A Pilot Study of Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants (CTEPP)

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Foreword

The mission of the National Exposure Research Laboratory (NERL) is to provide scientific understanding, information and assessment tools that will quantify and reduce the uncertainty in EPA's exposure and risk assessments for environmental stressors. These stressors include chemicals, biologicals, radiation, and changes in climate, land use, and water use. The Laboratory's primary function is to measure, characterize, and predict human and ecological exposure to pollutants. Exposure assessments are integral elements in the risk assessment process used to identify populations and ecological resources at risk. The EPA relies increasingly on the results of quantitative risk assessments to support regulations, particularly of chemicals in the environment. In addition, decisions on research priorities are influenced increasingly by comparative risk assessment analysis. The utility of the risk-based approach, however, depends on accurate exposure information. Thus, the mission of NERL is to enhance the Agency's capability for evaluating exposure of both humans and ecosystems from a holistic perspective.

The National Exposure Research Laboratory focuses on four major research areas: predictive exposure modeling, exposure assessment, monitoring methods, and environmental characterization. Underlying the entire research and technical support program of the NERL is its continuing development of state-of-the-art modeling, monitoring, and quality assurance methods to assure the conduct of defensible exposure assessments with known certainty. The research program supports its traditional clients -- Regional Offices, Regulatory Program Offices, ORD Offices, and Research Committees -- as well as ORD's Core Research Program in the areas of health and ecological exposure analysis and assessment.

Human exposure to multimedia contaminants, including persistent organic pollutants is an area of concern to EPA because of the possible adverse health effects of these compounds. These compounds may originate from industrial processes and combustion and are present in a variety of microenvironments. The efforts described in this report provide an important contribution to our ability to measure and evaluate human exposure to pollutants.

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Abstract

The Pilot Study of Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants (CTEPP) investigated the aggregate exposures of 257 preschool children and their primary adult caregivers to pollutants commonly detected in their everyday environments. The target compounds include organophosphate (OP) pesticides, OP metabolites, organochlorine (OC) pesticides, pyrethroid pesticides and metabolites, acid herbicides, polycyclic aromatic hydrocarbons (PAH), phthalates, phenols, polychlorinated biphenyls (PCB), PAH metabolites, and atrazine. Some of the target compounds are persistent indoors and sometimes outdoors, so that very low levels may exist in the children's surroundings and provide a source of non-acute exposure. The primary purposes of the research were to increase the understanding of children's exposures to persistent and non-persistent organic pollutants, and to gain information on the various activities, environmental media, and pollutant characteristics that may influence children's exposures. The overall objectives were to measure the aggregate exposures of approximately 260 preschool children and their adult caregivers to low levels of a suite of pesticides and other organic pollutants that the children may encounter in their everyday environments and to apportion the routes of exposure and estimate the relative contributions of each route. Within these objectives, four major, specific goals for the CTEPP study were accomplished in this report. These goals were: (1) to measure the concentrations of the target pollutants in multimedia samples collected at the homes and at day care centers of 257 preschool children in six North Carolina (NC) counties and six Ohio (OH) counties, (2) to determine the distributions of child characteristics, activities, and locations that contributed to their exposures, (3) to estimate the aggregate exposures of the preschool children to these pollutants that they may encounter in their everyday environments, and (4) to apportion the routes of exposure. Results will also be used to identify important hypotheses to be tested in future research.

A two-state sampling plan was used to select and recruit study participants. In each state, a total of four urban and two rural counties were randomly selected. The counties were located in three distinct geographical regions of each state. These regions were the mountains, the Piedmont, and the coastal plain of NC, and the northern, central, and southern regions of OH. Dual sampling frames (the day care and the telephone components) were used in each state. To recruit participants in households whose children attended child day care centers, 13 centers in the six NC counties and 16 centers in the six OH counties were selected using probability sampling. Children were then selected randomly from classrooms having children in the eligible age group of two to five years, and their participation was recruited through their parents. To recruit participants in households whose children did not attend child day care centers, list-assisted, random digit dialing telephone sampling in the selected counties was used.

The calculated response rates in NC were 53% for day care centers and 50% for day care parents. In OH these response rates were 57% for OH day care centers and 31% for OH day care parents. The calculated response rate for the telephone sample was 58% in NC and 57% in OH. In NC, children and their caregivers in 130 households participated in the study; in OH, 127 households participated. Approximately half of the children in each state attended child day care centers (63 in NC and 58 in OH). About 84% of the NC participants and 87% of the OH participants lived in urban locations. Low-income households, classified according to federal guidelines for the Women, Infants, and Children (WIC) program (185% of the federal poverty level), comprised 46% of the sampled households in NC and 38% of those in OH.

More than 5,000 discrete personal and environmental samples, including quality control samples, were collected in each state and analyzed. Additionally, house/building characteristics observation surveys, pre- and post-monitoring questionnaires, day care food menus, and detailed child/adult time-activity and food diaries provided ancillary information necessary to estimate aggregate exposures and to aid in interpretation of the CTEPP data.

Field sampling for the day care component took place over a 48-h period at each child's day care center and simultaneously at his/her home. Field sampling for the telephone component took place over a 48-h period at each participant's home. Environmental samples included indoor and outdoor air, outdoor play area soil, indoor floor dust (carpet dust) or if no carpet, hard floor surface wipes, and household/day care drinking water. Personal samples included duplicate diet, hand wipes, and urine. If a pesticide had been applied in the seven days prior to or during sampling, transferable residues, hard floor surface wipes and food preparation surface wipes were also collected. Approximately 10% of the children were videotaped for about 2 h at their homes in OH during sampling to supplement and validate the activity diaries and observations.

All samples, including quality control samples, were extracted, and then analyzed by gas chromatography/mass spectrometry for over 50 target compounds. These compounds included two organophosphorus (OP) pesticides, two OP metabolites, ten organochlorine (OC) pesticides, three pyrethroid pesticides, one pyrethroid metabolite, three acid herbicides, nine polycyclic aromatic hydrocarbons (PAHs), six PAH metabolites, two phthalates, three phenols, 17 polychlorinated biphenyls (PCBs), and atrazine. These compounds, with the exception of atrazine, PAH metabolites and pyrethroid metabolites, were analyzed in the environmental and personal samples. Atrazine was analyzed only in drinking water samples. Only one OP metabolite, 3,5,6-trichloro-2-pyridinol (3,5,6-TCP), was analyzed in the NC environmental and personal samples; both 2-isopropyl-6-methyl-4-pyrimidinol (IMP) and 3,5,6-TCP were measured in the OH samples. In the NC urine samples, two OP metabolites; IMP and 3,5,6-TCP; 2,4-dichlorophenoxyacetic acid (2,4-D), two hydroxy PAHs: 1-hydroxybenz[*a*]anthracene and 3-hydroxychrysene; and pentachlorophenol were analyzed. In the OH urine samples, these same metabolites and/or parent compounds were analyzed, in addition to five hydroxy PAHs (1-hydroxypyrene, 3-hydroxybenz[*a*]anthracene, 3-hydroxybenzo[*a*]pyrene, 6-hydroxychrysene, and 6-hydroxyindeno[1,2,3-*cd*]pyrene) and 3-phenoxybenzoic acid (3-PBA).

Two similarly formatted CTEPP databases were developed, one for the NC study and one for the OH study. Each database contained questionnaire data, analytical data, and metadata, and provided sufficient documentation to allow the data to be understood by a diverse set of users. Descriptive statistics were calculated for sample size, mean, standard deviation, percentage detected, minimum and maximum reported values, and selected percentiles (25^{th}, 50^{th}, 75^{th}, and 95^{th}). The distributions of participant characteristics, activities, and locations that are important for exposure were quantified, based on the questionnaire data. Potential exposures and potential absorbed doses were estimated for selected target compounds, based on the percentage of the samples that had detectable levels of these compounds, the measured concentrations, the participants' activity patterns, and assumed physiological parameters. Statistical analyses to meet the four goals of the study were performed on log-transformed data, using analysis of variance (ANOVA) models. The data summaries presented in this report represent only the children and their primary caregivers in NC and OH who participated in this study.

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Acknowledgments

In a large study such as CTEPP, many people contribute to its success. The CTEPP study was conceptualized by EPA's National Exposure Research Laboratory (NERL) on the basis of three small studies of preschool children's exposures conducted earlier by NERL. NERL staff, with support from Battelle, developed the study design. Battelle performed the recruitment, field sampling, sample analysis, and statistical and data analysis of the two (NC and OH) field exposure studies.

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Executive Summary

The Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants (CTEPP) study is one of the largest aggregate exposure studies of preschool children (i.e., 2 to 5 years of age) performed in the United States. These young children are suspected of having greater exposures to pesticides and other pollutants in their everyday environments compared to older children and adults. These greater exposures may result from what preschool children drink or eat, where they spend their time, and what they do in these locations. The primary goals of this landmark study were:

1. to measure the concentration of chemical pollutants in multimedia samples collected at the homes and day care centers of preschool children,
2. to determine the distribution of child characteristics, activities, and locations that contributed to their exposures,
3. to estimate the aggregate exposures to the pollutants they may come in contact with in their everyday environments, and
4. to evaluate the contribution of each route of exposure.

This report presents the results of statistical analyses conducted to address these primary study goals. Data analysis will continue over the next year to more fully characterize those factors that are responsible for preschool children's exposure and to evaluate the relationship between environmental concentrations, exposure factors, and biomarkers of exposure. The entire CTEPP study database will be made available to scientists in EPA program and regional offices, to researchers in industry and academia, and to the general public to allow the data to be used in additional analysis, as input to exposure models, and in developing risk assessments for preschool children.

The CTEPP study was conducted in six counties in North Carolina (NC) and six counties in Ohio (OH). These two states were selected to provide exposure information in two different geographical regions of the United States (i.e., the Southeast and Midwest). Overall, 257 preschool children and their adult caregivers took part in the study. Participants were recruited from eligible homes and child day care centers in the twelve counties. Participants were selected from several categories to allow for comparisons between home vs. day care settings, urban vs. rural locations, and low income vs. middle/high income environments. Although, the study focused on preschool children, information was also collected on the adult caregivers for comparison purposes. The results presented in this report apply only to the study participants; they have not been generalized to preschool children living in either state or to children in general.

Monitoring was performed over a 48-h period at the children's homes and/or day care centers. Environmental (air, dust, and soil) and personal (hand wipe, diet, water, and urine)

samples were collected. Surface wipe samples were collected from homes with recent pesticide applications. Questionnaires and diaries were used to collect information on housing characteristics, products used in the home, and activities of the participants. Multimedia samples were analyzed for over 50 pollutants belonging to such classes as the organophosphate (OP) pesticides, OP metabolites, organochlorine (OC) pesticides, pyrethroid pesticides, pyrethroid metabolites, acid herbicides, polycyclic aromatic hydrocarbons (PAHs), PAH metabolites, phthalates, phenols, and the polychlorinated biphenyls (PCBs). These pollutants were selected because they have been commonly detected in indoor and outdoor environments and/or because they are potentially carcinogenic, mutagenic, or endocrine-disrupting chemicals in humans.

Results of the study showed there were low levels of many pollutants in both the homes and day care centers where preschool children spend their time. Children can become exposed to these pollutants when they breathe the air, ingest food and water, ingest soil and dust, and touch contaminated surfaces. An absorbed dose occurs when pollutants are taken into the body though such routes as the lungs, intestines, and skin. Exposure and absorption into the body has been confirmed by measuring the same pollutants or metabolites of these pollutants in urine samples collected from children in the study.

The most frequently detected pollutants in environmental media were those commonly used in the home, those found in products used throughout the home, or those formed as a result of common processes. These pollutants included chlorpyrifos, diazinon, *cis*- and *trans*-permethrin, *alpha*- and *gamma*-chlordane, and pentachlorophenol, which are pesticides used in households. CTEPP was the first study to measure the metabolites of chlorpyrifos (3,5,6-trichloro-2-pyridinol [TCP]) and diazinon (2-isopropyl-6-methyl-4-pyrimidinol [IMP]) in environmental samples. These two compounds were detected at a very high rate in most sample types. Benzybutylphthalate, di-*n*-butylphthalate, and bisphenol-A, are commonly used plasticizers that were frequently detected. The PAHs were also frequently detected in most environmental samples. PAHs are formed during processes which involve burning of specific substances, with indoor sources including smoking and cooking, and outdoor sources including motor vehicles, incinerators, fires, and power plants. Target pollutants were detected most often in dust and indoor air samples. Only the PAHs were detected at a high rate in soil samples. Very few pollutants were detected in liquid food samples.

Median values of measured concentrations for selected pollutants are shown in Table ES-1 by state. The highest concentrations in most samples were found for the two phthalates, benzylbutylphthalate and di-*n*-butylphthalate. For the other pollutants, concentration rankings depended upon the media and the properties of the chemicals.

Table ES-1. Median Concentrations of Selected Pollutants Measured in Multiple Media.

	Indoor Air, ng/m^3		Dust, ng/g		Outdoor Air, ng/m^3		Dermal Wipe, ng/m^2		Solid Food, ng/g	
Pollutants/Metabolite	**NC**	**OH**	**NC**	**OH**	**NC**	**OH**	**NC**	**OH**	**NC**	**OH**
Chlorpyrifos	6.1	1.8	140	62	0.28	0.20	160	60	0.17	0.18
3,5,6-TCP	1.8	0.65	92	42	0.23	0.21	130	78	2.6	1.9
cis-Permethrin	0.41	< [a]	800	500	<	<	530	240	<	<
trans-Permethrin	0.27	<	730	390	<	<	300	190	<	<
Benzo[*a*]pyrene	0.08	<	200	930	0.09	<	<	40	<	<
Benzylbutylphthalate	<	<	19,000	19,000	<	<	7,900	<	<	11
Di-*n*-butylphthalate	240	260	6,800	6,400	<	<	9,000	<	<	<
Bisphenol-A	1.6	0.98	<	28	<	<	5,900	4,600	4.1	3.5

[a] "<" indicates that the median value falls below the MDL for the pollutant within the specified sample medium.

Comparisons of environmental measurements between home and day care settings, urban and rural locations, and low-income and middle/high-income environments showed few instances where the geometric mean concentration in one setting differed by a factor of three or more (when rounded) from the other setting, and where this difference was statistically significant. Incidences where such differences were observed included the following:

- ***Day Care vs. Home Environments.*** In both NC and OH, floor dust loadings (ng/m^2) averaged higher in day care centers than in homes, and this difference was statistically significant, for a number of current use pesticides, PAHs, and phthalates. This was likely a result of more dust being found in the day care centers, rather than higher concentrations of pollutants in the dust.

- ***Urban vs. Rural Environments.*** In OH, concentrations of the PAHs in dust samples, diazinon and IMP in outdoor air samples, and TCP in soil samples averaged higher in urban compared to rural settings, and this difference was statistically significant. In NC, the concentration of 2,4-D in floor dust samples tended to be higher in urban compared to rural settings.

- ***Low Income vs. Middle/High Income Environments.*** In NC, indoor air concentrations of diazinon and the permethrins averaged higher in low-income compared to middle/high-income environments, with the difference being statistically significant. The same was true for selected PAHs in soil. In both OH and NC, 2,4-D concentrations in dust were higher in middle/high-income compared to low-income homes. Finally in both states, floor dust loadings (ng/m^2) for pesticides were higher in low-income compared to middle/high-income homes. Again, this is likely a result of more dust found in low-income homes rather than to higher pesticide concentrations in the dust.

For 27 target pollutants, information on environmental and personal sample concentrations was combined with activity data to estimate potential exposure (ng/day) for each study participant by the inhalation, dietary ingestion, and indirect ingestion exposure routes. For each of these three exposure routes, potential absorbed dose (ng/kg/day) was also calculated by assuming a 50% absorption rate and dividing potential exposure by body weight. Results through the dermal route were not reported due to uncertainties in the assumptions required for the calculations. However, absorbed doses of these pollutants through the dermal route of exposure were assumed to be low.

For eight of the target pollutants (chlorpyrifos, diazinon, 3,5,6-TCP, *cis*-permethrin, *trans*-permethrin, 2,4-D, di-*n*-butylphthalate, and bisphenol-A), aggregate potential exposure and absorbed dose estimates were calculated by summing over all three routes. In both states, aggregate exposure and dose estimates were highest for di-*n*-butylphthalate, bisphenol-A, and 3,5,6-TCP. The NC and OH children had the highest median aggregate potential exposure levels to di-*n*-butylphthalate (42,900 and 8,310 ng/day), bisphenol-A (2,560 and 1,880 ng/day), and 3,5,6-TCP (1,230 and 930 ng/day). Median aggregate potential absorbed dose was highest among the NC and OH children for these same three pollutants (1,250 and 262 ng/kg/day for di-*n*-butylphthalate, 71.4 and 60.8 ng/kg/day for bisphenol-A, and 37.7 and 25.4 ng/kg/day for 3,5,6-TCP for NC and OH children, respectively). The median aggregate potential absorbed doses of di-*n*-butylphthalate was over four times greater in NC children compared to OH children. For di-*n*-butylphthalate, bisphenol-A, and 3,5,6-TCP, the relative importance of the exposure routes was dietary ingestion, followed by inhalation and indirect ingestion. In addition in both states, the children had the highest estimated aggregate exposures and absorbed doses to di-*n*-butylphthalate.

In several cases, there were significant differences in the calculated exposure and dose estimates between different groups of children. Those differences for which the geometric mean estimate was at least three times higher (when rounded) in one category than another included the following:

- ***Day Care vs. Stay-at-Home Children.*** In OH, exposure and dose estimates for diazinon, the PAHs, and benzylbutylphthalate via the indirect ingestion route were higher for day care children than stay-at-home children. Likewise, dietary exposure and dose estimates for benzylbutylphthalate and the permethrins were higher for the same group of children.

- ***Urban vs. Rural Children.*** In NC, exposure and dose estimates for 2,4-D by the indirect ingestion route were higher for children in urban compared to rural locations. In OH, PAHs showed higher estimates via the indirect ingestion route for urban children.

- ***Low Income vs. Middle/High Income Children.*** In NC, exposure and dose estimates for 2,4-D via the indirect ingestion route were higher for children in middle/high-income compared to low-income environments.

Because the indirect ingestion route was most frequently associated with sizable (and statistically significant) differences in exposure and dose estimates between groups of children, but yet accounted for a relatively small amount of the total or aggregate exposure for each child, it is not surprising that similar differences were not observed for aggregate exposure.

Some pollutants or metabolites were frequently detected and measurable in the children's urine samples, including 3,5,6-TCP, 2,4-D, and pentachlorophenol. Median urinary concentrations of 3,5,6-TCP, 2,4-D, and pentachlorophenol were 5.3, 0.7, and 0.4 ng/mL, respectively, for NC children. For OH children, median urinary concentrations of 3,5,6-TCP, 2,4-D, and pentachlorophenol were 5.1, 1.0, and 0.8 ng/mL, respectively. On average, levels of 3,5,6-TCP in urine samples for both NC and OH children were at least five times greater than those for 2,4-D or pentachlorophenol. As with estimates of aggregate potential exposure and absorbed dose, there were no incidences where differences in urinary concentrations were highly significant between various groups of children.

Finally, comparisons between children and their adult caregivers showed that children were generally exposed to higher levels of pollutants than adults in the same household, with the difference being statistically significant. Much of these differences was likely attributable to differences in physiological factors (i.e., ventilation rates and body weights) and activity patterns (i.e., daily soil and dust ingestion rates) between children and adults.

Chapter 1
Introduction

1.1 Background

Young children, especially those of preschool age, are hypothesized to have greater exposures than do older children or adults to pesticides and semivolatile organic pollutants, including some compounds that may have endocrine-disrupting effects or developmental toxicity. These greater exposures may result from what children eat and drink, where they spend their time, and what they do there. The impact of the exposures may be greater on young children because of their smaller body masses, immature body systems, and rapid physical development.

Organochlorine (OC) and organophosphate (OP) pesticides, pyrethroid pesticides, acid herbicides, polycyclic aromatic hydrocarbons (PAHs), phthalates, phenols, and polychlorinated biphenyls (PCBs), are pollutants commonly found in multiple environmental media. Many of these compounds are persistent in the indoor and outdoor environments. Some have been shown to have deleterious effects on health, exhibiting not only acute toxicity, but also possible chronic effects at low levels. Many are sufficiently volatile or soluble to evaporate and condense, or to move otherwise through environmental media – air, water, and soil. They can enter indoor microenvironments through intrusion of outdoor air, inadvertent transport by people or pets, and other means (1-4). Additionally, there are many potential sources of these pollutants indoors, such as pesticides, home chemicals, environmental tobacco smoke, consumer products, and building materials.

With the passage of the Food Quality and Protection Act of 1996 (FQPA), new, more stringent standards for pesticide residues in foods were set, to provide increased emphasis on health protection for infants and children. The exposure component of the risk assessment for pesticides is now required to

- Consider the potentially greater susceptibility of children to pesticide exposure, compared to adults, and

- Account for aggregate exposures to the pesticides from all sources, including food, drinking water, and non-occupational applications of the pesticides in homes, schools, day care centers, and other microenvironments.

Essentially, the FQPA states that exposure assessments must be conducted for infants and children and that these exposure assessments must include and be reliable for all sources of pesticide exposure. Because young children learn about their environment by exploring not only the appearance and texture of objects, but also their taste and smell, both dietary and indirect

ingestion can play an important role in their exposures. However, very little information on children's aggregate exposures is available at the present time, and the dominant pathways and media through which such exposures may take place are known uncertainly. The Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants (CTEPP) study provides some of this information.

In our previous work, methods to measure and estimate the exposures of preschool children in low-income families to PAHs were developed and evaluated (5,6). Preschool children's aggregate exposures to PAHs through three exposure routes including inhalation, dietary and indirect ingestion were estimated for 24 children (7). Further studies of an extensive suite of pollutants including OP and OC pesticides, acid herbicides, PAHs, phthalates, phenols, and PCBs concentrations in multiple media at nine child day care centers and of the aggregate exposures of nine preschool children to these pollutants were conducted (8-10). Results from these studies suggested that dietary and indirect ingestion could be important contributors to children's exposures. In addition, the children's potential absorbed doses resulting from their exposures could exceed those of adults living in the same households. This background work, along with the new requirements of the FQPA, led to the conceptualization, development, and realization of the CTEPP study.

1.2 Study Overview

The CTEPP study provides data on aggregate exposures of 257 children to pesticides and other persistent and non-persistent organic pollutants in several microenvironments, and has improved the methods for determining their exposures and the routes of exposure. The study results also allow identification of important hypotheses to be tested in future research. The following four major, specific goals were established for the CTEPP study:

1. To measure the environmental concentrations of pesticides and other persistent and non-persistent organic pollutants in multiple media at the homes and day care centers of 257 preschool children in six North Carolina and six Ohio counties,

2. To determine the distributions of child characteristics, activities, and locations that contributed to these children's exposures to the selected pollutants,

3. To estimate the exposures of the preschool children to these pollutants that they may encounter in their everyday environments, and

4. To apportion the exposures through the ingestion, inhalation, and dermal routes.

In meeting these goals, the following seven hypotheses were tested in the study:

1. Exposures of children to the target pollutants are similar at home and at day care.

2. Exposures of children to the target pollutants are similar for low-income households compared to those in other households.

3. Exposures of children to the target pollutants are similar for urban and rural households.

4. Routes of exposure and their relative importance are different for the different chemical classes of pesticides and other persistent and non-persistent organic pollutants.

5. Ingestion is a major route of exposure of the selected children and adults living in the same household.

6. Diet is a major contributor to children's ingestion exposures.

7. Children's exposures to the target pollutants (and the potential absorbed doses resulting therefrom) are significantly greater than those of adults living in the same household.

CTEPP investigated the exposures of 257 preschool children and their adult care givers to a large number of persistent and non-persistent organic pollutants in their everyday surroundings. These exposures, through the dietary and indirect ingestion, inhalation, and dermal absorption routes, were measured in the participants' homes and child day care environments, in non-occupational settings. The target compounds include OP pesticides and metabolites, OC pesticides, pyrethroid pesticides and a metabolite, acid herbicides, PAHs, phthalates, phenols, PCBs, PAH metabolites, and atrazine. The specific compounds were selected because they may be carcinogenic, mutagenic, acutely or chronically toxic, or possibly disruptive to the human endocrine system, and because they are commonly found in both indoor and outdoor environments.

To minimize selection bias, a population-based, multistaged stratified random sampling plan was devised for the CTEPP study (11). The target population for CTEPP was children between the ages of 18 months and five years. The study consisted of two separate field studies, one conducted in North Carolina (NC) and the other in Ohio (OH). Within each state, four urban and two rural counties were selected randomly according to population, distributed among three distinct geographical regions of each state to ensure a broad range of likely exposures. These regions were the mountains, the Piedmont, and the coastal plain of NC, and northern, central, and southern regions of OH. Two sampling frames, (1) the telephone component (households containing children who do not attend day care) and (2) the day care component (households containing children attending day care centers) were constructed within each state. For the telephone component, a list-assisted, random digit dialing telephone sampling in the selected counties was used. The calculated response rate for the telephone sample was 58% in NC and 57% in OH. For the day care component, 13 centers in the six chosen NC counties and 16 centers in the six chosen OH counties were recruited. Children were then selected randomly from classrooms having children in the eligible age group of two to five years, and their participation was recruited through their parents. The calculated response rates in NC were 53% for day care centers and 50% for day care parents. In OH, the response rates were 57% for OH

day care centers and 31% for OH day care parents. For ease of discussion, the participants from the telephone component are referred to as stay-at-home participants (children) and the participants from the day care component are referred to as day care participants (children) throughout the report

In NC, children and their caregivers in 130 households participated in the study, while in OH, 127 households participated. Approximately half of the children in each state attended day care centers (63 in NC and 58 in OH). About 84% of the NC participants and 87% of the OH participants lived in urban locations. Low-income households, classified according to federal guidelines for the Women, Infants, and Children (WIC) program (185% of the federal poverty level), comprised 46% of the sampled households in NC and 38% of those in OH.

Fifty Standard Operating Procedures (SOPs) were prepared for the CTEPP study, covering subject recruitment, field sampling, storing and shipping of samples, administering questionnaires, data processing, and laboratory procedures. All field activities, laboratory operations, and data handling were performed following these SOPs. The list of the CTEPP SOPs is given in Appendix A.

More than 5,000 discrete personal and environmental samples, including quality control samples, were collected in each state (NC and OH) and analyzed. Additionally, house/building characteristics observation surveys, pre- and post-monitoring questionnaires, day care food menus, and detailed child/adult time-activity and food diaries provided ancillary information necessary to estimate aggregate exposures and to aid in interpretation of the CTEPP data.

Field sampling for the participants from the day care component took place over a 48-h period at each participating child's day care center and simultaneously at his/her home. Field sampling for the participants from the telephone survey component took place over a 48-h period at each participant's home. Environmental and personal samples were collected at the participants homes and/or day care centers:

- to identify the sources of exposures in the participants' environments,
- to determine the important routes of exposure (inhalation, ingestion, and dermal absorption) and,
- to allow estimation of potential exposure and potential absorbed dose through multiple sample media

The environmental samples collected in this study included indoor and outdoor air, outdoor play area soil, and indoor floor (carpet) dust, or if no carpet, hard floor surface wipes. If a pesticide had been applied in the home or day care center in the seven days prior to sampling, transferable residues, hard floor surface wipes, and food preparation surface wipes were also collected. Personal samples collected in this study included drinking water, duplicates of all food and beverages that the participants ate or drank during the 48-h sampling period, hand wipes, and urine. In addition, approximately 10% of the children (26) in OH were videotaped for about 2 h at their homes. Note that the videotaped data are not presented in this report.

The collected field samples and field and laboratory quality control samples were extracted, then analyzed by gas chromatography/mass spectrometry for over 50 target compounds[1]. These compounds included the following:

- two OP pesticides: chlorpyrifos and diazinon;
- two OP metabolites: 2-isopropyl-6-methyl-4-pyrimidinol (IMP) and 3,5,6-trichloro-2-pyridinol (3,5,6-TCP);
- ten OC pesticides: aldrin, *alpha*-chlordane, *gamma*-chlordane, *p.p'*-DDE, *p,p'*-DDT, dieldrin, endrin, heptachlor, lindane, and pentachloronitrobenzene;
- three pyrethroid pesticides: cyfluthrin and *cis*- and *trans*-permethrin;
- one pyrethroid metabolite: 3-phenoxybenzoic acid (3-PBA);
- three acid herbicides: dicamba, 2,4-D, and 2,4,5-T;
- nine PAHs: benz[*a*]anthracene (BaA), benzo[*a*]pyrene (BaP), benzo[*b*]fluoranthene, benzo[*e*]pyrene, benzo[*ghi*]perylene, benzo[*k*]fluoranthene, chrysene, dibenz[*a,h*]anthracene, and indeno[1,2,3-*cd*]pyrene;
- six PAH metabolites: 1-hydroxybenz[*a*]anthracene, 1-hydroxypyrene, 3-hydroxybenz[*a*]anthracene, 3-hydroxybenz[*a*]pyrene, 3-hydroxychrysene, 6-hydroxyindeno[1,2,3-*cd*]pyrene, and 6-hydroxychrysene;
- two phthalates esters: benzylbutyl phthalate and di-*n*-butyl phthalate;
- three phenols: bisphenol-A, nonylphenol, and pentachlorophenol (PCP);
- 17 PCBs: PCBs 10, 15, 28, 44, 52, 70, 77, 95, 101, 105, 110, 118, 126, 138, 153, 169, and 180; and
- one triazine: atrazine.

These pollutants/metabolites, with the exception of atrazine, were analyzed in the multimedia samples. Atrazine was analyzed only in drinking water samples. Only one OP metabolite, 3,5,6-TCP, was analyzed in the NC multimedia samples, while both IMP and 3,5,6-TCP were measured in the OH environmental and personal samples. The NC urine samples were analyzed for the two OP metabolites, IMP and 3,5,6-TCP; 2,4-D; two hydroxy PAHs (1-hydroxybenz[*a*]anthracene and 3-hydroxychrysene); and PCP. The OH urine samples were analyzed for these same metabolites and/or parent compounds, in addition to five hydroxy PAHs (1-hydroxypyrene, 3-hydroxybenz[*a*]anthracene, 3-hydroxybenzo[*a*]pyrene, 6-hydroxychrysene, and 6-hydroxyindeno[1,2,3-*cd*]pyrene) and 3-PBA.

Two similarly formatted CTEPP databases were developed, one for the NC study and one for the OH study. Each database contained questionnaire data, analytical data, and metadata, and provide sufficient documentation to allow the data to be understood by a diverse set of users. Descriptive statistics were calculated for sample size, mean, standard deviation, percentage detected, minimum and maximum reported values, and selected percentiles (25^{th}, 50^{th}, 75^{th}, and

[1]Two carbamates, propoxur and bendicarb, were originally included on the list of target pollutants but were later removed due to the study's analytical methods being incompatible for these pollutants. Atrazine was only measured in drinking water because of co-eluting interference present in other sample media.

95th). The distributions of participant characteristics, activities, and locations that are important for exposure were quantified, based on the questionnaire data. Potential exposures and potential absorbed doses were estimated for selected target compounds, based on the percentage of samples that had detectable levels of these compounds, the measured concentrations, the participants' activity patterns, and assumed physiological parameters. Statistical analyses were performed on log-transformed data, using analysis of variance (ANOVA) models. The data summaries presented in this report represent only the children and their primary caregivers in NC and OH who participated in this study.

This report summarizes the recruitment, field sampling, chemical analyses, data analyses, and the study findings for both the NC and OH field studies.

Chapter 2
Conclusions

2.1 Overview

The CTEPP study examined the aggregate exposures of 257 preschool children to pollutants commonly found in their everyday environments. This study was conducted in six counties each in North Carolina (NC) and Ohio (OH) which are in two different geographical locations – the Southeast and the Midwest – of the United States. The overall goals of this study were (1) to measure the concentrations of the target pollutants in multimedia samples collected at the homes and at day care centers of 257 preschool children in six NC counties and six OH counties, (2) to determine the distributions of child characteristics, activities, and locations that contributed to their exposures, (3) to estimate the aggregate exposures of the preschool children to these pollutants that they may encounter in their everyday environments, and (4) to apportion the routes of exposure. Participants were recruited randomly from selected homes and child day care centers. Monitoring was performed over a 48-h period at the children's homes and/or day care centers. Environmental (air, dust, and soil) and personal (hand wipes, diet, water, urine) samples were collected. In addition, surface wipe samples including hard floor wipes, food preparation, and transferable residue (PUF) samples were collected from homes that had recent pesticide applications. The samples were analyzed by gas chromatography/mass spectrometry (GC/MS) for over 50 pollutants from such chemical classes as the organophosphate (OP) pesticides, organochlorine (OC) pesticides, pyrethroid pesticides, acid herbicides, polycyclic aromatic hydrocarbons (PAHs), phthalates, phenols, polychlorinated biphenyls (PCBs), and the triazine pesticide atrazine. The pollutants were selected because they had been commonly detected in the past in indoor and outdoor environments and/or were potentially carcinogenic, mutagenic, or endocrine disrupting chemicals in humans.

The study showed that the participating NC and OH preschool children were potentially exposed at their homes and day care centers to low levels of many of these pollutants from several sources. In addition, these children were potentially exposed/dosed at low levels to some of these pollutants through several pathways and routes. The conclusions derived from the study apply only to the children and their primary caregivers in NC and OH who participated in this study and cannot be generalized to all preschool children in either state. Therefore, the comparisons between results from NC and OH discussed below apply only to the results for children in the selected NC and OH counties. In addition, this data report has only discussed the potential exposures and potential absorbed doses of these preschool children and their primary caregivers to pollutants in these environments, *not* possible health effects associated with these exposures.

2.2 Goal 1

The CTEPP study's first goal was to measure the concentrations of the target pollutants in multimedia samples collected at the homes and day care centers of 257 preschool children in six NC and six OH counties.

2.2.1 Multimedia Sources of Potential Exposure

Many of the pollutants were detected in several environmental, personal, and biological media at the homes and day care centers of the participating NC and OH children. Pollutants that were detected in 50% or more of the samples in four or more types of environmental or personal media were regarded as "frequently detected" pollutants. For both NC and OH portions of the study, frequently detected pollutants included the following:

- **OP pesticides and metabolite**: chlorpyrifos, diazinon, and 3,5,6-TCP,
- **OC pesticides**: *alpha*-chlordane and *gamma*-chlordane**,**
- **Pyrethroid pesticides:** *cis*-permethrin and *trans*-permethrin,
- **PAHs**: benz[*a*]anthracene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*ghi*]perylene, benzo[*a*]pyrene, benzo[*e*]pyrene, chrysene, indeno[1,2,3-*cd*]pyrene,
- **Phthalates**: benzylbutylphthalate and di-*n*-butylphthalate, and
- **Phenols**: bisphenol-A and pentachlorophenol.

In addition, PCB 52 and IMP (the metabolite of diazinon) were classified as "frequently detected" pollutants within the OH portion of the study. PCB 52 was detected in more than 50% of samples in four types of media in OH but in only two types of media in NC. IMP was analyzed only in OH samples.

For pollutants that were frequently detected in indoor air, indoor floor dust, outdoor air, dermal wipe, and solid food samples, median concentrations within these media are given in Table 2.2.1 for both NC and OH. In both states, these median concentrations were generally higher for the indoor samples compared to the outdoor samples, although similar median values were observed in both indoor and outdoor environments for several PAHs, particularly in NC. Median PAH concentrations in indoor and outdoor air were slightly higher for NC air samples than for OH air samples. Both the NC and OH solid food samples contained only a few pollutants at median levels above the method detection limit (MDL). These pollutants were chlorpyrifos (0.17 and 0.18 ng/g), 3,5,6-TCP (2.3 and 1.9 ng/g), and bisphenol-A (4.1 and 3.5 ng/g), where the numbers in parentheses correspond to median levels in NC and OH solid food samples, respectively. It is of interest to note that median levels of 3,5,6-TCP were about 15 and 10 times higher than the chlorpyrifos levels in solid food samples from NC and OH, respectively. The break-down product of DDT, *p,p'*-DDE, was not classified as a frequently detected pollutant, but it was detected in greater than 50% of solid food samples. The median levels of *p,p'*-DDE were 0.16 and 0.18 ng/g, respectively, in NC and OH solid food samples. In dust samples, median concentrations of several PAHs were at least four times lower in homes and/or day care centers of NC children compared to OH. In dermal wipe samples, median concentrations of all PAHs were higher in OH than in NC. Lastly, median levels of bisphenol-A

were much higher in the dermal wipe samples in NC (5,900 ng/m^2) and OH (4,600 ng/m^2) compared to the other frequently detected pollutants (≤ 530 ng/m^2).

Table 2.2.1. Median Levels of Pollutants Frequently Detected in Air, Dust, Dermal Wipe, and Solid Food Samples Collected at the Homes and Day Care Centers of Preschool Children in NC and OH

	Indoor Air, ng/m^3		Dust, ng/g		Outdoor Air, ng/m^3		Dermal Wipe, ng/m^2		Solid Food, ng/g	
Pollutant/Metabolite	**NC**	**OH**	**NC**	**OH**	**NC**	**OH**	**NC**	**OH**	**NC**	**OH**
Chlorpyrifos	6.1	1.8	140	62	0.28	0.20	160	60	0.17	0.18
Diazinon	2.0	0.97	21	25	0.09	0.15	33	<[a]	<	<
3,5,6-TCP	1.8	0.65	92	42	0.23	0.21	130	78	2.6	1.9
IMP	–[b]	0.53	–	15	–	0.33	–	<	–	0.43[c]
alpha-Chlordane	0.84	0.23	24	11	0.09	0.09	34	<	<	<
gamma-Chlordane	1.5	0.34	36	13	0.13	0.10	42	<	<	<
cis-Permethrin	0.41	<	800	500	<	<	530	240	<	<
trans-Permethrin	0.27	<	730	390	<	<	300	190	<	<
Benz[*a*]anthracene	<	<	130	640	0.064	<	<	31	<	<
Benzo[*b*]fluoranthene	0.13	<	350	1700	0.19	<	<	79	<	<
Benzo[*k*]fluoranthene	<	<	110	620	0.064	<	<	40	<	<
Benzo[*ghi*]perylene	0.12	<	190	930	0.13	<	<	46	<	<
Benzo[*a*]pyrene	0.08	<	200	930	0.09	<	<	40	<	<
Benzo[*e*]pyrene	<	<	190	930	0.095	<	<	57	<	<
Chrysene	0.10	<	180	940	0.12	<	<	53	<	<
Indeno[1,2,3-*cd*]pyrene	0.09	<	180	880	0.095	<	<	41	<	<
Bisphenol-A	1.6	0.98	<	28	<	<	5900	4600	4.1	3.5

[a] "<" indicates that the median value falls below the MDL for the pollutant in this matrix.
[b] IMP was not measured in the NC samples.
[c] Reported value was underestimated because the recoveries of the matrix spike samples were less than 50%.

Although the two phthalates do not appear in Table 2.2.1, their median concentrations were high compared to other pollutants for two or more of the media types included in this table. The phthalate data were corrected for the background levels found in corresponding field blanks. Median concentrations for benzylbutylphthalate were 19,000 ng/g and 7,900 ng/m^2 in dust and dermal wipe samples, respectively, in homes and/or day care centers in NC. For di-*n*-butylphthalate, median concentrations were 6,800 ng/g and 9,000 ng/m^2 in the dust and dermal

wipe samples from NC. In OH, median concentrations of benzylbutylphthalate and di-*n*-butylphthalate were 19,000 and 6,400 ng/g in dust samples and were below the MDL within dermal wipe samples. Note that higher background levels were observed in OH dermal wipe samples compared to NC samples. These background median levels of the MDL were 6,400 and 8,000 ng/m^2 for benzylbutylphthalate, and 1,900 and 8,200 ng/m^2 for di-*n*-butylphthalate, in NC and OH dermal wipes, respectively.

Liquid food and soil media types were not included in Table 2.2.1, because measured concentrations of the frequently detected pollutants were typically low or below the MDL in these media. Only one pollutant, bisphenol-A, had median concentrations in liquid food samples which were above the MDL (0.46 ng/mL in NC and 0.49 ng/mL in OH). Generally, PAH concentrations in soil samples were lower than the corresponding dust samples. Median levels of the frequently detected PAHs ranged from 0.66 to 3.2 ng/g in NC soil and from 12 to 33 ng/g in OH soil. The median level of di-*n*-butylphthalate was 44 ng/g in OH soil, but below the MDL in NC soil.

Table 2.2.2 presents median concentrations of pollutants that were frequently detected in three types of surface samples that were collected after recent pesticide applications at homes in NC and OH (hard floor surface wipe, food preparation surface wipe, and transferable residues [PUF]). Median levels of chlorpyrifos and benzylbutylphthalate in the hard floor surface wipes, along with benzylbutylphthalate in transferable residues, were more than four times greater in samples collected from NC homes than those from OH homes. In addition, median levels of di-*n*-butylphthalate were slightly lower in all three surface sample types collected in NC homes than those from OH homes. In NC, median levels of the pyrethroid pesticides (*cis*- and *trans*-permethrin) ranged from 210 to 600 ng/m^2 in these surface wipes and transferable residue samples and were higher than those of the OP pesticides, while median levels of the pyrethroid pesticides ranged from 31 to 65 ng/m^2 for these sample types in OH homes.

In summary, several pollutants, including chlorpyrifos, 3,5,6-TCP, *cis*-permethrin, *trans*-permethrin, benz[*a*]anthracene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*ghi*]perylene, benz[*a*]anthracene, benzo[*b*]fluoranthene benzo[*k*]fluoranthene, benzo[*ghi*]perylene, benzo[*a*]pyrene, benzo[*e*]pyrene, chrysene, indeno[1,2,3-*cd*]pyrene, benzylbutylphthalate, di-*n*-butylphthalate, and bisphenol-A, were frequently detected in several environmental media such as air, dust, and surface wipes, as well as in personal samples such as dermal wipes and foods, collected at the homes and day care centers of participating children in both states. Therefore, children could be potentially exposed to these pollutants in multiple environmental and personal media through different exposure routes.

Table 2.2.2. Median Levels of Pollutants Measured in Surface Samples Which Were Collected After Recent Pesticide Applications at Homes in NC and OH

Pollutant/Metabolite	Hard Floor Surface Wipe, ng/m^2		Food Prep. Surface Wipe, ng/m^2		Trans. Residue (PUF), ng/m^2	
	NC	OH	NC	OH	NC	OH
Chlorpyrifos	68	16	69	12	35	20
Diazinon	12	<[a]	16	<	33	7.3
cis-Permethrin	500	63	600	<	230	37
trans-Permethrin	400	65	260	<	210	31
Chrysene	25	47	6.4	<	18	16
Benzylbutylphthalate	29,000	6,100	2,100	2,000	28,000	5,400
Di-*n*-butylphthalate	5,000	7,200	3,400	5,500	5,100	7,500
Bisphenol-A	210	660	260	500	410	260

[a] "<" indicates that the median value falls below the MDL for the pollutant in this matrix.

2.2.2 Testing Important Hypotheses

One approach to addressing the first three of the seven hypotheses listed in Section 1.0 was to fit an analysis of variance model to the least squares mean of the log-transformed measurements of target pollutants in various environmental and personal sample media to determine whether these measurements differed significantly between 1) day care and home environments, 2) urban and rural environments, and 3) low-income and middle/high income environments. These measurements represented potential exposure levels for the participating children.

Comparisons between day care centers and home environments: When comparing environmental and personal sample measurements between day care centers and home environments in NC, highly significant differences ($p<0.01$) were frequently observed among the different pollutants and sample media, with higher levels frequently found in day care centers compared to homes. This was especially true for dust when pollutant concentrations were expressed as ng/m^2 (dust loadings). Loadings of diazinon, *alpha*-chlordane, *gamma*-chlordane, *cis*-permethrin, and *trans*-permethrin in dust were 10.0, 11.1, 11.1, 5.6 and 6.3 times higher, respectively, at day care centers than at homes in NC. Loadings of several PAHs (benz[*a*]anthracene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*ghi*]perylene, benzo[*a*]pyrene, benzo[*e*]pyrene, chrysene, dibenz[*a,h*]anthracene, and indeno[1,2,3-*cd*]pyrene) in dust ranged between 7.7 to 8.3 times higher at day care centers than at homes in NC. Loadings of benzylbutylphthalate and di-*n*-butylphthalate were both 10 times higher, and loadings of pentachlorophenol were 4.2 times higher, in dust at day care centers compared to homes in NC. In children's dermal wipe samples, bisphenol-A loadings were three times higher when collected

at day care centers versus homes in NC. However, highly significant differences between day care and home environments occurred less frequently when levels in floor dust were expressed in concentration units (ng/g). These results were partly due to the higher dust loadings measured in carpets at day care centers compared to homes in NC. The mean value of fine dust particle (<150μm) loadings in NC day care centers was more than twice that in NC homes.

Similar to NC, highly significant differences ($p<0.01$) were frequently observed among the different pollutants and sample media in OH, with higher levels frequently found in day care centers compared to homes, especially for dust when expressed as a loading. Loadings of chlorpyrifos, diazinon, 3,5,6-TCP, cyfluthrin, *cis*-permethrin, and *trans*-permethrin were 7.1, 5.9, 3.4, 4.3, 5.0, and 5.3 times higher, respectively, at day care centers than at homes in OH. Similarly, levels of PAHs (benz[*a*]anthracene, benzo[*b*]fluoranthene, benzo[*ghi*]perylene, benzo[*a*]pyrene, benzo[*e*]pyrene, chrysene, dibenz[*a,h*]anthracene, and indeno[1,2,3-*cd*]pyrene) ranged between 5.6 and 6.7 times higher at day care centers than at homes in OH. Loadings of benzylbutylphthalate and di-*n*-butylphthalate were both 7.1 times higher in dust loadings at day care centers compared to homes in OH. In addition, levels of bisphenol-A and PCB 52 were 3.0 and 4.2 times higher, respectively, at day care centers than at homes in OH. However, like for NC, highly significant differences between OH day care and home environments occurred less frequently when levels in floor dust were expressed in concentration units (ng/g), partly due to the amounts of dust at OH day care centers being generally higher (approximately three times) than in OH homes.

Comparisons between urban and rural environments: Only the acid herbicide 2,4-D had dust concentrations (ng/g) which were highly significantly different ($p<0.01$) between urban and rural locations for NC, with concentrations being 3.2 times higher in urban settings compared to rural settings. In OH, there were several pollutants having concentrations in dust which were highly significantly different between urban and rural settings. Concentrations of PAHs (benz[*a*]anthracene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*ghi*]perylene, benzo[*a*]pyrene, benzo[*e*]pyrene, chrysene, dibenz[*a,h*]anthracene, and indeno[1,2,3-*cd*]pyrene) in OH dust samples ranged from 3.3 to 4.0 times higher in urban compared to rural environments. When PAH levels in dust were expressed as loadings (ng/m^2), the levels of benz[*a*]anthracene and chrysene were 3.2 and 3.0 times higher in urban than rural environments.

Comparisons between low-income and middle/high-income environments: In NC, several pollutants and sample media had highly statistically significant ($p<0.01$) differences occurring for children in the low-income compared to middle/high-income groups. Concentrations (ng/m^3) of diazinon, *cis*-permethrin, and *trans*-permethrin in indoor air samples were 3.6, 4.2, and 3.9 times higher, respectively, for low-income households than middle/high-income households. Loadings (ng/m^2) of diazinon, 3,5,6-TCP, *cis*-permethrin, and benzylbutylphthalate in NC dust samples were 6.3, 3.4, 3.2, and 4.8 times higher, respectively, for low-income households than for middle/high-income households. In contrast, concentrations of 2,4-D in dust samples (ng/g) were 4.5 times higher for middle/high-income households compared to low-income households.

In OH, loadings of chlorpyrifos in dust samples (ng/m^2) were 3.4 times higher in low-income households compared to middle/high-income households. In contrast, concentrations of

2,4-D in dust samples (ng/g) were 4.2 times higher in middle/high-income households than in low-income households.

Summary: As determined from analyses performed on environmental and personal sample media measurements, highly significant differences in floor dust loadings (ng/m^2) occurred between day care and home environments in both NC and OH for diazinon, the pyrethroid pesticides, the nine PAHs, and the two phthalates, with loadings at homes averaging less than one-third of the loadings observed in day care centers. These results were partly due to the higher levels of dust in the carpets at day care centers compared to homes in both states. NC preschool children were potentially exposed to higher levels of 2,4-D in dust samples (ng/g) within an urban location compared to a rural setting, suggesting that 2,4-D may have been used as a lawn herbicide for weed control more frequently in urban than in rural locations. OH children were potentially exposed to higher levels of several PAHs in dust (ng/g and ng/m^2) when in an urban location compared to a rural setting; PAH concentrations (ng/g) tended to be at least two times higher in urban dust samples than in rural dust samples in OH. Through indoor air, NC preschool children were potentially exposed to higher levels of diazinon, *cis*-permethrin, and *trans*-permethrin when in low-income environments compared to middle/high-income households. In addition, the NC preschool children were exposed to higher levels of diazinon, 3,5,6-TCP, *cis*-permethrin, and benzylbutylphthalate in dust (ng/m^2) when in low-income compared to middle/high-income households. However, concentrations of 2,4-D tended to be higher in dust samples (ng/g) from middle/high-income than from low-income households. In OH, levels of chlorpyrifos in dust (ng/m^2) were higher in low-income than in middle/high-income households, while concentrations of 2,4-D in dust samples were higher in middle/high-income households compared to low-income households.

2.3 Goal 2

The second goal of the CTEPP study was to determine the distributions of child characteristics, activities, and locations that contributed to their exposures. The factors that were considered important for determining the children's and their primary caregiver's potential exposures and potential absorbed doses to pollutants were the following:

- physical characteristics of the participant (body weight and hand surface area),
- children's activity patterns (frequency of placing toys and other objects in the mouth, pacifier use, teething, and frequency of washing hands),
- locations where children spent their time (indoor and outdoors at homes, at day care centers, or other locations)
- volume of liquid and weight of solid food consumed by the participant over a 24-h period.

These factors were used in the algorithms to estimate the children's exposures to pollutants at homes and/or day care centers through the inhalation and ingestion (dietary and indirect) routes of exposure. Exposures via the dermal route were not estimated for the children in this study.

2.4 Goal 3

The third goal of the CTEPP study was to estimate potential exposure level (ng/day) and potential absorbed dose (ng/kg/day) of the pollutants that the study participants may encounter in their everyday environments. ***Potential exposure*** (ng/day) is defined as the total amount of a pollutant that an individual comes in contact with over a 24-h period. ***Potential absorbed dose*** (ng/kg/day) is defined as the total dose that could be absorbed in the body by the three routes of exposure over a 24-h period, relative to the participant's body weight (kg). For each exposure route, potential absorbed dose was estimated by assuming a 50% absorption rate for all pollutants and participants. ***Aggregate potential exposure*** and ***aggregate potential absorbed* dose** were defined as the sums of the estimated potential exposure and potential absorbed dose, respectively, across all three exposure routes.

These estimates were made for selected pollutants via up to three routes of exposure (inhalation, dietary ingestion, and indirect ingestion). Then, for those pollutants having estimates available for all three exposure routes, aggregated potential exposure level and aggregated potential absorbed dose were calculated as the sum of the exposure/dose estimates across the three routes.

For each state, the following pollutants were considered for estimating potential exposure level and potential absorbed dose for the study participants:

- **OP pesticides/metabolite**: chlorpyrifos, diazinon, and 3,5,6-TCP,
- **OC pesticides**: *alpha*-chlordane, *gamma*-chlordane, *p,p'*-DDE, and heptachlor (NC only),
- **Pyrethroid pesticides**: cyfluthrin, *cis*-permethrin, and *trans*-permethrin,
- **Acid herbicide**: 2,4-D,
- **PAHs**: benz[*a*]anthracene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*ghi*]perylene, benzo[*a*]pyrene, benzo[*e*]pyrene, chrysene, dibenz[*a,h*]anthracene, and indeno[1,2,3-*cd*]pyrene,
- **Phthalates**: benzylbutylphthalate and di-*n*-butylphthalate,
- **Phenols**: bisphenol-A and pentachlorophenol, and
- **PCBs**: congeners 52, 95, and 101.

For most of these pollutants, potential exposure level and potential absorbed dose were estimated under a given exposure route for the study participants in a given state only when at least 45% of the samples collected in that state had detectable measurements for each media type entering into the calculation of the estimates.

For each state, aggregated potential exposure level and aggregated potential absorbed dose was estimated for the following eight pollutants (based on availability of exposure/dose estimates for each of the three exposure routes):

- **OP pesticides/metabolite**: chlorpyrifos, diazinon, and 3,5,6-TCP,
- **Pyrethroid pesticides**: *cis*-permethrin and *trans*-permethrin,
- **Acid herbicide**: 2,4-D,

- **Phthalate**: di-*n*-butylphthalate, and
- **Phenol**: bisphenol-A

2.4.1. Estimated Potential Exposure Levels for NC and OH Preschool Children

Potential exposure level (ng/day) was defined as the total amount of a pollutant that an individual comes in contact with over a 24-h period. The estimated potential exposure levels of the participating NC and OH preschool children were quantified by one or more routes of exposure for each of the pollutants mentioned above.

For the NC children, the estimated median potential exposure levels were highest for di-*n*-butylphthalate (1,800 ng/day) through the inhalation route of exposure, followed by lower levels of heptachlor (62 ng/day) and chlorpyrifos (47 ng/day). Estimated exposures to other pollutants via the inhalation route were less than 20 ng/day. When considering the dietary ingestion route, median potential exposure levels for NC children were highest for di-*n*-butylphthalate (39,000 ng/day), bisphenol-A (2,700 ng/day), and 3,5,6-TCP (1,200 ng/day), while exposures to other pollutants were less than 200 ng/day. When considering the indirect ingestion route, median potential exposure levels for NC children were highest for benzylbutylphthalate (920 ng/day) and di-*n*-butylphthalate (350 ng/day), *cis*-permethrin (48 ng/day), and *trans*-permethrin (35 ng/day) while estimated exposures to other pollutants were less than 10 ng/day.

For the OH children, the estimated median potential exposure levels were highest for di-*n*-butylphthalate (2,000 ng/day) through the inhalation route of exposure, followed by lower levels of pentachlorophenol (18 ng/day) and chlorpyrifos (15 ng/day). Estimated exposures to other pollutants via the inhalation route were less than 10 ng/day. When considering the dietary ingestion route, median potential exposure levels for OH children were highest for benzylbutylphthalate (9,400 ng/day), bisphenol-A (1,700 ng/day), and 3,5,6-TCP (860 ng/day), while exposures to other pollutants were less than 150 ng/day. When considering the indirect ingestion route, median potential exposure levels for OH children were highest for benzylbutylphthalate (630 ng/day) and di-*n*-butylphthalate (210 ng/day), while exposures to PAHs except for dibenz[*a*,*h*]anthracene (6.2 to 53 ng/day) and to *cis*- and *trans*-permethrin (18 and 12 ng/day) were each greater than 10 ng/day, and estimated exposures to other pollutants were less than 10 ng/day. These results suggest that participating children had the highest potential exposure levels to phthalates through all three routes of exposure.

2.4.2. Estimated Potential Absorbed Doses for NC and OH Preschool Children

Potential absorbed dose (ng/kg/day) was defined as the total amount that could be absorbed into the body over a 24-h period, relative to the child's body weight (kg). For each exposure route, potential absorbed dose was estimated under the assumption that all pollutants had a 50% absorption rate into the body for all exposure routes (17). The estimated potential absorbed doses of the NC and OH preschool children were quantified by one or more routes of exposure for each of the pollutants mentioned above.

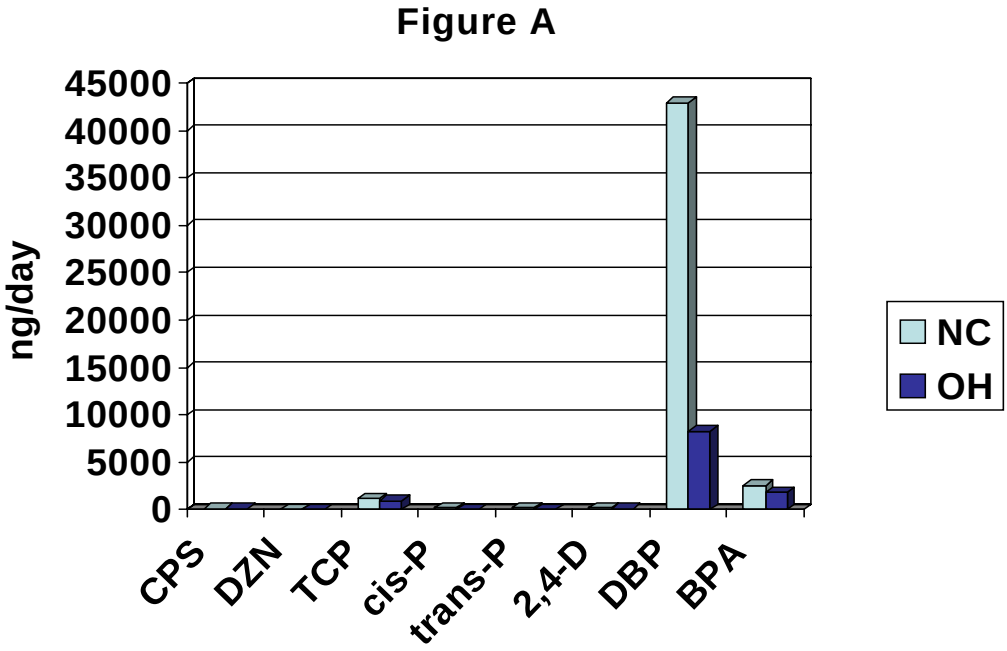
For the NC children, estimated median potential absorbed doses were highest for di-*n*-butylphthalate (56 ng/kg/day) through the inhalation route of exposure, followed by much lower concentrations for heptachlor (1.7 ng/kg/day) and chlorpyrifos (1.4 ng/kg/day). When considering the dietary ingestion route, median potential absorbed doses for NC children were highest for di-*n*-butylphthalate(1,100 ng/kg/day), followed by bisphenol-A (74 ng/kg/day). Benzylbutylphthalate had the highest estimated median potential absorbed doses (26 ng/kg/day) under the indirect ingestion route of exposure, followed by di-*n*-butylphthalate (9.7 ng/kg/day).

For the OH children, estimated median potential absorbed doses were highest for di-*n*-butylphthalate (57 ng/kg/day) through the inhalation route of exposure, while all other pollutants had estimated median potential absorbed doses via the inhalation route of less than 0.6 ng/kg/day. When considering the dietary ingestion route, median potential absorbed doses for OH children were highest for benzylbutylphthalate (270 ng/kg/day), bisphenol-A (52 ng/kg/day) and 3,5,6-TCP (25 ng/kg/day), while median estimated potential absorbed doses through the indirect ingestion route were highest for benzylbutylphthalate (18 ng/kg/day), followed by di-*n*-butylphthalate (5.7 ng/kg/day). Like for potential exposure level, these results suggest that the preschool children had the highest potential absorbed doses to the phthalates through all three routes of exposure.

2.4.3. Estimated Aggregated Potential Exposure Levels for NC and OH Preschool Children

Aggregated potential exposure (ng/day) was defined as the sum of the estimated potential exposure levels across all three exposure routes – inhalation, direct ingestion and indirect ingestion – and was estimated for the eight pollutants mentioned earlier. Figure 2.4.1 presents median values of the aggregated potential exposure levels for the study participants.

NC children had the highest median aggregated potential exposure levels to di-*n*-butylphthalate (42,900 ng/day), followed by bisphenol-A (2,560 ng/day), and 3,5,6-TCP (1,230 ng/day), while the lowest median aggregated potential exposure level was observed for diazinon



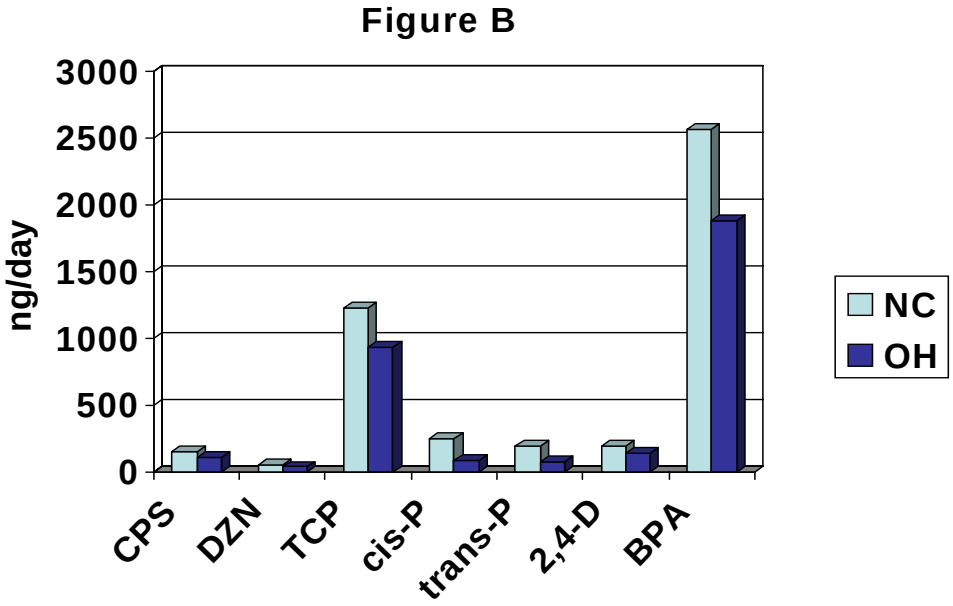


Figure 2.4.1 Estimated Median Aggregate Potential Exposure Levels of NC and OH Preschool Children to Eight Pollutants in Their Everyday Environments.

Legend: CPS = Chlorpyrifos; DZN = Diazinon; TCP = 3,5,6-Trichloro-2-pyridinol *Cis*-P and *Trans*-P = *Cis*- and *Trans*-Permethrin; 2,4-D = 2,4-Dichlorophenoxyacetic acid; DBP = Di-*n*-butylphthalate; BPA = Bisphenol-A

Note: Figures A and B are equivalent, except Figure B excludes DBP.

(51.6 ng/day). OH children had the highest median aggregate potential exposure levels to di-*n*-butylphthalate (8,310 ng/day), bisphenol-A (1,880 ng/day), and 3,5,6-TCP (930 ng/day), while the lowest median aggregate potential exposure level was observed for diazinon (38.6 ng/day). Thus, children in both states had the highest potential aggregate exposures to di-*n*-butylphthalate, bisphenol-A, and 3,5,6-TCP in their everyday environments. However, NC children had five times greater median aggregate potential exposure levels to di-*n*-butylphthalate than OH children.

2.4.4. Estimated Aggregated Potential Absorbed Doses for NC and OH Preschool Children

Aggregate potential absorbed dose (ng/kg/day) was defined as the sum of the estimated potential absorbed dose across all three exposure routes – inhalation, dietary ingestion, and nondietary ingestion – and was estimated for the eight pollutants mentioned earlier. Figure 2.4.2 presents median values of the aggregated potential absorbed doses for the study participants.

The NC and OH children had the highest median aggregated potential absorbed doses to di-*n*-butylphthalate (1,250 and 262 ng/kg/day) and bisphenol-A (71.4 and 60.8 ng/kg/day), respectively. Both the NC and OH children had the lowest median aggregated potential doses to diazinon (1.44 and 1.13 ng/kg/day), respectively.

The results show that both the NC and OH children had the highest estimated aggregated potential absorbed doses to di-*n*-butylphthalate in their everyday environments. However, the NC children had over four times greater median aggregated potential absorbed doses of di-*n*-butylphthalate than the OH children.

2.4.5 Urinary Biomarker Concentrations as a Indicator of Absorbed Dose

Several acid pollutants and metabolites were measured in urine samples collected over the 48-h sampling period from each study participant. Of these, 3,5,6-TCP, 2,4-D, and pentachlorophenol were used as indicators of aggregated potential absorbed doses. For NC children, median urinary concentrations were 5.3 ng/mL for 3,5,6-TCP (98% detected), 0.7 ng/mL for 2,4-D (94% detected), and 0.4 ng/mL for pentachlorophenol (89% detected). Similar median levels were observed for OH children: 5.1 ng/mL for 3,5,6-TCP (100% detected), 1.0 ng/mL for 2,4-D (98% detected), and 0.8 ng/mL for pentachlorophenol (99% detected).

In urine samples, NC and OH children had at least five times greater levels of 3,5,6-TCP compared to 2,4-D and pentachlorophenol. Overall, NC and OH children were exposed to low levels of these pollutants or their metabolites at their homes and/or day care centers over the 48-h sampling period.

