ANALYSIS OF THE NATIONAL HUMAN ACTIVITY PATTERN SURVEY (NHAPS) RESPONDENTS FROM A STANDPOINT OF EXPOSURE ASSESSMENT

PERCENTAGE OF TIME SPENT, DURATION, AND FREQUENCY OF OCCURRENCE FOR SELECTED MICROENVIRONMENTS BY GENDER, AGE, TIME-OF-DAY, DAY-OF-WEEK, SEASON, AND U.S. CENSUS REGION

FINAL REPORT

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NOTICE

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ABSTRACT

The National Human Activity Pattern Survey (NHAPS) 24-hour diary data collected from 9,386 respondents interviewed between October 1992 and September 1994 were recoded and regrouped into ten locations, seven exposure-relevant activities, and two smoker-present categories. For all the NHAPS respondents, the mean number of occurrences and durations in selected microenvironments (location x activity x smoker present category), and the percentage of time spent in the microenvironments were calculated over the 24-hour diary day and by time-of-day (midnight to midnight of the diary day in one minute and 3-hour time segments). In addition to overall calculations, the data were divided by gender (male/female), age (adult/child), day-of-week (weekend/weekday), season (fall/winter and spring/summer), and the four census regions. The largest overall percentages of time were spent in the Residential-Indoors location (69%) with 5.5% percent of the time spent in vehicles and almost 8% of the time spent in outdoor locations. The largest percentages of time in any location x exposure activity microenvironment were for the Eating/Drinking, Housekeeping, Food Preparation, and Bathing exposure activities -- all taking place in the Residential-Indoor location.

Many of the NHAPS follow-up questions on personal exposure to air and water pollutants -- asked after the 24-hour diaries were collected -- contained many missing, "refused to answer," or "don't know" responses, or were coded in an unwieldy mixed-type format (categorical and numeric data). Only the yes/no categorical follow-up questions with an adequate sample size were analyzed (percentage of "yes" responses). Overall percentages of "yes" responses that were greater than 50% occurred for: using an air freshener; using a dish washer; washing dishes by hand; giving or taking a bath; taking a shower; children swimming over the last month; having a door leading directly outdoors; using a microwave; running/walking outdoors; walking to a car in the driveway; and having a welcome mat.

All analyses of the NHAPS sample were weighted against the 1990 US Census to account for the: (1) oversampling done on weekends; (2) probability of sampling adults (18 and up) vs. children; (3) probability of a household's selection; (4) disproportionate weekday ratios; (5) unrepresentative male/female ratio; (6) disproportionate sampling by season; and (7) unrepresentative ratios among ten age groups. The NHAPS data base is large and rich enough to provide material for very detailed exposure studies targeted on specific populations in the United States. The results presented here are a fraction of the possible analyses that can be used in total human exposure assessment. Since minute-by-minute 24-hour diaries provide the most complete and accurate human activity pattern data, future human activity pattern studies should further focus the exposure-relevance of the diary activity categories.

TABLE OF CONTENTS

NOTICE ii

ACKNOWLEDGMENTS ii

ABSTRACT iii

LIST OF TABLES viii

LIST OF FIGURES xiii

1. INTRODUCTION 1-1
   - 1.1 Objective and Scope of this Report 1-1
   - 1.2 Background 1-3
   - 1.3 The Analyses Presented in this Report 1-5
   - 1.4 Calculation Methodology 1-9
   - 1.5 Using the Results: Exposure Assessments 1-10

2. SUMMARY OF THE DATA-COLLECTION METHODOLOGY 2-1

3. GEOGRAPHIC, SOCIOECONOMIC, AND TEMPORAL DIVISIONS OF THE RESPONDENTS 3-1
   - 3.1 Geographic Divisions 3-1
   - 3.2 Socioeconomic Divisions 3-12
   - 3.3 Temporal Divisions 3-16

4. WEIGHTING OF THE DATA 4-1

5. MICROENVIRONMENTS IN THE 24-HOUR DIARIES: SELECTED LOCATION x ACTIVITY x SMOKER-PRESENT CATEGORIES 5-1
   - 5.1 Locations, Activities, and Smoker-Present Categories 5-3
   - 5.2 Location x Activity and Location x Smoker-Present Microenvironments 5-15

6. *24-HOUR DIARY RESULTS*: DURATION AND FREQUENCY OF OCCURRENCE FOR SELECTED MICROENVIRONMENTS

   I. BY DAY-OF-WEEK, SEASON AND BACKGROUND FACTORS 6-1
   - 6.1 Locations 6-2
   - 6.2 Exposure Activities 6-12
   - 6.3 Smoker-Present Categories 6-24
   - 6.4 Locations x Smoker-Present Categories 6-26
   - 6.5 Locations x Activities 6-40
   - 6.6 Summary and Discussion 6-49

   II. BY TIME-OF-DAY IN MINUTE TIME SEGMENTS BY DAY-OF-WEEK, SEASON, AND BACKGROUND FACTORS 6-51
   - 6.7 Locations 6-53
   - 6.8 Exposure Activities 6-57
   - 6.9 Smoker-Present Categories 6-67

   III. BY TIME-OF-DAY IN EIGHT 3-HOUR SEGMENTS 6-69

7. RESULTS OF THE FOLLOW-UP QUESTIONS ON PERSONAL EXPOSURE 7-1

8. CONCLUSIONS, RECOMMENDATIONS, AND FUTURE WORK 8-1

9. REFERENCES 9-1

APPENDIX A: CONCEPTUAL METHODOLOGY AND BACKGROUND A-1
A1. Total Human Exposure, Human Activity Patterns, and the Generalized Microenvironment A-1
A2. A Mathematical Formalism for Microenvironments A-4
A3. The Microenvironment Calculations in This Report A-8
A4. Modeling Human Exposure A-11

APPENDIX B: DETAILED EXAMPLES OF THE METHODOLOGY USED FOR CALCULATIONS IN THIS REPORT (WITH SAS COMPUTER CODE) B-1
B1. Episodic: Duration and Frequency of Occurrence of Microenvironments B-1
B2. Time-of-Day I: Fraction of Respondents in Each Microenvironment by Minute B-5
B3. Time-of-Day II: Duration of Microenvironments by Eight 3-Hour Segments B-12

NOTICE TO THE READER

To help avoid any confusion, we have compiled the following eleven items concerning our analyses of the National Human Activity Pattern Survey (NHAPS) data:

1. The analyses in this report are focused on the minute-by-minute NHAPS 24-hour diaries with limited analyses of the NHAPS follow-up questions (see Section 7).
2. Table 1-1 in the introduction gives a complete index of the figures and tables in this report containing the results of the 24-hour diaries -- broken down by the type of human activity pattern calculation (percentage of time spent, 24-hour duration, etc.) and the subgroups covered (age, gender, time-of-day, day-of-week, and season).
3. The final ten location groupings that were used for diary calculations in this report were: Residential-Indoor, Residential-Outdoor, In Vehicle, Near Vehicle(s), Other Outdoor, Office/Factory, Mall/Store, School/Church/Public Bldg., Bar/Restaurant, and Other Indoor.
4. The final eight activity groupings that were used for diary calculations in this report were: Food Preparation, Laundry/Dishes, Housekeeping, Bathing, Yardwork/Maintenance, Sports/Exercise, Eating/Drinking, and No Exposure (sleeping, watching TV, etc.). The No Exposure activity group contains activity categories that contribute little or no additional information on exposure beyond what the locations contribute. For example, if the location is In Vehicle and the activity is Traveling in Vehicle, then the location is sufficient to designate that the respondent may be exposed to automobile exhaust while driving on roadways. Thus, the Traveling in Vehicle activity was assigned to the No Exposure group.
5. In this report both the doers and the non-doers were analyzed for diary calculations of the percentage of time spent in each location and activity. Only the doers were analyzed for the percentage of time spent exposed to environmental tobacco smoke (ETS). For all calculations of mean microenvironment duration and frequency of occurrence, only the doers were considered, although tables are included giving both the doer and the total sample sizes.
6. No frequency distributions or statistical comparisons of distributions of time spent (*e.g.*, percentage or duration) are presented in this report.
7. In exposure research, microenvironments are defined as combinations of locations **and** activities (see Appendix A), although in this report we also present analyses according to locations alone and activities alone.
8. Another report (J. Robinson; J. Blaire (1995) "Estimating Exposure to Pollutants Through Human Activity Pattern Data: The National Microenvironmental Activity Pattern Survey", Annual Report, Survey Research Center, U. of Maryland) provides the detailed National Human Activity Pattern Survey (NHAPS) data-collection methodology.
9. This report is meant only as a presentation of selected examples of results that can be obtained from the NHAPS data, and **not** a comprehensive treatment that will be of use to all human exposure assessors.
10. Appendix A contains a development of exposure concepts -- including the use of activity patterns in total human exposure assessment.
11. Appendix B contains detailed examples of the computer methodology used in this report including the SAS computer code, the computer hardware used, and the amount of computer time required.

LIST OF TABLES

No.	Description	Page No.
1-1	Index of the statistical calculations presented in this report	1-6
1-2	How different percentages of time spent and numbers of people experiencing a microenvironment (doers) contribute to the overall significance of the microenvironment	1-13
1-3	How each microenvironmental quantity (HAP calculation or experiment) is used to estimate exposures	1-14
2-1	Summary of the NHAPS features	2-2
2-2	Frequency distribution of the time interviews began	2-3
2-3	Frequency distribution of the type of interview	2-3
2-4	Frequency distribution of the number of non-business phones in each household	2-3
2-5	Description of the two NHAPS data files	2-5
3-1	The NHAPS geographic variables for each respondent	3-2
3-2	List of NHAPS frequencies grouped by EPA Region, Census Region, and state.	3-5
3-3	Comparison of Census with NHAPS by EPA Region	3-8
3-4	Comparison of Census with NHAPS by Census Region	3-9
3-5	The number of NHAPS respondents in each area code by state	3-10
3-6	The 20 most populated U.S. cities in 1990	3-13
3-7	The NHAPS demographic variables for each respondent	3-14
3-8	The number of NHAPS respondents by gender	3-17
3-9	The number of NHAPS respondents by age	3-17
3-10	The number of NHAPS respondents by race	3-17
3-11	The number of NHAPS respondents by Hispanic origin	3-17
3-12	The number of NHAPS respondents by education level	3-17
3-13	The number of NHAPS respondents by employment status	3-17
3-14	The number of NHAPS respondents by number of adults in household	3-17
3-15	The number of NHAPS respondents by number of children under 18	3-18

3-16 List of the NHAPS temporal variables 3-18

3-17 The number of NHAPS respondents by study quarter 3-18

3-18 The number of NHAPS respondents by season 3-18

3-19 The number of NHAPS respondents by year 3-18

3-20 The number of NHAPS respondents by weekend vs. weekday 3-18

3-21 The number of NHAPS respondents by day-of-week 3-18

4-1 The twenty gender and age subgroups for the calculation of weights 4-5

4-2 The 1990 U.S. Census population joint frequency and proportions for each age and gender subpopulation 4-5

4-3 The NHAPS joint frequency and proportions for each age and gender subgroup 4-5

4-4 The sample weights calculated for each subgroup *h* and assigned to each individual *i* 4-5

4-5 Comparison of the weighted sample with the 1990 U.S. Census by marginal grouping factors 4-8

4-6 Consistency check of the weighted joint sample proportion for gender and age across season and weekend vs. weekday 4-9

5-1 The NHAPS microenvironmental variables 5-2

5-2 The original WHR location codes matched with NEWLOC groupings 5-4

5-3 The NEWLOC locations recoded from WHR 5-7

5-4 The NEWACT exposure activities recoded from RACT and FACT 5-9

5-5 The REGACT exposure activities regrouped from NEWACT 5-11

5-6 The original RACT activity codes matched with REGACT groupings 5-11

5-7 The five largest non-exposure RACT categories 5-11

5-8 The NHAPS smoker-present categories 5-14

5-9 Frequency table for SMKEXP (time exposed to ETS) with SMKB assignment (number of people exposed) 5-14

5-10 The location x activity microenvironmental matrix 5-16

5-11 The location x smoker-present microenvironmental matrix 5-17

6-1 The weighted percentages of time spent in each location on the diary day across each subgroup 6-3

6-2 The mean weighted 24-hour duration (minutes) in each location (for doers) on the diary day for each subgroup 6-3

6-3 The weighted number of NHAPS respondents (sample size) in each location (the doers) on the diary day by each subgroup 6-3

6-4 The weighted percentages of time spent in each exposure activity on the diary day across each subgroup 6-13

6-5 The mean weighted 24-hour duration (minutes) in each exposure activity (for doers) on the diary day for each subgroup 6-13

6-6 The weighted number of NHAPS respondents (doer sample size) in each exposure activity on the diary day by each subgroup 6-13

6-7 The weighted percentages of time spent in each location x smoker-present microenvironment on the diary day across each subgroup 6-28

6-8 The mean weighted 24-hour duration (minutes) in each location x smoker-present microenvironment (for doers) on the diary day for each subgroup 6-28

6-9 The weighted mean frequency of occurrence of each location x smoker-present microenvironment (for doers) on the diary day by each subgroup 6-28

6-10 The weighted number of NHAPS respondents (doer sample size) in each location x smoker-present microenvironment on the diary day by each subgroup 6-28

6-11 The overall weighted percentage of time spent in 21 out of 70 location x activity microenvironments 6-41

6-12 The overall weighted percentage of people doing (the doers) 21 out of 70 location x activity microenvironments 6-42

6-13 The overall weighted mean 24-hr durations of 21 out of 70 location x activity microenvironments 6-43

6-14 The overall weighted mean 24-hr number of occurrences of 21 out of 70 location x activity microenvironments 6-45

6-15 Comparison across subgroups of percentage of time spent in nine selected location x activity microenvironments 6-46

6-16 Comparison across subgroups of 24-hour duration in nine selected location x activity microenvironments 6-46

6-16b The weighted doer sample sizes of nine selected location x activity microenvironments across each subgroup 6-46

6-17 Percentage of respondents who entered a location beginning in each of eight consecutive 3-hour time segments 6-70

6-18 Cumulative durations (minutes) of locations originating in the eight consecutive 3-hour time segments 6-70

6-19 Percentage of respondents who entered an exposure activity beginning in each of eight consecutive 3-hour time segments 6-73

6-20 Cumulative durations (minutes) of exposure activities originating in the eight consecutive 3-hour time segments 6-73

6-21 Cumulative duration and percentage of respondents for ETS exposures originating in each of eight 3-hour time segments 6-77

7-1 The ten NHAPS follow-up question categories with example activities and associated chemicals 7-2

7-2 The NHAPS follow-up variables with category, A or B questionnaire, and the number of missing, refused, and "don't know" responses 7-3

7-3 Percentage of "yes" responses for follow-up questions on chemical exposure (CE) 7-9

7-4 Percentage of "yes" responses for follow-up questions on combustions sources (CS) 7-12

7-5 Percentage of "yes" responses for follow-up questions on washing and bathing (WA and BA) 7-12

7-6 Percentage of "yes" responses for follow-up questions on medical background (MB) 7-14

7-7 Percentage of "yes" responses for follow-up questions on housing characteristics (HC) 7-14

7-8 Percentage of "yes" responses for follow-up questions for other categories 7-16

8-1 Comparison of the utility of 24-hour diaries vs. follow-up questions 8-2

8-2 Suggested specific exposure activity categories for microenvironments in the minute-by-minute 24-hour diaries for future HAP studies 8-4

A-1 An example episodic formulation of ten persons in indoor and outdoor microenvironments over a 12-hour period A-10

A-2 An example time-of-day formulation of ten persons with frequencies of indoor and outdoor microenvironments over 12-hours in half-hour increments A-12

A-3 Example breakdown of the time-of-day formulation M_t into microenvironmental factor terms m A-15

A-4 Example breakdown of the 12-hour total exposure array $E(i,j)$ into exposure arrays e for each combination of microenvironmental factors (indoors/outdoors and smoker-present/no-smoker-present) A-16

B-1 Example 24-hour diary file in the episodic format for person ID# 1.1 ..... B-2

B-2 Example microenvironment calculations of percentage of time spent, 24-hour duration, and 24-hour frequency of occurrence using person ID# 1.1 ..... B-3

B-3 Example time-of-day format for person ID# 1.1 ..... B-7

B-4 Example output data file containing the overall weighted fraction of respondents in each location (NEWLOC category) for every minute of the diary day..... B-11

Note: Tables and figures are numbered in the order they were referenced in the text with their number preceded by the section number and a hyphen (-). For example, the 5th table in Section 3 is labeled "Table 3-5".

LIST OF FIGURES

No.	Description	Page No.
1-1	The four levels of human activity pattern analysis used in this report	1-8
2-1	Histogram of the number of minutes each interview lasted	2-3
3-1	Map of the number of NHAPS respondents in each state and EPA region	3-3
3-2	Map of the number of people in each state and EPA region from the 1990 Census	3-3
3-3	Bar chart comparison of NHAPS respondents vs. the Census by EPA Region	3-4
3-4	Bar chart comparison of NHAPS respondents vs. the Census by Census Region	3-7
3-5	Plots of males and females by four age groups and ten age groups in 1990	3-15
4-1	SAS program for calculation of weights	4-6
6-1	The overall weighted percentage of time spent in each location	6-4
6-2	The overall weighted and unweighted mean 24-hr durations in each location	6-4
6-3	The weighted percentage of time spent in each location for males vs. females	6-6
6-4	The weighted and unweighted mean 24-hr durations in each location for males vs. females	6-6
6-5	The weighted percentage of time spent in each location for each age group	6-7
6-6	The weighted and unweighted mean 24-hr durations in each location for each age group	6-7
6-7	The weighted percentage of time spent in each location for each census region	6-8
6-8	The weighted and unweighted mean 24-hr durations in each location for each Census Region	6-8
6-9	The weighted percentage of time spent in each location for weekends vs. weekdays	6-10
6-10	The weighted and unweighted mean 24-hr durations in each location for weekends vs. weekdays	6-10
6-11	The weighted percentage of time spent in each location for each season	6-11
6-12	The weighted and unweighted mean 24-hr durations in each location for each season	6-11
6-13	The overall weighted percentage of time spent in each exposure activity	6-14
6-14	The overall weighted and unweighted mean 24-hr durations of each exposure activity	6-14
6-15	The weighted percentage of time spent in each exposure activity for males vs. females	6-15

6-16 The weighted and unweighted mean 24-hr durations in each exposure activity for males vs. females 6-16

6-17 The weighted percentage of time spent in each exposure activity for each age group 6-18

6-18 The weighted and unweighted mean 24-hr durations in each exposure activity for each age group 6-18

6-19 The weighted percentage of time spent in each exposure activity for each Census Region 6-19

6-20 The weighted and unweighted mean 24-hr durations in each exposure activity for each Census Region 6-19

6-21 The weighted percentage of time spent in each exposure activity for weekdays vs. weekends 6-21

6-22 The weighted and unweighted mean 24-hr durations in each exposure activity for weekdays vs. weekends 6-22

6-23 The weighted percentage of time spent in each exposure activity for each season 6-23

6-24 The weighted and unweighted mean 24-hr durations in each exposure activity for each season 6-24

6-25 The weighted percentage of people exposed to ETS for each subgroup 6-25

6-26 The weighted percentage of time that those who were exposed to ETS on the diary day were exposed for each subgroup 6-25

6-27 The weighted mean 24-hr duration of ETS exposure by each subgroup 6-25

6-28 The overall weighted percentage of time spent, mean number of occurrences, and mean 24-hr duration of ETS exposure in each location 6-29

6-29 The weighted percentage of time spent exposed to ETS in each location for males vs. females 6-30

6-30 The weighted mean 24-hr number of occurrences and mean 24-hr duration of ETS exposure in each location for males vs. females 6-31

6-31 The weighted percentage of time spent exposed to ETS in each location by age group 6-33

6-32 The weighted mean 24-hr duration of ETS episodes in each location by age group 6-33

6-33 The weighted mean 24-hr number of occurrences of ETS exposure in each location by age group 6-33

6-34 The weighted percentage of time spent exposed to ETS in each location by census region 6-35

6-35 The weighted mean 24-hr duration of ETS episodes in each location by Census Region 6-35

6-36 The weighted mean 24-hr number of occurrences of ETS exposure in each location by Census Region 6-35

6-37 The weighted percentage of time spent exposed to ETS in each location by weekend vs. weekday 6-36

6-38 The weighted mean 24-hr number of occurrences and mean 24-hr duration of ETS episodes in each location by weekend vs. weekday 6-37

6-39 The weighted percentage of time spent exposed to ETS in each location by season 6-38

6-40 The weighted mean 24-hr duration of ETS episodes in each location by season 6-38

6-41 The weighted mean 24-hr number of occurrences of ETS exposure in each location by season 6-38

6-42 3-D plot of the overall weighted percentage of time spent in 21 out of 70 location x activity microenvironments 6-41

6-43 3-D plot of the overall weighted number of people doing (the doers) 21 out of 70 location x activity microenvironments 6-42

6-44 3-D plot of the overall weighted mean 24-hr duration in 21 out of 70 location x activity microenvironments 6-43

6-45 3-D plot of the overall weighted mean 24-hr number of occurrences of 21 out of 70 location x activity microenvironments 6-45

6-46 3-D plot of the overall weighted percentage of time spent in nine location x activity microenvironments across each subgroup 6-47

6-47 3-D plot of the overall weighted mean 24-hour duration in nine location x activity microenvironments across each subgroup 6-48

6-48 Stacked plot of overall fraction of respondents in each location by time-of-day 6-52

6-49 Individual plots of the overall fraction of respondents in each exposure activity by time-of-day 6-54

6-50 Individual plots of the fraction of respondents in each location by time-of-day for each age group 6-56

6-51 Individual plots of the fraction of respondents in each location by time-of-day for weekdays vs. weekends 6-58

6-52 Plots of the fraction of respondents in the Residential-Outdoor and Other Outdoor locations by season 6-59

6-53 Stacked plot of overall fraction of respondents in each exposure activity by time-of-day 6-60

6-54 Individual plots of the overall fraction of respondents in each exposure activity by time-of-day 6-62

6-55 Individual plots of the fraction of respondents in each exposure activity by time-of-day for each age group 6-64

6-56 Individual plots of the fraction of respondents in each exposure activity by time-of-day for weekdays vs. weekends 6-65

6-57 Individual plots of the fraction of respondents in the Yardwork/Maintenance and Sports/Exercise exposure activities by time-of-day for each season 6-66

6-58 Plots of the fraction of respondents exposed to environmental tobacco smoke (ETS) by time-of-day for gender, age, weekday vs. weekend, and season 6-68

6-59 3-D plot of the percentage of respondents initiating a microenvironment in each of the eight 3-hour time segments for each location 6-71

6-60 3-D plot of the mean total duration in each location for each of the eight 3-hour time segments 6-72

6-61 3-D plot of the percentage of respondents initiating a microenvironment in each of the eight 3-hour time segments by exposure activity 6-75

6-62 3-D plot of the mean total duration in each exposure activity for each of the eight 3-hour time segments 6-76

6-63 Bar charts of the percentage of respondents exposed to ETS and the duration of exposure to ETS (minutes) in each of the eight 3-hour time segments 6-78

7-1 The percentage of "yes" responses to NHAPS follow-up variables for chemical exposure (CE) #1 7-10

7-2 The percentage of "yes" responses to NHAPS follow-up variables for chemical exposure (CE) #2 7-11

7-3 The percentage of "yes" responses to NHAPS follow-up variables for combustion sources (CS) 7-13

7-4 The percentage of "yes" responses to NHAPS follow-up variables for washing and bathing (WA/BA) 7-13

7-5 The percentage of "yes" responses to NHAPS follow-up variables for medical background (MB) 7-15

7-6 The percentage of "yes" responses to NHAPS follow-up variables for housing characteristics (HC) 7-15

7-7 The percentage of "yes" responses to NHAPS follow-up variables for other categories (DS, OC, ED) 7-17

A-1 The basic questions posed in human activity pattern analysis A-2

A-2 Example percentage of people in indoor vs. outdoor microenvironments by time-of-day in half-hour increments over a 12-hour period A-12

B-1 The SAS code for calculating total time spent, 24-hour durations, and 24-hour frequencies of occurrence of microenvironments using the episodic formulation B-4

B-2 The SAS code for converting the NHAPS data from the episodic to the time-of-day formulation B-6

B-3 The SAS code used to concatenate the 24 files containing the time-of-day formulation for each hour of the diary day B-6

B-4 The SAS code used to calculate the unweighted and weighted numbers of respondents in each location for every minute of the diary day B-10

B-5 The SAS code used to calculate weighted and unweighted overall mean durations in each of the eight 3-hour time segments over the 24-hour diary day B-14

Note: Figures and tables are numbered in the order they were referenced in the text with their number preceded by the section number and a hyphen (-). For example, the 5th figure in Section 3 is labeled "Figure 3-5".

1. INTRODUCTION

1.1 Objective and Scope of This Report

The U.S. Environmental Protection Agency (EPA) has a continuing interest in the estimation of human exposure to toxic chemicals using the microenvironmental data (locations and activities) collected in human activity pattern (HAP) surveys. Since the Total Exposure Assessment Methodology (TEAM) studies have shown that indoor sources of pollution outnumber outdoor sources, and the 1988-1990 California Air Resource Board (CARB) California Activity Pattern (CAP) HAP study[1-3] and the 1985 University of Maryland Americans' Use of Time (AUT) HAP study[4] show that Americans spend most of their time in a variety of indoor locations, information on where and how people are exposed to indoor pollutants is crucial in total human exposure (THE) assessment.[5-7] This report analyzes the EPA's National Human Activity Pattern Survey (NHAPS)[8,9] by duration and frequency of occurrence of microenvironments (combinations of locations, activities, and smoker-present categories) for selected time periods (time-of-day, day-of-week, season) and background factors (age, gender, census region). Completed in December 1994, NHAPS is the largest and most current HAP survey available. It will soon be included in the THERDbASE modeling and relational data base computer environment,[10] which has been developed by the EPA. For this report, durations and frequencies of occurrence for an exposure-relevant subset of all possible microenvironments are given in the form of means, percentages of time spent, and percentage of respondent occurrences, and can be readily included in the EPA's Exposure Factors Handbook. The contents of this report will also help to focus the exposure emphasis, follow-up questions, and location and activity categories for future HAP studies. A comprehensive description of the NHAPS data-collection methodology -- including example questionnaires -- is presented in another work.[8]

In addition to a cross section of the kinds of analyses that are useful in exposure research (Sections 6 and 7), we have included the major NHAPS features (Section 2), time and background

factor divisions with comparisons to the 1990 U.S. Census (Section 3), weighting factors (Section 4), and microenvironment designations (Section 5) -- including lists of variables, samples sizes, and codes -- so that this report will be a useful reference to all human exposure modelers, exposure/risk assessors, and environmental health professionals as they use the NHAPS data to conduct future exposure studies across the United States. The analyses in this report are **not** a comprehensive summary of every possible categorical division of the data and many researchers will desire more specific breakdowns. However, when combined with the detailed descriptions of the analysis methodology in Appendices A and B, the analyses that are presented here provide a guide for future work. By reading this report researchers can find: (1) useful breakdowns and examples of ways to present the NHAPS data by location, exposure activity, smoker-present category and selected combinations; (2) which NHAPS variables and/or microenvironments are relevant for their work; (3) whether NHAPS contains sufficient data for the breakdowns of interest; and (4) examples of appropriate ways to weight the NHAPS data.

We only considered those exposure activities that could be related to *explicit exposures* such as cooking (particles), cleaning (detergents), showering (water contaminants or chloroform), eating (food contaminants), or exercising (accelerated inhalation of air contaminants). Activities such as traveling, sleeping, dressing, talking, or watching TV were placed into a "No Exposure" category since no explicit exposure to contaminants corresponds to these categories. Exposure may still be occurring during these activities if there is contact with (*i.e.*, proximity to) pollutant sources such as engine exhaust in traffic, carpet fumes in the bedroom, or fabric irritants, but this information is not contained in the NHAPS data. After locations such as In Vehicle or In Residence are analyzed, the activities in the No Exposure category give very little or no additional information that can be used to infer exposure. In addition, there are too many different kinds of activities in the No Exposure category to warrant analyzing each of them. Consequently, separate analyses were not done for these activities.

The results in this report may be used directly in point estimates (*i.e.*, long-term averages) of human exposure. However, estimates of frequency distributions of exposure (*i.e.*, probabilistic modeling) will require researchers to use the NHAPS data to calculate frequency distributions of microenvironment duration and frequency of occurrence. These statistics are not presented in this report.

1.2 Background

NHAPS and CAP are part of recent efforts to estimate human exposure to pollutants by interviewing a sample of individuals in a target population, and categorizing their 24-hour routines (diaries) and/or answers to follow-up exposure questions according to exposure-related *events* such as: (1) occupying a location; or (2) an activity. These events are stored as human activity patterns which provide answers to the basic "who", "what", "where", "how long", "how often", and "when" questions about the target population that are critical in efforts to model personal exposure to pollutants for specific populations. The 24-hour diaries in HAP surveys are particularly useful in probabilistic models (using Monte-Carlo sampling techniques), which provide frequency distributions of exposure.

For CAP, California adults and children were interviewed between October 1987 and February 1990[1-3] and follow-up questions were focused on personal exposure to contaminants in air (tobacco smoke, solvents, engine exhaust, etc.), while NHAPS has collected information on both air and water exposure (showering, swimming, tap water consumption, etc.). Both studies contain essentially equivalent 24-hour diary formats (although the location and activity categories are somewhat different) including information on the presence of smokers. The CAP data have been used in exposure modeling[11-13] and other exposure assessments[14-18] to estimate what portions of the target population are being exposed, how much they are exposed, and for how long. Likewise, NHAPS will also provide a rich database for estimates of exposure for various subpopulations across the entire United States.

There are two approaches to total human exposure (THE) assessment: the "direct" and the "indirect" approaches.[19-21] In the direct approach, multiple individuals or households in the target population are equipped with monitoring devices that measure concentrations of pollutant for later analysis. This approach provides immediate data for the estimation of frequency distributions of exposure across an entire population. Examples of the direct approach are the Total Exposure Assessment Methodology (TEAM) studies.[22-26] In contrast, the indirect approach combines HAP data and pollutant concentration data for the same population -- usually from different studies -- and uses an exposure model to calculate frequency distributions of exposure across the target population.[11-13,27-29] The direct and indirect approaches produce similar results, but with the use of a large HAP survey such as NHAPS, the indirect approach is a more cost-effective way to study many different populations across the country.

In the evolution of exposure modeling and THE assessment, the concept of the *microenvironment* has proved useful in classifying different kinds of exposure. The microenvironment is the basic building block of HAP survey diaries and is defined by the time period that some combination of exposure events (an activity occurring in a particular location) -- called an *episode* -- occurs. In this report we split the microenvironmental concept into a *microenvironmental-factor* component (location, activity, and smoker-present categories by themselves or in combination) and a time component (beginning and ending times over the 24-hour diary day or -- for time-of-day analysis -- equal time intervals such as a minute or 3-hours). See Appendix A for a discussion of the microenvironmental concept and its use in human exposure modeling.

Before undergoing a new monitoring study or modeling effort, investigators can discover -- using the indirect exposure assessment approach and a data base such as NHAPS -- for which time periods and geographic and socioeconomic subpopulations a specific microenvironment occurs long enough and frequently enough to pose a potentially significant risk to human health. For example, estimates of the exposure to carbon monoxide (CO) from environmental tobacco smoke (ETS) in

office settings (as determined by monitoring studies using actual smokers in real offices) can be weighted by the total duration of all office setting locations obtained from NHAPS to determine the seriousness of office CO exposures from ETS, and which city, state, gender, age group, etc., is connected with the most risk.

1.3. The Analyses Presented In This Report

In this report, 24-hour statistical calculations on each respondent's 24-hour diary are based on two derived variables that quantify how long and how often microenvironments are occurring in the NHAPS sample: (1) the duration of microenvironments **D**; and (2) the frequency of occurrence of microenvironments **O**. The number of respondents experiencing each microenvironment -- the doer sample size **N** -- was also calculated. The six calculations presented in this report are the: (1) sample proportion (percent) of **time spent** over 24-hours -- based on **D** alone; (2) sample proportion of **people** over 24-hours -- based on **N**; (3) descriptive statistics (means) of both **D** and **O**; (4) sample proportion of occurrences by minute -- based on **O** alone; (5) descriptive statistics of **D** by 3-hour segments; and (6) the sample proportion of **people** by each of the eight 3-hour segments in the 24-hour diary day (see Table 1-1 for an index of results figures and tables corresponding to each of the six analyses). The descriptive statistics of **D** and **O** were only performed on respondents for which each microenvironment occurred -- referred to as the "doers". The sample proportions of time spent were performed over all respondents, *i.e.*, both the doers and non-doers, except for calculations on exposure to ETS where only the doers were considered.

Since many of the follow-up questions on frequency of occurrence and duration of exposure events (*e.g.*, number of minutes spent exposed to glue) had missing data or were recoded in an unwieldy format that contained both categorical (for example, "under one minute" or "over two hours") and interval (an exact number of minutes) data, they were not analyzed. The follow-up variables concerning the occurrence or non-occurrence of exposure events on the diary day or in some other time

Table 1-1. Index of Tables and Figures in Section 6 Containing the Results of **D,O,N** Statistical Calculations for Selected Microenvironments Over the Respondents' 24-hour Diaries by Time and Background Grouping Factors

	[a]Derived Variable(s)	[b]Statistical Calculations	[c]Time Unit of Study	[d]*Grouping Factors* Time	Back-ground	[e]*Microenvironments* Location (10)	Activity (7)	Smoker-Present (2)	Location x Smoker-Present (20)	Location x Activity (70)
1.	**D**	Sample Proportion of Time Spent	24-Hour Diary Day	-	-	f 6-1, t 6-1	f 6-13, t 6-4	f 6-26	f 6-28, t 6-7	f 6-42, t 6-11
				-	Gender	f 6-3, t 6-1	f 6-15, t 6-4	f 6-26	f 6-29, t 6-7	t 6-15
				-	Age	f 6-5, t 6-1	f 6-17, t 6-4	f 6-26	f 6-31, t 6-7	t 6-15
				-	Region	f 6-7, t 6-1	f 6-19, t 6-4	f 6-26	f 6-34, t 6-7	t 6-15
				Day of Week	-	f 6-9, t 6-1	f 6-21, t 6-4	f 6-26	f 6-37, t 6-7	t 6-15
				Season	-	f 6-11, t 6-1	f 6-23, t 6-4	f 6-26	f 6-39, t 6-7	t 6-15
2.	**N**	Sample Proportion (or number) of Respondent Occurrences	24-Hour Diary Day	-	-	t 6-3	t 6-6	f 6-25	t 6-10	f 6-43, t 6-12
				-	Gender	t 6-3	t 6-6	f 6-25	t 6-10	t 6-16b
				-	Age	t 6-3	t 6-6	f 6-25	t 6-10	t 6-16b
				-	Region	t 6-3	t 6-6	f 6-25	t 6-10	t 6-16b
				Day of Week	-	t 6-3	t 6-6	f 6-25	t 6-10	t 6-16b
				Season	-	t 6-3	t 6-6	f 6-25	t 6-10	t 6-16b
3.	**D, O**	Descriptive Statistics (Means)	24-Hour Diary Day	-	-	f 6-2, t 6-2	f 6-14, t 6-5	f 6-27	f 6-28, t 6-8, 9	f 6-44,45, t 6-13,14
				-	Gender	f 6-4, t 6-2	f 6-16, t 6-5	f 6-27	f 6-30, t 6-8,9	t 6-16
				-	Age	f 6-6, t 6-2	f 6-18, t 6-5	f 6-27	f 6-32,33, t 6-8,9	t 6-16
				-	Region	f 6-8, t 6-2	f 6-20, t 6-5	f 6-27	f 6-35,36, t 6-8,9	t 6-16
				Day of Week	-	f 6-10, t 6-2	f 6-22, t 6-5	f 6-27	f 6-38, t 6-8,9	t 6-16
				Season	-	f 6-12, t 6-2	f 6-24, t 6-5	f 6-27	f 6-40,41, t 6-8,9	t 6-16
4.	**O**	Sample Proportion of Microenvironment Occurrences	Minute	Time of Day	-	f 6-48,49	f 6-53,54	f 6-58		
				Time of Day	Gender			f 6-58		
				Time of Day	Age	f 6-50	f 6-55	f 6-58		
				Time of Day	Region			f 6-58		
				Time of Day ◇ Day of Week	-	f 6-51	f 6-56	f 6-58		
				Time of Day ◇ Season	-	f 6-52	f 6-57	f 6-58		
5.	**D**	Descriptive Statistics (Means)	3-Hour Segment	Time of Day	-	f 6-60, t 6-18	f 6-62, t 6-20	f 6-63, t 6-21		
6.	**N**	Sample Proportion of Respondent Occurrences	3-Hour Segment	Time of Day	-	f 6-59, t 6-17	f 6-61, t 6-19	f 6-63, t 6-21		

[a] **D** = duration of microenvironments, **O** = frequency of occurrence of microenvironments, **N** = sample size of respondents experiencing a microenvironment (the doers) on the 24-hour diary day or some other time unit (*e.g.*, 3 hours). [b] Proportion of Time Spent and Proportion of Occurrences are usually reported in percentages or counts for each microenvironment. Descriptive statistics are reported as means only. [c] The time unit used for each statistical calculation is an absolute fixed-interval time such as 24-hours, minute or 3-hour segment. [d] Hyphens designate analyses over all respondents. [e] Parentheses contain the number of categories in each microenvironment. Cells contain the figure (f) or table (t) in Section 6 where the results of corresponding calculations are presented. Blank cells indicate no analyses were done for the corresponding breakdown. ***Note:*** This table contains only analyses of the 24-hour time diaries and no analyses of the follow-up

variables. Sample proportions are over all respondents except for smoker-present calculations which are for doers only. All calculations were weighted by time and background factor selection probabilities. Weighting is discussed in Section 4.

period (*e.g.* the last month or the last six months) that had enough valid responses were analyzed by the percentage of "yes" answers (Section 7). A "yes" response can be used to represent an exposure to the corresponding chemical source, with higher percentages of "yes" responses in each subgroup representing higher exposures.

For the 24-hour diaries, the original NHAPS microenvironmental factors (locations, activities, and smoker-present categories) were recoded into new categories according to (Section 4): (1) their relevance to personal exposure assessment; and (2) adequate sample size. The resulting microenvironments were broken down according to the background factors of gender (male/female), four age groups (0-4, 5-17, 18-64, 65 and over), and the four U.S. census regions (northeast, midwest, south, and west), and the time factors of day-of-week (weekend/weekday), season (fall, winter, spring, summer), and time-of-day. The follow-up questions were also analyzed by each background and time factor except time-of-day since the responses to each follow-up question did not contain time-of-day information. The development of appropriate weighting factors for all calculations is discussed in Section 4.

In theory, the total number of possible analyses (of the 24-hour diaries) is equal to the number of microenvironmental factors times the number of time factors times the number of background factors times the number of calculations (Figure 1-1). For example, in this report we use 10 locations, 7 activities, two smoker-present categories, time-of-day by minute and 3-hour segments, day-of-week by weekend and weekday, spring/summer and fall/winter seasons, four age groups, gender, the four census regions, and six **D**,**O,N**-calculations, which gives 10 x 7 x 2 x 2 x 2 x 2 x 4 x 2 x 4 x 6 = 215,040 possible analyses. Of these, 150,528 are based on the 49 microenvironments that had fewer than 100 occurrences. Since for obvious reasons we cannot present all the possible analyses, we have chosen to omit location x activity and location x smoker-present analyses for calculations involving time-of-day (calculation #'s 4, 5, and 6 in Table 1-1). The proportion of microenvironment occurrences for time-of-

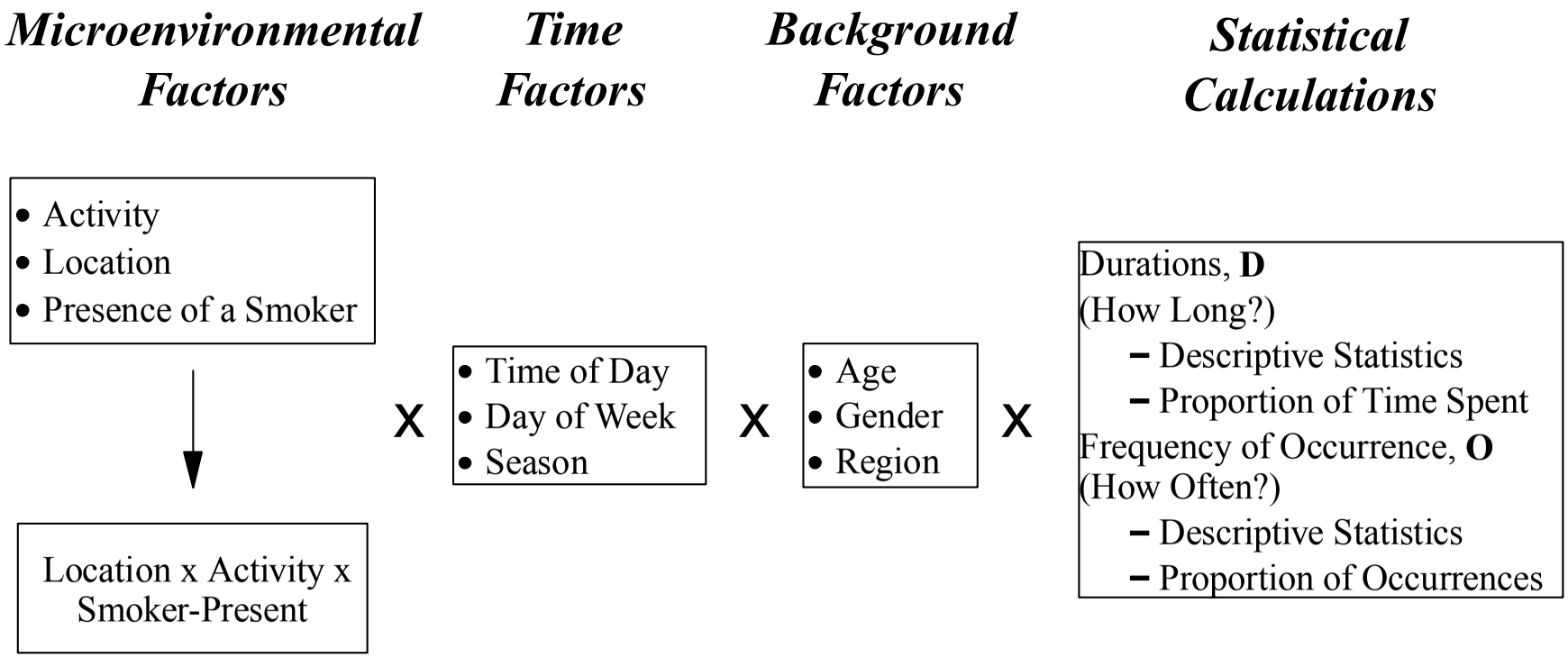


Figure 1-1. The four levels of analysis used in this report for the NHAPS 24-hour human activity pattern diaries: (1) three microenvironmental factors; (2) three time factors; (3) three background factors; and (4) two calculations for the "How Long?" category and two calculations for the "How Often?" category.

day at minute resolution (calculation #4) were done for selected background factors, and the 3-hour segmented descriptive statistics and sample proportions of people (calculations #5 and #6) were only done over all the respondents. Besides time-of-day by day-of-week and season, no calculations were done for mixed time factors or mixed background factors.

