



# STATEMENT

## Synopsis of RIOPA Research Report Part II



HEALTH  
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## Pollutants in Indoor, Outdoor, and Personal Air: Composition of Particulate Matter

### INTRODUCTION

Many epidemiologic studies have shown an association between exposure to particulate matter (PM) and increased morbidity and mortality. These types of studies often use ambient (outdoor) concentrations measured at fixed monitoring sites as a surrogate for personal exposure. However, the adequacy of this surrogate measure continues to be an important research and policy question, despite much recent research to address it. The factors that influence the relation between outdoor particle concentrations and personal exposure need to be better understood. This involves assessing: the similarities and differences in levels and characteristics of particles in various microenvironments; how outdoor particles contribute to indoor concentrations; and how individual activity patterns influence personal exposure and resulting dose.

HEI and NUATRC sought to fund research to (1) characterize personal exposure to particles in different indoor and outdoor microenvironments and in geographic locations that differ in types and sources of particles, topography, and climate; and (2) identify distinctive characteristics of particles that would improve exposure estimates in epidemiologic studies. Ideally, studies to address the second objective would determine particle characteristics (eg, concentration, size, and composition) and describe the relation between overall personal exposure and the surrogate measures of exposure used in many epidemiologic studies.

The Relationships of Indoor, Outdoor, and Personal Air (RIOPA) study was designed to provide such information for PM<sub>2.5</sub> (PM of 2.5 μm or smaller in aerodynamic diameter), a large number of volatile organic compounds (VOCs), and carbonyls. Dr Turpin's component of the larger project focused on PM<sub>2.5</sub> species—key constituents of PM<sub>2.5</sub> that include sulfur, organic and elemental carbon, polycyclic aromatic hydrocarbons (PAHs),

chlordanes, trace elements, and functional groups (atoms attached to carbon that can influence a molecule's behavior). These analyses are presented here in Part II of this Research Report; Part I presents the analyses for the VOCs and carbonyls.

### APPROACH

The RIOPA study addressed the hypothesis that outdoor sources contribute a substantial proportion of the pollutant concentrations in the indoor air and personal air (breathing zone) for residents who live near those sources. The investigators measured indoor, outdoor, and personal exposure concentrations of 16 VOCs, 10 carbonyls, and PM<sub>2.5</sub> during two 48-hour sampling periods in different seasons between the summer of 1999 and the spring of 2001. The study included approximately 100 homes with 100 residents in each of three cities with different air pollution sources and weather conditions: Los Angeles CA, Houston TX, and Elizabeth NJ. Homes were selected by their distance from various sources. Approximately 300 residents in 300 homes participated in the full RIOPA study; samples from 219 homes and their residents were analyzed for PM<sub>2.5</sub> and its components.

Dr Turpin and colleagues aimed to: (1) characterize and compare indoor, outdoor, and personal PM<sub>2.5</sub> mass composition; (2) estimate the contribution of outdoor PM<sub>2.5</sub> and its components to indoor concentrations and to personal exposures using residential air exchange rates (AERs); and (3) conduct exploratory analyses of indoor and personal PM<sub>2.5</sub> concentrations to identify particulate sources.

PM<sub>2.5</sub> filter samples were collected inside and directly outside each home. Organic PM<sub>2.5</sub> sampling artifacts were also measured. Gas- and particle-phase samples were collected for measurement of selected semivolatile organic compounds. Personal PM<sub>2.5</sub> filter samples were collected using a personal environmental monitor worn by each participant.

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This Statement, prepared by the Health Effects Institute and the National Urban Air Toxics Research Center, summarizes a research project funded jointly by HEI and NUATRC. It was conducted by Dr Barbara J Turpin at Rutgers University, New Brunswick NJ. The complete report (HEI Number 130 Part II; NUATRC Number 10), *Relationships of Indoor, Outdoor, and Personal Air (RIOPA): Part II. Analyses of Concentrations of Particulate Matter Species*, can be obtained from HEI or NUATRC (see reverse side). **RIOPA 130 Part II**

## RIOPA Research Report Part II

Samples or subsets of samples were analyzed for PM<sub>2.5</sub> mass, elements, organic and elemental carbon, functional groups, PAHs, and chlordanes.