2.4.6. Testing Important Hypothesis

Analyses of estimated potential exposure levels, potential absorbed doses, aggregated potential exposure levels, aggregated potential absorbed doses, and urinary concentrations of the participating children were performed to address the first three of the seven hypotheses listed in

Figure A

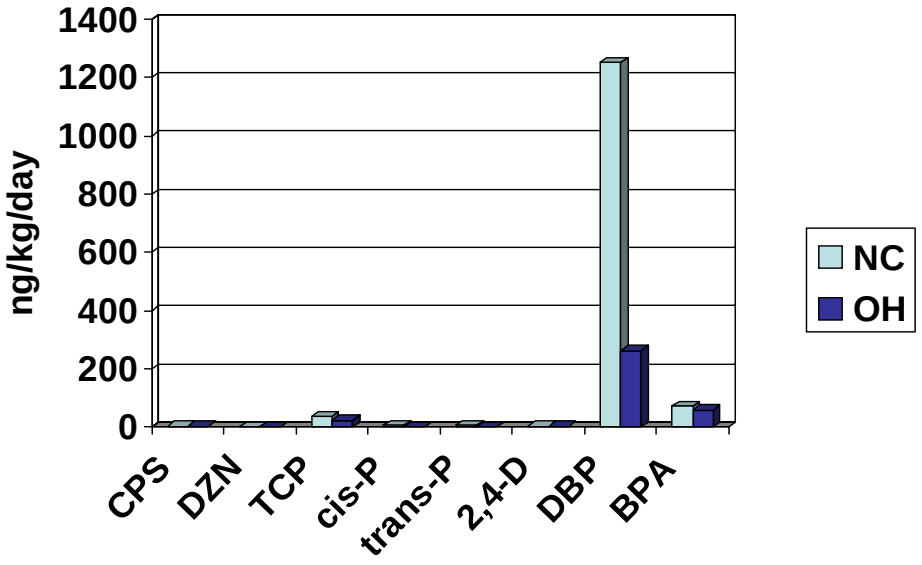


Figure B

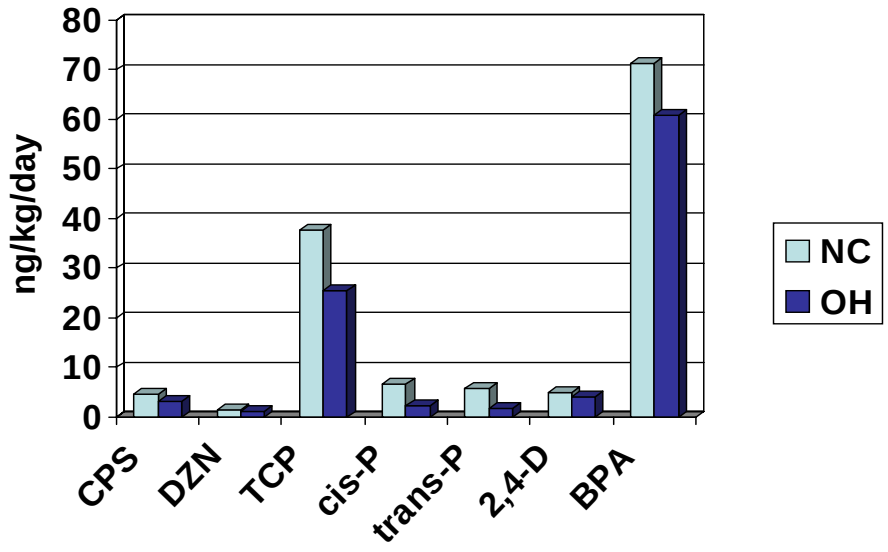


Figure 2.4.2 Estimated Median Aggregate Potential Doses of NC and OH Preschool Children to Eight Pollutants in Their Everyday Environments

Legend: CPS = Chlorpyrifos; DZN = Diazinon; TCP = 3,5,6-Trichloro-2-pyridinol *Cis*-P and *Trans*-P = *Cis*- and *Trans*-Permethrin; 2,4-D = 2,4-Dichlorophenoxyacetic acid; DBP = Di-*n*-butylphthalate; BPA = Bisphenol-A

Note: Figures A and B are equivalent, except Figure B excludes DBP.

Section 1.0. An analysis of variance approach was taken to determine whether these estimates and concentrations differed significantly between 1) day care children and stay-at-home children, 2) children in urban and rural environments, and 3) children in low-income and middle/high-income environments.

The comparisons between the exposures of children and adults in the same households in NC and OH are not discussed in this section. The results in chapter 9 showed that children were generally exposed to significantly higher levels of pollutants than adults in the same household, however, these results were likely due to differences in physiological factors (i.e., ventilation rates and body weights), activity patterns (i.e., hand-to-mouth and object-to-mouth), or consumption of different types of food.

Comparisons between day care children and stay-at-home children: For the nine PAHs and for benzylbutylphthalate via the indirect ingestion route, OH day care children ranged up to 3.3 times higher potential exposures and potential absorbed doses compared to stay-at-home children, and these differences were highly significant. For the dietary ingestion exposure route, highly significant differences existed in potential exposure level and/or potential absorbed dose between OH day care children and stay-at-home children for *cis*- and *trans*-permethrin and for benzylbutylphthalate, with day care children having approximately three times the levels, on average, compared to stay-at-home children. For NC children, potential exposure level or potential absorbed dose for one group (day care children or stay-at-home children) was always less than three times the value of the second group, on average, across the pollutants and exposure routes.

Comparisons between children in urban and rural environments: NC children who lived in urban counties had 3.4 times and 3.7 times higher potential exposures and potential absorbed doses, respectively, to 2,4-D through the indirect ingestion route of exposure compared to rural children, and these differences were highly significant ($p<0.01$). Similarly, OH children living in urban counties had 3.2 to 3.7 times higher potential exposures and potential absorbed doses of each of the nine PAHs through the indirect ingestion route of exposure compared to rural children, and these differences were highly significant.

Comparisons between children in low-income and middle/low- income environments: Between low-income and middle/high-income children in both NC and OH, potential exposure and potential absorbed dose estimates of 2,4-D were highly significantly different under the indirect ingestion route, with low-income children averaging 30% or less of the estimates of middle/high-income children, on average.

Summary: The largest differences between urban and rural children, between day care and stay-at-home children, and between low-income and middle/high-income children in potential exposure level and potential absorbed dose, as well as the most frequent occurrences of significant differences, occurred within the indirect ingestion exposure route for both states. There were relatively few occurrences of highly significant differences between population strata for either aggregated potential exposure levels or aggregated potential absorbed dose among the eight pollutants for which these measures were calculated for the study participants, and no

difference deemed to be highly significant was at least three times larger, on average, for one stratum versus another. There were no highly significant differences in urinary concentrations of 3,5,6-TCP, 2,4-D or pentachlorophenol between any strata.

2.5 Goal 4

The fourth goal of the CTEPP study was to apportion the aggregated potential exposure levels and aggregated potential absorbed dose estimates for the NC and OH children across the inhalation, dietary ingestion, and indirect ingestion routes of exposure. These aggregated potential exposure levels and aggregated potential absorbed doses could be quantified through the three routes of exposure for eight pollutants: chlorpyrifos, diazinon, 3,5,6-TCP, *cis*-permethrin, *trans*-permethrin 2,4-D, di-*n*-butylphthalate, and bisphenol-A. Statistical analyses involved calculating the proportions of the aggregate potential exposure levels and aggregate potential doses by each route of exposure for each child, then fitting a logistic regression model to these proportions to estimate mean proportions as a function of environmental type, urbanicity, and income status.

Figures 2.5.1 and 2.5.2 illustrate the overall estimates of the mean proportions by route of exposure for NC and OH children, respectively. The results show that for both states, the dietary ingestion route was the primary route of exposure to all eight pollutants. Greater than 92% of the aggregated potential exposure levels and aggregated potential absorbed doses of the children were to bisphenol-A, 3,5,6-TCP, 2,4-D, and di-*n*-butylphthalate through the dietary ingestion route of exposure. In addition, about 50% of the aggregated potential exposure levels and potential absorbed doses of *trans*-permethrin, *cis*-permethrin, diazinon, and chlorpyrifos were through the dietary ingestion route of exposure. The OP pesticides, chlorpyrifos and diazinon, contributed most to the inhalation route of exposure for NC and OH children, while the pyrethroids, *cis*-permethrin and *trans*-permethrin, contributed most to the indirect ingestion route of exposure. Therefore, children in both states were predominantly exposed to the eight chemicals through ingestion, primarily dietary in nature.

Mean proportions associated with each exposure route were also calculated by stratum (urban children, rural children, low-income children, middle/high-income children, day care children, stay-at-home children), and statistical analysis was performed to determine whether a particular type of stratum (urbanicity, income level, day care attendance) had a significant effect on the mean proportion for a given exposure route. Results of this analysis showed that there were several highly statistically significant ($p<0.01$) differences in the exposures of NC or OH children between pairs of strata. However, these statistically significant differences between each strata were frequently not realistically meaningful, except in some instances. For example, for diazinon, mean proportions for the inhalation route of exposure differed significantly ($p<0.01$) between low-income children (46%) and middle/high-income children (34%) for NC children.

For the NC and OH children, Table 2.5.1 presents the relative importance of the children's exposures to the eight target pollutants through the inhalation, dietary ingestion, and indirect ingestion routes of exposure.

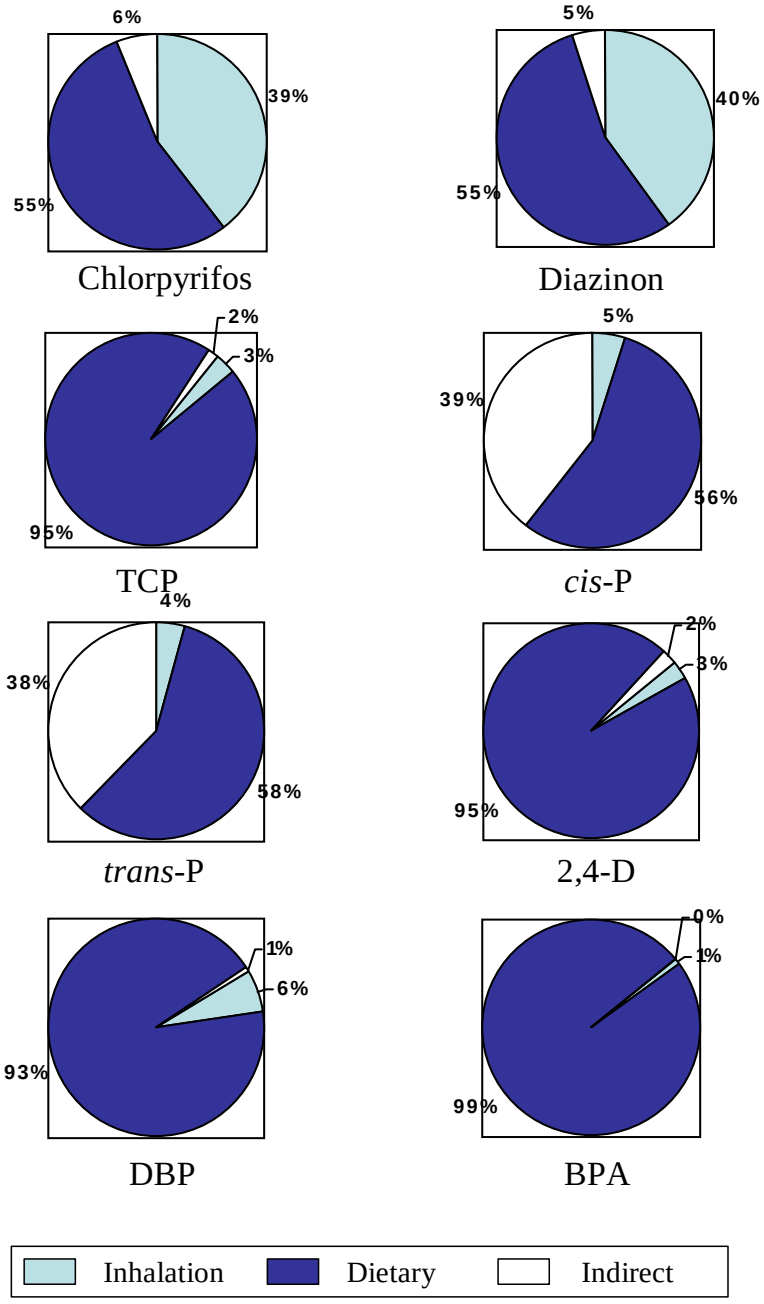


Figure 2.5.1 Estimated Mean Proportion of Aggregated Potential Exposure and Potential Absorbed Dose for NC Children, by Exposure Route

Legend: TCP = 3,5,6-Trichloro-2-pyridinol; *Cis*-P and *Trans*-P = *Cis*- and *Trans*-Permethrin; 2,4-D = 2,4-Dichlorophenoxyacetic acid; DBP = Di-*n*-butylphthalate; BPA = Bisphenol-A.

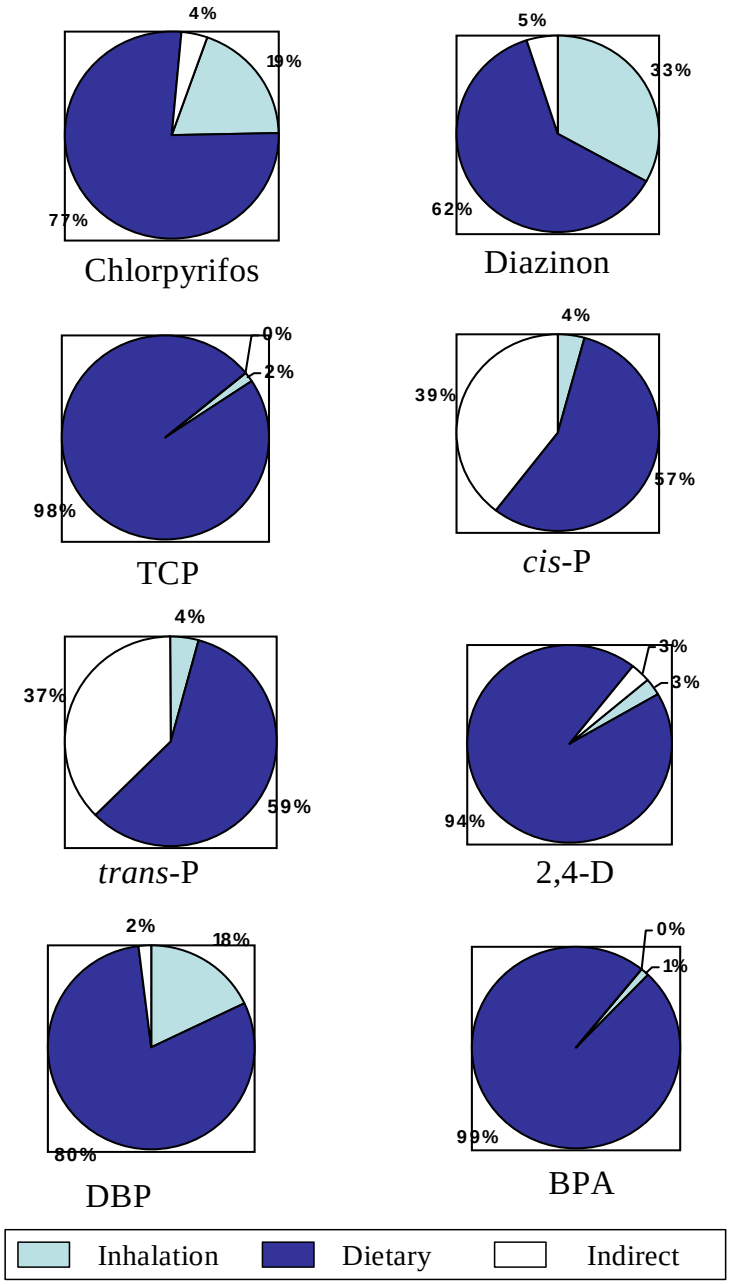


Figure 2.5.2 Estimated Mean Proportion of Aggregated Potential Exposure and Potential Absorbed Dose for OH Children, by Exposure Route

Legend: TCP = 3,5,6-Trichloro-2-pyridinol; *Cis*-P and *Trans*-P = *Cis*- and *Trans*-Permethrin; 2,4-D = 2,4-Dichlorophenoxyacetic acid; DBP = Di-*n*-butylphthalate; BPA = Bisphenol-A. .

Table 2.5.1 The Relative Importance of the NC and OH Children's Exposures to the Eight Pollutants Through the Inhalation, Dietary Ingestion, and Indirect Ingestion Routes of Exposure.

Chemical Class	Pollutant(s)	Apportionment of Aggregated Exposure/Dose
OP Pesticides	Chlorpyrifos	***NC:*** dietary ingestion . inhalation > indirect ingestion
	Diazinon	***OH:*** dietary ingestion > inhalation > indirect ingestion
OP Metabolite	3,5,6-TCP	***NC:*** dietary ingestion > inhalation > indirect ingestion
		OH: dietary ingestion > inhalation > indirect ingestion
Pyrethroid Pesticides	*cis*-Permethrin	***NC:*** dietary ingestion . indirect ingestion > inhalation
	trans-Permethrin	***OH:*** dietary ingestion > indirect ingestion > inhalation
Acid Herbicide	2,4-D	***NC:*** dietary ingestion > inhalation > indirect ingestion
		OH: dietary ingestion > indirect ingestion . inhalation
Phthalate	Di-*n*-butylphthalate	***NC:*** dietary ingestion > inhalation > indirect ingestion
		OH: dietary ingestion > inhalation > indirect ingestion
Phenol	Bisphenol-A	***NC:*** dietary ingestion > inhalation > indirect ingestion
		OH: dietary ingestion > inhalation > indirect ingestion

In summary, the NC and OH children had similar mean proportions of aggregated potential exposure level and of aggregated potential absorbed dose for the eight pollutants across the three routes of exposure considered in this study. The dominant route of exposure for these children was through dietary ingestion for all eight pollutants. The OP pesticides, chlorpyrifos and diazinon, contributed most to the inhalation route of exposure, while the pyrethroids, *cis*- and *trans*-permethrin contributed most to the indirect ingestion route of exposure.

Chapter 3
Recommendations

The CTEPP study has provided a wealth of data on young children's exposures to pollutants in their everyday environments. The study findings indicate that the participating children in NC and OH could have been potentially exposed and could have acquired potential doses to low levels of many of the targeted pollutants from several sources, through several pathways and routes.

EPA will use these data in the future for the following:

- To estimate the dermal exposures of the NC and OH preschool children to the eight most prevalent pollutants, in order to estimate better their aggregate exposures to these pollutants in their everyday environments.

- To refine the algorithms that are currently used to determine children's potential exposures and potential absorbed doses to these pollutants.

- To refine models and human health risk assessments, particularly for children.

- To compare the levels of potential exposure and potential absorbed doses with possible human health effects, particularly in children.

Chapter 4
Sampling Design and Participant Recruitment

4.1 Sampling Design

A population-based, stratified random sampling design (Figure 4.1.1) was developed to collect the data needed to meet the objectives of the study. In each state, four urban and two rural counties, representing three distinct geographical areas in the state, were randomly selected. Within these counties, there were two sampling frames (components), which were designed to allow testing of the study hypotheses, and in particular, to test whether the children's exposures are significantly different at day care versus at home. The first sampling component, the telephone component, was composed of households that were selected randomly through list-assisted telephone sampling. The telephone component enrolled households with preschool children who did not attend day care. The second sampling component, the day care component, was composed of child day care centers that were randomly selected and enrolled households with preschool children who did attend day care. Within these components, the households and child day care centers were stratified by income.

In both North Carolina (NC) and Ohio (OH), six counties were selected using stratified random sampling. Because of stratification, the samples represented different regions, urban and rural areas, and low-income and middle/high-income areas of each state. The sample selection process targeted counties with larger population and in particular, larger population in the low-income groups, by selecting counties using probabilities proportional to size (PPS) within each stratum. The county population in the low-income segment was used as a measure of size. This approach ensured greater representation of low-income families than would have occurred otherwise. The locations of these counties in the two states are shown in Figure 4.1.2. The selected counties were in three distinct geographical areas in each state. In NC, these geographical areas were the coastal plain, the Piedmont, and the mountains. In OH, the areas were the northern, central, and southern regions.

Within each of the two states, the samples were further stratified according to degree of urban character (urbanicity) and family income. The urbanicity stratification was imposed at the first stage of selection by classifying counties as predominantly urban or rural. A county was considered urban if it was within or contained wholly or in part a Metropolitan Statistical Area (MSA) as defined by the Office of Management and Budget (OMB Bulletin No. 99-04). Income stratification was performed at subsequent stages of selection for the day care component and the telephone component. This stratification was used to distinguish between low-income and middle/high-income households and day care centers. Day care centers were classified as low-income if they received Federal assistance to serve low-income clients under the Head Start

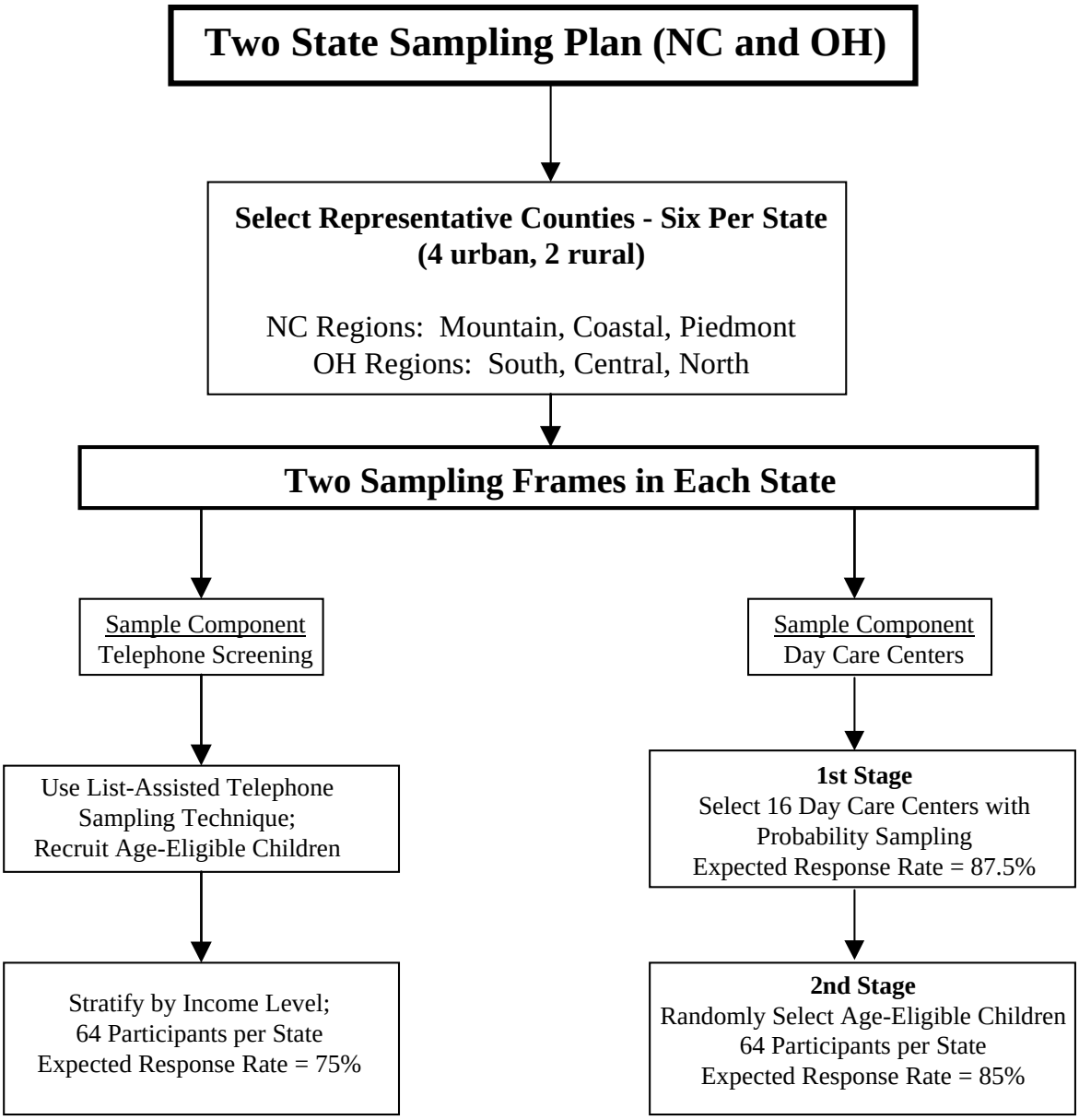
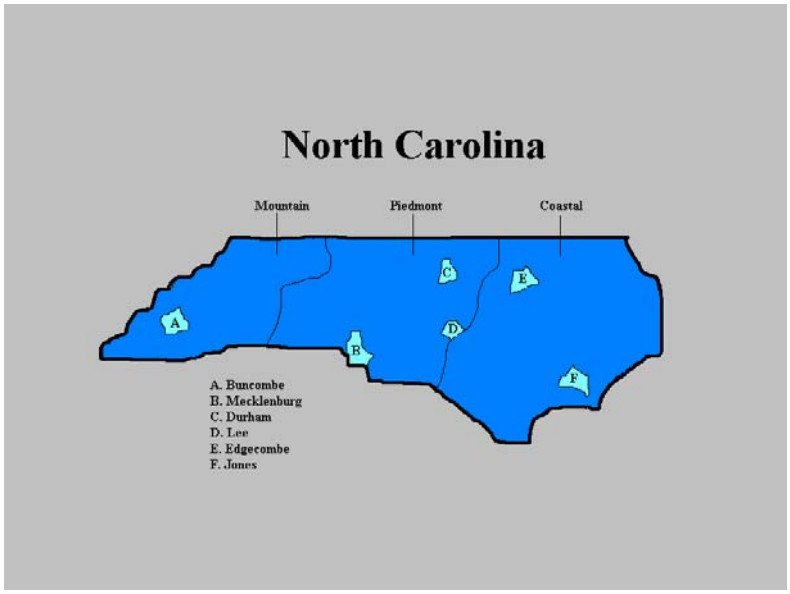
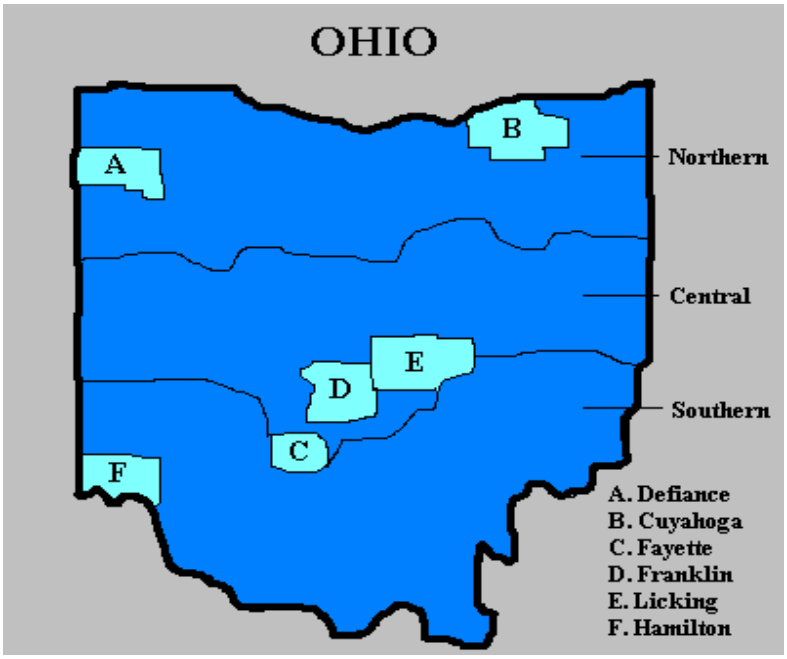


Figure 4.1.1 CTEPP Overall Sampling Design



A



B

Figure 4.1.2 Six Counties in North Carolina (A) and Ohio (B) Selected by Stratified Random Sampling

program. Low-income families were classified according to the federal guidelines for assistance eligibility under the Women, Infants, and Children program (WIC, 2000). A household was classified as low-income if its household income was below 185% of the federal poverty guidelines (Federal Register, 2000). In 2000, the WIC eligibility level for a family of two was $20,813 and for a family of four was $31,534.

In the day care component, all eligible child day care centers in the six selected counties were identified. A child day care center was considered eligible if it was a commercial or not-for-profit service provider, which provided child care services to seven or more preschool children at a location other than the service provider's personal residence. During the second-stage sampling frame, these centers were divided into the two income strata. From these strata, a random sample of targeted centers and a random sample of eligible children within each participating center were selected. In the telephone component, a random sample of telephone numbers was selected, using list-assisted telephone sampling techniques in the six counties in each state. The anticipated sample size was 128 children in each state, with half (64) from the day care center sample (children who attended day care) and the other half (64) from the telephone sample (children who did not attend day care). This dual frame approach provided maximum coverage for the target population.

4.2 Recruitment

4.2.1 Recruitment of the Day Care Center Component

Recruitment of the day care center component was conducted in two stages, as diagramed in Figure 4.2.1. In the first stage, master lists of all day care centers in NC and of all those in OH were compiled. For the six target counties in each state, a complete list of day care centers in each county was prepared and sorted by urbanicity and income. From these lists, approximately 16 centers were targeted for selection; of these at least four were Head Start centers, which served primarily low-income clients. The centers were contacted through telephone calls and mailings. In the second stage of the day care center component, eligible children who attended the day care centers were selected randomly from up to two classrooms in each participating center. Classroom information was requested from each of the centers. Parents or primary caregivers were contacted through the centers, as discussed below, to obtain informed consent for study participation.

Because every eligible child day care center must be licensed to operate in its state, the state licensing agencies were the main sources of comprehensive lists of centers in both NC and OH. Additionally, to ensure the completeness of the master lists of child day care centers, the lists obtained from the state agencies were supplemented with information on centers from other sources. The most updated CD-ROM national telephone database (Pro-CD, 1999-2000, infoUSA Inc.) was searched, and a list of eligible day care centers in the target counties was prepared. In addition to the CD-ROM national telephone database, an Internet search was done. Centers that appeared on the CD-ROM national telephone database and/or the Internet were cross-checked against the lists provided by state licensing agencies. Centers that appeared on the

CD-ROM national telephone database and/or Internet, but did not appear on the list from state licensing agencies, were called to determine the eligibility status of the center. Additional eligible centers were then added to the master list.

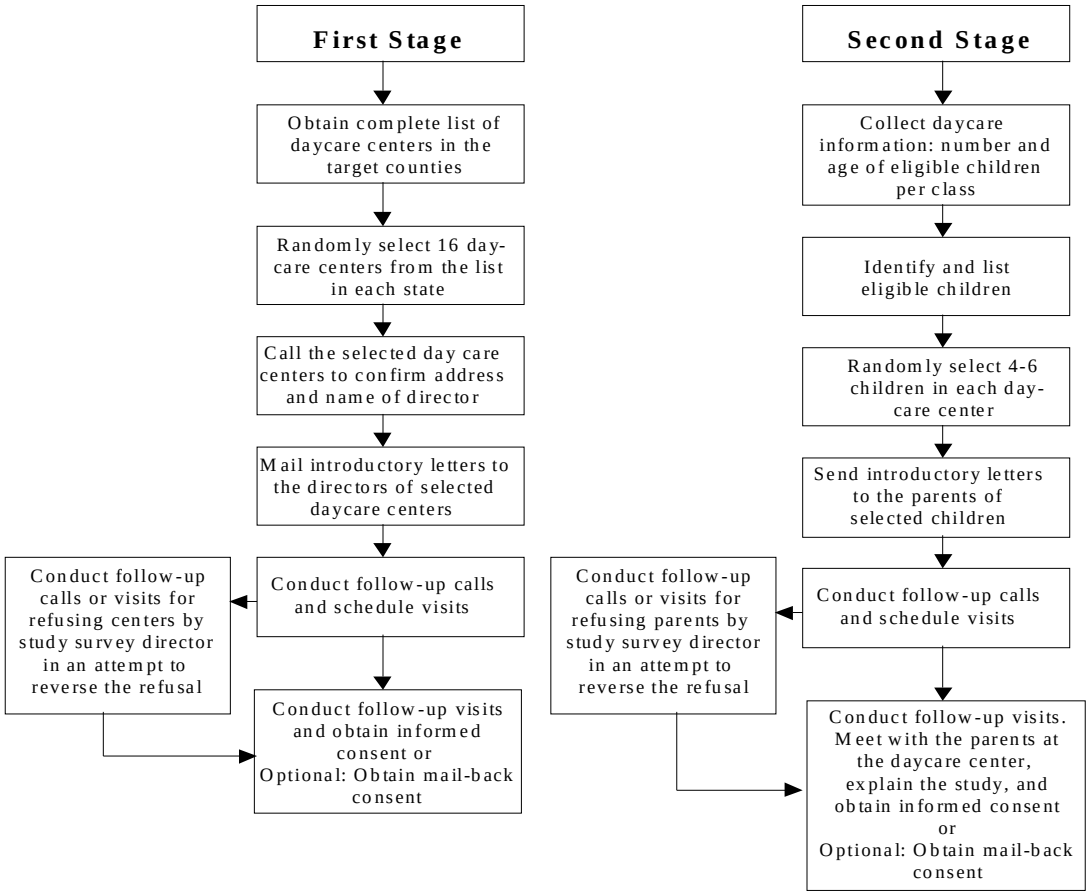


Figure 4.2.1 Procedures for Recruiting Day Care Center Component

This sampling component was then stratified by county and by whether or not the center received Federal assistance to serve low-income clients (Head Start centers). Within each stratum, day care centers were selected, with probability proportional to the number of children enrolled in the center. A total of 16 centers, including at least four Head Start centers, were targeted for recruitment in each state. Further details on the day care center sample recruitment can be found in the recruitment reports from NC and OH (Appendix B).

Screening calls were conducted by the recruitment team, to confirm the addresses of the selected centers and the names of the center directors. After confirmation, the recruitment team sent an introductory letter, a study brochure, and a gift certificate (as incentive for the center to participate) to each day care center director by overnight express mail. Approximately three days after the letters were mailed, the recruitment team made follow-up calls to each director. To encourage participation of each center, the team made follow-up visits to the center director, and the Battelle field team leader contacted the center as needed. The first stage recruitment activities were completed by obtaining informed consent forms from each day care center.

The second sampling stage of the day care component involved selecting a random sample of eligible children from up to two classrooms in the selected centers. Children in the child day care center component were eligible if they were between the ages of 18 months and 5 years, toilet-trained or able to provide at least one urine sample, and not being breast-fed. In addition, they had to attend a state-licensed child day care center, serving seven or more children, on three consecutive days, for at least 25 h per week.

The second stage recruitment activities began with the determination of the number of age-eligible children in each classroom. Classroom Information sheets were sent to and completed by the day care director. These sheets requested the following information for each classroom: name of the classroom, total number of children in the classroom, and the initials and ages of eligible children. Two classrooms and five children in each classroom were selected randomly. Following the selection of the children, the recruitment team asked the day care director to distribute the recruitment package, which contained an introductory letter, a study brochure, and a gift certificate (as incentive for the household to participate), to the parents of the selected children. Parents were encouraged to call the project toll-free number to ask about the study. In consultation with the day care center director, the recruitment team also set up an appropriate time, typically two or three days after the letters were sent, to meet with the parents at the day care center.

During the meeting with the parents, the recruitment team established rapport with the parents and the child, and gave a small gift to the child, such as a book or small toy. The recruitment team emphasized the positive experiences that we and the participants had in our previous pilot studies. An informed consent form was obtained from the parents, and they were asked to complete the Recruitment Survey (Form #1; Table 5.2.2). The recruitment team then scheduled an initial sampling date with each family.

4.2.2. Recruitment of the Telephone Sample Component

The procedures for recruiting households by telephone sampling are diagramed in Figure 4.2.2. A telephone sample list, which included addresses, was ordered from a commercial survey sampling firm (Marketing Systems Group [MSG], Genesys Sampling System, http://www.genesys-sampling.com). The sample design used for the telephone component was: (1) to identify efficiently, through telephone contact, households having one or more children in the eligible age range, that met the sampling targets in the household low-income or middle/high-income domains, and (2) to provide coverage of households with unlisted telephone numbers.

The survey sampling firm used Census data, marketing research data, and other sources to classify directory-listed households as having either one or more children in the age range of 18 months to 5 years, or having no children in that age group. The same data were used to assign the directory-listed households to an income range. All directory-listed households in each of the six counties were assigned to one of the following four strata:

1. Directory-listed households with income above $25,000 and having one or more children in the target age range
2. Directory-listed households with income below or equal to $25,000 and having one or more children in the target age range
3. Directory-listed households with income above $25,000 and having no children in the target age range
4. Directory-listed households with income below or equal to $25,000 and having no children in the target age range

In some counties, as many as 30% of households could have unlisted telephone numbers. To ensure inclusion of those households that did not appear in the directories, a Random Digit Dialing (RDD) approach was used. To implement the RDD approach, the survey sampling firm first identified all telephone exchanges in the selected county. Telephone exchanges having very low percentages of directory-listed households, primarily nonresidential or business areas, in the selected county were deleted. From the remaining exchanges, a systematic random sample of all numbers was drawn. Some of these telephone numbers were residential, and some were business or nonworking numbers. To prevent a directory-listed telephone number from being sampled in both the RDD frame and the directory-listed frame, the survey sampling firm selected the RDD sample of telephone numbers first. The sampled telephone numbers were compared to the database of directory-listed telephone numbers. Those telephone numbers that were directory-listed were removed from the directory-listed frame, prior to the stratification described above. The list-assisted samples, corresponding to the four strata above, and the RDD samples were combined in replicate files. This telephone sample selection did not include households without home telephones; however, they were represented in the day care sample component.

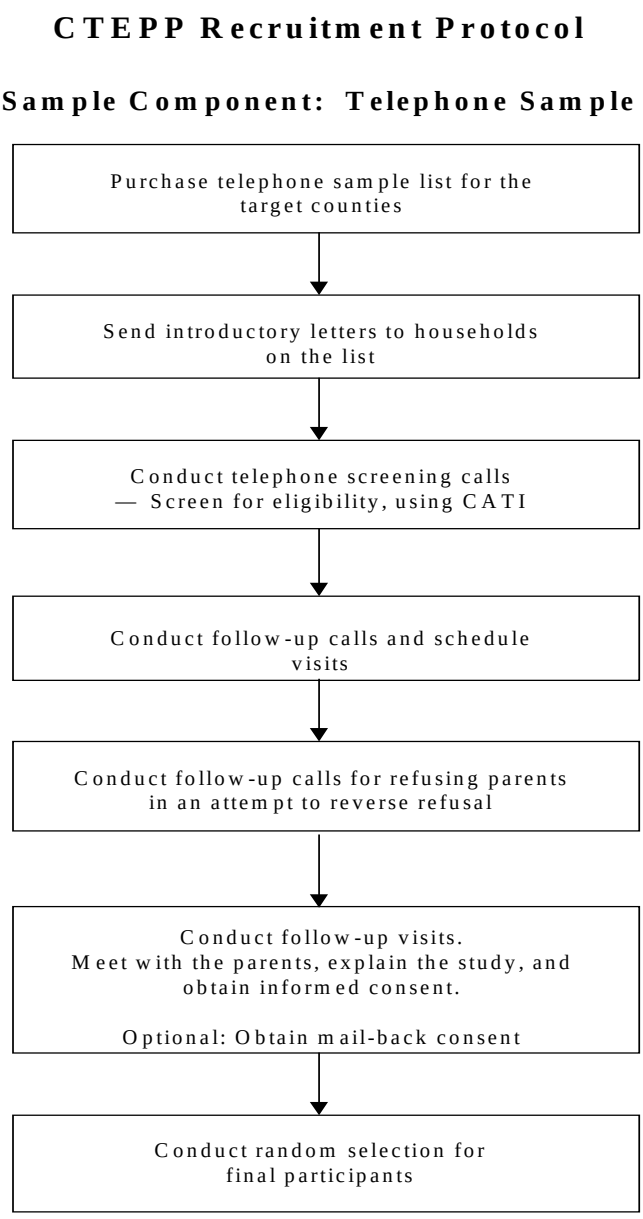


Figure 4.2.2 Procedures for Recruiting Telephone Sample Component

Introductory letters and a study brochure were sent to households in the telephone list that had valid addresses. A Computer Assisted Telephone Interview (CATI) system was developed to facilitate the screening process. All numbers in the files were called and screened for eligible subjects. Children were eligible for this telephone sample component if they were between the ages of 18 months and 5 years, toilet-trained or able to provide at least one urine sample, not being breast-fed, and not attending a day care center. The final participants were randomly selected from the eligible subjects. Staff visited those households that tentatively agreed to participate in the study. At these visits, the staff explained the study further and obtained informed consent.

4.3 Recruitment Results

4.3.1 North Carolina

Recruitment of subjects for the NC field study was conducted in two phases. Recruitment of Phase I participants began in four NC counties (Durham, Buncombe, Lee, and Mecklenburg) in early February 2000, but was suspended on February 29 for four months due to the OMB 2000 Census requirement. The OMB prohibited other federally-sponsored surveys from occurring during the period from March to June 2000 while the 2000 U.S. Census was conducted.). Recruitment of subjects in these counties resumed in July 2000 and continued through December 2000. Phase I field sampling activities were completed with 48 households in December 2000. Recruitment of Phase II subjects was conducted for the two eastern NC counties affected by severe flooding from Hurricane Floyd (Edgecombe and Jones) from February 26 through March 30, 2001. Twelve additional subjects and their adult caregivers from the day care center sample component were enrolled in Phase II. In Jones County, although one day care center agreed to participate in the study, no parents were willing to participate, because they were still dealing with the flooding problems from the hurricane.

A conservative approach was used to calculate the final response rate. During the recruitment period, some people refused to be screened and some could not be reached. As a result, their eligibility status was unknown. A calculated eligibility rate was used to estimate the number of eligible subjects in this group of status-unknown subjects. This eligibility rate, which was determined from the known responses, was calculated as the total number of eligibles divided by the sum of the total number of eligibles and ineligibles. To calculate the final response rate, the number of eligible subjects who agreed to participate was divided by the estimated total number of eligible subjects – the total of those eligibles who responded plus the estimated eligibles. This approach tends to underestimate the final response rate, because it does not include the number of status-unknown subjects who might be eligible and agree to participate in the study but could not be reached.

Table 4.3.1 summarizes the response rates for the NC study. Overall, 98% of the recruitment target for day care participants in NC was achieved through enrollment of a total of 63 of 64 target households. Overall, 105% of the targeted number (67 of 64 targeted) of telephone sample households in NC were enrolled in the CTEPP study. All recruitment activities for NC were completed by March 30, 2001.

Table 4.3.2 provides the overall recruitment results for NC for the children who were recruited at home or at day care. The final recruitment results for the NC field study led to the enrollment of 130 children, ranging in age from 20 to 64 months, and their primary adult caregivers.

Table 4.3.1 Summary of CTEPP North Carolina Response Rates

Sampling Frame	Summary
Child Day Care Component: Child Day Care Centers	
(A) Eligible and Recruited Child Day Care Centers	13
(B) Eligible Child Day Care Centers	17
(C) Ineligible Child Day Care Centers	5
(D) Unknown Eligibility	10
(E) Calculated Response Rate[a]	53%
Child Day Care Component: Day Care Parents	
(A) Eligible and Recruited Day Care Parents	69
(B) Eligible Day Care Parents	85
(C) Ineligible Day Care Parents	26
(D) Unknown Eligibility	71
(E) Calculated Response Rate[a]	50%
Telephone Screening Component	
(A) Eligible and Recruited Stay-at-Home Parents	272
(B) Eligible Stay-at-Home Parents	333
(C) Ineligible Stay-at-Home Parents	6547
(D) Unknown Eligibility	2807
(E) Calculated Response Rate [a]	58%

[a] Calculated Response Rate, E = (A)/(B + (B/(B + C)) x D)

Table 4.3.2 Summary of CTEPP North Carolina Participant Characteristics

Final NC Results		Telephone Sample				Day Care Sample				
		Unknown	**Low-income**	**Mid-income**	**Subtotal**	**Unknown**	**Low-income**	**Mid-income**	**Subtotal**	**Total**
Urban	Buncombe		6	1	**7**		6	4	**10**	**17**
	Durham		5	21	**26**		5	12	**17**	**43**
	Mecklenburg	3	2	15	**20**	1	11	3	**15**	**35**
	Edgecombe		1	1	**2**	1	11	0	**12**	**14**
	Total Urban	**3**	**14**	**38**	**55**	**2**	**33**	**19**	**54**	**109**
Rural	Lee		4	3	**7**	1	5	3	**9**	**16**
	Jones	1	3	1	**5**		0	0	**0**	**5**
	Total Rural	**1**	**7**	**4**	**12**	**1**	**5**	**3**	**9**	**21**
	Total NC	**4**	**21**	**42**	**67**	**3**	**38**	**22**	**63**	**130**
	% of Total	**6%**	**31%**	**63%**	**100%**	**5%**	**60%**	**35%**	**100%**	

Thirteen NC day care centers (eight regular day care and five Head Start) participated in the study. Sixty-three day care children, day care teachers, and their caregivers successfully completed the field activities of the study. Sixty-six stay-at-home children and their caregivers, successfully completed the field activities of the study. One stay-at-home participant did not complete the study. The distribution of low-income and middle/high-income of the NC families in the telephone sample component was very close to the original sampling design. However, in the day care sample, low-income families were over-enrolled, with 60% of the day care sample classified as low-income. This over-enrollment of low-income families in the day care sample occurred because many of the children in the regular day care centers, those not catering specifically to low-income families through the Federally funded Head Start program, came from families that were classified as low-income. Further information on the NC field study can be found in the NC Recruitment Report (Appendix B) and in our published paper on the CTEPP sampling design and field methodology (11).

4.3.2 Ohio

Recruitment of subjects for the OH field study began in January 2001 and was completed in November 2001. Fifty-eight households were successfully recruited. Table 4.3.3 summarizes the response rates for the OH study. For the day care sample component, 91% of the recruitment target for day care participants in OH was achieved through enrollment of a total of 58 of 64 target households. For the telephone sample component, a total of 165 potentially eligible households were identified. Overall, 108% of the target stay-at-home participants were recruited through enrollment of a total of 69 of 64 target households. All recruitment for OH was completed in November 2001.

Table 4.3.4 provides the overall recruitment results for OH, for both the stay-at-home and day care children. The final recruitment results for the OH field study led to the enrollment of 127 children, ranging in age from 20 to 65 months, and their primary adult caregivers.

Sixteen OH day care centers (12 regular day care and 4 Head Start) participated in the study. Fifty-eight day care children and their caregivers, participated successfully in the field activities of the study, with simultaneous sampling both at the centers and at the children's homes. Sixty-nine households in which the children did not attend day care participated successfully in the field activities of the study, with sampling for the children and their primary caregivers at the children's homes. The distribution of low-income and middle/high-income families in the OH telephone sample component is very close to the original sampling design, with 26% of the stay-at-home participants classified as low-income. However, as in NC, the low-income families were over-enrolled in the day care sample component, with 50% of the day care participants classified as low-income. Further information on the OH field study can be found in the OH Recruitment Report (Appendix B) and in our published paper on the CTEPP sampling design and field methodology (11).

Table 4.3.3 Summary of CTEPP Ohio Participant Response Rates

Sampling Frame	Summary
Child Day Care Component: Child Day Care Centers	
(A) Eligible and Recruited Child Day Care Centers	16
(B) Eligible Child Day Care Centers	24
(C) Ineligible Child Day Care Centers	4
(D) Unknown Eligibility	5
(E) Calculated Response Rate[a]	57%
Child Day Care Component: Day Care Parents	
(A) Eligible and Recruited Day Care Parents	71
(B) Eligible Day Care Parents	100
(C) Ineligible Day Care Parents	8
(D) Unknown Eligibility	141
(E) Calculated Response Rate[a]	31%
Telephone Screening Component	
(A) Eligible and Recruited Stay-at-Home Parents	165
(B) Eligible Stay-at-Home Parents	191
(C) Ineligible Stay-at-Home Parents	4598
(D) Unknown Eligibility	2449
(E) Calculated Response Rate[a]	57%

[a] Calculated Response Rate, E = (A)/(B + (B/(B + C)) x D)

Table 4.3.4 Summary of CTEPP Ohio Participant Characteristics

Final OH Results		Telephone Sample				Daycare Sample				
		Unknown	**Low-income**	**Mid-income**	**Subtotal**	**Unknown**	**Low-income**	**Mid-income**	**Subtotal**	**Total**
Urban	Cuyahoga	1	4	11	**16**		10	10	**20**	**36**
	Licking			7	**7**		4		**4**	**11**
	Franklin		7	13	**20**	2	6	8	**16**	**36**
	Hamilton		2	15	**17**	1	9	0	**10**	**27**
	Total Urban	**1**	**13**	**46**	**60**	**3**	**29**	**18**	**50**	**110**
Rural	Defiance		2	4	**6**	2		2	**4**	**10**
	Fayette		3		**3**			4	**4**	**7**
	Total Rural	**0**	**5**	**4**	**9**	**2**	**0**	**6**	**8**	**17**
	Total OH	**1**	**18**	**50**	**69**	**5**	**29**	**24**	**58**	**127**
	% of Total	**1%**	**26%**	**72%**	**100%**	**9%**	**50%**	**41%**	**100%**	

In addition to the field sampling and data collection described above for both NC and OH, 26 children in OH were videotaped for about two hours in their homes, in order to supplement the information collected within activity diaries and other observations. Videotaping started in OH in April 2001 and ended in October 2001. Sixty-nine percent of these 26 OH children were stay-at-home children; 88% percent of them lived in urban counties; and 38% percent of them were from low-income families. Fifty percent of the participants were female, and the children's ages ranged from two to five years.

4.4 Evaluation

Recruitment strategies included minimizing the burden on participants, ensuring confidentiality, providing incentives for participation, and using carefully selected and trained field staff. Throughout the study, the staff were encouraged to be sensitive to participants' concerns and to persevere in recruitment.

The most frequent concern related to participant burden was the lack of center staff or parent time. Day care teachers in particular were concerned about collection and storage of urine samples. Several ways of reducing participant burden were used. These included providing individual training to participants prior to the field sampling, providing assistance for urine collection at the centers, offering flexible sampling schedules, and providing a project toll-free telephone number to call for assistance. Additionally, actual contact time between staff and participants during sampling was kept as short as possible.

A major concern of some participants, especially of the directors and staff of child day care centers, was whether individual data would be released to any regulatory agency or to others. To allay this concern, a Certificate of Confidentiality for the study was obtained from the National Institute of Mental Health. This Certificate provided legal protection of the privacy of the individual data. Under this Certificate, the study researchers cannot and will not release any individual data to anyone, including the courts, without written permission of the individual.

To encourage participation, both monetary and non-monetary incentives were offered to participants. Participating families and child day care centers received $100 to cover their costs of providing food and other samples. If the children were to be videotaped for about 2 h, an additional incentive payment of $50 was furnished to the participating household; a $25 gift certificate for a book or other appropriate item for the classroom was provided to child care centers. At each visit to homes or centers, field staff brought small age-appropriate gifts for the participating children. Field staff encouraged participants to realize that they were performing important research, and that their participation was valuable. Participants were given a project T-shirt and pen. All participants received a framed certificate, acknowledging their contributions, at the conclusion of field sampling.

To enhance response rates in the study, user-friendly materials and brochures were developed. Letters and statements of endorsement were obtained from child care organizations, such as the National Head Start Organization, and from past pilot study participants. Press

releases prepared by the U.S. EPA describing the study were used in the selected areas, and EPA's principal investigator provided radio interviews. Prior to personal contact with centers and parents, introductory letters and brochures were sent to them by overnight courier. Multiple follow-up calls and personal visits were made by study staff to potential participants. Throughout, the study staff tried to develop a sense of a research partnership between centers, teachers, parents, and researchers.

For the initial telephone screening of potential participants, scripts were developed for interviewers, so that the screening information could be entered directly into the computer. Written consent forms for participation and for possible future contact were developed.

4.5 Recommendations

Study recruitment required far more effort and time than initially anticipated. In the future, similar studies should allocate more time and staff resources to the recruitment of participants. Recruitment should begin at least four months prior to field sampling. In addition, the problem with participant recruitment was exacerbated by the requirement that no contact could be made with subjects during the 2000 Census, which meant that some participant recruiting had to occur during the field activity phase of the study.

Overall, the recruitment methods worked well. However, several participants indicated that they should receive greater compensation for performing data collection activities that they found burdensome. In addition, increased monetary incentives should help to increase the response rates and participant cooperation.

Recommendations to improve day care center participation in future studies of this type include the following:

- Increase the compensation to day care centers, both to the center director and to the individual classroom teachers.
- Prepare a special document that would contain information to ease the concerns of the center directors. This information would address privacy issues and guarantees, compensation for time spent on the project activities, a description of day care recruitment procedures and study activities, and the assistance that would be provided by study staff.
- Design and implement a study web site that would explain the study and also provide a means for participants to ask questions.
- Increase the staff and resources for the project recruitment team, so that more intensive recruitment activities, such as follow-up visit to the day care centers, can be conducted.
- Increase the compensation to day care parents.
- Conduct additional in-depth staff training on subject recruitment and data collection activities.

- Have at least two or three staff members attend meetings with parents at the center. This would ensure full attention by the staff to all participants and minimize parents' waiting time.
- Minimize participant burden as much as possible.

Although the telephone recruiting worked very well, the advance mailings were not very effective, as about 65% of the mailed packages were returned as undeliverable. Recommendations to improve participation for stay-at-home participants in future studies of this type include the following:

- Increase the compensation to the parents.
- Mail the study brochure and introductory letter to the potential participant immediately after their initial telephone screening is completed.
- Minimize participant burden as much as possible.

Chapter 5
Field Monitoring

5.1 Overview

The CTEPP study collected environmental and personal samples as well as supplemental information to aid in the interpretation and assessment of the children's exposures to pollutants at homes or day care centers. For children who stayed at home during the day with their primary caregivers, field samples, questionnaires, and time-activity/food diaries were collected at their homes over a 48-h period. For children who attended day care, these above samples were collected at both their day care centers and homes simultaneously over a 48-h period. Household and center observation surveys, day care menus and other ancillary information were collected before or immediately after sampling.

Field staff collected samples of outdoor play area soil, indoor and outdoor air, indoor floor dust, and drinking water at homes and child day care centers. The adult caregiver collected duplicate diets, dermal (hand) wipes, and multiple spot urine samples for themselves and for their child while at home. The teachers collected the above samples for day care children while at day care. If a pesticide application had occurred inside or outside the home or day care center within the seven days preceding sampling or during the 48-h monitoring period, additional types of field samples were collected. These additional samples consisted of transferable residues (PUF roller samples), hard floor surface wipes, and food preparation surface wipes. Supplemental information was collected through pre- and post-monitoring questionnaires, house/building characteristic observation surveys, child/adult activity and food diaries, and day care food menus. In addition, 26 children were videotaped for about two hours in their homes in Ohio (OH) to supplement the questionnaires and activity diaries.

Field sampling started in North Carolina (NC) in July 2000 and was completed by March 2001. It was completed in the mountain and Piedmont regions by December 2000. However, field sampling in the two coastal counties was delayed because of the severe hurricane flooding that had occurred the previous year. In this region, field sampling was completed by April 2001. In OH, there were no significant delays in field sampling activities at participants' homes and/or day care centers. Field sampling started in late April 2001 in urban counties, Franklin and Licking, in central OH, because of their close proximity to Battelle's facility in Columbus, OH. Field sampling was completed in the rest of central, northern and southern regions of the state by November 2001. Overall, field samples were collected at a total of 130 homes and 13 day care centers in NC, and at 127 homes and 16 day care centers in OH.

5.2 Field Data Collection

Table 5.2.1 summarizes the field data collection procedures and sampling activities that took place over a 48-h period at a participant's home and/or day care center. This approach was used for both the NC and OH field studies. There were three field sampling teams (labeled as teams A, B, and C), with two staff members in each team. Two field sampling teams, A and B, collected the field data simultaneously at different homes or day care centers. A third field sampling team, C, served as a backup team and was responsible for field preparation and training participants.

Subjects were scheduled in the same cluster of locations within a county in the same sampling week. The time needed to complete the field sampling work for each state was about 24 to 30 weeks, depending on the availability of the participants and the weather. One week prior to each scheduled sampling date, the participants were trained to collect urine, hand wipe and food samples, and were given instructions for filling out the Child Activity Diary. At that time, they were given the opportunity to ask additional questions and voice any concerns they had about their participation.

For stay-at-home participants, field sampling activities took place at the households of approximately eight children per week. These activities occurred over a 48-h period for three consecutive days. Typical sampling schedules were: (1) Monday to Wednesday, (2) Tuesday to Thursday, or (3) Wednesday to Friday. The initial sampling appointments generally ranged from 7 a.m. to 8 p.m; sampling began shortly thereafter and continued for the following 48 h. In a given week, field sampling activities began at four households on Day 1, and each of two field teams was responsible for the activities at four households per week.

For day care participants, field sampling activities occurred at one day care center per week, representing from four to six participating children. Sampling activities also occurred at the households of these children during that week. Field sampling took place simultaneously during a 48-h period at each child's day care center and at her/his home. In a given week, field sampling activities began at the day care center and at the households of two or three children on Day 1, and each of two field teams was responsible for the activities at two or three households per week.

5.2.1 Environmental and Personal Samples

All field sampling procedures were conducted according to Standard Operating Procedures (CTEPP-SOPs: 2.10 - 2.27). The list of all CTEPP SOPs is presented in Appendix A. The multimedia samples that were collected at the children's homes and day care centers are described below, in Sections 5.2.1.1 through 5.2.1.10.

Table 5.2.1 Summary of Field Data Collection Procedures and Sampling Activities over a 48-h Period at a Participant's Home and/or Day Care Center

Sampling Day	Data Collection and Sampling Activity/Task
Day 1	< Obtain signed consent form < Conduct Pre-monitoring Interview < Complete the House/Building Characteristic Observation Survey < Provide instructions on food sample collection, give food containers and cooler, ask if it's OK to store the food samples in the participant's refrigerator < Remind parent and teacher--no vacuuming during the 48-hour period (sweeping with a broom is OK) < Review the instructions for collecting urine and hand wipe samples < Give the sample collection supplies to the parent and teacher (e.g., urine and hand wipe) < Review instructions for recording in the Child Activity Diary < Set up indoor air monitor, mark the location on the sketch, record air log < Set up outdoor air monitor, mark the location on the sketch, record air log < Take pictures of sampling activities. ***Note:*** *Each child's supplies (clean sample containers) are stored in a clean container with name labeled on top).*
Day 2	< Complete activities pending since Day 1, if any < Check outdoor air monitor, record air log < Check with the parent and teacher for questions about or problems with sampling activities < Videotape child's activities, if applicable
Day 3	< Complete activities pending since Day 1, if any < Unload indoor air samplers, record air log, remove air monitors < Collect dust sample, vacuum the house (must unload the indoor air samplers first) < Unload outdoor air samplers, record air log, remove air monitors < Collect one soil sample (children's usual outdoor play area), mark the location on the sketch < Collect hard floor surface wipe sample < Collect food preparation surface wipe sample < Collect PUF roller sample for transferable residues < Pick up food samples, examine the samples, remove any non-edible materials < Pick up urine and hand wipe samples < Pick up the Child Activity Diary < Conduct Post-monitoring Interview < Present a *Certificate of Appreciation* to the parent and teacher < Confirm the check mailing information with the parent and teacher < Take pictures of sampling activities < Videotape child's activities, if randomly selected

5.2.1.1 Outdoor Play Area Soil

Outdoor play area soil was sampled from the location identified by the teacher or the primary caregiver as most often used by the children. A scraping (putty) knife was used to collect the soil from the top 0.5 cm of soil in a 1 ft^2 (0.1 m^2) area and placed into a glass jar. If a play area did not have bare soil or dirt (e.g., grass, sand), the sample was collected near a subject's sidewalk, driveway, or garden, reasonably close to the identified play area.

5.2.1.2 Indoor Floor Dust

The high-volume small surface sampler (HVS3; Cascade Stack Sampling Systems, Bend, Oregon) method was used to collect floor dust from a 0.76 m^2 area of carpet (12). The samples were collected in the room the child used most often at the residence or day care center. The initial sampled area was 0.76 m^2. Additional 0.76 m^2 areas of the carpet were sampled until a sufficient amount of dust was collected for analysis (typically ~1.0 g) The dust sample was transferred from the Teflon catch bottle to a glass jar. A hard floor surface wipe, described below, replaced the floor dust sample when no carpeted areas were available.

5.2.1.3 Indoor and Outdoor Air

Outdoor and indoor air was sampled over a 48-h period using filter and a backup XAD-2 trap to collect pollutants in air (8). Briefly, outdoor samples were collected using a Thomas pump (Model 107CAB18A; Thomas Compressor and Vacuum Pumps, Sheboygan, MI). Indoor samples were collected using an SKC pump (Model 224-PCXR8; SKC, Inc., Eightyfour, PA). Flow rates for both pumps were set at a range of 3.9 to 4.1 L/min using a calibrated flow meter. The inlet port of the sampling cartridge was placed approximately 75 cm above the floor or ground, at the approximate breathing height of children in the participant age group. The URG-2000 sampling cartridge (University Research Glassware Corp., Chapel Hill, NC) contained a pre-cleaned quartz fiber filter and an XAD-2 cartridge, to collect the targeted pollutants both in the vapor phase and condensed on particles < 10 µm. Outdoors, the sampling pump and controls were placed in a Styrofoam cooler, which was housed in a large, plastic doghouse, furnished by the field staff, to protect the equipment from inclement weather conditions. Indoors, the sampling equipment was placed in a Styrofoam cooler and housed in a child's playpen, also furnished by the field staff, which was covered by a stroller net to protect it from curious children or pets. Flow rates were recorded at the beginning and end of the sampling period.

5.2.1.4 Drinking Water

For the day care center component, field staff collected one drinking water sample from each participating child's home and one sample from each participating day care center. For the telephone component, only one drinking water sample was collected from each participating child's home. These samples were collected in either 1-L or 0.5-L plastic jugs and refrigerated until shipped to the laboratory.

5.2.1.5 Duplicate Plate Food and Beverages

Duplicate plate samples of the solid and liquid food served to the children (7,8) were collected for each child during the 48-h sampling period. At home, the adult caregiver provided the same amount of the same food and beverages, excluding drinking water, consumed by their child over the sampling period. The teachers provided duplicate servings of food and beverages consumed by the participating children while at day care. Because all children in a given classroom were served the same food on the same day, only one duplicate sample was provided for each classroom on a given day. If a child brought his/her food from home, the home caregiver was asked to provide a duplicate sample of that food. Composite solid and liquid food samples were collected separately in 2 L glass containers. These containers were placed in provided coolers with blue ice until they were picked up by field staff.

5.2.1.6 Dermal Hand Wipes

Adult caregivers and day care teachers collected dermal (hand) wipe samples from each participating child during the 48-h sampling period (8). Hand wipe samples were taken before the participants washed their hands. The hand wipe consisted of a gauze pad (SOF-WICK, 10 x 10 cm – 3 ply; Johnson & Johnson), which was pre-cleaned with dichloromethane (DCM), dried and wetted with 2 mL of 75% isopropanol in distilled water, and stored in a glass jar. The adult caregiver removed the pre-wetted gauze pad from the jar and wiped both hands of the child, according to a specified procedure (CTEPP-SOP-2.15), then put the wipe back into the jar. A total of four hand wipe samples were collected for each child (two per day, one each before lunch and dinner). All hand wipe samples were refrigerated or placed in provided coolers with blue ice until picked up by field staff. Adult participants collected their own dermal wipe samples according to these same procedures.

5.2.1.7 Transferable Residues

The polyurethane foam roller (PUF) method (13) was used to collect transferable residues from indoor floor surfaces (e.g., carpet, vinyl), at homes or at day care centers that had recent pesticide applications. Transferable residues were sampled at three locations where the child spent most of their time inside the home or day care center; these locations were not the same as those that were sampled for carpet dust with the HVS3. The PUF roller apparatus, having a pre-cleaned, dry PUF sampling cylinder was rolled on the indoor floor surface at a rate of approximately 10 cm/s for a 2 m distance (1 m up and back). This procedure was repeated, using the same PUF cylinder, at the other two selected locations. On completion of sample collection, the PUF cylinder was wrapped in muffled aluminum foil and placed in a Ziplock bag.

5.2.1.8 Food Preparation Surface Wipe

At homes and day care centers having recent pesticide applications, food surface preparation wipes were collected from the kitchen counters where food was prepared. The wipe consisted of a pre-cleaned, gauze pad (SOF-WICK, 10 x 10 cm – 3 ply; Johnson & Johnson), which was cleaned with DCM, dried, and then wetted with 2 mL of 75% isopropanol and stored in a glass jar. Masking tape was used to mark off a 38 x 38 cm (0.14 m^2) area of the counter. The sample was collected by wiping this part of the counter in one direction, folding the wipe in half and wiping the surface again in the opposite direction, then returning it to the glass jar.