1.4 Calculation Methodology

The 24-hour *time unit* (the diary day) can be used to calculate proportions of time spent and frequency distributions of **D** and **O** by day-of-week and seasonal time factors (calculations #1 and #3 in Table 1-1). But for calculations by time-of-day (calculation #'s 4, 5 & 6), we need to use a series of much smaller fixed-length time units such as minutes or 3-hour segments. While **D**-calculations (proportion of time spent and frequency distributions) require durations obtained from the beginning and ending times of each microenvironment, **O**-calculations are based on the simple occurrence or non-occurrence of a microenvironment in a specified time interval, and can be easily applied over these smaller time units. But small time units destroy duration information within the time unit since the beginning and ending times of some microenvironments extend beyond each absolute time boundary, and when the length of the time unit is reduced to the finest resolution of the microenvironment's beginning and ending times (one minute for NHAPS), duration information is completely destroyed. Thus, no **D**-calculations could be done for time-of-day at minute resolution (calculation #4 in Table 1-1).

For 24-hour calculations the NHAPS respondents' 24-hour diaries were first sorted by microenvironment (including their beginning times, ending times, and corresponding durations), and then the doers were selected and grouped according to the time and background factors. **D** and **O** were obtained by adding up all the time each doer spent in each microenvironment over the entire 24-hour diary day and counting the number of times each doer entered each microenvironment over the entire 24-hour diary day, respectively.

In contrast, when the time unit was less than 24-hours (for one minute and 3-hour time-of-day analyses), the beginning and ending times in the multiple-record NHAPS respondents' 24-hour diaries

(grouped by time and background factors) were first converted into a constant number of records (1440 minutes or eight 3-hour segments) specifying the microenvironments occurring during each time unit. After the records were sorted by time unit and microenvironment, **O** was obtained by counting the number of microenvironments within each time and microenvironment grouping. Technically, **D** cannot be obtained within time units that are smaller than the microenvironment durations, but for 3-hour segment time units we assigned **D** to the 24-hour time unit durations of microenvironments that began within each 3-hour time unit. For example, as we count all the respondents that are located inside their home beginning in the 2nd 3-hour time segment (out of 8 total), the ending time of some of the episodes may fall outside the 2nd 3-hour time unit boundary. Instead of truncating the episode so that it fits in this 3-hour time unit, we used the full duration -- with untruncated ending times -- regardless of the 3-hour segment in which it terminates (for example, see Appendix B).

Note: The conceptual methodology employed in this report is given in Appendix A. Detailed examples of the calculation methodology for both the 24-hour and time-of-day analyses in this report -- including SAS computer code -- are given in Appendix B.

Technical Note: The work presented in this report was completed using the SPSS (© SPSS Inc,) and SAS (© SAS Inc.) statistical software packages. All graphics were done using SAS, Freelance Graphics for Windows™ (©Lotus), and Microsoft Excel for Windows™ (©Microsoft).

Technical Disclaimer: The data summaries and methodology in this report are not comprehensive, and are meant as examples for researchers that will be conducting more specific (and thorough) analyses of the NHAPS data for use in their own work. Sample weights and selected time and background weights have been incorporated in reported statistics, but these may not be appropriate for all uses of the data.

1.5 Using the Results: Exposure Assessments

Total human exposure assessments are concerned with the confluence of a pollutant concentration at a certain place (x, y, z coordinate) and time and a human being at the same place and time. In this way, as chemical toxins come into contact with a person via air (lungs, skin), water (gut, skin), soil (gut, skin), or food (gut) media (*i.e.*, the inhalation, ingestion, or dermal pathways) at time t and spatial coordinates x, y, and z, the person is said to be *exposed*. The results of the HAP calculations described above can be used to determine the time (time-of-day, season, day-of- week) and spatial coordinates (location) for

different exposure events (exposure activities such as cooking or having a smoker present) and subgroups. The concept of a *microenvironment* is used to describe all the exposure-relevant time and space factors that are contained in the HAP data (see Appendix A).

In this report we present the time and space aspects of exposure in terms of: (1) which microenvironments occupy the largest fraction of time over the entire sample; (2) the fraction of respondents that is experiencing each microenvironment on the 24-hour diary day -- the doers; (3) the length of time (24-hour duration) that the doers are spending in the microenvironments; and (4) the relative fractions of time, fractions of respondents, and durations across background (gender, age, region) and time (time of day, day of week, season) factors. These quantities obtained purely from HAP data can be used to estimate exposure across different subgroups (background and time factors); however, one must assume that pollutant concentrations have approximately the same magnitude across the subgroups.

Accurate assessments of exposure for populations depend on accurate knowledge of the pollutant concentrations and their movement to the lungs, gut, or skin of the population of human subjects (obtained from measurement, air monitoring, or modeling). Ideally, HAP data for a population and microenvironmental pollutant data for the same population are combined to give point estimates (using mean concentrations and times spent in microenvironments) or frequency distributions of population exposure (distributions of time spent and pollutant concentration are Monte-Carlo sampled). For dermal and ingestion exposures, in addition to measurements of toxin concentrations, we must measure the volume of material eaten or applied and the surface area for the person being exposed over the duration of the microenvironment. Air exposure estimates require: (1) the pollutant concentrations (assumed to be homogeneous) as determined from monitoring surveys or deterministic models that in turn require pollutant source strengths and pollutant movement mechanisms (air exchange rates, removal rates, etc.); and (2) inhalation rates.

Given HAP data only, the estimation of population exposures across different subgroups is probably most accurate for the air-inhalation pathway since the amount of exposure is approximately

proportional to the duration of time spent in a microenvironment (assuming pollutant magnitudes and inhalation rates are about the same for different demographic groups at different times). Conversely, dermal or ingestion exposures can vary greatly from person-to-person for the same microenvironment duration.

In this report, we don't use the HAP results to assign explicit exposures (*i.e.*, we are **not** conducting an exposure assessment), but we do use the results to compare *potential exposure* (*i.e.*, exposure that may occur in a microenvironment) across subgroups for each kind of microenvironment (location, activity, and smoker-present), which is probably most accurate for exposure to air pollutants. The "yes or no" follow-up questions (in Section 7) are also used to assign potential exposures for different subgroups. The percentage of time spent in microenvironments during the 24-hour diary day over the entire population is used to assign the significance of a microenvironment to the population. Likewise, as more people are experiencing a microenvironment during the 24-hour diary day, that microenvironment is assigned more exposure significance for the population. Microenvironments may appear significant based on the overall amount of time being spent, but not significant based on the number of people experiencing them. In this case, the relatively small segment of the population experiencing them -- the doers -- are spending large amounts of time (durations) in these microenvironments (see Table 1-2, Case #2). Alternatively, microenvironments that do not appear significant based on the overall percentage of time spent may be experienced by a large segment of the population. Here, the large number of doers are not spending much time in these microenvironments (see Table 1-2, Case #3). When using amounts of time spent in microenvironments or frequencies of occurrence of microenvironments to assign relative exposures for the population as a whole and for the doers, it should be noted that small durations may result in large exposures if the magnitude of exposure is large. Table 1-3 gives a summary of each microenvironmental quantity (for HAP data and experimental data) and describes how they can be used to estimate population exposures.

Table 1-2. How Different Percentages of Time Spent and Numbers of People Experiencing a Microenvironment (Doers) Contribute to the Overall Significance of the Microenvironment With the Corresponding Doer Durations

Case	Percentage of Time Spent	Number of People (Doers)	Duration for Doers
1	Significant	Significant	Either Short or Long
2	Significant	Not Significant	Long
3	Not Significant	Significant	Short
4	Not Significant	Not Significant	Either Short or Long

Table 1-3. How Each Microenvironmental Quantity (HAP Calculation or Experiment) Is Used to Estimate Exposure

	Microenvironmental Quantity	HAP Variable	Doers or Non-Doers + Doers	Purpose/Comment
1	Percentage of Time Spent	**Duration, D**	Doers + Non-Doers	Assigns significance of microenvironments based on the number of people being exposed and the length of the exposures; large percentages could result from long exposure durations or from large numbers of people experiencing the exposures
2	Percentage of Respondents	**Sample Size, N**	Doers + Non-Doers	Assigns significance of microenvironments based on the number of people being exposed; confirms that large percentages of time spent are resulting from large numbers of people experiencing a microenvironment and not a small number of people experiencing long exposure durations; also used to analyze the movement of respondents through microenvironments over the diary day in fixed time frames (1 minute, 3-hours, etc.)
3	Percentage of Time Spent	**Duration, D**	Doers	Assigns significance of microenvironments based on the length of exposures of those exposed; can be compared with the percentage of time spent for doers and non-doers combined to estimate number of people experiencing each microenvironment as provided by the percentage of respondents (#2)
4	Mean 24-Hour Durations	**Duration, D**	Doers	Assigns significance of microenvironments based on the length of exposures of those exposed
5	Percentage of Microenvironment Occurrences	**Microenviron. Occurrences, O**	Doers + Non-Doers	Assigns relative significance of microenvironments during a given time frame (1 minute, 3-hours, 24-hours, etc.); equal to the proportion of respondents at the time resolution of the study
6	Mean 24-Hour Frequency of Occurrence	**Microenviron. Occurrences, O**	Doers	Indicates significance of microenvironments based on how often exposures occur during the day for those that are exposed
7	*Exposure Magnitude (Means, Standard Deviations, Percentiles)	**from Monitoring, Measurement, or Modeling**	Doers	Determines microenvironments that may pose a significant exposure risk based on magnitudes of exposures, *e.g.*, average pollutant concentrations; cannot assign significance of exposure across a population since this requires population exposure durations; can be combined with HAP studies to estimate exposure magnitudes across populations

Note: Magnitudes of exposures are determined from factors "unknown" in human activity pattern (HAP) studies alone such as air exchange rates, source strengths, or from actual monitoring studies. The *significance* of a microenvironment for a given population is defined by how much it poses a serious exposure risk for that population. HAP studies can assign significance based on the time spent in microenvironments as determined from: the duration of microenvironments **D**, the number of respondents in each microenvironment **N**, and the number of times the microenvironment occurs **O**. A microenvironment may not be significant for the population as a whole but can pose a very serious exposure risk for the members of the population that experience it (small numbers of people with large durations). Alternatively, microenvironments that appear to be significant for the whole population may be experienced by large numbers of respondents, but they may not have very large durations. * = Not obtained from HAP studies

2. SUMMARY OF THE DATA-COLLECTION METHODOLOGY

The NHAPS study was designed to be used in the assessment of personal exposure to pollutants in air and water systems with which people in the United States come into contact throughout their typical daily routine. The complete data-collection methodology (including example questionnaires) is presented in another work.[8] Carried out between October 1992 and September 1994, NHAPS is an extensive data resource, containing geographic (EPA region, U.S. census region, state, zip code, etc.) socioeconomic (gender, age, race, education, etc.) and time/season (quarter, month, day of week, etc.) information on 9,386 different respondents (*i.e.*, respondents were never re-interviewed in the study) distributed over 8 seasonal quarters throughout the entire nation (see Table 2-1 for a summary of the NHAPS features). Detailed minute-by-minute 24-hour diaries were collected for each respondent containing 82 different possible locations (Residence-Kitchen, Residence-Garage, Office, School, Bar-Restaurant, Automobile, etc.), 91 different activities (Cleaning, Food Preparation, Bathing, etc.), and whether a smoker was ever present or not. Additionally, respondents were asked some fraction of 175 exposure-related follow-up questions (focused on air and water pathways) on specific pollutant sources (paint, glue, etc.) or prolonged background activities (gas heaters, wood smoke, etc.).

The interviews began with random selection of a respondent from the selected household. Saturdays and Sundays were oversampled to insure an adequate weekend sample size. The interviews lasted an average of 23 minutes with most beginning between 6:00 and 9:00 pm (Figure 2-1 and Table 2-2). If the respondent chosen was a child too young to provide responses, an adult (18 and older) in the household gave a proxy interview (Table 2-3). Since either an adult or a child could have been chosen from the household, and their probability of selection depends on the number of adults/children in the household and the criteria used for selection, a compensating weight was created. This weight

was combined with the probability of household selection based on the number of non-business phones in

Table 2-1. Summary of the National Human Activity Pattern Survey (NHAPS) Features

Dates of Data Collection	October 1992 through September 1994 (8 three-month seasonal quarters)
Data Collection Instrument	Telephone interviews using a Random-Digit Dial (RDD) method and Computer Assisted Telephone Interviewing (CATI)
Data Types	(1) 24-hour diaries with beginning and ending times at minute resolution, (2) demographic questions, and (3) 175 follow-up questions on medical background, housing characteristics, and exposure to chemicals
Number of Total Respondents	9,386
Response Rate	63% (65% for last seven quarters; first quarter was 46% from difficulties in procedure and training schedules)
Cooperation Rate	Excluding those respondents not contacted (or because they were not interviewed for other factors) the cooperation rate was over 75%
Geographic Coverage of Respondents	The 48 contiguous United States, *i.e.*, excluding Alaska and Hawaii, by state, EPA region, U.S. census region, telephone area code, working postal zip code, and residential postal zip code
Socio-economic Coverage of Respondents	Ages 0 to 93, gender, race, education, employment status, etc.
Emphasis of 175 Follow-up Questions	Personal exposure to contaminants in air and water from household sources
24-Hour Diary Location Categories	82 categories arranged by Own House, Friend's/Other's House, Traveling, Other Indoor, and Other Outdoor
24-Hour Diary Activity Categories	91 categories arranged by Non-Free Time (Paid Work, Household Work, Child Care, Obtaining Goods/Services, Personal Care) and Free Time (Educational, Organizational, Social, Recreational, Communications)
Diary Variables for each Microenvironment	date (month, day & year), starting time, ending time, elapsed time (duration), presence of a smoker, heavy breathing activity (yes or no), location category, and activity category
Total Diary Records (Microenvironments)	157,234
Number of Different Microenvironments Per Person	Range = 1 to 59; Mean = 17

Table 2-2. Number of NHAPS Respondents by the Time the Interview Began

TIME	Code	Frequency	Percent
MIDNIGHT	0	2	0
8:00 AM	8	1	0
9:00 AM	9	67	0.7
10:00 AM	10	215	2.3
11:00 AM	11	308	3.3
NOON	12	417	4.4
1:00 PM	13	452	4.8
2:00 PM	14	503	5.4
3:00 PM	15	565	6
4:00 PM	16	598	6.4
5:00 PM	17	914	9.7
6:00 PM	18	1329	14.2
7:00 PM	19	1347	14.4
8:00 PM	20	1302	13.9
9:00 PM	21	1002	10.7
10:00 PM	22	305	3.2
11:00 PM	23	46	0.5
Missing	.	13	0.1
Total		9386	100

Note: The variable used to produce the frequency distribution is in the upper left hand corner of the table.

Table 2-3. Number of NHAPS Respondents by Type of Interview

TYPE	Code	Frequency	Percent
ADULT	1	7514	80.1
CHILD	2	837	8.9
PROXY	3	338	3.6
PROXY	4	697	7.4
Total		9386	100

Note: The variable used to produce the frequency distribution is in the upper left hand corner of the table.

Table 2-4. The Number of NHAPS Respondents by the Number of Non-Business Phones in Each Household

PHONES	Code	Frequency	Percent
	1	8394	89.4
	2	840	8.9
	3	83	0.9
	4	8	0.1
	5	4	0
	6	6	0.1
Missing	9	51	0.5
Total		9386	100

Note: The variable used to produce the frequency distribution is in the upper left hand corner of the table.

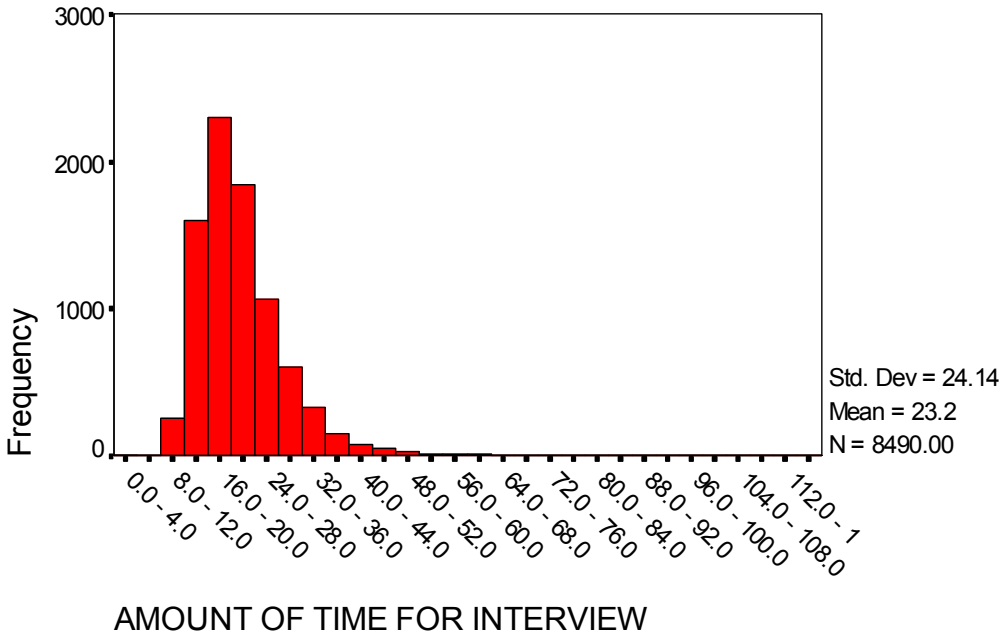


Figure 2-1. Histogram of the number of minutes that each interview lasted.

each household (Table 2-4) to give the weighting variable WEIGHT. In this report WEIGHT was used to calculate a joint frequency table across various subgroups (age, gender, day ofweek, season), which was then used to create an overall weighting variable WEIGHT4 that improved the representativeness of the NHAPS sample with respect to these subgroups using 1990 Census data (see Sections 3 and 4).

Each of the 9,386 persons interviewed were asked to recount their entire daily routine from midnight to midnight on the day immediately previous to the day that they were interviewed. The beginning and ending times of each microenvironment in these diaries were recorded with a time resolution of one minute in the "diary" data file (Table 2-5). Together, the set of beginning and ending times for each microenvironment spanning one day comprise a comprehensive, sequential account of a person's locations, activities, and proximity to smokers (for example, see Table B-1 in Appendix B). The qualification of presence-of-a-smoker was expanded in the last two quarters of the study (April 1994 to September 1994) from the simple "smoker-present" category to the fraction of time a smoker was present: "the entire time"; "more than half the time"; "half of the time"; "less than half the time"; or "hardly any of the time".

The NHAPS study did not collect any minute-by-minute diary data on the respondents' proximity to specific pollutant sources (besides a smoker). For example, there are gaps in the source type such as cleaning agent, pesticide, solvent, or stove, and in their method of use. Minute-by-minute categories for housing characteristics such as windows open or heat on, and types of exercise such as running or hiking are also missing.

After the 24-hour diaries were collected each respondent was asked follow-up questions on personal exposure, household characteristics, and medical background, which were stored in the "main" data file (Table 2-5). Each of the 175 follow-up questions were placed on either an A questionnaire or a B questionnaire or both. A nationally representative number of respondents were

given each questionnaire (4,723 for A only and 4663 for B only). The main file also contains all the demographic, respondent identification, and time variables (respondent ID #, interview date, time interview began, duration of interview, number of phones in household, type of interview, age, race, etc.). In addition to "yes or no" questions on specific exposure issues (do you use a humidifier?, does your house have a basement?, etc.), many of the follow-up questions concerned frequencies of occurrence and durations of exposure events (how many cigarettes do you smoke?, for how many minutes did you take a shower?, etc.). Table 7-2 in Section 7 lists each variable and its descriptive label.

Table 2-5. Description of the Two NHAPS Data Files

Filename	**Description**
MAIN.XXX *455 variables* *9,386 records*	Main file containing household and identification information (respondent ID#, length of interview, etc.), demographic background information (region, gender, age, etc.), temporal information (day of week, month, year, etc.), responses to the 175 exposure follow-up questions, and frequencies in each location and activity diary category for all 9,386 respondents.
DIARY.XXX *16 variables* *157,234 records*	Diary file containing multiple-record 24-hour diaries for each of the 9,386 respondents. The variable set of records correspond to all the different microenvironments each respondent visited and include the location, activity, and smoker-present codes, and the beginning and ending times for each microenvironment.

Note: Each file has a variable containing a unique identification code for each respondent that was used to link the information in the two files. The files were supplied in SPSS-format (XXX = SYS) but were converted into SAS-format (XXX = SSD) for most of the analyses.

3. GEOGRAPHIC, SOCIOECONOMIC, AND TEMPORAL DIVISIONS OF THE RESPONDENTS

To conduct exposure assessments for different populations in the U.S., the NHAPS data must be broken down into specific socioeconomic and geographic subgroups. For example, scientists may wish to determine the effects of tobacco smoke in the home on females in the state of Pennsylvania. Before the NHAPS data can be used for such a specific subgroup, there must first be enough NHAPS respondents for the statistical analysis. Researchers should examine the NHAPS data to determine whether the subgroups they are interested in: (1) have adequate sample size; and (2) occur in representative proportions when compared to the population. Here, the NHAPS sample sizes are compared to the 1990 U.S. Census[30] for EPA region, U.S. census region, gender, and age to determine their representativeness. The proportions of respondents interviewed on each quarter and day of the week are also compared to their desired values (1/7 for each day of the week and 1/8 for each seasonal quarter). The gender, age, day of week, and season subgroups were used in Section 4 to develop appropriate weighting factors based on the 1990 U.S. Census.

3.1 Geographical Divisions

The NHAPS geographical variables are zip code, state, area code, EPA region, and U.S. census region (Table 3-1). Although the zip codes variables may be useful for the study of subpopulations in several densely-populated urban regions, the usefulness of zip codes may be limited because: (1) more than 50% of the work zip codes (ZIPWORK) are missing; and (2) the number of respondents in most zip codes may not be adequate to conduct a complete analysis. Divisions by area code will probably be more appropriate in the study of a larger number of metropolitan areas.

A relative comparison of NHAPS and Census proportions is defined as the ratio of the percentages in each state of the Census data to NHAPS. A comparison of the number of NHAPS respondents in each state vs. the 1990 U.S. Census (Table 3-2) shows generally good agreement with the relative comparisons of most states close to 1 (see Figures 3-1 to 3-3). The only state that was

Table 3-1. The NHAPS Geographical Variables for Each Respondent

[a]Variable Name	Variable Label	Example
AREA	State	Alabama, Arizona, ...
EREGION	EPA Region	1, ..., 10
CREGION	Census Region	1, 2, 3, 4
RACD	Telephone Area Code	702, 415, 617, 301, ...
ZIPWORK	U.S. Postal Zip code of Main Workplace	
ZIPHOME	U.S. Postal Zip code of Home	

[a]57.8% of the ZIPWORK values are missing; 6.3% of the ZIPHOME values are missing.

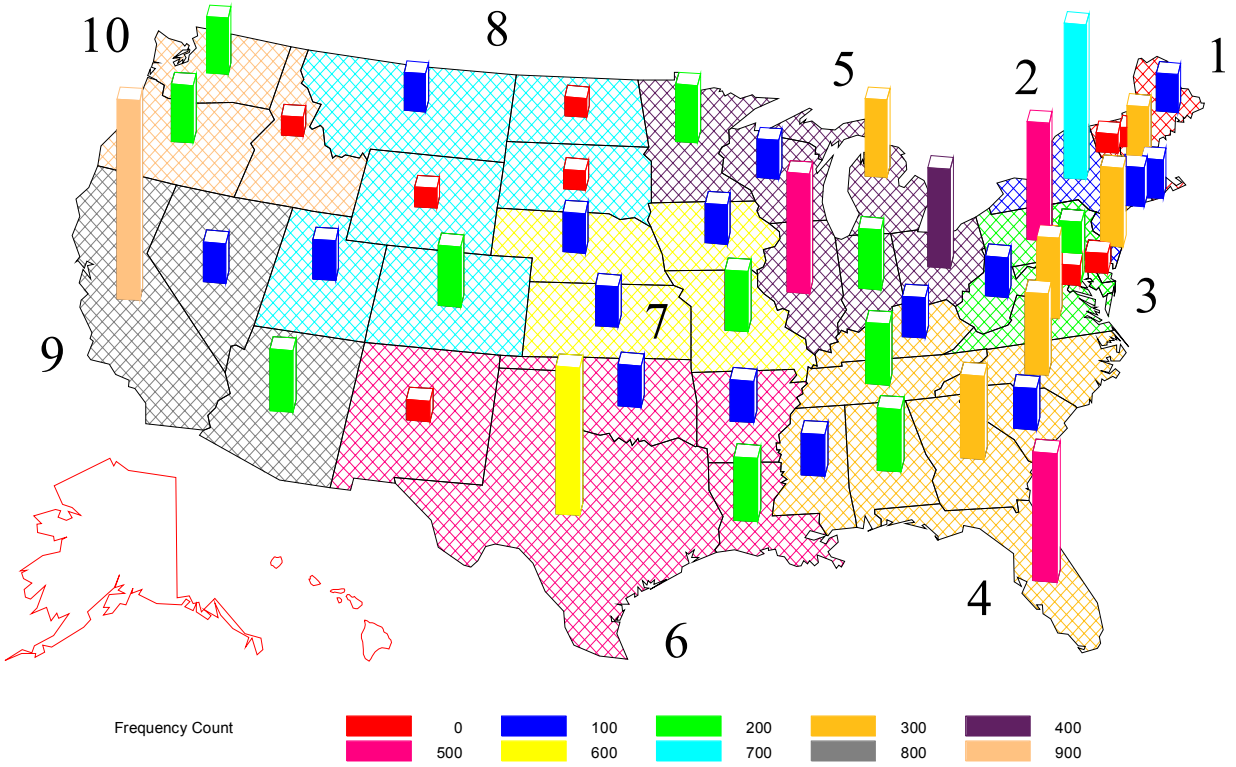


Figure 3-1. Map of the U.S. showing the number of NHAPS respondents in each state grouped by the ten labeled EPA Regions. There were no NHAPS respondents in either Alaska or Hawaii.

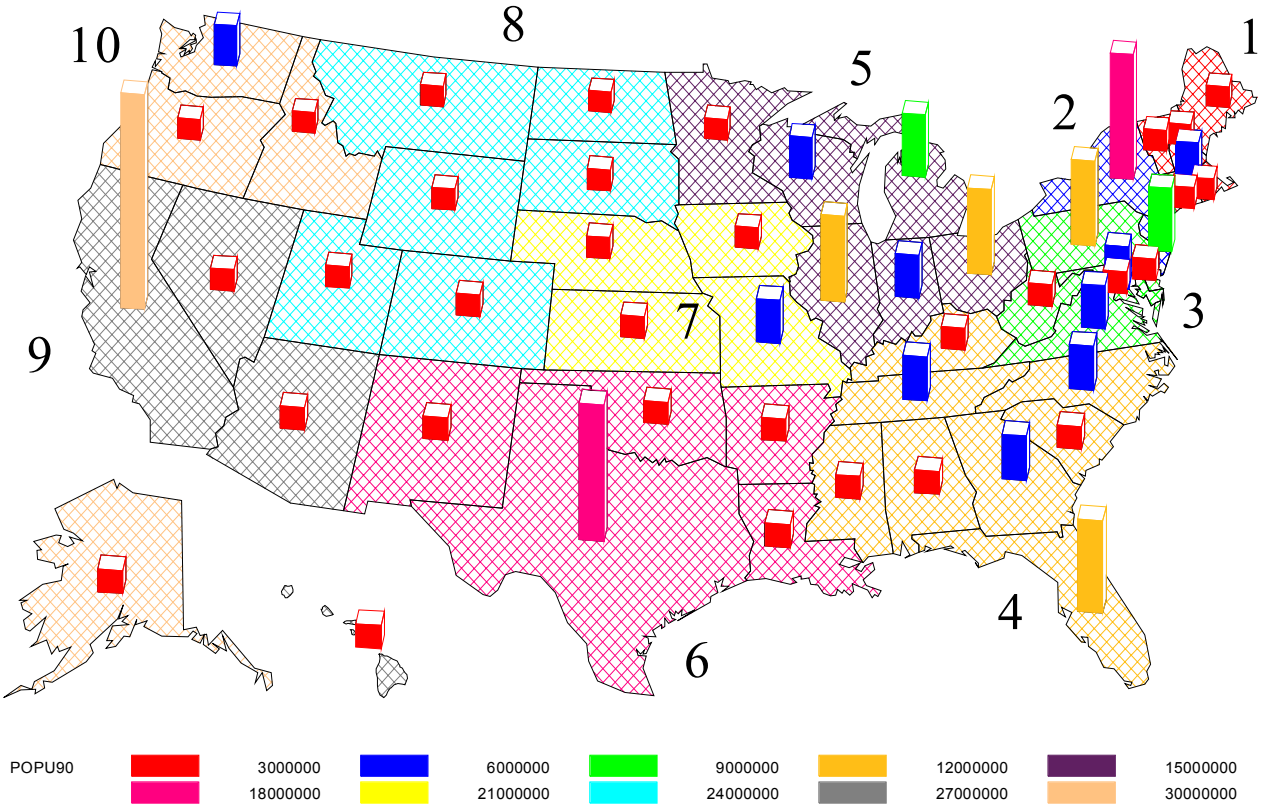


Figure 3-2. Map of the U.S. showing the population of each state as reported in the 1990 U.S. Census and grouped into the ten labeled EPA Regions.

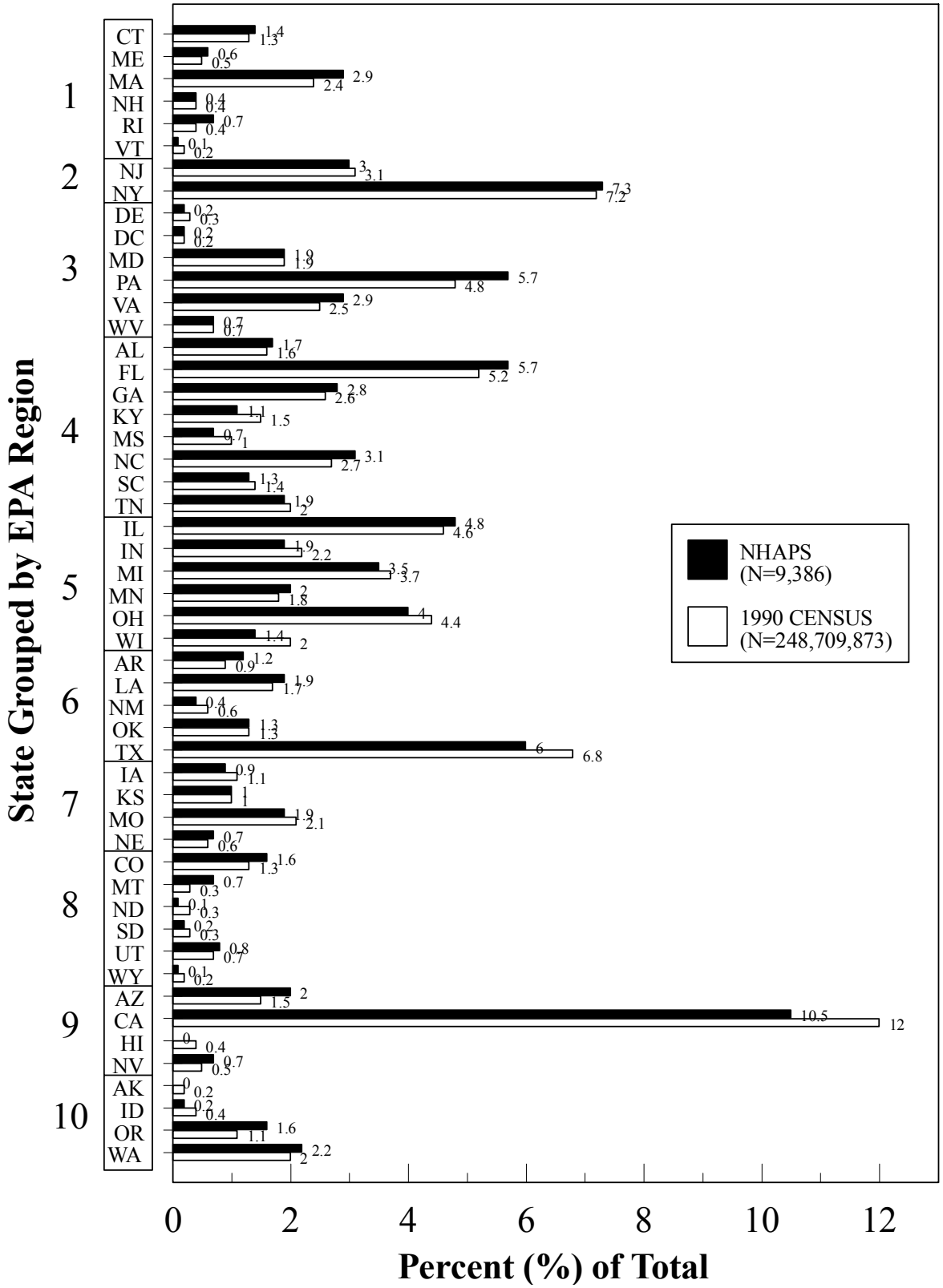


Figure 3-3. Percentage comparison bar chart of the 9,386 NHAPS respondents vs. the 248,709,873 1990 Census participants broken down by state and EPA Region.

Table 3-2. List of States Grouped Alphabetically Within Each EPA Region, Ranked by the 1990 U.S. Census Population with Comparison to the Number of NHAPS Respondents That Were Interviewed

EPA Region	Census Region	Rank	State Code (STFIPS)	State Name	State Abbrev.	No. NHAPS Respond.	%	1990 U.S. Census Population	%	% Diff	% Ratio
1	1	27	9	CONNECTICUT	CT	129	1.37	3,287,116	1.32	0.05	0.96
1	1	38	23	MAINE	ME	54	0.58	1,227,928	0.49	0.08	0.86
1	1	13	25	MASSACHUSETTS	MA	275	2.93	6,016,425	2.42	0.51	0.83
1	1	40	33	NEW HAMPSHIRE	NH	39	0.42	1,109,252	0.45	0.03	1.07
1	1	43	44	RHODE ISLAND	RI	63	0.67	1,003,464	0.40	0.27	0.60
1	1	49	50	VERMONT	VT	12	0.13	562,758	0.23	0.10	1.77
2	1	9	34	NEW JERSEY	NJ	278	2.96	7,730,188	3.11	0.15	1.05
2	1	2	36	NEW YORK	NY	687	7.32	17,990,455	7.23	0.09	0.99
3	3	46	10	DELAWARE	DE	22	0.23	666,168	0.27	0.03	1.14
3	3	48	11	DISTRICT OF COLUMBIA	DC	21	0.22	606,900	0.24	0.02	1.09
3	3	19	24	MARYLAND	MD	176	1.88	4,781,468	1.92	0.05	1.03
3	1	5	42	PENNSYLVANIA	PA	538	5.73	11,881,643	4.78	0.95	0.83
3	3	12	51	VIRGINIA	VA	270	2.88	6,187,358	2.49	0.39	0.86
3	3	34	54	WEST VIRGINIA	WV	62	0.66	1,793,477	0.72	0.06	1.09
4	3	22	1	ALABAMA	AL	157	1.67	4,040,587	1.62	0.05	0.97
4	3	4	12	FLORIDA	FL	534	5.69	12,937,926	5.20	0.49	0.91
4	3	11	13	GEORGIA	GA	266	2.83	6,478,216	2.60	0.23	0.92
4	3	23	21	KENTUCKY	KY	99	1.05	3,685,296	1.48	0.43	1.40
4	3	31	28	MISSISSIPPI	MS	63	0.67	2,573,216	1.03	0.36	1.54
4	3	10	37	NORTH CAROLINA	NC	290	3.09	6,628,637	2.67	0.42	0.86
4	3	25	45	SOUTH CAROLINA	SC	124	1.32	3486703	1.40	0.08	1.06
4	3	17	47	TENNESSEE	TN	180	1.92	4,877,185	1.96	0.04	1.02
5	2	6	17	ILLINOIS	IL	455	4.85	11,430,602	4.60	0.25	0.95
5	2	14	18	INDIANA	IN	176	1.88	5,544,159	2.23	0.35	1.19
5	2	8	26	MICHIGAN	MI	327	3.48	9,295,297	3.74	0.25	1.07
5	2	20	27	MINNESOTA	MN	186	1.98	4,375,099	1.76	0.22	0.89
5	2	7	39	OHIO	OH	373	3.97	10,847,115	4.36	0.39	1.10
5	2	16	55	WISCONSIN	WI	134	1.43	4,891,769	1.97	0.54	1.38
6	3	33	5	ARKANSAS	AR	108	1.15	2,350,725	0.95	0.21	0.82
6	3	21	22	LOUISIANA	LA	180	1.92	4,219,973	1.70	0.22	0.88
6	4	37	35	NEW MEXICO	NM	40	0.43	1,515,069	0.61	0.18	1.43
6	3	28	40	OKLAHOMA	OK	126	1.34	3,145,585	1.26	0.08	0.94
6	3	3	48	TEXAS	TX	565	6.02	16,986,510	6.83	0.81	1.13
7	2	30	19	IOWA	IA	82	0.87	2,776,755	1.12	0.24	1.28
7	2	32	20	KANSAS	KS	94	1.00	2,477,574	1.00	0.01	0.99
7	2	15	29	MISSOURI	MO	174	1.85	5,117,073	2.06	0.20	1.11
7	2	36	31	NEBRASKA	NE	68	0.72	1,578,385	0.63	0.09	0.88
8	4	26	8	COLORADO	CO	153	1.63	3,294,394	1.32	0.31	0.81
8	4	44	30	MONTANA	MT	63	0.67	799,065	0.32	0.35	0.48
8	2	47	38	NORTH DAKOTA	ND	14	0.15	638,800	0.26	0.11	1.72
8	2	45	46	SOUTH DAKOTA	SD	19	0.20	696,004	0.28	0.08	1.38
8	4	35	49	UTAH	UT	77	0.82	1,722,850	0.69	0.13	0.84
8	4	51	56	WYOMING	WY	14	0.15	453,588	0.18	0.03	1.22
9	4	24	4	ARIZONA	AZ	188	2.00	3665228	1.47	0.53	0.74
9	4	1	6	CALIFORNIA	CA	988	10.53	29,760,021	11.97	1.44	1.14
9	4	41	15	HAWAII	HI	0	0.00	1,108,229	0.45	0.45	0.00
9	4	39	32	NEVADA	NV	63	0.67	1,201,833	0.48	0.19	0.72
10	4	50	2	ALASKA	AK	0	0.00	550,043	0.22	0.22	0.00
10	4	42	16	IDAHO	ID	18	0.19	1,006,749	0.40	0.21	2.11
10	4	29	41	OREGON	OR	154	1.64	2,842,321	1.14	0.50	0.70
10	4	18	53	WASHINGTON	WA	208	2.22	4,866,692	1.96	0.26	0.88
Total						9,386	100	248,709,873	100		

Note: The last two columns (% Diff and % Ratio) are the absolute difference between the NHAPS vs. Census percentages in each state (absolute comparison) and the ratio of the Census percentage to the NHAPS percentage in each state (relative comparison), respectively.

oversampled in NHAPS (assuming the Census is an accurate measure of the number of inhabitants) with a relative comparison under 0.5 was Montana. States that were undersampled at a relative comparison over 1. 5 were Vermont, Mississippi, North Dakota, and Idaho. No NHAPS respondents were interviewed in either Alaska or Hawaii.

Because statistical analysis will require further subdivisions by demography and/or time, there should probably be at least 100 people in each area code grouping. The 20 states (including Washington D.C.) that do **not** have at least 100 NHAPS respondents are Delaware, the District of Columbia (D.C.), Idaho, Iowa, Kansas, Kentucky, Maine, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Dakota, Rhode Island, South Dakota, Utah, Vermont, West Virginia, and Wyoming (see Table 3-2). The states with over 500 NHAPS respondents were California, Florida, New York, Pennsylvania, and Texas.

The percentage of NHAPS respondents sampled in each of the 10 EPA Regions is comparable to the population observed in the 1990 U.S. Census (Figure 3-4, Table 3-3) with all relative comparisons of the Census vs. NHAPS clustered from 0.9 to 1.2. There is a sufficient NHAPS sample size in each EPA Region to perform a detailed statistical analysis with a low of 340 NHAPS respondents in EPA Region 8. Six of the other regions have between 900 and 1800 respondents, with the remaining three having between 350 and 600 respondents.

