



STATEMENT

Synopsis of RIOPA Research Report Part I



HEALTH
EFFECTS
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Pollutants in Indoor, Outdoor, and Personal Air: Collection Methods and Descriptive Analyses

BACKGROUND

Urban populations are exposed to a complex mixture of possibly toxic pollutants generated and emitted by a variety of outdoor and indoor sources. These pollutants occur naturally or result from human activities; they may be present in the form of gases, liquid droplets, or solid particles. The US Environmental Protection Agency (EPA) defines an air toxic as any substance known or suspected to cause harm to humans or the environment. The Clean Air Act Amendments of 1990 list 188 air toxics as hazardous air pollutants; these include volatile organic compounds (VOCs), carbonyls (aldehydes and ketones), and components often associated with particulate matter (PM). The Amendments require the EPA to evaluate the possible health risks from air toxics and, if appropriate, control their ambient levels. To achieve this objective, the EPA identified pollutants that may be most hazardous to health and categorized them as urban air toxics (emitted from all sources) or mobile-source air toxics; some pollutants appear on both lists. Currently, the EPA regulates ambient levels of fine PM through the National Ambient Air Quality Standards for PM_{2.5} (PM of 2.5 μm or smaller).

Understanding personal exposures to both air toxics and PM—and how different sources contribute to individual exposures—has been considered an important first step in assessing the possible public health risks from these species in the urban environment. The Relationships of Indoor, Outdoor, and Personal Air (RIOPA) study was designed to provide such information for a large number of VOCs and carbonyls, including some that are listed as urban and mobile-source air toxics, and for PM_{2.5}.

APPROACH

The investigators measured indoor, outdoor, and personal exposure concentrations of 16 VOCs, 10 carbonyls, and PM_{2.5} during two 48-hour sampling

periods in different seasons between the summer of 1999 and the spring of 2001. The study included 100 homes with 100 adult 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 distance from various sources.

In this report the investigators (1) compare concentrations of the pollutants measured in indoor, outdoor, and personal air (within the subject's breathing zone), and in vehicles for carbonyls; (2) examine the effects of city, season, type of home, and other variables on measured concentrations; and (3) quantify how much outdoor sources contributed to the indoor concentrations using measurements of outdoor–indoor air exchange rates.

The VOCs measured include

- some on the EPA's list of urban air toxics (benzene, carbon tetrachloride, chloroform, trichloroethylene);
- some on the EPA's list of mobile-source air toxics (benzene, chloroform, ethyl benzene, MTBE, *m*- & *p*-xylenes, *o*-xylene, styrene, and toluene); and
- some that originate primarily from indoor sources (α -pinene, β -pinene, and *d*-limonene).

The carbonyls measured include

- some from the EPA's lists of urban air toxics and mobile-source air toxics (acetaldehyde and formaldehyde);
- several that are present at low levels in mobile-source emissions (acrolein, butyraldehyde, crotonaldehyde, hexaldehyde, isovaleraldehyde, propionaldehyde, and valeraldehyde); and
- two that are primarily formed as a result of photochemical reactions with hydrocarbons (glyoxal and methylglyoxal)

Continued

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 Drs Clifford P Weisel, Junfeng (Jim) Zhang, and Barbara J Turpin of the Environmental and Occupational Health Sciences Institute, Piscataway NJ. The complete Research Report (HEI Number 130; NUATRC Number 7), *Relationships of Indoor, Outdoor, and Personal Air (RIOPA): Part I. Data Collection and Descriptive Analyses* can be obtained from HEI or NUATRC (see reverse side).

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The investigators used passive organic vapor monitors to collect VOC samples. For carbonyls, they used two sampling methods: a conventional active sampler and a new passive sampler that was developed as part of the study. The new sampler performed better for several carbonyls and was used most; therefore the Investigators Report presents only the analyses and conclusions based on the passive samples. For PM_{2.5}, indoor and outdoor samples were collected on filters mounted in a Harvard impactor; personal samples were collected on smaller filters mounted in a personal monitor.

RESULTS AND INTERPRETATION

The homes and subjects selected did not proportionally represent the greater population. Rather, homes close to sources were preferentially sampled in order to examine the impact of possibly high exposures. In addition, the characteristics of the subjects and the homes differed among cities. Thus comparing results among the three areas, extrapolating the numeric results obtained in this study to the general population, or attributing them to a given city or region must be considered with caution.

The analyses of the aggregate data suggest some trends that will need to be verified with more detailed analyses. With a few exceptions, mean and median personal exposure and indoor concentrations of VOCs and carbonyls were higher than the outdoor concentrations within each city and for the whole data set. Personal PM_{2.5} concentrations were higher than indoor and outdoor concentrations. The finding that personal exposure concentrations were higher than outdoor concentrations for many compounds indicates that indoor sources contribute to, and in some cases dominate, personal exposures; this is consistent with results from other studies.

Several VOCs were present only at low levels in all environments and were not detected in many outdoor samples. The species detected in more than 60% of outdoor samples common to all three cities were MTBE, carbon tetrachloride, benzene, ethyl benzene, *m*- & *p*-xylenes, and *o*-xylene. MTBE had the highest outdoor concentrations. Although cities with different types of sources were chosen and homes near sources were preferentially sampled, the ranges of outdoor VOC concentrations were generally similar in the three cities. The median outdoor concentrations of carbonyls were more variable than VOCs across the cities (with the exception of formaldehyde).

Indoor concentrations of several VOCs and carbonyls differed among cities. The species with the highest indoor concentrations were the VOCs MTBE, toluene, α -pinene, and *d*-limonene and the carbonyls formaldehyde, acetaldehyde, and acetone. Personal exposure concentrations for several VOCs and some carbonyls also differed among cities.

Among the three cities, differences in indoor and outdoor PM_{2.5} levels were slight, but differences in personal PM_{2.5} exposures were more pronounced.

The analyses of the outdoor contributions to indoor air suggested that some VOCs (MTBE, benzene, carbon tetrachloride, and trichloroethylene) were primarily generated outdoors and contributed 90% to 100% of the indoor concentrations. Outdoor concentrations of other VOCs (chloroform, α -pinene, β -pinene, and *d*-limonene) and most carbonyls (including formaldehyde, acetaldehyde, and hexaldehyde) contributed less to indoor air (13% to 43% of indoor concentrations). The carbonyls that contributed most were acrolein, crotonaldehyde, and propionaldehyde (50% to 63%). For PM_{2.5}, outdoor air contributed 60% of the indoor concentration.

CONCLUSIONS

The RIOPA study generated a rich database on the concentrations of air toxics and PM_{2.5} for a large number of subjects and their homes. Few investigators have looked at personal, indoor, and outdoor concentrations of a suite of VOCs, carbonyls, and PM_{2.5} in a large set of subjects in multiple urban centers. (The information on PM_{2.5} composition [published as Part II of this Research Report] provides needed information about exposure to the components of PM.)

With a few exceptions, median indoor, outdoor, and personal air concentrations of the various compounds were similar for the three cities. This was unexpected given the wide variety of pollutant sources. Both the higher concentrations of species in personal samples compared with outdoor samples and the contributions of outdoor air to indoor concentrations of each species confirm and extend earlier findings.

Future analyses of this data set will help clarify the impact of proximity to sources and the individual factors associated with high personal exposure levels. Overall, the data collected in the RIOPA study increase the database on the distribution of concentrations for many air toxics and PM_{2.5} and supply data for assessing whether these levels are of health concern.



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