HEI

STATEMENT

Synopsis of Research Report 127

HEALTH EFFECTS INSTITUTE

Personal, Indoor, and Outdoor Particulate Exposure for Patients with Cardiovascular Disease

INTRODUCTION

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, for some susceptible groups, such as elderly individuals with cardiovascular disease, personal exposure is largely influenced by time spent indoors. This fosters the uncertainty of 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 central-site ambient PM monitors. One objective of RFA 98-1 was to characterize personal exposure to PM in different indoor and outdoor microenvironments, and in geographic locations that differ in types and sources of particles, topography, and climate so as 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 Brunekreef and his colleagues to assess the correlations between pairs of personal, indoor, and outdoor concentrations to $PM_{2.5}$ for two groups of elderly people with cardiovascular disease living in Amsterdam, The Netherlands, and in Helsinki, Finland.

In both Amsterdam and Helsinki, the outdoor concentrations were measured at fixed monitoring sites near the subjects' residences. Indoor concentrations were measured in participants' homes using the same type of monitor used for outdoor measurements. Personal exposures were monitored with a different type of sampler that subjects kept with them during each monitoring period. All measurements were taken between November 1998 and June 1999.

The subjects were 50 to 84 years of age, did not smoke, and had been diagnosed with coronary artery disease or other cardiac disorders. Information about time they spent indoors and outdoors and in different activities (eg, cleaning, cooking, sleeping) was collected using questionnaires. Although the subjects themselves did not smoke, it became apparent that a number of them were exposed to environmental tobacco smoke (ETS), an exposure the authors needed to consider carefully in analyzing and interpreting the data.

RESULTS

In each city, among subjects who did not report exposure to ETS, personal and indoor $PM_{2.5}$ levels were similar, whereas outdoor levels were higher than both. Among the same subjects, personal, indoor, and outdoor $PM_{2.5}$ concentrations were higher and more variable in Amsterdam than those

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This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Dr Bert Brunekreef at Utrecht University, The Netherlands. The complete report, *Personal, Indoor, and Outdoor Exposures to $PM_{2.5}$ and Its Components for Groups of Cardiovascular Patients in Amsterdam and Helsinki*, can be obtained from HEI or our website (see reverse side).

in Helsinki. The higher concentrations for personal and indoor $PM_{2.5}$ in Amsterdam may have several possible explanations; an example is that the outdoor concentrations were also higher in Amsterdam, thus contributing more to personal and indoor concentrations. The reasons for differences such as these need further exploration.

In addition to $PM_{2.5}$, the study also measured absorbance, the amount of light absorbed by particles. The more light absorbed, the darker the particle and, thus, the higher the amount of carbon. Therefore, absorbance often serves as a surrogate measure for elemental carbon (EC). However, in this study, the correlations between absorbance and EC concentrations were found to be different between the two cities: The median absorbance was higher than the median EC concentration in Helsinki whereas in Amsterdam it was lower. This difference demonstrates the need to perform site-specific calibrations of absorbance before using it as a proxy for EC.

The concentrations of most elements in indoor and personal samples were similar, and sulfate and elemental sulfur were the highest of all constituents evaluated.

Among participants living in homes free of ETS in both cities, for $PM_{2.5}$ mass, the correlations between pairs of personal, indoor, and outdoor measurements were high; the highest were between personal and indoor measurements. For elemental concentrations, correlations between pairs of personal, indoor, and outdoor measurements were generally low with the exception of sulfate and elemental sulfur, which are primarily from outdoor origin. The poorest correlations were for copper and silica in all pairs of measurements.

From information acquired via the subjects' questionnaires, the authors estimated the time subjects spent on daily activities (such as sleeping, cooking, cleaning), being exposed to ETS, and being outside or traveling in a vehicle. In both cities, as one would expect for this population of elderly persons with compromised health, the subjects spent a large portion of time in their own homes. Thus, indoor sources (eg, ETS, gas stoves, dusting) contributed more to their personal exposure to $PM_{2.5}$ than outdoor sources. Nevertheless, in both cities, after excluding ETS exposure and outliers, both indoor and outdoor sources of $PM_{2.5}$ and its constituents significantly contributed to personal exposures.

INTERPRETATION

The results of this study support the assumption that underlies many epidemiologic studies of the health effects of $PM_{2.5}$: that outdoor air pollution can contribute significantly to personal exposure, even among a group of people who spend a large portion of their time indoors, and during times of the year when homes are more likely to be sealed due to weather.

Although the group of subjects in this study is not representative of the general population in these two countries, it was a valuable group to study because other epidemiologic studies have found that subjects with cardiovascular diseases may be particularly susceptible to PM exposure and, due to their impaired health, they are likely to spend more time at home and be less active than younger or healthier populations.

Nevertheless, certain characteristics of the study limit the ability to generalize the findings. First, the ambient monitors used were located closer to the subjects' homes than the central monitors often used in epidemiologic studies, thus increasing the likelihood that ambient measurements in this study would be correlated with personal exposures. Second, these results are based on a limited population in two northern European cities with specific housing characteristics (eg, a high proportion of natural gas cooking in Amsterdam) that limits one's ability to generalize to other cities, especially in other climates.

Although this study found that outdoor sources contribute substantially to personal exposure, even in this population who spend much of their time indoors, this finding comes with a caution. The findings about potential indoor sources, specifically ETS, revealed that it is critical to quantify the contributions from both indoor and outdoor sources to determine a more accurate association between personal and outdoor exposure; and that policymakers need to focus on both indoor and outdoor sources of pollution. Future exposure study designs need to include better controls for exposure to ETS and consider more carefully other indoor sources of pollutants.

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