5.2.1.9 Hard Floor Surface Wipe

At homes and day care centers either having recent pesticide applications or having little or no carpeted floor surfaces for dust sampling, hard floor surface wipe samples were collected on indoor floors (i.e., tile, vinyl, hardwood floors) where the children spent most of their time The wipe consisted of a gauze pad (SOF-WICK, 10 x 10 cm – 3 ply; Johnson & Johnson), which was cleaned with DCM, dried, and wetted with 2 mL of 75% isopropanol and stored in a glass jar. Masking tape was used to mark off a 38 x 38 cm (0.14 m^2) area of the floor. The sample was collected by wiping the designated area of the floor in one direction, then folding the wipe in half, and wiping the surface again in the opposite direction, then returning the wipe to the jar.

5.2.1.10 Urine

Spot urine samples were collected from each child over the 48-h monitoring period (8). The child urinated into a plastic urine collector (bonnet) that was placed under the toilet seat. The urine was then poured into a 120 mL plastic bottle by the adult. Adult caregivers, when at home, collected three urine samples per day (first morning void, after lunch, and after dinner or before bedtime) from their child. Day care teachers collected one urine sample from the child each day after lunch. All urine samples were refrigerated or placed into provided coolers with blue ice until picked up by field staff. Adult participants collected their own urine samples at the same frequency following similar procedures. Note: The spot urine samples for adults and children were composited over the 48-h period, with the exception of those collected at homes with recent pesticide applications, which were stored and analyzed separately.

5.2.2 Supplemental Information

Supplemental information was collected to help assess the children's exposures to pollutants in their everyday surroundings. Table 5.2.2 summarizes the types of collected supplemental data. The same types of forms were used in both the NC and OH studies to collect these data. The recruitment survey (Form #1) was used to collect the subject's eligibility information. This form was administered either by an interviewer, using Computer Assisted Telephone Interviewing (CATI), or as a Self-Administered Questionnaire. The house/building characteristics survey described the physical characteristics of the sampled house (Form #2) and

Table 5.2.2 Types of Questionnaires, Diaries, or Menus Collected from Participants

Supplemental information	Types of information
Recruitment survey (Form #1)	Identify potential participants in a household.
House/building characteristics observation survey (Form #2)	Document the physical characteristics of the house and identify/inventory possible sources of pollutants.
Day care center/building characteristics survey (Form #3)	Document the physical characteristics of the day care center and identify and inventory possible sources of pollutants.
Parent pre-monitoring questionnaire (Form #4)	Identify the individuals living in the home and describes the sources and routes of potential exposure to pollutants.
Day care center pre-monitoring interview (Form #5)	Identify the individuals within the day care center/classroom and describe the sources and routes of potential exposure to pollutants.
Parent post-monitoring questionnaire (Form #6)	Provide information on the child's activities and potential exposure to pollutants over the 48-h sampling period.
Day care center post-monitoring questionnaire (Form #7)	Provide information on the child's activities and potential exposure to pollutants over the 48-h sampling period.
Child activity diary and food survey-home group (Forms #8/AM and #8/PM)	Provide information on the child's activity patterns and food consumption patterns at home.
Child activity diary and food survey-day care group (Forms #9 and #10)	Provide information on the child's activity patterns and food consumption patterns at day care center.
Day care center menus	Provide daily dietary menus up to three months prior to field sampling at a day care center.

day care center (Form #3) and collected information for identifying possible sources of pollutants. These forms were filled out by the field staff. Pre- and post-monitoring questionnaires (Forms #4 to #7) collected general information on the households and day care centers, as well as specific information on the possible sources of contamination in the children's surrounding environments, on the usage of pesticides, and on the children's usual activities and their activities during the 48-h sampling period. Child's activity and food diaries (Forms #8, #9, #10) documented the information on the child's activities and food consumption patterns over the 48-h sampling period. Forms #4 through #10 were filled out by teachers and home caregivers. Additionally, day care center food menus were collected; these provided information on the food served at the centers a few weeks before field sampling occurred.

5.2.3 Sample Custody, Field Storage, Shipping, Laboratory Receipt, and Laboratory Storage

The NC and OH field samples collected by participants during the 48-h sampling period (food, hand wipe, and urine) were temporarily stored in the provided cooler with ice packs or in the participant's home refrigerator until collected by the project staff at the end of the sampling period. Samples collected from NC were temporarily stored in freezers at or below -10°C at the NC field office until shipped on dry ice to the Battelle laboratory in Columbus, OH on a weekly basis. OH field samples were stored in freezers at or below -10°C in the analytical laboratories until being prepared for analysis.

Before field sampling, all sample containers were appropriately identified and labeled with their purpose and with bar codes, then checked by the QC staff at the field office. Just prior to leaving the field office for a sampling appointment, the field team conducted a sample and equipment inventory and verified all sample ID labels again. During field sampling, the field team collected samples and noted sample conditions on the field sample/data check list. After the samples were collected and brought back to the field office, they were processed immediately by the receiving team. Sample conditions and collection information were recorded into the CTEPP Tracking System. All labels were checked and samples were transported and stored in accordance with specifications described in the field sample handling SOPs (CTEPP SOPs 3.10 - 3.12 and 4.10 - 4.12).

Strict sample custody procedures were followed throughout the collection and analysis activities. A sample chain of custody form was used to document all collection, shipment, receipt, analysis, processing, and handling steps that each sample underwent as it passed from one individual to the next. This record was initiated in the field by the responsible field staff member and captured the original field collection of the sample, as well as all subsequent operations performed. Each sample custody record contained, at a minimum, the following information: participant identification code, sample ID, the operation performed on the sample (e.g., collection, processing, shipment, receipt, storage, laboratory procedure, disposal), initials of the person performing the operation, date on which the operation was initiated, and any relevant remarks or comments pertaining to the sample. The sample custody form was a hand-written paper record. In addition, a computer-based tracking system was employed, into which the scanned information from the sample bar codes, as well as other pertinent information

for all collected samples, was entered. At the laboratory, the samples were stored in freezers at or below -10°C until sample preparation and chemical analysis.

5.2.4 Quality Control

Quality Assurance/Quality Control (QA/QC) procedures (including pre-field assessment and field assessment) were implemented throughout the field data collection periods in NC and OH.

For pre-field assessment, the sampling equipment was calibrated and the sampling media were prepared in the laboratory prior to shipment to the field. Equipment was always tested when it was set up and when it was removed, to ensure that it performed to specifications defined in the relevant SOPs. All SOPs and field forms were field tested prior to project implementation. SOPs and field forms that were found to be inadequate were revised and finalized prior to field implementation.

For field assessment, field duplicates were collected for air samples. The dust, soil, food, urine, and drinking water samples were bulk samples; different aliquots of the same samples were used as field duplicates. Field blanks, which underwent the same handling and shipping procedures as real field samples but did not go through the sample collection step, were generated in the field to document any possible contamination that might have occurred in field sample handling and shipping. Field blanks were prepared and analyzed using the same methods as field samples.

Questionnaire results obtained during field visits were reviewed by technicians in the field. The final checks for completeness were performed by the QC team members at the field office.

Quality assurance orientation for CTEPP NC and OH field data team members included an overview of program and facility QA requirements, QA requirement documents, field data record keeping and quality assurance/quality control monitoring. The Battelle Quality Assurance Officer (QAO) conducted field audits in both the NC and OH field studies. Field inspections performed by the Battelle QAO included facility preparation and sample storage areas in Durham NC, as well as Day-3 sampling activities. The QAO also inspected the Battelle Columbus OH laboratory facilities for adherence to sample receipt, inspection, storage, preparation and analysis procedures and oversaw sampling preparation and set-up, Day-1 sampling, and sample preparation performed in Columbus. In addition, Battelle Field Team Leaders conducted periodic internal field audits as described in CTEPP SOP 2.25. The EPA QAO and EPA Task Order Project Officer (TOPO) also performed field audits in NC and OH. There were no non-compliance findings observed during these audits. All recommendations generated during internal and external audits, technical systems audits (TSAs) and surveillances were formally documented in laboratory internal records or in responses to EPA audit reports.

5.3 Results

Results of the NC and OH field data collection activities are summarized in Sections 5.3.1 and 5.3.2.

5.3.1 North Carolina

Tables 5.3.1 and 5.3.2 summarize the completeness associated with the collection of field samples and supplemental information (questionnaires/diaries), respectively, from NC. Field data collection activities in the NC study achieved greater than 99% completeness for field samples, 100% for collected questionnaires/diaries, and greater than 99% for data collected on the questionnaires/ diaries.

The proposed samples were the ones that the field staff or participants planned to collect at home or at day care. The collected samples were the ones that were actually collected in the field. Empty liquid food containers were collected in some households, because the adult caregivers claimed that they or the child participants drank only water. Thus, we did not count the liquid food samples from these households. Completeness of field data collection was expressed as a percentage of all samples collected in the field that had data generated in the laboratory.

Despite the fact that participants were paid ($25) sufficiently in advance to cover their cost of duplicate food samples, some participants were still reluctant to provide us these samples. Solid food samples with the smallest weights (12.3 g of adult food and 7.76 g of child food) were collected from the same low-income household. The adult caregiver in this household claimed that they did not consume large amounts of food. Two day care centers provided only snacks and the children brought their own lunches. Since these lunches were prepared at the children's homes, the parents were asked to prepare duplicate lunches, which were provided as part of the at-home food samples. In one household, the adult participant withdrew from the study after the Day-1 sampling event because the domestic partner did not want to continue the study. Therefore, only partial field samples were collected and analyzed. However, a complete set of questionnaires/ diaries was collected from this household.

As shown in Table 5.3.2, 100 % of data forms were collected from the participating households and day care centers, and more than 99% of the data were collected from these forms. Data values labeled as"incomplete" were treated as missing data, i.e., data that participants failed to provide and/or which could not be obtained by re-contacting the participants. After all attempts were made to re-contact the participants in order to obtain missing information, the any uncollected data were coded as "Missing". Responses of "Don't Know" (as stated by the participant) or "Refused" were not treated as missing data items because these were valid responses.

Table 5.3.1 Summary of the Completeness of the NC Sample Collection

Sample Description	Proposed	Collected [b]	Reported	Samples Voided	Completeness (%)
Hand Wipe Adult	198	197[c]	197	0	100
Hand Wipe Child	284	283[c]	283	0	100
Drinking Water	155	155	155	0	100
Food Preparation Surface Wipe	18	18	18	0	100
Hard Floor Surface Wipe	46	46	46	0	100
Indoor Air Acid	151	151	150[d]	1	99.3
Indoor Air Neutral	151	151	151	0	100
Floor Dust	154	154	154	0	100
Liquid Food Adult	130[a]	123[e]	122[f]	1	99.2
Liquid Food Child	166[a]	164[e]	163[g]	1	99.4
Outdoor Air Acid	154	154	154	0	100
Outdoor Air Neutral	154	155[h]	154	1	99.4
Transferable Residues	18	18	18	0	100
Solid Food Adult	130	130	130	0	100
Solid Food Child	166	166	166	0	100
Outdoor Play Area Soil	143	143	143	0	100
Urine Adult	618, 190[i]	615, 190h[i]	615, 190	0	100
Urine Child	744, 283[i]	739, 283[i]	739, 283	0	100

[a] Empty jars were collected for the liquid food samples because the participants claimed they drank only water.

[b] Samples collected include all field samples and field blanks but not laboratory generated QC samples.

[c] The participant withdrew from the study after day-1 sampling because the domestic partner refused to participate.

[d] One sample was voided due to pump malfunction (air volume sampled equaled zero).

[e] Count does not include the empty jars that were collected from households in which the adult and/or child only drank water.

[f] One sample was spilled during preparation.

[g] The field staff dropped one liquid food sample while loading the van.

[h] One extra outdoor air sample was collected to replace one sample due to pump malfunction.

[i] The first number is the number of individual collected urine samples, and the second number is the number of both composite and non-composite samples.

Table 5.3.2 Summary of the Completeness of the NC Questionnaire/Diary Collection

Form Number	Proposed	Collected	Reported	Completeness for Collected Forms (%)	Completeness for Collected Data[a] (%)
Form # 1	130	130	130	100	99.6
Form # 2	130	130	130	100	99.8
Form # 3	13	13	13	100	99.8
Form # 4	130	130	130	100	99.9
Form # 5	13	13	13	100	99.8
Form # 6	130	130	130	100	99.3
Form # 7	63	63	63	100	99.9
Form # 8	67	67	67	100	99.0
Form # 9	63	63	63	100	99.7
Form # 10	63	63	63	100	99.6

[a] A SAS program was used to calculate the percentage of completeness for the data collected on each form using the equation Completeness (%) = [(A-B)/A]*100

where A = Count the total number of filled, valid data variables (not empty)
B = Count the number of data variables coded as "missing"

5.3.2 Ohio

Tables 5.3.3 and 5.3.4 summarize the completeness associated with the collection of field samples and supplemental information (questionnaires/diaries), respectively, from OH. Field data collection activities in the OH study achieved greater than 99% completeness for field samples, 100% for collected questionnaires/diaries, and greater than 94% completeness for the data collected on the questionnaires/diaries. In addition, all proposed children (26) were successfully videotaped at their homes in OH; therefore, 100% completeness was achieved for the videotaping activities.

Table 5.3.3 Summary of the Completeness of the OH Sample Collection

Sample Description	Proposed	Collected [b]	Reported	Samples Voided	Completeness (%)
Hand Wipe Adult	196	196	196	0	100
Hand Wipe Child	283	283	283	0	100
Drinking Water	157	157	157	0	100
Food Preparation Surface Wipe	16	16	16	0	100
Hard Floor Surface Wipe	38	38	38	0	100
Indoor Air Acid	150	150	150	0	100
Indoor Air Neutral	150	150	150	0	100
Floor Dust	157	157	157	0	100
Liquid Food Adult	127[a]	122[c]	122	0	100
Liquid Food Child	171[a]	170[c]	170	0	100
Outdoor Air Acid	156	156	155	1[d]	99.4
Outdoor Air Neutral	156	156	156	0	100
Transferable Residues	18	18	18	0	100
Solid Food Adult	127	127	127	0	100
Solid Food Child	170	170	170	0	100
Outdoor Play Area Soil	143	143	143	0	100
Urine Adult	634, 194[e]	634, 194[e]	634, 194[e]	0	100
Urine Child	756, 266[e]	756, 266[e]	756, 266[e]	0	100

[a] Empty jars were collected for the liquid food samples because the participants claimed they drank only water.
[b] Samples collected include all field samples and field blanks but not laboratory generated QC samples.
[c] Count does not include the empty jars that were collected from households in which the adult and/or child only drank water.
[d] One sample was lost during laboratory extraction.
[e] The first number is the number of individual urine samples collected, and the second number is the number of both composite and non-composite samples.

Table 5.3.4 Summary of the Completeness of the OH Questionnaire/Diary Collection

Form Number	Proposed	Collected	Reported	Completeness for Collected Forms (%)	Completeness for Collected Data[a] (%)
Form # 1	127	127	127	100	98.8
Form # 2	127	127	127	100	100
Form # 3	16	16	16	100	99.8
Form # 4	127	127	127	100	99.9
Form # 5	16	16	16	100	99.4
Form # 6	127	127	127	100	99.9
Form # 7	58	58	58	100	99.6
Form # 8	69	69	69	100	99.9
Form # 9	58	58	58	100	95.1
Form # 10	58	58	58	100	94.0

[a] A SAS program was used to calculate the percentage of completeness for the data collected on each form using the equation Completeness, (%) = (A-B)/A*100

where A = Count the total number of filled, valid data variables (not empty)

B = Count the number of data variables coded as "missing"

5.4 Evaluation

Several problems were encountered during field sample collection. A frequent problem encountered at the day care centers was the teachers' difficulty in recording the time-activity diary for more than one child in a classroom. Although project field staff went over the recording procedures carefully with the teachers before sampling, the detail required was overwhelming for some of them. As a result, coverage of the time periods in the child activity diaries was sometimes incomplete. In future studies, this information should be collected by a more simplified method.

Some day care teachers were reluctant to collect and store children's urine samples for later pickup. Field staff, therefore, assisted in urine sample collection at day care centers when requested. Some parents had difficulty understanding the need and procedures for duplicate plate food sample collection and the time-activity diary recording procedures. Thorough pre-sampling training of the adult participants by the field staff was necessary to communicate these procedures.

Training of day care teachers and parents was conducted at the participating day care centers in each state. The project staff first consulted with the day care director to identify the best time for the training (normally in the afternoon before the pickup time of the children). A flyer about the upcoming CTEPP study meeting was then distributed to all selected parents and classroom teachers a few days before the scheduled training date. The meeting was designed to accomplished the following: (1) training of teachers in the selected classrooms (often best accomplished when children were napping); (2) training of parents; (3) meeting with the day care cook or kitchen staff to explain food collection; and (4) meeting with the day care director to confirm sampling dates at the day care and to discuss the information needed for pre-monitoring interview (e.g., day care floor plan and chemical use information).

Training for teachers and parents included a brief study background discussion (e.g., what the study was about, why it was important, what assistance was needed from them) and a step-by-step demonstration of the procedures for completing the child activity diary and for collecting urine, hand wipe, and duplicate food samples. Best results were achieved when two to three staff members were available to train a small group of participants. The training emphasized hands-on practice. Instruction sheets were handed out to participants after training for use at home. In addition to the training, the staff also reviewed the informed consent process with the parent and asked the parent to complete the recruitment survey if informed consent had been obtained earlier. After the training was completed, a project T-shirt was presented to each participant. Finally the staff confirmed the sampling schedule with the parent and gave them a money order for $25 to cover their cost for providing duplicate food samples. Similar training was conducted for the telephone component participants at their homes. Once a subject was determined to be eligible through the telephone screening process, an appointment was made to meet with the subject at his/her house to go over the study procedures.

Communication issues in the field were related to problems with directions, equipment malfunctions, and scheduling changes. Participants were therefore encouraged to contact the field staff by phone at any time necessary, and all field staff were provided with cellular phones to facilitate communication with the participants and other staff members.

In one household, the study was unable to collect outdoor air samples due to no available electrical outlet for the air pump. In another household, a valid indoor air sample for acid analysis could not be obtained because the air pump did not operate properly. In one household, the participant refused to continue the study after Day-1, resulting in incomplete sets of dermal hand wipes and the child liquid food sample. The urine samples from three households were combined incorrectly by the laboratory staff, requiring the collection and processing of make-up urine samples from these households. One liquid food sample was dropped while field staff were loading the van.

5.5 Recommendations

Despite efforts to enhance participant cooperation in collecting food samples (i.e., training and pre-paying for food samples provided by the participants), there were still some missing food samples due to participants' reluctance to collect duplicate food samples. This was particularly problematic when the participants ate in a restaurant. In some situations, the project staff was able to purchase the missing food samples from the same restaurant. We recommend an increase in participant compensation or a decrease in the participant burden (i.e., collecting 24-h instead of 48-h food samples) to improve the participants' cooperation in future studies.

Some air sampling problems were caused by severe storms or an unreliable power supply at the sampling site. For future similar studies, we recommend self-powered (i.e., battery-powered) air pumps for air sampling. A battery backup system is also a good alternative; however, such systems can only provide temporary power for approximately 18 h.

Chapter 6
Sample Analysis Procedures

6.1 Overview

In the CTEPP study, more than 50 compounds were measured in 11 different types of sample matrices. Target compounds included two organophosphate (OP) pesticides, two OP metabolites, three pyrethroid pesticides, one pyrethroid metabolite, 10 organochlorine (OC) pesticides, three acid herbicides, nine polycyclic aromatic hydrocarbons (PAHs), two phthalates, three phenols, 17 polychlorinated biphenyls (PCBs), seven PAH metabolites, and one triazine. (Note that two carbamates, propoxur and bendicarb were originally included on the list of target pollutants but were later removed due to the study's analytical methods being incompatible for these pollutants.) The target pollutants and their metabolites were divided into two groups, neutral and acidic, based on their chemical properties. According to sample media, various extraction and cleanup methods were employed for these pollutants/metabolites in each group. The neutral and acidic pollutants and OP metabolites that were measured in the environmental and personal samples, except urine, are listed in Tables 6.1.1 and 6.1.2, respectively[1]. The target acidic pollutants/metabolites that were measured in urine are listed in Table 6.1.3. With the exception of creatinine in urine samples, Battelle performed all analyses of CTEPP field samples. No cross-checks by independent laboratories were used to confirm measured levels in some samples.

Both neutral and acidic pollutants as well as OP metabolites were measured in air, indoor floor dust, soil, hand wipe, hard floor surface wipe, food preparation surface wipe, transferable residue (PUF), and child food samples. Adult food samples were analyzed only for acidic pollutants and OP metabolites. Child food samples from North Carolina (NC) were analyzed for all neutral and acidic pollutants as well as one OP metabolite. Child food samples from Ohio (OH) were analyzed for all the target pollutants and two OP metabolites, except for the PCBs. Note that one OP metabolite, 3,5,6-trichloro-2-pyridinol (3,5,6-TCP), was measured in the NC samples and two OP metabolites, 3,5,6-TCP and 2-isopropyl-6-methyl-4-pyrimidinol (IMP), were measured in the OH samples. Drinking water samples were analyzed only for atrazine. Floor surface wipe samples, when collected to replace floor dust samples from homes without carpet, were analyzed for neutrals and acids. Additionally, food preparation surface wipe, hard floor surface wipe, and transferable residue samples were collected in homes where pesticides had been applied recently (within seven days of field sampling or during the 48-h monitoring period). In NC and OH, recent pesticide applications were only reported at homes and none at day care centers. The pesticides applied to the NC homes were all neutral pollutants, therefore,

[1]Participants were still able to purchase and apply both chlorpyrifos and diazinon at their residences or day care centers in NC and OH during the study.

Table 6.1.1 Neutral Target Pollutants for the CTEPP Study

Target Pollutants		
OP Pesticides	*trans*-Permethrin	**PCBs**[a]
Chlorpyrifos	**PAHs**	PCB 44 (2,2',3,5'-tetrachlorobiphenyl)
Diazinon	Benz[*a*]anthracene	PCB 52 (2,2',5,5'-tetrachlorobiphenyl)
OC Pesticides	Benzo[*a*]pyrene	PCB 70 (2,3',4',5-tetrachlorobiphenyl)
Aldrin	Benzo[*b*]fluoranthene	PCB 77 (3,3',4,4'-tetrachlorobiphenyl)
alpha-Chlordane	Benzo[*e*]pyrene	PCB 95 (2,2',3,5',6-pentachlorobiphenyl)
gamma-Chlordane	Benzo[*ghi*]perylene	PCB 101 (2,2',4,5,5'-pentachlorobiphenyl)
p,p'-DDE	Benzo[*k*]fluoranthene	PCB 105 (2,3,3',4, 4'-pentachlorobiphenyl)
p,p'-DDT	Chrysene	PCB 110 (2,3,3',4',6-pentachlorobiphenyl)
Dieldrin	Dibenz[*a,h*]anthracene	PCB 118 (2,3',4,4',5-pentachlorobiphenyl)
Endrin	Indeno[1,2,3-*cd*]pyrene	PCB 138 (2,2',3,4,4',5'-pentachlorobuphenyl)
Heptachlor	**Phthalates**	PCB 153 (2,2',4,4',5,5'-hexachlorobiphenyl)
Lindane	Benzylbutylphthalate	PCB 180 (2,2',3,4,4',5,5'-heptachlorobiphenyl)
Pentachloronitrobenzene	Di-*n*-butylphthalate	**Triazine**
Pyrethroid Pesticides	**Phenols**	Atrazine
Cyfluthrin	Bisphenol-A	
cis-Permethrin	Nonylphenol	

[a] Data were reported for 12 PCBs, but not for PCBs 10, 15, 28, 126, and 169. The data for the five PCBs were excluded because the presence of the volatile PCBs 10, 15, and 28 with the presence of closely eluted interference peaks could not provide useful information for Aroclor patterns and none of the PCBs 126 and 169 were detected in the samples.

Table 6.1.2 Acidic Target Pollutants and Metabolites for the CTEPP Study

Target Pollutants and Metabolites
OP Metabolites
2-Isopropyl-6-methyl-4-pyrimidinol (IMP) [a]
3,5,6-Trichloro-2-pyridinol (3,5,6-TCP)
Acid Herbicides
Dicamba
2,4-Dichlorophenoxyacetic acid (2,4-D)
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)
Phenols
Pentachlorophenol (PCP)

[a] IMP was measured only in the OH samples.

Table 6.1.3 Target Pollutants and Metabolites Measured in The CTEPP Urine Samples

Target Pollutants and Metabolites	
OP Metabolites	3-Hydroxybenz[*a*]anthracene [a]
2-Isopropyl-6-methyl-4-pyrimidinol (IMP)	3-Hydroxybenzo[*a*]pyrene[a]
3,5,6-Trichloro-2-pyridinol (3,5,6-TCP)	3-Hydroxychrysene
Pyrethroid Metabolite	6-Hydroxychrysene[a]
3-Phenoxybenzoic acid (3-PBA) [a]	6-Hydroxyindeno[1,2,3-*cd*]pyrene [a]
Acid Herbicides	1-Hydroxypyrene [a]
2,4-Dichlorophenoxyacetic acid (2,4-D)	**Phenols**
PAH Metabolites	Pentachlorophenol (PCP)
1-Hydroxybenz[*a*]anthracene	

[a] These metabolites were measured only in the OH samples.

the wipe and transferable residue samples were only analyzed for neutral pollutants. The pesticides applied to the OH homes were either neutral or acidic pollutants. Therefore, these OH samples were analyzed for either neutral or acidic pollutants/metabolites depending upon the type of pesticides that had been applied.

Environmental samples were solvent-extracted using Soxhlet extraction, sonication, accelerated solvent extraction (ASE), or refluxing techniques. Most samples required cleanup to remove potential interferences. Acidic compounds were derivatized using silylation or methylation, depending upon the compound. The specific gravity and creatinine concentrations of the urine samples were measured. Urine samples were then hydrolyzed under acidic conditions, extracted, derivatized, and cleaned up prior to analysis. Concentrated extracts of all samples were analyzed by gas chromatography/mass spectrometry (GC/MS) in the selected ion monitoring mode. Thirty different SOPs, as listed in Appendix A, were used due to the large variety of chemicals and matrices that were considered for extraction and analysis. Flow charts of the sample preparation and analysis methods used for all the target pollutants/metabolites in each sample media are given in Appendix C.

Quality control (QC) samples were analyzed to assess the overall quality of the analytical results. These QC samples included: (1) field and laboratory duplicates, (2) duplicate GC/MS analyses of sample extracts, (3) matrix spike samples (MSSs), and (4) field and laboratory blanks. Surrogate recovery standards (SRSs) were used to assess recovery in every sample.

6.2 Procedures for North Carolina and Ohio samples

The same sample analysis procedures were used to determine target pollutants and metabolites in environmental and personal samples collected in both NC and OH. As noted in Tables 6.1.2 and 6.1.3, a few additional acidic pollutants/metabolites were measured in the OH samples, along with the target compounds analyzed in the NC samples.

6.2.1 Extraction

Several types of samples required processing prior to extraction. Dust samples were sieved, and only the fine dust samples (<150 μm) were extracted. Any visible small rocks were removed from the soil samples, and then the sample was mixed with a glass rod before an aliquot was taken for extraction. Liquid food samples were thawed for 2 to 5 days in a refrigerator prior to extraction. Solid food samples were thawed (~2-5 days), homogenized with dry ice using a food processor (Hobart Food Chopper, 33"x19"x9.5"); and stored in glass jars at < -10^{o}C for subsequent extraction. Urine samples were composited for each child and adult over the 48-h period at homes, except from homes with recent pesticide applications. The urine samples from the homes with recent pesticide applications were extracted individually. If the child attended day care, the urine samples collected from the day care center were not combined with the urine samples collected from the child's home. All other samples were processed as received from the field. Table 6.2.1 summarizes the SRSs and internal standards (ISs) used in the different types of samples. The SRSs were added to each sample prior to extraction, and the ISs were added to the concentrated sample extracts prior to GC/MS analysis. Table 6.2.2 summarizes the sample

preparation methods employed for each type of samples. Detailed preparation and extraction methods are described in CTEPP SOPs 5.12-5.23 and 5.27-5.29. Typically, all samples were extracted within 14 days of receipt.

Table 6.2.1 Surrogate Recovery Standards and Internal Standards for Chemical Analysis

Compound Class	Surrogate Recovery Standards	Internal Standards
Neutral Pollutants		
OP Pesticide	p,p'-DDE-d_4	Diazinon-d_{10}
OC Pesticide	p,p'-DDE-d_4	Phenanthrene-d_{10}, p,p'-Dibromobiphenyl
Pyrethroid Pesticide	p,p'-DDE-d_4	p,p'-Dibromobiphenyl
PAH	Dibenz[*a*,*h*]anthracene-d_{14}	p,p'-Dibromobiphenyl, Benzo[*e*]pyrene-d_{12}
Phthalate	Benzylbutylphthalate-d_4	p,p'-Dibromobiphenyl
Phenol	Bisphenol-A-d_6	p,p'-Dibromobiphenyl
PCB	2,2,4,5,5'-Pentachlorobiphenyl-C_{13}	Phenanthrene-d_{10}
Triazine [a]	NA [b]	Atrazine-d_5
Acidic Pollutants/Metabolites		
OP Metabolite	NA[b]	TCP-$C_{13}N_{15}$
Acid Herbicide	2,4-D-C_{13}	Dicamba-d_3
Phenol	2,4-D-C_{13}	Dicamba-d_3, TCP-$C_{13}N_{15}$
Acidic Pollutants/Metabolites in Urine		
OP Metabolite	NA[b]	TCP-$C_{13}N_{15}$
Pyrethroid Metabolite	2,4-D-C_{13}	Dicamba-d_3
Acid Herbicide	2,4-D-C_{13}	Dicamba-d_3
PAH Metabolite	2,4-D-C_{13}	Dicamba-d_3
Phenol	2,4-D-C_{13}	Dicamba-d_3

[a] Atrazine was measured only in drinking water samples.
[b] NA denotes not available.

Table 6.2.2 Summary of Sample Extraction Methods

Medium	Target Chemicals	Summary of Method
Air	Neutral pollutants	Soxhlet extract overnight (~14 h) with 80 mL dichloromethane (DCM); concentrate with Kuderna-Danish concentrator (KD); if cleanup is needed, solvent exchange to hexane; Florisil solid phase extraction (SPE) clean up with 18 mL of 15% ethyl ether (EE) in hexane; concentrate with KD.
	Acidic pollutants/metabolites	Soxhlet extract overnight (~14 h) with 80 mL acetonitrile (ACN); concentrate with KD; split sample extract for silylation and methylation. Silylate with 100 µL MTBSTFA at 70EC for 1 h. Methylate in 50 µL methanol with etheral diazomethane (diazald, carbitol, 37% aqueous KOH).
Dust/Soil	Neutral pollutants	0.5 g of dust or 1-2 g of soil, sonicate for 15 min with 2 x 10 mL of 10% diethyl ether in hexane; concentrate with KD; if cleanup is needed, Florisil SPE clean-up with 12 mL of 15% EE in hexane and 6 mL DCM; concentrate with KD.
	Acidic pollutants/metabolites	0.5 g of dust or 5 g of soil, accelerated solvent extraction (ASE) with acetone at 120EC and 2000 psi for 3 cycles of 10 min; concentrate with KD; split sample extract for silylation and methylation. Silylate with 100 µL MTBSTFA at 70EC for 1 h. Methylate in 50 µL methanol with etheral diazomethane; solvent exchange into isooctane; Florisil SPE clean up with 12 mL of 15% EE in hexane and 6 mL DCM; concentrate with KD.
Drinking Water	Atrazine	100 mL of drinking water, C18 SPE with 12 mL of 50% DCM in hexane; dry with sodium sulfate; filter through quartz fiber filter; concentrate with KD.
Solid Food	Neutral pollutants	12 g of solid food, ASE with DCM at 100EC and 2000 psi for 2 cycles of 5 min; dry with sodium sulfate; concentrate with KD; GPC clean-up with DCM; collect fractions F1 and F2 separately. Concentrate F2 with KD; F1: solvent exchange into ACN; ENVI-Carb clean up with 48 mL ACN; concentrate with KD or TurboVap
	Acidic pollutants/metabolites	8 g of solid food, ASE with methanol at 110EC and 2000 psi for 2 cycles of 5 min; concentrate with KD; extract with 15 mL MilliQ water; adjust to pH>12 with 40% KOH; extract with 3x20 mL hexane; discard hexane; acidify to pH<2 with conc. HCl; extract with 3x20 mL DCM; dry with sodium sulfate; concentrate with KD; split extract for silylation and methylation. Silylate with 100 µL MTBSTFA at 70EC for 1 h. Methylate in 50 µL methanol with etheral diazomethane.

Table 6.2.2 Summary of Sample Extraction Methods (cont.)

Medium	Target Chemicals	Summary of Method
Liquid Food	Neutral pollutants	30 mL of liquid food, reflux in 60 mL DCM for 1.5 h, filter, extract with 2x20 mL DCM, dry with sodium sulfate, filter, concentrate with KD, filter extract on micron acrodisc PTFE filter, GPC clean-up with DCM, collect fractions F1 and F2 separately. Concentrate F2 with KD. F1: solvent exchange into ACN; ENVI-Carb clean up with 48 mL ACN; concentrate with KD or TurboVap
	Acidic pollutants/metabolites	10 mL of liquid food, extraction method 1 or 2: *Method 1 for non-clear liquid food:* ASE with methanol at 110EC and 2000 psi for 2 cycles of 5 min; concentrate with KD for subsequent liquid-liquid partitioning as method 2. *Method 2 for clear liquid food:* liquid-liquid partitioning with 10 mL milliQ water and 10 mL sample, filter through quartz filter; add up to15 mL MilliQ water to resulting extract from either method 1 or 2; adjust to pH>12 with 40% KOH; extract with 3x20 mL hexane; discard hexane; acidify to pH<2 with concentrated HCl; extract with 3x20 mL DCM; dry with sodium sulfate; concentrate with KD; split extract for silylation and methylation. Silylate with 100 µL MTBSTFA at 70EC for 1 h. Methylate in 50 µL methanol with etheral diazomethane.
Dermal, Floor Surface, Food Preparation Wipes	Neutral pollutants	Soxhlet extract overnight (~14 h) with 300 mL DCM; filter on quartz fiber filter; concentrate with KD, if needed, Florisil SPE clean-up with 18 mL of 15% EE in hexane; concentrate with KD.
	Acidic pollutants/metabolites	ASE with acetonitrile (ACN) at 120EC and 2000 psi for 3 cycles of 5 min; concentrate with KD; split sample extract for silylation and methylation. Silylate with 100 µL MTBSTFA at 70EC for 1 h. Methylate in 50 µL methanol with etheral diazomethane. If needed, Florisil SPE clean-up with 18 mL of 15% EE in hexane; concentrate with KD.
Urine	Acidic pollutants/metabolites	1 mL urine: hydrolysis with 100 µL conc. HCl at 80EC for 1 h; add 1 mL of 20% NaCl solution, 1 mL chlorobutane (CB), and 10 µL of internal standard; mix and centrifuge; remove 800 µL of the extract and silylate with 100 µL MTBSTFA at 70EC for 1 h; transferred to GC vial. 10 mL urine: hydrolysis with 500 uL conc. HCl and 1 mL of CB at 80EC for 1 h; add 10 mL of 20% NaCl solution and extract with 3x10 mL DCM; concentrate with KD; methylate in 50 µL methanol with etheral diazomethane.

Prior to GC/MS analysis, two different derivatization methods, methylation and silylation, were used for the acidic compounds. Dicamba, 2,4-D, 2,4,5-T, 3-PBA, and hydroxy-PAHs were methylated using diazomethane. 3,5,6-TCP and IMP were silylated using N-(t-butyldimethylsilyl)-N-methyl-trifluoroacetamide (MTBSTFA). Pentachlorophenol (PCP) could be derivatized by methylation or silylation, and in early analyses the silylated derivative was used. However,
interferences were seen in some dust samples. Therefore, PCP was analyzed in most samples as the methyl derivative. After cleanup and derivatization, sample extracts were concentrated to 1 mL and spiked with internal standards, as shown in Table 6.2.2. Extracts were stored in a freezer at < -10EC until analysis. Typically, all samples were analyzed within 14 days of extraction.

6.2.2 Sample Analysis

All concentrated sample extracts and standard solutions were analyzed by 70 eV electron impact (EI) GC/MS. The Hewlett-Packard GC/MS was operated in the selected ion monitoring mode. Data acquisition and processing were performed with a ChemStation data system. The GC column was a DB-5 fused silica capillary (60 m x 0.32 mm, 0.25 µm film thickness). Helium was used as the GC carrier gas. The GC/MS operation conditions used for different types of samples are summarized in Table 6.2.3. Peaks monitored were the molecular ion peaks and their associated characteristic fragment ion peaks. Identification of the target compounds was based on their GC retention times relative to their internal standard and relative abundance of the monitored ions. Quantification of target compounds was based on comparisons of the integrated ion current response of the target ions to those of the respective internal standards using average response factors for the target compounds, generated from standard calibrations. The response factor was calculated using the following equation:

$$R_f = (A_s/A_{is}) \times (C_{is}/C_s)$$

where

A_s = area of quantification ion for target pollutant in the standard solution
A_{is} = area of quantification ion for internal standard in the standard solution
C_{is} = concentration of internal standard in the standard solution
C_s = concentration of target pollutant in the standard solution
Rf = response factor of target pollutant

The target pollutant concentration in the sample was calculated using the following equation:

$$C_s = (A_s/A_{is}) \times (C_{is}/R_{favg})$$

where

A_s = area of quantification ion for target pollutant in the sample extract
A_{is} = area of quantification ion for internal standard in the sample extract
C_{is} = concentration of internal standard in the sample extract
C_s = concentration of target pollutant in the sample extract
R_{favg} = average response factor of target pollutant

Table 6.2.3 Summary of GC/MS Operating Conditions

Medium	Target Chemicals	Summary of Method
Air, Dust, Soil, Solid Food, Liquid Food, Dermal Wipes, Floor Surface Wipes, Food Preparation Wipes, Transferable Residue	OP and OC pesticides, pyrethroid pesticides, PAHs, phthalates, and phenols	Injection volume: 1 µL Solvent delay: 7 min Inlet: 290EC Oven: 70EC (2 min hold), 15EC/min to 150EC, 6EC/min to 290EC Transfer line: 290EC
	PCBs	Injection volume: 1 µL Solvent delay: 7 min Inlet: 290EC Oven: 70EC (2 min hold), 20EC/min to 150EC, 4EC/min to 290EC (4 min hold) Transfer line: 290EC
	Acid herbicides and PCP	Injection volume: 1 µL Solvent delay: 7 min Inlet: 290EC Oven: 90EC, 8EC/min to 290EC Transfer line: 290EC
	OP metabolites (3,5,6-TCP and IMP), and PCP	Injection volume: 1 µL Solvent delay: 7 min Inlet: 290EC Oven: 90EC, 8EC/min to 290EC Transfer line: 290EC
Drinking Water	Triazine (atrazine)	Injection volume: 1 µL Solvent delay: 7 min Inlet: 290EC Oven: 70EC, 20EC/min to 190EC, 4EC/min to 215EC, 27EC/min to 290EC Transfer line: 290EC
Urine	Pyrethroid metabolite (3-PBA), 2,4-D, PAH metabolites, and PCP	Injection volume: 1 µL Solvent delay: 7 min Inlet: 290EC Oven: 90EC, 8EC/min to 290EC (5 min) Transfer line: 290EC
	OP metabolites (3,5,6-TCP, IMP)	Injection volume: 1 µL Solvent delay: 7 min Inlet: 290EC Oven: 90EC, 8EC/min to 290EC Transfer line: 290EC

6.2.3 Supplemental Measurements on Urine Samples

Creatinine concentration and specific gravity were measured in the urine samples so that comparisons of urine metabolite concentrations could be made from sample to sample on a common basis, considering that the dilution level of individual urine samples can vary greatly depending on the individuals' muscle activity, kidney efficiency, and the amount of water that they ingest. Creatinine is a byproduct of the breakdown of creatine and phosphocreatine, an energy storage compound in muscle. The more active the person, the greater the amount of creatinine excreted in the urine. The specific gravity is the weight of a known amount of urine compared to the weight of an equal amount of water. Specific gravity measures the kidney's ability to concentrate or dilute urine in relation to plasma. Because urine is a solution of minerals, salts, and compounds dissolved in water, the specific gravity of urine is greater than 1. Urine specific gravity increases as the urine becomes more concentrated.

Aliquots (10 mL each) of composited urine samples were removed for creatinine analysis. The non-composited urine samples were not analyzed for creatinine, because of the small sample size per void and the need to analyze the urine samples for parent compounds or metabolites. The urine sample aliquots were sent to the Ohio State University Clinical Laboratory for creatinine analysis. The method employed was the Jaffee Picric Acid, colorimetric method. Specific gravity measurements were performed on all composited and non-composited urine samples, using reagent strips purchased from Lab Essentials Inc. (Monroe, GA), Urine Reagent Strips (9-parameter). The reagent end of the strip was dipped into the urine sample. After one minute, the color of the test strip was compared to the standard color chart, and the specific gravity value was recorded.

6.2.4 Method Evaluation

6.2.4.1 Instrument Performance

The GC/MS system was calibrated with perfluorotributylamine according to the manufacturer's instructions, to verify that acceptable performance criteria were achieved, before analyzing any standard solutions and/or samples. A multi-point calibration curve (typically five points) was constructed with calibration standards for each sample set. An average response factor (Rf) of each target pollutant was generated from the multi-point calibration curve. The percent relative standard deviation (% RSD) of the calculated Rf values in all the calibration solutions was required to be within ± 25%. The calculated values of the standard solutions were checked to ensure that the relative percent difference (%RPD) was within ± 30% of the expected values. If the % RSD values of some compounds were greater than ± 25%, the GC/MS system was checked to determine the sources of this variation. Appropriate corrective actions (i.e., cleaning the source) were taken. The calibration standard solutions and the sample set were then re-analyzed, and another multi-point calibration curve was generated for quantification.

6.2.4.2 Method Performance

6.2.4.2.1 North Carolina Method precision was evaluated based on the results from duplicate samples and duplicate GC/MS analyses. One field duplicate air sample for neutral analysis, and one for acid analysis, were collected in the NC study. Duplicate NC samples for dust, soil, food and urine were duplicate aliquots of these samples. Duplicate wipe and transferable residue samples were not obtained because it was not feasible to obtain true duplicate samples for these sample media. For example, once a surface has been wiped or sampled with a PUF roller, there is no other equivalent surface from which a duplicate sample can be obtained. A summary of the mean and standard deviation (SD) values of the %RPD of the duplicate NC samples are given in Tables 6.2.4 through 6.2.6. For neutral pollutants in the multimedia samples, the mean %RPD ranged from 0 to 26%, except for PCB 52 for which the mean %RPD ranged from 0 to 36%. The mean %RPD for acidic pollutants/metabolites ranged from 0 to 16%. Duplicate GC/MS analyses were performed on randomly selected sample extracts for all sample media (the same sample extract was analyzed twice by GC/MS). Results of the mean and SD for the %RPD of the duplicate GC/MS analyses are summarized in Tables 6.2.7 to 6.2.9. The mean %RPD ranged from 0 to 9% for all neutral and acidic pollutants/metabolites.

Overall method accuracy was evaluated by measuring the recoveries of the MSSs and SRSs that had been spiked onto all field samples. Recoveries of the MSSs for dust, soil, liquid food, solid food, and urine samples were obtained from different aliquots of the corresponding spiked and non-spiked samples. Recoveries of the MSSs of air, wipe, and PUF samples were obtained from the spiked blank sample media. The mean and SD values of the recovery data from the NC matrix spike samples are summarized in Tables 6.2.10 to 6.2.12. Typical spiking levels of MSSs and SRSs by matrix are shown in these Tables. With few exceptions, satisfactory recoveries were obtained for most target pollutants/metabolites in all types of samples. Mean recoveries ranged from 54±6.5 to 130±6.5% for neutral pollutants. Mean recoveries ranged from 64±16 to 99±23% for acidic pollutants/metabolites. High background levels of the two phthalates were found in the non-spiked blank sample media as well as in the field samples. Consequently, the spiked levels of the two phthalates were not high enough in most of the matrix spike samples to provide satisfactory recovery data. For the same reason, satisfactory recoveries for target OP pesticides and PAHs could not be obtained in a few dust and soil samples. Interference peaks were observed for bisphenol-A, cyfluthrin, and *cis*-permethrin. Recovery data for these samples were not included in calculating the mean and SD as noted in Table 6.2.10. A *trans*-permethrin standard was not available at the early stage of the NC field study, thus some of the matrix spike samples did not contain this compound.

Recovery data of SRSs are summarized in Tables 6.2.13 to 6.2.15. Quantitative recoveries for the SRSs including *p,p'*-DDE-d_4, dibenz[*a,h*]anthracene-d_{14}, PCB101-C_{13}, and 2,4-D-C_{13} were obtained in most NC field samples. Recoveries for SRSs ranged from 56±9.5 to 120±18% for neutral pollutants and from 75±11 to 91±18%for acidic pollutant, 2,4-D-C_{13}. Interference peaks were observed for benzylbutylphthalate-d_4 and bisphenol-A-d_6, in some air, dust, soil, and wipe samples. Therefore, satisfactory recoveries were not obtained.

Field blanks and laboratory method blanks were used to assess background contamination from field sample handling and laboratory sample processing. Results of the neutral and acidic

pollutants/metabolites in field blanks and laboratory blanks from NC are summarized in Tables 6.2.16 to 6.2.17. Typically, field blanks were taken every other week during the sampling periods in each state. Field blanks for air, wipe, and PUF samples were unspiked sampling cartridges, precleaned wipes, and precleaned PUFs respectively. These cartridges, wipes, and PUFs were taken to the field and treated the same way as field samples, but were not exposed. Field blanks for dust/soil and liquid/solid food were empty containers that were used for collecting the respective samples and went through the same field handling procedures as field samples. Because the same kind of wipes was used for dermal wipes, floor surface wipes, and food preparation wipes, all the wipe samples shared the same field blanks. Dust and soil samples shared the same field blanks, because the same type of containers was used for these samples.

The reported median and SD values in Tables 6.2.16 and 6.2.17 were generated from the combined field blanks and laboratory blanks data. These tables do not include the pollutants/metabolites that were not detected in the blanks from all sample media. If the target pollutant/metabolite was detected in some of the blanks, the non-detected blank results were replaced by the method detection limit (MDL) divided by the square root of two for all media, except liquid food, in the determination of the median and SD values. Non-detected results for liquid food blanks were replaced by the MDL divided by ten. With few exceptions, most target pollutants/metabolites were not detected in the field blanks and laboratory method blanks. The median values of these pollutants/metabolites were below or close to the method detection limits in these blanks. Measurable amounts of bisphenol-A in wipe samples, and of the two phthalates in all sample media, were found in the field blanks and laboratory method blanks in NC. Therefore, background correction was performed for these samples, before the data were used for the statistical analysis discussed in Chapter 8 of this report. Two PUF method blanks (11% of all PUF samples) were analyzed for neutrals; one did not contain any detectable target pollutants except for the two phthalates. The other PUF blank contained few PCBs; visible particles were observed in this blank PUF, which were probably due to contamination in the laboratory. There were 29 (6.1% of total urine samples) method blanks, and 12 (2.5% of total urine samples) field blanks, which were collected and analyzed for target pollutants/metabolites in urine. None of the urine blanks had any detectable target compounds.

Only one target pollutant, atrazine, was measured in the drinking water samples, thus all QC data for the drinking water samples are summarized in Table 6.2.18. There was no SRS for the water samples, because atrazine-d_5 was used as an internal standard. Overall method precision was very good; the mean of the %RPD of duplicate water samples was 2.2 ± 3.5%, and a similar result was obtained from the duplicate GC/MS analyses. Average recovery of the matrix spike samples was 84 ± 20%. Trace amounts of atrazine were found in some of the blank samples.

Table 6.2.4 Results for Duplicate Samples for Neutral Pollutants - North Carolina

Pollutant	Air		Dust/Soil		Liquid Food		Solid Food	
Number of QC samples	2		30		10		6	
Percent of field samples	0.7		10		6.1		3.6	
	Relative Percent Difference, %							
OP Pesticides	mean [a]	SD	mean	SD	mean	SD	mean	SD
Chlorpyrifos	24	NA	14	27	-	-	-	-
Diazinon	- [b]	-	5.4	8.9	-	-	-	-
OC Pesticides								
Aldrin	-	-	1.2	3.1	-	-	-	-
alpha-Chlordane	1.3	NA [c]	4.2	5.6	-	-	-	-
gamma-Chlordane	9.3	NA	4.3	5.9	-	-	-	-
p,p'-DDE	-	-	1.7	4.2	-	-	4.4	6.9
p,p'-DDT	-	-	2.8	7.6	-	-	0.25	0.44
Dieldrin	-	-	3.0	9.3	-	-	-	-
Endrin	-	-	0.22	0.85	-	-	-	-
Heptachlor	4.2	NA	1.5	3.3	-	-	-	-
Lindane	7.4	NA	-	-	-	-	2.9	5.0
Pentachloronitrobenzene	-	-	-	-	-	-	-	-
Pyrethroid Pesticides								
Cyfluthrin	-	-	0.63	1.59	-	-	-	-
cis-Permethrin	-	-	3.1	4.9	1.3	2.4	2.5	3.4
trans-Permethrin	-	-	4.6	6.1	5.2	9.7	8.9	15
PAHs								
Benz[*a*]anthracene	-	-	21	23	0.76	1.7	4.5	4.0
Benzo[*a*]pyrene	-	-	14	12	-	-	3.6	1.8
Benzo[*b*]fluoranthene	-	-	14	11	-	-	5.3	0.45
Benzo[*e*]pyrene	-	-	17	14	-	-	1.9	0.95
Benzo[*ghi*]perylene	-	-	16	15	-	-	-	-
Benzo[*k*]fluoranthene	-	-	9.9	8.0	-	-	0.59	0.51
Chrysene	-	-	15	15	0.19	0.42	3.2	1.7
Dibenz[*a,h*]anthracene	-	-	9.6	12	-	-	-	-
Indeno[1,2,3-*cd*]pyrene	-	-	13	11	-	-	-	-
Phthalates								
Benzylbutylphthalate	6.0	NA	23	25	23	23	26	26
di-*n*-Butylphthalate	13	NA	20	26	18	9.4	18	11
Phenols								
Bisphenol-A	-	-	2.3	4.6	2.8	3.2	2.9	2.5
Nonylphenol	-	-	1.1	4.2	1.4	3.1	-	-
PCBs								
PCB 44	-	-	0.04	0.15	-	-	-	-
PCB 52	36	NA	1.5	3.4	-	-	-	-
PCB 70	-	-	0.67	2.2	-	-	-	-
PCB 77	-	-	-	-	-	-	-	-
PCB 95	7.8	NA	1.8	6.9	-	-	-	-
PCB 101	7.6	NA	1.9	6.4	-	-	-	-
PCB 105	-	-	1.2	4.5	-	-	-	-
PCB 110	-	-	0.71	1.8	-	-	-	-
PCB 118	-	-	1.2	2.5	-	-	-	-
PCB 138	-	-	0.04	0.14	-	-	-	-
PCB 153	-	-	0.51	1.5	-	-	-	-
PCB 180	-	-	0.76	2.9	-	-	-	-

[a] Only one duplicate air sample was collected for neutral pollutants; the reported mean value of RPD is the RPD value of the duplicate samples.
[b] - denotes that the target pollutant was below detection limit in all duplicate samples.
[c] NA denotes not applicable.

Table 6.2.5 Results for Duplicate Samples for Acidic Pollutants/Metabolites - North Carolina

Pollutant	Air		Dust/Soil		Liquid Food		Solid Food	
Number of QC samples	2		20		28		44	
Percent of field samples	0.7		6.7		9.8		15	
	Relative Percent Difference, %							
OP Metabolites	mean [a]	SD	mean	SD	mean	SD	mean	SD
3,5,6-TCP	16	NA [c]	8.0	8.9	5.8	7.0	7.7	6.5
Acid Herbicides								
Dicamba	- [b]	-	-	-	-	-	-	-
2,4-D	-	-	2.6	5.6	0.33	1.2	4.7	7.7
2,4,5-T	-	-	-	-	-	-	0.47	2.1
Phenols								
PCP	0.69	NA	4.8	4.4	-	-	1.3	3.5

[a] Only one air duplicate sample was collected for acidic pollutants; the reported mean value of RPD is the RPD for the duplicate samples.
[b] - denotes that the target pollutant was below detection limit in all duplicate samples.
[c] NA denotes not applicable.

Table 6.2.6 Results for Duplicate Samples for Urine Analysis - North Carolina

Pollutant	Urine	
Number of QC samples	26	
Percent of field samples	5.5	
	Relative Percent Difference, %	
OP Metabolites	mean	SD
IMP	- [a]	-
3,5,6-TCP	7.9	7.3
Acid Herbicides		
2,4-D	2.5	3.2
PAH Metabolites		
1-Hydroxybenz[*a*]anthracene	4.0	14
3-Hydroxychrysene	-	-
Phenols		
PCP	8.2	8.5

[a] - denotes that the target pollutant was below detection limit in all duplicate samples.

Table 6.2.7 Results for Duplicate Analyses of the Same Sample Extract for Neutral Pollutants - North Carolina

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
	PCB	Others	PCB	Others	PCB	Others	PCB	Others	PCB	Others	PCB	Others
Number of QC samples	24	28	38	34	36	42	34	34	30	26	-	2
Percent of field samples	7.9	9.2	13	11	12	15	21	21	18	16	0.0	11
	Relative Percent Difference, %											
OP Pesticides	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean [a]	SD
Chlorpyrifos	3.3	3.1	2.7	5.0	5.5	4.6	0.38	1.1	3.9	5.5	0.29	NA [b]
Diazinon	2.0	3.1	3.5	5.2	1.5	3.5	0.02	0.08	2.6	5.9	1.1	NA
OC Pesticides												
Aldrin	0.35	0.91	- [c]	-	0.42	1.9	-	-	0.52	1.9	-	-
alpha-Chlordane	2.4	2.9	4.0	6.2	2.8	5.5	-	-	0.56	1.3	-	-
gamma-Chlordane	2.1	3.0	3.1	4.3	1.8	2.6	-	-	0.85	2.1	-	-
p,p'-DDE	-	-	2.9	5.6	0.09	0.39	0.39	0.86	3.3	3.4	-	-
p,p'-DDT	0.34	1.3	0.62	1.3	0.11	0.36	-	-	0.50	1.8	-	-
Dieldrin	1.8	5.4	2.6	5.9	2.4	10	-	-	-	-	-	-
Endrin	1.5	2.8	0.89	2.2	0.02	0.10	-	-	-	-	-	-
Heptachlor	2.6	4.1	0.69	1.7	1.6	3.8	-	-	0.54	0.99	-	-
Lindane	-	-	0.08	0.33	0.90	3.1	-	-	0.00	0.00	-	-
Pentachloronitrobenzene	-	-	-	-	-	-	-	-	-	-	-	-
Pyrethroid Pesticides												
Cyfluthrin	0.21	0.78	1.4	3.9	0.99	2.4	-	-	-	-	0.05	NA
cis-Permethrin	1.9	3.6	7.4	13	5.9	6.9	0.60	1.7	0.43	1.2	3.5	NA
trans-Permethrin	2.0	3.4	4.7	5.5	7.7	8.1	0.61	1.7	0.33	0.67	0.33	NA
PAHs												
Benz[*a*]anthracene	3.2	4.9	4.8	5.2	3.1	4.4	0.21	0.85	2.6	3.8	7.8	NA
Benzo[*a*]pyrene	2.6	4.6	4.6	5.5	2.1	4.9	-	-	0.89	2.1	-	-
Benzo[*b*]fluoranthene	3.4	7.2	6.0	11	2.0	3.7	-	-	1.7	2.6	-	-
Benzo[*e*]pyrene	2.6	3.1	3.0	3.2	2.5	4.4	-	-	0.86	1.3	-	-
Benzo[*ghi*]perylene	4.0	6.1	5.1	6.3	3.6	7.2	-	-	-	-	-	-
Benzo[*k*]fluoranthene	2.4	2.9	4.6	4.8	1.9	5.3	-	-	1.2	2.3	-	-
Chrysene	3.3	5.6	3.3	3.0	2.7	4.5	0.05	0.22	0.74	1.2	-	-
Dibenz[*a,h*]anthracene	0.72	1.9	2.9	3.8	0.55	2.0	-	-	-	-	-	-
Indeno[1,2,3-*cd*]pyrene	5.6	7.2	6.4	6.9	3.6	9.0	-	-	-	-	-	-

Table 6.2.7 Results for Duplicate Analyses of the Same Sample Extract for Neutral Pollutants - North Carolina (cont.)

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
Phthalates	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Benzylbutylphthalate	7.6	10	8.9	11	7.3	8.0	2.0	1.6	5.8	7.4	3.1	NA
di-*n*-Butylphthalate	3.9	6.4	4.7	4.1	3.1	3.2	3.3	5.7	3.6	6.8	4.4	NA
Phenols												
Bisphenol-A	6.5	8.9	1.2	2.7	8.6	7.7	3.1	3.3	4.1	2.6	5.4	NA
Nonylphenol	0.71	2.7	2.7	8.5	1.3	4.4	0.14	0.59	0.1	0.34	-	NA
PCBs												
PCB 44	0.47	1.6	0.54	2.3	0.46	2.0	-	-	-	-	-	-
PCB 52	4.6	6.2	1.2	3.1	1.3	4.4	-	-	-	-	-	-
PCB 70	0.86	2.6	-	-	0.24	1.0	-	-	-	-	-	-
PCB 77	-	-	-	-	-	-	-	-	-	-	-	-
PCB 95	2.2	3.8	0.69	2.5	0.59	1.7	-	-	0.03	0.12	-	-
PCB 101	1.4	2.6	0.99	2.5	0.35	1.5	-	-	-	-	-	-
PCB 105	-	-	-	-	-	-	-	-	-	-	-	-
PCB 110	1.7	3.1	1.7	3.4	0.60	1.9	-	-	-	-	-	-
PCB 118	0.79	2.8	2.4	5.3	0.18	0.64	-	-	-	-	-	-
PCB 138	-	-	1.3	3.4	0.13	0.56	-	-	-	-	-	-
PCB 153	0.45	1.6	2.1	6.1	1.4	3.9	-	-	-	-	-	-
PCB 180	0.10	0.35	1.3	3.7	0.25	0.93	-	-	-	-	-	-

[a] Only one duplicate GC/MS analysis for OC, OP, PAH, PE, Phenols, and PY performed on the PUF sample; the reported mean value of RPD is the RPD of the duplicate GC/MS analyses.
[b] NA denotes not applicable.
[c] - denotes that the target pollutant was below detection limit in all duplicate GC/MS analyses.

Table 6.2.8 Results for Duplicate Analyses of the Same Sample Extract for Acidic Pollutants/Metabolites - North Carolina

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food	
	silylate	methylate	silylate	methylate	silylate	methylate	silylate	methylate	silylate	methylate
Number of QC samples	22	20	40	32	21	22	16	22	34	38
Percent of field samples	7.3	6.6	13	11	8.2	8.6	5.6	7.7	12	13
	Relative Percent Difference, %									
OP Metabolites	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
3,5,6-TCP	5.7	6.0	4.1	4.5	5.5	4.3	1.5	1.7	3.1	3.6
Acid Herbicides										
Dicamba	-[a]	-	2.3	7.0	-	-	-	-	0.99	2.1
2,4-D	2.4	7.0	1.6	2.7	0.89	2.9	-	-	2.8	4.0
2,4,5-T	0.12	0.37	-	-	-	-	-	-	-	-
Phenols										
PCP	7.9	6.2	5.3	4.7	1.5	2.7	-	-	0.15	0.64

[a] - denotes that the target pollutant was below detection limit in all duplicate GC/MS analyses.

Table 6.2.9 Results for Duplicate Analyses of the Same Sample Extract for Urine - North Carolina

Pollutant	Urine	
Number of QC samples	54	
Percent of field samples	11	
	Relative Percent Difference, %	
OP Metabolites	mean	SD
IMP	1.1	3.9
3,5,6-TCP	3.9	2.8
Acid Herbicides		
2,4-D	4.6	5.4
PAH Metabolites		
1-Hydroxybenz[*a*]anthracene	1.3	2.7
3-Hydroxychrysene	0.44	1.4
Phenols		
PCP	3.7	3.7

Table 6.2.10 Results for Matrix Spike Samples for Neutral Pollutants - North Carolina

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
Typical spike level, ng	50		20		20		50		50		50	
Number of QC samples	15		19		21		10		8		2	
Percent of field samples	4.9		6.4		7.3		6.1		4.8		11	
	Percent Recovery, %											
OP Pesticides	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Chlorpyrifos [a]	100	13	89	18	110	18	110	17	95	25	85	20
Diazinon [b]	81	9.5	80	12	96	17	54	6.5	58	18	84	3.5
OC Pesticides												
Aldrin	90	9.2	80	14	95	15	93	16	83	11	87	19
alpha-Chlordane	95	9.8	76	14	99	18	91	18	71	9.1	74	1.1
gamma-Chlordane	92	11	76	17	95	17	88	18	72	8.4	76	3.8
p,p'-DDE	96	13	80	14	96	18	88	18	80	11	84	0.33
p,p'-DDT	110	17	97	20	130	35	120	41	110	14	110	
Dieldrin	87	10	83	21	95	16	88	13	91	16	86	5.7
Endrin [c]	100	13	96	19	110	22	100	20	91	10	85	-
Heptachlor	100	15	96	23	100	21	100	28	96	18	89	12
Lindane	92	10	83	11	100	17	97	20	92	11	95	6.2
Pentachloronitrobenzene	97	13	75	14	110	22	120	31	110	17	78	7.9
Pyrethroid Pesticides												
Cyfluthrin [d]	100	15	100	19	110	16	64	12	88	13	91	23
cis-Permethrin [e]	120	17	100	31	110	20	88	15	97	14	82	6.4
trans-Permethrin [f]	-	-	-	-	-	-	86	25	78	14	-	-
PAHs												
Benz[*a*]anthracene	110	20	96	23	110	26	110	25	85	15	90	12
Benzo[*a*]pyrene	110	12	87	15	98	19	120	17	89	15	92	16
Benzo[*b*]fluoranthene	110	13	95	21	120	23	100	15	82	10	85	10
Benzo[*e*]pyrene	95	11	83	15	95	16	87	11	73	7.8	78	7.0
Benzo[*ghi*]perylene	93	11	89	19	91	16	110	15	95	12	77	1.8
Benzo[*k*]fluoranthene	110	14	87	16	100	20	110	14	81	9.7	85	4.8
Chrysene	100	15	86	19	100	22	93	20	71	9.2	96	17
Dibenz[*a,h*]anthracene	110	18	91	19	99	20	110	15	87	15	77	5.7
Indeno[1,2,3-*cd*]pyrene	99	15	93	20	95	20	110	18	89	15	77	7.7

Table 6.2.10 Results for Matrix Spike Samples for Neutral Pollutants - North Carolina (cont.)

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
Phthalates	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Benzylbutylphthalate [g]	-	-	110	28	-	-	74	24	67	13	-	-
di-*n*-Butylphthalate [h]	-	-	100	29	-	-	61	25	61	1.7	-	-
Phenols												
Bisphenol-A [i]	91	17	69	12	110	27	130	10	100	17	80	30
Nonylphenol [j]	100	16	89	22	120	16	130	9.5	125	14	85	31
PCBs												
PCB 44	92	14	79	13	100	16	90	13	74	12	86	7.8
PCB 52	91	14	81	16	100	16	88	11	75	13	87	5.5
PCB 70	93	11	80	13	110	17	95	12	81	18	91	8.4
PCB 77	100	12	88	15	110	19	100	16	89	8.7	98	24
PCB 95	89	13	74	12	100	17	86	13	78	23	81	12
PCB 101	92	13	78	12	100	17	91	14	79	18	91	8.7
PCB 105	100	13	87	18	120	22	99	18	82	9.7	100	23
PCB 110	97	14	81	17	110	19	100	12	77	12	97	15
PCB 118	99	13	86	17	120	23	100	16	86	20	97	23
PCB 138	100	16	86	17	110	22	96	18	73	9.4	100	25
PCB 153	97	13	85	16	120	21	96	17	74	8.8	97	25
PCB 180	110	16	89	21	120	27	97	19	78	16	110	19

[a] Data for two dust/soil samples were excluded because of low spike level.
[b] Data for one dust/soil sample was excluded because of low spike level.
[c] Data for one PUF sample was excluded because of matrix effect.
[d] Data for seven dust/soil, two wipe, six liquid food, and one solid food were excluded because of low spike level, or interference.
[e] Data for 12 dust/soil and five wipe samples were excluded because of low spike level or matrix effect.
[f] Trans-permethrin standard was included in the matrix spike solution in part of NC field study.
[g] Data for all air, wipe, and PUF as well as 15 dust/soil, seven liquid food, and six solid samples were excluded because of low spike level or interference.
[h] Data for all air, wipe, and PUF as well as 12 dust/soil, seven liquid food and six solid food samples were excluded because of low spike level or interference.
[i] Data for 12 dust/soil, 13 wipe, and two liquid food samples were excluded because of low spike level, or matrix effect.
[j] Data for four dust/soil, five wipe, and three liquid food samples were excluded because of matrix effect.