AERs, expressed as the number of indoor air volumes replaced each hour by outdoor air, were measured using a technique developed specifically for application to relatively small spaces, including homes. Investigators measured the number of air exchanges per hour at each home during each sampling period.

The investigators used AERs to calculate the contribution of outdoor air to indoor PM<sub>2.5</sub> mass using three methods, each with increasingly more realistic assumptions: one that assumed the infiltration factor was constant across homes; one that assumed the infiltration factor varied according to measured AERs for each home; and one that estimated an independent infiltration factor for each home and sampling day using measured PM<sub>2.5</sub> species, AER, and housing characteristics.

### RESULTS AND INTERPRETATION

A number of analyses quantified and compared indoor, outdoor, and personal exposure concentrations of PM<sub>2.5</sub> and its components. Some key results are summarized below.

When data from all three cities were combined, the median PM<sub>2.5</sub> concentrations indoors and outdoors were about the same and personal concentrations were about twice as high.

Among the cities and within each city, indoor and outdoor particle concentrations differed little, whereas differences in personal exposures were more pronounced.

The ratio of personal exposure to outdoor median concentrations varied among cities; it was notably lowest in Los Angeles (1.6 vs 2.3 in Elizabeth and 2.4 in Houston). This variation could reflect differences in the strength of indoor sources, AERs, and personal activities. The degree of correlation between indoor and outdoor concentrations did not have much impact on correlations with personal PM<sub>2.5</sub> concentrations.

When specific constituents of PM<sub>2.5</sub> were assessed, organic matter dominated PM<sub>2.5</sub> concentrations both indoors and outdoors. Differences in the composition of outdoor, indoor, and personal PM<sub>2.5</sub> were observed, however. Indoor organic PM<sub>2.5</sub> concentrations were nearly twice as high as outdoor concentrations, which indicates the importance of indoor sources.

Similarly, chlordane concentrations were higher indoors than outdoors. This is most likely due to strong indoor emissions from volatilization of termiticides used during home construction.

In contrast, elemental carbon concentrations indoors and outdoors were well correlated, with indoor concentrations generally lower than outdoor concentrations.

This suggests that indoor emissions of elemental carbon were low.

The concentrations of PAHs were substantially more variable indoors than outdoors. Phenanthrene was consistently the largest measured contributor to PAH mass in both indoor and outdoor air.

The methods used to estimate how much outdoor sources of PM<sub>2.5</sub> contributed to indoor concentrations produced broadly consistent results: over 60% of indoor concentrations in Los Angeles, 70% in Elizabeth, and over 40% in Houston. PM<sub>2.5</sub> of outdoor origin contributed much less to personal PM<sub>2.5</sub> exposure—approximately 25% to 33%.

As shown above, outdoor contributions to indoor concentrations were much lower for Houston homes than for those in Los Angeles and Elizabeth, and the same pattern was observed for the outdoor contribution to personal exposure. The investigators suggest that this difference could be attributed to the more common use of air conditioning in Houston, which tends to reduce air exchanges; they did not test this hypothesis, however.

The investigators attempted to characterize a source of exposure error in epidemiologic time-series studies, namely variations in particle infiltration behavior. Three approaches were used to explore how AERs, particle properties, and housing characteristics can influence particle infiltration. When used in conjunction with concentrations measured at fixed monitoring sites, information on AERs can minimize uncertainty in estimates of exposure to PM<sub>2.5</sub> of outdoor origin.

### CONCLUSIONS

Dr Turpin and her colleagues have contributed important information by (1) characterizing and comparing the composition of indoor, outdoor, and personal PM<sub>2.5</sub> in the three cities; and (2) estimating the contribution of outdoor PM<sub>2.5</sub> and its components to indoor and personal exposures. This is one of the most comprehensive studies to characterize PM<sub>2.5</sub> exposures and one of the first to measure PM<sub>2.5</sub> functional groups.

Although the lack of a population-based sampling strategy limits the generalizability of the results for broad epidemiologic analyses, the compositional data provide insight on exposure to PM<sub>2.5</sub> constituents for a large number of subjects and homes selected on the basis of distance from various outdoor sources.

This study has generated a rich database that can be used to identify what levels of exposure could be related to health concerns, the sources of air toxics, and factors associated with high exposures. HEI and NUATRC are currently developing additional opportunities to explore aspects of these data.



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