Each of the four U.S. Census regions (Table 3-4) has approximately 2000 to 3000 NHAPS respondents each. The relative comparisons between the 1990 Census and NHAPS are all near 1.

The NHAPS sample sizes by area code within each state are listed in Table 3-5. The 37 area code subregions within each state that have more than 100 NHAPS respondents are: (1) Alabama; (2) Arizona; (3) Arkansas; (4) the Los Angeles, California area; (5) the San Francisco, California Bay area; (6) eastern California; (7) northeastern California; (8) northwest California; (9) the northwest section of

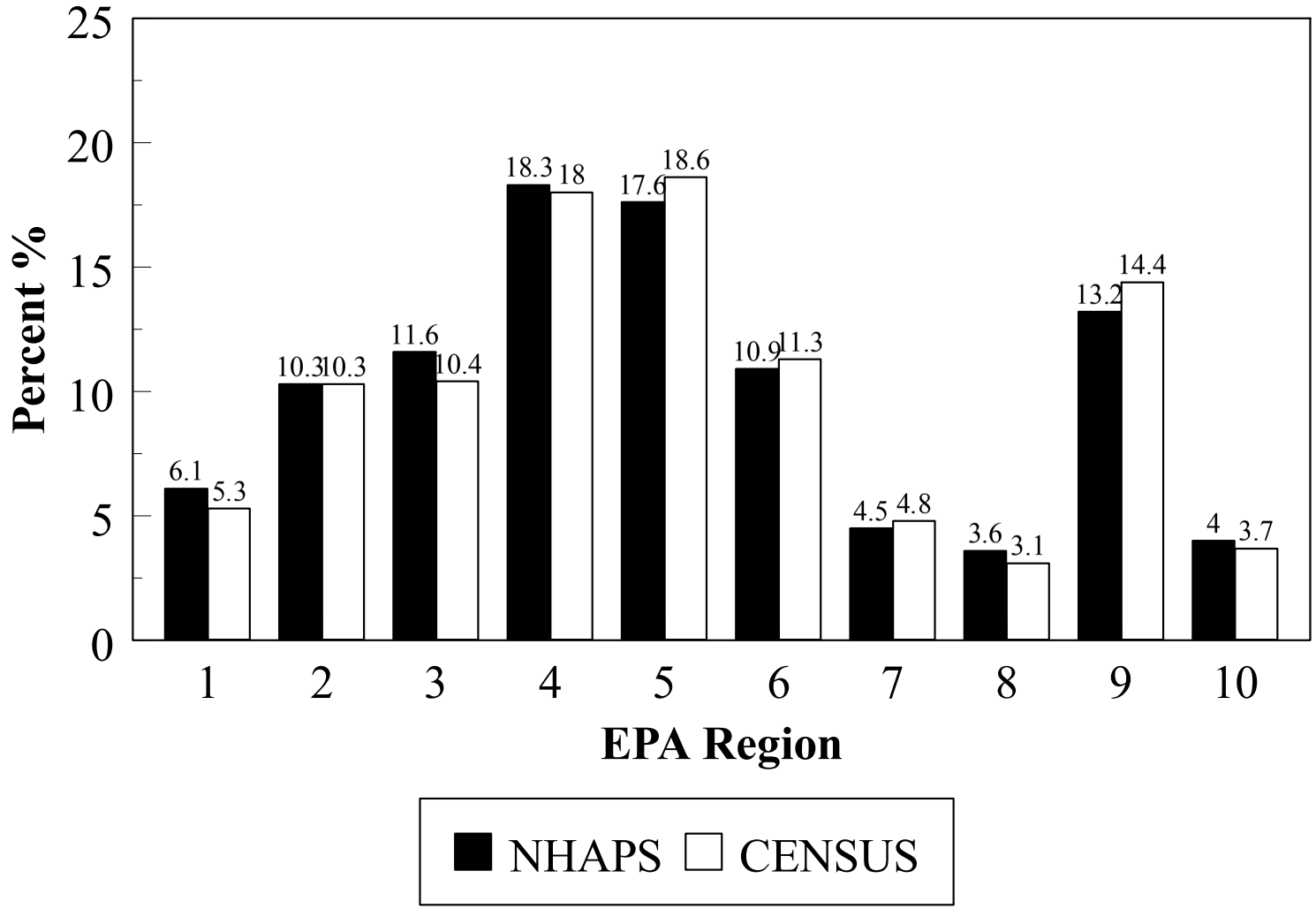


Figure 3-4. Side-by-side percent comparison of the number of NHAPS respondents vs. the 1990 U.S. Census in each EPA Region.

Table 3-3. Comparison of 1990 U.S. Census Population With Number of NHAPS Respondents in Each EPA Region

EPAREG	EPA Region Name	Composite States	No. NHAPS Respondents	%	1990 U.S. Census Population	%	% Ratio
1	NEW ENGLAND	CT, ME, MA, NH, RI, VT	572	6.1	13,206,943	5.3	1.2
2	NORTH ATLANTIC	NJ, NY	965	10.3	25,720,643	10.3	1.0
3	MID ATLANTIC	PA, DE, DC, MD, VA, WV	1089	11.6	25,917,014	10.4	1.1
4	SOUTH ATLANTIC	AL, FL, GA, KY, MS, NC, SC, TN	1713	18.3	44,707,766	18.0	1.0
5	MIDWEST	IL, IN, MI, MN, OH, WI	1651	17.6	46,384,041	18.6	0.9
6	SOUTH CENTRAL	AR, LA, OK, TX, NM	1019	10.9	28,217,862	11.3	1.0
7	CENTRAL	IA, KS, MO, NE	418	4.5	11,949,787	4.8	0.9
8	NORTH CENTRAL	ND, SD, CO, MT, UT, WY	340	3.6	7,604,701	3.1	1.2
9	PACIFIC	AZ, CA, HI, NV	1239	13.2	35,735,311	14.4	0.9
10	MOUNTAIN	AK, ID, OR, WA	380	4.0	9,265,805	3.7	1.1
	TOTAL		9386	100	248,709,873	100	

Note: See Table 3-2 for STFIPS and state names. The NHAPS data does not include any respondents for Alaska or Hawaii. The last column (% Ratio) is the ratio of the percentages in each state (relative comparison).

Table 3-4. Comparison of 1990 U.S. Census Population With Number of NHAPS Respondents in Each Census Region

CENSREG	Census Region Name	States	No. NHAPS Respondents	%	1990 U.S. Census Population	%	% Ratio
1	NORTHEAST	CT, ME, MA, NH, RI, VT, NJ, NY PA	2075	22.1	50,809,229	20.4	1.1
2	MIDWEST	IL, IN, MI, MN, OH, WI, IA, KS, MO, NE, ND, SD	2102	22.4	59,668,632	24.0	0.9
3	SOUTH	DE, DC MD, VA, WV, AL, FL, GA, KY, MI, NC, SC, TN, AR, LA, OK, TX	3243	34.6	85,445,930	34.4	1.0
4	WEST	NM, CO, MT, UT, WY, AZ, CA, HI, NV, AK, ID, OR, WA	1966	20.9	52,786,082	21.2	1.0
	TOTAL		9386	100	248,709,873	100	

Note: See Table 3-2 for STFIPS and state names. The NHAPS data does not include any respondents for Alaska or Hawaii. The last column (% Ratio) is the ratio of the percentages in each state (relative comparison).

Table 3-5. The Number of NHAPS Respondents in Each Area Code Arranged by State

No.	STFIPS	Census Region	EPA Region	Abbrev.	State	Area Code Sub Region	Area Code	Area Code Frequency	State Frequency	State Percent
1.	1	3	4	AL	ALABAMA	ALL	205	157	157	1.7
2.	2	4	10	AK	ALASKA	ALL	907	0	0	0
3.	4	4	9	AZ	ARIZONA	ALL	602	188	188	2
4.	5	3	6	AR	ARKANSAS	ALL	501	108	108	1.2
5.	6	4	9	CA	CALIFORNIA	Fresno Area	209	92	988	10.5
6.					CALIFORNIA	Los Angeles	213	70		
7.					CALIFORNIA	Santa Monica Area	310	148		
8.					CALIFORNIA	South Bay Area	408	38		
9.					CALIFORNIA	West Bay Area	415	58		
10.					CALIFORNIA	East Bay Area	510	50		
11.					CALIFORNIA	Eastern	619	105		
12.					CALIFORNIA	Northwestern	707	44		
13.					CALIFORNIA	Santa Ana Area	714	77		
14.					CALIFORNIA	San Luis Obispo Area	805	61		
15.					CALIFORNIA	San Fernando Area	818	76		
16.					CALIFORNIA	Southeastern	909	49		
17.					CALIFORNIA	Northeastern	916	120		
18.	8	4	8	CO	COLORADO	Northwest	303	115	153	1.6
19.					COLORADO	Southeast	719	38		
20.	9	1	1	CT	CONNECTICUT	ALL	203	129	129	1.4
21.	10	3	3	DE	DELAWARE	ALL	302	22	22	0.2
22.	11	3	3	DC	D.C.	ALL	202	21	21	0.2
23.	12	3	4	FL	FLORIDA	Miami Area	305	127	534	5.7
24.					FLORIDA	Eastern	407	128		
25.					FLORIDA	Southwestern	813	150		
26.					FLORIDA	Northern	904	129		
27.	13	3	4	GA	GEORGIA		212	1	266	2.8
28.					GEORGIA	Atlanta Area	404	130		
29.					GEORGIA	Northern	706	86		
30.					GEORGIA	Southern	912	49		
31.	15	4	9	HI	HAWAII	ALL	808	0	0	0
32.	16	4	10	ID	IDAHO	ALL	208	18	18	0.2
33.	17	2	5	IL	ILLINOIS	Springfield Area	217	91	455	4.8
34.					ILLINOIS	Peoria Area	309	21		
35.					ILLINOIS	Chicago Area	312	78		
36.					ILLINOIS	Southern	618	38		
37.					ILLINOIS	North Central	708	165		
38.					ILLINOIS	Rockford Area	815	62		
39.	`18	2	5	IN	INDIANA	Northern	219	61	176	1.9
40.					INDIANA	Central	317	80		
41.					INDIANA	Southern	812	35		
42.	19	2	7	IA	IOWA	Eastern	319	33	82	0.9
43.					IOWA	Central	515	23		
44.					IOWA	Western	712	26		
45.	20	2	7	KS	KANSAS	Southern	316	34	94	1
46.					KANSAS	Northern	913	60		
47.	21	3	4	KY	KENTUCKY	Western	502	54	99	1.1
48.					KENTUCKY	Eastern	606	45		
49.	22	3	6	LA	LOUISIANA	Western	318	91	180	1.9
50.					LOUISIANA	Eastern	504	89		
51.	23	1	1	ME	MAINE	ALL	207	54	54	0.6
52.	24	3	3	MD	MARYLAND	Western	301	62	176	1.9
53.					MARYLAND	Baltimore Area	410	114		
54.	25	1	1	MA	MASSACHUSETTS	Western	413	32	275	2.9
55.					MASSACHUSETTS	Central	508	137		
56.					MASSACHUSETTS	Boston Area	617	106		
57.	26	2	5	MI	MICHIGAN	Detroit Area	313	184	327	3.5
58.					MICHIGAN	Central	517	46		
59.					MICHIGAN	Western	616	82		
60.					MICHIGAN	Northeastern	810	15		

61.	27	2	5	MN	MINNESOTA	Northern	218	6	186	2
62.					MINNESOTA	Southern	507	36		
63.					MINNESOTA	Central	612	144		
64.	28	3	4	MS	MISSISSIPPI	ALL	601	63	63	0.7
65.	29	2	7	MO	MISSOURI	Eastern	314	73	174	1.9
66.					MISSOURI	Southwestern	417	38		
67.					MISSOURI	Northwestern	816	63		
68.	30	4	8	MT	MONTANA	ALL	406	63	63	0.7
69.	31	2	7	NE	NEBRASKA	Western	308	30	68	0.7
70.					NEBRASKA	Eastern	402	38		
71.	32	4	9	NV	NEVADA	ALL	702	63	63	0.7
72.	33	1	1	NH	NEW HAMPSHIRE	ALL	603	39	39	0.4
73.	34	1	2	NJ	NEW JERSEY	Newark Area	201	101	278	3
74.					NEW JERSEY	Trenton Area	609	54		
75.					NEW JERSEY	Central	908	123		
76.	35	4	6	NM	NEW MEXICO	ALL	505	40	40	0.4
77.	36	1	2	NY	NEW YORK	Manhattan Area	212	64	687	7.3
78.					NEW YORK	North Central	315	78		
79.					NEW YORK	Hempstead Area	516	111		
80.					NEW YORK	Eastern	518	87		
81.					NEW YORK	South Central	607	43		
82.					NEW YORK	Western	716	90		
83.					NEW YORK	Bronx, Brook, Queens	718	158		
84.					NEW YORK	White Plains Area	914	56		
85.	37	3	4	NC	NORTH CAROLINA	Western	704	100	290	3.1
86.					NORTH CAROLINA	Central	910	30		
87.					NORTH CAROLINA	Eastern	919	160		
88.	38	2	8	ND	NORTH DAKOTA	ALL	701	14	14	0.1
89.	39	2	5	OH	OHIO	Northeast	216	154	373	4
90.					OHIO	Northwest	419	50		
91.					OHIO	Southwest	513	95		
92.					OHIO	Southeast	614	74		
93.	40	3	6	OK	OKLAHOMA	Western	405	62	126	1.3
94.					OKLAHOMA	Eastern	918	64		
95.	41	4	10	OR	OREGON	ALL	503	154	154	1.6
96.	42	1	3	PA	PENNSYLVANIA	Philadelphia Area	215	163	538	5.7
97.					PENNSYLVANIA	Pittsburgh Area	412	111		
98.					PENNSYLVANIA	Reading Area	610	46		
99.					PENNSYLVANIA	East Central	717	142		
100.					PENNSYLVANIA	West Central	814	76		
101.	44	1	1	RI	RHODE ISLAND	ALL	401	63	63	0.7
102.	45	3	4	SC	SOUTH CAROLINA	ALL	803	124	124	1.3
103.	46	2	8	SD	SOUTH DAKOTA	ALL	605	19	19	0.2
104.	47	3	4	TN	TENNESSEE	East	615	157	180	1.9
105.					TENNESSEE	West	901	23		
106.	48	3	6	TX	TEXAS	Southwestern	210	62	565	6
107.					TEXAS	Dallas Area	214	72		
108.					TEXAS	Southeastern	409	62		
109.					TEXAS	South Central	512	103		
110.					TEXAS	Houston Area	713	91		
111.					TEXAS	Northern	806	38		
112.					TEXAS	North Central	817	70		
113.					TEXAS	Northeastern	903	33		
114.					TEXAS	Western	915	34		
115.	49	4	8	UT	UTAH	ALL	801	77	77	0.8
116.	50	1	1	VT	VERMONT	ALL	802	12	12	0.1
117.	51	3	3	VA	VIRGINIA	Eastern	703	153	270	2.9
118.					VIRGINIA	Western	804	117		
119.	53	4	10	WA	WASHINGTON	Western	206	166	208	2.2
120.					WASHINGTON	Eastern	509	42		
121.	54	3	3	WV	WEST VIRGINIA	ALL	304	62	62	0.7
122.	55	2	5	WI	WISCONSIN	Eastern	414	86	134	1.4
123.					WISCONSIN	Southwestern	608	22		
124.					WISCONSIN	Northern	715	26		

125.	56	4	8	WY	WYOMING	ALL	307	14	14	0.1
	Total								9,386	100

Colorado; (10) Connecticut; (11-14) all four area codes in Florida; (15) the Atlanta, Georgia area; (16) north central, Illinois; (17) the Baltimore, Maryland area; (18) the Boston, Massachusetts area; (19) central Massachusetts; (20) the Detroit, Michigan area; (21) central Minnesota; (22) the Newark, New Jersey area; (23) central New Jersey; (24) the New York City area -- 212, 516, 718, 914; (25) western North Carolina; (26) eastern North Carolina; (27) northeastern Ohio; (28) Oregon; (29) the Philadelphia, Pennsylvania area; (30) east central Pennsylvania; (31) the Pittsburgh, Pennsylvania area; (32) south Carolina; (33) eastern Tennessee; (34) south central Texas; (35) eastern Virginia; (36) western Virginia; and (37) western Washington.

The 20 most-populated cities according to the 1990 U.S. Census are listed in Table 3-6 with the surrounding metropolitan NHAPS sample size. In future analyses of the NHAPS data, it may be useful to study these metropolitan regions. Notice that the 20 most populated cities in 1990 tend to fall into the most populated states (see Table 3-2).

3.2 Socioeconomic Divisions

The major NHAPS socioeconomic divisions are gender, age, race, education, employment status, and number of children and adults in the household (Table 3-7). Other variables that relate to housing characteristics or living options such as the number of windows kept open or when the respondent moved into their house are summarized in Section 7 (the NHAPS follow-up questions).

Joint age and gender frequencies in the 1990 U.S. Census for two different age groupings are given in Figure 3-5. Notice how males occur in higher numbers under age 25, whereas females occur in higher numbers for age 35 and up. The age group with the largest discrepancy between numbers of males and females is the 75 and up group where the number of males is 54% of the number of females.

Fifty four percent of the NHAPS respondents were female as compared to 51% for the 1990 U.S. Census (Table 3-8). The largest percentages of the NHAPS respondents fell in the 25 to 34 (17%) and

35 to 44 (16%) age groups (Table 3-9). About 28% of the respondents were under age 25 and 37% were

Table 3-6. The 20 Most Populated U.S. Cities in 1990 with the Surrounding NHAPS Sample Size

Rank	City	Area Code(s)	1990 U.S. Census Population	Surrounding NHAPS Sample Size
1	New York, NY	212,718	7,322,564	222
2	Los Angeles, CA	213	3,485,398	70
3	Chicago, ILL	312	2,783,726	78
4	Houston, TX	713	1,630,553	91
5	Philadelphia, PA	215	1,585,577	163
6	San Diego, CA	619	1,110,549	105
7	Detroit, MI	313	1,027,974	184
8	Dallas, TX	214	1,006,877	72
9	Phoenix, AZ	602	983,403	188
10	San Antonio, TX	210	935,933	62
11	San Jose, CA	408	782,248	38
12	Indianapolis, IN	317	741,952	80
13	Baltimore, MD	410	736,014	114
14	San Francisco, CA	415	723,959	58
15	Jacksonville, FL	904	672,971	129
16	Columbus, OH	614	632,910	74
17	Milwaukee, WI	414	628,088	86
18	Memphis, TN	901	610,337	23
19	Washington, DC	202	606,900	21
20	Boston, MA	617	574,283	106

Note: Area codes in less populated regions have a larger coverage so the NHAPS sample sizes are larger than they would be for just the immediate metropolitan region.

Table 3-7. The NHAPS Demographic Variables for Each Respondent

Variable	Label	Example
ADULT	# of Adults in Household	
AGEKID*	Age of Youngest Child	
EDUC*	Res.'s Last Grade or Year of School	1, 2, 3, ... 12, ... 18, ...
EMP*	Employment Status of Respondent	
HISP	Is Res. of Hispanic Origin-Descent	Yes/No
KID1*	# Children Under 18 in Household	
KIDS	Any Children Under 18 Living in HH	Yes/No
KREL*	Relationship to Child	
KSEX	Gender of Child with Proxy Interviews	
RACE	Race or Ethnic Group of Respondent	White, Black, Asian, ...
RECAGE	Age of Respondent	
REDUC*	Education Level of Respondent	High School, College, Adv. Deg., ...
RSEX	Respondent Sex	Male/Female
WORKPLCE*	Main Work Place	
WOUT*	# of Hours per Week Worked Outdoors	
WKHRS*	# of Hours Worked for Pay Last Week	
WNGHT*	# of Hours Worked Between 6 PM and 6 AM	
UNEMP*	Reason for Not Employed	
YOB	Respondent Year of Birth	

Note: Demographic variables denoted by an asterix (*) have a substantial number of missing or "refused to answer" values. Additional variables that may have some demographic interest are described in Section 7 (the NHAPS follow-up questions).

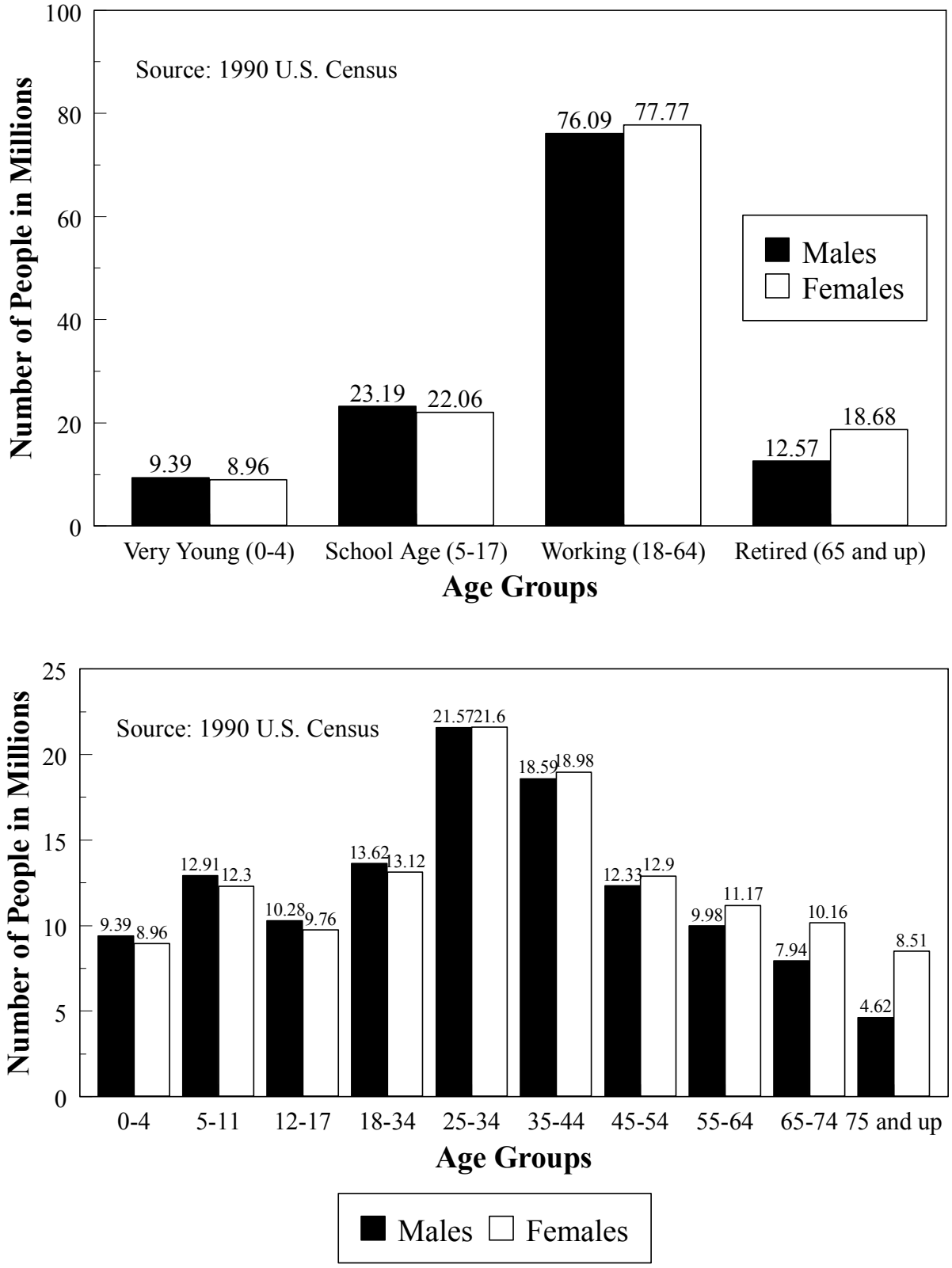


Figure 3-5. Plots of the number of male and female Americans in each of four age groups (top) and ten age groups (bottom) obtained from the 1990 U.S. Census.

age 45 and older. For the groupings shown, the largest discrepancy between NHAPS and the Census occurred for the 5 to 17 age group (14% vs. 18%).

Over 80% of the NHAPS respondents were white with 10% black (Table 3-10). About 4% were Hispanic and less than 2% were Asian. The remainder were either some other race or refused to answer. Ninety one percent of respondents said they were not of Hispanic origin (Table 3-11). About 28% of the NHAPS respondents graduated from high school only, with 13% finishing college and 10% with some kind of post-graduate work. For 21% of the respondents no information (either missing or "refused to answer") is available on level of education (Table 3-12). Forty-four percent of the NHAPS respondents were employed full time with 8.5 % employed part time (Table 3-13). About 28% of the respondents said they were not employed and a substantial number of respondents have no employment data available (20%). The majority of the NHAPS respondents' households had two adults (56%) with one adult as the next largest percentage (26%). Above four adults (4%) the number of respondents trailed off rapidly (Table 3-14). Sixty one percent of the respondents' households had no children under age 18 (Table 3-15).

3.3 Temporal Divisions

Variables related to the date of the interview (DATE, QUARTER, WEND) give information for day of week, day of month, month, year and seasonal quarter (Table 3-16). The number of respondents in each quarter of the NHAPS study were fairly uniform (approximately 13%) except for the first quarter when only 7.8% of the respondents were interviewed (Table 3-17). The proportion of respondents interviewed during each season (winter, spring, summer, fall) ranged from 20 to 27% (Table 3-18). Most of the respondents were interviewed on a weekday (67%). This value is somewhat smaller than the ideal figure (5/7 = 71%) since the weekends were intentionally oversampled (Tables 3-20 and 3-21).

Note: In the following tables the NHAPS variable is given in the upper left-hand corner of the table.

Table 3-8. Number of NHAPS Respondents by Gender

RSEX	Code	No. NHAPS Respondents	%	1990 U.S. Census	%
Males	1	4294	45.75	121239418	48.75
Females	2	5088	54.21	127470455	51.25
Refused	9	4	0		
Total		9386	0.0004	248709873	100

Table 3-9. Number of NHAPS Respondents by two Different Age Groupings

RECAGE	Code 1	Code 2	No. NHAPS Respondents	% 1	% 2	1990 U.S. Census	% 1	% 2
UNDER 5	1	1	499	5.3	5.3	18354443	7.4	7.4
5 TO 11	2	2	703	7.5	13.8	25207871	10.1	18.2
12 TO 17	3	-	589	6.3		20042118	8.1	
18 TO 24	4	3	799	8.5	64.7	26737766	10.8	61.9
25 TO 34	5	-	1622	17.3		43175932	17.4	
35 TO 44	6	-	1489	15.9		37578903	15.1	
45 TO 54	7	-	1187	12.6		25223086	10.1	
55 TO 64	8	-	962	10.2		21147923	8.5	
65 TO 74	9	4	816	8.7	14.4	18106558	7.3	12.5
75 AND OLDER	10	-	533	5.7		13135273	5.2	
Missing	99		187	2.0				
Total			9386			248709873		

Table 3-10. Number of NHAPS Respondents by Race

RACE	Code	No. NHAPS Respondents	%
WHITE	1	7591	80.9
BLACK	2	945	10.1
ASIAN	3	157	1.7
SOME OTHER RACE	4	182	1.9
HISPANIC	5	385	4.1
REFUSED	9	126	1.3
Total		9386	100

Table 3-11. Of Hispanic Origin?

HISP	Value	Frequency	Percent
NO	0	8534	90.9
YES	1	702	7.5
DK	8	47	.5
REF	9	103	1.1
Total		9386	100.0

Table 3-12. Number of NHAPS Respondents by Education Level

REDUC	Code	Frequency	Percent
LESS THAN HIGH SCHOOL	1	834	8.9
HIGH SCHOOL GRAD	2	2612	27.8
LESS THAN COLLEGE	3	1801	19.2
COLLEGE GRAD	4	1247	13.3
POST GRAD	5	924	9.8
No Data	.	1872	19.9
MISSING	9	96	1
Total		9386	100

Table 3-13. Number of NHAPS Respondents by Employment Status

EMP	Code	Frequency	Percent
Full time	1	4096	43.6
Part time	2	802	8.5
Not Employed	3	2644	28.2
Refused	9	71	0.8
Missing		1773	18.9
Total		9386	100

Table 3-14. Number of NHAPS Respondents by Number of Adults in Household

ADULTS	Code	Frequency	Percent
1	1	2479	26.4
2	2	5296	56.4
3	3	1057	11.3
4	4	406	4.3
5	5	71	0.8
6	6	13	0.1
7	7	5	0.1
8	8	1	0
10	10	2	0
More than 10	11	1	0
Refused	99	55	0.6
Total		9386	100

Table 3-15. Kids Under 18?

KIDS	Value	Frequency	Percent
NO	0	5691	60.6
YES	1	3566	38.0
REF	9	129	1.4
TOTAL		9386	100

Table 3-16. List of the NHAPS Temporal Variables

Variable	Label	Example
DATE	Date of Interview	010192 (January 1, 1992)
QUARTER	Study Quarter	1, 2, 3, 4, 5, 6, 7, 8
WEND	Day of Sample	Weekday, Weekend
SEASON*	Season of Sample	Win, Spr., Sum., Fall
DAY	Day of Week	M,T,W,Th,Fr,Sat,Sun
YEAR	Year of Sample	1992-1994

* = data was recoded from the original NHAPS variables

Note: In the following tables the % Desired is the desired proportion and % Ratio is the ratio of the desired proportion with the sample proportion.

Table 3-17. Number of NHAPS Respondents in Each Seasonal Quarter

QUARTER	Code	Frequency	Percent	% Desired	% Ratio
9/92 to 12/92	1	731	7.8	12.5	1.6
1/93 to 3/93	2	1288	13.7	12.5	0.91
4/93 to 6/93	3	1228	13.1	12.5	0.95
7/93 to 9/93	4	1256	13.4	12.5	0.93
10/93 to 12/93	5	1157	12.3	12.5	1.02
1/94 to 3/94	6	1236	13.2	12.5	0.95
4/94 to 6/94	7	1210	12.9	12.5	0.97
7/94 to 10/94	8	1280	13.6	12.5	0.92
Total		9386	100		

Table 3-18. Number of NHAPS Respondents in Each Season

SEASON	Code	Frequency	Percent	% Desired	% Ratio
Winter	1	2524	26.9	25	0.93
Spring	2	2438	26.0	25	0.96
Summer	3	2536	27.0	25	0.93
Fall	4	1888	20.1	25	1.24
Total			100		

Table 3-19. Number of NHAPS Respondents by Year of Interview

YEAR	Code	Frequency	Percent	% Desired	% Ratio
	92	356	7.5	12.5	1.66
	93	2475	52.4	50.0	0.95
	94	1885	39.9	37.5	0.94
Missing	.	7	.1		
Total		4723	100.0		

Table 3-20. Number of NHAPS Respondents by Weekend vs. Weekday

WEND	Code	Frequency	Percent	% Desired	% Ratio
Weekday	1	6316	67.3	71.43	1.06
Weekend	2	3070	32.7	28.57	0.87
Total		9386	100		

Table 3-21. Number of NHAPS Respondents by Day of Week

DAY	Code	Frequency	Percent	% Desired	% Ratio
Monday	1	1457	15.5	14.3	0.92
Tuesday	2	1457	15.5	14.3	0.92
Wednesday	3	1391	14.8	14.3	0.97
Thursday	4	1179	12.6	14.3	1.13
Friday	5	832	8.9	14.3	1.61
Saturday	6	1267	13.5	14.3	1.06
Sunday	7	1803	19.2	14.3	0.74
Total		9386	100		

4. WEIGHTING OF THE DATA

As shown in the previous section, the NHAPS data are not ideally representative of the larger U.S. population in terms of geographic, socioeconomic, and temporal variables. The data have fairly similar proportions as the 1990 U.S. Census for states, EPA regions, and Census regions. But since they do not adequately match the Census for age, gender, day of week, or season, we must derive weighting factors for these subdivisions. Other divisions of the data such as employment status, educational status, race, etc. were not considered because of one or more of the following: (1) proportions of these subgroups vary greatly across other geographic and socioeconomic variables, and they can be considered by future investigators for specific divisions of the country; (2) responses to status-related questions may not be very reliable when obtained from telephone-interview surveys; (3) a substantial number of values (>20%) for education and employment status variables were missing or "refused to answer"; and (4) it is simpler to obtain a two-way frequency distribution across age and gender only, rather than for three or more socio-economic subdivisions. Only age and gender were obtained from the Census since day-of-week and season proportions are absolute quantities (*e.g.* 1/4 for each season) that are easily calculated for the NHAPS study and that are constant across the Census. Although the U.S. 1990 Census is the most recent nationwide survey of population characteristics that is complete and readily available, other researchers may choose to weight the NHAPS data with more up-to-date population surveys available for subdivisions of the population of interest.

Each subdivision of the population (*e.g.*, the Census) is called a subpopulation, and each subdivision of the sample data (*e.g.* NHAPS) is called a subgroup. When weighting data for subgroups that appear to misrepresent the "true" population, one must consider the following eight points: (1) weighting can be used to compensate for oversampling in different regions or time periods, *e.g.*, day of the week; (2) the data must have a sufficient sample size in each subgroup to weight their proportions so the overall weighted statistics (*e.g.* mean) give a good estimate; (3) in general, an *n*-way population

proportion (the *joint* proportion) should be applied to define the weight for each subgroup when we don't know if the *n*-ways (age x gender, etc.) are independent; (4) by using joint proportions, one *universal* weighting factor variable can be obtained for weighting across all subgroups; (5) if joint proportions are not used, then the universal weighting factor must be determined by repeatedly weighting by the marginal proportions until every subgroup proportion matches the true population proportion; (6) if the weighted joint sample proportions match the population joint proportions, then the weighted marginal sample proportions match the population marginal proportions, but not vice-versa; (7) it should be noted that not every possible unrepresentative variable can be identified or measured, and that only the variables that are thought to be the most important should be used to construct the *n*-way population proportion; and (8) if weighted results are significantly different from unweighted results, then the data are probably severely undersampled and cannot be corrected by weighting.

***Technical Disclaimer**:* The sample weights and selected time and background weights that have been incorporated in the statistics given in this report may not be appropriate for all uses of the data, and further analysis may be required.

The Weighting Methodology Used in This Report

In this report we consider the NHAPS data to be a stratified random sample with subgroups formed from background factors (gender, age, region) and time factors (day-of-week, season). The sample of n total observations can be classified into L subpopulations with sample sizes $n_1, n_2, \ldots, n_L$ and means $\bar{x}_1, \bar{x}_2, \ldots, \bar{x}_L$. As Cochran[32] notes, in stratified sampling the sample mean can be defined as:

(1) $$\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n} = \frac{\sum_{h=1}^{L} n_h \bar{y}_h}{n}$$

where

y_i = the value obtained for each individual i
$\bar{y}_h$ = the sample mean for all y_i in subgroup h
$\bar{y}$ = the sample mean
n_h = the number of samples in subgroup h
n = the total number of samples in the stratified sample

L = the number of different subgroups

If some of the sample subgroups are misrepresented with respect to the true population, *i.e.* some of the subgroups were either oversampled or undersampled in the survey, then the sample mean $\bar{y}$ is not the best estimator of the population mean. As Cochran points out, a suitable estimator of the population mean for use in stratified sampling is:

(2) $$\bar{y}_{st} = \frac{\sum_{h=1}^{L} N_h \bar{y}_h}{N}$$

where
N_h = the number of individuals in the hth subpopulation
$N = N_1 + N_2 + \ldots + N_L$ = the total number of individuals
L = the number of different subdivisions

The number of individuals N_h in each subpopulation is obtained from the true population, *e.g.* the U.S. Census.

To obtain $\bar{y}_{st}$ in computerized calculations, the concept of a weighting variable λ is introduced. First, we define the sample proportion p_h for each subgroup h, which -- for an unrepresentative stratified random sample -- is not significantly equal to the population proportion P_h:

(3) $$\left(p_h = \frac{n_h}{n}\right) \neq \left(P_h = \frac{N_h}{N}\right)$$

Taking the ratio of the sample proportion and the population proportion gives the subgroup h sample weight λ_h:

(4) $$\lambda_h = \frac{P_h}{p_h}$$

where $\lambda_h > 0$ and $\lambda_h \neq 1$

In general, each subgroup mean $\bar{y}_h$ should be weighted by λ_h so that the sample proportion p_h is rescaled to match the population proportion P_h. However, in our computer methodology, we assign a sample

weight $\lambda_i = \lambda_h$ to each individual that falls into the hth subgroup so that the weighted sample mean $\bar{y}_{wt} = \bar{y}_{st}$ is calculated as follows:[31]

$$\bar{y}_{wt} = \frac{\sum_{i=1}^{n} \lambda_i y_i}{\sum_{h}^{n} \lambda_i} = \text{the weighted sample mean} \tag{5}$$

where
λ_i = the sample weight assigned to individual i
y_i = the value obtained for each individual i

Although Equation 5 is equivalent to Equation 2, it is formulated in terms of weighting variables λ_i for each individual i rather than subgroup means $\bar{y}_h$ for each subgroup h. When the sample and population proportions are obtained from n-way frequency tables for the given grouping factors (age, gender, etc.), the individual weights λ_i can be used to calculate the weighted sample mean $\bar{y}_{wt}$ for any combination of subgroups.

Example for Age and Gender Subgroups

In this report the major background factors for analysis of microenvironments were two gender groups (male/female) and ten age groups -- giving twenty total subgroups (Table 4-1). The population reference was the 1990 U.S. Census with 248,709,873 total individuals. The sample weights λ_h were calculated for each subgroup h by forming joint frequency tables -- containing the population proportion P_h and the sample proportion p_h for each subgroup h -- for both the Census population (Table 4-2) and the NHAPS survey (Table 4-3) and taking the ratio P_h/p_h for each subgroup. The individuals were assigned a weight $\lambda_i = \frac{P_h}{p_h}$ if they fell into the hth subgroup (Table 4-4).

The Final Weight

Given the individual sample weights λ_i, there are currently many statistical software packages -- SAS, SPSS, and BMDP -- that have built-in procedures to compute the weighted mean to estimate the

Table 4-1. The Twenty Gender and Age Subgroups for the Calculation of Weights

	Age Groups									
Gender	0-4	5-11	12-17	18-24	25-34	35-44	45-54	55-64	65-74	>74
Males	1	2	3	4	5	6	7	8	9	10
Females	11	12	13	14	15	16	17	18	19	20

Table 4-2. The 1990 U.S. Census Population Joint Frequency and Proportions for Each Age and Gender Subpopulation (N = 248,709,873)

	Males		Females	
Age Group	N_h	% (P_h)	N_h	% (P_h)
0-4	9,392,409	P_1=3.78	8,962,034	P_{11}=3.60
5-11	12,908,033	P_2=5.19	12,299,838	P_{12}=4.95
12-17	10,283,836	P_3=4.13	9,758,282	P_{13}=3.92
18-24	13,616,119	P_4=5.47	13,121,647	P_{14}=5.28
25-34	21,572,869	P_5=8.67	21,603,063	P_{15}=8.69
35-44	18,594,227	P_6=7.48	18,984,676	P_{16}=7.63
45-54	12,325,335	P_7=4.96	12,897,751	P_{17}=5.19
55-64	9,981,417	P_8=4.01	11,166,506	P_{18}=4.49
65-74	7,941,613	P_9=3.19	10,164,945	P_{19}=4.09
>74	4,623,560	P_{10}=1.86	8,511,713	P_{20}=3.42

Table 4-3. The NHAPS Sample Joint Frequency and Proportions for Each Age and Gender Subgroup (n = 9,196)

	Males		Females	
Age Group	n_h	% (p_h)	n_h	% (p_h)
0-4	270	p_1=2.88	228	p_{11}=2.43
5-11	369	p_2=3.93	333	p_{12}=3.55
12-17	285	p_3=3.04	303	p_{13}=3.23
18-24	414	p_4=4.41	385	p_{14}=4.10
25-34	781	p_5=8.32	841	p_{15}=8.96
35-44	679	p_6=7.23	810	p_{16}=8.63
45-54	528	p_7=5.63	659	p_{17}=7.02
55-64	435	p_8=4.63	527	p_{18}=5.61
65-74	303	p_9=3.23	513	p_{19}=5.47
>74	177	p_{10}=1.89	356	p_{20}=3.79

Note: Respondents with missing age or gender values were discarded.

Table 4-4. The Sample Weights λ_h Calculated for Each Subgroup h and Assigned to Each Individual i (Sorted by Age and Gender)

	Subgroup						
Weight	n_1	n_2	n_3	…	n_{18}	n_{19}	n_{20}
λ_i	$\lambda_1 \ldots \lambda_{270}$	$\lambda_{271} \ldots \lambda_{639}$	$\lambda_{640} \ldots \lambda_{924}$	…	$\lambda_{7801} \ldots \lambda_{8327}$	$\lambda_{8328} \ldots \lambda_{8840}$	$\lambda_{8841} \ldots \lambda_{9196}$
$\lambda_h = \frac{P_h}{p_h}$	$= \frac{P_1}{p_1}$	$= \frac{P_2}{p_2}$	$= \frac{P_3}{p_3}$	…	$= \frac{P_{18}}{p_{18}}$	$= \frac{P_{19}}{p_{19}}$	$= \frac{P_{20}}{p_{20}}$
	= 1.31	= 1.32	= 1.36	…	= 0.80	= 0.78	= 0.90

Note: The i subscripts for each individual weight λ_i run over all the respondents sorted by subgroup from individual 1 to individual 9,196.

Note: In the following SAS source code, `demo2` is the main file containing all background factors of the respondents, `weight` is "the likelihood of kids+adults being selected", and `weight4` is the final weight that we used in all estimations of population means.