Table 6.2.11 Results for Matrix Spike Samples for Acidic Pollutants/Metabolites - North Carolina

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food	
Typical spike level, ng	50		50		50		50		50	
Number of QC samples	20		19		12		14		21	
Percent of field samples	6.6		6.4		4.7		4.9		7.1	
	Percent Recovery, %									
OP Metabolites	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
3,5,6-TCP	80	11	8	18	80	8.2	69	14	80	7.8
Acid Herbicides										
Dicamba	64	16	72	16	75	13	74	14	88	13
2,4-D [a]	67	18	76	23	77	15	80	15	92	15
2,4,5-T	69	15	78	19	74	15	80	14	99	14
Phenols										
PCP	99	23	78	26	69	11	67	14	78	14

[a] Data for four dust/soil samples were excluded because of low spike level or matrix effect.

Table 6.2.12 Results for Matrix Spike Samples for Urine Analysis - North Carolina

Pollutant	Urine	
Typical spike level, ng/sample	25	
Number of QC samples	32	
Percent of field samples	6.8	
	Percent Recovery, %	
OP Metabolites	mean	SD
IMP [a]	7.2	3.2
3,5,6-TCP	99	11
Acid Herbicides		
2,4-D	98	12
PAH Metabolites		
1-Hydroxybenz[*a*]anthracene [b]	92	22
3-Hydroxychrysene [b]	95	18
Phenols		
PCP	79	10

[a] Low recoveries were obtained for IMP because the analytical method used was developed for 3,5,6-TCP, not IMP.
[b] Data for three urine samples were excluded because of matrix effect or interference.

Table 6.2.13 Results for Surrogate Recovery Standards for Neutral Pollutants - North Carolina

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
Typical spike level, ng	50		50		20		50		50		50	
Number of QC samples	351		371		346		202		197		23	
Percent of field samples	110		120		120		120		120		130	
	Percent Recovery, %											
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Benzylbutylphthalate-d_4 [a]	120	18	110	21	120	15	74	25	56	9.5	110	16
Bisphenol-A-d_6 [b]	110	21	73	22	110	19	110	21	100	21	55	19
Dibenz[*a*,*h*]anthracene-d_{14} [c]	110	18	87	19	99	19	110	22	88	21	87	11
p,p'-DDE-d_4	97	14	84	19	100	18	89	22	73	15	97	14
PCB101-C_{13}	98	14	86	18	110	17	90	21	69	10	95	11

[a] Data for 231 air, 83 dust/soil, and 126 wipe samples were excluded because of interference or matrix effect.
[b] Data for 97 air, 210 dust/soil. 147 wipe, 36 liquid food, and 36 solid food samples were excluded because of interference or matrix effect.
[c] Data for 24 dust/soil and 39 solid food samples were excluded because of matrix effect or interference.

Table 6.2.14 Results for Surrogate Recovery Standards for Acidic Pollutants - North Carolina

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food	
Typical spike level, ng	50		50		50		50		50	
Number of QC samples	355		359		290		332		379	
Percent of field samples	120		120		110		110		130	
	Percent Recovery, %									
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
2,4-D-C_{13} [a]	79	15	79	14	75	11	75	14	91	16

[a] Data for 11 air samples were excluded because of matrix effect.

Table 6.2.15 Results for Surrogate Recovery Standards for Urine Analysis - North Carolina

Pollutant	Urine	
Typical spike level, ng	20	
Number of QC samples	564	
Percent of field samples	120	
	Percent Recovery, %	
	mean	SD
2,4-D-C_{13}	91	18

Table 6.2.16 Results for Blank Samples Having Detectable Neutral Pollutants - North Carolina

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
	MB	FB	MB	FB	MB	FB	MB	FB	MB	FB	MB	FB
Number of QC samples	17	12	23	12	15	13	8	12	7	12	2	0
Percent of field samples	5.6	3.9	7.7	4.0	5.2	4.5	4.9	7.4	4.2	7.2	11	0
	Concentration											
	ng/m^3		ng/g		ng/sample		ng/mL		ng/g		ng/m^2	
OP Pesticides	median	SD	median	SD	median	SD	median	SD	median	SD	median	SD
Chlorpyrifos	0.06	0.01	- [a]	-	-	-	-	-	-	-	-	-
Pyrethroid Pesticides												
cis-Permethrin	0.06	0.03	-	-	-	-	0.003	0.03	-	-	-	-
trans-Permethrin	-	-	-	-	-	-	0.003	0.07	-	-	-	-
Phthalates												
Benzylbutylphthalate	28	78	41	96	360	490	9.8	43	36	86	7000	1500
di-*n*-Butylphthalate	24	21	38	59	300	500	42	46	94	130	9000	8800
Phenols												
Bisphenol-A	-	-	-	-	7.1	15	-	-	-	-	-	-

a. - denotes not detected in all blanks.

Table 6.2.17 Results for Blank Samples Having Detectable Acidic Pollutants/Metabolites - North Carolina

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food	
	MB	FB	MB	FB	MB	FB	MB	FB	MB	FB
Number of QC samples	19	12	15	12	12	11	7	12	17	12
Percent of field samples	6.3	4.0	5.1	4.0	4.7	4.3	2.5	4.2	5.7	4.0
	Concentration									
	ng/m^3		ng/g		ng/sample		ng/mL		ng/g	
	median	SD	median	SD	median	SD	median	SD	median	SD
OP Metabolites										
3,5,6-TCP	0.06	0.01	1.4	0.56	0.71	0.88	-	-	0.09	0.03
Phenols										
PCP	0.06	1.1	- [a]	-	-	-	-	-	-	-

a. - denotes not detected in all blanks.

Table 6.2.18 Results for Water Samples - North Carolina

Pollutant	Drinking Water Samples							
	Duplicate		Analytical Duplicate		MSS		Blank	
							MB	FB
Number of QC	28		28		16		15	13
Percent of field	18		18		10		9.7	8.4
	Relative Percent Difference, %		Relative Percent Difference, %		Percent Recovery, %		Concentration, ng/mL	
	mean	SD	mean	SD	mean	SD	median	SD
Atrazine	2.2	3.5	2.3	5.1	84	20	0.01	0.02

6.2.4.2.2 Ohio For the OH study, results of the %RPD of duplicate samples for neutral pollutants, acidic pollutants/metabolites, and pollutants/metabolites in urine are summarized in Tables 6.2.19, 6.2.20, and 6.2.21, respectively. The mean of the %RPD was between 0% and 18% for all duplicate samples, except for the two phthalates. The mean of the %RPD for the two phthalates ranged from 7.1% to 38%. Results of the %RPD of duplicate GC/MS analyses are summarized in Tables 6.2.22 to 6.2.24. As expected, %RPD values from the duplicate GC/MS analyses were smaller than those from the duplicate samples.

Recovery data for the OH matrix spike samples are summarized in Tables 6.2.25 to 6.2.27. Recovery data of SRSs are summarized in Tables 6.2.28 to 6.2.30. With few exceptions, quantitative matrix spike and SRS recoveries were obtained for the target compounds in all sample media. Mean recoveries ranged from 70±16% to 130±23% for neutral pollutants, from 71±8.2% to 100±11% for acidic pollutants/metabolites. Because of the high background levels found in the nonspiked blank sample media as well as the high levels found in field samples, the spiked levels of the two phthalates were not high enough in most of the matrix spike samples. As a result, satisfactory recoveries could not be obtained. For the same reason, satisfactory recoveries for diazinon, PAHs, and *trans*-permethrin could not be obtained in one matrix spike sample. Interference peaks were observed for bisphenol-A, cyfluthrin, and *cis*-permethrin in some samples. Recovery of IMP was not acceptable (<50%) in liquid food, solid food, and urine samples. This was mainly because the analytical method developed for the other OP metabolite, 3,5,6-TCP, was also used to measure IMP, but was found to be inadequate to measure IMP in some matrices. Different analytical methods need to be developed and evaluated for quantitative determination of IMP in these sample media.

Quantitative recoveries for the SRSs including p,p'-DDE-d_4, dibenz[*a*,*h*]anthracene-d_{14}, PCB101-C_{13}, and 2,4-D-C_{13} were obtained in most OH field samples. Interference peaks were observed for the benzylbutylphthalate-d_4 and bisphenol-A-d_6, in some air, dust, soil, and wipe samples; satisfactory recoveries for these SRSs were not obtained.

Results of the OH field blanks and laboratory blanks are summarized in Tables 6.2.31 to 6.2.33. Note that the reported median and SD values were from the combined field blanks and laboratory method blanks. The median concentrations of the target pollutants/metabolites were below or close to the method detection limits. Measurable amounts of the two phthalates were found in the field blanks and laboratory method blanks in all media, and cis- and trans-permethrin were found in air blanks. Therefore, background-corrected data for these samples were used for the statistical analysis discussed in Chapter 8 of this report.

Table 6.2.19 Results for Duplicate Samples for Neutral Pollutants - Ohio

Pollutant	Dust/Soil		Liquid Food		Solid Food	
Number of QC samples	22		8		10	
Percent of field samples	7.2		4.8		5.9	
	Relative Percent Difference, %					
OP Pesticides	mean	SD	mean	SD	mean	SD
Chlorpyrifos	4.8	8.9	0.79	1.6	9.6	5
Diazinon	7.8	10	-[a]	-	1.6	2.5
OC Pesticides						
Aldrin	-	-	-	-	-	-
alpha-Chlordane	3.9	5.6	-	-	-	-
gamma-Chlordane	4.2	5.2	-	-	-	-
p,p'-DDE	3.8	7.7	-	-	4.8	4.2
p,p'-DDT	1.9	4.4	-	-	-	-
Dieldrin	3.1	6.9	-	-	-	-
Endrin	0.18	0.60	-	-	-	-
Heptachlor	-	-	-	-	-	-
Lindane	-	-	-	-	-	-
Pentachloronitrobenzene	-	-	-	-	-	-
Pyrethroid Pesticides						
Cyfluthrin	3.7	6.3	-	-	-	-
cis-Permethrin	3.3	4.0	-	-	2.3	2.4
trans-Permethrin	2.8	3.5	-	-	3.9	4.2
PAHs						
Benz[*a*]anthracene	18	14	-	-	0.37	0.84
Benzo[*a*]pyrene	13	12	-	-	0.63	1.4
Benzo[*b*]fluoranthene	8.3	7.7	-	-	3.7	6.6
Benzo[*e*]pyrene	13	9.4	-	-	-	-
Benzo[*ghi*]perylene	11	8.5	-	-	-	-
Benzo[*k*]fluoranthene	5.8	5.3	-	-	0.36	0.50
Chrysene	14	10	-	-	2.5	3.5
Dibenz[*a,h*]anthracene	10	8.9	-	-	-	-
Indeno[1,2,3-*cd*]pyrene	11	7.0	-	-	-	-
Phthalates						
Benzylbutylphthalate	22	34	29	28	30	28
di-*n*-Butylphthalate	15	11	38	17	7.1	2.8
Phenols						
Bisphenol-A	2.3	3.9	4.7	9.3	9.6	12
Nonylphenol	-	-	-	-	-	-
PCBs						
PCB 44	0.79	1.7	NM	-	-	-
PCB 52	1.4	2.4	NM	-	-	-
PCB 70	1.1	2.9	NM	-	-	-
PCB 77	-	-	NM	-	-	-
PCB 95	4.1	6.5	NM	-	-	-
PCB 101	2.1	3.2	NM	-	-	-
PCB 105	0.55	1.8	NM	-	-	-
PCB 110	2.3	4.3	NM	-	-	-
PCB 118	1.1	1.6	NM	-	-	-
PCB 138	1.2	3.4	NM	-	-	-
PCB 153	3.3	5.4	NM	-	-	-
PCB 180	0.73	2.4	NM	-	-	-

[a] - denotes not detected in all duplicate samples.
[b] NM denoted that PCBs were not measured in liquid food samples.

Table 6.2.20 Results for Duplicate Samples for Acidic Pollutants/Metabolites - Ohio

Pollutant	Dust/Soil		Liquid Food		Solid Food	
Number of QC samples	20		22		16	
Percent of field samples	6.7		7.6		5.4	
	Relative Percent Difference, %					
OP Metabolites	mean	SD	mean	SD	mean	SD
IMP	3.5	5.3	1.5	5.0	7.1	5.3
3,5,6-TCP	5.0	3.4	2.1	2.4	6.3	5.6
Acid Herbicides						
dicamba	1.3	2.8	- [a]	-	2.0	5.6
2,4-D	5.2	7.8	-	-	1.9	3.0
2,4,5-T	0.66	2.1	-	-	-	-
Phenols						
PCP	4.2	4.4	-	-	0.33	0.93

a. - denotes not detected in all duplicate samples.

Table 6.2.21 Results for Duplicate Samples for Urine Analysis - Ohio

Pollutant	Urine	
Number of QC samples	26	
Percent of field samples	5.7	
	Relative Percent Difference, %	
OP Metabolites	mean	SD
IMP	- [a]	-
3,5,6-TCP	4.8	6.1
Acid Herbicides		
2,4-D	4.1	4.0
PAH Metabolites		
1-Hydroxybenz[*a*]anthracene	0.18	0.44
3-Hydroxychrysene	-	-
Phenols		
PCP	4.9	3.4

a. - denotes not detected in all duplicate samples.

Table 6.2.22 Results for Duplicate Analyses of the Same Sample Extract for Neutral Pollutants - Ohio

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
	PCB	Others	PCB	Others	PCB	Others	PCB	Others	PCB	Others	PCB	Others
Number of QC samples	32	34	44	30	54	38	NM [a]	18	28	24	4	4
Percent of field samples	10	11	15	10	19	14	-	11	16	14	29	29
	Relative Percent Difference, %											
OP Pesticides	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Chlorpyrifos	2.0	2.6	2.3	3.4	2.3	2.8	-	-	2.5	3.7	5.7	8.1
Diazinon	3.7	5.3	3.7	4.4	1.4	2.9	-	-	0.23	0.57	1.3	1.9
OC Pesticides												
Aldrin	0.05	0.20	0.11	0.42	- [b]	-	-	-	-	-	-	-
alpha-Chlordane	3.0	3.7	3.4	2.9	1.8	4.2	-	-	0.66	2.3	-	-
gamma-Chlordane	4.1	4.0	3.5	3.6	1.8	3.2	-	-	0.66	2.3	-	-
p,p'-DDE	-	-	2.7	3.2	-	-	-	-	1.5	1.8	-	-
p,p'-DDT	-	-	2.7	4.6	0.10	0.43	-	-	-	-	-	-
Dieldrin	0.18	0.74	0.57	1.6	-	-	-	-	0.35	1.2	9.0	13
Endrin	0.11	0.30	0.04	0.15	-	-	-	-	-	-	-	-
Heptachlor	1.2	2.7	0.54	1.5	-	-	-	-	0.06	0.21	-	-
Lindane	-	-	0.40	1.6	-	-	-	-	-	-	-	-
Pentachloronitrobenzene	0.80	3.0	-	-	-	-	-	-	-	-	-	-
Pyrethroid Pesticides												
Cyfluthrin	-	-	2.3	4.0	0.19	0.57	-	-	-	-	-	-
cis-Permethrin	3.5	4.1	3.6	3.6	2.3	3.4	-	-	-	-	2.4	1.7
trans-Permethrin	1.6	2.4	2.4	1.9	4.3	4.9	-	-	-	-	3.4	0.50
PAHs												
Benz[*a*]anthracene	2.0	3.7	2.6	1.9	2.0	2.4	-	-	0.30	0.81	3.4	4.4
Benzo[*a*]pyrene	0.31	0.71	2.3	1.8	1.7	2.1	-	-	0.07	0.23	6.7	2.2
Benzo[*b*]fluoranthene	1.2	2.6	3.7	2.7	2.5	3.6	-	-	2.2	4.8	3.6	4.2
Benzo[*e*]pyrene	2.2	3.7	2.8	2.2	2.9	3.3	-	-	0.66	2.0	4.6	4.5
Benzo[*ghi*]perylene	1.5	3.5	3.6	2.7	2.6	2.3	-	-	-	-	4.2	0.34
Benzo[*k*]fluoranthene	0.88	1.8	3.3	3.5	3.3	3.3	-	-	0.12	0.42	2.8	0.98
Chrysene	1.8	2.6	2.8	3.2	2.4	2.2	-	-	0.85	2.5	1.7	1.0
Dibenz[*a,h*]anthracene	-	-	4.9	4.1	3.4	6.3	-	-	-	-	-	-
Indeno[1,2,3-*cd*]pyrene	0.83	1.6	4.3	4.0	3.7	3.5	-	-	-	-	2.2	0.44

Table 6.2.22 Results for Duplicate Analyses of the Same Sample Extract for Neutral Pollutants - Ohio (cont.)

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
Phthalates	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Benzylbutylphthalate	11	21	6.1	9.8	2.6	3.1	3.8	4.6	2.4	1.8	1.3	0.79
di-*n*-Butylphthalate	9.1	26	7.5	13	1.6	2.7	3.3	4.0	1.2	0.95	0.87	0.42
Phenols												
Bisphenol-A	3.5	4.1	2.1	3.6	3.4	3.8	2.6	3.2	3.8	1.9	2.9	0.58
Nonylphenol	-	-	-	-	-	-	-	-	-	-	-	-
PCBs												
PCB 44	0.26	1.0	0.51	1.7	0.41	1.5	NM	-	-	-	-	-
PCB 52	4.7	5.4	1.5	2.4	0.67	1.8	NM	-	0.23	0.87	8.5	4.0
PCB 70	0.71	1.5	0.72	1.5	1.2	3.4	NM	-	-	-	0.62	0.87
PCB 77	-	-	-	-	-	-	NM	-	-	-	-	-
PCB 95	1.7	2.8	1.9	3.6	0.57	2.6	NM	-	-	-	-	-
PCB 101	0.78	2.7	0.83	1.4	0.43	1.6	NM	-	-	-	3.9	5.4
PCB 105	-	-	0.29	1.3	0.11	0.58	NM	-	-	-	-	-
PCB 110	0.27	1.1	1.4	2.5	0.25	0.84	NM	-	-	-	4.3	4.8
PCB 118	-	-	0.89	1.8	0.25	0.98	NM	-	-	-	-	-
PCB 138	-	-	0.67	1.6	-	-	NM	-	-	-	-	-
PCB 153	-	-	1.7	3.6	-	-	NM	-	-	-	-	-
PCB 180	-	-	0.72	1.8	-	-	NM	-	-	-	-	-

[a] NM denotes that PCBs were not measured in liquid food samples.
[b] - denotes not detected in all duplicate GC/MS analyses.

Table 6.2.23 Results for Duplicate Analyses of the Same Sample Extract for Acidic Pollutants/Metabolites - Ohio

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food	
	silylate	methylate	silylate	methylate	silylate	methylate	silylate	methylate	silylate	methylate
Number of QC samples	28	26	28	42	30	20	24	30	16	16
Percent of field samples	9.2	8.5	9.3	14	12	7.9	8.3	10	5.4	5.4
	Relative Percent Difference, %									
OP Metabolites	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
IMP	3.1	3.10	1.9	2.8	1.5	2.8	0.68	1.7	4.1	5.1
3,5,6-TCP	5.0	6.5	1.1	1.3	3.6	2.9	0.85	1.5	2.9	2.3
Acid Herbicides										
Dicamba	0.03	0.10	1.1	2.4	0.05	0.14	-	-	0.19	0.53
2,4-D	2.7	5.7	2.6	4.2	1.2	1.7	-	-	0.32	0.52
2,4,5-T	- [a]	-	-	0.01	-	-	-	-	-	-
Phenols										
PCP	2.9	4.2	1.8	1.7	1.6	2.3	0.38	1.5	0.06	0.16

[a] - denotes not detected in all duplicate GC/MS analyses.

Table 6.2.24 Results for Duplicate Analyses of the Same Sample Extract for Urine - Ohio

Pollutant	Urine	
Number of QC samples	56	
Percent of field samples	12	
	Relative Percent Difference, %	
OP Metabolites	mean	SD
IMP	0.05	0.21
3,5,6-TCP	1.8	1.6
Acid Herbicides		
2,4-D	3.1	2.8
PAH Metabolites		
1-Hydroxybenz[*a*]anthracene	- [a]	-
3-Hydroxychrysene	-	-
Phenols		
PCP	4.9	3.8

[a] - denotes not detected in all duplicate GC/MS analyses.

Table 6.2.25 Results for Matrix Spike Samples for Neutral Pollutants - Ohio

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food	
Typical spike level, ng	50		20		20		25		50	
Number of QC samples	19		11		7		6		7	
Percent of field samples	6.2		3.7		2.5		3.6		4.1	
	Percent Recovery, %									
OP Pesticides	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Chlorpyrifos	97	13	81	6.8	110	12	89	11	100	17
Diazinon [a]	77	13	77	7.8	95	120	72	13	78	12
OC Pesticides										
Aldrin	84	9.8	81	12	91	14	90	8.4	93	14
alpha-Chlordane	91	12	72	4.0	95	12	73	9.3	78	8.3
gamma-Chlordane	91	11	75	7.3	96	15	72	9.4	76	6.7
p,p'-DDE	95	12	76	5.7	93	15	81	11	77	13
p,p'-DDT	96	23	88	13	110	15	89	12	110	17
Dieldrin	87	12	92	15	93	15	90	6.0	93	13
Endrin	94	12	82	8.5	110	10	90	10	100	9.8
Heptachlor	90	15	95	13	100	16	83	13	100	7.2
Lindane	86	9.1	81	11	120	7.3	87	12	110	12
Pentachloronitrobenzene	87	11	82	16	110	10	100	16	120	14
Pyrethroid Pesticides										
Cyfluthrin [b]	97	19	100	14	100	15	71	18	110	16
cis-Permethrin [c]	100	17	110	30	99	12.	87	19	110	27
trans-Permethrin [d]	88	11	86	7.1	97	1.8	68	27	85	17
PAHs [e]										
Benz[*a*]anthracene	89	17	87	21	95	16	91	16	100	24
Benzo[*a*]pyrene	76	18	90	15	95	19	91	13	100	13
Benzo[*b*]fluoranthene	88	16	95	24	97	17	96	12	92	13
Benzo[*e*]pyrene	75	12	82	14	92	17	81	7.8	82	11
Benzo[*ghi*]perylene	72	12	90	15	88	17	89	14	100	17
Benzo[*k*]fluoranthene	84	19	86	8.8	93	15	99	7.9	96	17
Chrysene	85	14	90	18	91	15	78	12	83	17
Dibenz[*a,h*]anthracene	74	15	79	6.1	92	16	100	16	100	20
Indeno[1,2,3-*cd*]pyrene	70	16	87	13	91	19	100	18	100	16

Table 6.2.25 Results for Matrix Spike Samples for Neutral Pollutants - Ohio (cont.)

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food	
Phthalates	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Benzylbutylphthalate [f]	-	-	80	12	-	-	-	-	120	15
di-*n*-Butylphthalate [g]	-	-	91	11	-	-	-	-	76	5.8
Phenols										
Bisphenol-A [h]	78	10	567	4.2	110	13	97	24	130	23
Nonylphenol	86	12	76	20	100	12	100	19	130	12
PCBs [i]										
PCB 44	89	13	75	5.1	80	14	-	-	84	12
PCB 52	88	11	78	9.5	87	8.7	-	-	86	11
PCB 70	93	14	76	6.0	87	8.3	-	-	90	11
PCB 77	92	15	83	14	90	17	-	-	100	13
PCB 95	87	14	72	7.2	81	11	-	-	78	12
PCB 101	90	12	73	7.7	87	8.6	-	-	86	12
PCB 105	99	14	79	7.4	88	11	-	-	100	19
PCB 110	93	12	73	7.1	88	9.0	-	-	91	13
PCB 118	97	13	74	6.3	87	13	-	-	98	15
PCB 138	94	12	78	8.4	86	10	-	-	94	14
PCB 153	93	12	76	7.5	86	11	-	-	95	15
PCB 180	99	15	78	8.3	85	12	-	-	98	17

[a] Data for diazinon in one dust/soil sample was excluded because of low spike level.
[b] Data for two dust/soil samples were excluded because of interference.
[c] Data for eight dust/soil samples were excluded because of interference or low spike level.
[d] Data for one dust/soil sample was excluded because of low spike level.
[e] Data for all target PAHs in one dust/soil sample was excluded because of low spike level.
[f] Data for air, wipe, and liquid food can not be obtained because of low spike level; data for seven dust/soil, six liquid food, and five solid food samples were excluded because of low spike level or matrix effect.
[g] Data for air, wipe, and liquid food can not be obtained because of low spike level; data for eight dust/soil, six liquid food, and five solid food samples were excluded because of low spike level or matrix effect.
[h] Data for two air samples, eight dust/soil samples were excluded because of matrix effect.
[i] PCBs were not measured in liquid food samples.

Table 6.2.26 Results for Matrix Spike Samples for Acidic Pollutants/Metabolites - Ohio

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
Typical spike level, ng	50		50		50		50		50		50	
Number of QC samples	14		8		9		11		9		1	
Percent of field samples	4.6		2.7		3.5		3.8		3.0		25	
	Percent Recovery, %											
OP Metabolites	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean [a]	SD
IMP	93	12	63	35	79	13	6.6	4.6	10	5.9	59	NA
3,5,6-TCP	86	12	82	8.7	86	14	79	13	86	17	56	NA
Acid Herbicides												
Dicamba	77	10	72	11	79	15	82	9.9	78	6.0	26	NA
2,4-D	80	9.3	71	8.2	82	9.9	83	11	85	8.2	51	NA
2,4,5-T	85	8.8	81	12	83	11	84	6.4	86	9.1	51	NA [b]
Phenols												
PCP	77	7.0	86	12	79	5.9	84	18	84	10	75	NA

[a] The reported mean value for the PUF sample was the recovery data of the one matrix spike PUF sample analyzed.
[b] NA denotes not applicable.

Table 6.2.27 Results for Matrix Spike for Urine Analysis - Ohio

Pollutant	Urine	
Typical spike level, ng	25	
Number of QC samples	14	
Percent of field samples	3.0	
	Percent Recovery, %	
OP Metabolites	mean	SD
IMP [a]	5.0	2.3
3,5,6-TCP	96	10
Acid Herbicides		
2,4-D	98	20
PAH Metabolites		
1-Hydroxybenz[*a*]anthracene	95	16
3-Hydroxychrysene	100	11
Phenols		
PCP	96	18

[a] Low recoveries were obtained for IMP because the analytical method used was developed for 3,5,6-TCP, not IMP.

Table 6.2.28 Results for Surrogate Recovery Standards for Neutral Pollutants - Ohio

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
Typical spike level, ng	50		20		20		25		50		20	
Number of QC samples	360		347		317		192		198		17	
Percent of field samples	120		120		110		110		120		120	
	Percent Recovery, %											
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Benzylbutylphthalate-d_4 [a]	120	38	100	28	110	28	61	12	63	15	110	8.9
Bisphenol-A-d_6 [b]	92	25	65	14	100	13	97	19	120	20	65	6.5
Dibenz[*a*,*h*]anthracene-d_{14}	80	18	75	16	92	16	98	19	100	21	75	12
p,p'-DDE-d_4	98	18	82	31	94	15	80	18	75	12	100	14
PCB101-C_{13}	94	16	78	11	89	11	NM [c]	-	93	19	95	8.5

[a] Data for 85 liquid food and 119 solid food were excluded because of matrix effect.
[b] Data for 256 dust/soil, 75 wipe, 22 solid food, and 14 PUF were excluded because of interference or matrix effect.
[c] NM denotes that PCBs were not measured in liquid food samples.

Table 6.2.29 Results for Surrogate Recovery Standards for Acidic Pollutants - Ohio

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
Typical spike level, ng	50		50		50		50		50		70	
Number of QC samples	357		350		281		336		333		5	
Percent of field samples	120		120		110		120		110		120	
	Percent Recovery, %											
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
2,4-D-C_{13}	80	15	81	11	82	10	90	13	88	12	53	1.8

Table 6.2.30 Results for Surrogate Recovery Standards for Urine Analysis - Ohio

Pollutant	Urine	
Typical spike level, ng	20	
Number of QC samples	518	
Percent of field samples	110	
	Percent Recovery, %	
	mean	SD
2,4-D-C_{13}	95	20

Table 6.2.31 Results for Blank Samples with Detectable Neutral Pollutants - Ohio

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
	MB	FB	MB	FB	MB	FB	MB	FB	MB	FB	MB	FB
Number of QC samples	18	14	11	14	12	14	5	14	4	14	1	1
Percent of field samples	5.9	4.6	3.7	4.7	4.3	5.0	3.0	8.3	2.3	8.2	7.1	7.1
Concentration												
	ng/m^3		ng/g		ng/sample		ng/mL		ng/g		ng/m^2	
OP Pesticides	median	SD	median	SD	median	SD	median	SD	median	SD	median	SD
Chlorpyrifos	0.06	0.01	-	-	-	-	-	-	-	-	-	-
OC Pesticides												
p,p'-DDT	- [a]	-	-	-	-	-	0.003	0.03	-	-	-	-
Pyrethroid Pesticides												
Cyfluthrin	0.62	0.08	-	-	-	-	-	-	-	-	-	-
cis-Permethrin	0.06	0.52	-	-	-	-	0.003	0.21	-	-	-	-
trans-Permethrin	0.06	0.44	-	-	-	-	0.003	0.22	-	-	-	-
PAHs												
Benz[*a*]anthracene	0.06	0.02	-	-	-	-	-	-	-	-	-	-
Chrysene	0.06	0.01	-	-	-	-	-	-	-	-	-	-
Phthalates												
Benzylbutylphthalate	27	50	66	47	360	1400	14	12	10	12	4100	4800
di-*n*-Butylphthalate	44	43	130	170	760	1800	25	7.2	66	41	18000	23000
Phenols												
Bisphenol-A	0.62	0.55	-	-	7.1	11	0.03	0.67	-	-	388	510
PCBs												
PCB 44	0.03	0.02	-	-	-	-	-	-	-	-	-	-
PCB 52	0.03	0.02	-	-	0.71	0.83	-	-	-	-	-	-
PCB 70	0.03	0.03	-	-	0.71	0.83	-	-	-	-	-	-
PCB 110	0.03	0.01	-	-	0.71	0.83	-	-	-	-	-	-

[a] - denotes that the pollutant was not detected in all the blanks.

Table 6.2.32 Results for Blank Samples with Detectable Acidic Pollutants/Metabolites - Ohio

Pollutant	Air		Dust/Soil		Wipes		Liquid Food		Solid Food		PUF	
	MB	FB	MB	FB	MB	FB	MB	FB	MB	FB	MB	FB
Number of QC samples	21	14	11	14	9	14	8	14	9	14	-	1
Percent of field samples	6.9	4.6	3.7	4.7	3.2	5.0	2.8	4.8	3.0	4.7	-	25
Concentration												
	ng/m^3		ng/g		ng/sample		ng/mL		ng/g		ng/m^2	
OP Metabolites	median	SD	median	SD	median	SD	median	SD	median	SD	median	SD
IMP	0.06	0.01	-	-	-	-	-	-	-	-	-	-
3,5,6-TCP	0.06	0.03	-	-	0.71	0.89	-	-	0.09	0.05	-	-
Acid Herbicides												
2,4-D	0.12	0.03	- [a]	-	1.4	1.7	-	-	-	-	-	-
Phenols												
PCP	0.12	0.27	-	-	-	-	-	-	-	-	-	-

[a] - denotes that the pollutant was not detected in all the blanks.

Table 6.2.33 Results for Blank Samples with Detectable Urine Pollutants - Ohio

Pollutant	Urine	
	MB	FB
Number of QC samples	16	14
Percent of field samples	3.5	3.0
	Concentration, ng/mL	
	median	SD
OP Metabolites		
3,5,6-TCP	0.71	0.18

The QC data for the OH water samples are summarized in Table 6.2.34. The overall method precision was very good. The mean of the RPD of duplicate water samples was 2.1 ± 3.4%; similar results were obtained from the duplicate GC/MS analyses. The average recovery of the matrix spike samples was 79 ± 4.7%. Trace amounts of atrazine were found in some of the blank samples.

Table 6.2.34 Results of Analysis of Water Samples - Ohio

Pollutant	Drinking Water Samples							
	Duplicate		Analytical Duplicate		MSS		Blank	
							MB	FB
Number of QC samples	8		26		5		5	14
Percent of field samples	5.1		17		3.2		3.2	8.9
	Relative Percent Difference, %		Relative Percent Difference, %		Percent Recovery, %		Concentration, ng/mL	
	mean	SD	mean	SD	mean	SD	median	SD
Atrazine	2.1	3.4	2.3	1.8	79	4.7	0.01	0.001

6.3 Evaluation

Due to budget constraints, different analytical methods could not be used for each compound class. Instead, the OP and OC pesticides, pyrethroid pesticides, PAHs, phthalates, phenols except for PCP, PCBs, and triazine were grouped as neutral pollutants, and the acid herbicides, PCP and metabolites for OP pesticides, pyrethroid pesticides, and PAHs were grouped as acid pollutants/metabolites.

Two carbamate pollutants, propoxur and bendiocarb, were not included in the day care pilot studies, and were added later to the CTEPP study design at the suggestion of the EPA Office of Pesticide Programs, in hopes that the CTEPP methods might be able to detect these compounds (7-10). However, the analytical methods used in the CTEPP study were not tested for these two compounds. Unfortunately, these two pollutants decompose partially on the GC column and interference compounds co-eluted with both propoxur and bendiocarb. Therefore, useful data were not obtained for these two compounds.

Atrazine could be measured accurately in water samples, but there were interference problems in other sample media. For air, dust, soil, and wipe samples, there was an interference compound that eluted at the same retention time as atrazine on the GC column, and which also had the same ion ratio of the monitored ions as those observed for atrazine. This was initially observed in the air samples, when extremely high concentrations (>1000 ng/mL) were detected for what was believed to be atrazine. The sample extracts were re-analyzed using GC/MS in full mass scan mode in an attempt to confirm the presence of atrazine in these sample extracts. The full mass scan results showed that an interference compound, which was an unsaturated aliphatic hydrocarbon, eluted at the same retention time and had the same monitored ion ratio as did atrazine. Therefore, atrazine was measured only in drinking water samples.

Interference peaks were also observed for cyfluthrin, *cis*-permethrin, bisphenol-A-d_6, and benzylbutylphthalate-d_4 in some samples. These interference peaks affected only the quantification of the SRSs, benzylbutylphthalate-d_4 and bisphenol-A-d_6, and did not affect the quantification of the native chemicals benzylbutylphthalate and bisphenol-A. If the interference components were not completely resolved from the peaks of target pollutants, estimated values were obtained and reported. These data were coded with "INT" in the database to show the presence of the interferences. Note that the interference peak for *cis*-permethrin became insignificant when the concentrations of this compound exceeded 100 to 500 ng/mL, depending upon the sample. In these cases, the INT codes were not reported in the database. In some samples, interferences were observed for one of the surrogate recovery standard (SRS), bisphenol-A-d6, but not for the native compound bisphenol-A. Similar interferences were observed for benzylbutylphthalate-d_6, but not for benzylbutylphthalate.

It is not surprising that phthalates were found in field blanks and laboratory blanks. Background levels varied greatly among different sample matrices. Phthalates were present in the analytical-grade solvents that were used for extracting samples and cleaning up sample extracts. Plastic-related materials were used in the disposal pipette holders and in the pre-packed solid phase extraction (SPE) columns that were used to clean up sample extracts. Depending upon the sample media, types of solvent used, and cleanup method employed, the background levels of phthalates varied. In general, the phthalate contamination increased with sample handling and number of cleanup steps. Also, in food samples, the elution band of the phthalates on the GPC column included many fatty acids and fatty acid esters that hindered low-level detection of pyrethroids such as cyfluthrin. The GPC fractions had to be cleaned up further, using ENVI-Carb columns for the food samples, in order to measure cyfluthrin.

The determination of a diazinon metabolite, IMP, in the environmental and personal samples was added late in the OH field study. We used the same analytical methods for TCP to measure IMP in these samples. Results of the matrix spike samples showed that IMP were quantatively measured in air, dust, soil, wipe but not in urine, solid food and liquid food samples. We have identified that IMP was lost during the liquid-liquid partitioning step. The overall recoveries of IMP in these samples were less than 10%, no statistical analyses were performed on these data.

6.4 Recommendations

We recommend evaluation of cleanup methods and/or different detection methods such as liquid chromatography (LC)/MS to determine carbamates in multimedia samples for future studies. In an on-going Battelle study for US EPA, we developed an analytical method for the determination of carbamates in water samples. This method consists of SPE extraction of water samples into acetonitrile (ACN) and LC/MS analysis of the ACN extracts.

We recommend evaluation of cleanup methods such as use of a C18 SPE column or an immunoaffinity (IA) purification column to determine atrazine in multimedia samples. In an on-going Battelle study for US EPA, we developed an IA column for atrazine, established the elution

profile of atrazine for the IA column. Preliminary results suggest that the IA column is an effective cleanup method for analysis of atrazine in dust and soil samples.

Different SRSs should be evaluated for phthalates and bisphenol-A to minimize the interference peaks observed in multimedia samples for future studies.

In a recent Battelle internal research and development study, we developed an analytical method that can provide quantitative recoveries of IMP from urine samples. We therefore recommend that this new analytical method be evaluated and refined as necessary for determining IMP in multimedia samples in future studies.

As noted earlier, phthalates were found in the field blanks and in the laboratory blanks. In this study, the phthalate contamination increased with increased sample handling and with the number of cleanup steps. For future studies, we recommend a different approach to measurement of phthalates in multimedia samples. Since phthalates are typically present at much higher concentrations than the other target pollutants in multimedia samples, we would conduct GC/MS analysis of the phthalates in dilute sample extracts prior to any cleanup steps for the neutral compound analyses, as a separate analysis. This approach would eliminate much of the exacting and time-consuming sample preparation work associated with limiting phthalate contamination from sample handling. The GC/MS analysis of the phthalates would include both the m/z 149 ion for quantification of low concentration pollutants, and the molecular ion for quantification of pollutants at higher levels.

Chapter 7
CTEPP Database

7.1 Overview

The CTEPP database was configured similarly to the database developed in the National Human Exposure Assessment Survey (NHEXAS)-Arizona study (14). The database followed the general format that was used in EPA's exposure database that was current at the start of the CTEPP study. The database, which comprises the two databases for the North Carolina (NC) and the Ohio (OH) field studies, contains the questionnaire data, the analytical data, and metadata. Sufficient detail was provided so that the data can be understood by a diverse set of users.

The CTEPP database is one of the largest current databases containing information on the environmental exposures of preschool children. The study's documentation, which includes the study design, Standard Operating Procedures, and Quality System Implementation Plan, will be placed in EPA's Environmental Information Management System (EIMS; http://oaspub.epa.gov/edr/eims$.startup). In addition, the metadata, which include abstracts, acronyms, keywords, and related entries will be placed in EIMS. The CTEPP data will be stored in the Human Exposure Database System (HEDS; http://www.epa.gov/heds/) . The CTEPP database will be made available to interested federal agencies, state and local agencies, non-governmental organizations, academia, and the general public.

7.2 Quality Assurance Procedures for the Database

Quality assurance and quality control(QA/QC) procedures were implemented within both the NC and OH databases. The QA/QC summaries are given in Appendix D. The following subsections provide information on the types of QA/QC procedures associated with the questionnaire data, analytical data, and metadata collected in this study.

7.2.1 Questionnaire Data

A comprehensive QA/QC plan was implemented to ensure data quality in all phases of questionnaire data collection. During the pre-data collection phase, each hard copy data form was tested by trained project staff for consistency and accuracy. Mock interviews and field data collection simulations were conducted to evaluate the effectiveness of the data forms. Once revisions were made to the data forms based on the outcome of these activities, final drafts were sent to EPA for review and approval. The data forms were further updated after receiving EPA's comments. The updated forms were reviewed and approved by the Battelle Institutional Review Board, the U.S. EPA Human Subjects Research Protection Official, and the U.S. Office of Management and Budget.

After final approval of the data forms, software components were programmed for use in the recruitment telephone survey and to allow double entry of the data. Standardized programming methods were used which inserted QC checks in all of these programs, including range checks, consistency checks, and skip pattern rules. These programs enforced the rules upon data entry. Before the programs were approved for actual data entry, they went through strict QA/QC checks for programming errors.

Before data collection began, telephone interviewers and field staff were trained in the study procedures, according to the SOPs, to ensure high data quality. Telephone interviewers were required to be certified for the study by passing a series of tests before they could initiate any contact with the study subjects. Training for the field data collection team members included a 40-h training session which incorporated at least one day of actual supervised field sample collection experience. Field staff were allotted additional time to practice their field data collection techniques.

After data collection began, data collection activities were monitored routinely. These efforts included the use of computer software and phone monitoring systems to monitor telephone recruitment data, and periodic internal field audits to ensure high quality of data collected in the field. In addition, external field audits were conducted by an EPA auditor and the EPA Task Order Project Officer (TOPO).

During field data collection, the field staff also reviewed the collected information while at the sampling site, to identify missing data items or questionable information. Any identified issues or problems were resolved at the sampling site before the field data collection team returned to Battelle. A Daily Activity Check List was also used to assist the field staff in conducting data collection activities and field edits.

After a data collection event at a sampling site was completed and the data forms were returned to Battelle, the receiving team conducted QC checks on each participant's data forms and study materials. The team used a Participant Data QC Check List to verify a standard list of important items. All data forms were then entered twice and verified, using the CTEPP Double Data Entry Program. Two data entry teams performed the data entry work and entered the data into two separate databases. These separate databases were compared for consistency, corrected if necessary, and combined into one database. As mentioned above, these data entry programs included range checks, consistency checks, and skip pattern rules.

Finally, after completing all the data collection tasks, the project staff conducted final QA/QC checks by reviewing data frequency reports and verifying randomly selected participant files. Data items in the database were checked against the data documentation manual and the actual participant data in the original data form. Personal identifiers were removed from the database to ensure participant confidentiality.

7.2.2 Analytical Data

Analytical data were electronically imported into the database according to CTEPP SOP 4.12. The analytical raw data (QUAN report) were generated from each instrument by a qualified analyst. The QUAN report was then reviewed by the Task Order Leader (TOL) for all the identified pollutants. The QUAN report was then electronically transferred into a custom report and saved as a "crd" file. The "crd" file was then electronically parsed into an Excel spreadsheet template. Data such as sample extraction weight and quality assurance codes were manually entered and saved as an Excel file with an extension of .xls by the first data reviewer. The TOL reviewed all the Excel files before they were imported into the analytical database. If any anomalous results were observed in the data, every effort was made to identify any problems in the sample collection, sample preparation, and/or analysis, which could have contributed to the anomaly. Data dictionaries and code sets for core analytical data, QA/QC data, and ancillary data were developed for the analytical database. The completed Excel spreadsheets were then electronically imported into the analytical database by the database staff.

Database queries were developed to perform QA/QC checks on the NC and OH analytical databases. These included (1) sample ID checks, (2) missing data checks, (3) duplicate data checks, (4) out-of-range checks, and (5) upper- and lower- concentrations checks.

The sample ID checks were performed to verify that all Sample IDs with reported data were valid Sample IDs, that is, that they were logged as being received from the field. If invalid sample IDs were detected, the database staff traced back to the original raw data, including laboratory record books and GC/MS logbooks, to identify the transcription error and to make the corrections accordingly. All corrections were documented in the database importing log book.

Missing data checks were performed to verify that all Sample IDs received from the field had a complete set of analytical data reported. Those samples that were received but did not have a complete set of analytical data and/or ancillary data for a stated reason in the electronic Chain of Custody (CoC) data were identified, and either the analytical data for these samples were found and imported into the database, or the samples were located, processed, analyzed, and reviewed, and the analytical data were imported into the database.

Duplicate data checks were performed to verify that the same analytical data were not imported into the database twice for a given sample. The database staff traced the sample results back to the laboratory record books, the GC/MS sequence logs, and/or the QUAN reports to confirm that duplicate data were the result of a double import, and not a QA/QC re-analysis (e.g. duplicate sample or duplicate injection). Once the duplicate data were identified as a double import, the set of results for the sample having the oldest sample import date were eliminated from the analytical database. If the duplicate data were identified as a QA/QC re-analysis, the proper QC code was added to the QC_Code data field, and the data for the first duplicate (only) remained in the Core_Analytical_Results table, and the data for the first and second duplicates were reported in the QA_QC_Results table.

Out-of-range checks were performed to verify that all data for data fields limited to a code set did not violate that code set. For data fields that were limited to a code set of values, queries were performed to identify data within those fields that did not belong to, or "violated", the code set. Once identified, the database staff traced the sample results back to the laboratory record books to identify the transcription error. The data in the database were corrected, and these corrections were documented.

Upper- and lower-level concentrations checks were performed on all results that were greater than plus or minus three standard deviations from the mean. Database queries were performed to identify those calculated results (Result1 and Result2) that were greater than or less than three standard deviations from the domain mean. Five percent of these data were reviewed again by the data reviewer. The data reviewer checked the QUAN report, all the parameters used for the results calculation, and the result calculation itself to make sure that identification and quantification were performed correctly. If the data reviewers detected any mis-identification and/or mis-quantification, corrections were made accordingly. The TOL approved the corrected data, and the database manager made the changes in the database. All activities were documented in the laboratory record books and database importing log.

After all checks were completed, the final calculation of results was performed within the database. A random subset (approximately 5%) of calculated results were recalculated using an independent calculation source (Excel) for validation. In addition, hand calculations were performed on one data set for each sample matrix using a calculator.

7.2.3 Metadata

Metadata were prepared in the format described in the "User Guide and Data Administration Guidelines for the USEPA's Environmental Information Management System (EIMS)," Version 1.3, Oct. 2001, including abstracts, related entries, key words, and acronyms, at the study, data table, and document level.

7.3 EPA Review

EPA conducted several independent QA/QC reviews of the early draft versions of the NC and OH databases. The EPA performed visual range checks. The data were normalized before identifying potential outliers. Outliers were identified based on whether they exceeded six standard deviations from the mean. For a randomly selected set of variables (about 5%), more extensive checks were performed including range checks, consistency, and skip pattern checks. When the EPA Database Manager or the EPA TOPO identified problems or errors (i.e., missing samples, duplicate samples, linkage problems) in the database, the EPA TOPO had Battelle verify that the data were correct and make any necessary changes to the data in the database.

After the draft final NC and OH databases were delivered to EPA, EPA conducted a more thorough QA/QC review of the databases. EPA repeated the extensive checks performed on the randomly selected variables. In addition, a new set of randomly selected variables

(additional 5%) were thoroughly checked. Furthermore, comparisons were made between earlier versions and the latest version of the database to assure that no unexplained changes had occurred. Any errors identified by EPA in the database were corrected by Battelle.

After EPA received the final versions of the NC and OH databases, EPA assigned data quality values to each sample in the Core_Analytical_Results table. The QA/QC protocol (SAS program) used to assess the quality of each sample is found in Appendix E. Each sample result was assigned one of the following data quality (QC_Flag code) values:

1 = good quality data
2 = questionable, but still acceptable data
3 = unusable data

Only sample results that had assigned QC_Flag code values of 1 or 2 were used in the statistical analyses discussed in Chapters 8 and 9. In addition, the data associated with one NC adult participant (PID972072) and accompanying child (PID972071) who withdrew from the study after Day 1 were excluded from the statistical analyses.

7.4 Evaluation

Within each record of the CTEPP database, the Participant Identification code (PID) was designed to be the key linking field that allows database users access to all of a given subject's study data, including questionnaire data and measured environmental and biological target compound levels. The PID was designed as a 6-digit composite data field. The first two digits contained the day care code (indicating whether or not the study participant attended day care, the specific day care, participant or non-day care participantand the state of origin). The next three digits were a unique participant identification number. The sixth digit contained the participant type code, which identified the sample as collected from a child or from an adult at home, or from a child at day care. Although the information contained within the PID was important, the first step database users had to do before querying the environmental, personal, or questionnaire data was to query the PID to separate it into its different pieces of information.

7.5 Recommendations

Based upon lessons learned from designing the CTEPP database, recommendations for designing large exposure databases on future studies are as follows:

(1) Avoid Composite Data Fields

Data fields should not be designed as a composite data field that contains several distinct pieces of data. If a piece of information is significant, it should be stored as its own separate data field. For example, the PID should actually have been separated into three separate data fields: 1) Day care ID, 2) Participant ID, and 3) Participant Type. Avoiding composite data fields would eliminate the need to write queries that separate out the bits of information contained within such fields, resulting in a more streamlined data extraction process.

(2) Design and Test Key Linking Fields

The key linking fields that allow a user access to all of the questionnaire, environmental, and personal data for a given subject should be planned and tested for a small pilot study prior to implementing them into a large study database.

(3) Add Link Tables for User Friendliness

Due to the complex nature of the CTEPP study design, it was not possible to have just one key field that linked all of the collected and calculated data for a given subject. As a result, several fields needed to be considered when bringing data together across all samples collected for a given subject. In the case of a study that has several "many-to-many" tables within its database (e.g., a single water sample is collected at a day care center, yet the analytical result for this sample is applicable to all study subjects attending the day care center, while conversely, a single study subject is associated with multiple samples such as urine, hand wipes, and food), an additional link table should be added to make the database more user-friendly. Designing a database containing many-to-many tables further complicates the relationships required to link the environmental and biological data with the questionnaire data. These relationships are not readily understood by those not intimately familiar with the study design. Link tables provide a user-friendly way of making use of the key linking fields without requiring the user to understand the relationships between those fields. An example of a useful link table is a table that lists all of the Sample IDs that are applicable for a given participant and makes the construction of the database queries that link environmental, biological, and questionnaire data much simpler.

Chapter 8
Statistical Analyses

8.1 Overview of Data Analysis

Data for a variety of parameters were available for statistical analysis. These data included the following:

- Concentrations of target pollutants in environmental samples collected at homes and day care centers. Environmental samples included indoor and outdoor air (ng/m^3), soil (ng/g), indoor floor dust collected via HVS3 vacuum (ng/m^2 and ng/g), and drinking water (ng/mL; atrazine only). For homes with recent pesticide applications, concentration data were available for dust collected via wipes from hard floors and food preparation surfaces (ng/m^2) and for transferable residues collected from floors via PUF roller (ng/m^2). Concentration data in dust collected via wipes from hard floors were also available for some locations that did not have carpeted floors from which dust could be collected via HVS3 vacuum.
- Concentrations of target pollutants in personal samples collected from children and adults. Personal samples included duplicate diet solid food samples (ng/g), duplicate diet liquid food samples (ng/mL), and hand wipes (ng/m^2). Adult food samples were analyzed only for selected acid pollutants.
- Information on characteristics, time spent at various locations, and activity patterns associated with the participating children and adults during the sampling period.
- Concentrations of selected acid pollutants and metabolites in urine samples collected from the participating children and adults (ng/mL and μmoles/mole creatinine). For both North Carolina (NC) and Ohio (OH), these pollutants and metabolites included 2,4-D, 1-hydroxybenz[*a*]anthracene, 3-hydroxychrysene, pentachlorophenol, and 3,5,6-TCP. For OH, seven additional metabolites were measured: 3-hydroxybenz[*a*]anthracene, 3-hydroxybenzo[*a*]pyrene, 6-hydroxychrysene, 6-hydroxyindeno[1,2,3-*cd*]pyrene, 1-hydroxypyrene, IMP, and 3-phenoxybenzoic acid.

Pollutant concentrations in multimedia samples (e.g., air, dust, soil, food) were combined with information on activity patterns and physiological parameters to estimate daily potential exposure and absorbed dose for each participant by each of three exposure routes: inhalation, dietary ingestion, and indirect ingestion.[1] ***Potential exposure***, expressed in ng/day and pmoles/day, is defined as the total amount of a pollutant that an individual comes in contact with over a 24-h period. Potential exposure is a route-specific parameter that was calculated from the

[1] Potential exposure and absorbed dose were not estimated for the dermal exposure route due to the limited availability of adequate methods and sufficient background data in the literature.

measured concentrations in those exposure media (multimedia samples) that were relevant to the given exposure route, along with the estimated contact rates with those media. ***Potential absorbed dose***, expressed in ng/kg/day and pmoles/kg/day, is defined as the total dose that could be absorbed into the body over a 24-h period, relative to the participant's body weight. For each exposure route, potential absorbed dose was estimated by assuming a 50% absorption rate for all pollutants and participants (17). This was a conservative approach and was adopted due to the lack of sufficient information available in the scientific literature for most CTEPP target pollutants on the nature of their absorption into the body. Future research may allow these results to be updated be performed on these data when more detailed and accurate absorption rate information becomes available for certain pollutants. For a given study participant, pollutant, and exposure route, potential exposure and potential absorbed dose were calculated if the criteria specified in Section 8.4 were achieved. Section 8.4 provides the detailed formulas that were used to calculate potential exposure and potential absorbed dose.

Aggregate potential exposure and ***aggregate potential absorbed dose*** were defined as the sums of the estimated potential exposure and potential absorbed dose, respectively, across all three exposure routes. Aggregate potential exposure and absorbed dose were calculated for the following eight pollutants and metabolites that were frequently detected (at or above 50%) in several types of multimedia: bisphenol-A, chlorpyrifos, diazinon, di-*n*-butylphthalate, 2,4-D, *cis*-permethrin, *trans*-permethrin, and 3,5,6-TCP.

The concentrations of several parent compounds or their metabolites (specified above) were measured in the urine of children and adults over the 48-h sampling period. Urine samples were combined spot samples rather than total void samples. This was done primarily to prevent placing undue burden on the participants if total void samples were to be collected across the 48-h sampling period. While using spot urine samples rather than total void samples has some limitations (e.g., not allowing for total volume over the 48-h period to be known), a steady-state assumption was made which implied that exposures were chronic in nature. This assumption was reasonable given that information on individual half-lives of the pollutants were unknown, pesticide applications were infrequent, and measured exposures tended to be low. The estimated aggregate potential exposures and absorbed doses of the children were compared with the concentrations of these pollutants in their urine.

Monitoring data were available from a probability sample of 129 children and 129 adults in North Carolina (NC) and a probability sample of 127 children and 127 adults in OH. It is important to note that the study design only permits the outcome of the statistical analyses to be used to characterize the subpopulation of children who reside in the selected counties and who participated in the CTEPP study. The results should not be used to make inferences on larger populations of children, such as all children "in NC, OH, or in the United States," "in low-income and middle/high-income families,"or "in day care centers." Neither can the study design permit results to be used to test hypotheses such as whether exposures differ significantly between all NC children and all OH children. For this report, the statistical summaries and analysis did not consider sample weights assigned to the study participants that would have allowed the results to represent larger populations of children. Future analyses could be

performed which calculate and take into account sampling weights, from which inferences could be drawn for the populations from which the participants were randomly recruited, namely, preschool children and their caregivers in the randomly-selected counties in NC and OH.

Statistical analyses were conducted to meet each of the four goals detailed in Table 8.1.1. Sub-goals are provided for three of the four goals. Table 8.1.1 also provides an overview of the types of statistical analyses used to address each goal or sub-goal. Details on the statistical analysis approaches are given in Section 8.5.

8.2 Preparation for Statistical Analysis

To prepare for the statistical analyses, several preliminary operations were performed on the collected study data:

- Because high and variable concentrations of selected pollutants were observed in some of the blank samples, it was necessary to apply a background correction to the measured concentrations for these pollutants in some matrices. Background correction to measured concentrations were performed in the following instances:

  - for benzylbutylphthalate and di-*n*-butylphthalate in all sample media collected in both states,
  - for bisphenol-A in dust wipe samples collected in NC, and
  - for *cis*- and *trans*-permethrin in air samples collected in OH.

  The following procedure was used to correct for background contamination. For a given pollutant and matrix, a t-test was applied to the blank data to determine if the mean blank value was significantly different from zero. The mean blank value and an upper 95% confidence bound on the mean were calculated. Then, background-corrected results were calculated by subtracting the mean value adjusted for sample volume, amount, or area (whichever is relevant for the given sample media).
- Sample results labeled as "not detected" were replaced by the method detection limit (MDL) divided by the square root of two for all media except liquid food samples. The pollutant concentrations detected in the liquid food samples were generally very low. When pollutants were detected in liquid food samples at levels close to the MDL, the signal-to-noise ratios for the chromatograms were greater than three. Therefore, not-detected results for the liquid food samples were replaced by the MDL divided by ten.

- In the database, the concentrations of pollutants in dermal wipes were given in ng/sample. Prior to statistical analyses, this value was converted to a loading (ng/m^2 of skin wiped). For each study participant, a tracing of one hand was taken on a sheet of paper, and this tracing was cut out and weighed (in grams). The following equation was then used to calculate the dermal wipe loading (ng/m^2):

Table 8.1.1 Study Goals and the Statistical Analysis Approaches Used to Address Each Goal

Study Goal (and Sub-goals)	Overview of Statistical Analysis Approach
Goal 1: To measure the concentrations of pesticides and other persistent and non-persistent organic pollutants in multimedia at the homes and day care centers of a set of preschool children in several North Carolina and Ohio counties: Sub-goal 1.1: To quantify the distribution of target pollutants in multimedia (environmental and personal) samples collected from homes and day care centers. Sub-goal 1.2: To determine on average how multimedia concentrations differ between – urban and rural environments – low-income and middle/high-income environments – microenvironments (home for families with stay-at-home children, home for families with day care children, and day care centers).	Sub-goal 1.1: The following descriptive statistics were calculated on the analytical measurements: sample size, mean (arithmetic and geometric), standard deviation (for untransformed and log-transformed data), percentage detected, minimum reported value, maximum reported value, and selected percentiles (25^{th}, 50^{th}, 75^{th}, 95^{th}). Boxplots of the observed data were also prepared. *(See Section 8.5.1)* Sub-goal 1.2: Mixed model analysis of variance (ANOVA) was performed on log-transformed analytical measurements, with the model including fixed effects of income status, urbanicity, and environment type and taking into account correlation in measurements for samples taken within the same day care center. F-tests performed on the model's fixed effects were used to make the statistical comparisons of interest. Results were reported as ratios of geometric means along with 95% confidence intervals, and t-tests were performed to determine whether a particular ratio was significantly different from one. *(See Section 8.5.2.1)*
Goal 2: To quantify the distribution of child characteristics, activities, and locations that are important for exposure.	Summary statistics (mean, standard deviation, median, minimum, maximum) were calculated on selected factors that were used to estimate potential exposure levels and potential absorbed dose. These factors included physical characteristics of the study participants (e.g., age, gender, body weight, height, hand surface area), the percentage of time that study participants spent indoors or outdoors at various locations, and the daily amount of solid and liquid food collected from study participants. In addition, the percentage of participating children within specified categories denoting how often certain activities occurred on a daily basis were reported, based upon information obtained from the study questionnaires.

Table 8.1.1 Study Goals and the Statistical Analysis Approaches Used to Address Each Goal (cont.)

Study Goal (and Sub-goals)	Overview of Statistical Analysis Approach
Goal 3: To estimate the exposures of the preschool children to these pollutants that they may encounter in their everyday environments: Sub-goal 3.1: To quantify the distribution of potential exposure and potential absorbed dose by exposure route. Sub-goal 3.2: To quantify the distribution of potential exposure and potential dose aggregated over all exposure routes. Sub-goal 3.3: To quantify the distribution of urinary biomarkers concentrations as an indicator of absorbed dose. Sub-goal 3.4: To determine on average how these exposure and dose metrics for each route and aggregated over routes differ between – children in urban and rural settings – children in low and middle/high-income families – day care and stay-at-home children – children and adults in the same household overall – children and adults by stratum.	Sub-goals 3.1 through 3.3: Descriptive statistics were calculated on estimates of potential exposure and potential absorbed dose (by exposure route), aggregate potential exposure, aggregate potential absorbed dose, and urinary biomarker concentrations. Statistics included sample size, mean (arithmetic and geometric), standard deviation (for untransformed and log-transformed data), percentage detected, minimum reported value, maximum reported value, and selected percentiles (25^{th}, 50^{th}, 75^{th}, 95^{th}). Boxplots of the exposure and dose estimates and of the urinary biomarker concentrations were also prepared. *(See Section 8.5.1)* Sub-goal 3.4: Mixed model ANOVA was performed on log-transformed estimates of each of these exposure and dose metrics, as well as on differences in log-transformed estimates between children and adults in the same household. This model included fixed effects of income status, urbanicity, and day care status and took into account correlation in measurements for children attending the same day care center. F-tests performed on the model's fixed effects were used to make the statistical comparisons of interest. Results were reported as ratios of geometric means along with 95% confidence intervals, and t-tests were performed to determine whether a particular ratio was significantly different from one. *(See Section 8.5.2.2)*

Table 8.1.1 Study Goals and the Statistical Analysis Approaches Used to Address Each Goal (cont.)

Study Goal (and Sub-goals)	Overview of Statistical Analysis Approach
Goal 4: To apportion the exposures through the inhalation, dietary ingestion, and indirect ingestion routes: Sub-goal 4.1: To estimate the proportion of aggregated potential exposure and absorbed dose that is associated with a given exposure route for the study children, overall and by stratum. Sub-goal 4.2: For each exposure route, determine if this proportion differs for children – in urban and rural settings – from low and middle/high-income families – who attend day care or stay at home. Sub-goal 4.3: Determine whether significant differences exist between exposure routes. Sub-goal 4.4: Characterize how these estimates differ overall between pairs of exposure routes. Sub-goal 4.5: Identify which pairs of exposure routes differ significantly in these estimates.	Sub-goal 4.1: Proportions of aggregated potential exposure and absorbed dose were calculated for each exposure route and analyzed using a logistic regression model that contained effects for income status, urbanicity, and day care status and that accounted for correlation between children attending the same day care center. *(See Section 8.5.2.3, analysis #1.)* Sub-goal 4.2: Wald chi-square tests were performed within the logistic regression to test for significance of the effects in the regression model for a given exposure route to determine whether the proportions differ significantly between two specified groups of children. Estimates of the average proportion within each group and corresponding 95% confidence intervals were reported. *(See Section 8.5.2.3, analysis #1.)* Sub-goal 4.3: Each study participant was represented by a three-dimensional vector of log-transformed potential exposure estimates for the inhalation, dietary, and indirect routes, and a multivariate mixed-model ANOVA was performed on these vectors. This model included fixed effects of income status, urbanicity, and day care status and took into account correlation in measurements for children attending the same day care center, as well as correlation between a participant's three exposure routes. A statistical test performed within this model fit determined whether significant differences existed in the log-transformed exposure or dose estimates among the three routes. *(See Section 8.5.2.3, analysis #2.)* Sub-goals 4.4 and 4.5: Within the multivariate mixed-model ANOVA, pairwise comparisons among the three exposure routes were performed, and these results were reported. *(See Section 8.5.2.3, analysis #2.)*

$$Loading = \frac{A \times D}{4 \times W} \quad (8\text{-}1)$$

where A corresponds to the analytical measurement (ng), D equals the density of the paper on which the hand tracing was made (~80 g/m^2), and W corresponds to the weight of the hand tracing (g). Since the hand wipe involved wiping the front and back of both hands, the reported weight of the hand tracing (W) was multiplied by four within this equation. Note that if a study participant had multiple wipe samples taken at home and/or day care over the 48-h period, the value of A for that participant at a particular location corresponded to the geometric mean of the multiple measurements taken at that location. If W was not reported for a given participant (one in NC, four in OH), then the average value for W was calculated from other participants within the same state and sex category and that were similar in age to the participant, and this average was used to calculate the participant's wipe loading.

- Occasionally, such as when homes did not have carpeted floors or when homes had recent pesticide applications, multiple hard floor surface wipes were collected in the same home. For each of these homes, the geometric mean of these multiple wipe sample results was calculated (after replacing "not detected" values as mentioned above) and used in the statistical analysis. The geometric mean was labeled as "not detected" only when all results used in its calculation were labeled as "not detected."

- A study participant may have had multiple urine samples taken due to recent pesticide application, or a child attending day care may have had urine samples taken both at home and at day care. In these situations, the geometric mean of a participant's urine sample results was calculated and used in the analyses. This geometric mean was labeled as "not detected" only when all results used in its calculation were labeled as "not detected."

