HEI

STATEMENT

Synopsis of Research Report 131

HEALTH EFFECTS INSTITUTE

# Characterization of Particulate and Gas Exposures of Sensitive Subpopulations Living in Baltimore and Boston

Epidemiologic studies conducted in a variety of locations have reported that short-term increases of particulate matter (PM) at low concentrations are associated with short-term increases in morbidity and mortality. The strongest associations have been found for individuals with compromised cardiac or respiratory function. However, personal exposure for some groups (particularly those considered to be susceptible to PM, such as children, older individuals, or those with cardiorespiratory conditions) is largely influenced by time spent indoors. This fact increases the uncertainty in using values from a fixed-site outdoor monitor as surrogate estimates of personal exposure. To adequately resolve this uncertainty, the nature of the association between outdoor particle concentrations and personal exposure levels must be more clearly assessed.

In 1998, HEI issued Request for Applications 98-1, "Characterization of Exposure to and Health Effects of Particulate Matter." At that time, most environmental epidemiologic studies had assessed exposure on the basis of ambient PM monitors at central sites. One objective of RFA 98-1 was to characterize personal exposure to PM in a variety of indoor and outdoor microenvironments and in geographic locations that differ in types and sources of particles, topography, and climate in order to determine the kind of exposure information necessary for epidemiologic studies. To address this objective, proposed studies would determine particle characteristics (eg, concentration, size, and composition) and describe the relation between personal exposure and the outdoor measurements of PM and other pollutants that typically have been used in epidemiologic time-series studies.

## APPROACH

HEI funded Dr Koutrakis and his colleagues to assess the correlations between personal exposure to PM less than or equal to 2.5 µm in aerodynamic diameter ($PM_{2.5}$) and gaseous copollutants and compare these measurements with those taken at central-site monitors. Three groups of possibly susceptible individuals (children, seniors, and individuals with chronic obstructive pulmonary disease) were recruited in two cities (Boston and Baltimore) in two seasons (summer and winter). Integrated 24-hour personal exposures were measured over 8 or 12 consecutive days by using pump-driven multipollutant personal exposure monitors equipped with filters for collecting PM and by using passive Ogawa samplers for collecting gaseous pollutants. Concentrations of ambient pollutants were obtained at central monitoring sites in Baltimore and Boston by using a variety of monitors. Participants in each city, season, and group completed questionnaires that provided information about housing characteristics and about activities they were engaged in at different locations throughout the day.

Ambient and personal pollutant levels were characterized by using summary statistics, graphic analyses, and analysis of variance. Measurements below the limit of detection, including negative values, were included in all analyses. Mixed-model regression analysis was used to evaluate the associations between the concentrations of (1) ambient $PM_{2.5}$ and ambient gaseous pollutants, (2) ambient pollutants and their corresponding personal exposure concentrations, (3) other ambient pollutants (gaseous and sulfate [$SO_4^{2-}$]), and (4) personal $PM_{2.5}$, and personal $PM_{2.5}$ (including $SO_4^{2-}$ as a surrogate for personal $PM_{2.5}$ of ambient origin) and personal gaseous exposures.

## RESULTS

The results indicate that the relation between ambient $PM_{2.5}$ levels and personal exposures to $PM_{2.5}$ varies by season, location, and home characteristics. Surprisingly, groups did not appear to differ in their

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This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Dr Petros Koutrakis at Harvard School of Public Health, Boston MA. The complete report, *Characterization of Particulate and Gas Exposures of Sensitive Subpopulations Living in Baltimore and Boston*, can be obtained from HEI or our website (see reverse side).