Part I: Create the sample proportion given the `weight` variable in the main file

```
proc freq data=demo2;
table rsex*age*day*season/out=res1 noprint;weight weight;run;
```

Part II: Create the overall weight by using the joint frequency of gender*age, day of week, season and `weight` due to kids+adults

```
data res2;set res1;
if rsex=1 then do;
 if age=1 then wtsad=(3.776452/28)/percent;
  else if age=2 then wtsad=(5.189996/28)/percent;
  else if age=3 then wtsad=(4.134872/28)/percent;
  else if age=4 then wtsad=(5.4747/28)/percent;
  else if age=5 then wtsad=(8.673909/28)/percent;
  else if age=6 then wtsad=(7.476272/28)/percent;
  else if age=7 then wtsad=(4.955708/28)/percent;
  else if age=8 then wtsad=(4.013277/28)/percent;
  else if age=9 then wtsad=(3.193123/28)/percent;
  else if age=10 then wtsad=(1.859017/28)/percent;
  else if age=. or age=99 then wtsad=.;
  end;
 else if rsex=2 then do;
 if age=1 then wtsad=(3.603409/28)/percent;
  else if age=2 then wtsad=(4.945456/28)/percent;
  else if age=3 then wtsad=(3.923560/28)/percent;
  else if age=4 then wtsad=(5.275885/28)/percent;
  else if age=5 then wtsad=(8.686050/28)/percent;
  else if age=6 then wtsad=(7.633262/28)/percent;
  else if age=7 then wtsad=(5.185862/28)/percent;
  else if age=8 then wtsad=(4.489772/28)/percent;
  else if age=9 then wtsad=(4.087069/28)/percent;
  else if age=10 then wtsad=(3.422346/28)/percent;
  else if age=. or age=99 then wtsad=.;
  end;
 else wtsad=.;
run;
```

Part III: Assign the overall weight from each subgroup to each individual respondent

```
proc sort data=demo2; by rsex age day season;
proc sort data=res2; by rsex age day season;
data demosad; merge demo2 res2; by rsex age day season;
drop count percent;
weight3=weight*wtsad;
weight4=weight3*9196/9379.539021;
run;
```

Part IV : Check the weighted sample proportion and unweighted sample proportion. We want the weighed sample proportion = population proportion

```
proc freq data=demosad;
table day wend age rsex rsex*age4 rsex*age;weight weight4;run;
proc freq data=demosad;
table day wend age rsex rsex*age4 rsex*age;run;
proc freq data=demosad;
table regionc regione;run;
proc freq data=demosad;
table regionc regione;weight weight4;run;

proc freq data=demosad;
table quarter season;weight weight4;run;
proc means data=demosad n sum;
var weight wtsad weight3 weight4;run;
```

Figure 4-1. The SAS code used in this report to generate the final weight (WEIGHT4).

population mean. In this report we have used a SAS program (Figure 4-1) to: (1) calculate the *n*-way sample proportion tables for gender (2 levels), age (10 levels), day-of-week (7 levels), and season (2 levels) -- giving 2 x 10 x 7 x 2 x 2 = 560 different subgroups; (2) assign the sample weights to each individual based on the 1990 Census data; and (3) check the representativeness of the final weighted joint sample proportion over combinations of each subgroup. The initial joint sample frequency tables were generated based on the sample likelihood of a child versus an adult being chosen from a household and for the likelihood of a household being chosen based on the number of non-business telephones -- obtained using the WEIGHT variable given in the main file. In the Census data, the population proportions for the factors of age and gender were assumed to have the same distribution across season and day of week. In other words, season and day of week are independent from the rest of the *n*-way factors. However, in the NHAPS sample data the same assumption should not be made, and the season and day-of-week factors must be included with age and gender factors in the *n*-way proportion table. In other words, we cannot simply use the *n*-way sample proportion of age and gender and multiply them by the marginal proportions for day-of-week (1/7 per day) and season (1/4 for Winter, Spring, Summer, Fall)

The weighted sample proportion significantly matches the 1990 U.S. Census proportion for each gender and age group (Table 4-5). The geographic factors (Census regions) were not considered in the weighting process, but there is still good agreement with the Census. The day-of-week and season divisions match their required proportions of 1/7 and 1/4, respectively, after weighting. In addition, since we have used the *n*-way proportions for all subdivisions, the final weighted *n*-way sample proportions contain statistically equal joint proportions of males, females, and respondents in each age group across each day-of-week and season division (Table 4-6), *i.e.*, the final weighted sample proportions p_h are now equal to the corresponding population proportion P_h with respect to each subdivision. Thus, our final weight (`WEIGHT4`), which allows for the interdependence of each grouping factor and is based on the joint

proportion of 560 subgroups and the household sample weight, can be used for analysis by any combination of subgroups.

Table 4-5. Comparison Check of the Weighted Sample with the U.S. 1990 Census by Marginal Grouping Factors

Grouping Factor	Unweighted Sample Proportion n = 9,386	Weighted Sample Proportion n = 9,196	1990 U.S. Census Proportion N = 248,709,873
Male	45.7	48.71	48.7
Female	54.2	51.29	51.3
Under 5	5.3	7.38	7.37
5-11	7.5	10.14	10.14
12-17	6.3	8.06	8.06
18-24	8.5	10.76	10.75
25-34	17.3	17.37	17.36
35-44	15.9	15.12	15.11
45-54	12.6	10.15	10.14
55-64	10.2	8.51	8.50
65-74	8.7	7.29	7.28
75+	5.7	5.22	5.28
Refused	2.0		
Northeast	22.1	20.3	20.4
Midwest	22.4	24.7	24.0
South	34.6	34.4	34.4
West	20.9	20.7	21.2
Monday	15.5	14.30 ≈ (1/7)*100	-
Tuesday	15.5	14.30	-
Wednesday	14.8	14.30	-
Thursday	12.6	14.30	-
Friday	8.9	14.30	-
Saturday	13.5	14.30	-
Sunday	19.2	14.30	-
Weekday	67.3	71.41 ≈ (5/7)*100	-
Weekend	32.7	28.59 ≈ (2/7)*100	-
Winter	26.9	25.02 ≈ (1/4)*100	-
Spring	26.0	25.02	-
Summer	27.0	25.02	-
Fall	20.1	24.95	-

Note: Individuals with missing age or gender values were dropped in the weighting procedure.

Table 4-6. Consistency Check of the Joint Sample Proportion for Gender and Age Across Season and Weekend vs. Weekday After Weighting

		Age Group									
Time	**Gender**	0-4	5-11	12-17	18-24	25-34	35-44	45-54	55-64	65-74	75+
Overall Census	Male	3.77	5.19	4.13	5.47	8.67	7.48	4.96	4.01	3.19	1.86
Overall	Male	3.78	5.19	4.14	5.48	8.68	7.48	4.96	4.02	3.20	1.79
Winter	Male	3.78	5.19	4.13	5.47	8.67	7.48	4.96	4.01	3.19	1.86
Spring	Male	3.78	5.19	4.13	5.47	8.67	7.48	4.96	4.01	3.19	1.86
Summer	Male	3.78	5.19	4.13	5.47	8.67	7.48	4.96	4.01	3.19	1.86
Fall	Male	3.79	5.20	4.15	5.49	8.70	7.50	4.97	4.02	3.20	1.60
Weekday	Male	3.78	5.19	4.14	5.48	8.68	7.48	4.96	4.02	3.20	1.77
Weekend	Male	3.78	5.19	4.13	5.47	8.67	7.48	4.96	4.01	3.19	1.86
Overall Census	Female	3.60	4.95	3.92	5.28	8.69	7.63	5.19	4.49	4.09	3.42
Overall	Female	3.61	4.95	3.93	5.28	8.69	7.64	5.19	4.49	4.09	3.42
Winter	Female	3.60	4.95	3.92	5.28	8.69	7.63	5.19	4.49	4.09	3.42
Spring	Female	3.60	4.95	3.92	5.28	8.69	7.63	5.19	4.49	4.09	3.42
Summer	Female	3.60	4.95	3.92	5.28	8.69	7.63	5.19	4.49	4.09	3.42
Fall	Female	3.61	4.96	3.93	5.29	8.71	7.65	5.20	4.50	4.10	3.43
Weekday	Female	3.61	4.95	3.93	5.28	8.69	7.64	5.19	4.49	4.09	3.43
Weekend	Female	3.60	4.95	3.92	5.28	8.69	7.63	5.19	4.49	4.09	3.42

Note: This table shows that after weighting (by `WEIGHT4`) the joint sample proportions for age and gender are almost all statistically identical across the time factors of season and day-of-week.

5. MICROENVIRONMENTS IN THE 24-HOUR DIARIES: SELECTED LOCATION x ACTIVITY x SMOKER-PRESENT CATEGORIES

The NHAPS data contain three variables -- WHR, RACT, and SMK -- corresponding to locations, activities, and smoker-present categories (Table 5-1). For this report, WHR was regrouped into a new variable NEWLOC. RACT and the adjunct activity variable FACT that contains verbatim accounts of the respondent's activity were used to create the regrouped exposure activity variables NEWACT and REGACT. Locations and activities were regrouped from the original NHAPS WHR, RACT, and FACT variables based on two criteria: (1) differentiation of types of human exposure; and (2) adequate sample size. For this report, SMK was simplified from categories that specified a broad smoker-present duration into categories for smoker-present and no-smoker-present only. Additional variables collected for each person give the diary month (DD), diary year (DYR), day of week (DAY), day of month (DMO), and the starting time (STRT), ending time (END), and elapsed time (ETOA) of each microenvironment (Table 5-1). As discussed in Section 2 the NHAPS diary data for each respondent consists of a variable number of multiple records corresponding to each microenvironment that the respondent visited for the entire day immediately before the day that the respondent was interviewed.

The microenvironments resulting from the regrouped locations and activities are relevant to different kinds of chemical exposure via the air and water pathway, and they can be used to ascertain exposure to chemicals via statistical analysis and modeling. The NEWACT and REGACT groupings were used for all analyses presented in this report. Since this report is meant as a summary of NHAPS with an emphasis on scientific exposure assessment, the location and activity groupings are not sociologically based.

Note: When the data was recoded into the new variables (NEWLOC, NEWACT, REGACT) with fewer location, activity, and smoker-present categories, the original WHR, RACT, FACT, and SMK variables were retained in the data base.

Table 5-1. The NHAPS Microenvironmental Variables for Each Respondent Diary

Variable	Variable Label	Example
DAY	Day of Diary (Day of Week)	Monday, Tuesday, ..., Sunday
DD	Diary DE (Day of Month)	1, 2, 3, 4, ..., 30 (31) (29) (28)
DMO	Diary Month	1, 2, 3, 4, ..., 12
DYR	Diary Year	92, 93, 94
STRT	Start Time	
END	End Time	
ETOA	Elapsed Time of Microenvironment	
FACT	Activity Text	"Bathing or Showering"
RACT	Activity Code	
NEWACT*	Primary Regrouped Activity Code	
REGACT*	Secondary Regrouped Activity Code	
SMK	Smoker Present (excluding the respondent)	Yes: "Entire"; ">Half"; "Half"; "<Half"; "Hardly Any", No
WHR	Location Code	
NEWLOC*	Regrouped Location Code	

Note: An asterix (*) designates regrouped or recoded variables that are different from the original NHAPS variables. Example diary records are presented in Appendix B, Table B-1.

5.1 Locations, Activities, and Smoker-Present Categories

Locations

The 83 original NHAPS location codes WHR (Table 5-2) are broken down into five areas: Own House, Friend's/Other's House, Traveling, Other Indoor, and Other Outdoor. Since they are too numerous for convenient analysis, they were regrouped into ten NEWLOC codes (Table 5-3). Whereas in the NHAPS study the residential location was treated the most thoroughly with specific codes for each kind of room indoors and each outdoor residential setting, the NEWLOC scheme groups all the residential locations into either an indoor or an outdoor residential location. Residential locations at one's own home were not differentiated from Residential locations at someone else's home (*i.e.*, respondent locations were grouped into a "Residential" NEWACT group even if the original NHAPS code states that they were at someone else's house). The remaining non-residential NHAPS locations were grouped into In Vehicle, Near Vehicle, Other Outdoors, Office/Factory, Mall/Other Store, School/Church/Hospital/Public Bldg., Bar/Restaurant, and Other Indoors. The In Vehicle locations include travel inside all cars, trucks, buses, trains, airplanes, boats, and public transit. Travel outdoors via motorcycle, bicycle, walking, stroller, etc., or waiting for transit outdoors were all grouped into Near Vehicle. The relatively small Other Outdoors location grouping (2,149 out of 154,234 occurrences) mostly includes various outdoor places associated with recreation such as sports stadiums, parks, and playgrounds. The Other Indoor grouping (2,056 occurrences) included all the remaining indoor locations such as auto-repair shops, health clubs, Laundromats, salons, and parking garages. These locations may be associated with very different kinds of exposures, but there are too few occurrences of each of them to warrant separate categories.

The frequencies for each NEWLOC grouping over all those reported are all at least 2000. A compromise was established between the creation of as many location groupings with different exposure characteristics as possible within the limitation of number of occurrences of that location over all 9,386

Table 5-2. The Original NHAPS Locations Codes WHR with the NEWLOC Regroupings

WHR Value	WHR Label	Frequ.	NEWLOC 10	20	30	40	50	60	70	80	90	100
OWN HOUSE												
100	OTHER, HOME	1	10									
101	HOME KITCHEN	19001	10									
102	HOME LIVING RM/FAMILY RM/DEN	21292	10									
103	HOME DINING ROOM	3053	10									
104	HOME BATHROOM	10964	10									
105	HOME BEDROOM	30243	10									
106	HOME STUDY/OFFICE	669	10									
107	HOME GARAGE	250	10									
108	HOME BASEMENT	417	10									
110	HOME UTILITY RM/LAUNDRY RM	572	10									
111	HOME POOL, SPA(OUTDOORS)	98		20								
112	HOME YARD, OTHER OUTSIDE HOUSE	3731		20								
113	HOME MOVING FRM RM TO RM	6106	10									
114	HOME MOVING IN/OUT OF THE HOUSE	664		20								
120	OTHER VERIFIED	227	10									
199	REF	39	10									
FRIEND'S/OTHERS' HOUSE												
200	OTHER, OTHER'S HOUSE		10									
201	OTHER'S KITCHEN	760	10									
202	OTHER'S LIVING RM/FAMILY RM/DEN	1895	10									
203	OTHER'S DINING ROOM	256	10									
204	OTHER'S BATHROOM	169	10									
205	OTHER'S BEDROOM	648	10									
206	OTHER'S STUDY/OFFICE	24	10									
207	OTHER'S GARAGE	35	10									
208	OTHER'S BASEMENT	61	10									
210	OTHER'S UTILITY RM/LAUNDRY RM	11	10									
211	OTHER'S POOL, SPA(OUTDOORS)	31		20								
212	OTHER'S YARD, OTHER OUTSIDE HOUSE	726		20								
213	OTHER'S MOVING FRM RM TO RM	849	10									
214	OTHER'S MOVING IN/OUT OF THE HOUSE	209		20								
220	OTHER VERIFIED	34	10									
299	REF	8	10									
TRAVELING												
300	OTHER, TRAVEL				30							
301	CAR	23562			30							
302	TRUCK (PICK-UP/VAN)	3663			30							
303	TRUCK (OTHERS)	287			30							
304	MOTORCYCLE/MOPED/SCOOTER	78				40						
305	BUS	864			30							
306	WALKING	3683				40						

307	BICYCLE/SKATEBOARD/ROLLER-SKATES	249				40						
308	IN A STROLLER/CARRIED BY AN ADULT	17				40						
310	TRAIN/SUBWAY/RAPID TRANSIT	195			30							
311	AIRPLANE	62			30							
312	BOAT	38			30							
313	WAITING FOR BUS, TRAIN, RIDE (AT STOP)	177				40						
314	WAITING FOR TRAVEL, INDOORS	41										100
320	OTHER VERIFIED	27			30							
399	REF	1			30							
OTHER INDOOR												
400	OTHER, INDOOR	1										100
401	OFFICE BLDG./BANK/POST OFFICE	2904						60				
402	INDUSTRIAL PLANT/FACTORY/WAREHOUSE	786						60				
403	GROCERY STORE/CONVENIENCE STORE	1546							70			
404	SHOPPING MALL/NON-GROCERY STORE	2179							70			
405	BAR/NIGHT CLUB/BOWLING ALLEY	442									90	
406	AUTO REPAIR SHOP/GAS STATION	222										100
407	INDOOR GYM/SPORTS OR HEALTH CLUB	454										100
408	PUBLIC BLDG./LIBRARY/MUSEUM/THEATER	628								80		
409	LAUNDROMAT	48										100
410	HOSPITAL/HEALTH CARE FACILITY/DR'S OFFICE	1092								80		
411	BEAUTY PARLOR/BARBER SHOP/HAIR DRESSERS	153										100
412	AT WORK/NO SPECIFIC MAIN LOCATION	197										100
413	SCHOOL	2108								80		
414	RESTAURANT	2533									90	
415	CHURCH	976								80		
416	HOTEL/MOTEL	475										100
417	DRY CLEANER	39										100
418	OTHER REPAIR SHOP	40										100
419	INDOOR PARKING GARAGE	6										100
420	OTHER VERIFIED	364										100
499	REF	16										100
OTHER OUTDOOR												
500	OTHER OUTDOOR											
501	SIDEWALK/STREET/NEIGHBORHOOD	1150				40						
502	PARKING LOT	286				40						
503	SERVICE STATION/GAS STATION	215				40						
504	CONSTRUCTION SITE	238				40						
505	SCHOOL GROUNDS/PLAYGROUND	343					50					

506	SPORTS STADIUM	143					50					
507	PARK/GOLF COURSE	749					50					
508	POOL,RIVER,LAKE	413					50					
510	RESTAURANT/PICNIC (OUTDOORS)	72					50					
511	FARM	213					50					
520	OTHER VERIFIED	210					50					
599	REF	6					50					
TOTAL		**157,234**	**97,584**	**5459**	**28699**	**6093**	**2149**	**3690**	**3725**	**4804**	**2975**	**2056**

Note: The NEWLOC location codes from Table 5-3 are: 10. Residence (Indoors), 20. Residence (Outdoors), 30. Traveling Inside Vehicle, 40. Near Vehicle (Outdoors), 50. Other Outdoor, 60. Office/Factory, 70. Mall/Grocery Store/Other Store, 80. School/Church/Hospital/Public Bldg., 90. Bar/Restaurant, and 100. Other Indoor. All occurrences of each old location are mapped onto a single new location.

Table 5-3. Recoded NEWLOC Locations with Overall Frequency of Occurrence

NEWLOC	Abbreviations	Code	Original NHAPS Codes	Frequ.	Perc.
Residence (Indoors)	Res. Indoors	10	100,101-110,113,115-199,201-210,213,215-299	97584	62.1
Residence (Outdoors)	Res. Outdoors	20	111,112,114,211,212,214	5459	3.5
Traveling Inside Vehicle	In Veh.	30	300, 301-303, 305, 310-312, 320, 399	28699	18.3
Traveling/Near Vehicle (Outdoors)	Near Veh.	40	304, 306-308, 313, 501-504	6093	3.9
Other Outdoor	Other Outdoors	50	505-599	2149	1.4
Office or Factory	Office/Fact.	60	401, 402	3690	2.3
Mall/Grocery Store/Other Store	Mall/Other Store	70	403, 404	3725	2.4
School/Church/Hospital/Public Bldg.	School/Pub. Bldg.	80	408, 410, 413, 415	4804	3.1
Bar or Restaurant	Bar/Rest.	90	405, 414	2975	1.9
Other Indoor	Other Ind.	100	314, 400,406, 407, 409, 411, 412, 416-499	2056	1.3
Total				157,234	100.0

Note: The Frequency and Percent columns give the number of times and the percentage of the number of times that a microenvironment occurred over all microenvironments for all 9,386 NHAPS respondents.

respondents. Additionally, we did not attempt to distinguish locations that are not explicitly exposure-related. For example, locations were not divided according to work-related activities. The only NEWLOC group that can be associated with work-related activities is Office/Factory. It is not possible to determine -- based on location alone -- whether work-related activities were occurring in any of the other locations. Respondents that are in stores, restaurants, bars, hospitals, etc. could be present either as patrons or as staff.

Activities

The original 91 NHAPS activity codes are broken down into NON-FREE time and FREE time groups that are each further divided into the five additional areas of Paid Work, Household Work, Child Care, Obtaining Goods/Services, and Personal Needs/Care for NON-FREE time, and Educational, Organizational, Entertainment/Social, Recreational, and Communications for FREE time (Table 5-4). These RACT categories are not the best groupings for exposure studies. Thus, they were used with the FACT variable to create more exposure-relevant categories in the NEWACT and REGACT variables (Tables 5-5 and 5-6).

The NEWACT categories were created by using as much detail as was available in the FACT and RACT variables. Whereas RACT contains very broad exposure-relevant groupings such as "Food Preparation" and "Cleaning House", the FACT variable contains more information on the specific kind of activity such as "Baking Cookies" or "Vacuuming the Carpet". However, the data appeared to be recorded inconsistently for different respondents with some of the activities coded with more detail than others. For example, sometimes the FACT variable was very specific in the kind of activity ("Baking", "Vacuuming", "Waxing the Floor", etc.) and sometimes it simply contained the general value label of the RACT variable or text of a similarly general nature. Thus, it does not seem appropriate to use the specific FACT variable for our final activity groupings, especially since the specific categories that were

Table 5-4. The Original NHAPS Activity Codes for RACT with the REGACT Regroupings

RACT Value	RACT Label	Frequency	REGACT 0	10	20	30	40	50	60	70
NON-FREE TIME										
Paid Work										
01	MAIN JOB	5461	0							
02	UNEMPLOYMENT	56	0							
03	TRAVEL DURING WORK	172	0							
05	SECOND JOB	41	0							
08	BREAKS	241	0							
09	TRAVEL TO/FROM WORK	6421	0							
Household Work										
10	FOOD PREPARATION	6670		10						
11	FOOD CLEANUP	1348	0		20					
12	CLEANING HOUSE	2465	0		20	30				
13	OUTDOOR CLEANING	825	0					50		
14	CLOTHES CARE	1177	0		20					
15	CAR REPAIR/MAINTEN.	169	0					50		
16	OTHER REPAIRS	386	0			30		50		
17	PLANT CARE	299	0					50		
18	ANIMAL CARE	1189	0			30		50		
19	OTHER H.HOLD WORK	1786		10		30		50		
Child Care										
20	BABY CARE	397					40			
21	CHILD CARE	1065					40			
22	HELPINGTEACHING	113	0							
23	TALKINGREADING	86	0							
24	INDOOR PLAYING	226	0							
25	OUTDOOR PLAYING	68	0							
26	MEDICAL CARE-CHILD	11	0							
27	CHILD CARE	662	0							
28	DRY CLEANING	18	0							
29	TRAVEL, CHILDCARE	901	0							
Obtaining Goods, Services										
30	SHOPPING FOR FOOD	1466	0							
31	SHOPPING FOR CLOTHESHH ITEMS	1931	0							
32	PERSONAL CARE SERVICES	121					40			
33	MEDICAL APPOINTMENTS	287	0							
34	GOVT/FIN. SERVICES	410	0							
35	CAR REPAIR SERVICES	297						50		
36	OTHER REPAIR SERVICES	12						50		
37	OTHER SERVICES	225						50		
38	ERRANDS	282	0							
39	TRAVEL, GOODS AND SERVICES	7620	0							
Personal Needs and Care										
40	WASHING, ETC	7188	0				40			
41	MEDICAL CARE	197	0							
42	HELP AND CARE	985	0							
43	EATING	18102								70
44	PERSONAL HYGIENE	1071	0							
45	SLEEPINGNAPPING	19329	0							
47	DRESSING, ETC	11375	0							
48	NA ACTIVITIES	461	0							
49	TRAVEL, PERSONAL CARE	5161	0							

FREE TIME										
Educational										
50	TENDING FT SCHOOL	1252	0							
51	OTHER CLASSES	21	0							
54	HOMEWORK	803	0							
55	USING LIBRARY	49	0							
56	OTHER EDUCATION	52	0							
59	OTHER TRAVEL, EDUCION	2127	0							
Organizational										
60	PROFESSIONALUNION	44	0							
61	SPECIAL INTEREST	16	0							
62	POLITICALCIVIC	13	0							
63	VOLUNTEER HELPING	42	0							
64	RELIGIOUS GROUPS	52	0							
65	RELIGIOUS PRICES	981	0							
66	FRATERNAL	4	0							
67	CHILDYOUTHFAMILY	21	0							
68	OTHER ORGANIZION	161	0							
69	TRAVEL ORGANIZIONAL	1758	0							
Entertainment/Social										
70	SPORTS EVENT	208	0							
71	ENTERTAINMENT	118	0							
72	MOVIESVIDEOS	287	0							
73	THEATER	47	0							
74	MUSEUMS	25	0							
75	VISITING	3071	0							
76	PARTIES	278	0							
77	BARSLOUNGES	206	0							
78	OTHER SOCIAL	116	0							
79	TRAVELSOCIAL	5033	0							
Recreation										
80	ACTIVE SPORTS	1807							60	
81	OUTDOOR RECREATION	303	0							
82	EXERCISE	631							60	
83	HOBBIES	44	0						60	
84	DOMESTIC CRAFTS	301	0					50		
85	ART	100	0					50		
86	MUSICDRAMADANCE	292	0							
87	GAMES	2903	0							
88	COMPUTER USE	256	0							
89	TRAVEL, RECREION	2663	0							
Communications										
90	RADIO	229	0							
91	TV	13289	0							
92	RECORDSTAPES	86	0							
93	READING BOOKS	527	0							
94	MAGAZINES, ETC	1600	0							
95	READING NEWSPAPER	1345	0							
96	CONVERSTIONS	1988	0							
97	LETTERS, WRITING PAPERWORK	764	0							
98	THINKINGRELAXING	2314	0							
99	TRAVEL RELED PASSIVE LEISURE	234	0							
TOTAL		**157,234**	**114344**	**6771**	**2730**	**2452**	**8577**	**1919**	**2439**	**18102**

Note: Some of the RACT coded activities were augmented with more detail from the FACT variable. In addition, by using FACT some RACT codes were found to have been miscoded. Thus, some occurrences for same value of the RACT variable were coded into different NEWACT or REGACT categories. If any occurrences in RACT/FACT matched a NEWACT or REGACT category they are listed in the table

above under the appropriated category. Different cases of the same RACT code were sometimes mapped to one of several REGACT categories.

Table 5-5. The NEWACT Activities Regrouped From the FACT and RACT Variables

NEWACT	New Code	Original NHAPS Codes	Frequency	Percent
No Exposure Activity	0	-	114344	72.7
Food Preparation/Cooking	10	10,19	6671	4.2
Eating or Drinking	15	43	18102	11.5
Cleaning Dishes or Kitchen	20	11,12,16	1527	1.0
Laundry	21	12,14,18	1203	.8
Housekeeping	22	12,16,19	2362	1.5
Sweeping/Vacuuming/Dusting	23	12	90	.1
Mowing Grass/Yardwork	25	13,17	1122	.7
Taking/Giving a Bath/Shower	30	20,21,32,40,42	7504	4.8
Hygiene/Using Bathroom	31	44	1073	.7
Washing Car	32	15,16,19,35	72	.0
Car/Equipment Maintenance	40	15,16,19,35	307	.2
Painting/Remodeling/Finishing	41	15,16,19,84,85	106	.1
Carpentry/House Maintenance	42	36,37	274	.2
Starting a Fire	50	10,16,19	38	.0
Sports or Exercise	60	80,82,83	2439	1.6
Total			157234	100.0

Note: The Frequency and Percent columns give the number of times and the percentage of the number of times that a microenvironment occurred over all microenvironments for all 9,386 NHAPS respondents.

Table 5-6. The Eight REGACT Activities Regrouped from NEWACT

REGACT	Abbreviations	Numeric Code	NEWACT Codes	Frequ.	Perc.
Non-Exposure-Related Activity	No Exposure	0	0	114,344	72.7
Cooking/Food Preparation	Food Preparation	10	10	6,671	4.2
Laundry/Dishes/Cleaning Kitchen	Dishes/Laundry	20	20,21	2,730	1.7
Housekeeping	Housekeeping	30	22,23	2,452	1.6
Bathing/Showering/Washing/ Using Bathroom	Bathing	40	30,31	8,577	5.5
Yardwork/Gardening/Car or House Maint.	Yardwork/Mainten.	50	25,32,40,41, 42,50	1,919	1.2
Sports or Exercise	Sports/Exercise	60	60	2,439	1.6
Eating or Drinking	Eating/Drinking	70	15	18,102	11.5

Note: The Frequency and Percent columns give the number of times and the percentage of the number of times that a microenvironment occurred over all microenvironments for all 9,386 NHAPS respondents. The presence-of-a-smoker activity is coded in the SMK variable.

Table 5-7. The Five Largest Non-Exposure RACT Categories (REGACT = NEWACT = 0)

RACT	NEWACT/REGACT Code	Frequency	Percent
Sleeping/Napping	0	19,329	16.9
Watching TV	0	13,289	11.6
Dressing, etc.	0	11,375	9.9
Travel-Goods/Services	0	7620	6.7
Travel-To and From Work	0	6921	5.6

Note: Percent is the percentage of the number of occurrences over all 157,234 microenvironments.

coded using FACT have a small sample size (Table 5-5). For example, Car/Equipment Maintenance, Building a Fire, Painting/Remodeling, etc. all have less than 500 occurrences, which is probably too small to conduct analyses across subgroups.

The NEWACT categories were regrouped into eight broader REGACT categories (Table 5-6) that each contain nearly 2,000 occurrences or more. These categories are not the only possible exposure-relevant groupings, but they represent our attempt to create useful exposure activities from the available data. The most frequent activities in the No Exposure exposure activity category (Table 5-7) -- into which 73% of all microenvironments were grouped -- were Sleeping/Napping (17% of microenvironments), Watching TV (12%), and Dressing, etc. (10%). The next two largest No Exposure activities were Traveling for Goods and Services (7%) and Traveling To and From Work (6%). Although it is possible for exposure to occur during activities in the No Exposure category, little or no information is added beyond that which the location category contributes. For example, it is only necessary to know that a person is inside a vehicle in estimating their exposure from automobile exhaust on the roadway.

The Cooking/Food Preparation exposure activity encompasses any activity where the respondent was preparing a snack or meal, regardless of whether cooking was involved. The Laundry/Dishes/Cleaning Kitchen exposure activity includes activities related to cleaning up in the kitchen and any activity related to washing clothes. The Housekeeping exposure activity includes general tidying-up, cleaning of floors or carpets, and any other activity related to house cleaning. The Bathing/Showering/Washing/Using the Bathroom exposure activity includes all activities related to giving or taking a bath or shower, and any other activity related to hygiene, toiletry, or other personal matters that may occur in the bathroom. The Yardwork/Gardening/Car or House Maintenance exposure activity covers any type of automobile, house, or yard maintenance, including remodeling, painting, washing the car, car repair, carpentry, fire-making, gardening, and mowing the lawn. The Sports/Exercise exposure

activity includes all team or individual sports and any other exercise-related activity. The Eating/Drinking exposure activity includes any activity where the respondent was consuming food.

Smoker-Present Categories

For the first 6 quarters of the NHAPS study the SMK microenvironment variable had only two Smoker-Present possibilities: 0 for no smoker present and 1 for a smoker present (not including times when the respondents themselves were smoking). The last two quarters contain seven possible Smoker-Present categories corresponding to different intensities of environmental tobacco smoke (ETS) exposure in each microenvironment, ranging from no exposure to exposure during the entire microenvironment (Table 5-8). The vast majority of microenvironments (90%) do not involve any ETS exposure, and of the 10% that do involve exposure, almost 8% indicate exposure the entire time. Thus, the six categories for incremental amounts of exposure -- including the "don't know" (SMK = 8) category of exposure -- were grouped into one SMKEXP ETS exposure category, giving three possible Smoker-Present categories: 0 for No Smoker Present, 1 for Smoker Present, and 8 for "don't know" responses. The presence of a smoker can occur simultaneously with any other type of activity and in any location.

The number of **people** exposed to ETS was determined from the SMKEXP microenvironmental variable by defining a variable SMKB for each respondent with values of 0 for people that were never exposed on the diary day, and 1 for people that were exposed for at least one minute on the diary day (Table 5-9). For example, if respondents had SMKEXP values of 0 all day (never exposed), then SMKB = 0 for those people. Respondents with all 1's were assigned SMKB = 1, respondents with both 1's and 8's were assigned SMKB = 1, and respondents with only 0's and 8's were omitted from calculations using SMKB.

Table 5-8. The NHAPS Smoker-Present Categories

SMK	Code	Regrouped Code	Frequency	Percent
NO	0	0	141507	90.0
YES-THE ENTIRE TIME	1	1	12146	7.7
YES-MORE THAN HALF	2	1	180	.1
YES-ABOUT HALF	3	1	734	.5
YES-LESS THAN HALF	4	1	1073	.7
YES-HARDLY ANY	5	1	734	.5
Don't Know	8	1	860	.5
Total			157234	100.0

Note: SMK codes 2-5 were only used in the last two quarters of the study. The Frequency and Percent columns give the number of times and the percentage of the number of times that a microenvironment occurred over all microenvironments for all 9,386 NHAPS respondents. The Regrouped Code is 0 for no smoker present and 1 if there is a smoker present for any amount of time. The "don't know" responses (SMK = 8) mean that the respondent did not know how long the exposure lasted (none of the time, half the time, less than half the time, etc.). These responses were considered as SMK = 0 in all analyses.

Table 5-9. The Frequency Table for SMKEXP (time exposed) with SMKB (people exposed) Assignment

SMKEXP	Case #	0's	1's	8's and 0's	8's and 1's
{0}, {1}, or {8}	1	5145	11	2	0
{0 and 1} or {0 and 8}	2	0	3623	234	0
{0, 1, and 8}	3	0	0	0	371
SMKB		**0**	**1**	**-**	**1**
Total Sample Size (unweighted)	9150 =	**5145**	**+3634**	**+0**	**+371**

Note: This frequencies table for occurrences of all combinations of 0 (No Smoker), 1 (Smoker Present) and 8 (Don't Know) in the SMKB variable gives the SMKEXP assignments of (0) no exposure over the entire diary day and (1) exposure of a Person at sometime on the diary day. The combinations corresponding to the shaded regions (all don't know 8 and no exposure 0 responses) were omitted in SMKB calculations. The samples sizes are different for the weighted data as presented in Section 6.

5.2 Location x Activity and Location x Smoker-Present Microenvironments

Location x Activity

In this report location x activity microenvironments are defined by a combination of: (1) a NEWACT location such as Residence-Indoors, Office/Factory, In Vehicle, Bar/Restaurant, or School/Public Bldg.; and (2) a REGACT exposure activity such as Yardwork/Maintenance, Bathing, Housekeeping, or Dishes/Laundry. A microenvironment matrix can be devised that contains rows for every possible location and columns for every possible activity (Table 5-10). The intersection of each row and column defines a unique microenvironment. For example, following the row for "Residential (Indoor)" to the column for "Bathing/Showering" results in a cell for the "Bathing or Showering at Home" microenvironment (`01040`).

The actual number of real and distinct microenvironments is typically less than the total number of locations times the total number of activities. It is possible that an intersection of a row and column results in a microenvironment that does not exist. For example, the "Doing Dishes/Laundry in Vehicle" microenvironment (`03020`) does not occur for any of the NHAPS interview respondents (Table 5-10). In addition, many of the microenvironments (cells) may not contain enough NHAPS respondents to do a complete analysis. For example, there were very few people interviewed who were preparing food at places other than the Residential (Indoor) or Residential (Outdoor) locations. Only 21 out of the 70 possible microenvironments for exposure activities 10-70 contain more than 100 occurrences. The most occurrences of any microenvironment were those in the Residential (Indoors) location with 22,605 total occurrences for microenvironments with exposure activities 10-70.

Location x Smoker-Present

A location x smoker-present microenvironmental matrix can also be devised containing location codes in each row and the two smoker-present categories in each column (one for "Smoker-Present" and

Table 5-10. The Location x Activity Microenvironmental Matrix with the 70 Resulting 5-Digit Numerical Microenvironmental Codes Obtained by Merging the Regrouped Location and Activity Codes (with Sample Sizes in Parentheses)

		REGACT Regrouped Activities							
NEWLOC Regrouped Locations	**Codes**	No Exp. 00	Food Prepar. 10	Dishes/ Laundry 20	House-keeping 30	Bathing/ Shower. 40	Yardwk/ Maint. 50	Sports/ Excercise 60	Eating/ Drinking 70
Residential Ind.	010	01000 (9339)	01010 (4204)	01020 (1814)	01030 (1842)	01040 (6309)	01050 (281)	01060 (308)	01070 (7847)
Residential Out.	020	02000 (2028)	02010 (94)	02020 (49)	02030 (122)	02040 (14)	02050 (1008)	02060 (446)	02070 (225)
In Vehicle	030	03000 (7742)	03010 (2)	03020 (0)	03030 (10)	03040 (9)	03050 (4)	03060 (7)	03070 (40)
Near Vehicle	040	04000 (2430)	04010 (1)	04020 (0)	04030 (1)	04040 (3)	04050 (150)	04060 (450)	04070 (74)
Other Outdoors	050	05000 (887)	05010 (8)	05020 (2)	05030 (8)	05040 (7)	05050 (44)	05060 (528)	05070 (143)
Office/Factory	060	06000 (1959)	06010 (3)	06020 (0)	06030 (1)	06040 (13)	06050 (2)	06060 (2)	06070 (332)
Mall/Store	070	07000 (2661)	07010 (2)	07020 (0)	07030 (1)	07040 (10)	07050 (3)	07060 (11)	07070 (90)
School/Pub. Bldg.	080	08000 (2887)	08010 (2)	08020 (3)	08030 (3)	08040 (21)	08050 (3)	08060 (75)	08070 (312)
Bar/Restaurant	090	09000 (630)	09010 (6)	09020 (0)	09030 (1)	09040 (7)	09050 (1)	09060 (46)	09070 (1833)
Other Indoors	100	10000 (818)	10010 (5)	10020 (56)	10030 (1)	10040 (181)	10050 (48)	10060 (256)	10070 (132)

Note: Shaded cells designate the 21 location x activity microenvironments with frequencies greater than 100 that were analyzed in this report (see Section 6 I).

Table 5-11. The Location x Smoker-Present Microenvironmental Matrix with the 20 Resulting 4-Digit Numerical Microenvironmental Codes Obtained by Merging the Location and Smoker-Present Codes (with Sample Sizes in Parentheses)

NEWACT Regrouped Locations		**SMKEXP Smoker-Present Categories** No Smoker Present	Smoker-Present
	Codes	0	1
Residential Ind.	010	0100 (9327)	0101 (2937)
Residential Out.	020	0200 (2834)	0201 (517)
In Vehicle	030	0300 (7217)	0301 (1559)
Near Vehicle	040	0400 (2587)	0401 (475)
Other Outdoors	050	0500 (1126)	0501 (348)
Office/Factory	060	0600 (1713)	0601 (424)
Mall/Store	070	0700 (2439)	0701 (374)
School/Pub. Bldg.	080	0800 (2790)	0801 (264)
Bar/Restaurant	090	0900 (1442)	0901 (1074)
Other Indoors	100	1000 (1027)	1001 (287)

Note: SMKEXP codes with values of 8 (don't know) were assumed to equal 0 (no smoker) in this report.

one for “No-Smoker-Present”). The sample sizes in Table 5-11 show that each microenvironment exists and has a substantial number of occurrences in the NHAPS data because it is possible for a smoker to be present in any of the regrouped locations. The location with the fewest number of smoker-present occurrences (code 1) is School/Church/Public Bldg. (80) with 264. Residential Outdoors, Near Vehicle, Other Outdoors, Office/Factory, Mall/Store, and Other Indoors all have fewer than 550 occurrences. The largest sample size falls in the Residential (Indoors) location at 2937 -- probably since the majority of time is spent indoors at home (see Section 6) -- with In Vehicle next at 1559, and Bar/Restaurant third at 1074.

6-I. *24-HOUR DIARY RESULTS*: DURATION AND FREQUENCY OF OCCURRENCE FOR SELECTED MICROENVIRONMENTS BY DAY-OF-WEEK, SEASON, AND BACKGROUND FACTORS

Each location, exposure activity, and presence of a smoker category was analyzed by: (1) the percentage of time spent; and (2) the mean doer 24-hour duration. Location x activity and location x smoker present microenvironments were also analyzed by the mean frequency of their occurrence (for doers) during the diary day. Comparisons between subgroups are based only on these results; no statistical comparisons of distributions were performed. Percentage of time spent was calculated over all respondents (both doers and non-doers) except for microenvironments when exposure to environmental tobacco smoke (ETS) occured, where only the doers were considered. All mean 24-hour durations were calculated over the pool of doers. Only the time spent actually experiencing each microenvironment was considered. For example, percentages of time spent exposed to ETS were only done for the respondents that were exposed for at least one minute on the diary day, and the mean 24-hour durations of exposures were calculated only from the microenvironments where these respondents reported a smoker present. Section 1 and Appendix A contain the methodology used to calculate durations and number of occurrences, and Appendix B contains detailed examples of each type of calculation.

The number of occurrences of microenvironments were only determined for each unique location x activity and location x smoker-present microenvironment. Since there are different entries in the diary file for each possible location x activity microenvironment, it is difficult to obtain number of occurrences for each location and activity by themselves. For example, a count of the number of microenvironments in the Residential-Indoors location would give new occurrences every time a new activity was initiated even though the respondent had not left the location. Counts of this sort can greatly overestimate the number of occurrences of locations and activities by themselves. Similarly, 24-hr cumulative durations were tabulated instead of the durations of <u>individual</u> microenvironments (with the same activity and location) since the

individual durations would be smaller than the actual time spent in one location across several activities -- or one activity across several locations.

All results described below are for weighted calculations (see Section 4) unless stated otherwise; however, the bar charts for 24-hr mean durations also contain the unweighted results. The development of the microenvironment categories (location, activity, smoker-present, and combinations) is described in Section 5.