- Urine sample concentrations (in both ng/mL and pmoles/mL) were adjusted in two ways: 1) by dividing by the sample's specific gravity, and 2) by dividing by the sample's creatinine level. Creatinine-adjusted urine concentration was expressed in both ng/mg creatinine and µmoles/mole creatinine. Descriptive statistics and statistical analyses were performed on unadjusted and adjusted urine concentrations, for both types of adjustments.

Data labeled as "unusable" by the study's quality control process were not used in statistical summaries and analyses. Measured concentrations were not adjusted based on the recoveries of QC samples (e.g., surrogate recovery samples) prior to including them in summaries or analyses.

8.3 Strata Considered in the Statistical Analysis

The study goals required the statistical analysis to make comparisons between different strata that were determined according to urbanicity, the income status of the participating families or day care centers, and the type of environment where samples were collected. The different types of statistical analyses required that multimedia sample locations and study participants be stratified. The strata that were considered in the statistical analyses, along with the criteria for placing sampling locations and study participants into strata, were as follows.

- Urban and rural strata: Sampling locations and study participants were placed in the "urban" or "rural" stratum based on the county in which they were located or resided:
  - NC locations and participants were placed in the "urban" stratum if they originated from Buncombe, Durham, Edgecombe, or Mecklenburg counties.
  - OH locations and participants were placed in the "urban" stratum if they originated from Cuyahoga, Franklin, Hamilton, or Licking counties.
  - NC locations and participants were placed in the "rural" stratum if they originated from Jones or Lee counties.
  - OH locations and participants were placed in the "rural" stratum if they originated from Defiance or Fayette counties.

  A county was classified as urban if it contained part of, or was contained within, a Metropolitan Statistical Area (MSA) as defined by the Office of Management and Budget (OMB Bulletin No. 99-04). Counties not meeting this criterion were classified as rural.

- Low-income and middle/high-income strata. Sampling locations from day care centers were placed in the "low income" stratum if the day care center was a Head Start center and in the "middle/high-income" stratum otherwise. Sampling locations from households, as well as all study participants whether stay-at-home or at-day care, were placed in the "low income" stratum if the household's income status (verified during recruitment) achieved the Women, Infants, and Children (WIC) program income guidelines for the period of 7/1/2000 to 6/30/2001, which was equivalent to falling below 185% of the U.S. Poverty Income Guidelines, and were placed in the "middle/high-income" stratum otherwise.

- Children enrolled in day care and children not enrolled in day care. Children were considered enrolled in day care if they attended one of the selected day care centers and were selected to participate based upon meeting all study criteria. Children verified as not attending a day care center or otherwise meeting the day care criteria were labeled as not enrolled in day care.

- Children and adults in the same household. When a child was recruited into the study, a primary caregiver residing in the same household was also identified to participate in the study by providing personal samples (e.g., food, dermal wipes, urine) and activity pattern information needed to calculate potential exposure and potential absorbed dose.

Table 8.3.1 shows the number of participants in each stratum, for both the NC and OH portions of the study. Because one adult caregiver participated with each child in the study, the number of children and adults in the study was the same within each stratum. While the number of day care and stay-at-home children in the study was similar within each state, the number of participants from urban settings was considerably higher than the number from rural settings. In addition, more middle/high-income households participated in the study compared to low-income households in each state, with the difference in number more apparent in OH. However, a few households in each state did not have sufficient information to allow for their income level to be categorized. Data associated with these households were not included in summaries and statistical analyses when the income status associated with each data value needed to be specified.

Table 8.3.1 Number of Study Participants in Each Stratum, by State

Stratum	Number of Participants			
	North Carolina		Ohio	
	Children	Adults	Children	Adults
Stay-at-Home Child	66	66	69	69
Child Attends Day Care	63	63	58	58
Low-income	59	59	41	41
Middle/High-income	66	66	73	73
Unknown income	4	4	13	13
Urban	108	108	110	110
Rural	21	21	17	17

8.4 Procedures for Calculating Potential Exposure and Potential Absorbed Dose

Estimates of potential exposure were calculated for each study participant under the inhalation, dietary ingestion, and indirect ingestion exposure routes using the equations given below. Estimates of potential exposure via the dermal route were not calculated and were assumed to be negligible. For each participant and exposure route, the potential absorbed dose estimate was calculated as 50% of the potential exposure estimate divided by the participant's body weight (Ross et al., 2001)[1]. Aggregate potential exposure and aggregate potential absorbed dose were defined as the sums of the potential exposure and potential absorbed dose estimates, respectively, across all three exposure routes.

[1] If a participant's body weight was not reported, then the average body weight for other participants within the same state and sex category that were similar in age to the participant was calculated and used in calculating the participant's potential absorbed dose. This approach was necessary for one NC child participant.

The concentrations of measured pollutants and metabolites in urine over the 48-h sampling period were used as biomarkers of exposure in the study participants. The urinary concentrations of pollutants and metabolites were compared between strata for children and adults.

For each state, Table 8.4.1 lists those pollutants and metabolites that were among those detected in at least 50% of the samples in at least one media type (as seen in Section 9.2) and which were considered for estimating potential exposure and potential absorbed dose in the study participants. Twenty-seven pollutants are listed for NC and 26 for OH. Eight of these pollutants are denoted with an asterisk, as their detection rates were high in multiple media, and some have been commonly found in household consumer products. For these eight pollutants, potential exposure and absorbed dose were estimated in NC and OH children and adults for each exposure route, and aggregate potential exposure and aggregate potential absorbed dose were calculated in these study participants across routes. For the remaining pollutants listed in Table 8.4.1, potential exposure and potential absorbed dose were estimated in children and adults for a given exposure route and state only when the following criteria were satisfied for that pollutant:

- Inhalation route: When at least 45% of the state's indoor air samples, or at least 45% of the state's outdoor air samples, have detected results (i.e., at or above the MDL)
- Dietary ingestion route: When at least 45% of the state's solid food samples, or at least 45% of the state's liquid food samples, have detected results
- Indirect ingestion route: When at least 45% of the state's (vacuum) floor dust samples, or at least 45% of the state's soil samples, have detected results.

Unless otherwise specified, when any of the data entering into the equations below were either not available, could not be assumed to be zero, or were labeled as invalid for a particular study participant, then the potential exposure and potential absorbed dose was not estimated for that participant under the given exposure route, and as a result, aggregate potential exposure and aggregate potential absorbed dose could not be calculated. For purposes of the statistical summaries and analyses, potential exposure level and potential absorbed dose estimates were labeled as "detected" when at least one of the concentrations entering into their calculation was labeled as "detected."

8.4.1 Potential Exposure via Inhalation

Potential exposure via inhalation (ng/day) is a weighted average of measured air concentrations in the different environments in which the participant was present, with the weights corresponding to the time spent in each environment, after adjusting for the participant's estimated ventilation rate:

Table 8.4.1 Pollutants Considered for Estimating Potential Exposure and Potential Absorbed Dose for Study Participants in a Given State

Pollutant	NC	OH	Pollutant	NC	OH
Benz[*a*]anthracene			Dibenz[*a,h*]anthracene		
Benzo[*b*]fluoranthene			Di-*n*-butylphthalate*		
Benzo[*k*]fluoranthene			*p,p'*-DDE		
Benzo[*ghi*]perylene			2,4-Dichlorophenoxyacetic acid*		
Benzo[*a*]pyrene			Heptachlor		
Benzo[*e*]pyrene			Indeno[1,2,3-*cd*]pyrene		
Benzylbutylphthalate			Pentachlorophenol		
Bisphenol-A*			*cis*-Permethrin*		
alpha-Chlordane			*trans*-Permethrin*		
gamma-Chlordane			PCB 52		
Chlorpyrifos*			PCB 95		
Chrysene			PCB 101		
Cyfluthrin			3,5,6-Trichloro-2-pyridinol*		
Diazinon*					

* Pollutants for which potential exposure and potential absorbed dose were calculated for each exposure route for the study participants in each state, and for which aggregate potential exposure and aggregate potential absorbed dose were calculated (across exposure routes).

$$Exp_{inh} = \frac{(C_{di}(t_{di}) + (C_{do}(t_{do}) + (C_{hi}(t_{hi}) + (C_{ho}(t_{ho}) + (C_{away}(t_{away})}{t_{di} + t_{do} + t_{hi} + t_{ho} + t_{away}} \quad (V \qquad (8\text{-}2)$$

where the notation is as follows:

C_{di} = Indoor air concentration in the participant's day care center classroom (ng/m^3)
C_{do} = Outdoor air concentration at the participant's day care center (ng/m^3)
C_{hi} = Indoor air concentration in the participant's home (ng/m^3)
C_{ho} = Outdoor air concentration at the participant's home (ng/m^3)
C_{away} = Air concentrations in indoor locations other than the participant's day care center or home where the participant may spend time (ng/m^3)
t_{di} = Time spent indoors at day care when indoor air is being sampled there (hr)
t_{do} = Time spent outdoors at day care when outdoor air is being sampled there (hr)
t_{hi} = Time spent indoors at home when indoor air is being sampled there (hr)

t_{ho} = Time spent outdoors at home when outdoor air is being sampled there (hr)
t_{away} = Time spent indoors at locations other than day care or home during the sampling period (hr)
V = Ventilation rate, estimated as follows from information in the EPA Exposure Factors Handbook:

- 6.8 m^3/day for children less than 36 months of age
- 8.3 m^3/day for children aged 36 months or higher
- 11.3 m^3/day for adult females
- 15.2 m^3/day for adult males

For each of the participating children and their adult caregivers, an air sample was collected over a 48-h period in each of the indoor and outdoor environments at their homes. In addition, an air sample was collected over a 48-h period in each of the indoor and outdoor environments of participating day care centers, with most centers having separate indoor air samples taken in each classroom containing a participating child. Thus, the values of C_{di}, C_{do}, C_{hi}, and C_{ho} for a given participant were taken to be the measured concentrations in the four air samples associated with that participant. However, no air samples were taken in indoor environments other than homes and day care centers to allow C_{away} to be estimated. Thus, to arrive at a value for C_{away}, the median of all indoor air concentration measures taken in a given state was calculated for each pollutant listed in Table 8.4.1, and this median, specified in Appendix F, was taken to be the estimate of C_{away} for each study participant in that state. Equation (8-2) does not include a term for air concentration in outdoor environments away from homes or day care centers, as the times spent in these other outdoor environments were assumed to be trivial (i.e., near zero) for the study participants.

For day care children, values of t_{di} and t_{do} in equation (8-2) were obtained from information recorded on the Child Activity Diary and Food Survey (Form 10), completed by day care teachers. For day care children and their adult caregivers, values of t_{hi} and t_{ho} were obtained from information recorded on Child Activity Diary and Food Survey (Form 9), completed by day care parents), and t_{away} was calculated from information recorded on Forms 09 and 10. For stay-at-home children and their adult caregivers, values of $t_{hi,}$ $t_{ho,}$ and t_{away} were determined from information recorded on Form 08 (Child Activity Diary and Food Survey, completed by "home" parents). For stay-at-home children and all adult caregivers in the study who were not exposed to a day care environment, t_{di} and t_{do} were both set equal to 0.

8.4.2 Potential Exposure via Dietary Ingestion

Potential exposure level via dietary ingestion (ng/day) is a weighted sum of measured concentrations in both solid and liquid food within the day care and home environments in which the participant was present, with each concentration multiplied by the amount of the collected sample (representing the total amount of food eaten by the participant):

$$Exp_d = [(C_{dl}(M_{dl}) + (C_{ds}(M_{ds}) + (C_{hl}(M_{hl}) + (C_{hs}(M_{hs})] \left(\frac{1}{N_f}\right) \quad (8\text{-}3)$$

where the notation is as follows:

C_{dl} = Concentration in liquid food sample collected in the participant's day care classroom (ng/mL)
C_{ds} = Concentration in solid food sample collected in the participant's day care classroom (ng/g)
M_{dl} = Total volume of liquid food sample collected in the participant's day care classroom (mL)
M_{ds} = Total weight of solid food sample collected in the participant's day care classroom (g)
C_{hl} = Concentration in the participant's liquid food sample collected at home (ng/mL)
C_{hs} = Concentration in the participant's solid food sample collected at home (ng/g)
M_{hl} = Total volume of the participant's liquid food sample collected at home (mL)
M_{hs} = Total weight of the participant's solid food sample collected at home (g)
N_f = Number of days over which all food samples (liquid and solid) associated with the participant were collected.

Because each food sample at a given location for a given study participant corresponded to a composite of total food consumed by the participant over a two-day period, the value of N_f was set equal to two for each participant. Participants that drank only water at day care and/or home were assumed to have liquid food sample concentrations (C_{dl} and C_{hl}, respectively) of 0 ng/mL for that environment. Although C_{dl} and C_{ds} were not measured for stay-at-home children and for all adult caregivers, the values of M_{dl} and M_{ds} for these participants were zero, and therefore, these concentrations were not a factor in calculating the potential exposure level.

8.4.3 Potential Exposure via Indirect Ingestion

Potential exposure via indirect ingestion (i.e., ingestion of dust and soil) (ng/day) is a weighted average of measured floor dust and soil concentrations in the indoor and outdoor environments, respectively, in which the study participant was present, with each concentration scaled by the participant's assumed ingestion rate:

$$Exp_n = \frac{(D_{dd}(M_d(t_{di}) + (D_{ds}(M_s(t_{do}) + (D_{hd}(M_d(t_{hi}) + (D_{hs}(M_s(t_{ho})}{t_{di} + t_{do} + t_{hi} + t_{ho}} \quad (8\text{-}4)$$

where the notation is as follows:

D_{dd} = Concentration in the day care center/classroom's HVS3 (vacuum) floor dust sample (ng/g)
D_{ds} = Concentration in day care center's play area soil sample (ng/g)
D_{hd} = Concentration in home's HVS3 floor dust sample (ng/g)
D_{hs} = Concentration in home's play area soil sample (ng/g)
M_d = Participant's estimated daily ingestion rate of dust (g/day)
M_s = Participant's estimated daily ingestion rate of soil (g/day)

and t_{di}, t_{do}, t_{hi}, and t_{ho} are defined in the same way as in equation (8-2) (i.e., times spent indoors and outdoors in the day care and home environments). For stay-at-home children and all adult caregivers who were not exposed to a day care environment, t_{di} and t_{do} were both set equal to 0. Any indirect ingestion that might have occurred outside of the day care center and home environments was assumed to be trivial, and therefore, was not included in equation (8-4). Daily ingestion rates of dust and soil were estimated according to the published literature (15-16) and from the collected questionnaire data on children's activity patterns. For participating children, daily ingestion rates were estimated by placing each child into one of three groups (Groups A, B, or C) according to information recorded on study survey forms on how often the child conducted activities that could lead to dust and soil ingestion, such as teething, chewing, and putting objects into his/her mouth. For soil ingestion activity, responses from the following two questions on Form 04 (parent pre-monitoring questionnaire) were evaluated:

(1) Question C5: How often did [the child] play with sand or dirt?
(2) Question C6: Which of the following have you seen your child eat: dirt, sand, snow?

For dust ingestion activity, responses from the following questions on Form 04 were evaluated:

(1) Question C12: Did your child use a pacifier in the past month?
(2) Question C13a: In the past month, did [your child] suck or chew his/her thumb/fingers?
(3) Question C13b: In the past month, did [your child] suck or chew his/her toe/foot?
(4) Question C16: Did [your child] ever put his/her mouth on the floor and lick the floor?
(5) Question C21: Is your child currently teething?
(6) Question C22: How often did [your child] put toys in his/her mouth?
(7) Question C23: Did [your child] put any things other than toys or food in his/her mouth?

Algorithms were established to assign a daily soil ingestion rate and a daily dust ingestion rates to a child based upon the responses to the above questions for that child, with the specific rates that entered into the algorithms being selected in conjunction with the published literature (15-16). Appendix G provides details on these algorithms. Separately for dust and soil ingestion, the algorithms placed children into Groups A, B, or C based upon whether their

activity levels were considered high, medium, or low, respectively. For both dust and soil, daily ingestion rates were assigned as follows:

- Children in Group A: Daily ingestion rate = 0.100 g/day
- Children in Group B: Daily ingestion rate = 0.050 g/day
- Children in Group C: Daily ingestion rate = 0.025 g/day

For all participating adult caregivers, assigned ingestion rates were M_d=25 mg/day for dust and M_s=50 mg/day for soil. Note that while the activity diaries and questionnaires provide useful information for exposure assessment, they were not fully validated prior to their use in this study.

8.5 Statistical Analysis

This section details the methods associated with the statistical summaries and analyses that were applied to the study data in order to address each of the study's goals and sub-goals. The data were prepared for analysis as discussed in Section 8.2, then were statistically summarized and analyzed using Version 8 (Release 8.2) of the SAS® System. These statistical methods were applied independently to data from NC and OH.

8.5.1 Descriptive Statistics

As mentioned in Table 8.1.1, descriptive statistics were generated on the study data in order to address the following five goals or sub-goals:

- Sub-goal 1.1: to quantify the distribution of target pollutants in multimedia samples at homes and day care centers
- Goal 2: to quantify the distribution of child characteristics, activities, and locations that are important for exposure
- Sub-goal 3.1: to quantify the distribution of potential exposure and potential absorbed dose by exposure route
- Sub-goal 3.2: to quantify the distribution of aggregate potential exposure and potential absorbed dose
- Sub-goal 3.3: to quantify the distribution of urinary biomarker concentrations as an indicator of absorbed dose.

The SAS® System's UNIVARIATE procedure was applied to the relevant study data to calculate the descriptive statistics. For Goal 2, the list of summarized parameters and the descriptive statistics calculated on these parameters were given in Table 8.1.1. For the four sub-goals, the descriptive statistics included the sample size, mean (arithmetic and geometric), standard deviation (for untransformed and log-transformed data), percent of results labeled as detected, minimum reported value, maximum reported value, and selected percentiles of the observed data distribution (25^{th}, 50^{th}, 75^{th}, 95^{th}). Means and standard deviations were reported only when at least 50% of the data entering into their calculation were detected. A given percentile was

reported only when the observed data values at the percentile exceeded the MDL. The maximum reported value was reported only when at least one detected measurement was reported, and the minimum reported value was reported only when 100% of the reported measurements were detected. These descriptive statistics are included as appendices to this report.

Also, for the four sub-goals specified above, boxplots were prepared which portrayed the distribution of observed data values as a box-type diagram, within which the 25^{th}, 50^{th}, and 75^{th} percentiles, the geometric mean, and the range of the data were expressed graphically. Details on how to interpret the boxplots are given in Section 9.3.1.

8.5.2 Analysis of Variance (ANOVA) Modeling

Model-based analysis of variance (ANOVA) methods were applied to the study data in order to address Sub-goal 1.2, Sub-goal 3.4, and Goal 4, as detailed in the three subsections below. In each case, the ANOVAs were repeatedly applied to different subsets of study data using the SAS® System's MIXED and GENMOD procedures, with each subset of data associated with a specific target pollutant and media type/dose metric. While the ANOVA approach applies when the data used in the analysis satisfies certain statistical assumptions, the same approach was applied to each subset of data (i.e., each combination of pollutant and sample type) when addressing a particular study goal. This was done in order to maintain consistency in approach across the repeated analyses, so that the outcomes of the analyses could be more comparable across the pollutants and sample types. Note that the outcome of statistical analyses of urine, potential exposure, and potential absorbed dose data was not affected by whether the data were expressed in mass concentration or molar concentration units.

8.5.2.1 Sub-goal 1.2: To determine on average how multimedia concentrations differ between urban and rural environments, low-income and middle high-income environments, and microenvironments

Multimedia (environmental and food) samples were collected at the homes and day care centers of the participating children. Within a day care center, indoor environmental samples were linked to children by classroom. These two locations, along with an indicator of whether or not a child attended day care, defined three possible *microenvironments*: 1) the day care microenvironment; 2) the home microenvironment for stay-at-home children, and 3) the home microenvironment for children attending day care. Additionally, multimedia samples were classified by income status (low or middle/high) and urbanicity (urban or rural) according to the microenvironment from which they were collected. The primary aim of the data analysis was to make statistical comparisons among the three microenvironments, although comparisons were also made according to income status and urbanicity.

For a given multimedia sample type and pollutant (with the exception of dermal wipes), let Y_{ijk} denote the log-transformed analytical measurement associated with a sample collected in the i^{th} environment type, where the sample is identified as follows:

- For samples collected in a day care center environment (i=1), the sample taken in the j^{th} classroom within the k^{th} day care center in the study.
- For samples collected in the home environment of a stay-at-home child (i=2), the sample collected in the k^{th} home of this type in the study. (Here, j is assumed to be equal to one as only one sample was taken per home).
- For samples collected in the home environment of a day care child (i=3), the sample taken in the k^{th} home of this type in the study. (Here, j is assumed to be equal to one as only one sample was taken per home.)

Then, for a particular combination of pollutant and environmental/food sample type, the following analysis of variance (ANOVA) model was applied to the log-transformed analytical measurements Y_{ijk}:

$$Y_{ijk} = \mu + \eta_i + \gamma_1 M_{ik} + \gamma_2 U_{ik} + \delta_k + \varepsilon_{ijk} \qquad (8\text{-}5)$$

where

μ = an overall constant,
η_i = effect of originating from the i^{th} environment type,
γ_1 = effect of originating from a middle/high-income environment versus a low income environment
M_{ik} = indicator of income status associated with the k^{th} day care center or home within the i^{th} environment type (i.e., M_{ik}=1 if middle/high-income and =0 if low income),
γ_2 = effect of originating from an urban environment versus a rural environment
U_{ik} = indicator of urbanicity associated with the k^{th} day care center or home within the i^{th} environment type (i.e., U_{ij}=1 if an urban area and =0 if a rural area),
δ_{jk} = a random term corresponding to the k^{th} home or day care center, and
ε_{ijk} = a random error term representing random variation not explained by the model.

Because no interactions are included in the model, any interaction effects are included in the random error term. The variance-covariance matrix of δ_k was defined to account for correlation in measurements for samples taken in different classrooms (j) within the same day care center (k), while the variance-covariance matrix of ε_{ijk} was defined under the assumption that the values of ε_{ijk} for different samples are independent.

The statistical significance of environment type (η_i), income status (γ_1), and urbanicity (γ_2) on the value of Y_{ijk} was determined by applying F-tests within the ANOVA, and significance levels of these F-tests were reported. When the F-test for the effect of environment type (η_i) was found to be significant at the 0.05 level and all three environment types were represented by the data, multiple comparisons (using Tukey's studentized range test) were performed to identify which of the three pairs of environment types differed significantly, and the significance levels (adjusted for the multiple comparisons) associated with each of the three pairs were reported. Additionally, a t-test was performed within the ANOVA to determine if the day care

environment differed significantly with the mean of the two home environment types, and the significance level of this test was also reported.

To characterize how the analytical measurements differ between two strata (e.g., urban vs. rural, low income vs. middle/high-income), the ANOVA model was used to estimate the average log-transformed analytical measurement ("least squares mean") for each stratum. Then, the difference in the least squares means of the two strata was calculated, a t-test was performed within the ANOVA to determine whether this difference was statistically significant at the 0.05 or 0.01 levels, and a 95% two-sided confidence interval on this difference was also calculated within the ANOVA. The estimated difference in least squares means and its 95% confidence interval were then exponentiated, resulting in a ratio of estimated geometric means between the two strata and a corresponding 95% two-sided confidence interval on this ratio. The estimated ratio, its 95% confidence interval, and the outcome of the statistical test for significant difference between the two strata were reported.

Because a statistical comparison between home and day care environments was also of interest, a linear contrast was constructed within the ANOVA to estimate the difference in average log-transformed measurements between these two environments. Because the home environment consisted of two of the three microenvironments (i.e., the home environment for day care children and the home environment for stay-at-home children), the linear contrast was specified as the average log-transformed analytical measurement for the day care microenvironment, minus the average of the average log-transformed analytical measurements associated with the two home microenvironments. As with the other comparisons of strata, a t-test was performed within the ANOVA to determine whether this difference between home and day care environments was significant at the 0.05 or 0.01 levels, and a 95% two-sided confidence interval on this difference was calculated within the ANOVA. A ratio of estimated geometric means between the home and daycare environments was also calculated, along with a 95% two-sided confidence interval on this ratio.

While all pollutants were considered in the analysis of environmental sample data, model (8-5) was applied to only those combinations of pollutant and multimedia samples that met the following two criteria:

- At least 50% of the values of Y_{ijk} were labeled as detected.
- Values of Y_{ijk} were available for at least two of the three environment types.

Within an application of the analysis, if data were available from only one of a given microenvironment (e.g., data were available for only one day care center), then data for that microenvironment were excluded from that application of the analysis. The check for whether at least 50% of the values were detected occurred after any necessary data exclusions were made.

For the adult food sample type, microenvironments were relevant based upon whether or not their child attended day care: home microenvironment for stay-at-home children (i=2), and home

microenvironment for day care children (i=3). This is because all adult-specific data were collected within the home microenvironment.

A slightly different ANOVA model was used for analysis of dermal wipe data. Dermal wipes were collected for each study participant (child and adult) at their home and, for day care children, at their day care center. Thus, day care children could have up to two dermal wipe measurements, corresponding to their home and day care microenvironments. The statistical analysis of dermal wipe data, therefore, needed to take into account correlation in the day care and home dermal wipe samples for day care children. In the analysis of dermal wipe data, let Y_{ijk} denote the log-transformed analytical measurement associated with a dermal wipe sample collected in the i^{th} environment type, where the sample is identified as follows:

- For day care children, the sample taken in the i^{th} environment (day care [i=1] or home [i=3]) from the j^{th} child enrolled in the k^{th} day care center of the study.
- For stay-at-home children and for all adult participants, the sample collected in the k^{th} home of the environment type determined by whether or not the child attends day care (i=2 or 3). (Here, j is assumed to be equal to one as only one child and one adult participated from each home.)

The ANOVA model applied to the dermal wipe sample data took the following form:

$$Y_{ijk} = \mu + \eta_i + \gamma_1 M_{ij} + \gamma_2 U_{ij} + \delta_k + \varepsilon_{ijk} \qquad (8\text{-}6)$$

where the terms are as defined for equation (8-5) except for the following:

M_{ij} = indicator of income status associated with the j^{th} study participant within the i^{th} environment type (i.e., M_{ij}=1 if middle/high-income and =0 if low income),
U_{ij} = indicator of urbanicity associated with the j^{th} study participant within the i^{th} environment type (i.e., U_{ij}=1 if an urban area and =0 if a rural area),

Because no interactions are included in the model, any interaction effects are included in the random error term (ε_{ijk}). The variance-covariance matrix of δ_k was defined to account for correlation in measurements for samples taken from different children (j) within the same day care center (k), while the variance-covariance matrix of ε_{ijk} was defined to account for correlation in measurements for samples taken from the same child (j) at different environment types (i) (i.e, day care and home).

The results for the tests of significance for environment, urbanicity, and income status on the log-transformed analytical measurement, and their estimated geometric ratios and associated 95% confidence intervals, were reported in the same manner as for the environmental/food samples. Model (8-6) was fitted separately for each pollutant, as well as separately for adults and children.

8.5.2.2. Sub-goal 3.4: To determine on average how potential exposure and absorbed dose metrics for each route and aggregated over routes differs between children in urban and rural settings, children in low and middle/high-income settings, day care children and stay-at-home children, and children and adults by stratum

The analysis approach presented in this subsection was performed on the potential exposure and absorbed dose estimates for the target pollutants listed in Table 8.4.1, when the data for these pollutants achieved the criteria specified in Section 8.4 for a given exposure route. The analyses were executed separately for each exposure route. In addition, this approach was performed on urine concentration data (both adjusted and unadjusted for specific gravity and creatinine concentration), separately for each pollutant measured in urine, and on aggregated potential exposure level and aggregated potential absorbed dose estimates, separately for each of the eight pollutants labeled with asterisks in Table 8.4.1.

Let j denote a specific household enrolled in the study. The analyses addressing Sub-goal 3.4 were performed on the measures Y_j, with separate analyses being conducted by pollutant and for each of the following definitions of Y_j:

- Log-transformed potential exposure level for the child in the j^{th} household (separate analyses by exposure route)
- Log-transformed potential absorbed dose for the child in the j^{th} household (separate analyses by exposure route)
- Log-transformed aggregated potential exposure level for the child in the j^{th} household
- Log-transformed aggregated potential absorbed dose for the child in the j^{th} household
- Log-transformed unadjusted urine concentration for the child in the j^{th} household
- Log-transformed urine concentration, adjusted for specific gravity, for the child in the j^{th} household
- Log-transformed urine concentration, adjusted for creatinine, for the child in the j^{th} household
- Difference in log-transformed potential exposure level between the child and adult in the j^{th} household (separate analyses by exposure route)
- Difference in log-transformed potential absorbed dose between the child and adult in the j^{th} household (separate analyses by exposure route)
- Difference in log-transformed aggregated potential exposure level between the child and adult in the j^{th} household
- Difference in log-transformed aggregated potential absorbed dose between the child and adult in the j^{th} household
- Difference in log-transformed unadjusted urine concentration between the child and adult in the j^{th} household
- Difference in log-transformed urine concentration, adjusted for specific gravity, between the child and adult in the j^{th} household

- Difference in log-transformed urine concentration, adjusted for creatinine, between the child and adult in the j^{th} household.

The ANOVA model applied to data for a given combination of pollutant and Y_j definition was the following:

$$Y_j = \mu + \gamma_1 M_j + \gamma_2 U_j + \gamma_3 D_j + \varepsilon_j \qquad (8\text{-}7)$$

where

μ = an overall constant,
γ_1 = effect of a middle/high-income household versus a low income household,
M_j = indicator of the j^{th} household's income status (M_j=1 if middle/high-income, =0 if low income),
γ_2 = effect of an urban household versus a rural household,
U_j = indicator of the j^{th} household's urbanicity (U_j=1 if urban, =0 if rural),
γ_3 = effect of a child enrolled in day care versus staying at home,
D_j = indicator of child's day care status in the j^{th} household (D_j=1 if day care, =0 if non-day care), and
ε_j = a random error term representing random variation not explained by the model.

The variance-covariance matrix of ε_j was defined to account for correlation in measurements among households whose children attend the same day care center.

In a given fitting of model (8-7), the statistical significance of urbanicity, income status, and day care status on the value of Y_j was determined by testing for the significance of their corresponding coefficients in the model using F-tests and reporting the significance levels of these tests. As in the previous models, because no interactions of these factors are included in the model, only the main effects of these factors were tested. Thus, any interaction effects are included in the model's random error term.

When the definition of Y_j corresponded to some child-specific measure (i.e., not a child vs. adult difference), the ratio of estimated geometric means between two strata (e.g., urban vs. rural, low income vs. middle/high-income, day care vs. non-day care) were reported for this measure as in the previous models, along with 95% two-sided confidence intervals. T-tests were also performed to determine whether a particular ratio was significantly different from one, implying no significant difference between the two strata represented by the ratio. When the definition of Y_j corresponded to a difference in measures between children and adults within the same household, the ratio of estimated geometric means for children versus adults in the same household were reported overall and for each stratum, along with 95% two-sided confidence intervals. In addition, a one-sided t-test was performed within the model fitting that tested whether, overall, children tended to have significantly higher measures than their adult caregivers. For the individual strata, two-sided t-tests were performed to test whether children's measures differed significantly from their adult caregivers.

8.5.2.3 Goal 4: To apportion the exposures through the inhalation, dietary ingestion, and indirect ingestion routes

For the eight pollutants highlighted in Table 8.4.1 for which aggregated potential exposure level and aggregated potential absorbed dose were estimated, this goal focuses on characterizing how these aggregated estimates were apportioned across the three exposure routes considered in this study (inhalation, dietary ingestion, and indirect ingestion) and noting which routes were more important contributors to aggregate potential exposure or aggregate potential absorbed dose than others. As indicated in Table 8.1.1, this goal was divided into the following five sub-goals:

4.1 To estimate the proportion of aggregated exposure and dose that is associated with a given exposure route for the study children overall and by stratum.
4.2 For each exposure route, determine if this proportion differs for children
  a. in urban and rural settings
  b. from low and middle/high-income families
  c. who attend day care or stay at home
4.3 Determine whether significant differences exist between exposure routes
4.4 Characterize how these estimates differ overall between pairs of exposure routes
4.5 Identify which pairs of exposure routes differ significantly in these estimates

To address each of these sub-goals, two types of analyses were developed and executed:

- Analysis #1 (Sub-goals 4.1 and 4.2): Characterizes the proportion of the aggregated value that is associated with a specific exposure route, both overall and by stratum, and determines whether these proportions differ significantly between strata. This analysis was performed separately by pollutant and exposure route.

- Analysis #2 (Sub-goals 4.3, 4.4, and 4.5): Compares average log-transformed measures between exposure routes. This analysis was performed separately by pollutant and for potential exposure and potential absorbed dose.

Each of these analysis approaches is now discussed.

Analysis #1. When applied to a given exposure route, this analysis involved calculating p_j, or the proportion of the estimated aggregated exposure that is associated with the given exposure route, for the j^{th} participant. To make statistical comparisons of the value of p_j between strata, the following logistic regression model was used:

$$\log(p_j/(1-p_j)) = \mu + \gamma_1 M_j + \gamma_2 U_j + \gamma_3 D_j + \varepsilon_j \qquad (8\text{-}8)$$

where the terms in this model are as defined for equation (8-7). Generalized estimating equations were used to allow values of the proportion p_j associated with children enrolled in the same day care center to be correlated.

The presence of significant differences among strata was determined by testing the statistical significance of the corresponding model coefficients via a Wald chi-square test. For example, the differences of the proportion between children living in urban areas and children living in rural areas was investigated by testing for the significance of the γ_2 coefficient in model (8-8). Significance levels of tests for significant differences between urban and rural strata, between middle/high and low income strata, and between day care and non-day care strata were reported, along with estimates and corresponding 95% confidence intervals for the average proportion for each stratum. The estimated average proportion for each stratum was determined by solving model (8-8) for the value of p_j for the given stratum (i.e., calculating the inverse logit).

Because the proportion p_j is calculated for each participant for a given exposure route, the outcome of this calculation is the same whether potential exposure level or potential absorbed dose is used. This is because the absorption rate (50%) and the participant's body weight cancel out from the numerator and denominator of the proportion equation. Thus, for a given exposure route, only one analysis was necessary between these two endpoints.

Analysis #2. To investigate whether potential exposure level or potential absorbed dose differed significantly among the three exposure routes and among strata, this analysis involved a multivariate ANOVA fitted to the log-transformed estimates for a given pollutant. This approach is similar to that discussed in Section 8.5.2.2, except the model is multivariate in nature in that it is applied to the vector of three log-transformed estimates associated with each exposure route. For the i^{th} entry (or exposure route) in this vector (i=1, 2, 3), the multivariate ANOVA model is as follows:

$$Y_{ij} = \mu + \gamma_1 M_j + \gamma_2 U_j + \gamma_3 D_j + \delta_j + \varepsilon_{ij} \qquad (8\text{-}9)$$

where

Y_{ij} = log-transformed exposure or dose estimate for the j^{th} study participant via the i^{th} exposure route,

μ = an overall constant,

γ_1 = effect of a middle/high-income household versus a low income household,

M_j = indicator of the household income status for the j^{th} study participant (M_j=1 if middle/high-income, =0 if low income),

γ_2 = effect of an urban household versus a rural household,

U_j = indicator of the urbanicity of the household containing the j^{th} study participant (U_j=1 if urban, =0 if rural),

γ_3 = effect of a child enrolled in day care versus staying at home,

D_j = indicator of child's day care status in the household containing the j^{th} study participant (D_j=1 if day care, =0 if non-day care),

δ_j = random day care center effect, which accounts for correlation between children attending the same day care center, and

ε_j = a random error term representing random variation not explained by the model that accounts for correlation between exposure routes for each participant.

When fitting model (8-9), a statistical test was performed to determine whether significant differences existed in the log-transformed exposure or dose estimates among the three exposure routes. Then, pairwise comparisons among the three exposure routes were performed, and the results were reported. In addition, the estimated ratio of geometric means between two exposure routes were calculated and reported for each pair of routes, along with a 95% confidence interval on the ratio.

Chapter 9
Results and Discussion

9.1 Overview

This chapter presents the results of the statistical analyses of the CTEPP study data. The presentation includes descriptive statistics and the outcome of statistical modeling efforts which were performed to address the following four statistical goals:

- **Goal 1:** To measure the environmental concentrations of pesticides and other persistent and non-persistent organic pollutants in multimedia at the homes and day care centers of a set of preschool children in several North Carolina (NC) and Ohio (OH) counties.
- **Goal 2:** To quantify the distribution of child characteristics, activities, and locations that are important for exposure.
- **Goal 3:** To estimate the exposures of the preschool children to these pollutants that they may encounter in their everyday environments.
- **Goal 4:** To apportion the exposures through the ingestion, inhalation, and dermal routes.

The results presented in this chapter characterize only those children who participated in the CTEPP study. The results should not be used to make inferences to larger populations of children, such as all children "in NC, OH, or in the United States," "in low-income and middle/high-income families," "in day care centers," etc. Neither can the study design permit results to be used to test hypotheses such as whether exposures differ significantly between all NC children and all OH children. The statistical analysis did not calculate sample weights assigned to the study participants that would represent larger populations of children.

Compound prevalence is reported for each pollutant by matrix for each state (section 9.2). Statistical analysis was conducted on the most frequently detected pollutants. The results of these analyses of the data that address the four specific goals of the study are presented in sections 9.3 through 9.6.

9.2 Method Quantifiable Limits and Compound Prevalence

The method quantifiable limits (MQLs) were based on instrumental performance alone and were estimated based on the lowest calibration standard that could be measured within 30% of the true value and had a signal-to-noise ratio that exceeded three to five. The method detection limit (MDL) was defined as the minimum concentration at which a pollutant can be detected in a sample and was estimated to be one-half of the MQL.

High and variable concentrations were observed in blank samples for several pollutants and matrices. These include:

- benzylbutylphthalate and di-*n*-butylphthalate in all sample media for both NC and OH,
- bisphenol-A in NC wipe blanks, and
- *cis*-permethrin and *trans*-permethrin in OH air blanks

For these pollutants and matrices, the MDL and MQL were calculated using the following equations:

$$MDL = [z_{0.95} * se(FMB)]/S$$

where z_α is the $\alpha*100^{th}$ percentile of the standard normal distribution ($z_{0.95} = 1.645$), se(FMB) is the standard error of the measurements associated with field blanks, and S corresponds to the sample volume, area, or weight, whichever is relevant for the given media type.

For each pollutant and metabolite, the MDL was initially reported in mass units (ng) for each collected multimedia sample and then converted to concentration units by dividing by the sample volume, weight, or area. Tables 9.2.1 and 9.2.2 give the median MDL values for neutral and acid pollutants, respectively, in the multimedia samples, while Table 9.2.3 provides the median MDL values for pollutants and metabolites measured in urine samples.

With some exceptions, median MDL values were the same or very similar across neutral pollutants for a given media type (Table 9.2.1). Median MDLs were somewhat higher for the two phthalates compared to other neutral pollutants, mainly due to the background corrections as described above. For bisphenol-A, nonylphenol, and cyfluthrin, the estimated instrumental detection limits were about ten times the detection levels of the other neutral pollutants due to their chromatographic properties and the relative abundances of the quantitation ions. For PCB congeners, the median MDL in transferable residue (PUF) samples was twice as large for OH than for NC due to differences in sample matrices. Among acid pollutants and metabolites measured in urine (Table 9.2.3), MDL values differed between the methylated pollutants/metabolites (2,4-D, hydroxy-PAHs, and PCP) and the silylated metabolites (3,5,6-TCP) due to the amounts of urine used for analysis (10 mL for the methylated pollutants/metabolites versus 1 mL for the silylated metabolites) and their different detection capabilities.

For each pollutant, percentages of collected samples with concentrations at or above the MDL are presented by media type in Tables 9.2.4 and 9.2.5 for NC and OH, respectively. Detection percentages associated with special samples collected from homes having recent pesticide applications (i.e., hard floor and food preparation surface wipes, PUF samples) are presented in Table 9.2.6 for NC and OH. Within these four tables, pollutants with detection percentages of at least 50% in a particular medium are shaded in gray. Similar tables

Table 9.2.1 Median MDL Values for Neutral Pollutants Measured in Multimedia Samples from North Carolina and Ohio

Pollutant [a]	Location	Median MDL Values								
		Indoor Air (ng/m^3)	Outdoor Air (ng/m^3)	Soil (ng/g)	Dust (ng/g)	Dermal Wipe (ng/m^2)	Solid Food (ng/g)	Liquid Food (ng/mL)	Surface Wipe (ng/m^2)	PUF [d] (ng/m^2)
Benzylbutylphthalate	NC	57	57	12	50	6,400	52	27	1,400	4.4
	OH	35	35	5.6	22	8,000	5.7	18	1,700	4.4
Di-*n*-butylphthalate	NC	13	13	7.7	32	1,900	62	22	400	4.4
	OH	25	25	23	94	8,200	18	7.4	1,800	4.4
Bisphenol-A	NC	0.87	0.87	4.9	20	320	0.83	0.33	68	44
	OH	0.87	0.86	5.0	25	280	0.83	0.33	69	44
Nonylphenol	NC	0.87	0.87	4.9	20	320	0.83	0.33	69	44
	OH	0.87	0.87	5.0	20	280	0.83	0.33	69	44
Cyfluthrin	NC	0.87	0.87	4.9	20	320	0.83	0.33	69	44
	OH	0.87	0.87	5.0	20	250	0.83	0.33	69	44
cis-Permethrin	NC	0.09	0.09	0.49	2.0	32	0.08	0.03	6.9	4.4
	OH	0.39	0.38	0.50	2.0	32	0.08	0.03	6.9	4.4
trans-Permethrin	NC	0.09	0.09	0.49	2.0	32	0.08	0.03	6.9	4.4
	OH	0.33	0.33	0.50	2.3	32	0.08	0.03	6.9	4.4
PCB congeners	NC	0.04	0.04	0.49	2.0	32	0.08	0.03	6.9	4.4
	OH	0.04	0.04	0.50	2.0	32 [b]	0.08	– [c]	6.9	8.8
All other neutral pollutants [a]	NC	0.09	0.09	0.49	2.0	32	0.08	0.03	6.9	4.4
	OH	0.09	0.09	0.50	2.0	32 [b]	0.08	0.03	6.9	4.4

[a] Atrazine is not showed in this table as it was measured only in drinking water samples. It had a median MDL value of 0.01 ng/mL for both NC and OH.

[b] Across PCB congeners and all other neutral pollutants, median MDL values in Ohio ranged from 31 to 32 ng/m^2.

[c] Ohio liquid food samples were not analyzed for PCB congeners.

[d] There were no field blanks for PUF samples in NC and only one field blank for PUF samples in OH; the MDLs for the two phthalates in PUF were not corrected for the background levels.

Table 9.2.2 Median MDL Values for Acid Pollutants and Metabolites Measured in Multimedia Samples from North Carolina and Ohio

Pollutant/ Metabolite	Location	Median MDL Values								
		Indoor Air (ng/m^3)	Outdoor Air (ng/m^3)	Soil (ng/g)	Dust (ng/g)	Dermal Wipe (ng/m^2)	Solid Food (ng/g)	Liquid Food (ng/mL)	Surface Wipe (ng/m^2)	PUF[b] (ng/m^2)
Dicamba	NC	0.17	0.17	0.40	4.0	63	0.25	0.20	14	--[a]
	OH	0.17	0.17	0.40	4.0	61	0.25	0.20	14	4.4
2,4-D	NC	0.17	0.17	0.40	4.0	63	0.25	0.20	14	--
	OH	0.17	0.17	0.40	4.0	61	0.25	0.20	14	4.4
IMP	OH	0.09	0.09	0.20	2.0	30	0.12	0.10	6.9	4.4
Pentachlorophenol	NC	0.09	0.09	0.40	4.0	63	0.25	0.20	14	--
	OH	0.17	0.17	0.40	4.0	61	0.25	0.20	14	4.4
2,4,5-T	NC	0.17	0.17	0.40	4.0	63	0.25	0.20	14	--
	OH	0.17	0.17	0.40	4.0	61	0.25	0.20	14	4.4
3,5,6-TCP	NC	0.09	0.09	0.20	2.0	33	0.12	0.10	6.9	--
	OH	0.09	0.09	0.20	2.0	31	0.13	0.10	6.9	4.4

[a] A dash indicates that the pollutant was not measured in PUF samples.
[b] There were no field blanks for PUF samples in NC and only one field blank for PUF samples in OH.

Table 9.2.3 Median MDL Values for Pollutants and Metabolites Measured in Urine Samples from North Carolina and Ohio

Pollutant/Metabolite	Median MDL Values in Urine (ng/mL)	
	NC	OH
2,4-D	0.20	0.20
1-hydroxybenz[*a*]anthracene	0.20	0.20
3-hydroxybenz[*a*]anthracene	--[a]	0.20
3-hydroxybenz[*a*]pyrene	--	0.20
3-hydroxychrysene	0.20	0.20
6-hydroxychrysene	--	0.20
6-hydroxy indeno[1,2,3-*cd*]pyrene	--	0.20
1-hydroxypyrene	--	0.20
Pentachlorophenol	0.20	0.20
3-PBA	--	0.20
3,5,6-TCP	1.0	1.0

[a] A dash indicates that the pollutant was not measured in urine samples.

Table 9.2.4 Percentages of NC Samples With Detectable Pollutant and Metabolite Levels (At or Above the MDL) in Multimedia and Urine Samples [a]

Pollutant/Metabolite [b]	Percentage of Results At or Above the MDL in Multimedia and Urine Samples							
	INDOORS		OUTDOORS		PERSONAL			
	Indoor Air	Dust	Outdoor Air	Soil	Dermal Wipe	Solid Food	Liquid Food	Urine
OP Pesticides and Metabolite								
Chlorpyrifos	100	100	83	18	80	63	11	-- [c]
Diazinon	100	96	51	16	51	22	0.68	--
3,5,6-TCP	99	100	88	69	98	99	40	97
OC Pesticides								
Aldrin	41	16	8.6	0.0	3.1	2.6	0.0	--
alpha-Chlordane	99	96	54	31	59	16	5.4	--
gamma-Chlordane	100	97	64	31	61	18	0.0	--
p,p'-DDE	31	41	0.71	15	3.6	58	21	--
p,p'-DDT	34	38	12	20	6.7	3.9	2.0	--
Dieldrin	40	45	14	13	4.9	2.0	0.0	--
Endrin	34	18	41	4.2	2.2	0.65	0.0	--
Heptachlor	93	43	61	4.9	20	14	0.0	--
Lindane	14	15	11	6.3	3.1	7.2	2.0	--
Pentachloronitrobenzene	14	2.8	2.9	0.0	0.45	0.65	1.4	--
Pyrethroid Pesticides								
Cyfluthrin	4.7	47	0.0	11	23	5.9	0.0	--
cis-Permethrin	65	100	18	21	82	42	17	--
trans-Permethrin	64	100	18	21	82	43	16	--
Acid Herbicides								
Dicamba	0.68	21	7.9	5.0	0.44	14	0.0	--
2,4-D	48	67	22	17	7.4	52	2.6	78
2,4,5-T	6.8	0.71	8.6	0.72	0.0	1.1	0.0	--
PAHs								
Benz[*a*]anthracene	48	100	53	73	38	31	1.3	--
Benzo[*b*]fluoranthene	61	100	68	77	31	32	2.0	--
Benzo[*k*]fluoranthene	43	100	51	71	28	16	0.0	--
Benzo[*ghi*]perylene	63	100	64	74	43	1.3	0.0	--
Benzo[*a*]pyrene	50	100	54	74	25	16	0.0	--
Benzo[*e*]pyrene	49	100	56	75	30	24	3.3	--
Chrysene	61	100	69	75	43	33	3.3	--
Dibenz[*a,h*]anthracene	4.7	96	3.6	55	9.4	0.0	0.0	--
Indeno[1,2,3-*cd*]pyrene	51	100	58	71	27	0.66	0.0	--

Table 9.2.4. Percentages of NC Samples With Detectable Pollutant and Metabolite Levels (At or Above the MDL) in Multimedia and Urine Samples [a] (cont.)

Pollutant/Metabolite [b]	Percentage of Results At or Above the MDL in Multimedia and Urine Samples							
	INDOORS		OUTDOORS		PERSONAL			
	Indoor Air	Dust	Outdoor Air	Soil	Dermal Wipe	Solid Food	Liquid Food	Urine
Phthalates								
Benzylbutylphthalate	34	100	6.4	34	57	3.2	4.3	--
Di-*n*-butylphthalate	100	100	39	36	84	32	30	--
Phenols								
Bisphenol-A	65	29	31	2.9	94	88	79	--
Nonylphenol	9.5	4.5	2.1	1.9	1.3	2.6	4.6	--
Pentachlorophenol	97	93	95	32	31	7.8	1.5	75
PCBs								
PCB 44	48	20	24	1.4	1.8	1.3	0.0	--
PCB 52	91	36	65	4.2	6.7	7.2	0.0	--
PCB 70	47	22	18	1.4	1.8	0.0	0.0	--
PCB 77	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
PCB 95	75	38	44	2.8	8.5	2.6	0.0	--
PCB 101	53	38	26	3.5	11	0.0	0.0	--
PCB 105	6.8	5.7	0.71	2.1	0.89	0.0	0.0	--
PCB 110	42	42	19	7.1	12	0.0	0.0	--
PCB 118	24	26	8.6	5.6	8.0	0.0	0.0	--
PCB 138	13	20	2.9	9.9	2.2	0.0	0.0	--
PCB 153	21	30	2.9	9.2	3.6	0.0	0.0	--
PCB 180	4.7	12	0.71	7.7	0.89	0.0	0.0	--
PAH Metabolites Measured in Urine Only								
1-hydroxybenz[*a*]anthracene	--	--	--	--	--	--	--	11
3-hydroxychrysene	--	--	--	--	--	--	--	2.8

[a] The percentages were calculated using results from individual samples. Multiple samples for the same person or room were considered as individual samples. Cells corresponding to pollutants having at least 50% of samples detected in the specified matrix are shaded in gray.

[b] In addition to the pollutants represented in this table, atrazine was measured in drinking water samples. Thirty-eight percent of NC drinking water samples had atrazine levels at or above the MDL.

[c] A dash indicates that the pollutant was not measured in the specified matrix.

Table 9.2.5 Percentages of OH Samples With Detectable Pollutant and Metabolite Levels (At or Above the MDL) in Multimedia and Urine Samples [a]

Pollutant/Metabolite [b]	Percentage of Results At or Above the MDL in Multimedia and Urine Samples							
	INDOORS		OUTDOORS		PERSONAL			
	Indoor Air	Dust	Outdoor Air	Soil	Dermal Wipe	Solid Food	Liquid Food	Urine
OP Pesticides and Metabolites								
Chlorpyrifos	99	100	75	39	61	66	7.1	-- [c]
Diazinon	98	97	74	32	39	17	1.9	--
IMP	95	87	86	40	25	86	33	-- [d]
3,5,6-TCP	100	99	88	80	94	99	36	97
OC Pesticides								
Aldrin	2.7	3.5	1.4	2.1	0.45	0.65	0.65	--
alpha-Chlordane	93	86	56	55	29	7.1	0.0	--
gamma-Chlordane	97	85	59	51	29	5.8	0.0	--
p,p'-DDE	35	48	2.8	42	4.5	73	6.5	--
p,p'-DDT	22	39	2.1	29	3.6	5.2	1.9	--
Dieldrin	12	21	7.0	17	0.45	8.4	0.0	--
Endrin	12	7.0	19	2.8	2.7	1.3	0.0	--
Heptachlor	34	5.6	18	2.1	2.2	7.8	1.3	--
Lindane	4.1	11	3.5	0.70	1.8	3.2	1.3	--
Pentachloronitrobenzene	11	0.70	3.5	0.0	1.3	1.9	0.0	--
Pyrethroid Pesticides and Metabolite								
Cyfluthrin	2.7	74	0.71	18	6.7	2.6	0.65	--
cis-Permethrin	22	100	22	5.6	82	30	0.0	--
trans-Permethrin	19	100	18	5.8	82	30	0.0	--
3-PBA	--	--	--	--	--	--	--	60
Acid Herbicides								
Dicamba	0.69	48	2.9	4.2	2.7	13	0.36	--
2,4-D	44	96	32	39	43	42	5.4	92
2,4,5-T	0.0	2.8	0.74	3.5	0.45	0.0	0.36	–
PAHs								
Benz[*a*]anthracene	38	100	26	92	58	28	0.65	--
Benzo[*b*]fluoranthene	27	100	36	92	78	39	1.9	--
Benzo[*k*]fluoranthene	21	100	25	92	68	16	1.3	--
Benzo[*ghi*]perylene	27	100	23	91	71	3.8	0.0	--
Benzo[*a*]pyrene	18	100	15	91	64	17	0.0	--
Benzo[*e*]pyrene	22	100	26	91	76	19	0.65	--
Chrysene	42	100	50	93	75	36	0.65	--
Dibenz[*a,h*]anthracene	0.68	99	0.0	75	18	1.3	0.0	--
Indeno[1,2,3-*cd*]pyrene	20	100	17	91	67	3.2	0.65	--

Table 9.2.5 Percentages of OH Samples With Detectable Pollutant and Metabolite Levels (At or Above the MDL) in Multimedia and Urine Samples [a] (cont.)

Pollutant/Metabolite [b]	Percentage of Results At or Above the MDL in Multimedia and Urine Samples							
	INDOORS		OUTDOORS		PERSONAL			
	Indoor Air	Dust	Outdoor Air	Soil	Dermal Wipe	Solid Food	Liquid Food	Urine
Phthalates								
Benzylbutylphthalate	33	100	11	37	46	58	6.6	--
Di-*n*-butylphthalate	97	100	49	58	45	25	3.3	--
Phenols								
Bisphenol-A	65	51	35	2.1	98	100	71	--
Nonylphenol	0.68	3.6	0.0	2.4	1.3	1.3	0.0	--
Pentachlorophenol	88	94	60	50	47	22	4.3	92
PCBs								
PCB 44	31	24	15	15	7.6	0.0	--	--
PCB 52	88	50	66	20	19	5.8	--	--
PCB 70	36	25	14	19	14	0.0	--	--
PCB 77	0.0	0.0	0.0	0.70	0.0	0.0	--	--
PCB 95	63	42	36	23	7.6	0.65	--	--
PCB 101	55	45	25	25	11	0.65	--	--
PCB 105	5.4	14	2.8	20	2.7	0.0	--	--
PCB 110	44	48	21	31	12	0.65	--	--
PCB 118	23	41	8.5	30	8.5	1.3	--	--
PCB 138	9.5	28	2.8	31	1.3	0.65	--	--
PCB 153	17	41	1.4	34	2.7	1.3	--	--
PCB 180	2.7	16	0.0	22	0.45	0.0	--	--
PAH Metabolites Measured in Urine Only								
1-hydroxybenz[*a*]anthracene	--	--	--	--	--	--	--	12
3-hydroxybenz[*a*]anthracene	--	--	--	--	--	--	--	1.1
3-hydroxybenz[*a*]pyrene	--	--	--	--	--	--	--	0.0
3-hydroxychrysene	--	--	--	--	--	--	--	0.67
6-hydroxychrysene	--	--	--	--	--	--	--	0.90
6-hydroxyindeno[1,2,3-*cd*]pyrene	--	--	--	--	--	--	--	0.0
1-hydroxypyrene	--	--	--	--	--	--	--	62

[a] The percentages were calculated using results from individual samples. Multiple samples for the same person or room were considered as individual samples. Cells corresponding to pollutants having at least 50% of samples detected in the specified matrix are shaded in gray.

[b] In addition to the pollutants represented in this table, atrazine was measured in drinking water samples. Fifty-nine percent of OH drinking water samples had atrazine levels at or above the MDL.

[c] A dash indicates that the pollutant was not measured in the specified matrix.

[d] Low recovery (<10%) of IMP was observed in matrix spikes, and therefore, IMP was not quantifiable in urine samples.

Table 9.2.6 Percentages of NC and OH Samples With Detectable Pollutant and Metabolite Levels (At or Above the MDL) in Surface Samples [a]

Pollutant/Metabolite	Percentage of Results At or Above the MDL in Samples Collected From Homes After Recent Pesticide Applications					
	North Carolina			Ohio		
	Hard Floor Surface Wipe	Food Prep. Surface Wipe	Trans. Residue (PUF)	Hard Floor Surface Wipe	Food Prep. Surface Wipe	Trans. Residue (PUF)
OP Pesticides and Metabolites						
Chlorpyrifos	91	89	94	73	62	85
Diazinon	69	61	67	31	31	54
IMP	--[b]	--	--	33	0.0	0.0
3,5,6-TCP	100	--	--	92	67	33
OC Pesticides						
Aldrin	13	5.6	11	3.8	0.0	0.0
alpha-Chlordane	59	56	44	23	15	23
gamma-Chlordane	66	56	44	23	15	23
p,p'-DDE	16	11	28	12	0.0	0.0
p,p'-DDT	19	17	28	19	7.7	0.0
Dieldrin	25	17	22	3.8	0.0	23
Endrin	13	28	11	0.0	0.0	7.7
Heptachlor	38	33	28	3.8	0.0	0.0
Lindane	9.4	0.0	28	0.0	0.0	0.0
Pentachloronitrobenzene	0.0	0.0	0.0	0.0	0.0	0.0
Pyrethroid Pesticides						
Cyfluthrin	6.3	0.0	78	7.7	0.0	0.0
cis-Permethrin	94	83	83	69	38	69
trans-Permethrin	94	83	83	69	38	69
Acid Herbicides						
Dicamba	0.0	--	--	0.0	0.0	0.0
2,4-D	7.1	--	--	42	0.0	33
2,4,5-T	0.0	--	--	0.0	0.0	0.0
PAHs						
Benz[*a*]anthracene	78	33	94	96	31	62
Benzo[*b*]fluoranthene	78	33	67	96	46	92
Benzo[*k*]fluoranthene	75	28	67	92	38	85
Benzo[*ghi*]perylene	88	17	67	92	31	85
Benzo[*a*]pyrene	81	17	61	88	31	85
Benzo[*e*]pyrene	88	17	67	96	38	92
Chrysene	88	50	83	96	46	85
Dibenz[*a,h*]anthracene	34	5.6	22	62	7.7	15
Indeno[1,2,3-*cd*]pyrene	84	22	67	96	31	69

Table 9.2.6 Percentages of NC and OH Samples With Detectable Pollutant and Metabolite Levels (At or Above the MDL) in Surface Samples [a] (cont.)

Pollutant/Metabolite	Percentage of Results At or Above the MDL in Samples Collected From Homes After Recent Pesticide Applications					
	North Carolina			Ohio		
	Hard Floor Surface Wipe	Food Prep. Surface Wipe	Trans. Residue (PUF)	Hard Floor Surface Wipe	Food Prep. Surface Wipe	Trans. Residue (PUF)
Phthalates						
Benzylbutylphthalate	97	56	100	77	54	100
Di-*n*-butylphthalate	100	72	100	65	85	100
Phenols						
Bisphenol-A	81	89	100	96	85	71
Nonylphenol	0.0	0.0	6.3	0.0	0.0	8.3
Pentachlorophenol	43	--	--	33	0.0	33
PCBs						
PCB 44	9.4	22	11	12	7.7	15
PCB 52	22	22	6.3	38	7.7	50
PCB 70	13	17	17	50	15	23
PCB 77	0.0	0.0	0.0	0.0	0.0	0.0
PCB 95	13	22	13	3.8	0.0	31
PCB 101	6.3	17	20	7.7	0.0	46
PCB 105	0.0	0.0	22	12	0.0	7.7
PCB 110	19	28	10	38	0.0	46
PCB 118	9.4	17	33	15	0.0	23
PCB 138	3.1	0.0	0.0	0.0	0.0	7.7
PCB 153	3.1	11	17	3.8	0.0	23
PCB 180	3.1	0.0	5.6	0.0	0.0	0.0

[a] The percentages were calculated using results from individual samples. Multiple samples for the same person or room were considered as individual samples. Cells corresponding to pollutants having at least 50% of samples detected in the specified matrix are shaded in gray.
[b] A dash indicates that the pollutant was not measured in the specified matrix.

documenting the percentages of samples with concentrations at or above the MQL are presented by media type in Appendix H for NC and OH. These percentages take into account all samples collected in the study within the given state for which a valid measurement for the pollutant was available.

For NC, pollutants and metabolites that were most commonly detected in the sampled environmental and personal media were the following:

- The OP pesticides, chlorpyrifos and diazinon, were frequently detected in indoor air (100%), floor dust (\$96%), transferable residue (\$67%), surface wipe (\$61%), outdoor air (\$51%), and dermal wipe (\$51%) samples. The metabolite of chlorpyrifos, 3,5,6-

TCP, had high detection rates in floor dust and hard floor surface wipes (100%), indoor air and solid food (99%), dermal wipe (98%), urine (97%), outdoor air (88%), and soil (69%) samples.

- Two OC pesticides, *alpha*- and *gamma*-chlordane, were both frequently detected in indoor air (\$99%), floor dust (\$96%), dermal wipe (\$59%), surface wipe (\$56%), and outdoor air (\$54%) samples.

- Two pyrethroid pesticides, *cis*- and *trans*-permethrin, were both frequently detected in floor dust (100%), surface wipe (\$83%), transferable residue (83%), dermal wipe (82%), and indoor air (\$64%) samples.

- The acid herbicide, 2,4-D, had the highest detection percentages in urine (78%), floor dust (67%), and solid food (52%) samples.

- All nine PAHs were frequently detected above 50% in dust, soil, and floor surface wipe samples, except for dibenz[*a,h*]anthracene in floor surface wipes (34%). These PAHs were frequently detected above 50% in outdoor air and transferable residue samples, except for dibenz[*a,h*]anthracene. Five of these PAHs (benzo[*b*]fluoranthene, benzo[*ghi*]perylene, benzo[*a*]pyrene, chrysene, and indeno[1,2,3-*cd*]pyrene) were detected in at least 50% of indoor air samples, while two other PAHs (benzo[a]anthracene and benzo[e]pyrene) were detected in slightly below 50% of the indoor air samples.

- The two phthalates, benzylbutylphthalate and di-*n*-butylphthalate, were frequently detected in floor dust (100%), transferable residue (100%), floor surface wipe (\$97%), dermal wipe (\$57%), and food preparation surface wipe (\$56%) samples. In addition, di-*n*-butylphthalate was detected in 100% of indoor air samples.

- Among the phenols, bisphenol-A was detected most frequently in transferable residue (100%), dermal wipe (94%), solid food (88%), surface wipe (\$81%), and liquid food (79%) samples. Pentachlorophenol was detected most frequently in indoor air (97%), outdoor air (95%), floor dust (93%), and urine (75%) samples.

For OH, pollutants and metabolites that were most commonly detected in the environmental and personal media were the following:

- The OP pesticides, chlorpyrifos and diazinon, were both frequently detected in indoor air (\$98%), floor dust (\$97%), and outdoor air (\$74%) samples. The two OP metabolites, IMP and 3,5,6-TCP, were also frequently detected in indoor air (\$95%), floor dust (\$87%), and outdoor air (\$86%) samples. In addition, 3,5,6-TCP was detected frequently in solid food (99%), urine (97%), dermal wipe (94%), floor surface wipe (92%), and soil (80%) samples.

- Two OC pesticides, *alpha*- and *gamma*-chlordane, were both frequently detected in indoor air ($93%) and floor dust ($85%) samples, while detection percentages for outdoor air ($56%) and soil ($51%) samples were somewhat lower but still above 50%.

- Two pyrethroid pesticides, *cis*- and *trans*-permethrin, were both frequently detected in floor dust (100%), dermal wipe (82%), hard floor surface wipe (69%), and transferable residue (69%) samples. Cyfluthrin was detected in 74% of the floor dust samples. A urinary metabolite of *cis*- and *trans*-permethrin, 3-PBA, was found in 60% of urine samples.

- The acid herbicide, 2,4-D, was frequently detected in floor dust (96%) and urine (92%) samples.

- The PAHs were frequently detected in floor dust ($99%), soil ($75%), floor surface wipe ($62%), transferable residue ($62% for all but dibenz[*a,h*]anthracene), and dermal wipe ($58% for all but dibenz[*a,h*]anthracene) samples.

- The two phthalates, benzylbutylphthalate and di-*n*-butylphthalate, were both detected most frequently in floor dust (100%), transferable residues (100%), and floor surface wipes ($65%). In addition, di-*n*-butylphthalate was detected in 97% of indoor air samples and 85% of food preparation surface wipe samples.

- Among the phenols, bisphenol-A was detected most frequently in solid food (100%), dermal wipe (98%), surface wipe ($85%), liquid food (71%), and transferable residue (71%) samples. Pentachlorophenol was detected most frequently in floor dust (94%), urine (92%), and indoor air (88%) samples.

