The National Morbidity, Mortality, and Air Pollution Study, Part III: Concentration–Response Curves and Thresholds for the 20 Largest US Cities* can be obtained from HEI or our website (see reversed side).

means of the Akaike information criterion (AIC), the investigators found that for total mortality and cardiovascular-respiratory mortality there was no evidence of a threshold down to daily ambient concentrations of PM_{10} as low as 10 µg/m^3. Thus, they concluded that their findings indicate that linear models without a threshold are appropriate for assessing the effect of air pollution on daily mortality. There was little evidence of an effect on mortality from other causes (other than cardiovascular-respiratory), however, until PM_{10} concentrations were above 50 µg/m^3. Therefore the investigators concluded that a threshold model could be reasonable to use for assessing the effect of PM_{10} on other cause mortality. They also reported that statistical tests identified little evidence of heterogeneity across cities.

COMMENT

The Special Panel of the Health Review Committee concluded that the investigators' work has advanced our understanding of the health effects of air pollution by developing complex statistical methods to describe the concentration–response relation. Due to the nature of the questions addressed in NMMAPS III, the results may have important implications for setting air quality standards. In general, log linear curves imply that there is no threshold and, therefore, that there is no concentration below which there is no effect. For this research, the Panel had some reservations regarding the investigators' conclusions that (1) the log-linear model is preferred for evaluating the health effects of PM_{10} and (2) the harmful effects of PM_{10} have no threshold at concentrations of practical importance for regulation. In addition, the Panel was not convinced that the AIC is the appropriate criterion on which to base the choice between models.

The Panel agreed with the investigators that the data provided little evidence against the log-linear model with regard to the relation between PM_{10} and cardiovascular-respiratory deaths. They concluded, however, that lack of evidence against should not be confused with evidence in favor of the log-linear model. If the relation between PM_{10} and other cause mortality was not log linear (as the investigators and Panel agree), then it is unlikely that the relation between PM_{10} and total mortality could be linear.

Panel members also had reservations about applying the AIC to determine which model better reflected the concentration–mortality relation. The AIC was designed to address whether a more complex model would better predict future observations than an alternative simpler model. The AIC was not designed to compare models to assess scientific theories of etiology, which is the objective of evaluating the shape of the concentration-response relation in this study.

The Panel advises caution in drawing conclusions from the apparent absence of a threshold. First, exposure measurement error could obscure any threshold that might exist. Second, the estimated city-specific concentration–response curves exhibited a variety of shapes. Although some of this variation could be the result of statistical variability or random error, some may reflect city-specific features of the pollutant mixture, differences in pollution monitoring networks, and differences in health status of the populations. Therefore, interpreting the shape of the composite curve, however well estimated, is difficult. Nonetheless, the reported associations are at ambient concentrations well below the current US daily standard for PM_{10}; thus the ambient concentration level at which any threshold might exist is likely to be correspondingly low.

The Panel recommended that studies in settings where the particulate matter concentrations are low would provide insight into whether associations with mortality extend to the low end of the concentration–response relation. Further insight into the extent to which differences among cities contribute to the effect estimates of concentration–response relations may be gained from an ongoing study sponsored in part by HEI, the *Air Pollution and Health: A Combined European and North American Approach* (APHENA), which includes cities with substantial variation in pollutant concentrations, composition and sources as well as several cities with daily monitoring of pollutants.

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