Technical Note: The percentage of time that respondents spend in each microenvironment (location, activity, smoker-present, and combinations) was determined by summing the time spent in each microenvironment and dividing by the total amount of time over all the respondents: 1440 minutes/day X 9,386 respondents = 13,515,840 total minutes. The overall frequency of occurrence and duration were determined by: (1) sorting the 157,234 NHAPS diary records for all 9,386 respondents by person and exposure activity, (2) compressing the records for each exposure activity into one record per person containing the number of times the exposure occurred during the diary day and the total time summed over each occurrence, and (3) calculating means of frequency of occurrence and duration for each exposure activity for each person. The doer sample size N is the number of people -- out of the 9,386 total respondents -- that were engaged in a given exposure activity at any time during the diary day.

6.1 Locations

The largest percentage of time spent over all the respondents was in the Residential-Indoors location (69%) (see Figure 6-1; Table 6-1 contains percentages of time spent across each subgroup). The next largest percentages were for the School/Public Bldg (7%), the In Vehicle (6%), and the Office/Factory (5%) locations. The percentage of time spent in the Residential-Outdoor location was about 4% with the Near Vehicle, Other Outdoor, Mall/Store, Bar/Restaurant, and Other Indoor locations all at about 2%. The Residential-Indoors location also has the largest 24-hour cumulative mean duration (996 min) over all the respondents (Figure 6-2; Table 6-2 contains durations across each subgroup). The next largest duration was for the Office-Factory location (388 min) followed by the School/Public Bldg (284 min) and the Other Indoor (226 min) locations. All the other locations had mean 24-hr durations of less than 200 min (3.3 hours). The smallest 24-hr durations were for the In Vehicle and Near Vehicle

Table 6-1. The Weighted Percentages of Time Spent in Each Location on the Diary Day Across Each Subgroup

Percentage	Overall	Males	Females	0-4	5-17	17-64	65+	Northwest	Midwest	South	West	WkDay	WkEnd	Winter	Spring	Sum	Fall
Residential -Indoors	68.73	64.79	72.47	84.08	67.81	64.71	80.84	68.77	68.22	68.75	69.24	66.91	73.26	71.2	66.76	67.27	69.68
Residential -Outdoor	3.69	4.49	2.93	5.38	5.05	2.93	4.48	3.25	3.41	4.03	3.89	3.12	5.12	1.71	5.33	5.18	2.54
In Vehicle	5.52	5.94	5.12	3.14	4.29	6.43	4.17	5.57	5.62	5.57	5.25	5.35	5.93	5.34	5.76	5.39	5.57
Near Vehicle	1.7	2.49	0.94	0.56	1.41	2.06	0.99	1.78	1.51	1.64	1.93	1.89	1.2	1.45	1.67	1.89	1.77
Other Outdoor	2.19	2.96	1.45	0.96	2.83	2.33	1.27	2.02	2.26	2.05	2.48	1.87	2.97	1.27	2.33	3.42	1.72
Office/Factory	5.39	6.46	4.38	0.05	0.18	8.42	1.18	5.9	5.27	5.49	4.88	7.02	1.34	5.37	5.5	5.44	5.26
Mall/Other Store	2.26	1.85	2.65	1.39	1.15	2.77	1.89	2.34	2.05	2.29	2.4	2.15	2.54	1.95	2.29	2.4	2.41
School/Public Bldg.	6.61	6.53	6.68	3.45	15.33	5.19	2.83	6.66	7.24	6.63	5.77	7.86	3.5	7.48	6.77	4.98	7.21
Bar/Restaurant	1.84	1.94	1.75	0.57	0.76	2.43	1.27	1.65	2.18	1.64	1.96	1.65	2.31	1.97	1.77	1.8	1.83
Other Indoor	2.07	2.55	1.63	0.42	1.18	2.74	1.07	2.05	2.24	1.91	2.19	2.17	1.84	2.24	1.85	2.22	1.99

Note: Subgroups are for gender, age, U.S. census region, day of week, and season. See Section 4 for a discussion of weighting.

Table 6-2. The Mean Weghted 24-Hour Duration (Minutes) in Each Location on the Diary Day by Each Subgroup

Duration D	Overall	Males	Females	0-4	5-17	17-64	65+	Northwest	Midwest	South	West	WkDay	WkEnd	Winter	Spring	Sum	Fall
Residential -Indoors	995.6	940.33	1047.91	1213.14	980.04	939.55	1165.41	993.65	991.43	995.46	1002.74	968.91	1062.38	1031.57	967.46	976	1007.34
Residential -Out.	155.84	176.41	133.21	190.73	167.46	142.36	166.34	149.79	158.37	162.24	147.82	141.62	183.99	116.36	170.98	169.15	139.41
In Vehicle	95.48	101.15	89.93	66.96	74.89	104.95	87.87	98.12	96.92	95.21	91.66	91.74	105.18	95.08	97.15	93.75	95.9
Near Vehicle	78.38	111.08	44.99	40.97	44.69	99.8	58.42	69.71	71.21	87.54	82.89	82.87	64.6	72.16	76.04	83.4	81.3
Other Outdoor	198.85	225.78	161.35	148.19	149.17	231.05	192.91	205.35	201.88	191.08	202.16	179.25	240.09	181.35	185.76	228.57	182.15
Office/Factory	387.96	411.54	359.16	32.68	105.86	413.73	165.97	391.22	384.21	405.75	358.37	401.56	269.06	379.55	394.8	390	387.6
Mall/Other Store	118.5	121.4	116.66	93.07	82.92	133.14	91.32	118.49	104.51	131.36	115.71	120.14	115.19	109.48	124.66	117.01	122.48
School/Public Bldg.	283.65	292.09	276.25	238.8	360.3	265.3	148.07	280.1	295.72	283.44	271.35	312.92	186.08	303.01	284.05	264.36	278.85
Bar/Restaurant	111.74	111.15	112.36	62.4	66.27	125.64	90.2	115.44	113.28	110.02	109.31	110.16	114.66	126.8	105.18	109.51	106.67
Other Indoor	226.46	260.78	189.41	106.12	153.77	258.3	147.42	216.6	251.02	222.25	215.83	222.1	240.49	240.9	209.87	248.76	206.86

Note: Subgroups are for gender, age, U.S. census region, day of week, and season. See Section 4 for a discussion of weighting.

Table 6-3. The Weighted Number of NHAPS Respondents (Sample Size N) in Each Location on the Diary Day by Each Subgroup

Doer Sample Size N	Overall	Males	Females	0-4	5-17	17-64	65+	Northwest	Midwest	South	West	WkDay	WkEnd	Winter	Spring	Sum	Fall
Residential-Indoors	9141	4444.5	4696.5	677.8	1668.2	5646.5	1148.6	1836.4	2222.1	3219.7	1862.8	6530.3	2610.7	2286.5	2285.8	2283.2	2285.5
Residential -Outdoor	3138	1643.5	1494.5	275.6	727.7	1689	445.8	574.9	694.6	1157.7	710.9	2084.7	1053.3	487.4	1033.3	1014.3	603.1
In Vehicle	7652.4	3786.1	3866.2	458.7	1382.5	5024.6	786.5	1506	1873.3	2728.7	1544.4	5518.9	2133.4	1861.8	1963.4	1906.4	1920.7
Near Vehicle	2863.6	1446.8	1416.7	134.7	759	1690.2	279.7	678	686	871.5	628	2160.1	703.4	667.8	725.8	749.7	720.3
Other Outdoor	1455.4	847	608.4	63.2	457.3	825.4	109.4	261.3	362.2	500.8	331.1	986.4	469	232.7	414.7	495.4	312.7
Office/Factory	1841	1012.1	828.9	15.6	40.1	1667.6	117.7	400.1	442.6	630.7	367.6	1651.9	189.1	468.9	461.2	462.3	448.7
Mall/Other Store	2529.6	984.1	1545.6	145.6	334.9	1705.6	343.5	524.2	633	811.7	560.7	1695.3	834.3	590.1	608.4	680.6	650.5
School/Public Bldg.	3085.8	1442.6	1643.2	141.4	1025.8	1602.4	316.2	631.1	790.2	1090.6	573.9	2373.8	712	818.2	789	624.4	854.1
Bar/Restaurant	2182.6	1124.1	1058.6	89.7	276.8	1583.8	232.4	380.2	621.7	696.3	484.4	1419	763.6	513.8	556.5	545.3	567.1
Other Indoor	1213	629.8	583.2	38.7	185.2	868.5	120.6	251.5	288	399.9	273.7	925	288	308.5	291.3	296	317.3

Note: Subgroups are for gender, age, U.S. census region, day of week, and season. See Section 4 for a discussion of weighting. The doer sample sizes are equal to the number of respondents entering each location on the diary day. The maximum number in each location is the total weighted sample size (N = 9196).

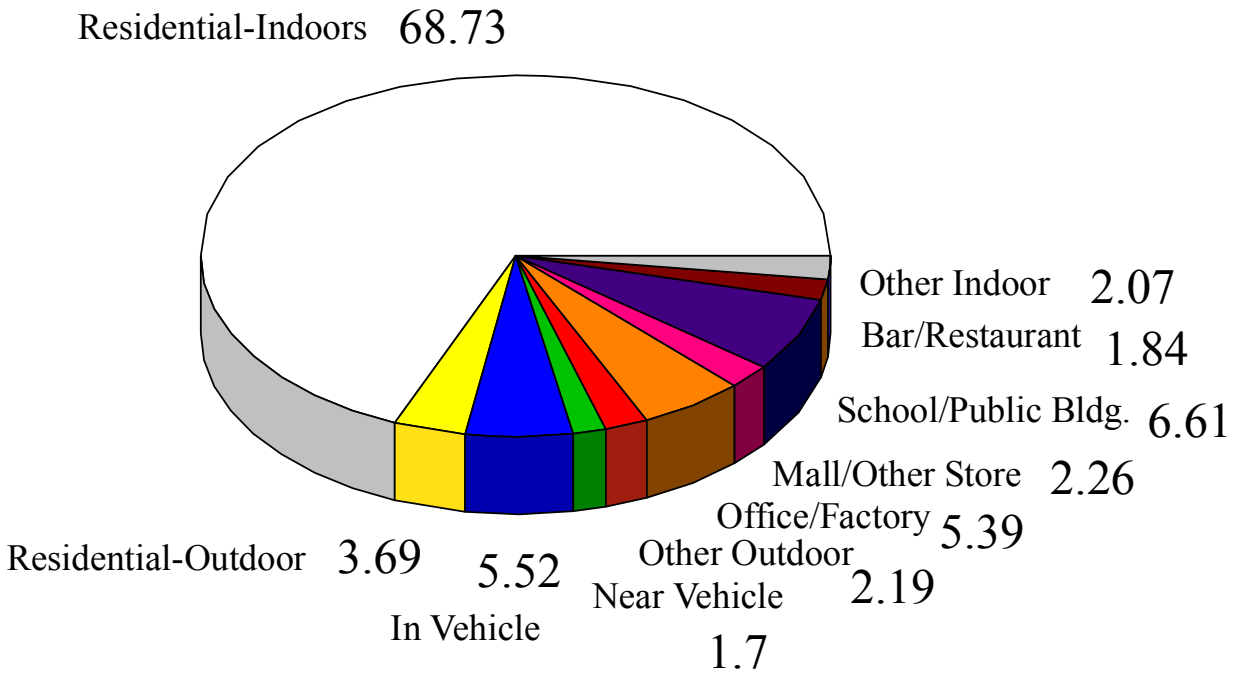


Figure 6-1. The overall weighted percentage of time spent by the respondents in each location. The total amount of time is 1,440 min x 9,196 respondents = 13,242,240 minutes.

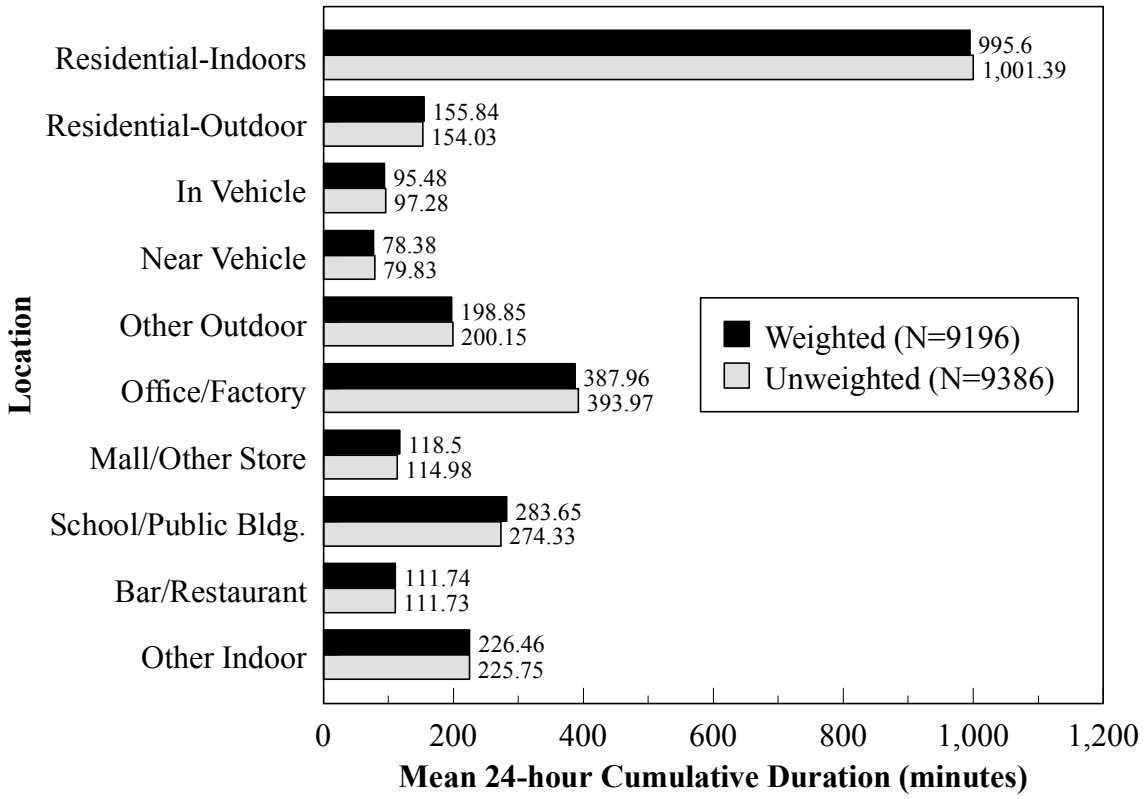


Figure 6-2. The overall weighted and unweighted mean 24-hour cumulative durations in each location. In the weighted analyses, 190 respondents with missing age or gender values were excluded. See Section 4 for a discussion of the weighting methodology.

locations (78-95 min). There is only a 1-4% difference between the overall unweighted and weighted mean durations. Samples sizes for the doers across each subgroup are given in Table 6-3.

Males spent more time than females in every location except for Residential-Indoor (72.47% F vs. 64.79% M) and Mall/Other Store (2.65% F and 1.85% M) (Figure 6-3). Differences also occurred for the Office/Factory (6.45% M and 4.38% F), Other Outdoor (2.96% M and 1.45% F), Near Vehicle (2.49% M and 0.94% F), and Residential-Outdoor (4.49% M and 2.93% F). The 24-hr mean durations for males are larger or roughly equal in every category except Residential-Indoors (1,048 min M and 940 min F) (Figure 6-4). The only category where males durations are more than twice as large as female durations are for the Near Vehicle location (111 min M and 45 min F).

There are striking similarities between the Very Young (ages 0-4) and the Retired (65+) age groups for both percentage of time spent and 24-hour mean durations (Figures 6-5 and 6-6). Both groups spend the majority of their time in the Residential-Indoor location (68% VY and 65% R) for about the same durations (980 min VY and 940 min R). The percentage of time spent and mean durations are also similar for every other location category except for Office/Factory (0.05%, 33 min VY; 1.18%, 166 min R). As expected, the Working age group (ages 18-64) spent the largest percentage of time in the Office/Factory location (8.42%) and for the longest mean duration (414 min); and the School Age age group (ages 5-17) spent the most time in the School/Public Bldg location (15.33%, 360 min).

There were not large differences between the percent time spent in each location between each of the four Census regions (Northeast, Midwest, South, and West) (Figure 6-7). The largest differences in percentage of time spent were only about 1% and occurred for: (1) the Residential-Indoors location between the Northeast (68%) and the other regions (69%); (2) the Residential-Outdoor location for the Northeast and Midwest (3%) vs. the South and West (4%); and (3) the School/Public Bldg location for the West (6%) vs. the other regions (7%). Differences between the mean 24-hr durations across

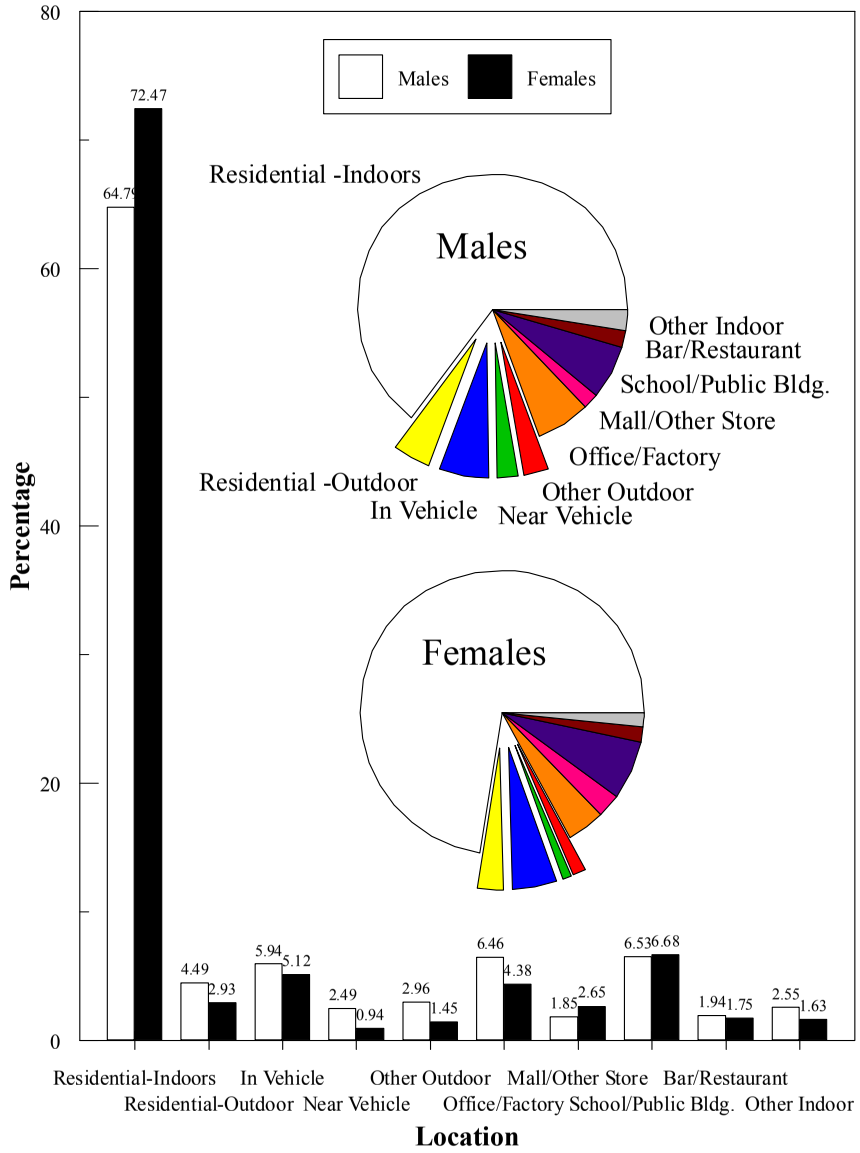


Figure 6-3. The weighted percentage of time spent in each location for males vs. females.

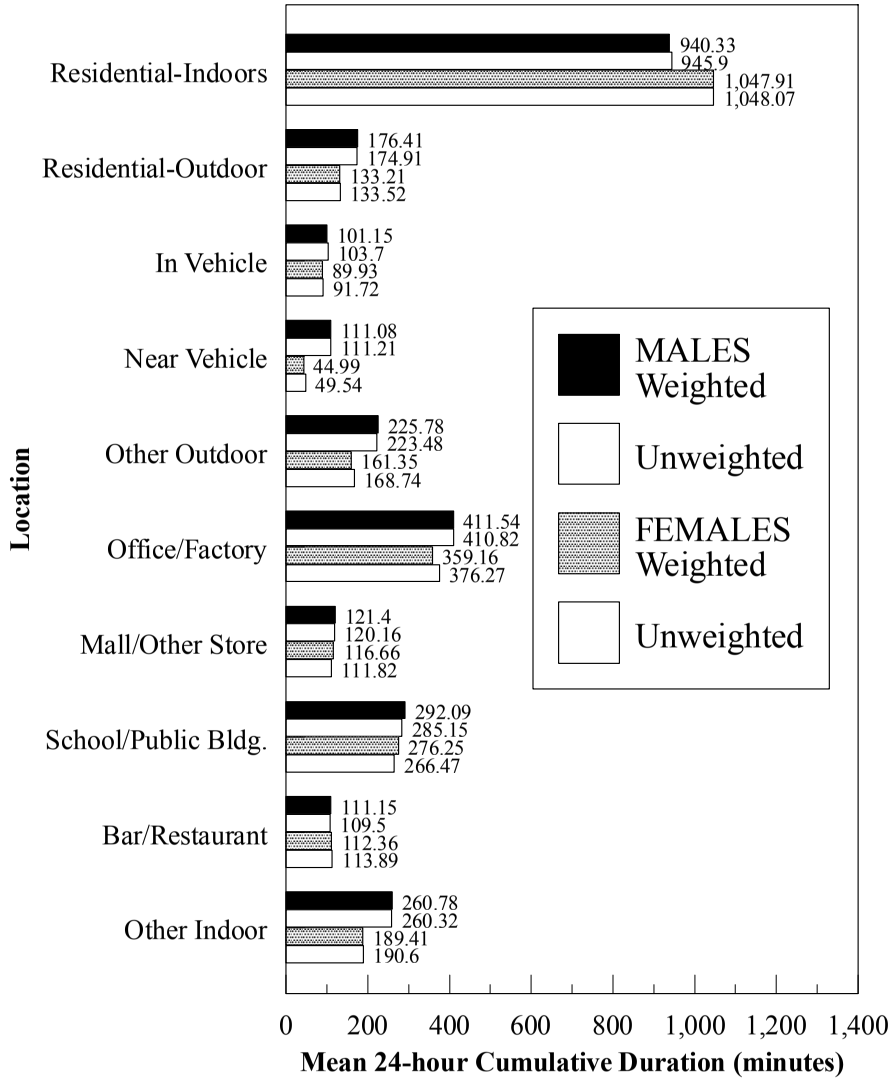


Figure 6-4. The weighted and unweighted mean 24-hour cumulative durations in each location for males vs. females.

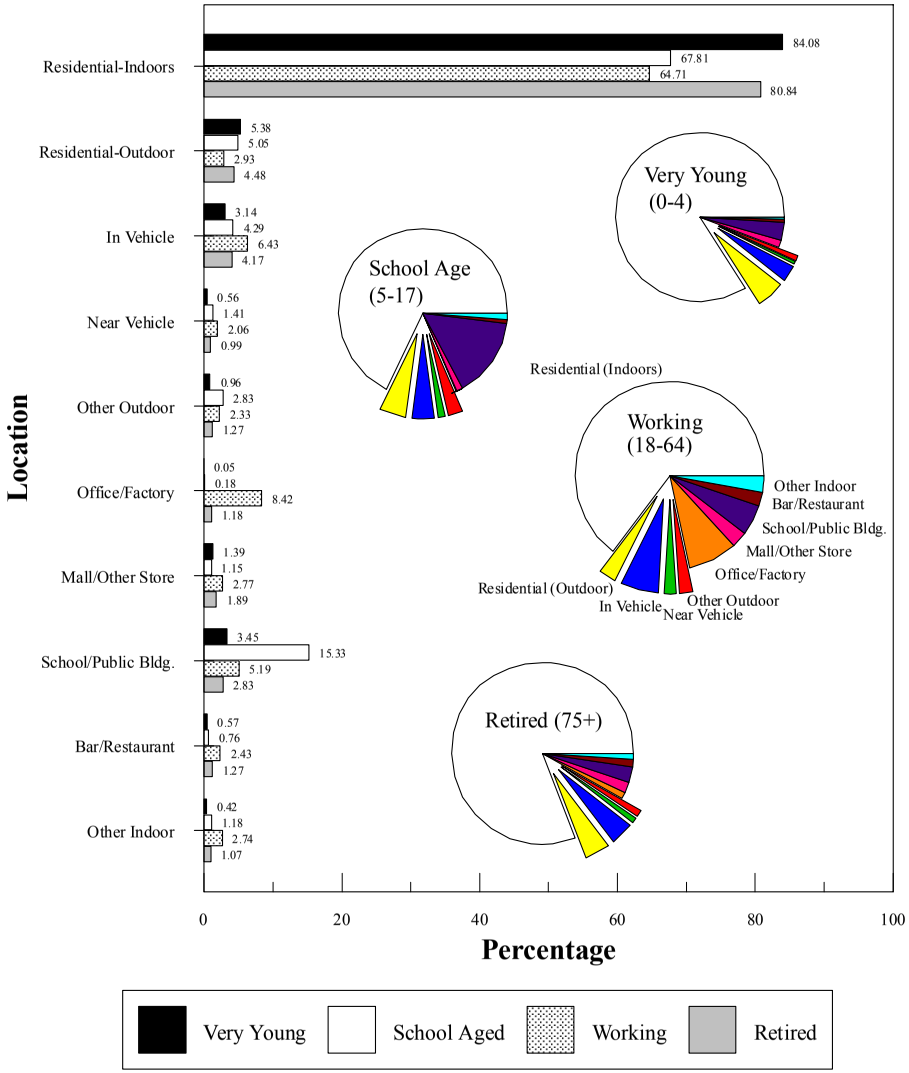


Figure 6-5. The weighted percentage of time spent in each location for each age group.

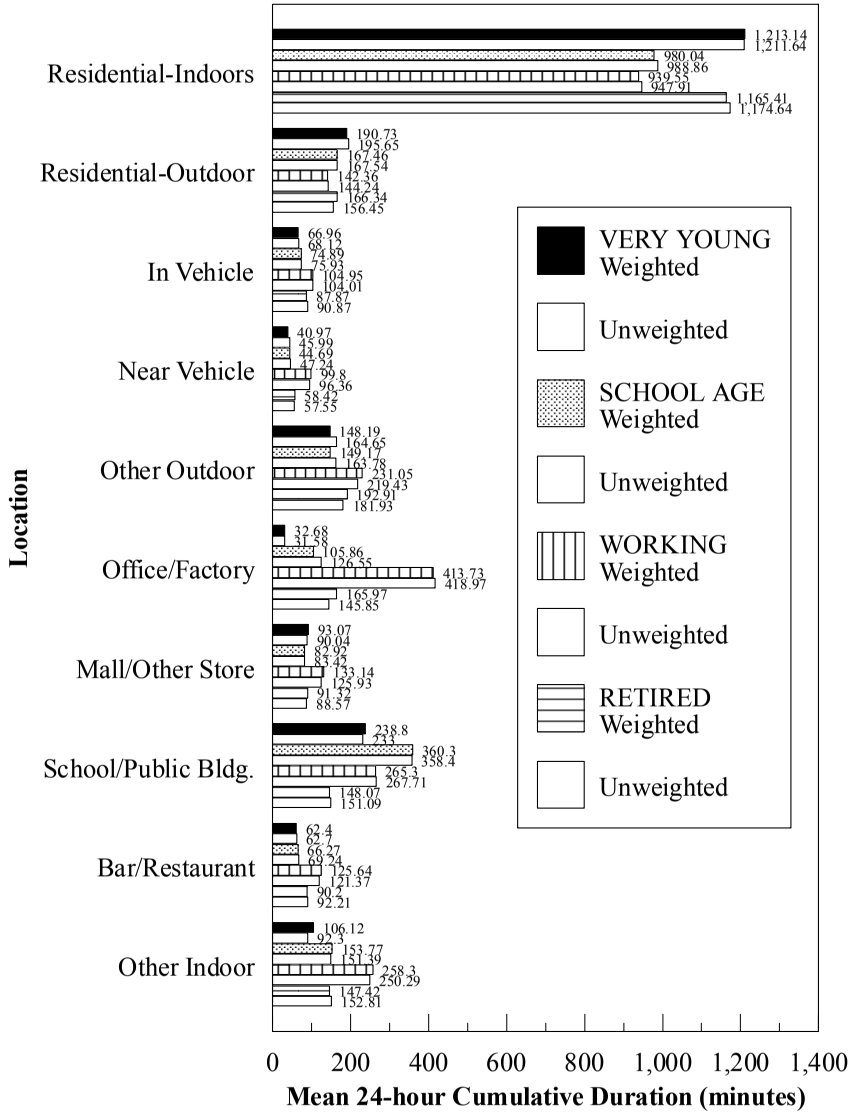


Figure 6-6. The weighted and unweighted mean 24-hour cumulative durations in each location for each age group.

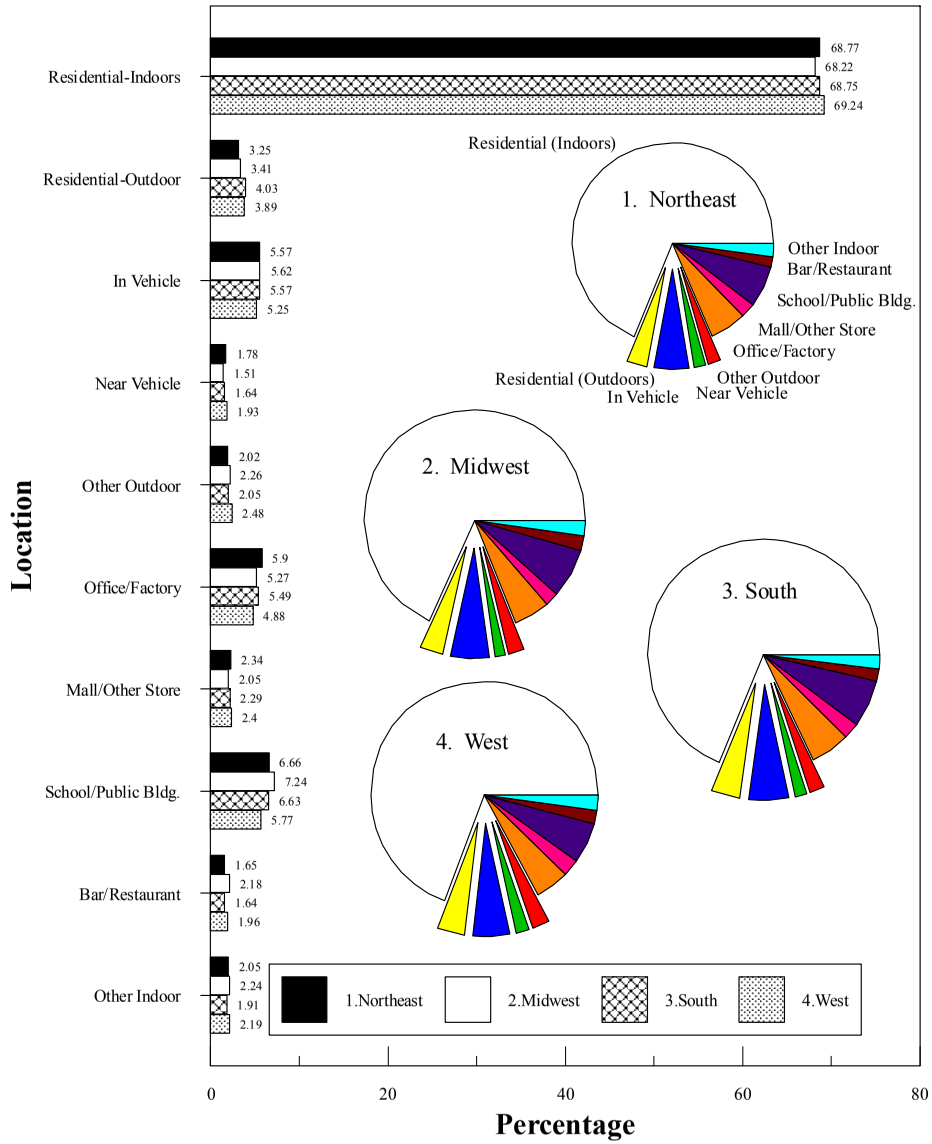


Figure 6-7. The weighted percentage of time spent in each location for each census region.

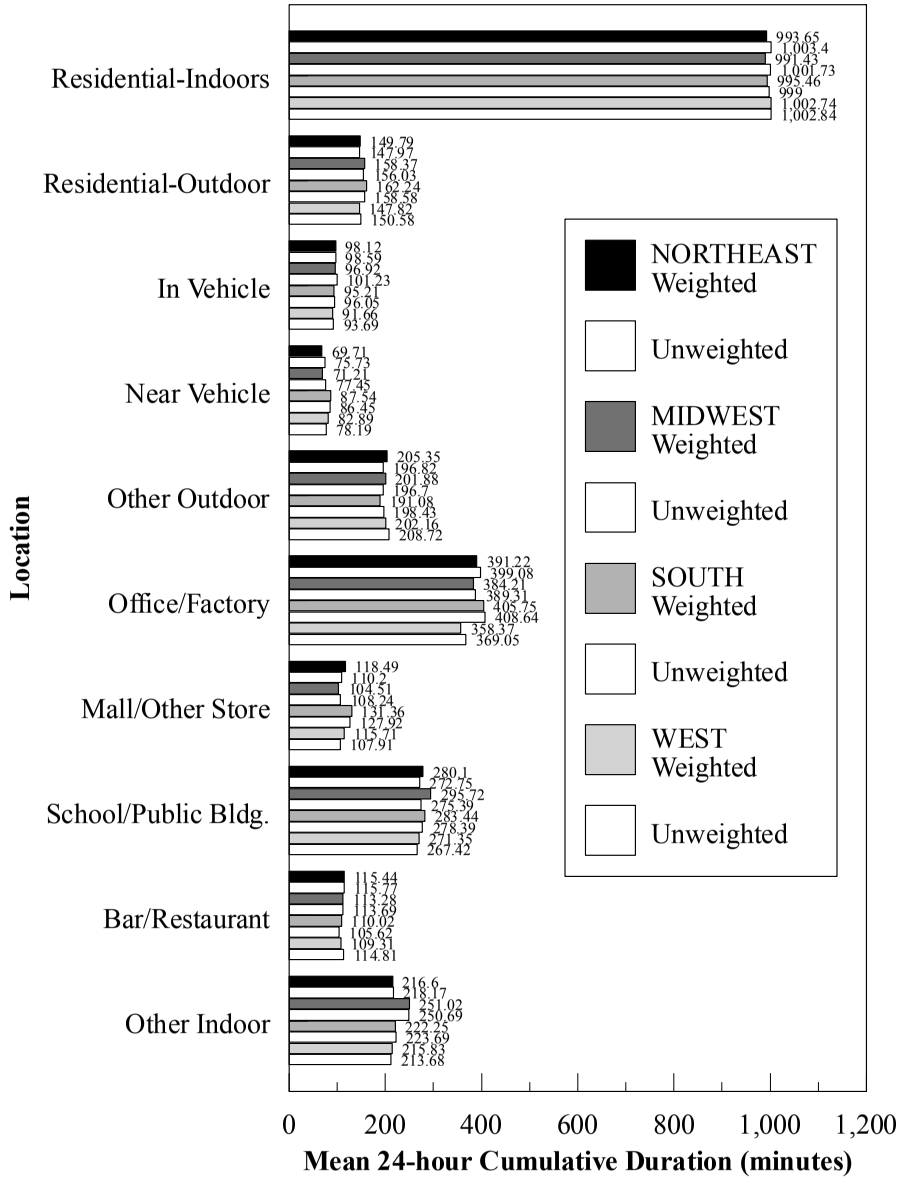


Figure 6-8. The weighted and unweighted mean 24-hour cumulative durations in each location for each census region.

geographic regions (Figure 6-8) were also small with the largest absolute differences occurring for: (1) the Office/Factory location between the West (358 min) and the other regions (384-406 min); (2) the Mall/Other Store location between the South (131 min) and the other regions (104-118 min); and (3) the Other Indoor location between the Midwest (251 min) and the other regions (216-222 min).

On weekends (WE) a higher percentage of time was spent and durations were longer than on weekdays (WD) in the Residential-Indoors (73%, 1062 min WE; 67%, 969 min WD), Residential-Outdoors (5%, 184 min WE; 3%, 142 min WD), and Other Outdoor (3%, 240 min WE; 2%, 179 min WD) locations (Figures 6-9 and 6-10). As expected, on weekdays more time was spent in the Office/Factory (7%, 402 min WD, 1%, 269 min WE) and School/Public Bldg (8%, 313 min WD, 4%, 186 min WE) locations.

There is not much variation across different seasons for percentage of time spent and mean duration in locations (Figures 6-11 and 6-12) except that: (1) slightly less time is spent in the Residential-Indoors location in the Spring and Summer seasons (67%, 967-977 min) than in the Winter and Fall seasons (69-71%, 1,007-1,032 min); (2) more time is spent in the Residential-Outdoor location in the Spring and Summer seasons (5%, 170-171 min) than in the Winter and Fall seasons (2-3%, 116-140 min); and (3) slightly more time is spent in the Other Outdoor location in the Summer (3%, 229 min) than for the Winter, Spring, and Fall seasons (1-2%, 181-186 min). In addition, in the summer season about 2% less time is spent in the School/Public Bldg location than in the other seasons, although the 24-hr durations are approximately the same (264-303 min).

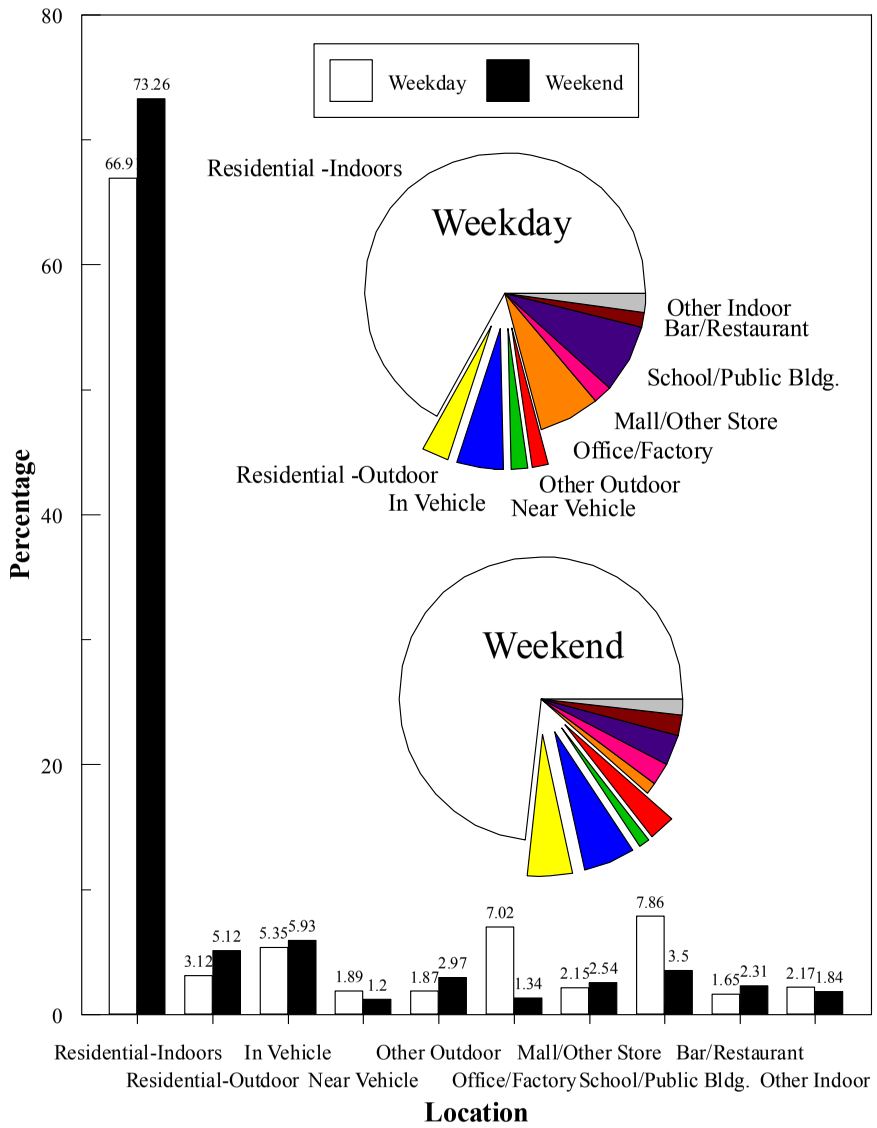


Figure 6-9. The weighted percentage of time spent in each location for weekdays vs. weekends.