For each state, the detection percentages in Tables 9.2.4 through 9.2.6 were used to classify the pollutants and metabolites measured in multimedia samples into the following three groups:

- Frequently Detected - pollutants detected in 50% or more of samples in 4 or more different media types.
- Sometimes Detected - pollutants detected in 50% or more of samples in 1, 2, or 3 media types.
- Rarely Detected: pollutants detected in less than 50% of the samples in all media types.

Results of this classification for each state are presented in Table 9.2.7.

Table 9.2.7 Pollutants Were Classified Into Three Groups, By State, Based On Their Level of Detection in the Multimedia Samples

North Carolina	Ohio
Frequently Detected	
OP pesticides/metabolites Chlorpyrifos, Diazinon, 3,5,6-TCP	OP pesticides/metabolites Chlorpyrifos, Diazinon, IMP, 3,5,6-TCP
OC pesticides *alpha*-Chlordane, *gamma*-Chlordane	OC pesticides *alpha*-Chlordane, *gamma*-Chlordane
Pyrethroid pesticides *cis*-Permethrin, *trans*-Permethrin	Pyrethroid pesticides *cis*-Permethrin, *trans*-Permethrin
PAHs Benz[*a*]anthracene, Benzo[*b*]fluoranthene, Benzo[*k*]fluoranthene, Benzo[*ghi*]perylene, Benzo[*a*]pyrene, Benzo[*e*]pyrene, Chrysene, Indeno[1,2,3-*cd*]pyrene,	PAHs Benz[*a*]anthracene, Benzo[*b*]fluoranthene, Benzo[*k*]fluoranthene, Benzo[*ghi*]perylene, Benzo[*a*]pyrene, Benzo[*e*]pyrene, Chrysene, Indeno[1,2,3-*cd*]pyrene
Phthalates Benzylbutylphthalate, Di-*n*-butylphthalate	Phthalates Benzylbutylphthalate, Di-*n*-butylphthalate
Phenols Bisphenol-A, Pentachlorophenol	Phenols Bisphenol-A, Pentachlorophenol
PCBs None	PCBs Congener 52
Sometimes Detected	
OC pesticides *p,p'*-DDE, Heptachlor	OC pesticides *p,p'*-DDE
Pyrethroid pesticides Cyfluthrin	Pyrethroid pesticides Cyfluthrin
Acid Herbicides 2,4-D	Acid Herbicides 2,4-D
PAHs Dibenzo[*a,h*]anthracene	PAHs Dibenz[*a,h*]anthracene
PCBs Congeners 52, 95, 101	PCBs Congeners 70, 95, 101

Table 9.2.7 Pollutants Were Classified Into Three Groups, By State, Based On Their Level of Detection in the Multimedia Samples (cont.)

North Carolina	Ohio
Rarely Detected	
OC Pesticides Aldrin, *p,p'*-DDT, Dieldrin, Endrin, Lindane, Pentachloronitrobenzene	OC Pesticides Aldrin, *p,p'*-DDT, Dieldrin, Endrin, Heptachlor, Lindane, Pentachloronitrobenzene
Acid Herbicides Dicamba, 2,4,5-T	Acid Herbicides Dicamba, 2,4,5-T
Phenols Nonylphenol	Phenols Nonylphenol
PCBs Congeners 44, 70, 77, 105, 110, 118, 138, 153, 180	PCBs Congeners 44, 77, 105, 110, 118, 138, 153, 180

The pollutants and metabolites that are classified as "frequently" or "sometimes" detected in Table 9.2.7 were among those considered for calculating potential exposure level and potential absorbed dose of these pollutants in the study participants. Although IMP was classified as "frequently" detected in OH multimedia samples, it was not measured in NC multimedia samples.

For the study participants, aggregate exposure level and aggregate potential absorbed dose were calculated for bisphenol-A (BPA), chlorpyrifos (CPS)**,** diazinon (DZN), di-*n*-butylphthalate (DBP), 2,4-D, *cis*- and *trans*- permethrin (*cis- and trans*-P), and the metabolite 3,5,6-TCP (TCP). These eight pollutants/metabolites were detected in a majority of samples across multiple media, including urine, and some were commonly found in consumer products used by the participating households and day care centers.

9.3 Goal 1: To Measure the Environmental Concentrations of Pesticides and Other Persistent and Non-Persistent Organic Pollutants in Multimedia (Environmental and Personal Samples) at Participating Homes and Day Care Centers.

Goal 1 focused on quantifying the concentration of each pollutant by medium and determining whether these concentrations differed significantly between microenvironments (i.e., urbanicity, income level, home versus day care environments).

9.3.1 Sub-goal 1.1: To Quantify the Distribution of Target Pollutants in Multimedia at Participating Home and Day Care Centers

Descriptive statistics for pollutant and metabolite concentrations in multimedia samples are given in Appendix I for NC and Appendix J for OH. These appendices display the descriptive statistics (number of samples, percentage of samples with detected results, arithmetic mean, standard deviation, geometric mean, log standard deviation, selected percentiles [25^{th}, 50^{th}, 75^{th}, and 95^{th}], and range) within two tables for each measured pollutant. For a given sample type, descriptive statistics are presented separately for samples collected at the homes of study participants and for samples collected at participating day care centers. In addition, for the home environment, descriptive statistics are presented separately for the homes of day care children and the homes of stay-at-home children. In these tables, the arithmetic and geometric means, as well as the standard deviations for both untransformed and log-transformed measurements, are specified only when more than 50% of the data entering into their calculation exceeded the MDL. In addition, percentiles of the observed data distribution are reported when the data values at the percentile exceeded the MDL, otherwise "<MDL" is displayed.

Overall median levels of the 27 target pollutants in NC multimedia samples are presented by sample type in Table 9.3.1 and Table 9.3.2 for home and day care center environments, respectively. Similarly, Table 9.3.3 and Table 9.3.4 contain median levels of the 26 target pollutants in OH multimedia samples for home and day care center environments, respectively. The pollutants are grouped by pollutant class, and medians are presented only when a pollutant achieved greater than a 50% detection rate in the given medium.

For the eight pollutants for which estimated aggregate potential exposures and potential absorbed doses were calculated, the distributions of valid measurements are presented as boxplots in Figures 9.3.1 through 9.3.5. The sample types and measurements represented within each figure are as follows:

- Figure 9.3.1: concentrations in indoor and outdoor air samples (both NC and OH), expressed in units of ng/m^3.
- Figure 9.3.2: concentrations in floor dust and soil samples (both NC and OH), expressed in units of ng/g.
- Figure 9.3.3 (NC) and Figure 9.3.4 (OH): loadings in floor dust samples, hard floor surface wipes, food preparation surface wipes, transferable residues, and dermal wipes (children and adults), expressed in units of ng/m^2.
- Figure 9.3.5: concentrations in solid food samples (children and adults, for both NC and OH), expressed in units of ng/g. Adult solid food sample data were available only for 2,4-D and 3,5,6-TCP.

Table 9.3.1 Median Levels of 27 Target Pollutants in NC Multimedia Samples Collected from Home Environments[a]

Pollutant/Metabolite	Median Values											
	INDOORS						OUTDOORS		PERSONAL			
	Indoor Air (ng/m^3)	Dust (ng/g)	Dust (ng/m^2)	Hard Floor Wipe (ng/m^2)	Food Prep. Wipe (ng/m^2)	Trans. Residue (PUF) (ng/m^2)	Outdoor Air (ng/m^3)	Soil (ng/g)	Dermal Wipe (ng/m^2)	Solid Food (ng/g)	Liquid Food (ng/mL)	Urine (ng/mL)
OP Pesticides and Metabolite												
Chlorpyrifos	6.2	140	94	68	69	35	0.27	<[b]	200	0.19	<	–[c]
Diazinon	2.0	18	16	11	16	33	0.090	<	<	<	<	--
3,5,6-TCP	1.9	96	83	50	--	--	0.23	0.57	190	2.3	<	4.5
OC Pesticides												
alpha-Chlordane	0.88	22	26	9.4	11	<	0.080	<	39	<	<	--
gamma-Chlordane	1.5	31	35	11	14	<	0.12	<	57	<	<	--
p,p'-DDE	<	<	<	<	<	<	<	<	<	0.16	<	--
Heptachlor	6.8	<	<	<	<	<	0.29	<	<	<	<	--
Pyrethroid Pesticides												
Cyfluthrin	<	<	<	<	<	1,000	<	<	<	<	<	--
cis-Permethrin	0.58	800	1,000	460	600	230	<	<	620	<	<	--
trans-Permethrin	0.36	630	850	360	260	210	<	<	490	<	<	--
Acid Herbicides												
2,4-D	<	32	36	<	--	--	<	<	<	0.35	<	0.43
PAHs												
Benz[*a*]anthracene	<	120	140	15	<	110	0.090	1.4	<	<	<	--
Benzo[*b*]fluoranthene	0.13	300	400	47	<	23	0.19	3.0	<	<	<	--
Benzo[*k*]fluoranthene	<	110	120	13	<	11	0.090	1	<	<	<	--
Benzo[*ghi*]perylene	0.13	180	210	19	<	16	0.14	1.3	<	<	<	--
Benzo[*a*]pyrene	0.080	180	210	20	<	9.5	0.090	1.9	<	<	<	--
Benzo[*e*]pyrene	<	180	190	18	<	15	0.11	1.5	<	<	<	--
Chrysene	0.10	170	190	23	<	18	0.12	1.7	<	<	<	--
Dibenz[*a,h*]anthracene	<	40	46	<	<	<	<	0.61	<	<	<	--
Indeno[1,2,3-*cd*]pyrene	0.090	160	200	17	<	8.8	0.10	1.2	<	<	<	--
Phthalates												
Benzylbutylphthalate	<	17,000	19,000	27,000	2,100	28,000	<	<	12,000	<	<	--
Di-*n*-butylphthalate	230	5,600	5,400	5,000	3,400	5,100	<	<	10,000	<	<	--
Phenols												
Bisphenol-A	1.8	<	<	250	260	410	<	<	6,900	4.3	0.45	--
Pentachlorophenol	1.5	60	73	<	--	--	0.91	<	<	<	<	0.36
PCBs												
PCB 52	0.53	<	<	<	<	<	0.090	<	<	<	<	--
PCB 95	0.090	<	<	<	<	<	<	<	<	<	<	--
PCB 101	0.060	<	<	<	<	<	<	<	<	<	<	--

[a] For urine, the median was based on data for NC children who were classified as "stay-at-home" children.
[b] "<" indicates that the median value falls below the MDL for the pollutant within the specified sample medium.
[c] Dashes indicate that no data were available for the pollutant within the specified sample medium.

Table 9.3.2 Median Levels of 27 Target Pollutants in NC Multimedia Samples Collected from Day Care Center Environments[a]

Pollutant/Metabolite	Median Values											
	INDOORS						OUTDOORS		PERSONAL			
	Indoor Air (ng/m^3)	Dust (ng/g)	Dust (ng/m^2)	Hard Floor Wipe (ng/m^2)	Food Prep. Wipe (ng/m^2)	Trans. Residue (PUF) (ng/m^2)	Outdoor Air (ng/m^3)	Soil (ng/g)	Dermal Wipe (ng/m^2)	Solid Food (ng/g)	Liquid Food (ng/mL)	Urine (ng/mL)
OP Pesticides and Metabolite												
Chlorpyrifos	3.0	140	570	130	–[c]	--	0.34	<[b]	170	0.10	<	--
Diazinon	2.3	65	180	33	--	--	0.12	<	65	<	<	--
3,5,6-TCP	0.93	66	200	53	--	--	0.13	<	100	2.9	0.10	5.1
OC Pesticides												
alpha-Chlordane	0.51	43	190	<	--	--	0.15	<	48	<	<	--
gamma-Chlordane	0.78	67	270	9.9	--	--	0.28	<	64	<	<	--
p,p'-DDE	<	<	<	<	--	--	<	<	<	0.16	<	--
Heptachlor	5.4	19	89	<	--	--	0.54	<	<	<	<	--
Pyrethroid Pesticides												
Cyfluthrin	<	<	<	<	--	--	<	<	<	<	<	--
cis-Permethrin	0.11	810	6,900	940	--	--	<	<	730	<	<	--
trans-Permethrin	<	860	4,100	730	--	--	<	<	360	<	<	--
Acid Herbicides												
2,4-D	0.33	23	56	<	--	--	<	<	<	<	<	0.66
PAHs												
Benz[*a*]anthracene	<	200	980	7.2	--	--	0.060	3.6	<	<	<	--
Benzo[*b*]fluoranthene	0.11	500	2,300	35	--	--	0.11	9.4	<	<	<	--
Benzo[*k*]fluoranthene	<	180	770	8.1	--	--	<	3.7	<	<	<	--
Benzo[*ghi*]perylene	0.10	280	1,200	12	--	--	0.10	4.8	60	<	<	--
Benzo[*a*]pyrene	<	270	1,300	7.9	--	--	0.070	5.9	<	<	<	--
Benzo[*e*]pyrene	<	280	1,200	15	--	--	0.070	5.0	<	<	<	--
Chrysene	0.090	220	1,100	53	--	--	0.090	5.3	<	<	<	--
Dibenz[*a,h*]anthracene	<	64	290	<	--	--	<	1.5	<	<	<	--
Indeno[1,2,3-*cd*]pyrene	<	230	1,100	12	--	--	0.064	4.4	<	<	<	--
Phthalates												
Benzylbutylphthalate	<	58,000	140,000	160,000	--	--	<	<	<	<	<	--
Di-*n*-butylphthalate	380	14,000	66,000	18,000	--	--	15	13	12,000	<	<	--
Phenols												
Bisphenol-A	<	31	120	<	--	--	<	<	28,000	3.6	0.79	--
Pentachlorophenol	1.2	81	430	<	--	--	0.77	<	<	<	<	0.43
PCBs												
PCB 52	0.50	8.2	47	<	--	--	0.080	<	<	<	<	--
PCB 95	0.11	<	<	<	--	--	0.050	<	<	<	<	--
PCB 101	0.080	4.3	16	<	--	--	0.050	<	<	<	<	--

[a] For urine, the median was based on data for NC children who were classified as "day care" children.
[b] "<" indicates that the median value falls below the MDL for the pollutant within the specified sample medium.
[c] Dashes indicate that no data were available for the pollutant within the specified sample medium.

Table 9.3.3 Median Levels of 26 Target Pollutants in OH Multimedia Samples Collected from Home Environments[a]

Pollutant/Metabolite	Median Values											
	INDOORS						OUTDOORS		PERSONAL			
	Indoor Air (ng/m^3)	Dust (ng/g)	Dust (ng/m^2)	Hard Floor Wipe (ng/m^2)	Food Prep. Wipe (ng/m^2)	Trans. Residue (PUF) (ng/m^2)	Outdoor Air (ng/m^3)	Soil (ng/g)	Dermal Wipe (ng/m^2)	Solid Food (ng/g)	Liquid Food (ng/mL)	Urine (ng/mL)
OP Pesticides and Metabolite												
Chlorpyrifos	1.7	52	64	24	12	20	0.20	<[b]	110	0.19	<	–[c]
Diazinon	0.97	20	22	<	<	7.3	0.17	<	<	<	<	--
3,5,6-TCP	0.63	41	38	9.0	7.6	<	0.23	0.70	120	1.9	<	5.3
OC Pesticides												
alpha-Chlordane	0.26	11	11	<	<	<	0.10	0.76	<	<	<	--
gamma-Chlordane	0.36	12	12	<	<	<	0.11	0.62	<	<	<	--
p,p'-DDE	<	<	<	<	<	<	<	<	<	0.19	<	--
Pyrethroid Pesticides												
Cyfluthrin	<	200	180	<	<	<	<	<	<	<	<	--
cis-Permethrin	<	470	450	89	<	37	<	<	330	<	<	--
trans-Permethrin	<	340	300	94	<	31	<	<	270	<	<	--
Acid Herbicides												
2,4-D	<	120	120	18	<	<	<	<	<	<	<	1.2
PAHs												
Benz[*a*]anthracene	<	570	620	23	<	8.4	<	15	43	<	<	--
Benzo[b]fluoranthene	<	1,500	1,800	54	<	25	<	33	120	<	<	--
Benzo[*k*]fluoranthene	<	520	590	22	<	9.3	<	12	64	<	<	--
Benzo[*ghi*]perylene	<	770	920	28	<	19	<	16	93	<	<	--
Benzo[*a*]pyrene	<	720	900	32	<	15	<	18	72	<	<	--
Benzo[*e*]pyrene	<	830	920	35	<	17	<	16	100	<	<	--
Chrysene	<	780	910	43	<	16	<	19	89	<	<	--
Dibenz[*a,h*]anthracene	<	170	190	8.1	<	<	<	4.2	<	<	<	--
Indeno[1,2,3-*cd*]pyrene	<	780	950	31	<	13	<	15	80	<	<	--
Phthalates												
Benzylbutylphthalate	<	17,000	16,000	4,800	2,000	5,400	<	<	<	11	<	--
Di-*n*-butylphthalate	250	5,200	5,700	6,800	5,500	7,500	<	46	<	<	<	--
Phenols												
Bisphenol-A	0.98	<	<	680	500	260	<	<	5,600	3.6	0.47	--
Pentachlorophenol	2.1	60	75	<	<	<	0.43	0.73	<	<	<	1.0
PCBs												
PCB 52	0.42	<	<	<	<	<	0.11	<	<	<	--	--
PCB 95	0.11	<	<	<	<	<	<	<	<	<	--	--
PCB 101	0.090	<	<	<	<	<	<	<	<	<	--	--

[a] For urine, the median was based on data for OH children who were classified as "stay-at-home" children.
[b] "<" indicates that the median value falls below the MDL for the pollutant within the specified sample medium.
[c] Dashes indicate that no data were available for the pollutant within the specified sample medium.

Table 9.3.4 Median Levels of 26 Target Pollutants in OH Multimedia Samples Collected from Day Care Center Environments[a]

Pollutant/Metabolite	Median Values											
	INDOORS						OUTDOORS		PERSONAL			
	Indoor Air (ng/m^3)	Dust (ng/g)	Dust (ng/m^2)	Hard Floor Wipe (ng/m^2)	Food Prep. Wipe (ng/m^2)	Trans. Residue (PUF) (ng/m^2)	Outdoor Air (ng/m^3)	Soil (ng/g)	Dermal Wipe (ng/m^2)	Solid Food (ng/g)	Liquid Food (ng/mL)	Urine (ng/mL)
OP Pesticides and Metabolite												
Chlorpyrifos	2.0	170	450	<[b]	–[c]	--	0.11	<	98	0.14	<	--
Diazinon	0.96	40	220	<	--	--	0.080	<	<	<	<	--
3,5,6-TCP	0.71	58	170	8.8	--	--	0.17	0.63	110	1.5	0.11	4.3
OC Pesticides												
alpha-Chlordane	0.18	11	41	<	--	--	0.064	<	<	<	<	--
gamma-Chlordane	0.26	13	53	<	--	--	0.070	<	<	<	<	--
p,p'-DDE	<	<	<	<	--	--	<	<	<	0.11	<	--
Pyrethroid Pesticides												
Cyfluthrin	<	340	1,400	<	--	--	<	<	<	<	<	--
cis-Permethrin	<	1,000	2,700	59	--	--	<	<	350	<	<	--
trans-Permethrin	<	550	2,600	45	--	--	<	<	280	<	<	--
Acid Herbicides												
2,4-D	<	140	640	<	--	--	<	<	<	<	<	0.87
PAHs												
Benz[*a*]anthracene	<	1,800	6,200	7.9	--	--	<	20	41	<	<	--
Benzo[b]fluoranthene	<	4,200	13,000	83	--	--	<	35	100	<	<	--
Benzo[*k*]fluoranthene	<	1,500	4,500	17	--	--	<	15	49	<	<	--
Benzo[*ghi*]perylene	<	2,300	7,100	15	--	--	<	19	78	<	<	--
Benzo[*a*]pyrene	<	2,100	7,800	15	--	--	<	20	65	<	<	--
Benzo[*e*]pyrene	<	2,200	7,000	34	--	--	<	19	67	<	<	--
Chrysene	0.072	2,400	7,800	120	--	--	0.090	20	91	<	<	--
Dibenz[*a,h*]anthracene	<	470	1,500	<	--	--	<	4.8	<	<	<	--
Indeno[1,2,3-*cd*]pyrene	<	2,200	7,300	15	--	--	<	20	70	<	<	--
Phthalates												
Benzylbutylphthalate	<	29,000	94,000	210,000	--	--	<	<	<	9.0	<	--
Di-*n*-butylphthalate	320	15,000	53,000	99,000	--	--	21	<	14,000	<	<	--
Phenols												
Bisphenol-A	0.92	28	160	410	--	--	<	<	3,000	3.5	0.51	--
Pentachlorophenol	1.3	36	00	<	--	--	0.22	<	<	<	<	0.81
PCBs												
PCB 52	0.49	7.2	26	<	--	--	0.10	<	<	<	--	--
PCB 95	0.10	6.0	16	<	--	--	<	<	<	<	--	--
PCB 101	0.10	6.1	16	<	--	--	<	<	<	<	--	--

[a] For urine, the median was based on data for OH children who were classified as "day care" children.
[b] "<" indicates that the median value falls below the MDL for the pollutant within the specified sample medium.
[c] Dashes indicate that no data were available for the pollutant within the specified sample medium.

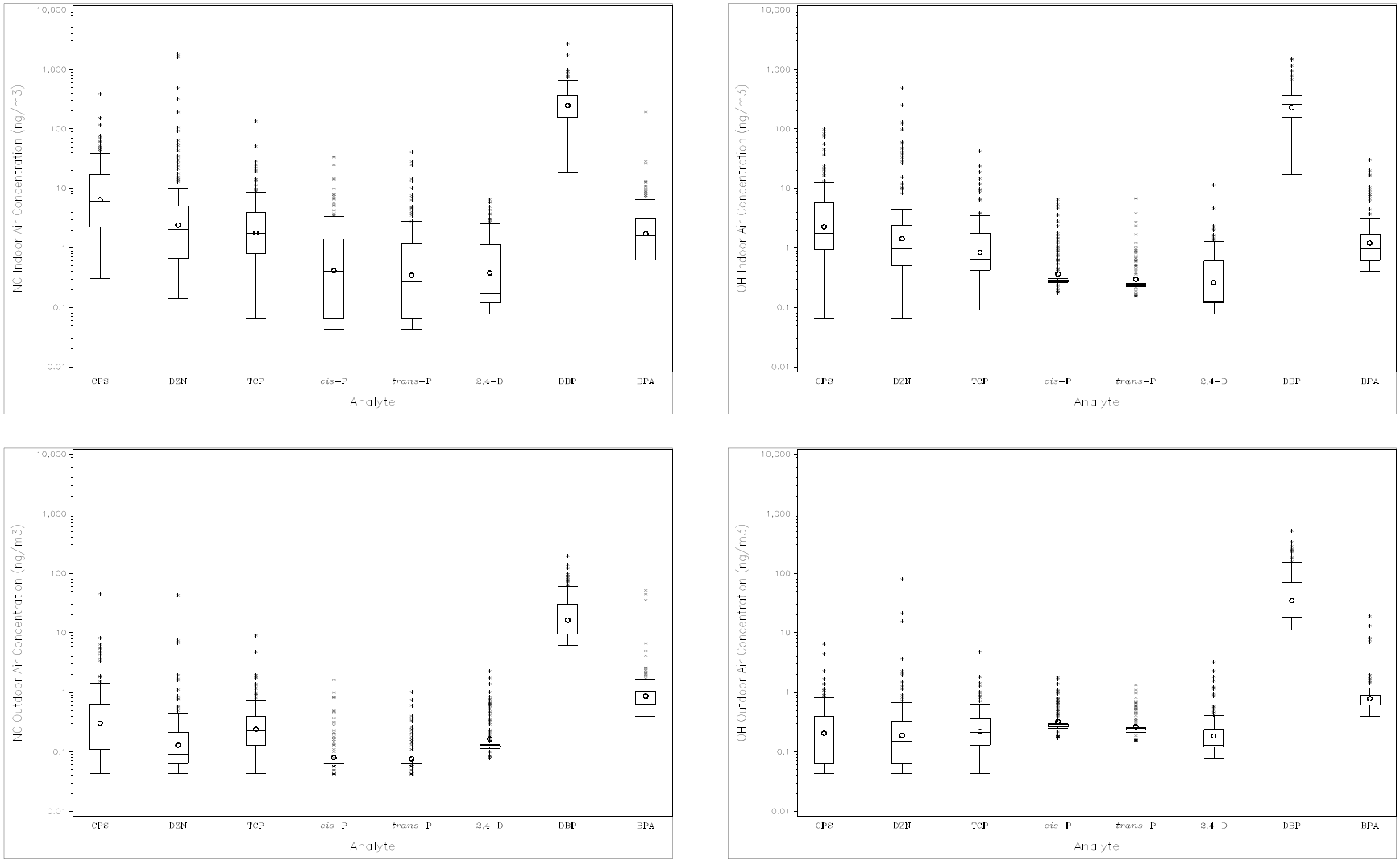


Figure 9.3.1 Boxplots of Pollutant Concentrations in <u>Indoor Air and Outdoor Air</u> <u>Samples</u> Collected at the Homes and Day Care Centers of Participating NC and OH Children, for Eight Pollutants

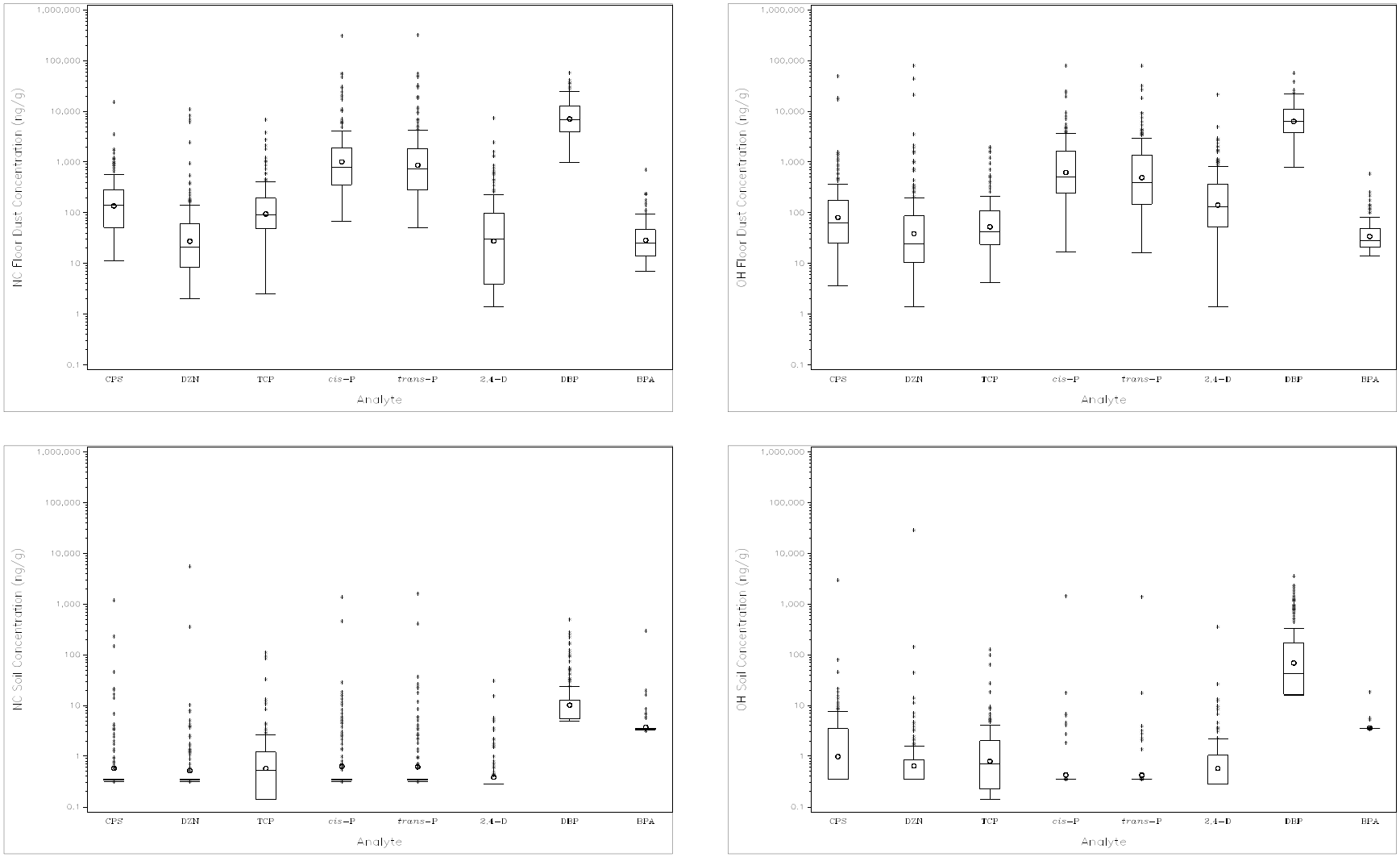


Figure 9.3.2 Boxplots of Pollutant Concentrations in <u>Dust and Soil Samples</u> Collected at the Homes and Day Care Centers of Participating NC and OH Children, for Eight Pollutants

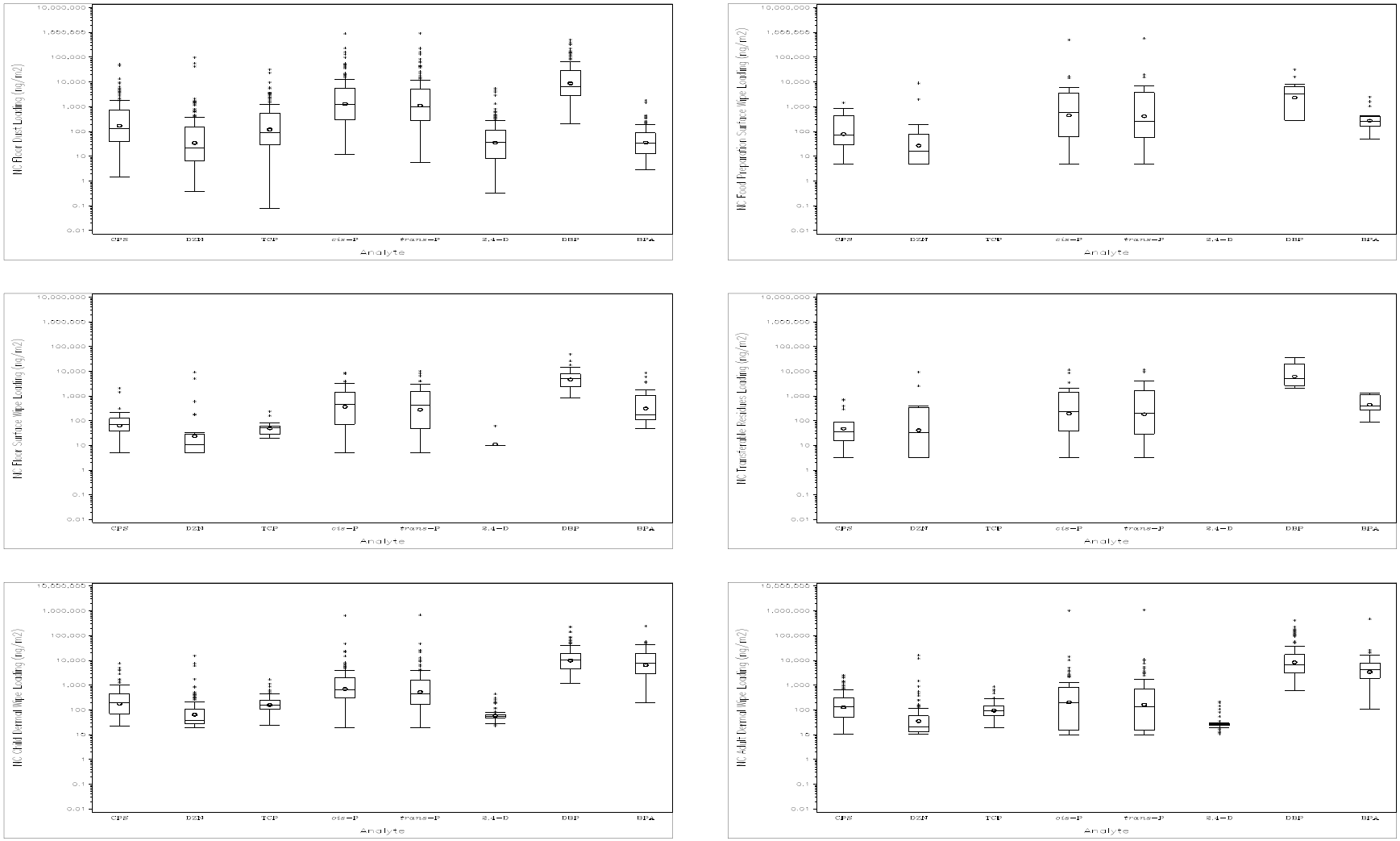


Figure 9.3.3 Boxplots of Pollutant Loadings in <u>Dust, Hard Floor Surface Wipe, Food Preparation Surface Wipe, Transferable Residues, and Children and Adult Dermal Wipe Samples</u> Collected at the Homes and Day Care Centers of Participating NC Children, for Eight Pollutants

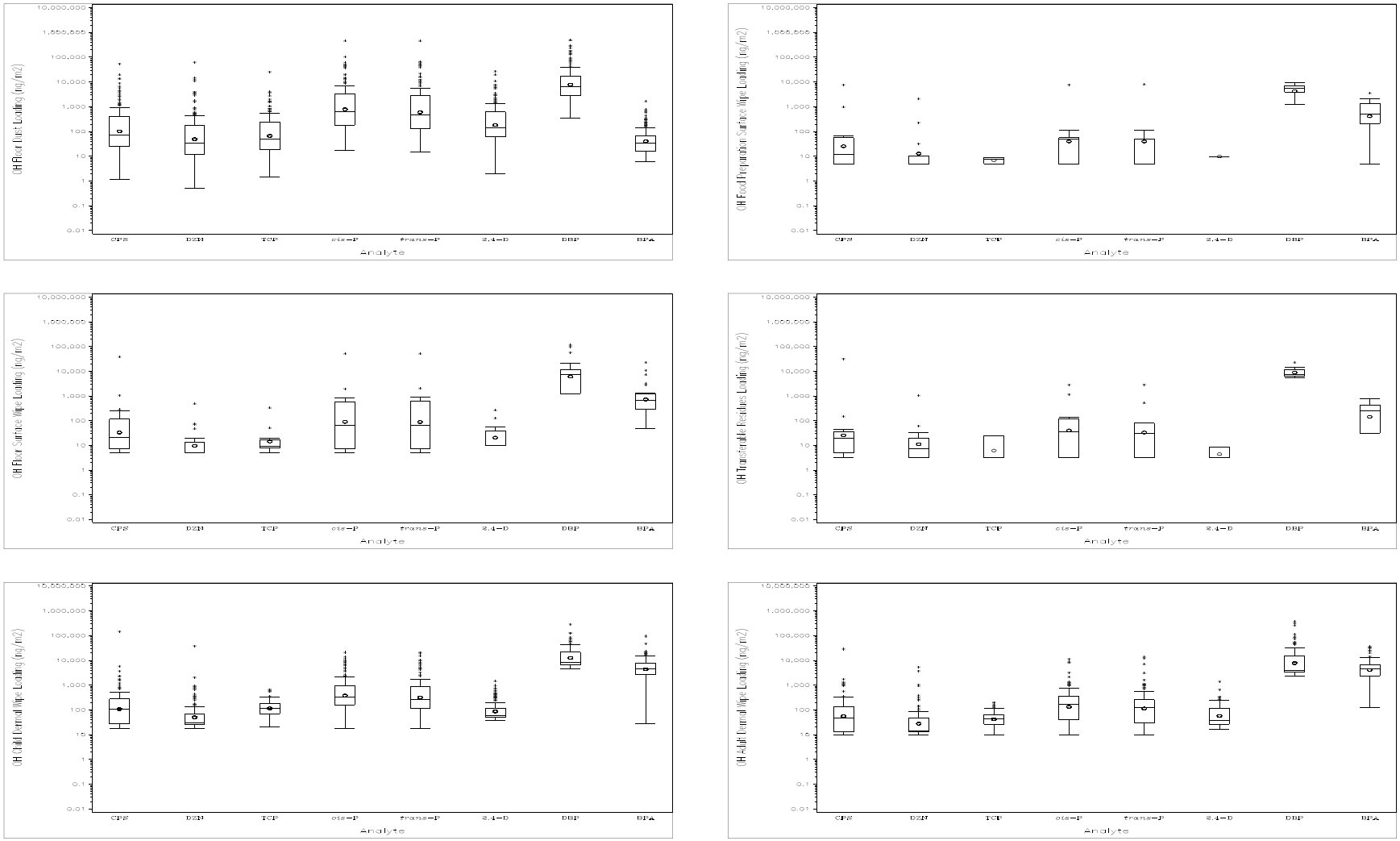


Figure 9.3.4 Boxplots of Pollutant Loadings in <u>Dust, Hard Floor Surface Wipe, Food Preparation Surface Wipe, Transferable Residues, and Children and Adult Dermal Wipe Samples</u> Collected at the Homes and Day Care Centers of Participating OH Children, for Eight Pollutants

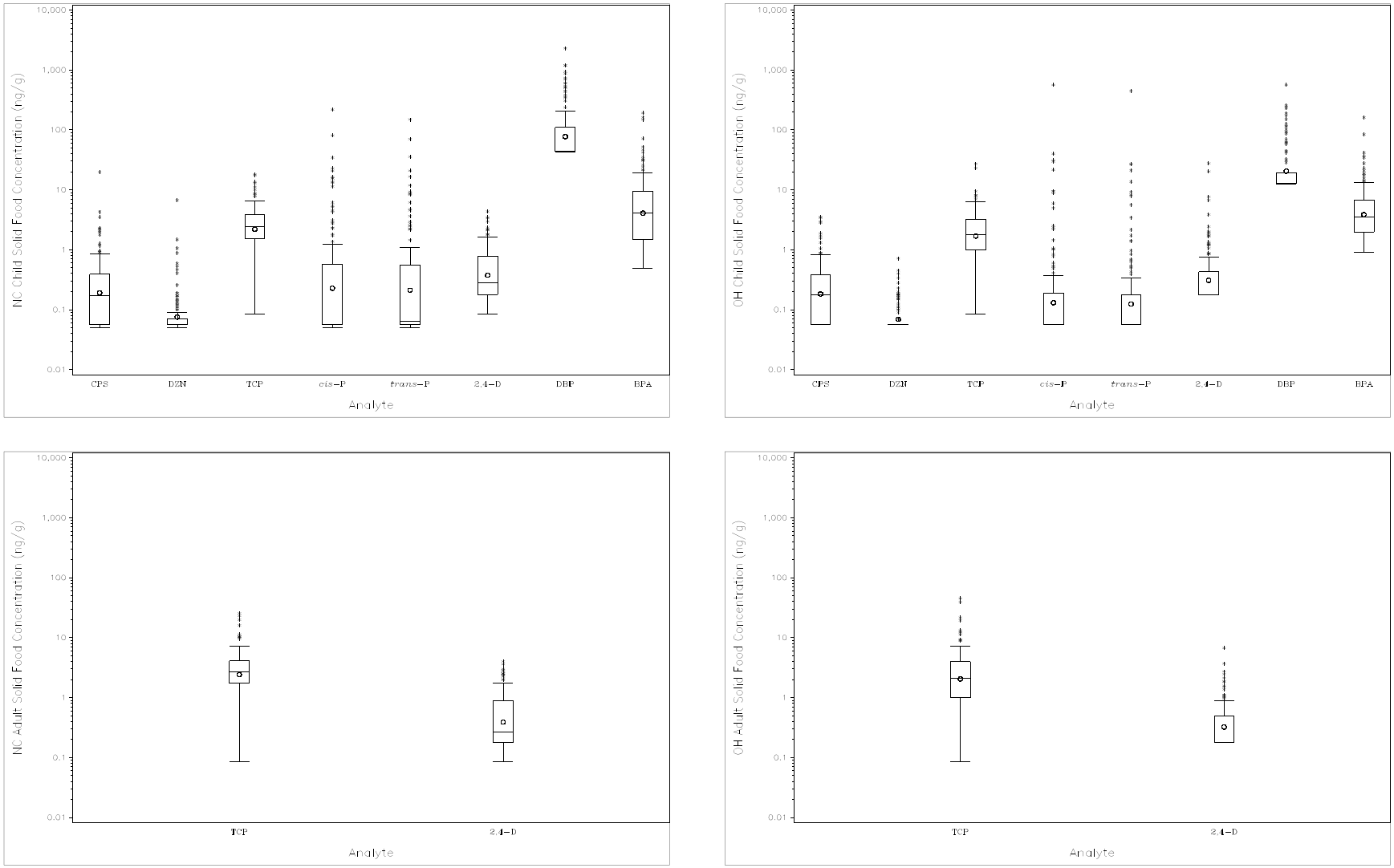


Figure 9.3.5 Boxplots of Pollutant Concentrations in <u>Solid Food Samples</u> Collected from Participating NC and OH Children and Adults, for Eight Pollutants

Each boxplot shows the distribution as a box-type diagram, where the lower and high limits of the box represent the 25th and 75th percentiles, respectively, of the observed data distribution. The length of the box (from top to bottom) represents the data's interquartile range (IQR), or the difference between the 75th and 25th percentiles, and is an indicator of data variability. A horizontal line within the box represents the 50th percentile, or median. The geometric mean is plotted with an open circle. Vertical lines extend from the top and/or bottom of the box to the value of the most extreme data point which falls within 1.5 IQRs from the box. Each data point extending beyond 1.5 IQRs from the box is plotted by an asterisk. Abbreviations for the pollutants that are specified along the horizontal axis of each figure were defined in the last paragraph of Section 9.2.

The boxplots show that, even when plotted using a logarithmic vertical axis, most data distributions for the eight pollutants and metabolites show skewness toward lower levels within all sample media, and most contain several measurements within the upper quartile that are at a considerable distance from the distribution's 75th percentile (i.e., top of box). This supports the approach of performing data analyses on log-transformed data, although some skewness remains in the distribution of the log-transformed data. Boxplots portrayed as very short boxes (e.g., measurements of the two permethrins within outdoor air samples from NC and OH) represent measurements that are nearly constant, which occurs most often when a large percentage of measurements are not detected. Other observations include the following:

- Indoor air and floor dust measurements tend to cover wider ranges than outdoor air and soil measurements, especially in NC.

- Soil concentrations tend to have highly skewed distributions across all pollutants, although on average, these concentrations are lower than for indoor dust.

- The distributions of loadings from surface wipe samples tend to be consistent between different surface types.

- Di-*n*-butylphthalate is frequently associated with higher measurements across the pollutants and metabolites, especially with regard to concentrations in air, dust, soil, and food samples.

9.3.2 Sub-goal 1.2: To Determine on Average How Multimedia Concentrations Differ Between Urban and Rural Environments, Low-Income and Middle/High-Income Environments, and Microenvironments (i.e., home for families with stay-at-home children, home for families with day care children, and day care centers)

To address this sub-goal, statistical analysis was performed on log-transformed measurements whenever at least 50% of these measurements were detected for a given pollutant and multimedia sample type. An analysis of variance using models (8-5) and (8-6) from Section 8.5.2.1 was performed to calculate a least squares mean of the log-transformed measurements for each environment type and microenvironment of interest. For a given pair of environment types

or microenvironments, the difference in the least-squares mean concentrations was calculated within the analysis of variance along with a 95% confidence interval on this difference, and a t-test was applied to test whether the difference was statistically significant. This difference and its confidence interval were exponentiated back to regular units, resulting in a ratio of the least-squares geometric mean concentrations for one environment type versus another and an approximate 95% confidence interval on this ratio.

For ease of discussion here and throughout Chapter 9, children recruited from the child day care sampling frame are referred to as "day care children," while those from the telephone screening sampling frame are referred to as "stay-at-home children." Analyses were performed and results are reported separately for NC and OH phases of the study, and pollutants are addressed according to their chemical class. Because no day care centers in this study had recent pesticide applications prior to multimedia sampling, no data were available from day care centers for food preparation surface wipes and transferable residue samples. In addition, no adult food or dermal wipe data were available for the day care environment.

For indoor and outdoor environmental samples and personal (food) samples, ratios and their 95% confidence intervals are presented by pollutant and sample type in Appendix K (Table K-1 for NC and Table K-2 for OH). These ratios are of the least-squares geometric mean concentration for the first environment type specified in the column heading versus the second specified type, and 95% confidence intervals are shown in parentheses. The t-test applied to the log-transformed data also is a test of whether this ratio differs significantly from one; p-values associated with these tests are also given in Appendix K (Table K-3 for NC and Table K-4 for OH). Within these tables, p-values for tests that compare a specific pair of microenvironments, as well as home versus day care environments, are presented only when the test for general differences among the three microenvironments was significant at the 0.05 level.

Table 9.3.5 has condensed the information provided within Tables K-1 and K-2 of Appendix K for a given sample type by presenting only those pollutants whose ratios were significantly different from one at the 0.05 level for pairs of strata determined by urbanicity, income status, or environmental type. Within Table 9.3.5, a dashed cell indicate that the statistical analysis was not performed because either the study design did not permit such analysis or the data were less than 50% detected. A blank cell means that the ratio was not significantly different from one at the 0.05 level. If a pollutant or sample type does not appear in this table, then none of the estimated ratios were significantly different from one at the 0.05 level.

To illustrate how to interpret the numbers in Tables K-1 and K-2 of Appendix K and Table 9.3.5, consider the results presented for *alpha*-chlordane in NC indoor floor dust (ng/m^2). Results of the model fitting indicated that the least squares mean log-transformed measure was 4.69 for the low-income stratum and 3.93 for the middle/high-income stratum (data not shown). The difference in these two least squares means is 0.76, which when exponentiated, becomes 2.13. It is interpreted as the estimated ratio of least-squares geometric mean concentrations between low-income and middle/high-income environments, and it implies that the geometric mean of *alpha*-chlordane in floor dust (ng/m^2) was estimated to be 113% higher in low-income

Table 9.3.5. Environmental and Food Samples: Estimated Ratios of Geometric Mean Pollutant Levels Between Urban and Rural, Low-Income and Middle/High-Income, and Home and Day Care Environments, When These Ratios Were Significantly Different from One at the 0.05 Level[a]

Pollutant/Metabolite	Sample Medium[b]	Estimated Ratio of Geometric Means (When Significantly Different from 1 at the 0.05 Level)					
		North Carolina			Ohio		
		Urban vs. Rural	Low- vs. Mid/High-Income	Home vs. Day Care	Urban vs. Rural	Low- vs. Mid/High-Income	Home vs. Day Care
OP Pesticides and Metabolites							
Chlorpyrifos	Outdoor air		0.64*				1.74*
	Dust (ng/g)					2.09*	0.37*
	Dust (ng/m^2)		2.88**	0.27*		3.39**	0.14**
	C-solid food					2.06**	
Diazinon	Indoor air		3.59**				
	Outdoor air				2.70**	0.60*	
	Dust (ng/g)		2.06*	0.36*			
	Dust (ng/m^2)		6.32**	0.10**		2.24*	0.17**
IMP	Indoor air	--	--	--		1.66*	
	Outdoor air	--	--	--	3.87**	0.48**	
	Dust (ng/m^2)	--	--	--			0.39*
3,5,6-TCP	Indoor air					1.72*	
	Outdoor air		0.65*	1.84*			
	Soil			2.29*	2.80**		
	Dust (ng/m^2)		3.40**			2.35*	0.29**
	C-solid food		0.48**				
OC Pesticides							
alpha-Chlordane	Outdoor air			0.44**			1.63*
	Soil	--	--	--		2.12*	2.80*
	Dust (ng/g)			0.42*			
	Dust (ng/m^2)		2.13*	0.09**			
gamma-Chlordane	Outdoor air		1.60*	0.41*			1.62*
	Dust (ng/g)			0.40*			
	Dust (ng/m^2)			0.09**			
Pyrethroid Pesticides							
Cyfluthrin	Dust (ng/g)	--	--	--	2.33*		
	Dust (ng/m^2)	--	--	--		2.12*	0.23**
cis-Permethrin	Indoor air		4.17**		--	--	--
	Dust (ng/m^2)		3.19**	0.18**		2.21*	0.20**
trans-Permethrin	Indoor air		3.85**		--	--	--
	Dust (ng/m^2)		2.89*	0.16**			0.19**

Table 9.3.5. Environmental and Food Samples: Estimated Ratios of Geometric Mean Pollutant Levels Between Urban and Rural, Low-Income and Middle/High-Income, and Home and Day Care Environments, When These Ratios Were Significantly Different from One at the 0.05 Level[a] (cont.)

Pollutant/Metabolite	Sample Medium[b]	Estimated Ratio of Geometric Means (When Significantly Different from 1 at the 0.05 Level)					
		North Carolina			Ohio		
		Urban vs. Rural	Low- vs. Mid/High-Income	Home vs. Day Care	Urban vs. Rural	Low- vs. Mid/High-Income	Home vs. Day Care
Acid Herbicides							
2,4-D	Dust (ng/g)	3.20**	0.22**		2.38*	0.24**	
	Dust (ng/m^2)	2.64*				0.39*	0.38*
	C-solid food[c]	1.60*			--	--	--
PAHs							
Benz[*a*]anthracene	Outdoor Air	1.58*					
	Soil		2.55**				
	Dust (ng/g)		0.54**		3.97**	0.58*	0.45*
	Dust (ng/m^2)			0.12**	3.19**		0.17**
Benzo[*b*]fluoranthene	Indoor air		1.95**		--	--	--
	Soil		2.54*				
	Dust (ng/g)		0.57**		3.63**	0.57*	0.44**
	Dust (ng/m^2)			0.12**	2.92**		0.16**
Benzo[*k*]fluoranthene	Soil		2.21*				
	Dust (ng/g)		0.56**		3.35**	0.58*	0.43**
	Dust (ng/m^2)			0.13**	2.70*		0.16**
Benzo[*ghi*]perylene	Indoor air		1.76**		--	--	--
	Soil		2.49**				
	Dust (ng/g)		0.57**		3.28**	0.56*	0.43**
	Dust (ng/m^2)			0.12**	2.64*		0.16**
Benzo[*a*]pyrene	Indoor air		1.94**		--	--	--
	Outdoor air	1.47*			--	--	--
	Soil		2.30*				
	Dust (ng/g)		0.55**		3.57**	0.55*	0.49*
	Dust (ng/m^2)			0.13**	2.87*		0.18**
Benzo[*e*]pyrene	Soil		2.49**				
	Dust (ng/g)		0.60*		3.40**	0.57*	0.45*
	Dust (ng/m^2)			0.12**	2.73*		0.16**
Chrysene	Indoor air		1.76**		--	--	--
	Soil		2.53**				
	Dust (ng/g)		0.59*		3.71**	0.56*	0.43**
	Dust (ng/m^2)			0.12**	2.99**		0.16**

Table 9.3.5. Environmental and Food Samples: Estimated Ratios of Geometric Mean Pollutant Levels Between Urban and Rural, Low-Income and Middle/High-Income, and Home and Day Care Environments, When These Ratios Were Significantly Different from One at the 0.05 Level[a] (cont.)

Pollutant/Metabolite	Sample Medium[b]	Estimated Ratio of Geometric Means (When Significantly Different from 1 at the 0.05 Level)					
		North Carolina			Ohio		
		Urban vs. Rural	Low- vs. Mid/High-Income	Home vs. Day Care	Urban vs. Rural	Low- vs. Mid/High-Income	Home vs. Day Care
Dibenz[*a*,*h*]anthracene	Dust (ng/g)		0.57**	0.52*	3.66**	0.58*	0.42**
	Dust (ng/m^2)			0.12**	2.94*		0.15**
Indeno[1,2,3-*cd*]pyrene	Indoor air		1.90**		--	--	--
	Soil		2.61**				
	Dust (ng/g)		0.59**		3.43**	0.56*	0.41**
	Dust (ng/m^2)			0.12**	2.75*		0.15**
Phthalates							
Benzylbutylphthalate	Dust (ng/g)		1.76**	0.48**			0.41**
	Dust (ng/m^2)		4.75**	0.10**		2.52**	0.14**
Di-*n*-butylphthalate	Indoor air			0.56**			0.56**
	Dust (ng/g)			0.50**			0.38**
	Dust (ng/m^2)		2.56**	0.10**		1.76*	0.14**
Phenols							
Bisphenol-A	Dust (ng/m^2)	--	--	--			0.33**
Pentachlorophenol	Indoor air		1.77*				2.16*
	Outdoor air		0.69*				
	Dust (ng/m^2)		2.56*	0.24*			
PCBs							
PCB 52	Dust (ng/m^2)	--	--	--			0.24**

[a] Dashed cells indicate that no analysis was performed due to the data being less than 50% detected. Blank cells indicate that a ratio was estimated but was not significantly different from one at the 0.05 level. Note that pollutants, or sample media for a given pollutant, have been excluded from this table if all cells within the rows corresponding to these pollutants or media would have been blank or dashed within this table. All estimated ratios for each sample medium and each pollutant, along with corresponding 95% confidence intervals on these ratios, are presented in Table K-1 (NC) and Table K-2 (OH) of Appendix K.

[b] "Dust" = Indoor floor dust collected via HVS3 vacuum. "C-solid food" = Children's solid food.

* Significantly different from 1 at the 0.05 level, but not at the 0.01 level.

** Significantly different from 1 at the 0.01 level.

environments than in middle/high-income environments. The 95% confidence interval of (1.03, 4.41) indicates that we can conclude with 95% confidence that the actual ratio falls within this interval. The single asterisk indicates that the estimated ratio (2.13) was significantly different from one (and, equivalently, that the difference of 0.76 between the least squares means of the log-transformed measurements was significantly different from zero) at the 0.05 level, but not at the 0.01 level (p=0.041). For *alpha*-chlordane in NC outdoor air samples, the estimated ratio of home versus day care environments was 0.44, implying that the geometric mean concentration at home environments was 44% of the corresponding geometric mean for day care centers. This ratio was significantly different from one at the 0.01 level (p=0.009).

For dermal wipe loadings, ratios and confidence intervals are presented by pollutant for children and adults in Appendix K (Table K-5 for NC and Table K-6 for OH). Appendix K also contains tables of p-values associated with t-tests applied to the log-transformed dermal wipe loadings (Table K-7 for NC and Table K-8 for OH). Those ratios found to be significantly different from one at the 0.05 level are listed in Table 9.3.6 for both states. All of these tables are constructed, and their contents are interpreted, in the same manner as in Tables K-1 through K-4 of Appendix K and Table 9.3.5.

9.3.2.1 Comparing Pollutant Concentrations in NC Multimedia Samples Among Strata

Significant differences between urban and rural sampling locations were observed rather infrequently in the NC data. Significant differences occurred at the 0.01 level only in two instances: for concentrations of 2,4-D in indoor floor dust (ng/g), and for loadings of bisphenol-A in adult dermal wipes. On average, concentrations of 2,4-D in floor dust (ng/g) were about 3.2 times higher in urban locations than in rural locations. Bisphenol-A levels in adult dermal wipe samples were about 2.6 times higher when taken in urban locations.

Within Table 9.3.5 and 9.3.6, across all pollutants and sample media for NC, significant differences in pollutant levels were most frequently observed between low-income and middle/high-income locations. In fact, whenever a pollutant had at least 50% detected data for NC in at least one sample medium, therefore allowing that data to be analyzed statistically, significant differences were observed at the 0.05 level between low-income and middle/high-income strata for that pollutant in at least one sample medium. Incidences of significant differences at the 0.01 level between low-income and middle/high-income strata were as follows, according to pollutant class:

- For the two OP pesticides, chlorpyrifos and diazinon, along with the metabolite 3,5,6-TCP, significant differences were observed at the 0.01 level in floor dust loadings (ng/m^2), with loadings in low-income households ranging from 2.9 times (chlorpyrifos) to 6.3 times (diazinon) higher on average than middle/high-income households. Levels of 3,5,6-TCP in children's solid food samples collected in low-income households were about 48% of the levels in samples collected in middle/high-income areas; this difference was significant at the 0.01 level. Diazinon levels in indoor

Table 9.3.6. Dermal Wipe Samples: Estimated Ratios of Geometric Mean Pollutant Levels Between Urban and Rural, Low-Income and Middle/High-Income, and Home and Day Care Environments, When These Ratios Were Significantly Different from One at the 0.05 Level[a]

Pollutant/Metabolite	Type of Dermal Wipe Sample	Estimated Ratio of Geometric Means (When Significantly Different from 1 at the 0.05 Level)					
		North Carolina			Ohio		
		Urban vs. Rural	Low- vs. Mid/High-Income	Home vs. Day Care	Urban vs. Rural	Low- vs. Mid/High-Income	Home vs. Day Care
OP Pesticides and Metabolites							
Chlorpyrifos	Child			1.75*		2.53**	
	Adult		1.91*	--		4.08**	--
3,5,6-TCP	Child			1.88**			
	Adult		1.47*	--			--
PAHs							
Chrysene	Adult	--	--	--	1.81*		--
Phthalates							
Benzylbutylphthalate	Child		1.64*		--	--	--
Phenols							
Bisphenol-A	Child			0.33**			2.90**
	Adult	2.61**		--			--

[a] Dashed cells indicate that the study data or design did not permit the given ratio to be estimated for the specified type of dermal wipe sample, or that no analysis was performed due to the data being less than 50% detected. Blank cells indicate that a ratio was estimated but was not significantly different from one at the 0.05 level. Note that pollutants, or sample types for a given pollutant, have been excluded from this table if all cells within the rows corresponding to these pollutants or sample types would have been blank or dashed within this table. All estimated ratios for each sample type and each pollutant, along with corresponding 95% confidence intervals on these ratios, are presented in Table K-5 (NC) and Table K-6 (OH) of Appendix K.

* Significantly different from 1 at the 0.05 level, but not at the 0.01 level.
** Significantly different from 1 at the 0.01 level.

air were about 3.6 times higher in low-income areas compared to middle/high-income areas; this difference was significant at the 0.01 level.

- Concentrations of *cis*- and *trans*-permethrin in indoor air were about 4 times higher in low-income locations compared to middle/high-income locations, with the difference being significant at the 0.01 level. For both pollutants, low-income locations had higher loadings in floor dust compared to middle/high-income locations, with loadings being about 220% higher for *cis*-permethrin (which was significant at the 0.01 level).

- Concentrations of 2,4-D in floor dust (ng/g) were about 4.5 times higher in middle/high-income locations compared to low-income locations; this difference was significant at the 0.01 level.

- Among the PAHs, concentrations in indoor floor dust were higher for middle/high-income locations, while concentrations in yard soil and indoor air were higher for low-income locations. For all nine target PAHs, indoor floor dust from middle/high-income locations had concentrations (ng/g) that were from 67% to 85% higher than low-income locations, with the difference being significant at the 0.01 level for all but benzo[*e*]pyrene and chrysene. For all PAHs except dibenz[*a,h*]anthracene, yard soil from low-income locations had concentrations that were from 121% to 161% higher than middle/high-income locations, with the difference being significant at the 0.01 level for benz[*a*]anthracene, benzo[*ghi*]perylene, benzo[*e*]pyrene, chrysene, and indeno[1,2,3-*cd*]pyrene. For five PAHs (benzo[*b*]flouranthene, benzo[*ghi*]perylene, benzo[*a*]pyrene, chrysene, and indeno[1,2,3-*cd*]pyrene), indoor air concentrations ranged from 76% to 94% higher in low-income areas than in middle/high-income areas, with the difference being significant at the 0.01 level.

- For di-*n*-butylphthalate and benzylbutylphthalate, loadings in indoor floor dust (ng/m^2) were 2.6 and 4.8 times as high, respectively, in low-income locations than in middle/high-income locations, with the difference being significant at the 0.01 level. In addition, benzylbutylphalate concentration in indoor floor dust (ng/g) averaged nearly 80% higher in low-income locations, with the difference also being significant at the 0.01 level.

Across pollutants and sample media, frequent incidences of significant differences in the NC data also occurred between home and day care environments. Home environments often had lower pollutant levels on average compared to day care environments, with 3,5,6-TCP being the primary exception. Incidences of significant differences at the 0.01 level were as follows:

- Among the OC pesticides and metabolite, only two instances of significant difference between home and day care environments at the 0.01 level were observed: for diazinon in floor dust (ng/m^2), where home environments averaged only 10% of the loading found in day care environments, and for 3,5,6-TCP in children's dermal wipes, where samples taken in home environments averaged 88% higher than in day care environments.

- For both *alpha*- and *gamma*-chlordane, differences in loadings found in indoor floor dust (ng/m^2) were significant between home and day care environments at the 0.01 level, with home environments averaging only 9% of the loadings in day care environments. For indoor floor dust concentration (ng/g) and outdoor air concentration, home environments averaged about 44% of the levels of *alpha*- and *gamma*-chlordane compared to day care environments, with the difference being significant at the 0.01 level for *alpha*-chlordane in outdoor air samples.

- For both *cis*- and *trans*-permethrin, significant differences were observed at the 0.01 level between home and day care environments for loadings in indoor floor dust (ng/m^2), with home environments having slightly less than 20% of the loadings observed in day care environments, on average.

- For each of the nine PAHs, loadings (ng/m^2) in indoor floor dust differed significantly at the 0.01 level between home and day care environments, with home environments having approximately 12% of the loadings observed in day care environments, on average.

- For benzylbutylphthalate and di-*n*-butylphthalate, levels in indoor floor dust samples taken from home environments averaged approximately 10% of the levels for day care environments when expressed as a loading (ng/m^2) and approximately 50% of the levels for day care environments when expressed as a concentration (ng/g). In each case, the difference was significant at the 0.01 level. In addition, concentrations of di-*n*-butylphthalate in indoor air were significantly different at the 0.01 level, with home environments averaging about 56% of the levels observed in day care environments.

- Among the two phenols, significant differences occurred between home and day care environments at the 0.01 level only for bisphenol-A in children's dermal wipe samples, where samples taken from day care environments had loadings that were approximately three times higher than for samples taken from home environments.

9.3.2.2 Comparing Pollutant Concentrations in OH Multimedia Samples Among Strata

Incidences of significant differences in sample media concentrations between urban and rural locations occurred more frequently for OH data compared to NC data, with the following differences being significant at the 0.01 level:

- Among the OP pesticides and metabolites, significant differences in outdoor air concentrations between urban and rural locations were observed at the 0.01 level for diazinon and IMP, with urban locations averaging 2.7 and 3.9 times the concentrations, respectively, of rural locations. In addition, for 3,5,6-TCP, significant differences in soil concentrations were observed at the 0.01 level, with urban locations averaging 2.8 times the concentrations of rural locations.

- Among all nine PAHs, significant differences were observed between urban and rural locations for indoor floor dust levels. When expressed as a concentration (ng/g), significance was at the 0.01 level, and urban locations averaged from 3.3 to 4.0 times higher loadings compared to rural locations. When expressed as a loading (ng/m^2), significance was at the 0.01 level for three PAHs (benz[*a*]anthracene, benzo[*b*]fluoranthene, and chrysene), where urban locations averaged from 2.9 to 3.2 times higher concentrations compared to rural locations.

While frequent occurrences of significant differences were observed in the OH data between low-income and middle/high-income strata, their occurrence was somewhat less frequent for OH than for NC. Incidences of significant differences at the 0.01 level were as follows, according to pollutant class:

- The most frequent occurrences of significant differences among income strata occurred with the OP pesticides and metabolites. Significant differences at the 0.01 level occurred for chlorpyrifos in dermal wipe samples for both children and adults, with low-income locations having 2.5 and 4.1 times the levels of middle/high-income locations, respectively. Significant differences at the 0.01 level also occurred for chlorpyrifos in children's solid food samples, where low-income locations had roughly twice the levels of middle/high-income locations, and for IMP in outdoor air samples, where middle/high-income locations had roughly twice the levels of low-income locations. For chlorpyrifos, diazinon, and 3,5,6-TCP, loadings in indoor floor dust (ng/m^2) averaged from 2.2 to 3.4 times higher in low-income locations than in middle/high-income locations, with the difference significant at the 0.01 level for chlorpyrifos.

- Concentrations of 2,4-D in indoor floor dust (ng/g) differed significantly at the 0.01 level between low-income and middle/high-income locations, with middle/high-income locations having about four times higher concentrations on average compared to low-income locations.

- Loadings of benzylbutylphthalate in indoor floor dust (ng/m^2) differed significantly at the 0.01 level, with loadings in low-income locations being 2.5 times higher than for middle/high-income locations.

The following occurrences of significant differences in OH data between home and day care environments were observed at the 0.01 level:

- For all OP pesticides and metabolites except IMP, significant differences in loadings were observed at the 0.01 level between home and day care environments for indoor floor dust (ng/m^2), with home environments having from 14% to 29% of the loadings observed in day care environments, on average.