exposures to the fraction of ambient $PM_{2.5}$ that contributes to personal $PM_{2.5}$, despite the presence of indoor $PM_{2.5}$ sources. Ambient concentrations of $SO_4^{2-}$, a component of $PM_{2.5}$, were strongly associated with personal exposures to $SO_4^{2-}$ and also with personal exposures to $PM_{2.5}$. The investigators concluded that, for a given season or city, ambient $PM_{2.5}$ and $SO_4^{2-}$ are strong predictors of respective personal exposures and that ambient $SO_4^{2-}$ is also a strong predictor of personal exposure to $PM_{2.5}$. Because $PM_{2.5}$ has substantial indoor sources and $SO_4^{2-}$ does not, the investigators concluded that personal exposure to $SO_4^{2-}$ accurately reflects exposure to ambient $PM_{2.5}$ and therefore the ambient component of personal exposure to $PM_{2.5}$ as well. This conclusion is tempered, however, by the different techniques used to measure ambient concentrations and personal exposures to $PM_{2.5}$ and $SO_4^{2-}$. How these differences may influence the findings is unclear.

For some gaseous pollutants measured in the study, most measurements were below the limit of detection. Particularly problematic were ozone ($O_3$) and sulfur dioxide ($SO_2$) measurements, more than 90% of which were below the limit of detection in both cities, and nitrogen dioxide ($NO_2$) measurements in Baltimore, 80% of which were below the limit of detection. Although the investigators handled the values below the limit of detection by using currently accepted methods, care should be taken in interpreting results with many such values.

The investigators also concluded that ambient concentrations of gaseous pollutants serve as a better surrogate for personal exposure to $PM_{2.5}$ than for personal exposure to gaseous pollutants. However, this conclusion is weakened by the high percentage of gaseous pollutant samples below the limit of detection in this study. Nevertheless, even with more sensitive measurements, the variability of removal mechanisms for gaseous pollutants in indoor environments may continue to result in weak correlations between ambient and personal gaseous data, since a major component of personal air includes indoor air. In contrast, most measurements of $PM_{2.5}$ and $SO_4^{2-}$ were above the limits of detection, giving more confidence to analyses that depend on them.

## INTERPRETATION

This study provides important information for understanding the relation between ambient measures of urban air pollution and personal exposures to the same pollutants. Ambient concentrations and personal exposures to a variety of urban air pollutants were measured in two cities, in two seasons, and in three groups of possibly susceptible individuals. The study design involved examination of important personal–ambient exposure issues for both $PM_{2.5}$ and gaseous air pollutants: differences by city, season, and sensitive subpopulations, as well as by day of the week. The study design was of high quality, with standardized measurements taken at consistent times of day. However, although investigators employed appropriate and state-of-the-art methods to monitor both personal and ambient concentrations of pollutants, some of these methods differed between cities or between measurements of ambient concentrations and personal exposures.

The investigators collected valuable information to better understand the use of ambient air pollution concentrations obtained from central monitors in the evaluation of health effects. The key results of the study and its implications are:

1. Ambient concentrations of $PM_{2.5}$ were strongly associated with personal exposure to $PM_{2.5}$, supporting the use, in epidemiologic studies, of exposure information for $PM_{2.5}$ from central monitoring sites.
2. The strength of the associations between personal exposures to $PM_{2.5}$ and ambient concentrations of $PM_{2.5}$ appeared to vary somewhat by city and season, as investigators hypothesized. In contrast, the variation among groups was not as great as was anticipated. The HEI Health Review Committee agreed that studying groups thought to be sensitive is valuable. The Committee cautioned, however, that results of this study should not be extended generally to other locations and populations, given that the groups studied did not represent the general population or even the subpopulations of which they are a part.
3. For these data, ambient concentrations of gaseous copollutants such as $O_3$, $NO_2$, and $SO_2$ correlated more strongly with measures of personal exposure to $PM_{2.5}$ than with personal measures of the same gaseous pollutants. On the basis of these results, the investigators recommended caution when interpreting results from previous time-series studies that included both gaseous and particulate pollutant concentrations. This caution is noteworthy. The high percentage of nonmeasurable data in this study precludes the ability to discern whether strong correlations actually do exist between ambient and personal gaseous data. On the other hand, even with a more sensitive measurement technique, the correlations observed may still be weak because of the variability in removal mechanisms for gases in indoor spaces.

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