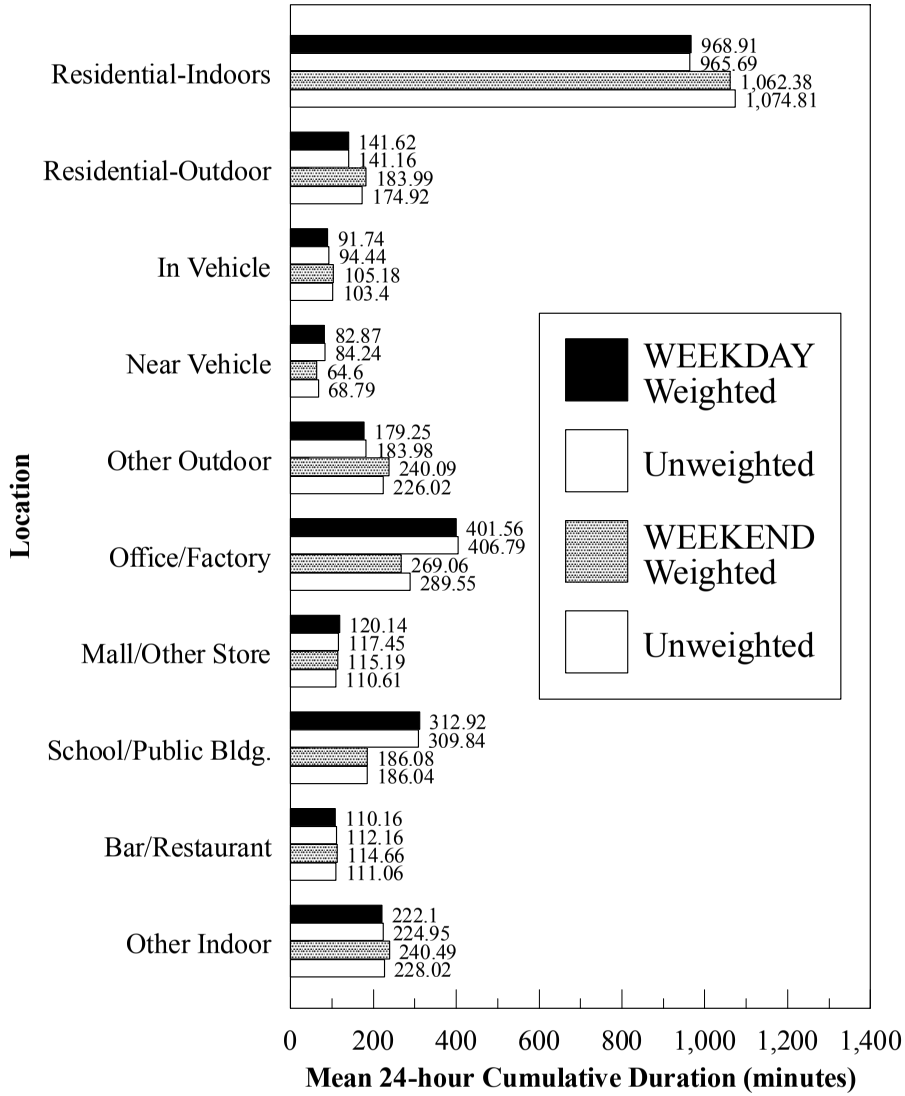


Figure 6-10. The weighted and unweighted mean 24-hour cumulative durations in each location for weekdays vs. weekends.

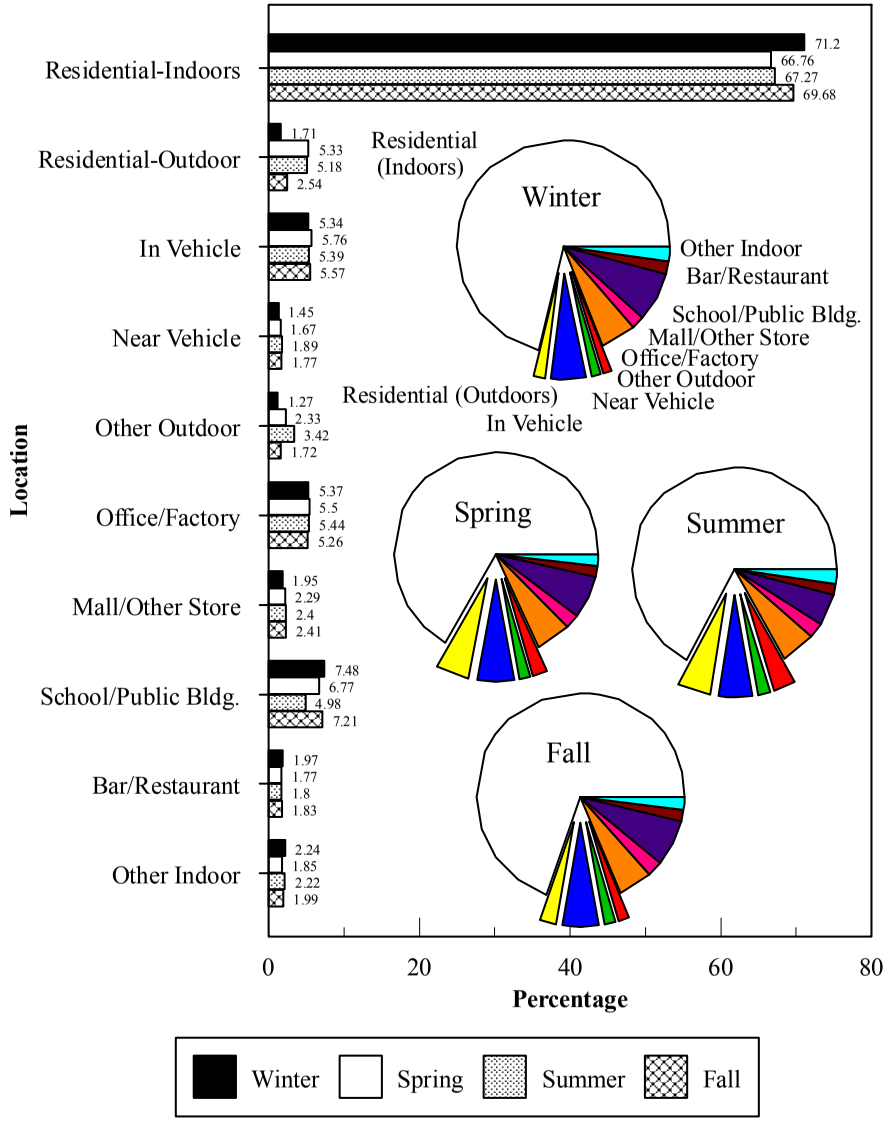


Figure 6-11. The weighted percentage of time spent in each location for each season.

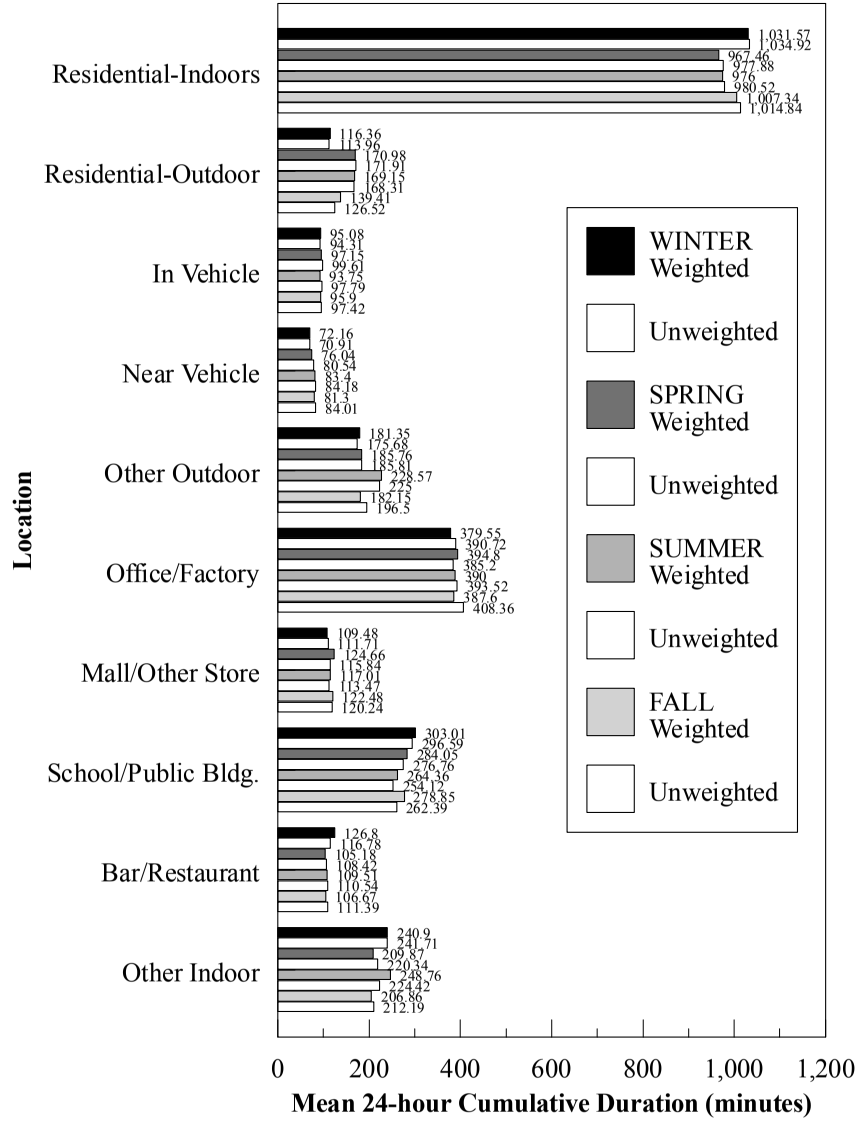


Figure 6-12. The weighted and unweighted mean 24-hour cumulative durations in each location for each season.

6.2 Exposure Activities

Below, we have only considered the percentage of the total time over all respondents that was spent in one of the exposure activities, *i.e.* the "No Exposure" category was excluded (see Section 3 for an explanation of the construction of exposure activities). Overall the percentage of time spent in all exposure activities was 13%. Males (12%) had less time in exposure activities than females (14%) and the Very Young and School Aged had less (10%) than the Working and Retired (13% and 17%, respectively). The Northeast and West had more time in exposure activities (14%) than the Midwest and South (13%). More time in exposure activities occurred on weekends (15%) than on weekdays (12%), and the Spring and Summer had more time in exposure activities (14%) than the Winter and Fall seasons (12%).

The largest percentage of any of the exposure activities (over the time spent being exposed only) was for Eating/Drinking (35%) (Figure 6-13; Table 6-4 contains percentages of time spent across all subgroups). The percentages of time spent in the Food Preparation, Housekeeping, Yardwork/Maintenance, and Sports/Exercise exposure activity categories were all 11-13%. The Bathing category took up about 9% and the Dishes/Laundry/Clean Kitchen category took up 6% of the time. In contrast, the largest mean 24-hr duration (Figure 6-14; Table 6-5 contains 24-hour durations across all subgroups) occurred for Yardwork/Maintenance (147 min), followed by Housekeeping (116 min) and Sports/Exercise (122 min). Eating/Drinking had the fourth largest mean 24-hr duration at 74 min. The durations for Food Preparation and Dishes/Laundry/Clean Kitchen were comparable to Eating/Drinking at 53 and 52 min, respectively. The smallest duration was for Bathing at 26 minutes. Unlike for locations, the ranking of exposure activities by duration does not closely match their ranking by percentage of time spent. This phenomenon occurs because percentages of time spent depend on the length of events and the number of people experiencing them, whereas the mean 24-hour durations presented here depend only on

Table 6-4. The Weighted Percentages of Time Spent in Each Exposure Activity on the Diary Day Across Each Subgroup

Percentage of Time	Overall	Males	Females	0-4	5-17	17-64	65+	Northwest	Midwest	South	West	WkDay	WkEnd	Winter	Spring	Sum	Fall
No Exposure	86.88	88.1	85.73	89.82	89.91	86.52	82.53	86.38	87.48	87.17	86.16	87.54	85.23	87.6	86.02	86.32	87.59
Cooking	1.55	0.73	2.33	0.14	0.22	1.92	2.47	1.57	1.52	1.52	1.6	1.56	1.51	1.54	1.63	1.48	1.54
Dishes/Laundry	0.79	0.22	1.34	0.06	0.12	0.96	1.4	0.86	0.76	0.75	0.83	0.76	0.88	0.86	0.76	0.81	0.74
Housekeeping	1.63	0.69	2.51	0.16	0.45	1.87	3.01	1.68	1.51	1.66	1.66	1.53	1.88	1.5	1.56	1.58	1.86
Bathing	1.23	1.14	1.32	1.43	1.11	1.29	1.03	1.19	1.11	1.33	1.25	1.22	1.26	1.32	1.37	1.13	1.11
Yardwork/Mainten.	1.48	2.18	0.82	0.15	0.4	1.75	2.5	1.36	1.4	1.45	1.77	1.29	1.95	0.98	2.04	1.68	1.23
Sports/Exercise	1.74	2.16	1.34	1.84	3.74	1.29	0.97	2.07	1.35	1.71	1.94	1.58	2.14	1.39	1.97	2.22	1.38
Eating/Drinking	4.7	4.78	4.62	6.4	4.06	4.4	6.09	4.9	4.88	4.41	4.79	4.51	5.15	4.81	4.66	4.77	4.55

Note: Subgroups are for gender, age, U.S. census region, day of week, and season. See Section 4 for a discussion of weighting. Percentage of time is over all respondents (doers + non-doers).

Table 6-5. The Mean Weighted 24-Hour Duration (for Doers) in Each Exposure Activity on the Diary Day by Each Subgroup

Doer Duration D	Overall	Males	Females	0-4	5-17	17-64	65+	Northwest	Midwest	South	West	WkDay	WkEnd	Winter	Spring	Sum	Fall
No Exposure	1251.1	1268.59	1234.49	1293.47	1294.75	1245.88	1188.4	1243.89	1259.66	1255.3	1240.7	1260.64	1227.28	1261.48	1238.72	1242.96	1261.27
Cooking	53.1	36.97	61.03	52.08	21.2	53.71	62.37	53.52	50.82	54.97	52.44	51.85	56.61	51.09	57.59	51.24	52.64
Dishes/Laundry	61.48	47.83	64.28	31.78	29.95	62.57	67.68	58.57	60.52	63.3	62.92	58.26	69.77	63.26	63.95	62.88	56.05
Housekeeping	116.06	115.25	116.28	65.4	62.44	120.41	128.83	109.64	117.27	121.52	112.64	107.47	138.52	116.85	120.44	108.99	118.34
Bathing	26	24.26	27.64	30.24	23.96	25.65	29.03	25.16	24.12	27.13	27.03	25.31	27.85	27	28.4	23.94	24.53
Yardwork/Maint.	147.24	170.26	109.69	80.24	100.61	150.99	155.11	138.85	146.32	158.16	140.78	138.77	163.79	129.73	160.37	139.83	154.04
Sports/Exercise	121.72	135.78	105.08	112.51	142.13	115.6	89.19	136.07	110.34	118.4	123.97	110.44	149.97	115.56	125.66	129.14	112.28
Eating/Drinking	73.58	74.32	72.86	94.38	62.37	70.42	91.72	75.78	75.99	69.8	74.93	70.52	81.28	74.85	73.45	74.56	71.43

Note: Subgroups are for gender, age, U.S. census region, day of week, and season. See Section 4 for a discussion of weighting.

Table 6-6. The Weighted Number of NHAPS Respondents (Doer Sample Size N) in Each Exposure Activity on the Diary Day by Each Subgroup

Doer Sample Size N	Overall	Males	Females	0-4	5-17	17-64	65+	Northwest	Midwest	South	West	WkDay	WkEnd	Winter	Spring	Sum	Fall
No Exposure	9196	4479.7	4716.3	679.1	1674.2	5692.9	1150	1842.6	2242.5	3237.4	1873.5	6567	2629.2	2300.5	2300.5	2301	2294.4
Cooking	3860.1	1272.8	2587.3	25.6	246.6	2930.9	657.1	776.8	967	1291.1	825.2	2850	1009.8	1001.3	938.4	954.7	965.7
Dishes/Laundry	1705.9	290.2	1415.7	17.2	94.1	1252.9	341.8	388.7	405.9	555.4	355.9	1229	476.9	449.4	392.5	428.2	435.8
Housekeeping	1857	388.7	1468.3	24.2	172.6	1273.1	387.1	407.2	416.4	635.6	397.7	1343	514	426.4	429	480.9	520.6
Bathing	6270.7	3037.6	3233.1	461.9	1112.3	4108.2	588.3	1257.4	1481	2284.7	1247.6	4560	1711.2	1613.9	1597.6	1565	1493.8
Yardwork/Mainten.	1332.3	826	506.3	18.6	94.7	952.6	266.3	259.1	308.2	426	338.9	881.2	451	249	420.5	398.5	264.2
Sports/Exercise	1893.8	1026.2	867.6	159.7	635.1	918.1	180.9	402.8	395.4	673.9	421.6	1354	540.1	398.6	518.6	570.7	405.9
Eating/Drinking	8453.8	4151.2	4302.6	663.5	1569.6	5121.7	1099	1714.5	2071.7	2943.1	1724.6	6053	2400.4	2128.9	2009.9	2121	2104.1

Note: Subgroups are for gender, age, U.S. census region, day of week, and season. See Section 4 for a discussion of weighting. The doer sample sizes are equal to the number of respondents entering each location on the diary day. The maximum number in each location is the total weighted sample size (N = 9196).

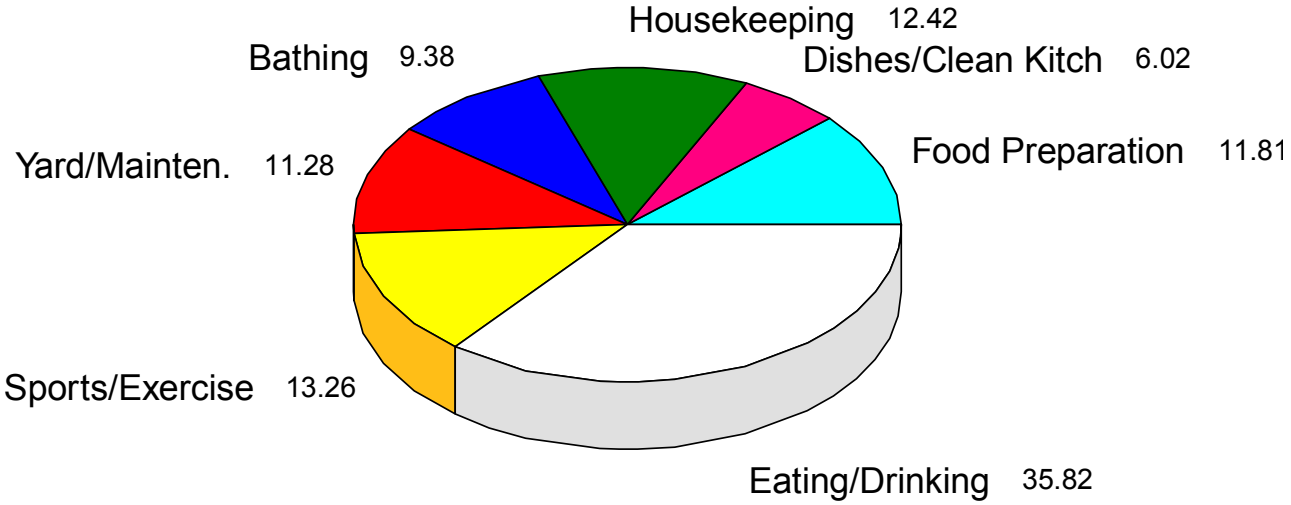


Figure 6-13. The overall weighted percentage of time spent by the respondents in each exposure activity -- excluding time spent in the No Exposure category. The total amount of time is 1,737,104 minutes = 1,440 min x 9,196 respondents (13,242,240 min) minus 11,505,136 min (the 86.88% spent in the No Exposure category, REGACT = 0).

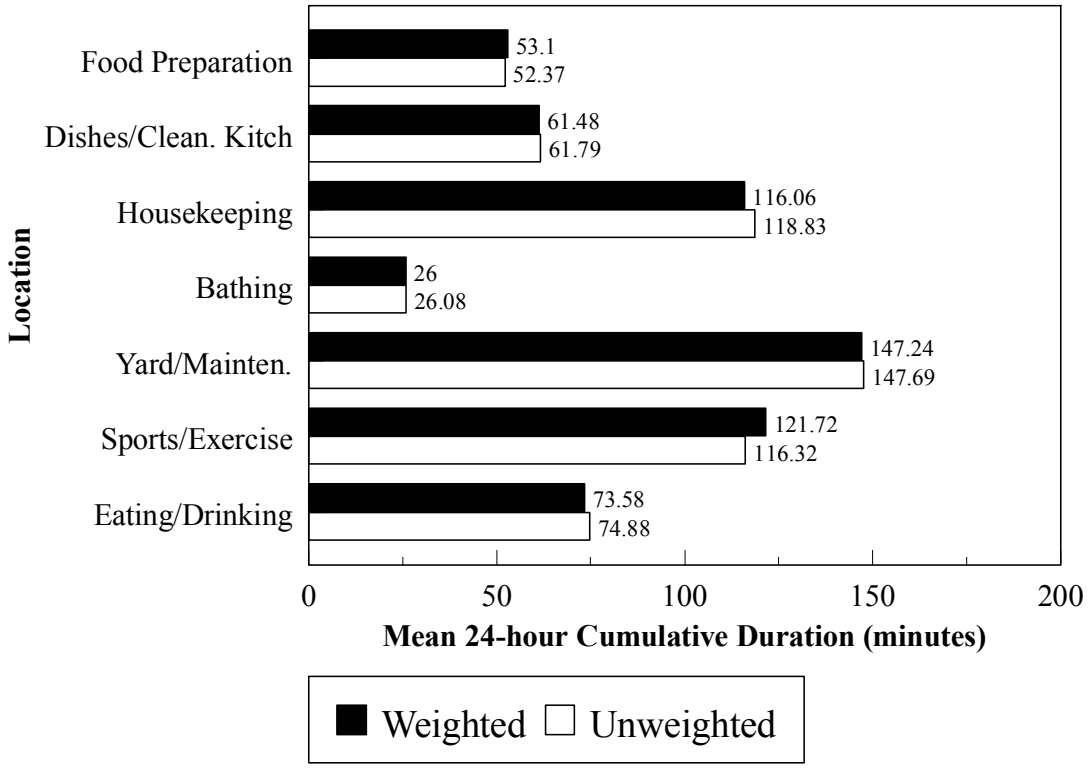


Figure 6-14. The overall weighted (N=9196) and unweighted (N=9386) mean 24-hour cumulative durations in each exposure activity. In the weighted analyses, 190 repondents with missing age or gender values were excluded. See Section 4 for a discussion of the weighting methodology.

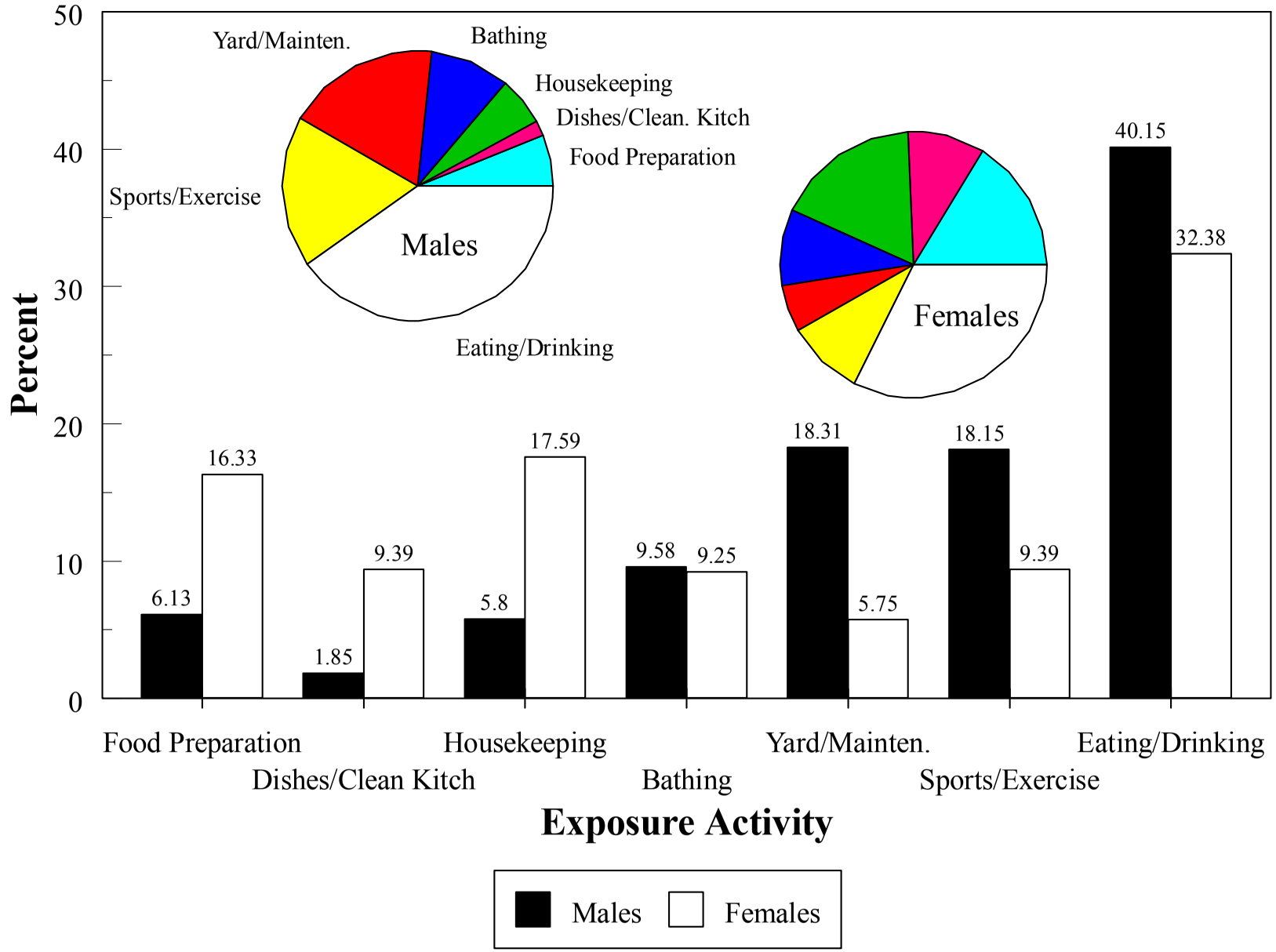


Figure 6-15. The weighted percentage of time spent in each exposure activity for males vs. females.

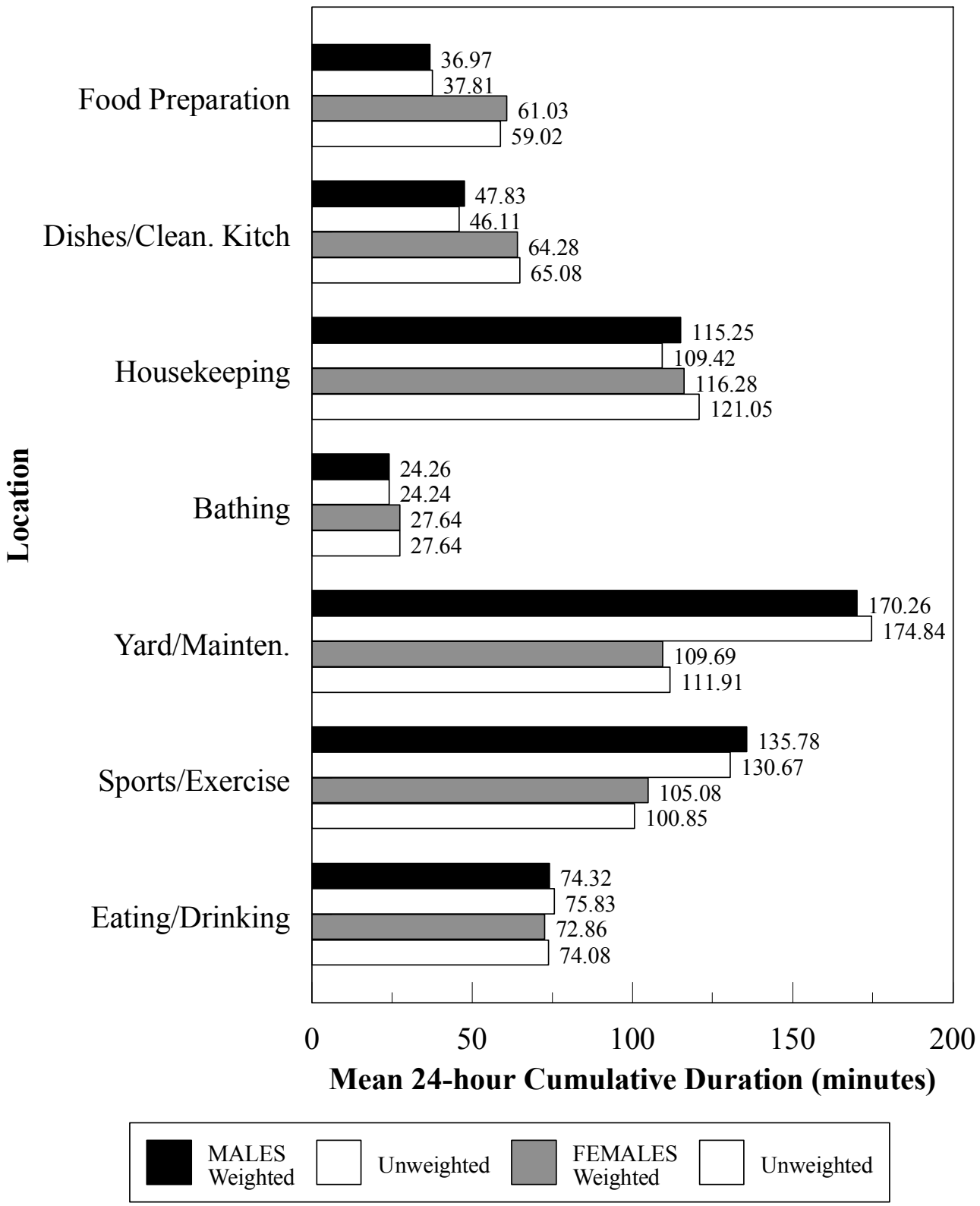


Figure 6-16. The weighted and unweighted mean 24-hour cumulative durations in each exposure activity for males vs. females.

the average length of events for just the people that experience them -- the doers. Table 6-6 contains samples sizes of the doers in each exposure activity across all subgroups.

The differences between the percentage of time spent in exposure activities by males vs. females are striking for every category except Bathing (9-10% for both) (Figure 6-15). Females are engaged in higherproportions for Food Preparation (6% M, 16% F), Dishes/Laundry/Clean Kitch (2% M, 9% F), and Housekeeping (6% M, 18% F), while males are occupied in higher proportions for Yardwork/Maintenance (18%M, 6% F), Sports/Exercise (18% M, 9% F), and Eating/Drinking (40% M, 32% F). The 24-hr durations (Figure 6-16) follow the same pattern except for: (1) Housekeeping and Eating/Drinking where the durations are approximately the same for both males and females (115-116 min and 73-74 min for each exposure activity, respectively); and (2) Bathing/Hygiene, where male durations are slightly smaller than those for females (24 min M, 28 min F).

The Very Young/School Age age groups, when compared to the Working/Retired age groups, have smaller percentages of time spent (Figure 6-17) in the Food Preparation (1-2% vs. 14%), Dishes/Laundry/Clean Kitch (0-1% vs 7-8%), Housekeeping (1-5% vs. 14-17%), and Yardwork/Maintenance (1-4% vs 12-14%) exposure activities. Of all age groups, the Very Young have the highest percentages of time spent for the Bathing (14% vs 6-11% for all the others) and Eating/Drinking (63% vs. 32-40% for all the others) exposure activities. The Sports/Exercise exposure activity has the highest percentage of time spent for the School Age age group (37%), followed by the Very Young (18%), the Working (10%), and the Retired (6%). The mean 24-hr durations (Figure 6-18) for the Dishes/Laundry/Clean Kitch, Housekeeping, Sport/Exercise, and Yardwork/Maintenance exposure activities follow the pattern of the percentages of time spent. However, the durations of the Very Young for Food Preparation are nearly equal to those for the Working, probably since many small children are assisting their parents. The Very Young/Retired durations are very similar for Bathing and

Eating/Drinking (30 min and 92-94 min, respectively) as they are for the School Age/Working durations (24-27 min and 62-70 min, respectively).

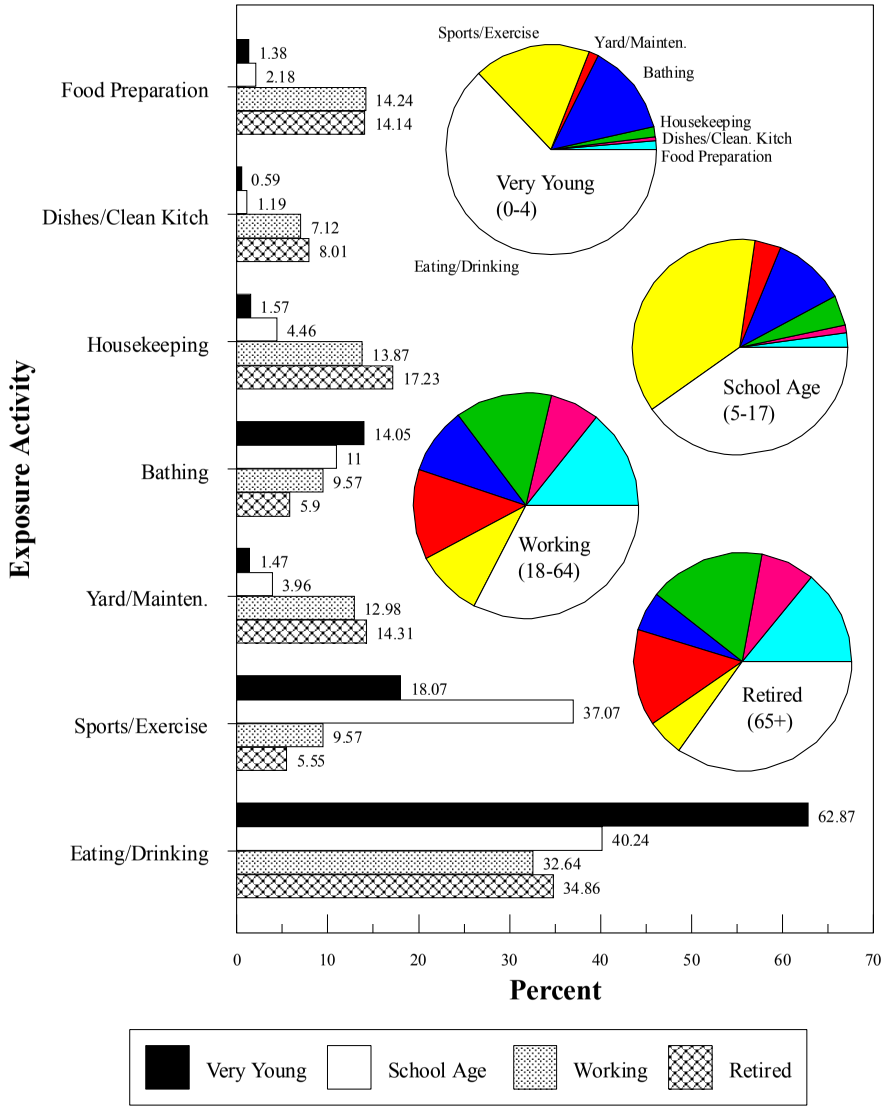


Figure 6-17. The weighted percentage of time spent in each exposure activity for each age group.

Figure 6-18. The weighted and unweighted mean 24-hour cumulative durations in each exposure activity for each age group.

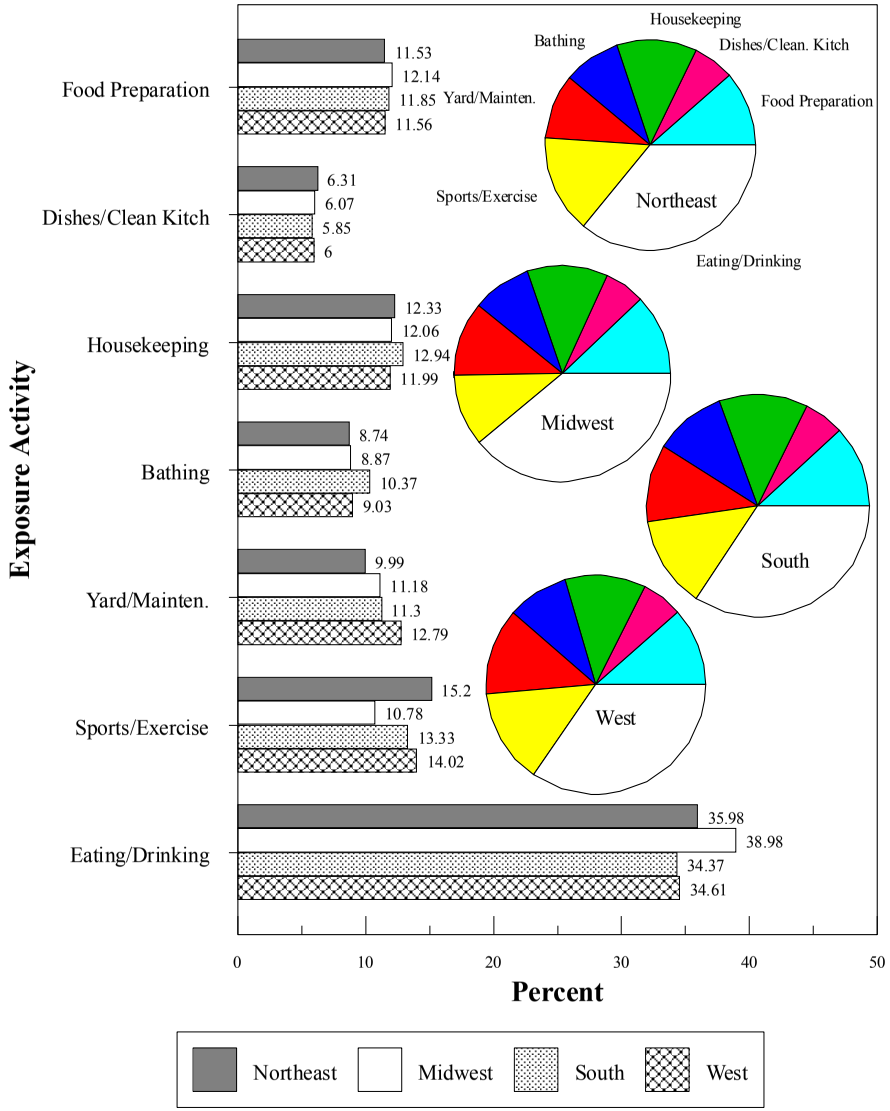


Figure 6-19. The weighted percentage of time spent in each exposure activity for each census region.

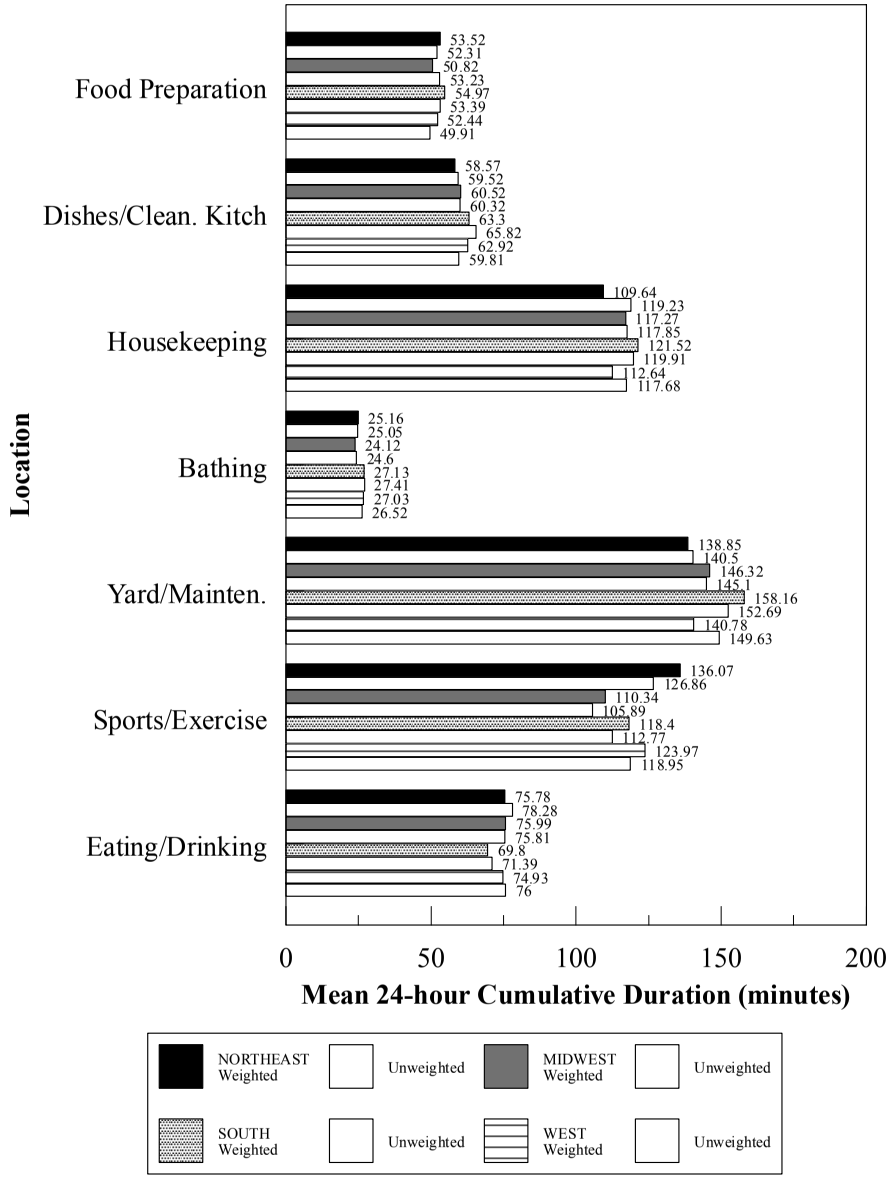


Figure 6-20. The weighted and unweighted mean 24-hour cumulative durations in each exposure activity for each census region.