- For all three pyrethroid pesticides, significant differences in loadings were observed at the 0.01 level between home and day care environments for indoor floor dust (ng/m^2), with day care environments having about five times higher loadings compared to home environments.

- Among the PAHs, significant differences were observed between home and day care environments for indoor floor dust levels. When expressed as a loading (ng/m^2), significance was at the 0.01 level for all nine PAHs, where home environments averaged from 15% to 18% of the loadings associated with day care environments. When expressed as a concentration (ng/g), significance was at the 0.01 level all but three PAHs (benz[*a*]anthracene, benzo[*a*]pyrene, and benzo[*e*]pyrene), where home environments averaged from 41% to 45% of the concentrations associated with day care environments.

- Similar to the PAHs, significant differences were present at the 0.01 level for both phthalates in indoor floor dust samples, regardless of whether the levels were expressed

as a concentration or a loading. When expressed as a loading (ng/m^2), home environments averaged 14% of the loadings associated with day care environments, while when expressed as a concentration (ng/g), home environments averaged about 40% of the concentrations associated with day care environments. In addition, indoor air concentrations of di-*n*-butylphthalate differed significantly at the 0.01 level between home and day care environments, with day care environments having roughly twice the concentration on average compared to home environments.

- For bisphenol-A, significant differences were observed at the 0.01 level between home and day care environments for loadings in floor dust samples (ng/m^2), with day care environments averaging roughly three times higher loadings compared to home environments, and for children's dermal wipe samples, where samples taken in home environments had about 2.9 times higher levels compared to day care environments.

- Significant differences were observed at the 0.01 level in floor dust loading (ng/m^2) of PCB 52, with day care environments having roughly four times the loadings, on average, compared to home environments.

9.4 Goal 2: To Quantify the Distributions of Child Characteristics, Activities, and Location that are Important for Exposure.

Important factors for helping to determine the estimated potential exposures and potential absorbed doses of the children and their primary caregivers to pollutants in these environments included their physical characteristics, activity patterns, locations where they spend their time, and the amount of food they consume. Table 9.4.1 contains summary statistics of the physical characteristics of the children and their primary caregivers including age, gender, body weight, height, and hand surface area in both states. Table 9.4.2 provides the common activities of the preschool children that were recorded by the parents in the questionnaires. These included such activities as frequency of placing toys and other objects in the mouth, pacifier use, teething, and frequency of washing hands. Table 9.4.3 and Table 9.4.4 contain the daily percentage of time that the participating children and adults, respectively, spent indoors or outdoors at their homes, day care centers, or other places. The children spent a daily average of 94% and 90% of their time indoors in NC and OH, respectively, while adults spent a daily average of 73% and 69% of their time indoors at their home in NC and OH, respectively. Table 9.4.5 contains summary statistics for the amount of solid food (g) and liquid food (mL) samples that were collected over the 48-h sampling period from children and their primary caregivers by group (stay at home or attended day care). Many of these factors were used to determine the children's estimated potential exposures and potential absorbed doses to pollutants at homes and day care centers.

Table 9.4.1 Summary of Selected Physical and Demographic Characteristics of the Participating Children and Their Primary Caregivers, for NC and OH

Physical Characteristics	Children		Adults	
	NC	OH	NC	OH
# Participants	129[a]	127	129[a]	127
# Participants, by Gender				
Male	58	63	8	12
Female	71	64	121	115
Age of participants (yr)[b]				
Mean	3.9/46.8	3.9/47.1	31.3	32.2
SE[c]	0.9/0.9	0.8/0.9	6.8	6.5
Median	3.9/47.2	4.0/47.9	31.0	32.0
Minimum	1.7/20.0	1.7/20.3	19.0	19.0
Maximum	5.5/65.5	5.6/66.6	46.0	49.0
Height of participants (cm)				
Mean	103.0	102.1	165.9	166.4
SE	8.8	9.0	7.9	8.3
Median	104.1	101.6	165.1	165.1
Minimum	78.7	78.7	144.8	152.4
Maximum	124.5	121.9	190.5	203.2
Weight of participants (kg)				
Mean	17.2	17.7	76.1	75.2
SE	4.3	4.0	19.4	19.4
Median	16.7	17.1	72.5	72.0
Minimum	10.4	10.8	45.0	45.0
Maximum	44.1	33.3	151.7	140.0
Hand surface area[d] of participants (cm^2)				
Mean	261.5	269.2	571.2	561.5
SE	42.1	44.6	70.0	73.7
Median	255.0	260.0	560.0	550.0
Minimum	175.0	190.0	460.0	410.0
Maximum	380.0	405.0	825.0	840.0
Highest education level				
11^{th} grade or less			12.3%	6.3%
High school (HS) graduate/GED			20.8%	22.1%
Post-HS training			5.4%	5.5%
Some college			23.1%	20.5%
College graduate			23.1%	34.6%
Post-graduate			14.6%	11.0%
Unknown (missing)			0.8%	0.0%

Table 9.4.1 Summary of Selected Physical and Demographic Characteristics of the Participating Children and Their Primary Caregivers, for NC and OH (cont.)

Physical Characteristics	Children		Adults	
	NC	OH	NC	OH
Racial background				
White	55.4%	70.1%	57.7%	73.2%
Black	36.9%	25.2%	36.9%	22.8%
Hispanic	3.9%	2.4%	2.3%	2.4%
Asian/Pacific Islander	0.0%	2.4%	0.0%	1.6%
Other	3.1%	0.0%	2.3%	0.0%
Unknown (missing)	0.8%	0.0%	0.8%	0.0%
Total household income				
Less than $15,000			20.0%	9.5%
$15,001 to $25,000			17.7%	16.5%
$25,001 to $35,000			6.9%	7.9%
$35,001 to $50,000			16.1%	24.4%
More than $50,000			35.4%	30.7%
Refused			3.1%	5.5%
Don't know			0.8%	2.4%
Unknown (missing)			0.0%	3.2%

[a] One adult and their child dropped out of the study before field sampling was completed.
[b] For children, age is given in total years, followed by total months.
[c] Standard error of the mean
[d] Hand surface are of both hands.

Table 9.4.2 Prevalence of Selected Daily Activities Among the Participating Children, as Recorded on Study Questionnaires

Daily Activities During the Previous Month	NC Children (n=129)	OH Children (n=127)
How often did your child play with sand or dirt?		
Most of the time	34%	29%
Sometimes	40%	36%
Almost never	26%	35%
Have you ever seen your child eat.....?		
Dirt	12%	8%
Sand	9%	5%
Snow	29%	5%
Did your child use a pacifier?		
Yes	5%	4%
No	95%	96%
Did your child ever put their mouth on the floor or lick the floor?		
Yes	10%	8%
No	89%	92%
Don't know	1%	–
Is your child currently teething?		
Yes	5%	2%
No	94%	98%
Don't know	1%	–
How often did your child put toys in their mouth?		
Frequently	25%	18%
Sometimes	33%	31%
Almost never	42%	51%
Did your child put anything[a] other than toys or food in their mouth?	33%	25%
Yes	67%	74%
No	–	1%
Missing data		
Did your child suck or chew their thumb or fingers?		
Yes	42%	15%
No	58%	85%
Did your child suck or chew their toe or foot?		
Yes	5%	1%
No	95%	99%
When your child was outside the house, how often did he/she walk barefoot?		
Most of the time	8%	22%
Sometimes	21%	24%
Almost never	71%	54%

Table 9.4.2 Prevalence of Selected Daily Activities Among the Participating Children, as Recorded on Study Questionnaires (cont.)

Daily Activities During the Previous Month	NC Children (n=129)	OH Children (n=127)
How often did your child take something to eat or drink when he/she were playing outside the house?		
Most of the time	15%	17%
Sometimes	35%	39%
Almost never	50%	44%
When your child was inside the house, how often did he/she walk barefoot		
Most of the time	75%	74%
Sometimes	16%	18%
Almost never	8%	8%
When your child was inside the house, how often did he/she sit or play on the floor?		
Most of the time	78%	74%
Sometimes	21%	23%
Almost never	1%	3%
How often did your child sleep or take a nap on the floor?		
Most of the time	5%	3%
Sometimes	12%	13%
Almost never	83%	84%
How often were your child's hand's washed before eating meals?		
Most of the time	77%	83%
Sometimes	20%	16%
Almost never	3%	1%
How often were your child's hands washed before eating snacks?		
Most of the time	35%	39%
Sometimes	43%	35%
Almost never	22%	25%
Don't know	–	1%
How often were your child's hands washed after playing outside the house?		
Most of the time	67%	60%
Sometimes	24%	32%
Almost never	9%	8%
How often were their hands washed before going to bed?		
Most of the time	83%	74%
Sometimes	8%	17%
Almost never	9%	9%

[a] "Anything" refers to objects other than toys or food that could be placed into the mouth.

Table 9.4.3 Daily Percentage of Time that Participating Children Spent Indoors or Outdoors at Homes, Day Care Centers, Or Other Places

Location	# Children	Percentage of Time Spent at the Given Location				
		Mean	SD	Median	Minimum	Maximum
North Carolina						
Indoors	129	94	4	95	81	100
at Home	129	72	15	71	48	100
at Day Care	63	27	6	26	14	41
Other location	129	9	7	8	0	36
Outdoors	129	6	4	5	0	19
at Home	129	4	4	3.1	0	19
at Day Care	63	3	2	3.0	0	10
Ohio						
Indoors	127	90	8	92	58	100
at Home	127	68	16	68	8	99
at Day Care	58	30	12	30	8	89
Other location	127	8	7	6	0	47
Outdoors	127	10	8	8	0	42
at Home	127	8	8	5	0	42
at Day Care	58	5	5	4	0	17

Table 9.4.4 Daily Percentage of Time that Participating Adults Spent Indoors or Outdoors at Homes or Other Places

Location	Percentage of Time Spent at the Given Location				
	Mean	SD	Median	Minimum	Maximum
North Carolina (N=129 adults)					
Indoors at Home	73	15	72	48	100
Outdoors at Home	3	4	2	0	21
Away from Home	24	15	25	0	48
Ohio (N=127 adults)					
Indoors at Home	69	17	69	8	100
Outdoors at Home	6	8	3	0	54
Away from Home	24	19	19	0	91

Table 9.4.5 Summary Statistics on the Daily Amount of Solid and Liquid Food Collected from Participating Children and Their Primary Caregivers in the Stay-at-Home and Day Care Groups[a]

Food Sample Type	State	N	Mean	SD	Median	Min	Max
Weight of Solid Food (g)							
Stay-at-home group Adults	NC	66	498.6	206.6	509.0	20.6	925.9
	OH	69	577.7	208.7	571.6	221.6	1102.8
Stay-at- home group Children	NC	66	355.4	151.0	328.7	74.7	891.3
	OH	69	364.9	104.1	353.0	141.5	623.9
Day care group Adults	NC	63	342.7	193.7	323.4	6.2	1378.5
	OH	58	310.4	149.1	274.4	102.5	792.0
Day care group Children	NC	63	504.9	143.6	511.9	207.7	773.3
	OH	58	432.0	138.8	417.1	188.1	806.0
Volume of Liquid Food (mL)							
Stay-at-home group Adults	NC	64	723.9	430.9	692.5	69.0	2326.0
	OH	67	748.6	392.6	700.0	124.0	1802.5
Stay-at-home group Children	NC	65	597.3	246.6	600.0	83.0	1550.0
	OH	69	559.4	230.6	545.0	144.0	1655.0
Day care group Adults	NC	57	565.4	320.2	548.0	80.0	1380.0
	OH	55	456.1	329.3	370.0	110.0	1387.5
Day care group Children	NC	62	777.5	277.9	780.0	237.0	1351.0
	OH	57	600.8	226.8	600.0	200.0	1140.0

[a] Solid and liquid food samples were composited separately over a 48-h period.

9.5 Goal 3: To Estimate the Exposures of Participating Preschool Children to CTEPP Pollutants that They May Encounter in Their Everyday Environments

The formulas used to estimate potential exposure level and potential absorbed dose for a given study participant via the inhalation, dietary ingestion, and indirect ingestion routes were given in Sections 8.4.1, 8.4.2, and 8.4.3, respectively. For the eight target pollutants specified at the end of Section 9.2, potential exposure level and potential absorbed dose were estimated for each exposure route in all study participants. For the remaining target pollutants specified in Table 8.3 of Section 8.4 (19 pollutants in NC and 18 pollutants in OH), potential exposure level and potential absorbed dose via a given exposure route were estimated for study participants within a given state only when the following criteria were satisfied:

- Inhalation route: When at least 45% of the state's samples have detected results (i.e., at or above the MDL) for indoor air and/or outdoor air

- Dietary ingestion route: When at least 45% of the state's samples have detected results (i.e., at or above the MDL) for solid food.
- Indirect ingestion route: When at least 45% of the state's samples have detected results (i.e., at or above the MDL) for floor dust.

For target pollutants achieving these criteria within a given exposure route, potential exposure level and potential absorbed dose results are presented in this section.

9.5.1 Sub-goal 3.1: To Quantify the Distribution of Potential Exposure and Potential Absorbed Dose by Exposure Route

Descriptive statistics of potential exposure level and potential absorbed dose estimates are presented by exposure route in Appendix L for NC children, Appendix M for OH children, Appendix N for NC adults, and Appendix O for OH adults. The descriptive statistics are calculated across all study participants, as well as for study participants within each stratum: urban, rural, low-income, middle/high-income, stay-at-home children (or adults with stay-at-home children), and day care children (or adults with day care children). The descriptive statistics in these tables are presented and interpreted in the same way as was discussed in Section 9.3.1, except the sample size (N) now corresponds to numbers of study participants.

For the target pollutants, overall median values of estimated potential exposure level and potential absorbed dose are summarized by exposure route in Table 9.5.1 for NC children, Table 9.5.2 for OH children, Table 9.5.3 for NC adults, and Table 9.5.4 for OH adults. For the eight pollutants for which potential exposure level and potential absorbed dose were calculated for each exposure route, boxplots of the distribution of estimated potential exposure level and potential absorbed dose are given in Figures 9.5.1 through 9.5.6, with each figure focused on either children or adults and a specific exposure route:

- Figure 9.5.1: inhalation route for children
- Figure 9.5.2: dietary ingestion route for children
- Figure 9.5.3: indirect ingestion route for children
- Figure 9.5.4: inhalation route for adults
- Figure 9.5.5: dietary ingestion route for adults (3,5,6-TCP and 2,4-D only)
- Figure 9.5.6: indirect ingestion route for adults.

Each figure contains separate boxplots for potential exposure level and potential absorbed dose, for each pollutant for which data were available to make these estimates, and for each state. See Section 9.3.1 for how to interpret these boxplots.

Table 9.5.1 Median Values of Estimated Potential Exposure and Potential Absorbed Dose for Target Pollutants in Participating NC Preschool Children, by Exposure Route

Pollutant/Metabolite	Potential Exposure Level (ng/day)			Potential Absorbed Dose (ng/kg/day)		
	Inhalation	Dietary Ingestion	Indirect Ingestion	Inhalation	Dietary Ingestion	Indirect Ingestion
OP Pesticide and Metabolite						
Chlorpyrifos	47	81	5.2	1.4	2.5	0.16
Diazinon	17	<[a]	0.98	0.51	<	0.030
3,5,6-TCP	14	1,200	4.5	0.43	38	0.12
OC Pesticides						
alpha-Chlordane	8.3	<	1.6	0.24	<	0.048
gamma-Chlordane	13	<	2.7	0.42	<	0.083
p,p'-DDE	<	88	0.21	<	2.6	0.0074
Heptachlor	62	<	0.92	1.7	<	0.028
Pyrethroid Pesticides						
Cyfluthrin	<	<	3.6	<	<	0.13
cis-Permethrin	4.6	85	48	0.14	2.6	1.4
trans-Permethrin	2.7	74	35	0.088	2.2	1.0
Acid Herbicides						
2,4-D	4.0	190	1.4	0.099	4.8	0.042
PAHs						
Benz[*a*]anthracene	0.75	<	5.5	0.023	<	0.17
Benzo[*b*]fluoranthene	1.2	<	14	0.035	<	0.46
Benzo[*k*]fluoranthene	0.61	<	4.8	0.019	<	0.15
Benzo[*ghi*]perylene	1.0	<	8.6	0.029	<	0.25
Benzo[*a*]pyrene	0.80	<	7.7	0.025	<	0.25
Benzo[*e*]pyrene	0.73	<	7.7	0.022	<	0.24
Chrysene	0.85	<	7.5	0.027	<	0.23
Dibenz[*a,h*]anthracene	<	<	1.9	<	<	0.058
Indeno[1,2,3-*cd*]pyrene	0.83	<	7.4	0.025	<	0.24
Phthalates						
Benzylbutylphthalate	<	<	920	<	<	26
Di-*n*-butylphthalate	1,800	39,000	350	56	1,100	9.7
Phenols						
Bisphenol-A	14	2,700	<	0.41	74	<
Pentachlorophenol	12	<	3.4	0.34	<	0.11
PCBs						
PCB 52	4.2	<	<	0.13	<	<
PCB 95	0.69	<	<	0.021	<	<
PCB 101	0.55	<	<	0.017	<	<

[a] "<" indicates that the estimates were labeled as "not detected" for more than 50% of participating NC children, meaning that all pollutant concentrations entering into the calculation of the estimate were not detected.

Table 9.5.2 Median Values[a] of Estimated Potential Exposure and Potential Absorbed Dose for Target Pollutants in Participating OH Preschool Children, by Exposure Route

Pollutant/Metabolite	Potential Exposure Level (ng/day)			Potential Absorbed Dose (ng/kg/day)		
	Inhalation	Dietary Ingestion	Indirect Ingestion	Inhalation	Dietary Ingestion	Indirect Ingestion
OP Pesticide and Metabolite						
Chlorpyrifos	15	78	2.7	0.38	2.1	0.083
Diazinon	8.0	<[a]	1.0	0.24	<	0.031
3,5,6-TCP	5.1	860	1.6	0.14	25	0.049
OC Pesticides						
alpha-Chlordane	2.1	<	0.40	0.063	<	0.011
gamma-Chlordane	2.7	<	0.45	0.088	<	0.012
p,p'-DDE	<	78	0.27	<	2.1	0.0075
Pyrethroid Pesticides						
Cyfluthrin	<	<	7.1	<	<	0.20
cis-Permethrin	<	<	18	<	<	0.49
trans-Permethrin	<	<	12	<	<	0.34
Acid Herbicides						
2,4-D	1.9	120	4.8	0.049	3.6	0.15
PAHs						
Benz[*a*]anthracene	<	<	22	<	<	0.62
Benzo[*b*]fluoranthene	<	31	53	<	0.93	1.5
Benzo[*k*]fluoranthene	<	<	22	<	<	0.60
Benzo[*ghi*]perylene	<	<	28	<	<	0.82
Benzo[*a*]pyrene	<	<	29	<	<	0.81
Benzo[*e*]pyrene	<	<	30	<	<	0.79
Chrysene	0.56	<	29	0.018	<	0.82
Dibenz[*a,h*]anthracene	<	<	6.2	<	<	0.18
Indeno[1,2,3-*cd*]pyrene	<	<	28	<	<	0.80
Phthalates						
Benzylbutylphthalate	<	9,400	630	<	270	18
Di-*n*-butylphthalate	2,000	<	210	57	<	5.7
Phenols						
Bisphenol-A	7.8	1,700	1.0	0.24	52	0.028
Pentachlorophenol	18	<	1.8	0.58	<	0.051
PCBs						
PCB 52	3.6	–[b]	0.23	0.10	--	0.0058
PCB 95	0.81	--	0.15	0.025	--	0.0041
PCB 101	0.72	--	0.18	0.021	--	0.0057

[a] "<" indicates that the estimates were labeled as "not detected" for more than 50% of participating OH children, meaning that all pollutant concentrations entering into the calculation of the estimate were not detected.

[b] Dashes indicate that no valid concentrations for the given pollutant were available for those sample media that enter into the calculation of the potential exposure and potential absorbed dose estimates for the given exposure route.

Table 9.5.3 Median Values[a] of Estimated Potential Exposure and Potential Absorbed Dose for Target Pollutants in Participating NC Adults, by Exposure Route

Pollutant/Metabolite	Potential Exposure Level (ng/day)			Potential Absorbed Dose (ng/kg/day)		
	Inhalation	Dietary Ingestion	Indirect Ingestion	Inhalation	Dietary Ingestion	Indirect Ingestion
OP Pesticides and Metabolites						
Chlorpyrifos	69	–[b]	3.2	0.45	--	0.021
Diazinon	23	--	0.43	0.14	--	0.0030
3,5,6-TCP	21	1,200	2.3	0.14	7.9	0.016
OC Pesticides						
alpha-Chlordane	9.5	--	0.55	0.064	--	0.0037
gamma-Chlordane	17	--	0.74	0.11	--	0.0052
p,p'-DDE	<[a]	--	<	<	--	<
Heptachlor	80	--	<	0.54	--	<
Pyrethroid Pesticides						
Cyfluthrin	<	--	1.2	<	--	0.0077
cis-Permethrin	5.6	--	20	0.036	--	0.14
trans-Permethrin	3.9	--	16	0.020	--	0.11
Acid Herbicides						
2,4-D	2.1	140	0.80	0.016	0.97	0.0058
PAHs						
Benz[*a*]anthracene	0.97	--	2.8	0.0067	--	0.018
Benzo[*b*]fluoranthene	1.6	--	7.0	0.011	--	0.051
Benzo[*k*]fluoranthene	0.77	--	2.5	0.0061	--	0.017
Benzo[*ghi*]perylene	1.5	--	4.2	0.010	--	0.029
Benzo[*a*]pyrene	1.0	--	4.2	0.0078	--	0.028
Benzo[*e*]pyrene	0.97	--	4.3	0.0069	--	0.026
Chrysene	1.2	--	4.1	0.0083	--	0.027
Dibenz[*a,h*]anthracene	<	--	0.96	<	--	0.0064
Indeno[1,2,3-*cd*]pyrene	1.1	--	3.9	0.0080	--	0.026
Phthalates						
Benzylbutylphthalate	<	--	420	<	--	3.1
Di-*n*-butylphthalate	2,600	--	130	18	--	0.96
Phenols						
Bisphenol-A	20	--	<	0.13	--	<
Pentachlorophenol	17	<	1.5	0.11	<	0.011
PCBs						
PCB 52	6.0	--	<	0.040	--	<
PCB 95	1.0	--	<	0.0065	--	<
PCB 101	0.68	--	<	0.0047	--	<

[a] "<" indicates that the estimates were labeled as "not detected" for more than 50% of participating NC adults, meaning that all pollutant concentrations entering into the calculation of the estimate were not detected.

[b] Dashes indicate that no valid concentrations for the given pollutant were available for those sample media that enter into the calculation of the potential exposure and potential absorbed dose estimates for the given exposure route.

Table 9.5.4 Median Values[a] of Estimated Potential Exposure and Potential Absorbed Dose for Target Pollutants in Participating OH Adults, by Exposure Route

Pollutant/Metabolite	Potential Exposure Level (ng/day)			Potential Absorbed Dose (ng/kg/day)		
	Inhalation	Dietary Ingestion	Indirect Ingestion	Inhalation	Dietary Ingestion	Indirect Ingestion
OP Pesticides and Metabolites						
Chlorpyrifos	20	–[b]	1.2	0.13	--	0.0079
Diazinon	11	--	0.48	0.076	--	0.0031
3,5,6-TCP	7.0	980	0.99	0.046	6.1	0.0068
OC Pesticides						
alpha-Chlordane	3.0	--	0.26	0.021	--	0.0018
gamma-Chlordane	4.1	--	0.31	0.030	--	0.0019
p,p'-DDE	<[a]	--	0.17	<	--	0.0012
Pyrethroid Pesticides						
Cyfluthrin	<	--	4.4	<	--	0.028
cis-Permethrin	<	--	10	<	--	0.074
trans-Permethrin	<	--	8.0	<	--	0.060
Acid Herbicides						
2,4-D	1.9	<	2.9	0.015	<	0.021
PAHs						
Benz[*a*]anthracene	<	--	13	<	--	0.092
Benzo[*b*]fluoranthene	<	--	34	<	--	0.23
Benzo[*k*]fluoranthene	<	--	13	<	--	0.075
Benzo[*ghi*]perylene	<	--	18	<	--	0.11
Benzo[*a*]pyrene	<	--	17	<	--	0.12
Benzo[*e*]pyrene	<	--	19	<	--	0.12
Chrysene	0.77	--	18	0.0061	--	0.12
Dibenz[*a,h*]anthracene	<	--	3.9	<	--	0.027
Indeno[1,2,3-*cd*]pyrene	<	--	18	<	--	0.11
Phthalates						
Benzylbutylphthalate	<	--	410	<	--	2.7
Di-*n*-butylphthalate	2,700	--	130	19	--	0.86
Phenols						
Bisphenol-A	11	--	<	0.076	--	<
Pentachlorophenol	23	<	1.3	0.16	<	0.0091
PCBs						
PCB 52	4.8	--	0.11	0.033	--	0.00072
PCB 95	1.2	--	0.084	0.0077	--	0.00065
PCB 101	1.0	--	0.11	0.0064	--	0.00076

[a] "<" indicates that the estimates were labeled as "not detected" for more than 50% of participating OH adults, meaning that all pollutant concentrations entering into the calculation of the estimate were not detected.

[b] Dashes indicate that no valid concentrations for the given pollutant were available for those sample media that enter into the calculation of the potential exposure and potential absorbed dose estimates for the given exposure route.

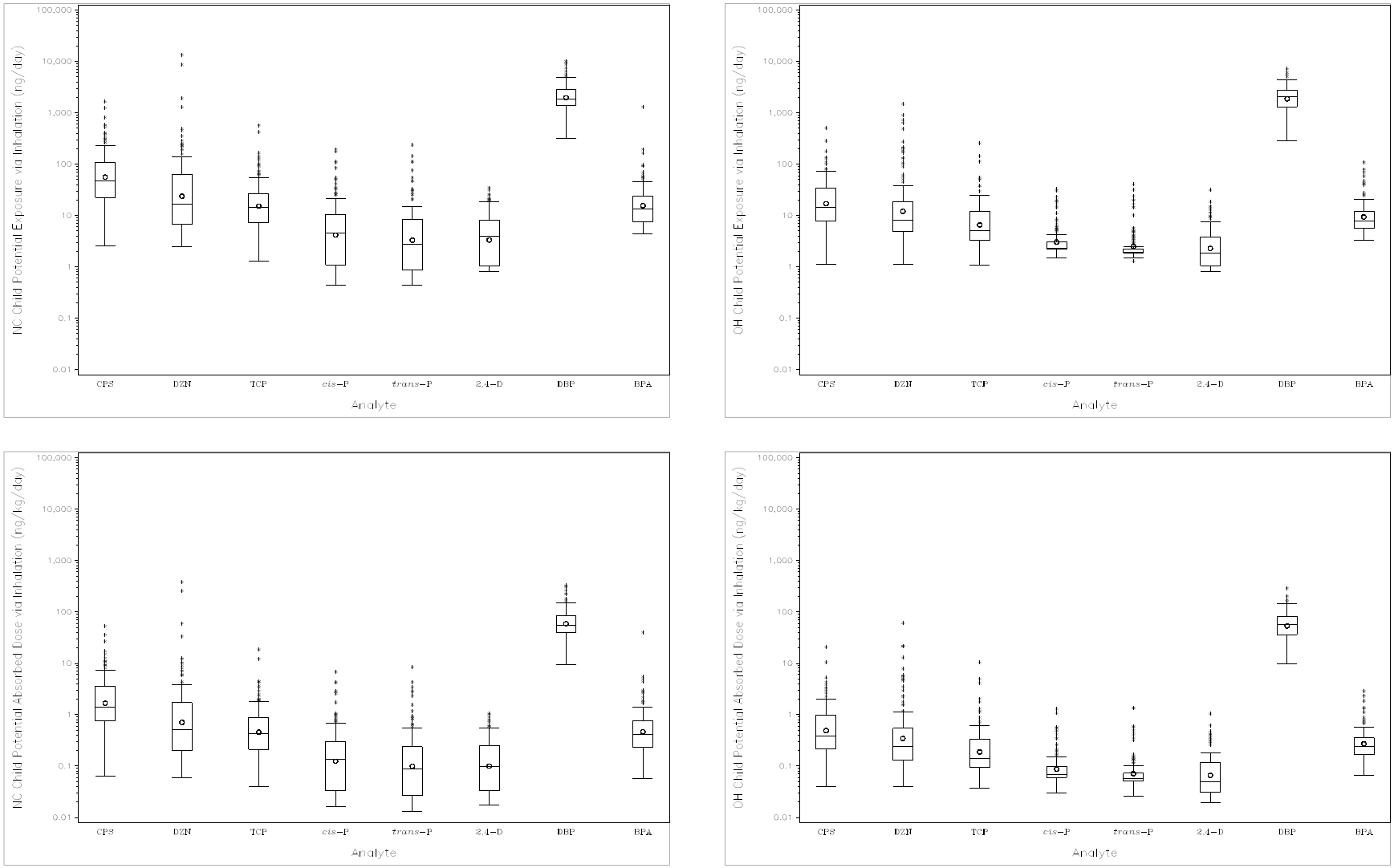


Figure 9.5.1 Boxplots of Estimated Potential Exposure and Potential Absorbed Dose via Inhalation for Participating NC and OH Children, for Eight Pollutants

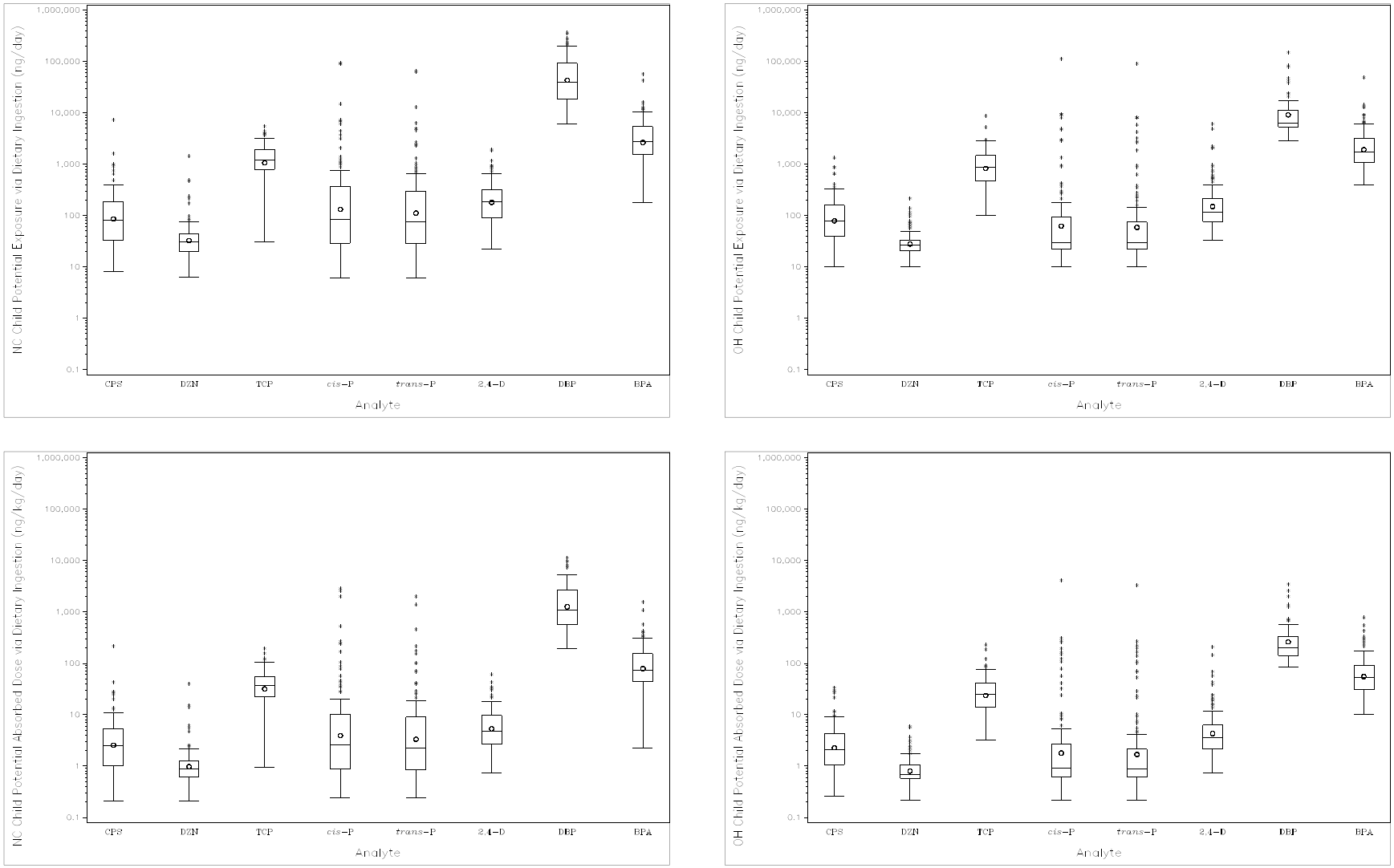


Figure 9.5.2 Boxplots of Estimated Potential Exposure and Potential Absorbed Dose via Dietary Ingestion for Participating NC and OH Children, for Eight Pollutants

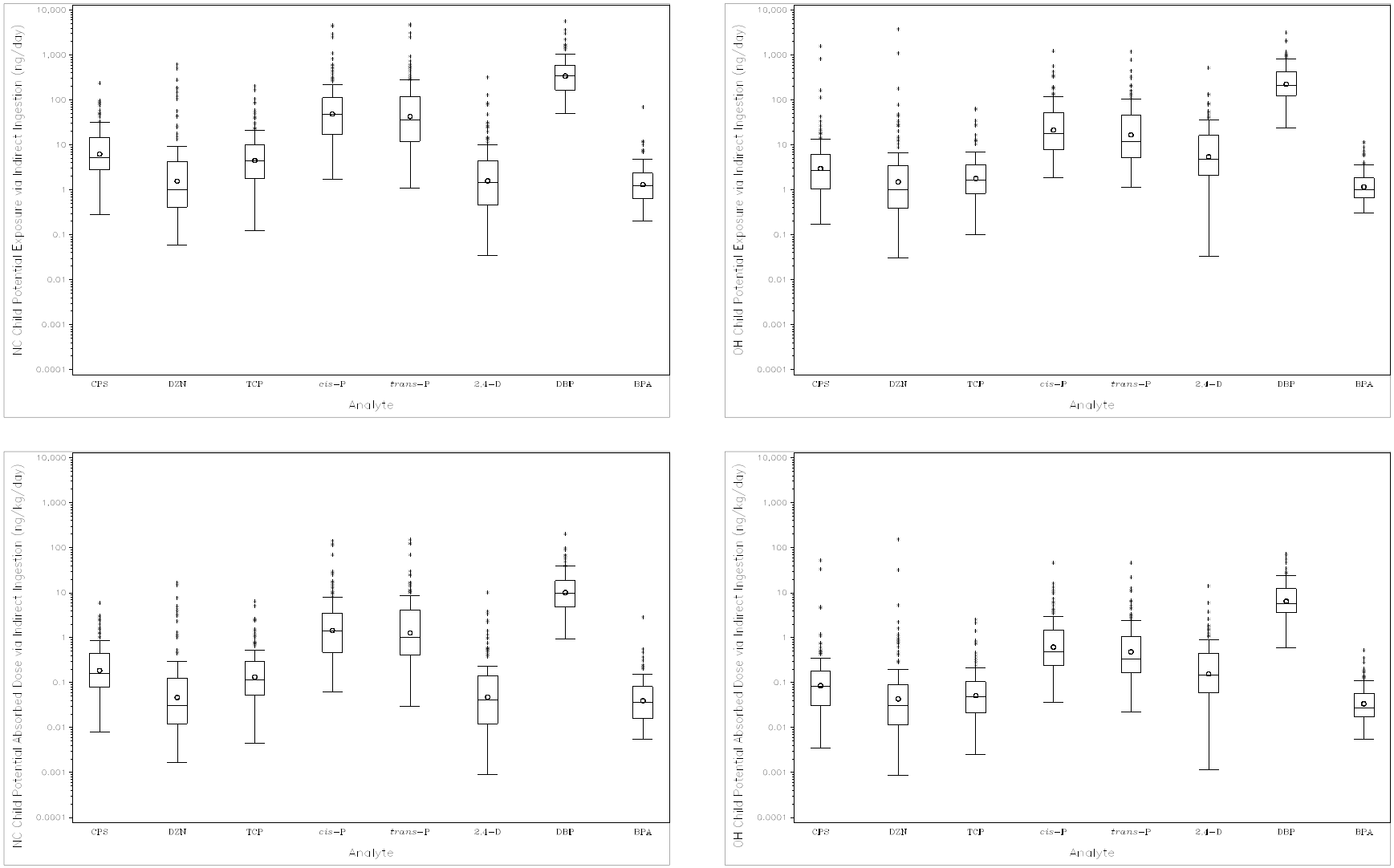


Figure 9.5.3 Boxplots of Estimated Potential Exposure and Potential Absorbed Dose via Indirect Ingestion for Participating NC and OH Children, for Eight Pollutants

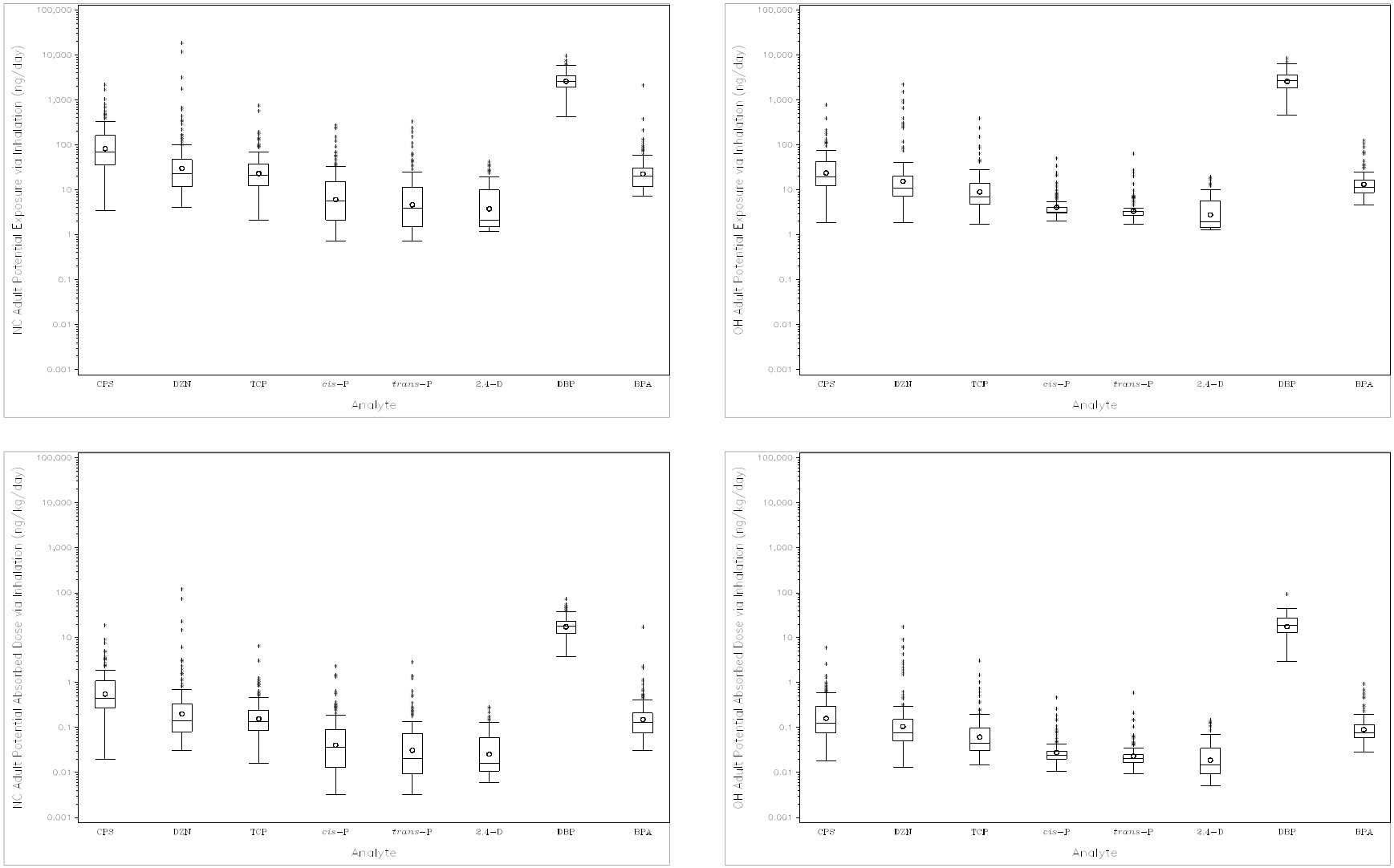


Figure 9.5.4 Boxplots of Estimated Potential Exposure and Potential Absorbed Dose via Inhalation for Participating NC and OH Adults, for Eight Pollutants

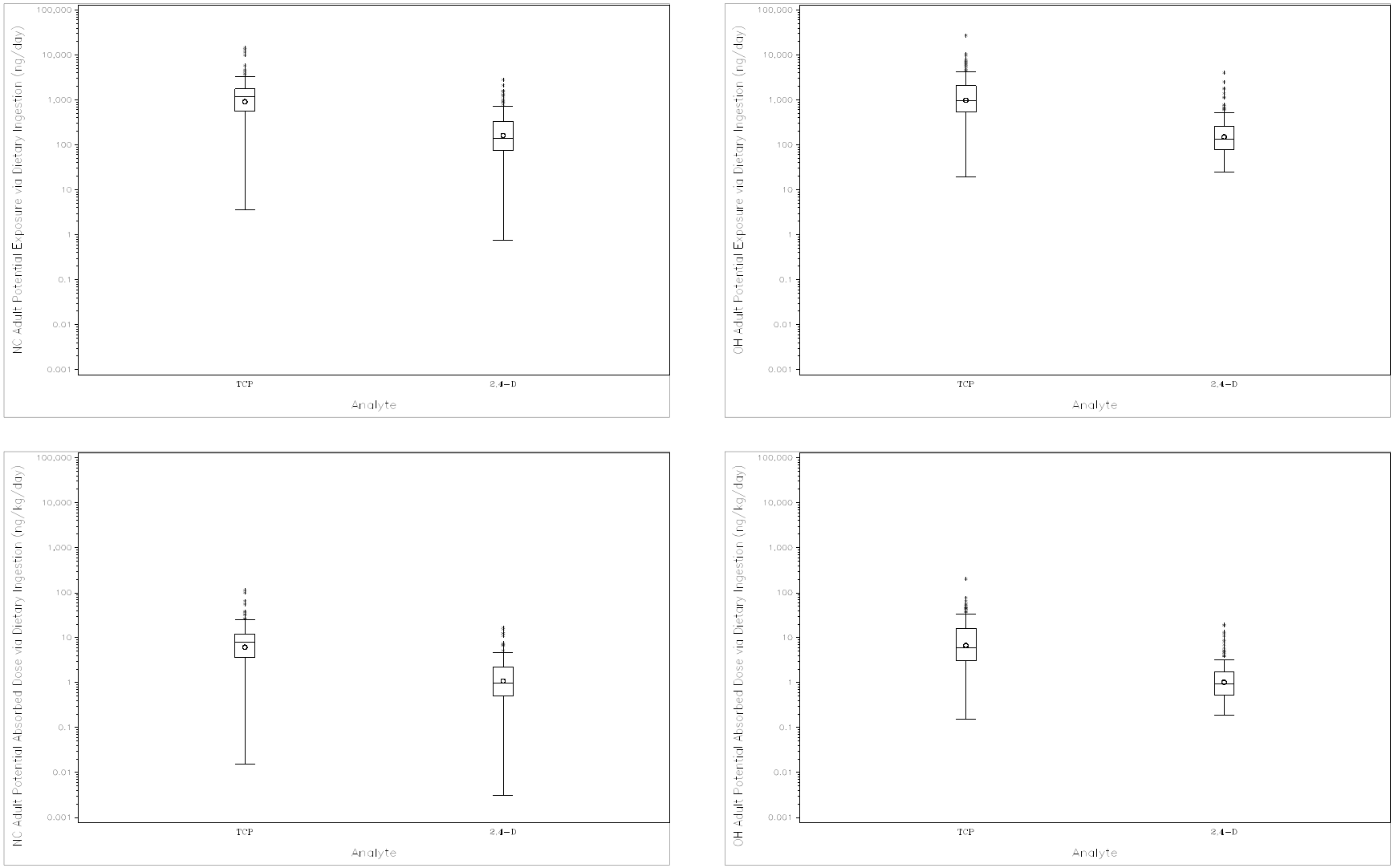


Figure 9.5.5 Boxplots of Estimated <u>Potential Exposure and Potential Absorbed Dose via Dietary Ingestion</u> for Participating NC and OH <u>Adults</u>, for Eight Pollutants Measured in Adult Food

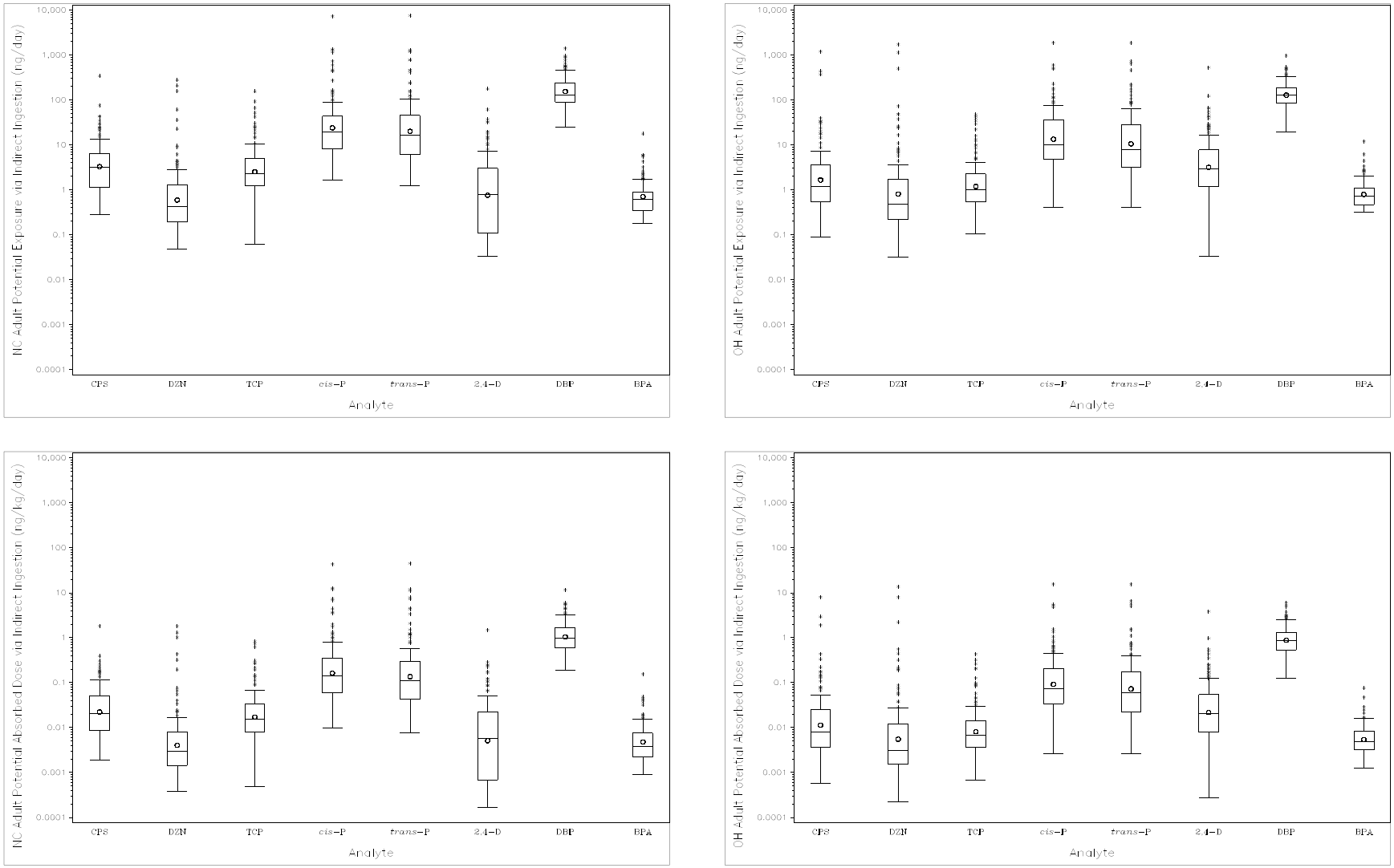


Figure 9.5.6 Boxplots of Estimated Potential Exposure and Potential Absorbed Dose via Indirect Ingestion for Participating NC and OH Adults, for Eight Pollutants

The shapes of the distributions of potential exposure and potential absorbed dose estimates that are portrayed in Figures 9.5.1 through 9.5.6 closely resemble those for the environmental and personal media that are given in Section 9.3.1. Di-*n*-butylphthalate estimates tend to be higher than estimates for the other pollutants, especially for inhalation. In addition, estimates tend to be higher across the board for NC than for OH under each exposure route.

9.5.2 Sub-goal 3.2: To Quantify the Distribution of Potential Exposure and Potential Dose Aggregated over All Exposure Routes

As discussed in Section 8.4, aggregate potential exposure and aggregate potential absorbed dose associated with a study participant were defined as the sums of the potential exposure and potential absorbed dose estimates, respectively, across all three exposure routes considered in this study (inhalation, dietary ingestion, and indirect ingestion). These aggregate estimates were calculated only for the eight target pollutants mentioned at the end of Section 9.2, for which potential exposure and potential absorbed dose estimates were calculated for each of the three exposure routes for each study participant.

Descriptive statistics of the potential aggregate exposure level and potential aggregate absorbed dose estimates are presented in Appendix L for NC children, Appendix M for OH children, Appendix N for NC adults, and Appendix O for OH adults. They are presented only in those tables that are associated with the eight target pollutants. (Note that these tables also contain route-specific data summaries.) Within these tables and in Table 9.5.5 and Table 9.5.6 for NC and OH, respectively, these descriptive statistics are presented across all study participants, separately for children and adults. In addition, within the appendix tables, descriptive statistics are presented for each stratum: urban, rural, low-income, middle/high-income, stay-at-home children (or adults with stay-at-home children), and day care children (or adults with day care children).

Boxplots of potential aggregate exposure level and potential aggregate absorbed dose estimates are given in Figure 9.5.7 for participating children and in Figure 9.5.8 for their adult caregivers. Each figure contains separate boxplots for potential aggregate exposure level and potential aggregate absorbed dose, for each pollutant for which data were available to make these estimates, and for each state. The boxplots show that aggregate potential exposure and dose estimates in the participating children were highest for di-*n*-butylphthalate and bisphenol-A, and to a lesser extent, 3,5,6-TCP. See Section 9.3.1 for how to interpret these boxplots.

9.5.3 Sub-goal 3.3: To Quantify the Distribution of Urinary Biomarkers Concentrations as an Indicator of Absorbed Dose

Concentrations of selected acid pollutants and metabolites in urine collected over the 48-h sampling period were used as biomarkers of exposure in study participants. These concentrations were summarized and analyzed 1) after adjusting for the urine sample's specific gravity, 2) after adjusting for the urine sample's creatinine level, and 3) without any adjustment.

Table 9.5.5 Summary of Aggregate Potential Exposure and Aggregate Potential Absorbed Dose Estimates for Eight Pollutants in NC Study Participants[a]

Pollutant/ Metabolite	Type of Measure	N	% Detected	Arith. Mean	S.D.	Geom. Mean	Percentiles				Max.
							25th	50th	75tt	95th	
OP Pesticides and Metabolite											
Chlorpyrifos	Children -- Aggregate Exposure[a]	109	100	359	801	174	78.9	152	295	1,180	7,630
	Children -- Aggregate Dose[b]	109	100	10.6	23.8	5.18	2.49	4.59	8.84	31.7	227
	Adults -- Aggregate Exposure	--[c]	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--
Diazinon	Children -- Aggregate Exposure	109	100	354	1,720	68.1	30.4	51.6	110	544	15,100
	Children -- Aggregate Dose	109	100	10.2	49.4	2.02	0.965	1.44	2.60	15.8	428
	Adults -- Aggregate Exposure	--	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--
3,5,6-TCP	Children -- Aggregate Exposure	113	100	1,480	1,010	1,110	804	1,230	1,960	3,780	5,600
	Children -- Aggregate Dose	113	100	43.8	30.9	33.3	22.6	37.7	57.8	100	199
	Adults -- Aggregate Exposure	117	100	1,660	2,130	1,010	596	1,310	1,770	4,390	14,400
	Adults -- Aggregate Dose	117	100	11.6	15.5	6.81	3.95	8.37	12.6	33.1	113
Pyrethroid Pesticides											
cis-Permethrin	Children -- Aggregate Exposure	109	100	3,290	15,000	306	88.9	246	656	6,840	93,300
	Children -- Aggregate Dose	109	100	92.5	412	9.08	2.71	6.72	21.5	243	2,850
	Adults -- Aggregate Exposure	--	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--
trans-Permethrin	Children -- Aggregate Exposure	106	100	1,870	8,720	252	77.9	193	555	4,870	65,300
	Children -- Aggregate Dose	106	100	52.4	235	7.52	2.37	5.82	19.5	154	2,000
	Adults -- Aggregate Exposure	--	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--
Acid Herbicides											
2,4-D	Children -- Aggregate Exposure	105	96	279	302	188	96.4	193	343	836	2,250
	Children -- Aggregate Dose	105	96	8.33	9.35	5.56	2.95	4.93	9.75	22.5	70.8
	Adults -- Aggregate Exposure	110	96	318	441	183	92.9	164	338	1,310	2,840
	Adults -- Aggregate Dose	110	96	2.11	2.90	1.24	0.557	1.12	2.28	6.86	16.8
Phthalates											
Di-*n*-butylphthalate	Children -- Aggregate Exposure	78	100	72,900	76,600	47,100	21,600	42,900	94,800	270,000	365,000
	Children -- Aggregate Dose	78	100	2,100	2,190	1,360	652	1,250	2,910	7,800	11,400
	Adults -- Aggregate Exposure	--	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--
Phenols											
Bisphenol-A	Children -- Aggregate Exposure	102	100	4,190	6,190	2,500	1,500	2,560	5,240	11,300	57,200
	Children -- Aggregate Dose	102	100	125	175	75.6	42.4	71.4	153	342	1,570
	Adults -- Aggregate Exposure	--	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--

[a] Aggregate potential exposure level (ng/day)
[b] Aggregate potential absorbed dose (ng/kg/day)
[c] Dashes indicate that insufficient data prevented aggregate potential exposure or aggregate potential absorbed dose from being estimated. An estimate is labeled "detected" if at least one of the sample media levels entering into its calculation is labeled "detected."

Table 9.5.6 Summary of Aggregate Potential Exposure and Aggregate Potential Absorbed Dose Estimates for Eight Pollutants in OH Study Participants[a]

Pollutant/ Metabolite	Type of Measure	N	% Detected	Arith. Mean	S.D.	Geom. Mean	Percentiles				Max.
							25th	50th	75tt	95th	
OP Pesticides and Metabolite											
Chlorpyrifos	Children -- Aggregate Exposure[a]	96	100	178	234	117	77.7	109	172	491	1,520
	Children -- Aggregate Dose[c]	96	100	5.39	8.25	3.37	2.04	3.10	5.11	17.1	61.8
	Adults -- Aggregate Exposure	--[c]	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--
Diazinon	Children -- Aggregate Exposure	112	100	142	534	54.1	29.9	38.6	67.0	378	5,430
	Children -- Aggregate Dose	112	100	4.62	21.3	1.56	0.872	1.13	1.89	11.0	221
	Adults -- Aggregate Exposure	--	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--
3,5,6-TCP	Children -- Aggregate Exposure	103	100	1,180	1,110	852	488	930	1,500	2,610	8,700
	Children -- Aggregate Dose	103	100	34.1	32.9	24.4	15.2	25.4	42.3	80.3	228
	Adults -- Aggregate Exposure	108	100	2,010	3,210	1,050	554	1,000	2,170	7,080	27,300
	Adults -- Aggregate Dose	108	100	14.5	23.4	7.22	3.27	6.39	16.5	47.1	200
Pyrethroid Pesticides											
cis-Permethrin	Children -- Aggregate Exposure	111	100	665	1,960	118	38.8	90.1	167	4,790	9,430
	Children -- Aggregate Dose	111	100	18.3	54.1	3.40	1.29	2.22	4.71	151	315
	Adults -- Aggregate Exposure	--	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--
trans-Permethrin	Children -- Aggregate Exposure	97	100	280	784	87.5	36.6	72.0	146	1,960	5,790
	Children -- Aggregate Dose	97	100	8.39	25.1	2.52	1.07	1.78	4.00	53.1	199
	Adults -- Aggregate Exposure	--	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--
Acid Herbicides											
2,4-D	Children -- Aggregate Exposure	95	99	350	736	175	81.0	141	245	2,070	6,090
	Children -- Aggregate Dose	95	99	10.1	23.5	5.05	2.35	4.13	7.48	39.1	210
	Adults -- Aggregate Exposure	106	99	278	393	166	92.5	147	269	1,140	2,540
	Adults -- Aggregate Dose	106	99	1.97	2.96	1.12	0.589	0.978	1.83	8.37	19.3
Phthalates											
Di-*n*-butylphthalate	Children -- Aggregate Exposure	43	100	19,500	27,600	12,200	7,330	8,310	16,900	81,000	152,000
	Children -- Aggregate Dose	43	100	539	703	353	205	262	467	2,080	3,570
	Adults -- Aggregate Exposure	--	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--
Phenols											
Bisphenol-A	Children -- Aggregate Exposure	67	100	3,620	6,310	2,150	1,270	1,880	3,540	12,800	48,600
	Children -- Aggregate Dose	67	100	101	130	63.8	34.1	60.8	93.9	328	775
	Adults -- Aggregate Exposure	--	--	--	--	--	--	--	--	--	--
	Adults -- Aggregate Dose	--	--	--	--	--	--	--	--	--	--

[a] Aggregate potential exposure level (ng/day)
[b] Aggregate potential absorbed dose (ng/kg/day)
[c] Dashes indicate that insufficient data prevented aggregate potential exposure or aggregate potential absorbed dose from being estimated. An estimate is labeled "detected" if at least one of the sample media levels entering into its calculation is labeled "detected."

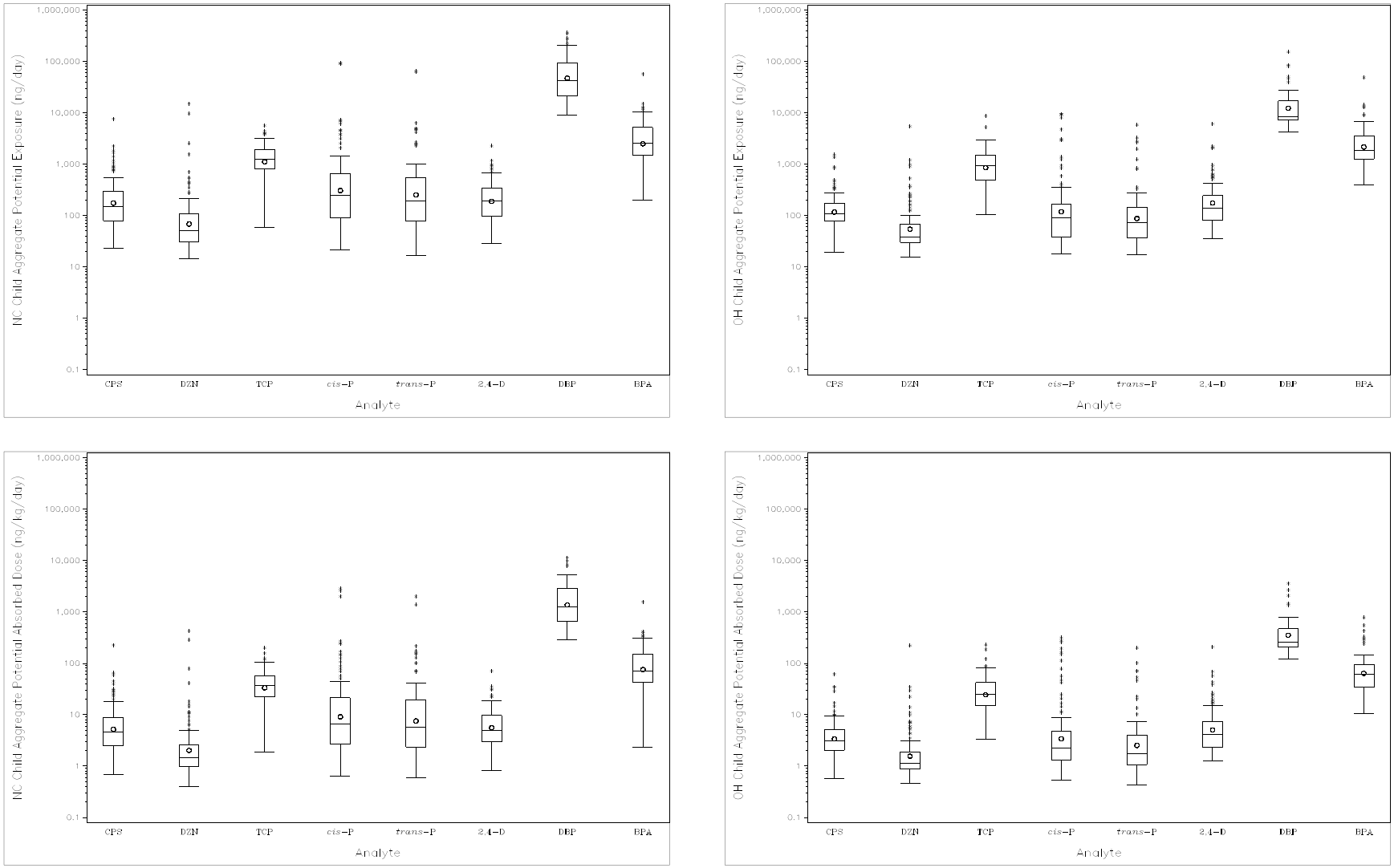


Figure 9.5.7 Boxplots of Estimated <u>Aggregate Potential Exposure and Aggregate Potential Absorbed Dose</u> for Participating NC and OH <u>Children</u>, for Eight Pollutants

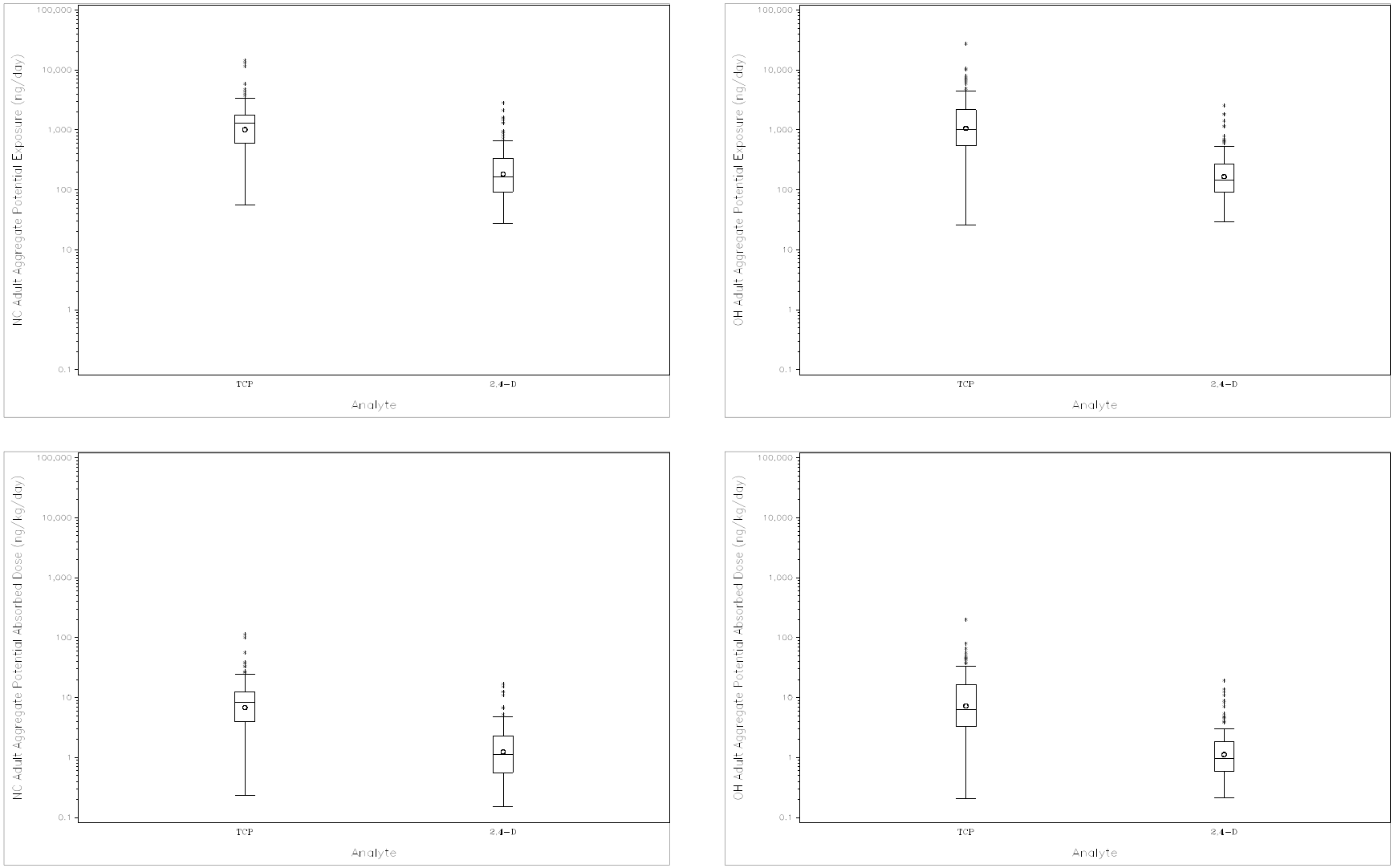


Figure 9.5.8 Boxplots of Estimated <u>Aggregate Potential Exposure and Aggregate Potential Absorbed Dose</u> for Participating NC and OH <u>Adults</u>, for Eight Pollutants

When multiple urine samples were taken for a given study participant during the study, the geometric mean concentration was used in the summaries and analyses.