Differences in percentages of time spent in each exposure activity are less than 1% across the Census regions (Figure 6-19) except that: (1) 10.4% of the time is spent Bathing in the South in comparison to 8-9%elsewhere; (2) 10% of the time is spent in Yardwork/Maintenance in the Northeast with 11% in the Midwest and South and 13% in the West; (3) 11% of the time is spent in Sports/Exercise in the Midwest with 13-15% spentelsewhere; and (4) 39% of the time is spent Eating/Drinking in the Midwest with 34-36% spent elsewhere. The only differences in mean 24-hr duration (Figure 6-20) that exceed 10-11 min are for: (1) Yardwork/Maintenance between the South (158 min) and the other regions (139-141 min); and (2) Sports/Exercise between the Northeast (136 min) and the other regions (110-124 min).

The exposure activities that had percentage of time differences that were greater than 2% between days of the week falling on Weekdays vs. Weekends (Figure 6-21) were Food Preparation (12.5% WD, 10% WE) and Yardwork/Maintenance (10% WD, 12% WE). The 24-hr durations of all exposure activities (Figure 6-22) were smaller on the Weekdays than on the Weekends. The greatest differences occurred for Housekeeping (107 min vs. 139 min), Yardwork/Maintenance (139 min vs. 164 min), and Sports/Exercise (110 min vs 150 min).

Differences in percentage of time spent tend to occur between the Winter/Fall (WF) and Spring/Summer (SS) season groupings (Figure 6-23). The largest differences were for Yardwork/Maintenance (8-10% WF, 12-15% SS) and Sports/Exercise (11% WF, 14-16% SS). The most Housekeeping occurred in the Fall (15% vs 11-12% for the other seasons) and the highest percentage of time spent Eating/Drinking occurred in the Winter (39% vs. 33-37% for the other seasons). The largest mean 24-hr durations (Figure 6-24) for Yardwork/Maintenance were for the Spring (160 min) and the Fall (154 min) seasons (130-140 min for Winter/Summer). The largest durations for Sports/Exercise were for the Spring/Summer season (126-129 min vs. 112-116 min for Winter/Fall).

Differences in mean duration between the four seasons did not exceed 10-11 min for the other exposure activities.

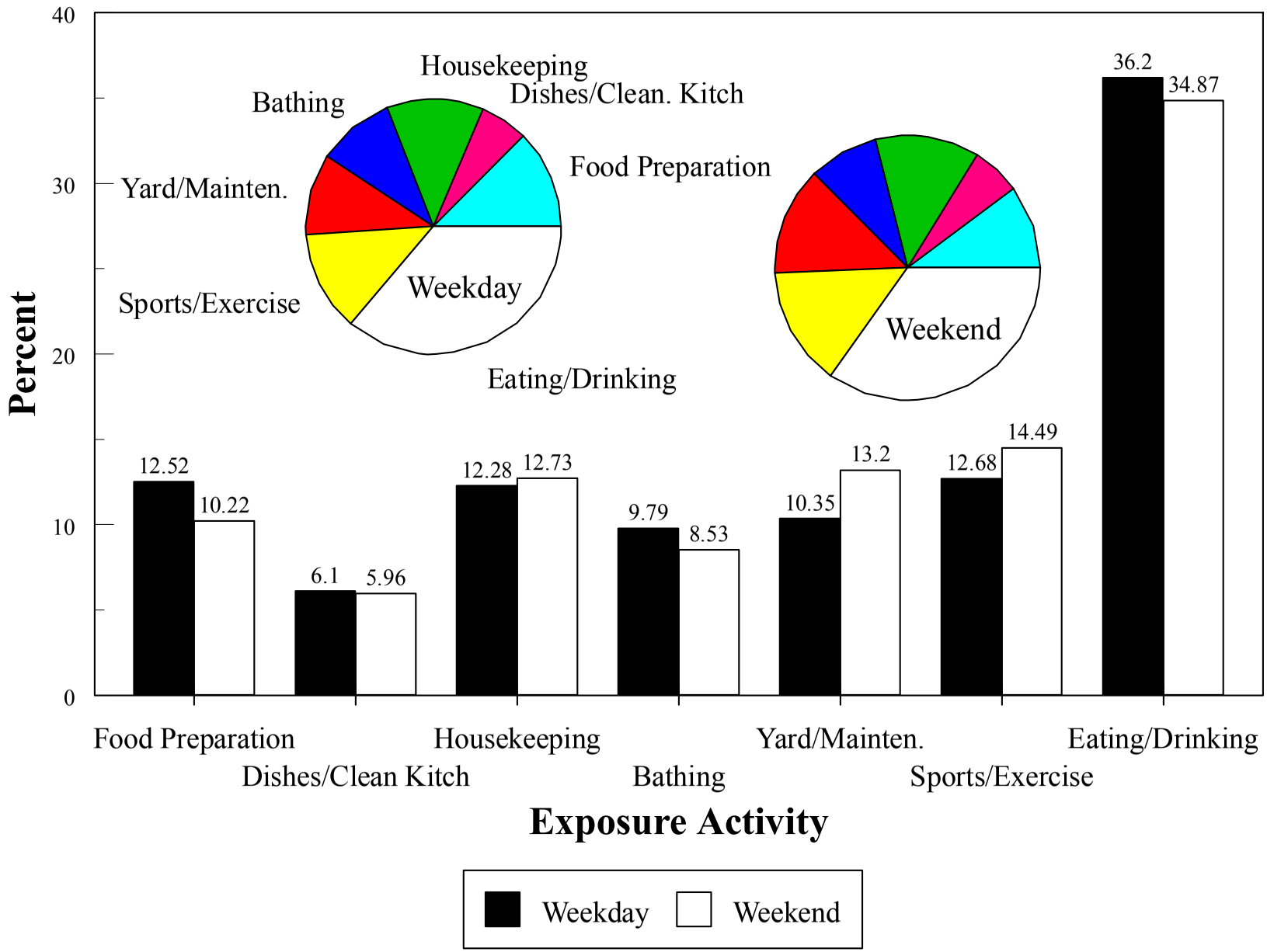


Figure 6-21. The weighted percentage of time spent in each exposure activity for weekdays vs. weekends.

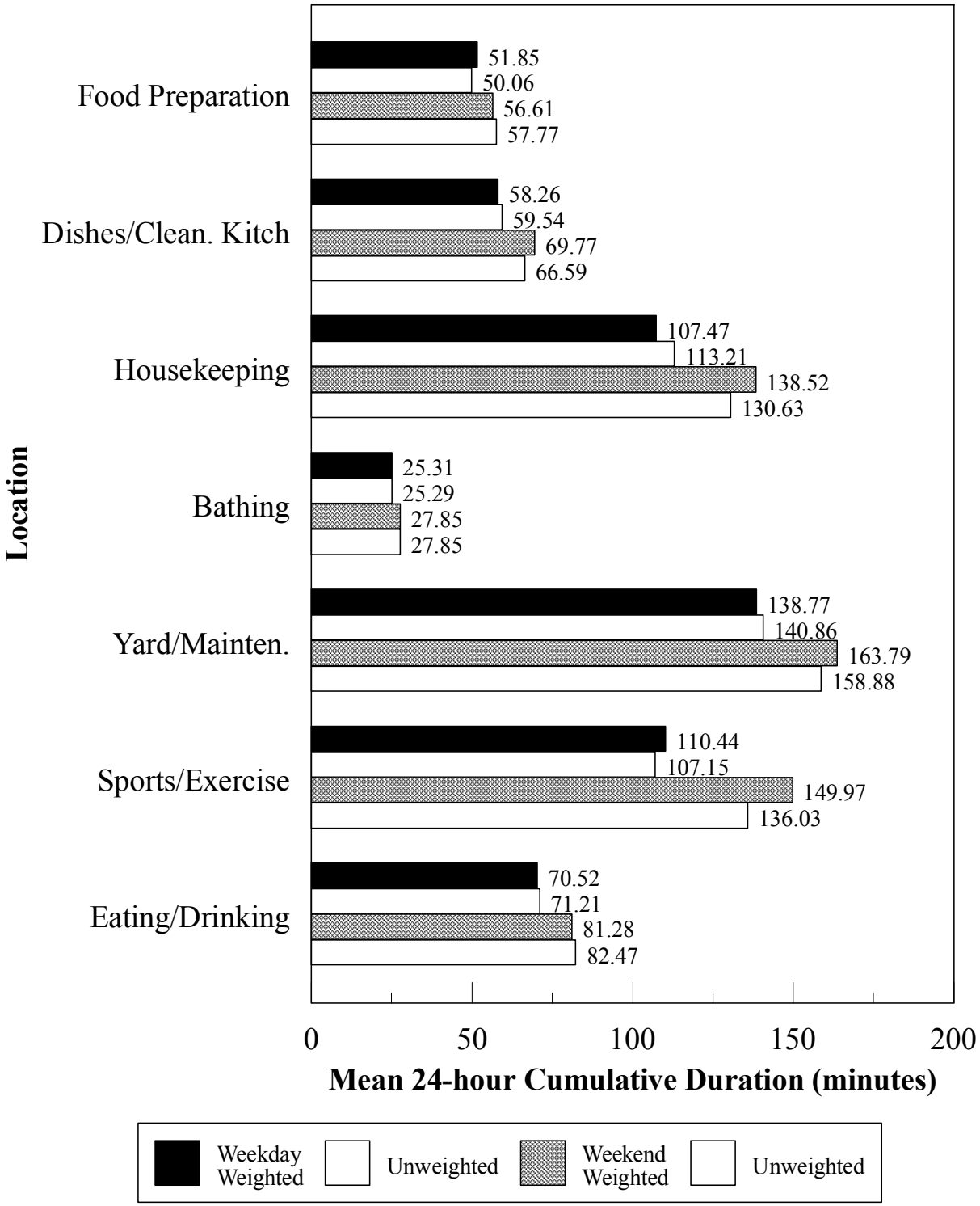


Figure 6-22. The weighted and unweighted mean 24-hour cumulative durations in each exposure activity for weekdays vs. weekends.

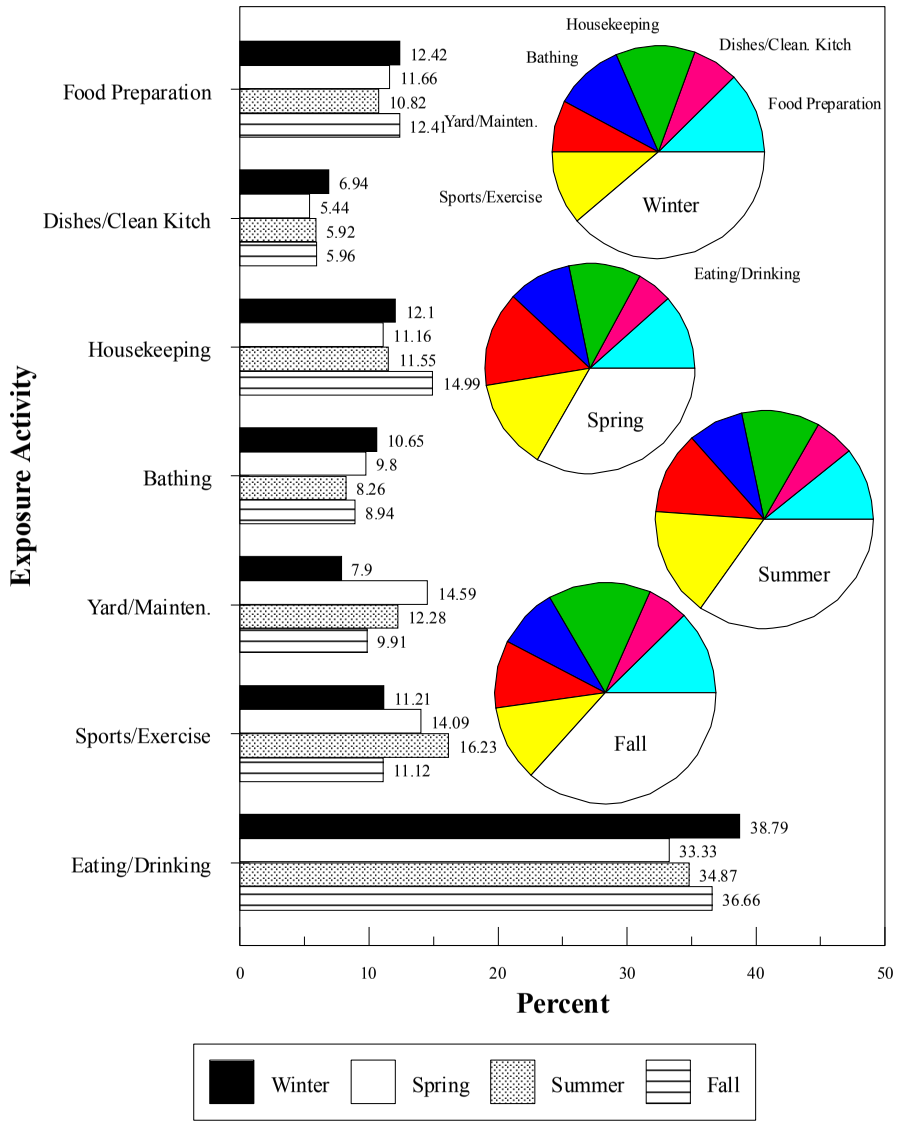


Figure 6-23. The weighted percentage of time spent in each exposure activity for each season.

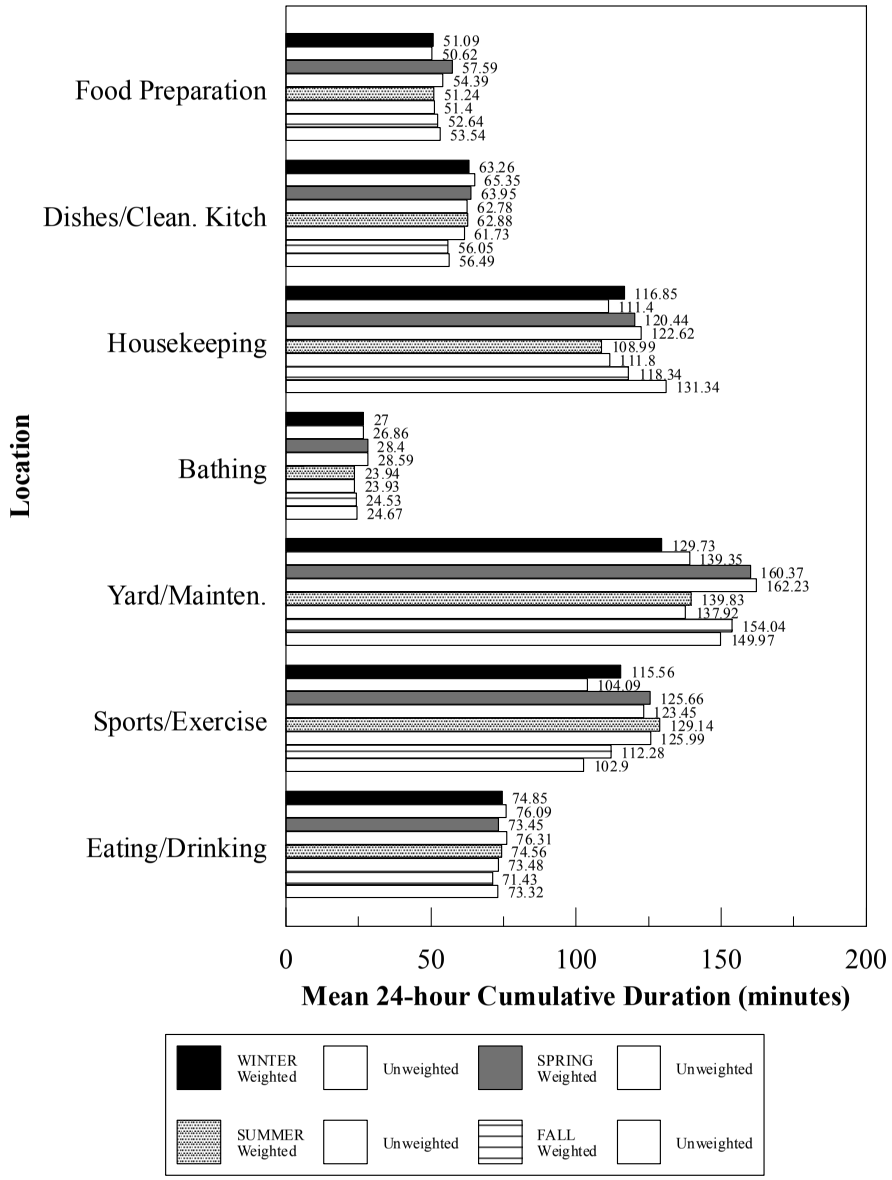


Figure 6-24. The weighted and unweighted mean 24-hour cumulative durations in each exposure activity for each season.

6.3 Smoker-Present Categories

The overall percentage of **people** exposed to ETS for at least one minute on the diary day was 45% (Figure 6-25). More male respondents were exposed (46%) than females (44%), and individuals in the School Age (5-17) and Working (18-64) age groups were more exposed (41% and 51%, respectively) than the Very Young (0-4) and Retired (65+) age groups (34% and 28% exposed, respectively). Those in the Northeast had the highest percentage of people exposed (49%), followed closely by the Midwest (48%) and the South (45%) with the West having the lowest exposure (38%). There were slightly more people exposed on the weekends (46%) than on weekdays (44%). The Winter, Spring, and Summer seasons all had similar numbers of people exposed (43-44%) while in the Fall season substantially more people were exposed (49%).

The overall percentage of **time** over the diary day that respondents were exposed to ETS -- including only those that were exposed at least one minute on the diary day -- was 26% (Figure 6-26). Males were exposed for a larger percentage of time (28%) than females (24%). The age group with the largest percentage of time exposed was the Working (28%), followed by the Very Young (26%), the Retired (24%), and the School Aged (18.5%). The South had the largest percentage of time exposed (28%), while the other regions had about the same exposure (24-25%). On weekends the percentage of time was greater (28%) than on weekdays (25%), while each season had about the same percentage of time exposed to environmental tobacco smoke (ETS) (25-26.5%).

The mean 24-hr cumulative durations of ETS exposure (371 min overall) follow a similar pattern as the percentage of time respondents were exposed (Figure 6-27). Males durations were longer than females (397 min vs. 345 min), and of any age group, the Working were exposed the longest (402 min), but they were followed closely by the Retired (382 min) and the Very Young (360 min) with the School Ages having the least exposure durations (261 min). The South had larger

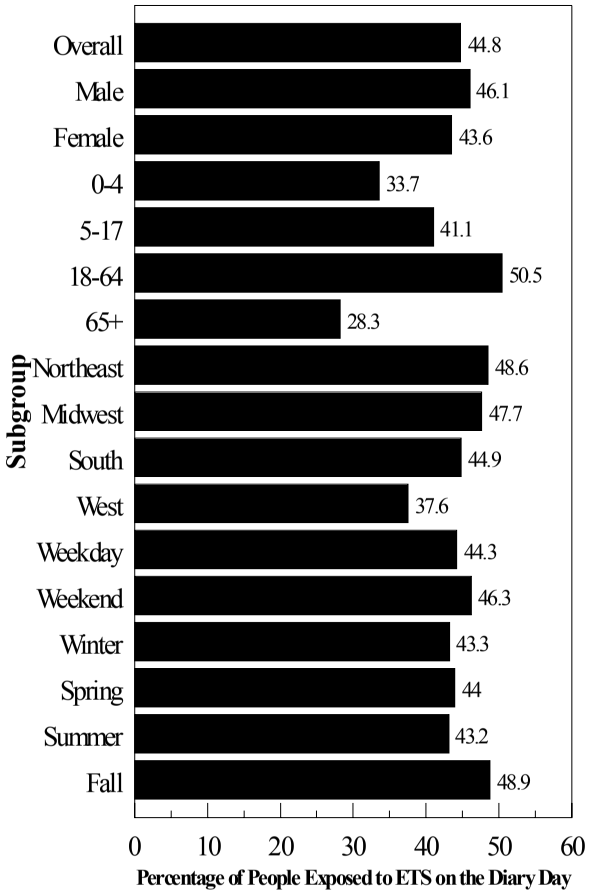


Figure 6-25. The weighted percentage of **people** that were exposed to ETS for at least one minute on the diary day according to each subgroup. The weighted sample size was 4,951.5 for those who were exposed and 4025.9 for those who were never exposed on the diary day.

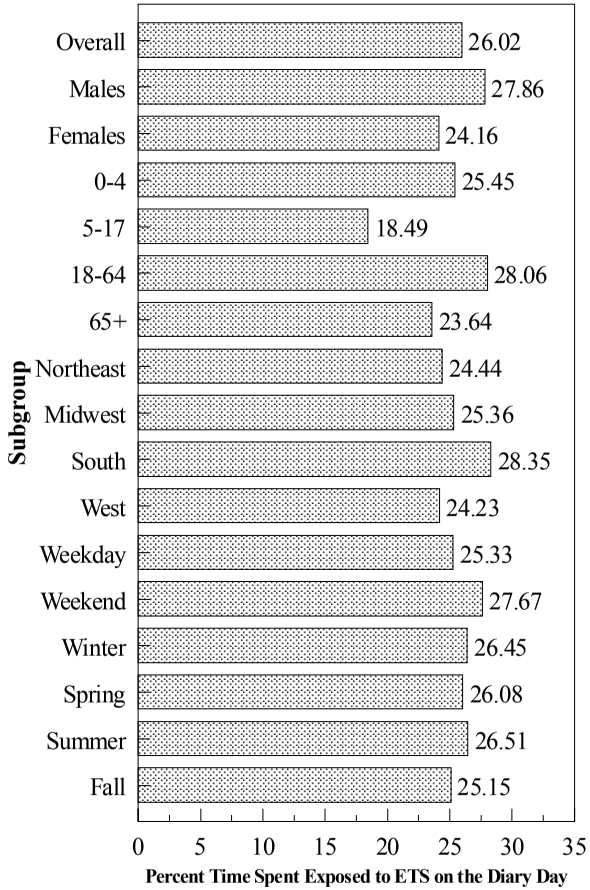


Figure 6-26. The weighted percentage of **time** that those who were exposed to ETS on the diary day were exposed -- for each subgroup. Total Time = 5,747,716 min.

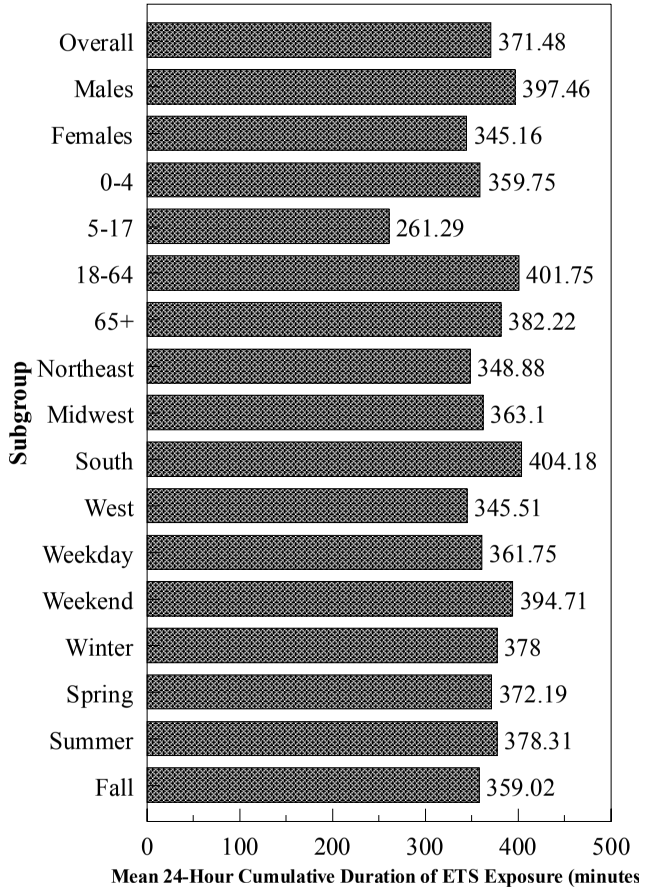


Figure 6-27. The weighted mean 24-hour cumulative durations of ETS exposure for those who were exposed for at least one minute on the diary day -- for each subgroup.

durations (404 min) than the other regions (345-363 min), weekend durations were longer (395 min) than on weekdays (362 min), and each of the seasons all had similar durations (359-378 min).

6.4 Locations x Smoker-Present Categories

Percentage of time spent exposed to ETS is dependent on both the length of exposure microenvironments and the number of people being exposed, whereas 24-hr durations are dependent on the length of each exposure microenvironment and the number of times it occurs on the diary day. Of those that were exposed to ETS for at least one minute on the diary day, the location with the largest overall percentage of time spent being exposed (based on total time spent exposed, *i.e.* **not** including time spent **not** being exposed) was Residential-Indoors (48%) (Figure 6-28; Table 6-7 contains the percentage of time spent across all subgroups). The next largest percentages of time spent exposed were for the Office/Factory (9.7%), Bar/Restaurant (8.8%), and In Vehicle (7%) locations. The two locations with the smallest percentage of time spent exposed to ETS were Mall/Other Store (3.5%) and School/Public Bldg (3.9%). In other locations respondents were exposed between 4% and 5.5% of the time. The largest overall 24-hr duration of ETS exposure (Figure 6-28; Table 6-9 contains 24-hr durations across all subgroups) occurred in the Office-Factory location (363 min), followed by Residential-Indoors (305 min), Other Indoor (256 min), School/Public Bldg (249 min), Other Outdoor (247 min), Mall/Other Store (198 min), Residential-Outdoor (178 min), Near Vehicle (160 min), Bar/Restaurant (143 min), and In Vehicle (79 min). The largest mean number of occurrences (Figure 6-28; Table 6-9 contains the frequence of occurrence across all subgroups)) was in the Residential-Indoors location (3) with the next closest location being In Vehicle (2). The next two highest mean number of occurrences were for the Office/Factory (1.6) and the Near Vehicle (1.5) locations. Number of occurrences in all the other locations fell between 1.1 and 1.4. Table 6-10 contains the doer sample size across all subgroups.

Table 6-7. The Weighted Percentages of Time Spent in Each Location x Smoker-Present Microenvironment on the Diary Day Across Each Subgroup

Percentage of Time	Overall	Males	Females	0-4	5-17	17-64	65+	Northwest	Midwest	South	West	WkDay	WkEnd	Winter	Spring	Sum	Fall
Residential -Indoors	48.06	40.87	56.44	81.88	67.3	41.37	62.68	48.53	48.97	48.57	44.74	45.23	54.23	55.29	45.69	39.74	51.16
Residential -Outdoor	5.01	5.38	4.58	8.68	7.01	4.47	4.73	4.18	3.98	6.27	4.68	3.53	8.24	2.5	7.51	7.46	2.76
In Vehicle	7.01	7.27	6.7	3.67	6.62	7.43	5.66	6.41	7.59	7.7	5.16	6.97	7.09	5.84	7.82	7.02	7.32
Near Vehicle	4.45	7.02	1.44	0.64	1.36	5.47	1.38	3.8	2.64	5.14	6.5	5.68	1.75	4.39	3.21	4.72	5.41
Other Outdoor	5.49	7.64	2.48	1.26	5.53	5.85	4.79	5.63	5.5	4.99	6.52	4.4	7.88	2.43	6.35	9.53	3.85
Office/Factory	9.68	11.99	7	0	0	12.23	5.45	10.74	9.69	9.87	7.87	13.14	2.12	9.48	9.86	10.35	9.09
Mall/Other Store	3.54	3.01	4.16	1.24	2.51	4	2.08	3.14	3.13	3.73	4.27	3.72	3.15	2.9	3.96	3.75	3.55
School/Public Bldg.	3.9	3.06	4.87	0.004	4.57	4.22	2.37	5.7	3.68	3.01	4.07	4.82	1.88	4.13	4.61	3.58	3.3
Bar/Restaurant	8.77	8.5	9.07	2.46	4.1	9.99	8.03	7.58	10.35	7.39	11.09	8.05	10.33	9.13	7.98	8.79	9.14
Other Indoor	4.1	5.25	2.76	0.17	0.99	4.97	2.83	4.28	4.48	3.34	5.1	4.45	3.33	3.91	3.01	5.06	4.41

Note: Subgroups are for gender, age, U.S. census region, day of week, and season. See Section 4 for a discussion of weighting. The percentage of time spent is over all respondents (doers + non-doers)

Table 6-8. The Mean Weighted 24-Hour Duration (Minutes) in Each Location x Activity Microenvironment (for Doers) on the Diary Day by Each Subgroup

Doer Duration D	Overall	Males	Females	0-4	5-17	17-64	65+	Northwest	Midwest	South	West	WkDay	WkEnd	Winter	Spring	Sum	Fall
Residential -Indoors	305.11	301.64	308.11	381.27	257.49	303.26	365.47	292.72	304.82	313.88	301.37	284.17	352.51	341.61	300.59	263.27	310.75
Residential -Outdoor	178.22	206.99	149.69	221.56	165.52	176.75	177.27	184.77	177.25	187.62	149.06	152.59	211.53	219.22	170.91	179.91	165.86
In Vehicle	78.65	87.3	69.87	57.03	62.22	82.8	77.3	74.84	81.37	82	68.7	77.26	81.82	69.23	90.31	77.49	77.62
Near Vehicle	159.93	214.94	65.18	60.1	35.3	188.87	125.12	98.7	98.92	237.5	212.13	178.69	91.66	166.49	139.85	155.92	171.98
Other Outdoor	247.15	299.22	162.61	94.59	149.71	277.26	280.92	288.45	237.04	255.78	212.24	223.57	283.66	271.09	229.37	268.52	221.59
Office/Factory	362.98	369.82	350.04	0	0	363.29	355.78	365.54	370.86	371.59	322.8	368.43	302.4	360.19	421.85	336.25	345.79
Mall/Other Store	198.35	200.35	196.69	128.32	101.68	232.19	105.03	202.35	171.63	198.91	235.56	209.62	174.2	167.51	209.05	250.11	178.05
School/Public Bldg.	248.96	221.76	273.54	5	206.98	265.2	169.02	297.39	237.91	217.95	256.01	268.18	177.58	204.42	274.8	334.59	221.76
Bar/Restaurant	142.95	142.24	143.74	98.22	98.09	153.79	98.43	134.94	141.38	148.23	144.63	138.88	150.48	153.67	131.75	145.8	141.03
Other Indoor	255.46	271.07	226.45	150	96.36	293.41	104.18	257.09	265.96	258.38	236.47	257.53	249.59	259.17	211.69	333.96	226.08

Note: Subgroups are for gender, age, U.S. census region, day of week, and season. See Section 4 for a discussion of weighting

Table 6-9. The Weighted Number of Occurrences of Each Location x Smoker-Present Microenvironment (for Doers) on the Diary Day by Each Subgroup

Doer Frequency O	Overall	Males	Females	0-4	5-17	17-64	65+	Northwest	Midwest	South	West	WkDay	WkEnd	Winter	Spring	Sum	Fall
Residential -Indoors	3.02	2.69	3.3	2.74	2.74	3.1	3.34	2.94	2.95	3.16	2.91	2.98	3.12	3.48	2.8	2.68	3.09
Residential -Outdoor	1.39	1.47	1.32	1.37	1.43	1.38	1.48	1.39	1.38	1.44	1.29	1.39	1.39	1.3	1.38	1.47	1.31
In Vehicle	2.32	2.31	2.33	1.97	1.94	2.41	2.3	2.09	2.58	2.32	2.14	2.36	2.24	2.4	2.28	2.21	2.39
Near Vehicle	1.5	1.5	1.51	1.91	1.36	1.54	1.07	1.42	1.34	1.53	1.82	1.56	1.3	1.6	1.43	1.4	1.56
Other Outdoor	1.34	1.36	1.3	1	1.32	1.36	1.33	1.53	1.33	1.25	1.32	1.36	1.3	1.51	1.19	1.37	1.39
Office/Factory	1.61	1.59	1.65	0	0	1.63	1.13	1.56	1.67	1.56	1.71	1.61	1.56	1.92	1.35	1.59	1.55
Mall/Other Store	1.14	1.18	1.11	1	1	1.18	1.1	1.12	1.19	1.09	1.21	1.18	1.05	1.06	1.2	1.16	1.14
School/Public Bldg.	1.21	1.16	1.26	1	1.07	1.26	1.02	1.36	1.11	1.19	1.18	1.25	1.06	1.24	1.2	1.24	1.16
Bar/Restaurant	1.26	1.28	1.23	1.27	1.04	1.27	1.34	1.2	1.27	1.31	1.22	1.23	1.31	1.27	1.18	1.35	1.24
Other Indoor	1.31	1.3	1.34	1	1.05	1.38	1.05	1.29	1.38	1.37	1.16	1.34	1.24	1.32	1.26	1.49	1.21

Note: Subgroups are for gender, age, U.S. census region, day of week, and season. See Section 4 for a discussion of weighting

Table 6-10. The Weighted Number of NHAPS Respondents (Doer Sample Size N) in Each Location x Smoker-Present Microenvironment on the Diary Day by Each Subgroup

Doer Sample Size N	Overall	Males	Females	0-4	5-17	17-64	65+	Northwest	Midwest	South	West	WkDay	WkEnd	Winter	Spring	Sum	Fall
Residential -Indoors	2355.6	1091.3	1264.3	173.7	449.2	1549.8	182.9	507	609.7	887.3	351.7	1633.6	721.9	599.8	557.9	550	647.9
Residential -Outdoor	420.3	209.2	211	31.7	72.8	287.3	28.4	69.1	85.3	191.5	74.4	237.6	182.7	42.3	161.3	151.1	65.5
In Vehicle	1332.2	670.6	661.6	52	182.9	1019.1	78.1	261.8	354	538.5	177.9	925.7	406.5	312.6	318	330.3	371.3
Near Vehicle	416	263.2	152.8	8.6	66.3	329.3	11.8	117.9	101.4	124.1	72.6	326.3	89.7	97.7	84.2	110.4	123.7
Other Outdoor	332.4	205.7	126.7	10.8	63.5	239.9	18.2	59.7	88	111.9	72.8	202	130.4	33.2	101.6	129.3	68.3
Office/Factory	399	261	137.9	0	0	382.6	16.3	89.9	99.1	152.2	57.8	366.1	32.9	97.5	85.8	112.2	103.5
Mall/Other Store	266.9	120.9	146	7.8	42.4	195.6	21.1	47.4	69.1	107.5	42.9	182	84.9	64.3	69.6	54.7	78.4
School/Public Bldg.	234.1	111.1	123	0.6	37.9	180.6	14.9	58.6	58.7	79.2	37.6	184	49.6	74.9	61.6	39	58.6
Bar/Restaurant	917.2	481.5	435.7	20.3	71.7	738.2	87	171.8	277.7	286	181.7	595.2	322.1	220.1	222.4	219.6	255.2
Other Indoor	240	156	84	0.9	17.7	192.4	29	50.9	63.9	74.1	51.1	177.6	62.6	55.9	52.2	55.2	76.8

Note: Subgroups are for gender, age, U.S. census region, day of week, and season. See Section 4 for a discussion of weighting. The doer sample sizes are equal to the number of respondents entering each location on the diary day. The maximum number in each location is the weighted sample size (N = 9196).

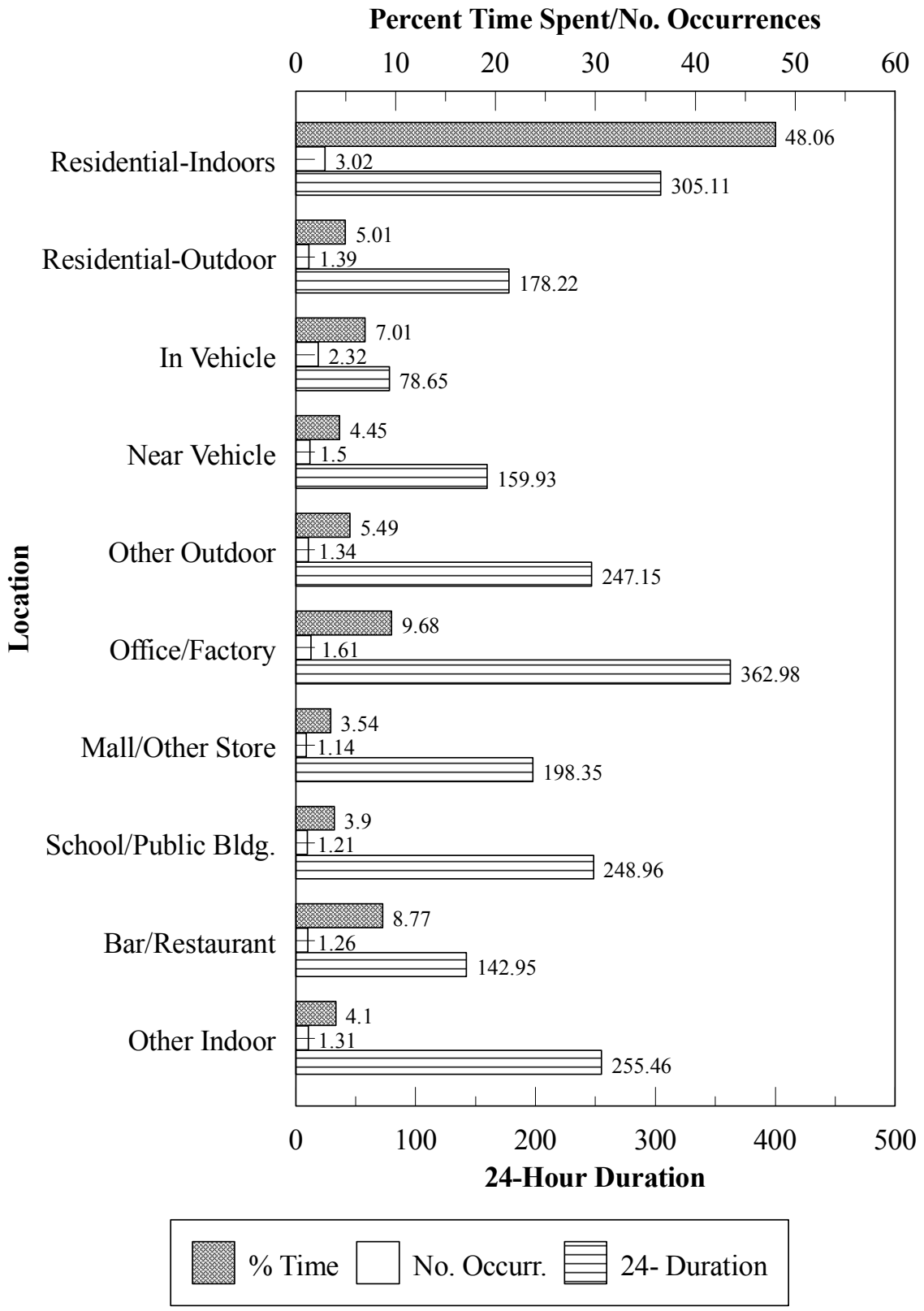


Figure 6-28. The overall weighted percentage of time spent, mean number of occurrences, and mean 24-hour cumulative durations (in minutes) of ETS exposure in each location.

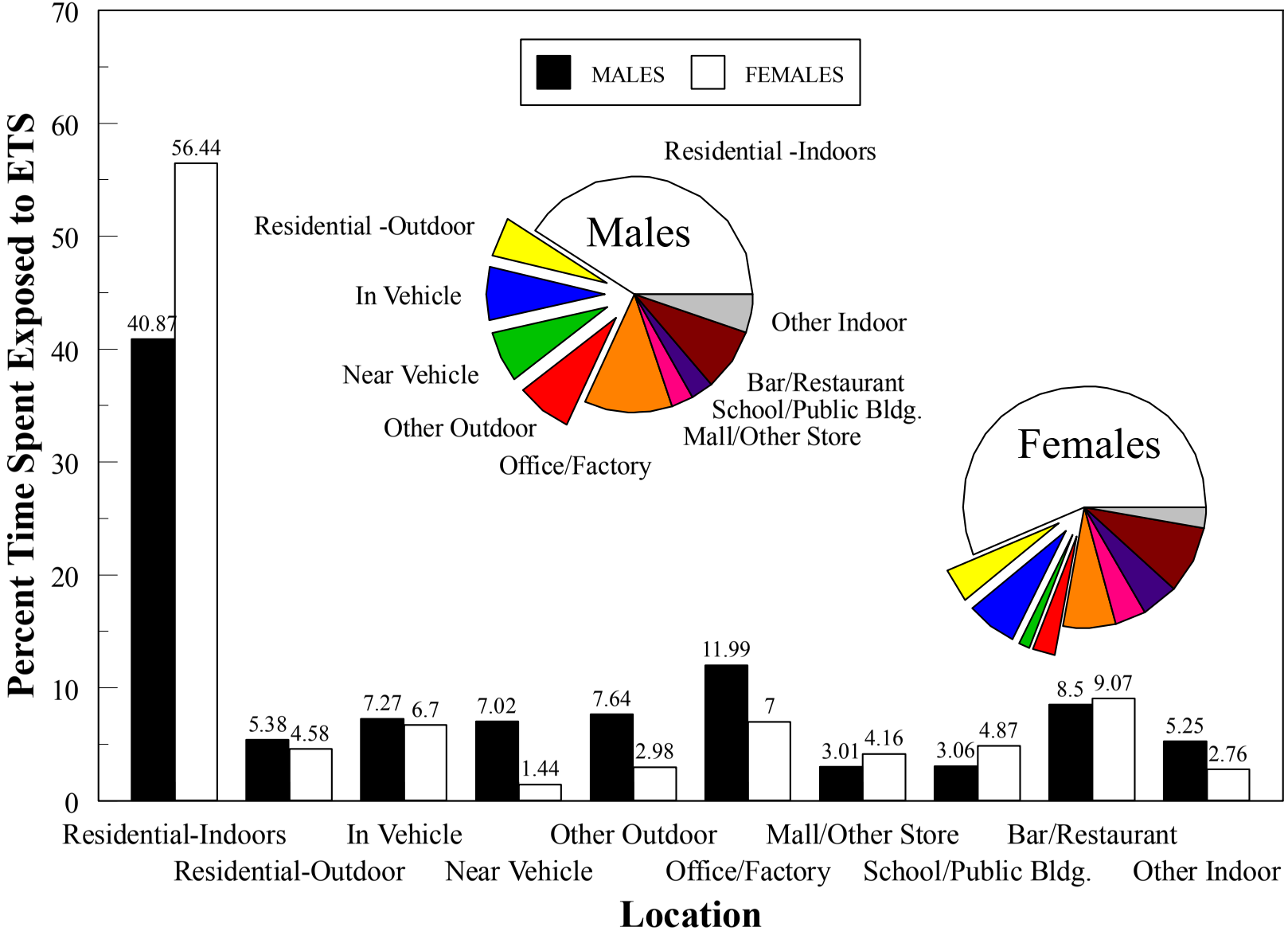


Figure 6-29. The weighted percentage of time spent exposed to ETS in each location for males vs. females. Only those exposed for at least one minute on the diary day were considered.