Descriptive statistics of the urine biomarker concentrations are presented in Appendix P for NC and Appendix Q for OH. Each appendix contains separate sets of tables for children and adults, and within each set, each pollutant and metabolite is represented by two tables for ease in display. The descriptive statistics are presented across all study participants, as well as separately for each stratum: urban, rural, low-income, middle/high-income, stay-at-home children (or adults with stay-at-home children), and day care children (or adults with day care children).

For both states, 3,5,6-TCP and 2,4-D were measured in urine samples of study participants and were considered in estimating aggregate potential exposure level and aggregate potential absorbed dose estimates for study participants. For these two target pollutants, along with pentachlorophenol, the descriptive statistics associated with unadjusted urine concentrations are also presented in Table 9.5.7 and Table 9.5.8 for NC children and OH children, respectively.

Boxplots of the unadjusted urine concentrations for 3,5,6-TCP and 2,4-D are presented in Figure 9.5.9, with separate boxplots for children and adults, as well as by state. These boxplots show that, in general, levels of 3,5,6-TCP covered a higher range than for 2,4-D, and for both, similar distributions were observed between children and adults and between NC and OH. While the boxplots in Figure 9.5.9 resemble those for aggregate potential exposure and absorbed dose that are given in Figure 9.5.8, the urine concentrations have less of a difference between the two states in the range covered by the distributions. See Section 9.3.1 for how to interpret the boxplots.

9.5.4 Sub-goal 3.4: To Determine on Average How These Exposure and Dose Metrics for Each Route and Aggregated over Routes Differ Between Children in Urban and Rural Settings, Children in Low- and Middle/High-Income Families, Day Care and Stay-at-Home Children, Children and Adults in the Same Household Overall, and Children and Adults by Stratum

To address this sub-goal, a statistical analysis was performed on the (log-transformed) potential exposure level and potential absorbed dose estimates (by exposure route and aggregated across routes[1]) and on urine biomarker concentrations to determine whether these measures differ significantly 1) between children in urban and rural settings, 2) between children in low- and middle/high-income families, and 3) between day care and stay-at-home children. In each case, an analysis of variance using model (8-7) in Section 8.5.2.2 was performed to calculate a least squares mean of the log-transformed measures for each stratum (i.e., urban, rural, low-income, middle/high-income, stay-at-home child, day care child). Then, in the manner described in

[1] Analysis of aggregated exposures and absorbed dose estimates was performed only for the eight pollutants mentioned at the end of Section 9.2.

Table 9.5.7 Summary of Unadjusted Urinary Biomarker Concentrations (ng/mL) for Three Pollutants and Metabolites Measured in the Urine of Participating NC Children[a]

Strata	N	% Detected	Arith. Mean	Standard Deviation	Geom. Mean	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
3,5,6-TCP										
Overall	128	98	7.28	10.3	5.22	3.70	5.26	8.18	15.5	104
Urban	107	98	7.28	10.9	5.18	3.68	5.22	8.28	13.3	104
Rural	21	100	7.28	6.93	5.46	3.95	5.29	6.51	19.9	30.9
Low-Income	59	98	6.55	7.36	4.90	3.40	5.08	5.86	19.9	49.1
Mid/High-Income	65	99	8.02	12.7	5.48	3.81	5.22	10.1	14.7	104
Home Children	65	97	8.12	13.7	5.15	3.68	5.16	8.27	15.5	104
Day Care Children	63	100	6.42	4.76	5.31	3.74	5.29	7.82	12.0	30.9
2,4-D										
Overall	128	94	0.775	0.561	0.594	0.343	0.652	1.09	1.97	2.64
Urban	107	94	0.812	0.575	0.624	0.349	0.690	1.10	2.11	2.64
Rural	21	95	0.583	0.453	0.465	0.280	0.430	0.656	1.40	1.97
Low-Income	59	97	0.836	0.558	0.665	0.405	0.736	1.10	1.97	2.64
Mid/High-Income	65	91	0.707	0.573	0.522	0.276	0.510	0.945	2.11	2.61
Home Children	65	88	0.715	0.556	0.519	0.245	0.510	1.07	1.93	2.41
Day Care Children	63	100	0.836	0.565	0.684	0.412	0.707	1.10	2.17	2.64
Pentachlorophenol										
Overall	128	89	0.605	0.629	0.433	0.262	0.394	0.654	1.92	3.45
Urban	107	89	0.639	0.672	0.447	0.258	0.400	0.694	2.43	3.45
Rural	21	91	0.433	0.280	0.369	0.290	0.328	0.500	0.901	1.33
Low-Income	59	95	0.659	0.625	0.498	0.296	0.460	0.773	1.92	3.45
Mid/High-Income	65	85	0.571	0.649	0.388	0.220	0.335	0.564	2.43	3.08
Home Children	65	80	0.641	0.734	0.419	0.246	0.370	0.658	2.70	3.45
Day Care Children	63	98	0.567	0.500	0.448	0.281	0.402	0.646	1.38	2.84

[a] For a given study subject, multiple sample results have been log-transformed (after replacing not detected results by the MDL divided by the square root of 2), averaged, and exponentiated back to regular units prior to summarizing the data within a stratum. This result is labeled as "detected" if any measurement entering into the calculation was detected. Thus, N specifies the number of participants having data entering into the summaries.

Table 9.5.8 Summary of Unadjusted Urinary Biomarker Concentrations (ng/mL) for Three Pollutants and Metabolites Measured in the Urine of Participating OH Children[a]

Strata	N	% Detected	Arith. Mean	Standard Deviation	Geom. Mean	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
3,5,6-TCP										
Overall	122	100	5.61	3.38	4.64	2.87	5.07	7.33	12.3	15.3
Urban	107	100	5.68	3.43	4.71	2.90	4.79	7.50	12.8	15.3
Rural	15	100	5.08	3.07	4.21	2.08	5.28	6.12	12.3	12.3
Low-Income	40	100	5.68	3.11	4.89	3.38	5.15	7.42	12.0	14.1
Mid/High-Income	70	100	5.69	3.59	4.60	2.73	5.12	7.78	13.3	15.3
Home Children	67	100	6.05	3.73	4.90	3.01	5.28	9.08	12.9	15.3
Day Care Children	55	100	5.06	2.84	4.34	2.68	4.43	6.88	11.2	12.8
2,4-D										
Overall	126	98	1.32	1.59	0.927	0.566	1.02	1.35	3.59	12.5
Urban	109	98	1.32	1.68	0.902	0.560	0.994	1.34	3.59	12.5
Rural	17	100	1.30	0.904	1.11	0.857	1.15	1.36	4.35	4.35
Low-Income	40	100	1.36	1.14	1.03	0.589	1.12	1.60	3.97	5.63
Mid/High-Income	73	97	1.37	1.90	0.908	0.550	1.02	1.33	7.04	12.5
Home Children	69	97	1.50	1.84	1.03	0.710	1.16	1.44	4.35	12.5
Day Care Children	57	100	1.10	1.21	0.816	0.525	0.809	1.17	3.21	7.55
Pentachlorophenol										
Overall	126	99	1.27	2.20	0.876	0.536	0.835	1.39	2.71	23.8
Urban	109	99	1.23	2.32	0.830	0.520	0.755	1.38	2.47	23.8
Rural	17	100	1.52	1.19	1.25	0.871	1.24	1.52	5.23	5.23
Low-Income	40	100	1.05	0.884	0.797	0.486	0.769	1.59	2.33	5.02
Mid/High-Income	73	99	1.47	2.80	0.959	0.640	0.876	1.39	3.56	23.8
Home Children	69	99	1.54	2.89	0.993	0.640	0.920	1.39	3.96	23.8
Day Care Children	57	100	0.946	0.638	0.753	0.483	0.738	1.36	2.37	2.71

[a] For a given study subject, multiple sample results have been log-transformed (after replacing not detected results by the MDL divided by the square root of 2), averaged, and exponentiated back to regular units prior to summarizing the data within a stratum. This result is labeled as "detected" if any measurement entering into the calculation was detected. Thus, N specifies the number of participants having data entering into the summaries.

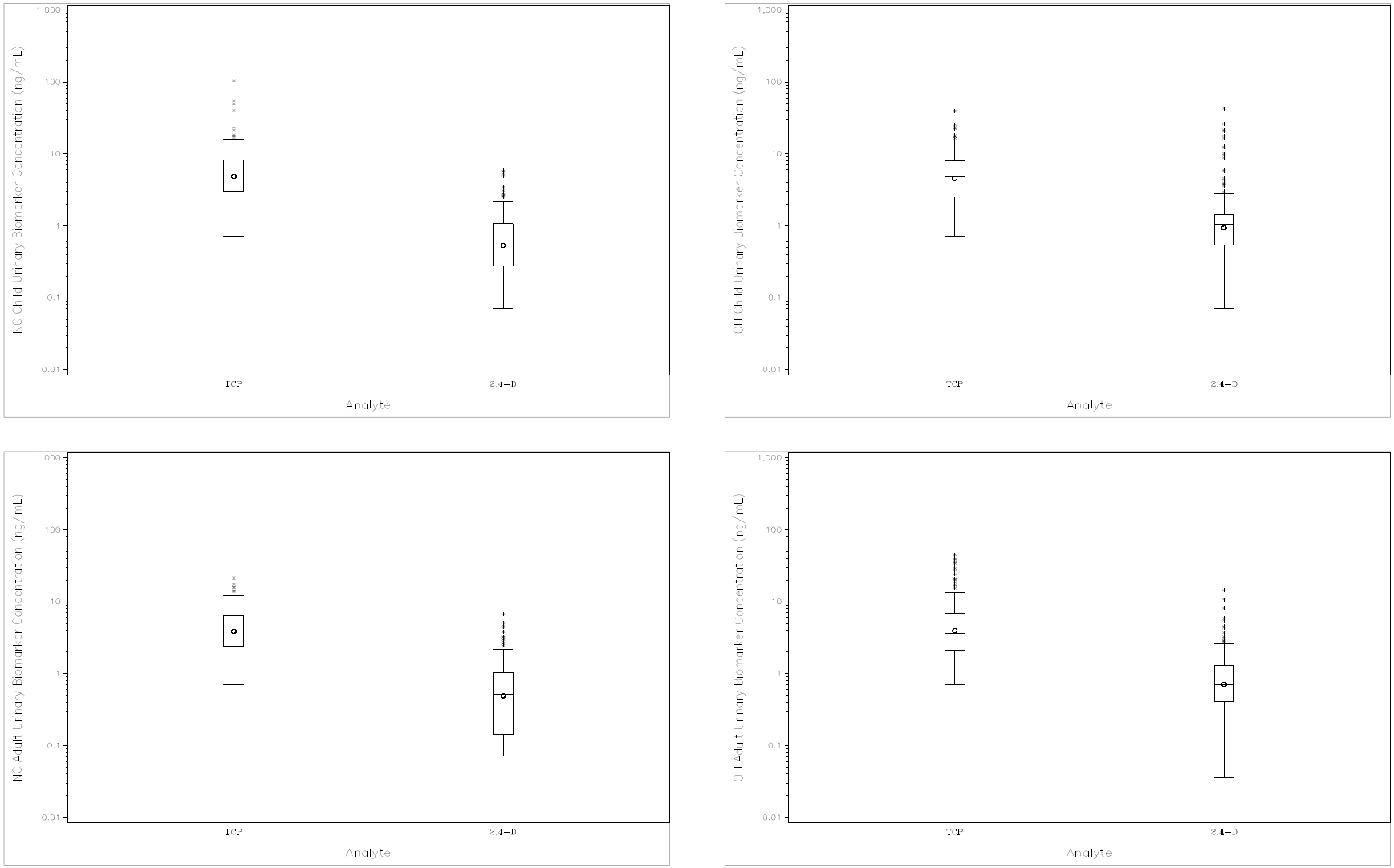


Figure 9.5.9 Boxplots of <u>Urinary Biomarker Concentrations</u> for Participating NC and OH Children and Adults, for Eight Pollutants

Section 9.3.2, a ratio of least-squares geometric mean concentrations was calculated between the above pairs of strata, along with an approximate 95% confidence interval on this ratio.

For children's potential exposure level and potential absorbed dose estimates, ratios and confidence intervals are presented by pollutant and exposure route in Appendix R (Table R-1 for NC and Table R-2 for OH). These ratios are of the least-squares geometric mean for the first stratum specified in the column heading versus the second specified stratum, and 95% confidence intervals are shown in parentheses. The t-test applied to the log-transformed data also is a test of whether this ratio differs significantly from one; p-values associated with these tests are also given in Appendix R, within the second, third, and fourth columns in Table R-3 (for NC) and Table R-4 (for OH).

Table 9.5.9 has condensed the information presented in Tables R-1 and R-2 of Appendix R by presenting only those ratios which were significantly different from one at the 0.05 level. Thus, Table 9.5.9 contains one row for each combination of pollutant, parameter, and exposure route having at least one of the three ratios significantly different from one at the 0.05 level in either state. When a ratio is not specified in this table and a dash does not appear in its place (meaning that the criteria placed on the percentage of detected concentrations entering into calculation of the exposure/dose estimate were met for performing statistical analysis), then the ratio was not significantly different from one at the 0.05 level.

To illustrate how to interpret the numbers in Table 9.5.9 and Tables R-1 and R-2, analysis of 3,5,6-TCP data from OH suggest that potential exposure level via inhalation is about 70% higher in low-income children than in middle/high-income children (ratio=1.70), and potential exposure level via indirect ingestion is about 81% higher in day care children than in stay-at-home children (ratio=1.81). Both are significantly different from one at the 0.05 level but not at the 0.01 level.

For the urinary biomarker concentrations, ratios between the specified strata and 95% confidence intervals on these ratios are presented by pollutant in Appendix R (Table R-5 for NC and Table R-6 for OH). For a given state, these concentrations were statistically analyzed, and ratios were reported, only for those pollutants in which at least 50% of urine samples had detected concentrations. P-values associated with t-tests applied to the log-transformed urinary biomarker concentrations to test whether these ratios differ significantly from one are also given in Appendix R, within the second, third, and fourth columns in Table R-7 (for NC) and Table R-8 (for OH). Among all ratios reported in Table R-5 and R-6 of Appendix R, significant differences from one were reported only for 2,4-D in OH, where the geometric mean for OH stay-at-home children was about 65% of the geometric mean for OH day care children under each form of the urinary concentration (i.e., unadjusted, creatinine-adjusted, specific gravity-adjusted).

Table 9.5.9 Estimated Ratios Between Selected Strata of Geometric Mean Potential Exposure and Potential Absorbed Dose Estimates in Participating NC and OH Children, When These Ratios Were Significantly Different from One at the 0.05 Level[a]

Pollutant/ Metabolite	Exposure/Dose Parameter and Pathway	Estimated Ratio of Geometric Means (When Significantly Different from 1 at the 0.05 Level)					
		North Carolina			Ohio		
		Urban vs. Rural	Low- vs. Mid/High-Income	Day Care vs. Home	Urban vs. Rural	Low- vs. Mid/High-Income	Day Care vs. Home
OP Pesticides and Metabolites							
Chlorpyrifos	Exposure/Dietary Ingestion[b]					2.00**	
	Exposure/Indirect Ingestion[c]						2.52**
	Dose/Dietary Ingestion[d]					2.06**	
	Dose/Indirect Ingestion[e]						2.33*
	Aggregated Exposure[f]					1.64*	
	Aggregated Dose[g]					1.66*	
Diazinon	Exposure/Inhalation[h]		2.24*				2.02*
	Exposure/Dietary Ingestion						1.37**
	Exposure/Indirect Ingestion						3.45**
	Dose/Inhalation[i]		2.14*				1.88*
	Dose/Dietary Ingestion						1.28*
	Dose/Indirect Ingestion						3.22*
	Aggregated Exposure						1.66*
	Aggregated Dose						1.52*
3,5,6-TCP	Exposure/Inhalation					1.70*	
	Exposure/Dietary Ingestion		0.65*	1.82*			
	Exposure/Indirect Ingestion						1.81*
	Dose/Inhalation					1.73*	
	Dose/Dietary Ingestion		0.60**				
	Aggregated Exposure		0.61*	1.76*			
	Aggregated Dose		0.56**				
Pyrethroid Pesticides							
Cyfluthrin	Exposure/Indirect Ingestion				2.47*		
	Dose/Indirect Ingestion				2.44*		
cis-Permethrin	Exposure/Inhalation		2.38**				
	Exposure/Dietary Ingestion						3.14**
	Exposure/Indirect Ingestion						1.95*
	Dose/Inhalation		2.26**				
	Dose/Dietary Ingestion						2.92**
	Aggregated Exposure						2.34*
	Aggregated Dose						2.16*

Table 9.5.9 Estimated Ratios Between Selected Strata of Geometric Mean Potential Exposure and Potential Absorbed Dose Estimates in Participating NC and OH Children, When These Ratios Were Significantly Different from One at the 0.05 Level[a] (cont.)

Pollutant/ Metabolite	Exposure/Dose Parameter and Pathway	Estimated Ratio of Geometric Means (When Significantly Different from 1 at the 0.05 Level)					
		North Carolina			Ohio		
		Urban vs. Rural	Low- vs. Mid/High-Income	Day Care vs. Home	Urban vs. Rural	Low- vs. Mid/High-Income	Day Care vs. Home
trans-Permethrin	Exposure/Inhalation		2.45**				
	Exposure/Dietary Ingestion						2.92**
	Dose/Inhalation		2.31**				
	Dose/Dietary Ingestion						2.72*
Acid Herbicides							
2,4-D	Exposure/Inhalation			2.23**			
	Exposure/Dietary Ingestion			1.59*			
	Exposure/Indirect Ingestion	3.39**	0.27**	0.54*	2.80*	0.29**	
	Dose/Inhalation			1.94*			
	Dose/Indirect Ingestion	3.68**	0.25**	0.47*	2.84*	0.29**	
PAHs							
Benz[*a*]anthracene	Exposure/Indirect Ingestion				3.69**	0.43**	3.29**
	Dose/Indirect Ingestion				3.65**	0.43**	3.08**
Benzo[*b*]fluoranthene	Exposure/Inhalation		1.58*				
	Exposure/Indirect Ingestion			1.81*	3.55**	0.43**	3.15**
	Dose/Inhalation		1.52*				
	Dose/Indirect Ingestion				3.52**	0.43**	2.94**
Benzo[*k*]fluoranthene	Exposure/Inhalation		1.25*				
	Exposure/Indirect Ingestion				3.18**	0.43**	3.16**
	Dose/Indirect Ingestion				3.16**	0.43**	2.95**
Benzo[*ghi*]perylene	Exposure/Indirect Ingestion				3.18**	0.43**	3.12**
	Dose/Indirect Ingestion				3.16**	0.43**	2.92**
Benzo[*a*]pyrene	Exposure/Inhalation		1.57**				
	Exposure/Indirect Ingestion				3.35**	0.41**	3.09**
	Dose/Inhalation		1.51*				
	Dose/Indirect Ingestion				3.32**	0.41**	2.89**
Benzo[*e*]pyrene	Exposure/Inhalation		1.36*				
	Exposure/Indirect Ingestion				3.23**	0.43**	3.04**
	Dose/Inhalation		1.31*				
	Dose/Indirect Ingestion				3.21**	0.44**	2.84**

Table 9.5.9 Estimated Ratios Between Selected Strata of Geometric Mean Potential Exposure and Potential Absorbed Dose Estimates in Participating NC and OH Children, When These Ratios Were Significantly Different from One at the 0.05 Level[a] (cont.)

Pollutant/ Metabolite	Exposure/Dose Parameter and Pathway	Estimated Ratio of Geometric Means (When Significantly Different from 1 at the 0.05 Level)					
		North Carolina			Ohio		
		Urban vs. Rural	Low- vs. Mid/High-Income	Day Care vs. Home	Urban vs. Rural	Low- vs. Mid/High-Income	Day Care vs. Home
Chrysene	Exposure/Inhalation		1.57**				
	Exposure/Indirect Ingestion				3.51**	0.42**	3.24**
	Dose/Inhalation		1.52*				
	Dose/Indirect Ingestion				3.47**	0.42**	3.03**
Dibenz[*a*,*h*] anthracene	Exposure/Indirect Ingestion				3.50**	0.44**	3.19**
	Dose/Indirect Ingestion				3.47**	0.44**	2.98**
Indeno[1,2,3-*cd*] pyrene	Exposure/Inhalation		1.48*				
	Exposure/Indirect Ingestion				3.34**	0.43**	3.20**
	Dose/Inhalation		1.43*				
	Dose/Indirect Ingestion				3.31**	0.43**	3.00**
Phthalates							
Benzylbutylphthalate	Exposure/Dietary Ingestion	--	--	--			2.83**
	Exposure/Indirect Ingestion						2.73**
	Dose/Dietary Ingestion	--	--	--			2.44*
	Dose/Indirect Ingestion						2.54**
Di-*n*-butylphthalate	Exposure/Inhalation			1.77**	0.65*		1.44*
	Exposure/Dietary Ingestion						2.17**
	Exposure/Indirect Ingestion						2.02**
	Dose/Inhalation			1.54**	0.63*		1.34*
	Dose/Dietary Ingestion		0.58*				1.87*
	Dose/Indirect Ingestion						1.88**
	Aggregated Exposure						2.07**
	Aggregated Dose						1.76*
Phenols							
Bisphenol-A	Exposure/Inhalation					1.38*	
	Exposure/Dietary Ingestion			2.47**			
	Dose/Dietary Ingestion			2.19**			
	Aggregated Exposure			2.12**			
	Aggregated Dose			1.85**			

Table 9.5.9 Estimated Ratios Between Selected Strata of Geometric Mean Potential Exposure and Potential Absorbed Dose Estimates in Participating NC and OH Children, When These Ratios Were Significantly Different from One at the 0.05 Level[a] (cont.)

Pollutant/ Metabolite	Exposure/Dose Parameter and Pathway	Estimated Ratio of Geometric Means (When Significantly Different from 1 at the 0.05 Level)					
		North Carolina			Ohio		
		Urban vs. Rural	Low- vs. Mid/High-Income	Day Care vs. Home	Urban vs. Rural	Low- vs. Mid/High-Income	Day Care vs. Home
PCBs							
PCB101	Exposure/Inhalation						1.73*

[a] Dashed cells indicate that no analysis was performed on the exposure/dose estimates for the given exposure route due to the sample media entering into their calculation not achieving requirements on the percentage of detected measures. Blank cells indicate that a ratio was estimated but was not significantly different from one at the 0.05 level. Note that pollutants, or exposure routes for a given pollutant, have been excluded from this table if all cells within the rows corresponding to these pollutants or exposure routes would have been blank or dashed within this table. All estimated ratios for each exposure route and each pollutant, along with corresponding 95% confidence intervals on these ratios, are presented in Table R-1 (NC) and Table R-2 (OH) of Appendix R.

[b] Potential exposure level via dietary ingestion

[c] Potential exposure level via indirect ingestion

[d] Potential absorbed dose via dietary ingestion

[e] Potential absorbed dose via indirect ingestion

[f] Aggregated potential exposure level

[g] Aggregated potential absorbed dose

[h] Potential exposure level via inhalation

[i] Potential absorbed dose via inhalation

* Statistically significantly different from 1 at the 0.05 level, but not at the 0.01 level.

** Statistically significantly different from 1 at the 0.01 level.

9.5.4.1 Results of Analyses on NC Exposure/Dose Estimates and Urinary Biomarker Concentrations

Between urban and rural NC children, potential exposure level and potential absorbed dose differed significantly at the 0.01 level in only one instance: for 2,4-D via indirect ingestion. On average, urban NC children had estimated potential exposure/dose estimates for 2,4-D via indirect ingestion that exceeded three times that of rural NC children.

Significant differences between low-income and middle/high-income strata in estimated potential exposure and/or absorbed dose via inhalation for NC children were observed at the 0.01 level for *cis*- and *trans*-permethrin and chrysene, and at the 0.05 level for five other PAHs (benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, benzo[*e*]pyrene, and indeno[1,2,3-*cd*]pyrene) and diazinon. Via the inhalation route, low-income NC children tended to have 36% to 58% higher exposure levels and absorbed doses of the PAHs compared to middle/high-income children, and from 100% to 150% higher exposure levels and absorbed doses for diazinon, *cis*- and *trans*-permethrin. Via the indirect ingestion route, significant differences existed in potential exposures and absorbed dose at the 0.01 level for 2,4-D, where low-income NC children experienced only 25% of the potential exposure levels and absorbed

doses compared to middle/high-income children. For 3,5,6-TCP, significant differences were observed at the 0.01 level for potential absorbed dose via the dietary ingestion route and for aggregate potential absorbed dose (and at the 0.05 level for potential exposure level via indirect ingestion and for aggregate potential exposure), where low-income NC children averaged about 60% of the potential exposures and absorbed doses compared to middle/high-income children.

Compared to stay-at-home children, NC children who attend day care centers were associated with 59% to 123% higher estimated potential exposure levels and absorbed doses to 2,4-D via the inhalation and dietary ingestion routes, but approximately 50% lower exposures/doses via the indirect ingestion route. These differences were statistically significant at the 0.05 level, with one (exposure via inhalation) significant at the 0.01 level. These two groups of children also differed significantly at the 0.01 level in estimated potential exposure levels and absorbed doses via dietary ingestion for bisphenol-A and via inhalation for di-*n*-butylphthalate. In each case, day care children tended to have from 54% to 147% higher estimated exposure or absorbed dose estimates compared to stay-at-home children. For bisphenol-A, the estimated aggregated potential exposure and absorbed dose for day care children was significantly different from (and approximately twice as high as) stay-at-home children at the 0.01 level.

Table R-5 of Appendix R shows that statistical analysis of urinary biomarker concentration was limited to 2,4-D, 3,5,6-TCP, and pentachlorophenol, as these were the only pollutants that were analyzed in urine (out of six) and detected in at least 50% of the samples for NC children. IMP measurements in NC urine samples were not statistically analyzed because the analytical method did not provide adequate quantitative recoveries. Urine concentrations for participating NC children did not differ significantly at the 0.05 level between the three pairs of strata (urban vs. rural, low-income vs. middle/high-income, day care vs. stay-at-home children) for these three pollutants, regardless of whether the concentrations were adjusted for specific gravity or creatinine levels.

9.5.4.2 Results of Analyses on OH Exposure/Dose Estimates and Urinary Biomarker Concentrations

Between urban and rural OH children, estimated potential exposure level and potential absorbed dose via the indirect ingestion route differed significantly at the 0.01 level for all nine target PAHs, where urban OH children had estimated potential exposure/dose estimates that were from three to four times as high, on average, than rural OH children, and at the 0.05 level for cyfluthrin and 2,4-D, where estimates for urban OH children were from two to three times as high as rural children. For di-*n*-butylphthalate via the inhalation route, estimated potential exposure/dose estimates for urban OH children differed significantly at the 0.05 level and were only about 65% of the estimates for rural OH children, on average. For those pollutants having aggregate exposure/dose calculated, no significant differences were observed at the 0.05 level between urban and rural OH children.

Significant differences between low-income and middle/high-income OH children in potential exposure and/or absorbed dose were observed at the 0.01 level for 2,4-D and all target PAHs via indirect ingestion and for chlorpyrifos via dietary ingestion. When significant differences occurred via indirect ingestion, low-income OH children tended to have exposures/doses that were 30% to 45% lower than middle/high-income OH children. In contrast, low-income OH children had chlorpyrifos exposures via dietary ingestion that were twice as high on average as for middle/high-income OH children. Exposures via inhalation to bisphenol-A and 3,5,6-TCP were 38% and 70% higher, respectively, for low-income children compared to middle/high-income children, but these were significant only at the 0.05 level. For those pollutants having aggregate exposure/dose calculated, significant differences in these aggregated estimates between low-income and middle/high-income OH children were observed only for chlorpyrifos and at the 0.05 level, with low-income children averaging about 65% higher estimates for both potential exposure and absorbed dose.

Significant differences in potential exposure and/or potential absorbed dose estimates between OH day care children and OH stay-at-home children were observed at the 0.01 level for chlorpyrifos, the nine target PAHs, benzylbutylphthalate, and *cis*-permethrin via indirect ingestion; for *cis*- and *trans*-permethrin via dietary ingestion; and for diazinon, benzylbutylphthalate, and di-*n*-butylphthalate via both exposure routes. In all of these instances, day care children averaged higher exposures and/or doses compared to stay-at-home children. The largest differences occurred with the PAHs and diazinon via indirect ingestion, where exposure/dose estimates averaged over three times higher for day care children than for stay-at-home children. Aggregate potential exposure level and/or aggregate potential absorbed dose differed significantly between day care and stay-at-home children at the 0.01 level for di-*n*-butylphthalate, and at the 0.05 level for diazinon and *cis*- and *trans*-permethrin, with the largest differences between the two groups occurring for the two permethrins (where day care children averaged more than double the exposure levels and/or doses compared to stay-at-home children when they differed significantly).

Table R-6 of Appendix R shows that statistical analysis of urinary biomarker concentration was performed for five pollutants (2,4-D, 3,5,6-TCP, 1-hydroxypyrene, pentachlorophenol, 3-PBA) that were analyzed in urine for OH and were detected in at least 50% of the samples for OH children. Urine concentrations differed significantly at the 0.05 level between day care and stay-at-home OH children only for 2,4-D, with this result holding for unadjusted and adjusted urine concentrations. Here, day care children tended to have 2,4-D concentrations in urine samples that were only about 65% of the concentrations for stay-at-home children. No other significant differences between strata were observed for any other pollutant, regardless of whether the concentrations were adjusted for specific gravity or creatinine levels.

9.5.4.3 Comparing Potential Exposure, Potential Absorbed Dose, and Urine Concentrations Between Children and Adults in the Same Household

For potential exposure level and potential absorbed dose, Table R-9 of Appendix R presents estimated ratios of geometric means for NC children versus adults in the same

household for a given exposure route, along with 95% confidence intervals on this ratio. Table R-10 presents the same results for the urinary biomarker concentrations for NC. The corresponding tables for the OH portion of the study are Table R-11 (potential exposure level and potential absorbed dose) and Table R-12 (urinary biomarker) of Appendix R. In Tables R-9 through R-12, a ratio of greater than one implies that the given exposure or dose measurement tended to be higher for the monitored child than for the child's adult caregiver in the same household. The columns of these tables specify the strata for which the ratio represents, with the first of these columns representing the entire set of study households within the given state. P-values for the statistical tests which were below 0.05 (indicating significant differences at the 0.05 level) are found in the last four columns of Table R-3 (for NC potential exposure and absorbed dose), Table R-4 (for OH potential exposure and absorbed dose), Table R-7 (for NC urinary biomarker concentrations) and Table R-8 (for OH urinary biomarker concentrations) in Appendix R.

For both states and for nearly all exposure routes, statistically significant differences were observed at the 0.01 level in potential exposure/dose estimates for each target pollutant between participating children and their adult caregivers living in the same households. The nature of the differences between children and adults was heavily influenced by the physiological and behavioral differences between them. For example, via the inhalation route, children tended to have lower potential exposures to these pollutants than their adult caregivers, but this was primarily due to their lower ventilation rates. In contrast, potential absorbed doses were higher for children than for adults because of their smaller body weights. Via the indirect ingestion route, children tended to have higher potential exposure/dose levels than adults, partly because children tend to have higher soil and dust ingestion rates than adults due to their different activity patterns. For the dietary ingestion route, statistical analyses to compare children and adult exposures could be performed only on 2,4-D, PCP, and 3,5,6-TCP data, due to neutral pollutants not being measured in adult food samples. When significant differences were present between children and adults for potential exposure/dose via dietary ingestion, children tended to have higher estimates than adults. For both states, estimated aggregate potential absorbed dose levels for 2,4-D and 3,5,6-TCP differed significantly at the 0.01 level between children and their adult caregivers within the same household, with children having roughly 4 to 5 times the potential absorbed dose compared to adults.

The estimates in Table R-10 of Appendix R indicate that there is no statistically significant difference in urinary 2,4-D concentrations (ng/mL) at the 0.05 level between participating NC children and adults in the same household when the concentrations are either unadjusted or adjusted for specific gravity. However, if adjusted for creatinine (μmole/mole), 2,4-D concentrations averaged about 80% higher in children samples versus adult samples. This difference was statistically significant at the 0.01 level, as were differences associated with children in NC urban areas, from low-income families, or who attended day care centers. When either unadjusted or adjusted for specific gravity, urinary concentrations in children were from 30% to 40% higher than their adult caregivers for PCP and 3,5,6-TCP, with the differences being statistically significant at the 0.05 level. However, when urinary concentrations were adjusted for creatinine levels, these differences became considerably larger and significant at the 0.01

level. This trend (i.e., children having higher concentrations of 2,4-D, PCP, and 3,5,6-TCP compared to their adult caregivers) agreed with that seen for estimated aggregate potential absorbed dose in Table R-9.

The descriptive statistics of NC urinary biomarker concentrations, found in Appendix P, show that two hydroxy-PAHs were detected in fewer children's urine samples than adults' urine samples. These two pollutants were detected in less than 3% of all children's urine samples (n=128). In contrast, detectable levels of 1-hydroxybenz[*a*]anthracene and 3-hydroxychrysene were found in approximately 31% and 8%, respectively, of adults' urine samples (n=128). In the previous pilot study (7), these two hydroxy-PAHs were detected in more than 70% of the urine samples (24 children and 24 adults). This greater detection in the earlier study is primarily due to the analytical method used in the previous study, which was targeted at PAH metabolites and had a lower estimated detection limits (~0.01 ng/mL). The method used for the CTEPP study was modified in order to include metabolites from other pollutant classes such as 2,4-D, PCP, and 3,5,6-TCP, which increased the estimated detection limit for hydroxy-PAHs to ~0.2 ng/mL.

For all five pollutants included in the analysis of OH urine data and in Table R-12, urine concentrations adjusted for creatinine levels differed significantly at the 0.01 level between OH children and adults in the same household, both overall and separately within each stratum. These creatinine-adjusted concentrations were higher in children samples by factors of 2 or 3 compared to adult samples. If no adjustment is made or when adjusting for specific gravity, urine concentrations differed significantly between children and adults at the 0.01 level for only three of the five pollutants (i.e., all but 1-hydroxypyrene and 3-phenoxybenzoic acid), and the extent to which children's concentrations were higher than adults was less than when a creatinine adjustment was made. Selected strata (rural, middle/high-income, day care children) did not see a significant difference at the 0.05 level between children and adults for 2,4-D urine concentrations that were either unadjusted or adjusted for specific gravity.

The descriptive statistics of OH urinary biomarker concentrations, found in Appendix Q, show that seven hydroxy-PAHs, 2,4-D, 3,5,6-TCP, 3-phenoxybenzoic acid, and PCP were measured in OH children and adults' urine samples. While IMP was also measured, the analytical method employed in this study could not provide quantitative recoveries for IMP, which contributed to less than 10% of urine samples having measurable levels of IMP. Detectable concentrations for 2,4-D, 3,5,6-TCP, 3-phenoxybenzoic acid, and PCP were found in most urine samples. While most OH children and adult urine samples had detectable concentrations for 1-hydroxypyrene, fewer urine samples had detectable levels of 1- and 3-hydroxybenz[*a*]anthracene and 3- and 6-hydroxy chrysene.

9.6 Goal 4: To Apportion Exposures among the Inhalation, Dietary Ingestion, and Indirect Ingestion Routes

For the eight pollutants and metabolites listed at the end of Section 9.2, aggregate potential exposure level and aggregate potential absorbed dose were estimated by summing the route-specific exposure/dose estimates across the three exposure routes characterized in this

study (inhalation, dietary ingestion, and indirect ingestion). The statistical analyses performed in support of Goal 4 characterized how these aggregate exposure/dose estimates were apportioned across the three exposure routes, so that the routes could be evaluated based on their contribution to total exposure/dose.

9.6.1 Sub-goal 4.1: To Estimate the Proportion of Aggregated Exposure and Dose that is Associated with a Given Exposure Route for Participating Children, Overall and by Stratum

Analysis #1 under Goal 4 involved calculating the proportion of aggregate potential exposure level and absorbed dose under each exposure route for each child participant, then fitting the logistic regression model (8-8) in Section 8.5.2.3 to these proportions to estimate mean proportions as a function of urbanicity, income category, and day care status. Table 9.6.1 contains estimates of the mean proportions that are attributable to each exposure route, calculated separately by pollutant and state across all participating children. Tables 9.6.2 and 9.6.3 contain mean proportions by stratum for NC and OH children, respectively, when the test for significance of the given strata (i.e., urban and rural strata, low-income and middle/high-income strata, or stay-at-home and day care strata) on the overall proportion was significant at the 0.05 level. Tables S-1 and S-2 of Appendix S contain estimates of mean proportions for each stratum and exposure route and 95% confidence intervals on these mean proportions, for participating children in NC and OH, respectively. Results presented in these tables represent mean proportions of both aggregate potential exposure level and aggregate potential absorbed dose.

Note that in some cases, the outcome of the statistical analysis presented in Tables 9.6.2 and 9.6.3, as well as Tables S-1 through S-4 in Appendix S, suggested that a significant stratum effect was present when, in fact, the estimated mean proportions within the different strata were either each very large or very small. Such an outcome does not necessarily suggest that the difference in the estimated proportion between the strata was significant from a practical standpoint. Thus, caution should be taken in making inferences from the results in these tables when the overall mean percentages for certain exposure routes were either very small (e.g., less than 5%) or very large (e.g., greater than 95%).

Among the adults in this study, exposure and dose estimates for all three exposure routes, and therefore aggregate exposure/dose estimates, could be characterized for only two of the eight pollutants (2,4-D and 3,5,6-TCP). This is because adult food samples were not analyzed for the other six pollutants, and therefore, dietary exposure/dose estimates could not be calculated for them. For these two pollutants, Table 9.6.4 contains estimates of the mean proportions attributable to each exposure route as calculated over all participating adult caregivers, by pollutant and state. Tables S-3 and S-4 of Appendix S contain estimates of mean proportions for each stratum and exposure route, as well as 95% confidence intervals on these mean proportions, for participating adults in NC and OH, respectively. Note from these two tables that for NC and OH adults, the stratum effect on the overall proportion was not significant at the 0.05 level for either of the two pollutants or for any of the exposure routes.

Table 9.6.1. Estimated Mean Proportion of Aggregate Potential Exposure Level and Potential Absorbed Dose in Participating NC and OH Children That is Attributable to Each Exposure Route, Calculated Across All Children[a]

Pollutant/Metabolite	Estimate of the Overall Mean Proportion of Aggregate Exposure/Dose in Participating Children					
	North Carolina			Ohio		
	Inhalation	Dietary Ingestion	Indirect Ingestion	Inhalation	Dietary Ingestion	Indirect Ingestion
OP Pesticides and Metabolite						
Chlorpyrifos	0.39	0.54	0.06	0.19	0.76	0.04
Diazinon	0.40	0.55	0.05	0.33	0.62	0.05
3,5,6-TCP	0.03	0.95	0.02	0.02	0.98	<0.01
Pyrethroid Pesticides						
cis-Permethrin	0.05	0.55	0.39	0.04	0.56	0.39
trans-Permethrin	0.04	0.57	0.37	0.04	0.58	0.37
Acid Herbicides						
2,4-D	0.03	0.95	0.02	0.03	0.92	0.03
Phthalates						
Di-*n*-butylphthalate	0.06	0.93	0.01	0.18	0.80	0.02
Phenols						
Bisphenol-A	0.01	0.99	<0.01	0.01	0.99	<0.01

[a] Estimates of mean proportions are based on a logistic regression analysis fitted to the mean proportions calculated for each participating child. Estimated 95% confidence intervals on these mean proportions are given in the second column of Table S-1 (NC) and Table S-2 (OH) of Appendix S.

Table 9.6.2 Estimated Mean Proportion of Aggregate Potential Exposure Level and Potential Absorbed Dose in Participating NC Children That is Attributable to Each Exposure Route, Calculated by Stratum, When Differences Between Pairs of Strata Were Significant at the 0.05 Level[a]

Pollutant/ Metabolite	Exposure Route	Stratum	Estimate of Stratum Mean Proportion	P-value of Test for Significant Stratum Effect
OP Pesticides and Metabolite				
Diazinon	Inhalation	Low-Income Children	0.46	0.008**
		Middle/High-Income Children	0.34	
	Indirect Ingestion	Low-Income Children	0.04	0.049*
		Middle/High-Income Children	0.06	
3,5,6-TCP	Inhalation	Low-Income Children	0.04	0.018*
		Middle/High-Income Children	0.02	
		Non-Day Care Children	0.03	0.019*
		Day Care Children	0.01	
Pyrethroid Pesticides				
cis-Permethrin	Inhalation	Low-Income Children	0.07	0.020*
		Middle/High-Income Children	0.03	
trans-Permethrin	Inhalation	Low-Income Children	0.07	0.004**
		Middle/High-Income Children	0.03	
		Non-Day Care Children	0.06	0.048*
		Day Care Children	0.03	
Acid Herbicides				
2,4-D	Dietary Ingestion	Urban Children	0.92	0.038*
		Rural Children	0.96	
	Inhalation	Urban Children	0.04	0.021*
		Rural Children	0.02	
	Indirect Ingestion	Low-Income Children	0.01	0.009**
		Middle/High-Income Children	0.03	
Phthalates				
Di-*n*-butylphthalate	Dietary Ingestion	Urban Children	0.91	0.014*
		Rural Children	0.94	
	Inhalation	Urban Children	0.08	0.010*
		Rural Children	0.05	
Phenols				
Bisphenol-A	Dietary Ingestion	Non-Daycare Children	0.98	<0.001**
		Daycare Children	0.99	
	Inhalation	Non-Daycare Children	0.02	<0.001**
		Daycare Children	0.01	

[a] Estimates of mean proportions for specific strata are based on a logistic regression analysis fitted to the mean proportions calculated for each participating child. Estimated 95% confidence intervals on these mean proportions are given in the fourth column of Table S-1 of Appendix S.
* Statistically significant at the 0.05 level, but not at the 0.01 level.
** Statistically significant at the 0.01 level.

Table 9.6.3 Estimated Mean Proportion of Aggregate Potential Exposure Level and Potential Absorbed Dose in Participating OH Children That is Attributable to Each Exposure Route, Calculated by Stratum, When Differences Between Pairs of Strata Were Significant at the 0.05 Level[a]

Pollutant/ Metabolite	Exposure Route	Stratum	Estimate of Stratum Mean Proportion	P-value of Test for Significant Stratum Effect
OP Pesticides and Metabolite				
Chlorpyrifos	Indirect Ingestion	Low-Income Children	0.03	<0.001**
		Middle/High-Income Children	0.05	
		Non-Day Care Children	0.03	0.038*
		Day Care Children	0.06	
Diazinon	Indirect Ingestion	Low-Income Children	0.03	0.009**
		Middle/High-Income Children	0.07	
3,5,6-TCP	Dietary Ingestion	Low-Income Children	0.97	0.023*
		Middle/High-Income Children	0.99	
	Inhalation	Low-Income Children	0.03	0.010**
		Middle/High-Income Children	0.01	
Pyrethroid Pesticides				
cis-Permethrin	Inhalation	Urban Children	0.06	0.010*
		Rural Children	0.03	
trans-Permethrin	Inhalation	Low-Income Children	0.02	<0.001**
		Middle/High-Income Children	0.06	
		Urban Children	0.05	0.015*
		Rural Children	0.03	
Acid Herbicides				
2,4-D	Dietary Ingestion	Low-Income Children	0.95	0.040*
		Middle/High-Income Children	0.89	
	Indirect Ingestion	Urban Children	0.07	<0.001**
		Rural Children	0.02	
Phthalates				
Di-*n*-butylphthalate	Dietary Ingestion	Non-Day Care Children	0.76	0.017*
		Day Care Children	0.84	
	Inhalation	Non-Day Care Children	0.22	0.047*
		Day Care Children	0.15	
	Indirect Ingestion	Non-Day Care Children	0.02	0.008**
		Day Care Children	0.01	
Phenols				
Bisphenol-A	Dietary Ingestion	Non-Daycare Children	0.99	0.015*
		Daycare Children	0.99	
	Inhalation	Urban Children	0.01	0.039*
		Rural Children	0.00	

[a] Estimates of mean proportions for specific strata are based on a logistic regression analysis fitted to the mean proportions calculated for each participating child. Estimated 95% confidence intervals on these mean proportions are given in the fourth column of Table S-2 of Appendix S.
* Statistically significant at the 0.05 level, but not at the 0.01 level.
** Statistically significant at the 0.01 level.

Table 9.6.4 Estimated Mean Proportion of Aggregate Potential Exposure Level and Potential Absorbed Dose in Participating NC and OH Adults That is Attributable to Each Exposure Route, Calculated Across All Adults[a]

Pollutant/Metabolite	Estimate of the Overall Mean Proportion in Participating Adults					
	North Carolina			Ohio		
	Inhalation	Dietary Ingestion	Indirect Ingestion	Inhalation	Dietary Ingestion	Indirect Ingestion
3,5,6-TCP	0.05	0.94	0.01	0.02	0.98	<0.01
2,4-D	0.05	0.93	0.01	0.04	0.93	0.03

[a] Estimates of mean proportions are based on a logistic regression analysis fitted to the mean proportions calculated for each participating adult. Estimated 95% confidence intervals on these mean proportions are given in the second column of Table S-3 (NC) and Table S-4 (OH) of Appendix S.

For NC children, the dietary ingestion exposure route was the dominant of the three routes for each of the eight pollutants, with the mean proportion exceeding 85% for 3,5,6-TCP, 2,4-D, di-*n*-butylphthalate, and bisphenol-A (Table 9.6.1). Similar results were observed for 3,5,6-TCP and 2,4-D in NC adults (Table 9.6.4). For the two OP pesticides (chlorpyrifos and diazinon), the mean proportion for the inhalation route in NC children was approximately 40%; this proportion was the highest seen for the inhalation route among the eight pollutants. (The estimated mean proportion for inhalation was less than 10% for each of the other six pollutants.) The mean percentage for the indirect ingestion route in NC children was below 10% for each pollutant except *cis*- and *trans*-permethrin, where the estimated percentages were 39% and 37%, respectively.

For OH children, the dietary ingestion exposure route was also the dominant of the three routes for each of the eight pollutants (Table 9.6.1). The mean proportion for the dietary ingestion route exceeded 90% for 3,5,6-TCP and 2,4-D (as it also did for OH adults), equaled 99% for bisphenol-A, equaled 80% for di-*n*-butylphthalate, exceeded 60% for the two OP pesticides (chlorpyrifos and diazinon), and exceeded 50% for *cis*- and *trans*-permethrin. The mean proportion for the inhalation route was largest for diazinon at 33%. The mean percentage for the indirect ingestion route was below 10% for most pollutants except for *cis*- and *trans*-permethrin, where the estimated percentages were 39% and 37%, respectively.

Because the two OP pesticides are more volatile than the two pyrethroid pesticides, this could partly contribute to differences in the level of importance of the exposure routes (inhalation vs. indirect ingestion) to total exposure/dose that was seen for both states.

9.6.2 Sub-goal 4.2: For Each Exposure Route, Determine if This Proportion Differs for Children in Urban and Rural Settings, from Low-and Middle/High-Income Families, and Who Attend Day Care or Stay at Home

The last column in Tables S-1 through S-4 of Appendix S contains p-values of tests performed in the logistic regression model fitting, with the tests determining whether the estimated mean proportion of total exposure/dose differs significantly between two strata for a given exposure route and pollutant. These tests were performed for three pairs of strata: low-income and middle/high-income level, urban and rural strata, and day care and stay-at-home children. For proportions of total exposure/dose associated with participating NC and OH children, those p-values falling below 0.05 were documented in the last columns of Tables 9.6.2 and 9.6.3, respectively. (For adults in both NC and OH, none of these p-values in Tables S-3 and S-4 of Appendix S are below 0.05 for either 3,5,6-TCP or 2,4-D.)

For NC children (Table 9.6.2), significant differences in the mean proportion were observed at the 0.05 level between low-income and middle/high-income strata for diazinon via the inhalation and indirect ingestion routes, for 3,5,6-TCP and for *cis*- and *trans*-permethrin via the inhalation route, and for 2,4-D via the indirect ingestion route. Significant differences between urban and rural children were observed at the 0.05 level for 2,4-D and di-*n*-butylphthalate via the dietary ingestion and inhalation routes. Significant differences between day care and non-day care children were observed at the 0.05 level for 3,5,6-TCP via the indirect ingestion route, for *trans*-permethrin via the inhalation route, and for bisphenol-A via each route. However, the estimated proportion of total exposure/dose of bisphenol-A attributed to indirect ingestion was virtually zero, implying that any difference among strata was not significant from a practical standpoint.

For OH children (Table 9.6.3), significant differences in the mean proportion were observed at the 0.05 level between low-income and middle/high-income strata for the two OP pesticides (chlorpyrifos and diazinon) via the indirect ingestion route, for 3,5,6-TCP via the dietary and inhalation routes, for *trans*-permethrin via the inhalation route, and for 2,4-D via the dietary ingestion route. Significant differences between OH urban and rural children were observed at the 0.05 level for bisphenol-A and *cis*- and *trans*-permethrin via the inhalation route and for 2,4-D via the indirect ingestion route. Significant differences between OH stay-at-home and day care children were observed at the 0.05 level for chlorpyrifos via the indirect ingestion route, for di-*n*-butylphthalate in each route, and for bisphenol-A via the dietary ingestion and inhalation routes.

9.6.3 Sub-goal 4.3: Determine Whether Significant Differences Exist Between Exposure Routes

Analysis #2 in Section 8.5.2.3 was used to compare average log-transformed potential exposure level and potential absorbed dose measures between exposure routes. This analysis involved fitting model (8-9) of Section 8.5.2.3 to log-transformed measures (represented as a vector of measures for the three exposure routes) within a multivariate analysis of variance

(ANOVA). This analysis was performed separately for each pollutant addressed under Goal 4, as well as separately for potential exposure level and potential absorbed dose, for children and adults, and for each state.

Results of the multivariate ANOVAs indicated that for each pollutant, highly significant differences existed between exposure routes for both potential exposure level and potential absorbed dose ($p<0.0001$). This result held for both children and adults in NC and OH. This result was apparent by reviewing the tables in Section 9.6.1, where one exposure route typically dominated the other two for each pollutant in each state. Note that the model was unable to converge when being fitted to potential exposure level estimates of *cis*-permethrin in OH children, and therefore, comparisons between exposure routes could not be performed in this instance.

9.6.4 Sub-goal 4.4: Characterize How These Estimates Differ Overall Between Pairs of Exposure Routes

For each pair of exposure routes, each multivariate ANOVA performed in Section 9.6.3 produced estimates of the ratio of geometric mean potential exposure level or potential absorbed dose between the two routes, along with a 95% confidence interval on the ratio. Tables S-5 and S-6 of Appendix S present these ratios and confidence intervals for participating children in NC and OH, respectively. Similarly, Tables S-7 and S-8 present ratios and confidence intervals for participating adult caregivers in NC and OH, respectively. Each row of these tables corresponds to a particular fit of the multivariate ANOVA. Those ratios that are significantly different from one at the 0.05 level are summarized in Table 9.6.5 for NC children, Table 9.6.6 for OH children, Table 9.6.7 for NC adults, and Table 9.6.8 for OH adults; further discussion of significant differences from one is found in Section 9.6.5.

For NC children, Table S-5 of Appendix S shows that for all eight pollutants and for both potential exposure level and potential absorbed dose, ratios of the dietary ingestion route versus either the inhalation route or the indirect ingestion route exceeded one. This implies that the estimated geometric mean exposure/dose estimate via dietary ingestion was larger than the geometric mean for either inhalation or indirect ingestion. Ratios of the inhalation route to the indirect ingestion route were greater than one for all pollutants but *cis*- and *trans*-permethrin, where the indirect ingestion route was more dominant than the inhalation route. For the two pollutants that were also included in the data analysis for NC adults (3,5,6-TCP and 2,4-D), the same conclusions held for both adults and children (Tables 9.6.5 and 9.6.6).

Table 9.6.5. Estimated Ratios Between Two Exposure Routes of Geometric Mean Potential Exposure Level and Potential Absorbed Dose Estimates in Participating NC Children, When These Ratios Were Significantly Different From One at the 0.05 Level[a]

Pollutant/ Metabolite	Parameter	Ratio of Geometric Means		
		Dietary Ingestion Route vs. Inhalation Route	Dietary Ingestion Route vs. Indirect Ingestion Route	Inhalation Route vs. Indirect Ingestion Route
OP Pesticides and Metabolite				
Chlorpyrifos	Potential Exposure Level		12.60**	8.92**
	Potential Absorbed Dose		12.61**	8.93**
Diazinon	Potential Exposure Level		20.70**	14.58**
	Potential Absorbed Dose		20.68**	14.62**
3,5,6-TCP	Potential Exposure Level	72.58**	229.05**	3.16**
	Potential Absorbed Dose	72.84**	230.39**	3.16**
Pyrethroid Pesticides				
cis-Permethrin	Potential Exposure Level	22.18**		0.09**
	Potential Absorbed Dose	22.17**		0.09**
trans-Permethrin	Potential Exposure Level	22.02**		0.08**
	Potential Absorbed Dose	21.81**		0.08**
Acid Herbicides				
2,4-D	Potential Exposure Level	48.67**	194.41**	3.99**
	Potential Absorbed Dose	48.63**	193.78**	3.98**
Phthalates				
Di-*n*-butylphthalate	Potential Exposure Level	22.92**	126.17**	5.50**
	Potential Absorbed Dose	22.61**	124.38**	5.50**
Phenols				
Bisphenol-A	Potential Exposure Level	207.17**	2235.24**	10.79**
	Potential Absorbed Dose	207.37**	2212.20**	10.67**

[a] Blank cells correspond to ratios that were not significantly different from one at the 0.05 level. All ratios are presented, regardless of their significance, along with 95% confidence intervals on these ratios, within Table S-5 of Appendix S.

** Significantly different from 1 at the 0.01 level.

Table 9.6.6. Estimated Ratios Between Two Exposure Routes of Geometric Mean Potential Exposure Level and Potential Absorbed Dose Estimates in Participating OH Children, When These Ratios Were Significantly Different From One at the 0.05 Level[a]

Pollutant/ Metabolite	Parameter	Ratio of Geometric Means		
		Dietary Ingestion Route vs. Inhalation Route	Dietary Ingestion Route vs. Indirect Ingestion Route	Inhalation Route vs. Indirect Ingestion Route
OP Pesticides and Metabolite				
Chlorpyrifos	Potential Exposure Level	6.03**	30.88**	5.12**
	Potential Absorbed Dose	6.06**	31.03**	5.12**
Diazinon	Potential Exposure Level	2.04**	20.68**	10.15**
	Potential Absorbed Dose	2.04**	20.78**	10.19**
3,5,6-TCP	Potential Exposure Level	132.32**	546.95**	4.13**
	Potential Absorbed Dose	129.55**	541.95**	4.18**
Pyrethroid Pesticides				
cis-Permethrin	Potential Exposure Level	–[b]	--	--
	Potential Absorbed Dose	22.00**	2.60*	0.12**
trans-Permethrin	Potential Exposure Level	24.32**	3.52**	0.14**
	Potential Absorbed Dose	24.29**	3.38**	0.14**
Acid Herbicides				
2,4-D	Potential Exposure Level	52.25**	47.52**	
	Potential Absorbed Dose	51.75**	47.22**	
Phthalates				
Di-*n*-butylphthalate	Potential Exposure Level	4.68**	53.07**	11.34**
	Potential Absorbed Dose	4.63**	51.94**	11.21**
Phenols				
Bisphenol-A	Potential Exposure Level	181.33**	1853.99**	10.22**
	Potential Absorbed Dose	183.70**	1851.10**	10.08**

[a] Blank cells correspond to ratios that were not significantly different from one at the 0.05 level. All ratios are presented, regardless of their significance, along with 95% confidence intervals on these ratios, within Table S-6 of Appendix S.
[b] No ratios were estimated due to the model being unable to converge when fitted to the data.

* Significantly different from 1 at the 0.05 level, but not at the 0.01 level.
** Significantly different from 1 at the 0.01 level.

Table 9.6.7. Estimated Ratios Between Two Exposure Routes of Geometric Mean Potential Exposure Level and Potential Absorbed Dose Estimates in Participating NC Adults, When These Ratios Were Significantly Different From One at the 0.05 Level[a]

Parameter	Ratio of Geometric Means		
	Dietary Ingestion Route vs. Inhalation Route	Dietary Ingestion Route vs. Indirect Ingestion Route	Inhalation Route vs. Indirect Ingestion Route
3,5,6-TCP (3,5,6-trichloro-2-pyridinol)			
Potential Exposure Level	41.76**	358.70**	8.59**
Potential Absorbed Dose	41.74**	358.31**	8.58**
2,4-D (2,4-dichlorophenoxyacetic acid)			
Potential Exposure Level	40.74**	379.85**	9.32**
Potential Absorbed Dose	40.88**	379.64**	9.29**

[a] Ratios are presented, along with 95% confidence intervals on these ratios, within Table S-7 of Appendix S.
** Significantly different from 1 at the 0.01 level.

Table 9.6.8. Estimated Ratios Between Two Exposure Routes of Geometric Mean Potential Exposure Level and Potential Absorbed Dose Estimates in Participating OH Adults, When These Ratios Were Significantly Different From One at the 0.05 Level[a]

Parameter	Ratio of Geometric Means (95%CI)		
	Dietary Ingestion Route vs. Inhalation Route	Dietary Ingestion Route vs. Indirect Ingestion Route	Inhalation Route vs. Indirect Ingestion Route
3,5,6-TCP (3,5,6-trichloro-2-pyridinol)			
Potential Exposure Level	102.37**	907.46**	8.86**
Potential Absorbed Dose	102.51**	907.69**	8.85**
2,4-D (2,4-dichlorophenoxyacetic acid)			
Potential Exposure Level	49.33**	78.75**	
Potential Absorbed Dose	49.32**	78.63**	

[a] Ratios are presented, along with 95% confidence intervals on these ratios, within Table S-8 of Appendix S.
** Significantly different from 1 at the 0.01 level.

For OH children, Table S-6 of Appendix S shows that for all eight pollutants and for both potential exposure level and potential absorbed dose, ratios of the dietary ingestion route versus either the inhalation route or the indirect ingestion route exceeded one in all instances, indicating that dietary ingestion was the dominant exposure route. The ratios of the inhalation route to the indirect ingestion route were greater than one for all pollutants but 2,4-D and *cis*- and *trans*-permethrin. For the two permethrins, Table 9.6.1 showed that the indirect ingestion route was more dominant than the inhalation route with regard to exposure/dose, while the two routes were equally inferior to dietary ingestion for 2,4-D. Although the ratio of 2,4-D exposure/dose estimates between the inhalation route and the indirect ingestion route exceeded one for OH adults (Table S-8 of Appendix S), implying larger exposure/dose estimates for the inhalation route in adults, the ratio was not significantly different from one at the 0.05 level for either children or adults in OH. Note that although the multivariate ANOVA model could not converge to solutions for potential exposure level in OH children for *cis*-permethrin, it is expected (upon viewing the results for the other pollutants) that the outcome would have been very similar to that given for potential absorbed dose for this pollutant.

The magnitudes of the ratios presented in the tables in this section, as well as the conclusions made by these ratios, are consistent with the findings found in the tables within Section 9.6.1. Note that in Tables S-5 through S-8, the second column presents the p-values of the tests of significant differences among exposure routes. As mentioned in Section 9.6.3, these p-values were all less than 0.0001 across all model fits for both NC and OH.

9.6.5 Sub-goal 4.5: Identify Which Pairs of Exposure Routes Differ Significantly in These Estimates

Within the multivariate ANOVA model fits discussed in Section 9.6.3 and Section 9.6.4, statistical tests were performed to determine whether the estimated ratios reported in Tables S-5 through S-8 of Appendix S were significantly different from one, thereby indicating that the pair of exposure routes had significantly different geometric mean exposure/dose measures. Those ratios that were significantly different from one at the 0.05 are presented in Tables 9.6.5 through 9.6.8, with each ratio followed by either one or two asterisks. One asterisk implies that the ratio is significantly different from one at the 0.05 level, while two asterisks indicate significance at the 0.01 level.

For NC children, Table 9.6.5 shows that the ratios of exposure/dose estimates between dietary ingestion and inhalation were significantly different from (and greater than) one at the 0.01 level for all pollutants but the two OP pesticides (chlorpyrifos and diazinon). Similarly, the ratios between dietary ingestion and indirect ingestion were significantly different from (and greater than) one at the 0.01 level for all pollutants but *cis*- and *trans*-permethrin. For all eight pollutants, the ratio of inhalation to indirect ingestion was significantly different from one at the 0.01 level, but these ratios were smaller than one for *cis*- and *trans*-permethrin and larger than one for the other six pollutants. Thus, these findings indicate that the ordering of the exposure routes for NC children based upon their relative importance to potential exposure/dose is as follows:

- *cis*- and *trans*-permethrin: dietary ingestion ≈ indirect ingestion > inhalation.
- chlorpyrifos and diazinon: dietary ingestion ≈ inhalation > indirect ingestion
- 2,4-D, 3,5,6-TCP, di-*n*-butylphthalate, bisphenol-A: dietary ingestion > inhalation > indirect ingestion

where "≈" indicates statistical equivalence. For 2,4-D and 3,5,6-TCP, the same ordering of the exposure routes occurred for NC adults as for children (Table 9.6.7).

For OH children, Table 9.6.6 shows that the ratios of exposure/dose estimates between dietary ingestion and either inhalation or indirect ingestion were significantly different from (and greater than) one for all eight pollutants, where significance was at the 0.05 level for potential absorbed dose of *cis*-permethrin (for dietary versus indirect ingestion routes) and at the 0.01 level in all other instances. For seven of the eight pollutants (i.e., all pollutants except 2,4-D), the ratio of inhalation to indirect ingestion was significantly different from one at the 0.01 level, but these ratios were smaller than one for *cis*- and *trans*-permethrin and larger than one for the other five pollutants. This ratio was not significantly different from one for 2,4-D. Thus, these findings, along with the magnitude of the reported ratios, indicate that the ordering of the exposure routes for OH children based upon their relative importance to potential exposure/dose is as follows:

- *cis*- and *trans*-permethrin: dietary ingestion > indirect ingestion > inhalation.
- 2,4-D: dietary ingestion > indirect ingestion ≈ inhalation
- chlorpyrifos, diazinon, 3,5,6-TCP, di-*n*-butylphthalate, bisphenol-A: dietary ingestion > inhalation > indirect ingestion.

For OH adults, the ordering of exposure routes was similar (Table 9.6.8):

- 2,4-D: dietary ingestion > inhalation ≈ indirect ingestion
- 3,5,6-TCP: dietary ingestion > inhalation > indirect ingestion.

The findings in this section indicate that dietary ingestion and inhalation are the two most important exposure routes for children's exposure to the two OP pesticides (chlorpyrifos and diazinon). This finding is in agreement with the previous pilot study (10). For the less volatile pyrethroids (*cis*- and *trans*-permethrin), dietary and indirect ingestion were the two most important exposure routes.

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