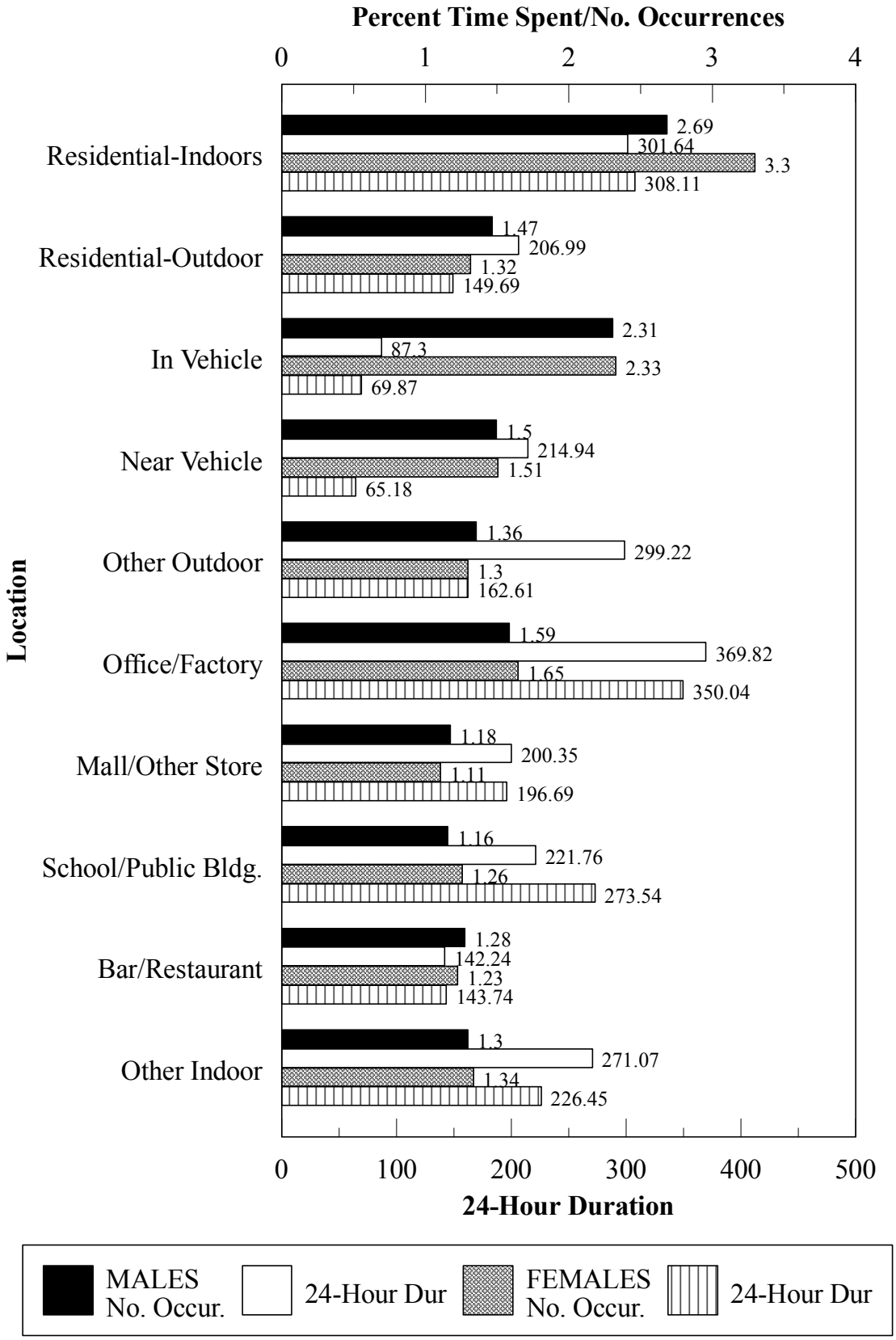


Figure 6-30. Weighted mean 24-hr number of occurrences and weighted mean 24-hr durations of ETS exposure in each location for males vs. females.

Females were exposed for a larger percentage of the time than males (Figure 6-29) in the Residential-Indoors (56% F, 41% M), Mall/Other Store (4% F, 3% M), and School/Public Bldg (5% F, 3% M) locations. But males had substantially larger percentages in the Near Vehicle (7% M, 1% F), Other Outdoor (8% M, 3% F), Office/Factory (12% M, 7% F), and Other Indoor (5% M, 3% F) locations. The percentages of time spent were about the same for males and females for the Residential-Outdoor (5%), In Vehicle (7%), and Bar/Restaurant (9%) locations. The largest differences in mean 24-hr durations of ETS exposure between males and females (Figure 6-30) occurred for the Other Outdoor (299 min M, 163 min F), Near Vehicle (215 min M, 65 min F), and Residential-Outdoor (207 min M, 150 min F). There were also differences for Other Indoor (271 min M, 227 min F) and School/Public Bldg (222 min M, 273 min F). Differences in 24-hr duration were within 20 min for all the other locations. The mean 24-hr number of occurrences of ETS exposure for each location were about the same for females and males (Figure 6-30).

The Very Young age group had the largest percentage of time exposed to ETS in the Residential-Indoor (82%) and Residential-Outdoor (9%) locations, while the Working age group had the least (41% and 4.5%, respectively) (Figure 6-31). The School Aged and Retired had nearly the same percentages for Residential-Indoors (63-67%). The Very Young had the least percentage of time exposed to ETS in the In Vehicle (4% vs. 6-7% for the other age groups), Near Vehicle (1%), Other Outdoor (1% vs. 5-6%), Office Factory (0%), Mall/Other Store (1% vs 2-4%), School/Public Bldg (0% vs. 2-5%), Bar Restaurant (2.5%), and Other Indoor (0.2%) locations. As expected, the Working and Retired age groups had the largest percentage of time for Office/Factory (12% and 6%, respectively) and Bar/Restaurant (8-10%). 24-hr durations of ETS exposure (Figure 6-32) were approximately the same for the Very Young and the Retired in the Residential-Indoor location (365-381 min vs. 257-303 for School and Working), whereas the Very Young had the longest 24-hr durations in the Residential-Outdoors location (222 min vs. 166-177 min for the others). Durations were substantially larger for the

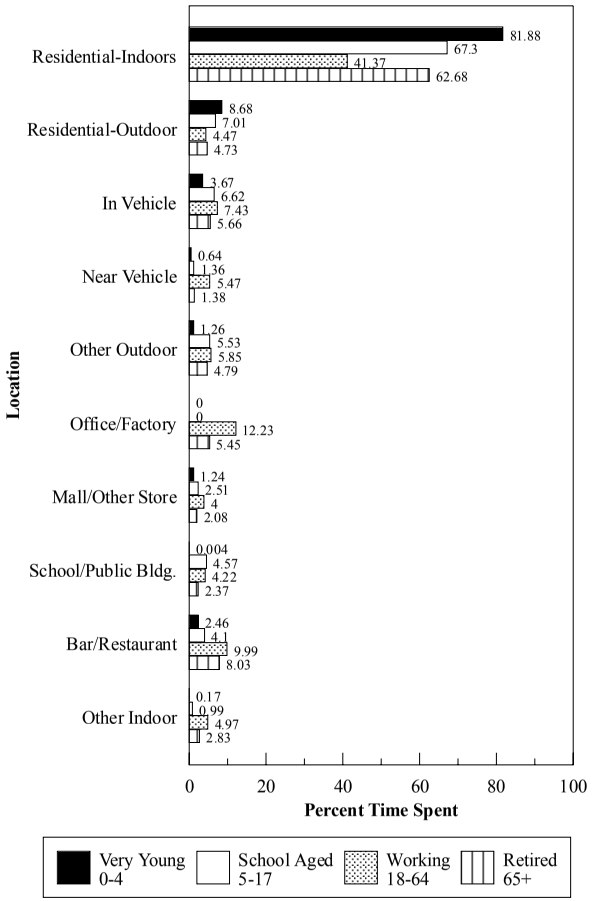


Figure 6-31. The weighted percentage of time spent exposed to ETS in each location by age group.

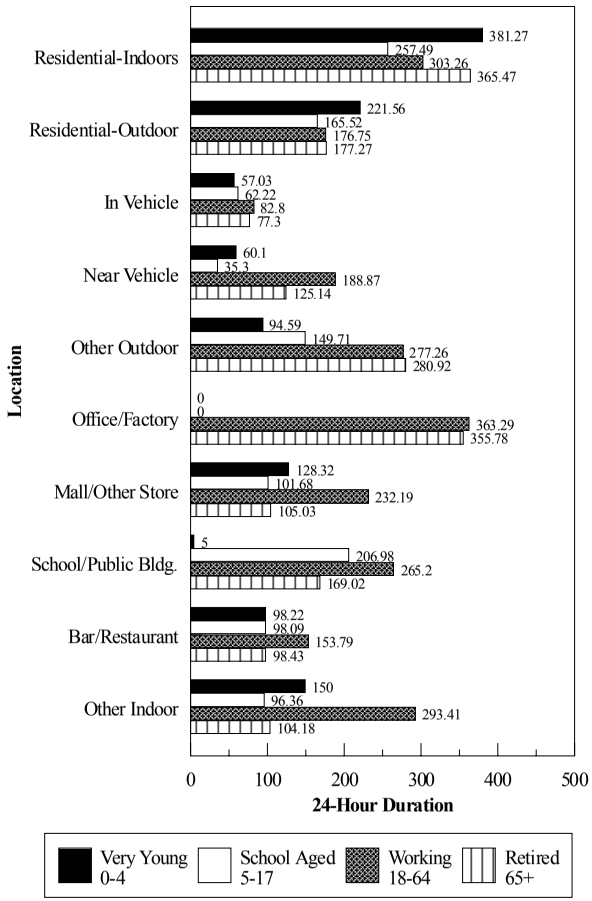


Figure 6-32. The weighted mean 24-hour duration of ETS episodes in each location by age group.

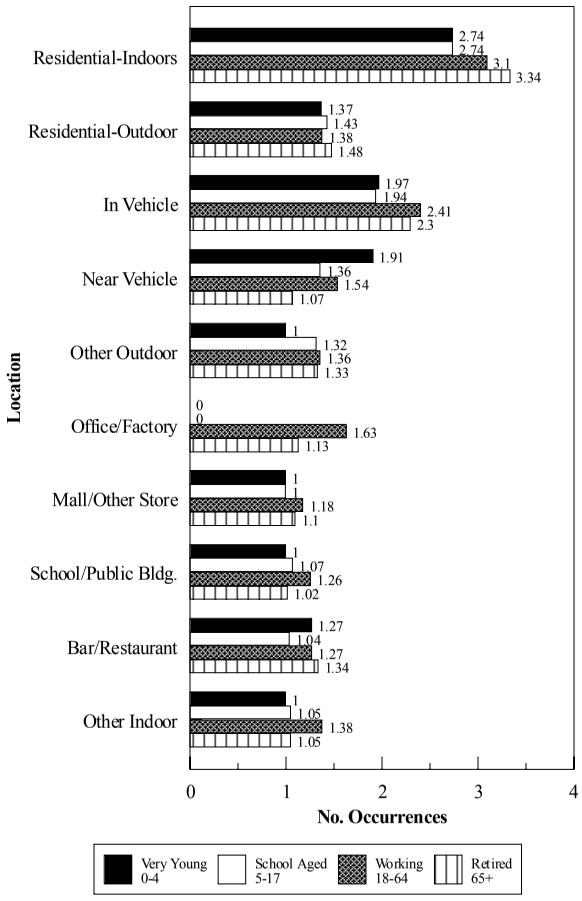


Figure 6-33. The weighted mean 24-hour number of occurrences of ETS exposure in each location by age group.

Working/Retired than the Very Young/School Aged in the Near Vehicle (125-189 min vs. 35-60 min for Very Young/School Aged), Other Outdoor (277-281 min vs. 94-150 min), and Office/Factory (356-363 min vs. 0 min) locations. The Working had the longest exposures in the Mall/Other Store (232 min vs. 101-128 for the others), Bar/Restaurant (154 min vs. 98 min for the others), and Other Indoor (293 min vs. 96-150 min for the others) locations. The duration of exposures in the School/Public Bldg locations were small for the Very Young (5 min) with the other age groups being fairly closely spaced (169-265 min). Most of the 24-hr mean number of occurrences of exposure to ETS (Figure 6-33) were closely spaced for each age group. However, the Working/Retired had a slightly higher mean number of occurrences in the Residential-Indoors (3.1-3.3 vs. 2.7 for the Very Young/School Aged) and In Vehicle (2.3-2.4 vs. 1.94-1.97) locations, the Very Young had the highest number of occurrences in the Near Vehicle location (1.9 vs. 1-1.5 for the others), and, as expected, the Working had the highest number of occurrences in the Office/Factory location (1.6 vs. 1.1 for Retired and 0 for Very Young/School Aged).

The percentage time spent being exposed to ETS for the Residential-Indoors locations is smallest for the West (45%) with the others regions having approximately the same percentage (49%) (Figure 6-34). The West also has the lowest percentage for the In Vehicle (5% vs. 6-8% for the other regions) and Office/Factory (8% vs. 10-11% for the other regions) locations. The Midwest and West have the largest percentage of time exposed to ETS in the Bar/Restaurant location (10-11% vs. 7-8% for the Northeast/South), and the Northeast had the largest percentage in the School/Public Bldg location (6% vs. 3-4% for the other regions). The mean 24-hr durations of ETS exposure in the Near Vehicle location was substantially larger for the South and West (212-237 min) than for the Northeast and Midwest (99 min) (Figure 6-35). The West had the smallest durations for the Residential-Outdoor, Other Outdoor, Office-Factory, and Other Indoor locations, but the largest durations in the Mall/Other Store location. The Northeast had the largest durations in the Other Outdoor and School/Public Bldg locations. The mean 24-hr number of occurrences were very closely clustered across all regions (Figure 6-36).

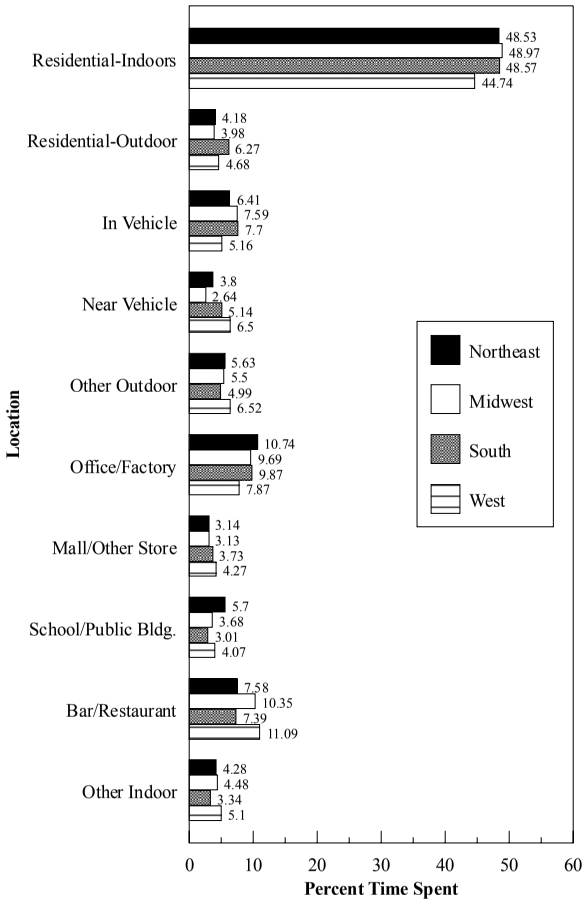


Figure 6-34. The weighted percentage of time spent exposed to ETS in each location by census region.

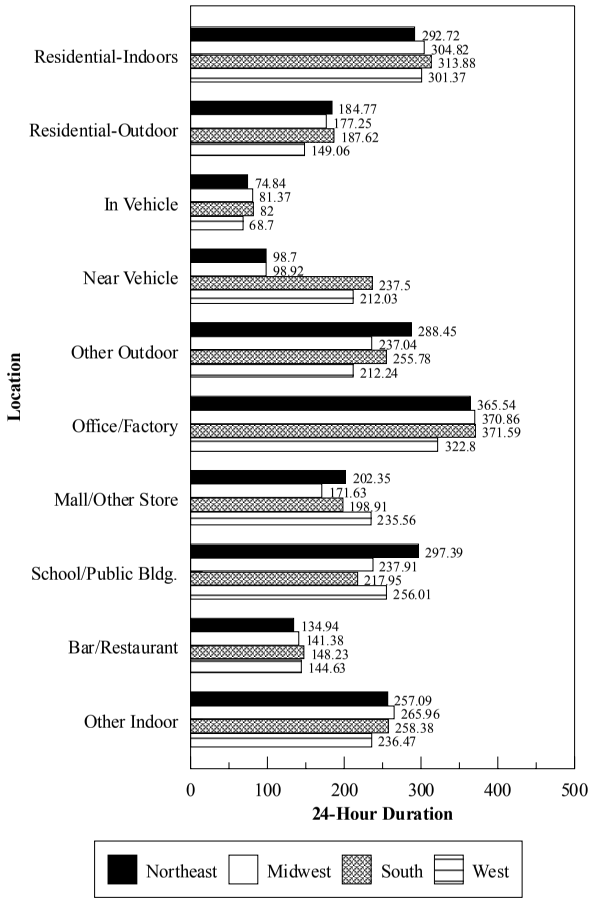


Figure 6-35. The weighted mean 24-hour duration of ETS episodes in each location by census region.

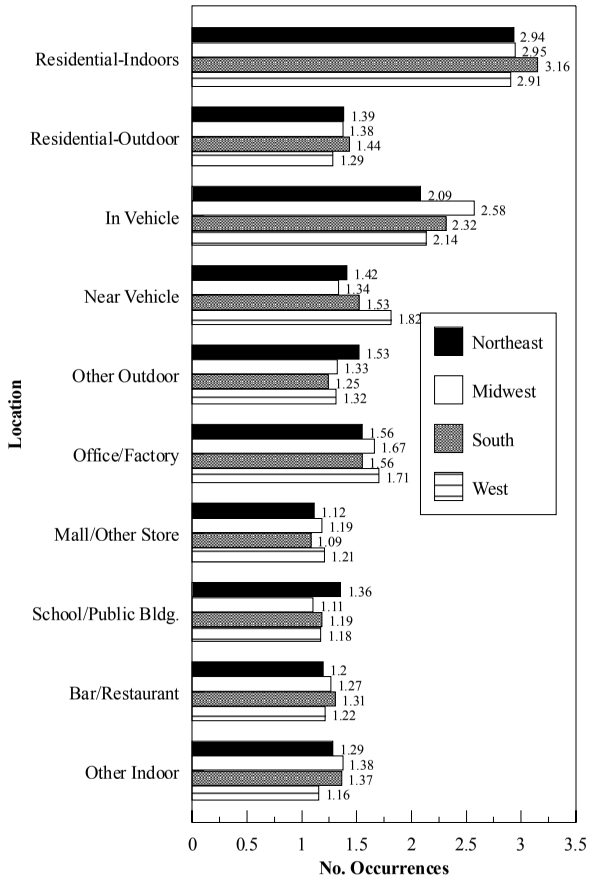


Figure 6-36. The weighted mean 24-hour number of occurrences of ETS exposure in each location by census.

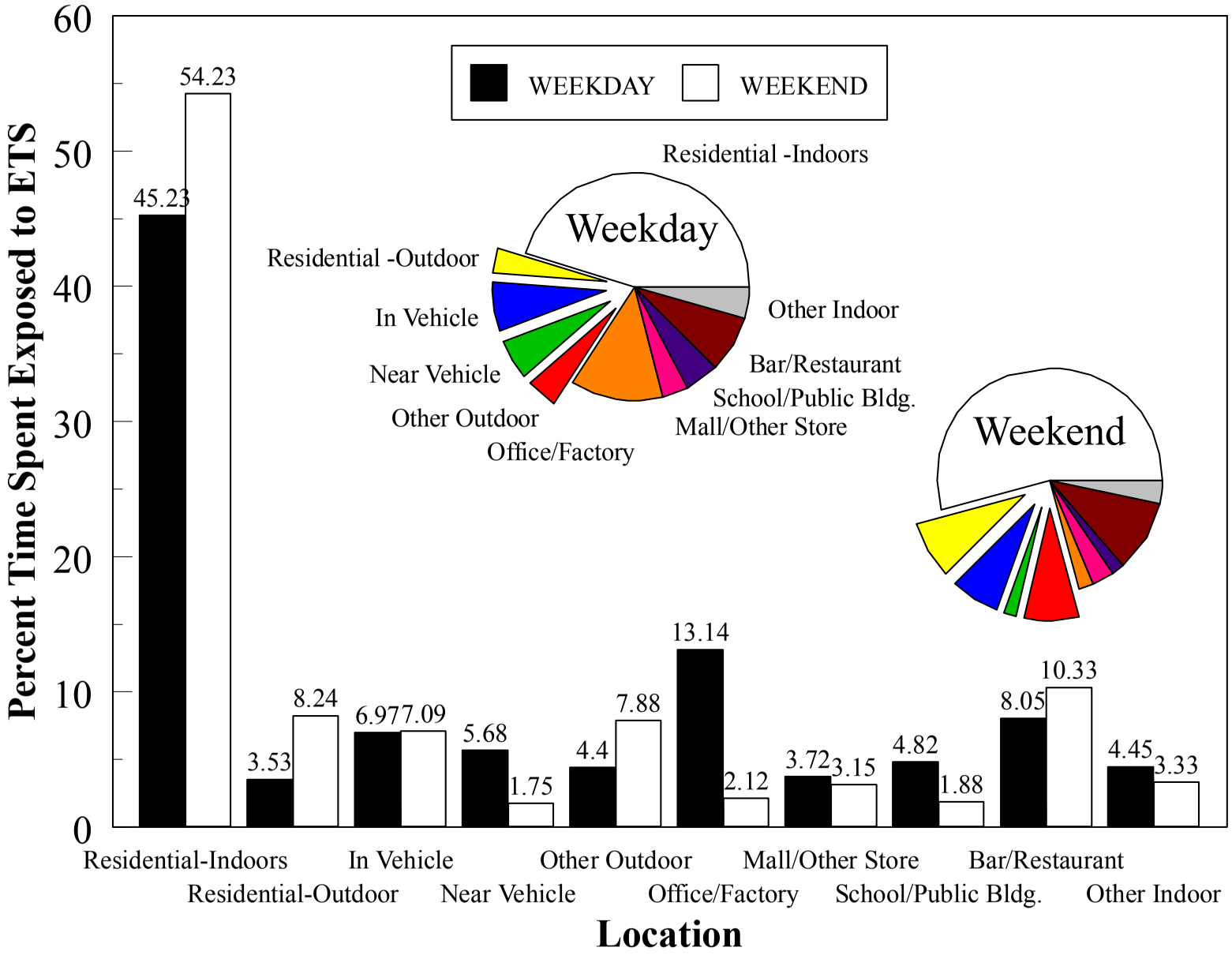


Figure 6-37. The weighted percentage of time spent exposed to ETS in each location by weekend vs. weekday.

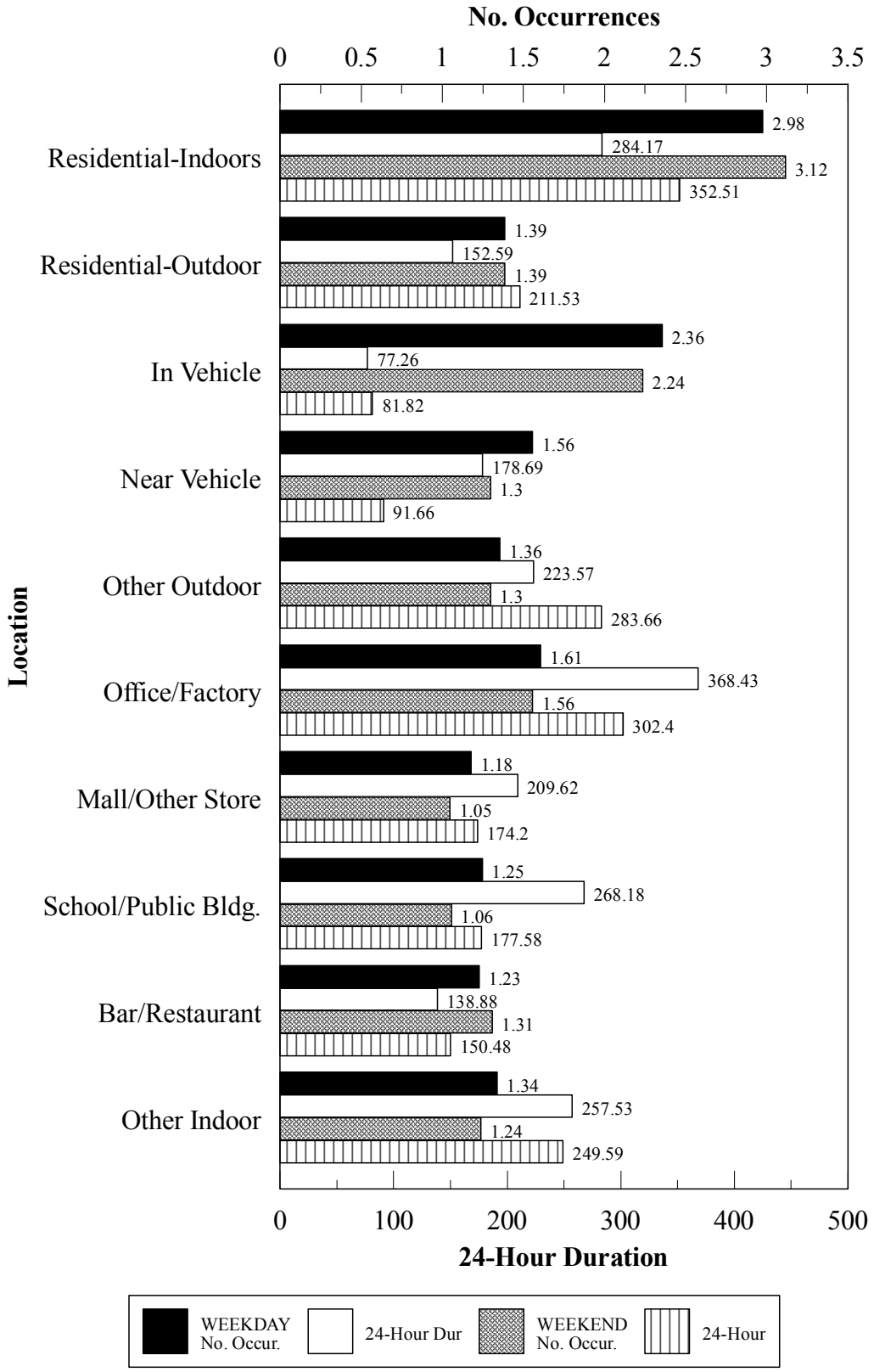


Figure 6-38. Weighted mean 24-hr number of occurrences and weighted mean 24-hr durations of ETS exposure in each location for weekends vs. weekdays.

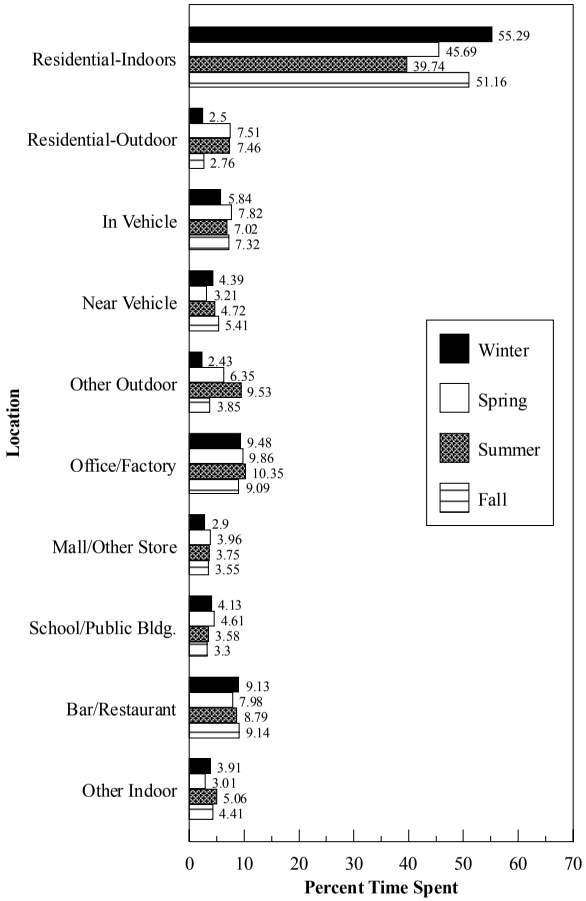


Figure 6-39. The weighted percentage of time spent exposed to ETS in each location by season.

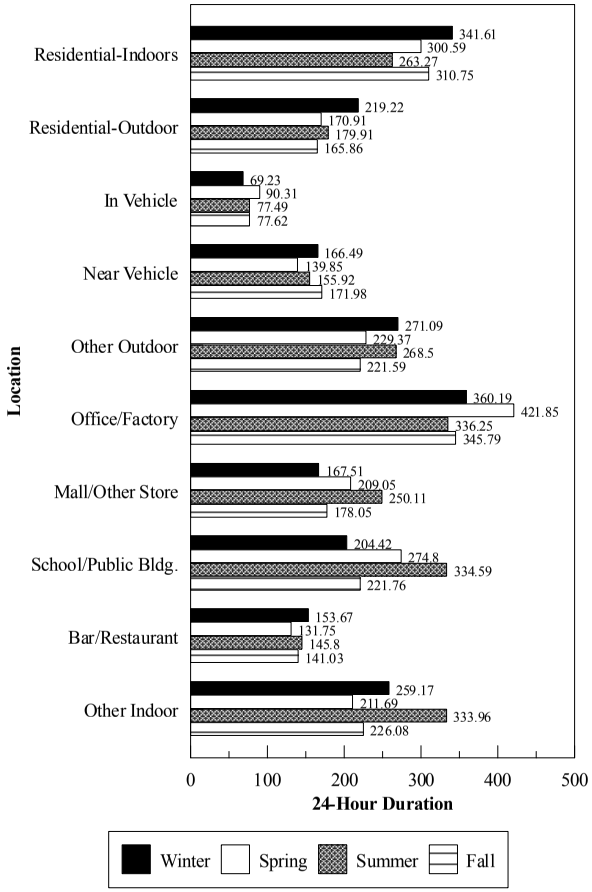


Figure 6-40. The weighted mean 24-hour duration of ETS episodes in each location by season.

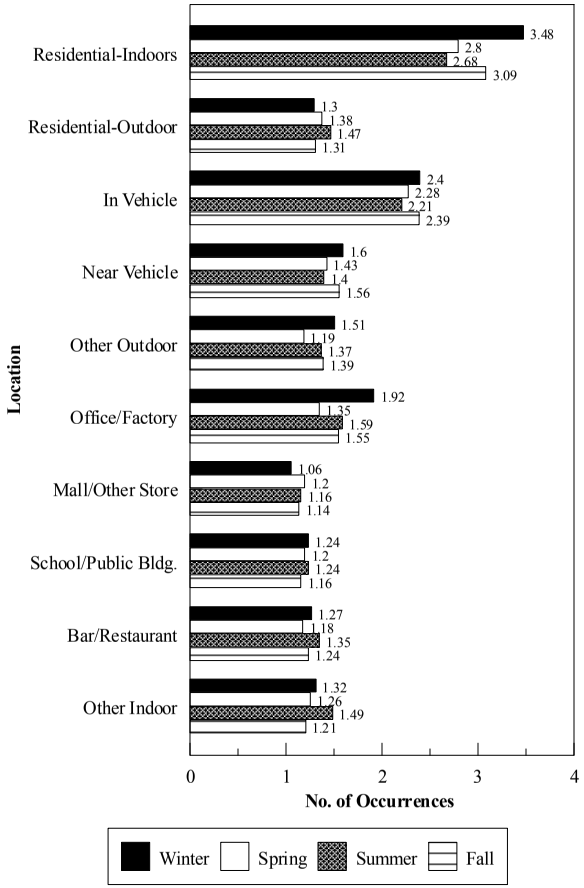


Figure 6-41. The weighted mean 24-hour number of occurrences of ETS exposure in each location by season.

The percentage of time exposed to ETS and exposure durations were substantially larger on weekdays than on weekends (Figure 6-37 and 6-38) for the Office/Factory (13%, 268 min vs. 2%, 302 min), School/Public Bldg (5%, 368 min vs 2%, 178 min), and Near Vehicle (6%. 179 min vs. 2%, 92 min) locations, whereas the percentages and durations were larger on weekends for the Residential-Indoors (54%, 352 min vs 45%, 284 min), Residential-Outdoors (8%, 212 min vs. 3.5%, 153 min), Other Outdoor (8%, 284 min vs. 4%, 224 min), and Bar/Restaurant (10%, 150 min vs. 8%, 139 min) locations. The number of occurrences of ETS exposure on weekends and weekdays were about the same for each location (Figure 6-38).

The Spring/Summer seasons have lower percentages of time spent exposed to ETS than Winter/Fall in the Residential-Indoors location (40-46% vs. 51-55%), whereas Spring/Summer have higher percentages than Winter/Fall in the Residential-Outdoor (7.5% vs. 3%) and Other Outdoor (6-10% vs. 2-4%) locations (Figure 6-39). Other locations do not have percentages of exposure to ETS that are very different across the seasons. Winter has the largest mean 24-hr duration of exposure to ETS (Figure 6-40) in the Residential-Indoors location (341 min), while summer has the smallest duration (263 min). Winter also has the largest duration in the Residential-Outdoor location (219 min vs. 166-180 for the other seasons), and the largest mean number of occurrences of ETS exposure (Figure 6-41) for the Residential-Indoors (3.5) and Office/Factory (1.9) locations.

6.5 Locations x Activities

Only the 21 location x activity microenvironments that had more than 100 occurrences over all the respondents' diary days were analyzed. Of the total time spent by all the weighted respondents on the diary days (9,196 x 1440 min = 13,242,240 min), the location x exposure activity microenvironment with the largest percentage of time (Figure 6-42 and Table 6-11) is Eating/Drinking-Residential-Indoors (3.4%) -- ignoring the time spent in the No Exposure category (Sleeping, Watching TV, Reading, etc.) which accounts for approximately 87% of the total time. The next largest percentages are for Housekeeping-Residential-Indoors (1.50%), Food Preparation-Residential-Indoors (1.49%), Bathing/Hygiene-Residential-Indoor (1.15%), Yardwork/Maintenance-Residential-Outdoor (1.08%), Eating/Drinking-Bar/Restaurant (0.87%), Dishes/Laundry/Clean Kitchen-Residential-Indoor (0.74%), Sports/Exercise-Other Outdoor (0.6%), and Sports/Exercise-Residential Outdoor (0.47%). The respondents spent 0.29% or less in each of the remaining microenvironments.

The location x activity microenvironments that had the largest percentage of **people** experiencing them at least once on the diary day were Residential-Indoor-Eating-Drinking (84%), Residential-Indoor-Bathing (67%), and Residential-Indoor-Food Preparation (41%) (Figure 6-43 and Table 6-12). Notice that while more people were Bathing than Preparing Food, the overall percentage of time spent was not as great.

The location x activity microenvironment with the largest mean 24-hr duration (Figure 6-44 and Table 6-13) is Yardwork/Maintenance-Residential-Outdoor (152 min), followed closely by Yardwork/Maintenance-Residential-Indoor (149 min), and Sports/Exercise-Other Outdoor (146 min). The four next largest durations were for Sports/Exercise-Residential-Outdoor (113 min), Housekeeping/Residential-Outdoor (113 min), Sports/Exercise-Other Indoor (112 min), and Housekeeping-Residential-Outdoor (108 min). The microenvironment with the smallest duration was Bathing-Residential-Indoor (25 min). The remaining microenvironments had 24-hr durations that were

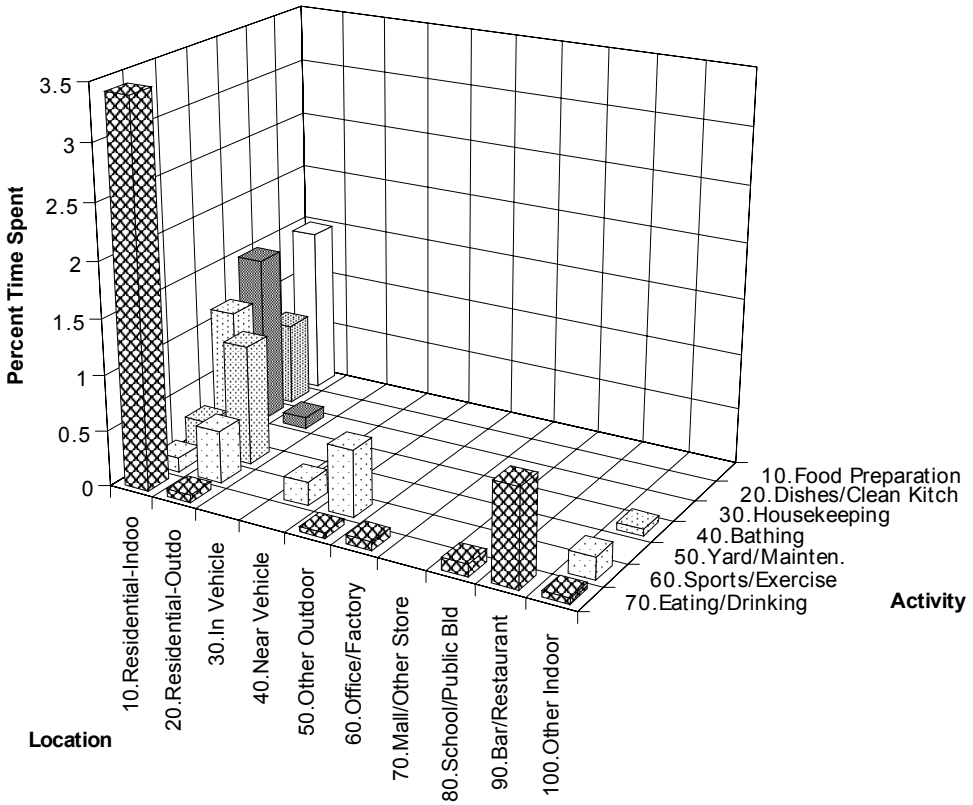


Figure 6-42. 3-D plot of the overall weighted percentage of time spent in 21 out of 70 location x activity microenvironments. The missing microenvironments had less than 100 occurrences over the diary days of all the respondents.

Table 6-11. The Overall Weighted Percentage of Time Spent in 21 Location x Activity Microenvironments

	Activity Location	10. Food Preparation	20. Dishes/ Clean Kitch	30. Housekeeping	40. Bathing	50. Yard/ Mainten.	60. Sports/ Exercise	70. Eating/ Drinking
10.	Residential-Indoor	1.49	0.74	1.5	1.15	0.29	0.13	3.42
20.	Residential-Outdoor			0.1		1.08	0.47	0.07
30.	In Vehicle							
40.	Near Vehicle					0.04	0.21	
50.	Other Outdoor						0.6	0.05
60.	Office/Factory							0.08
70.	Mall/Other Store							
80.	School/Public Bldg.							0.11
90.	Bar/Restaurant							0.87
100.	Other Indoor				0.06		0.2	0.05

Note: The missing percentages were for the 49 microenvironments with less than 100 occurrences overall..

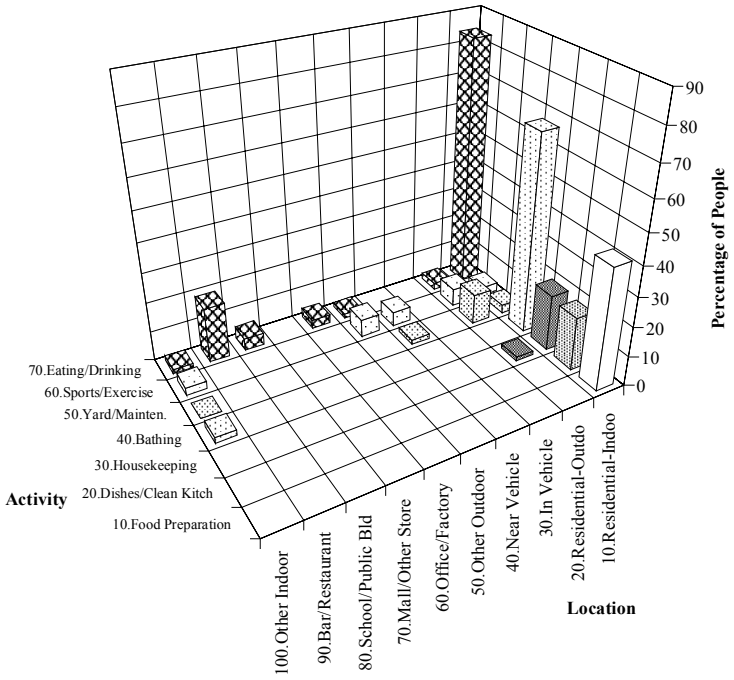


Figure 6-43. 3-D plot of the overall weighted (N = 9,196) percentage of doers (people experiencing a microenvironment on the diary day) in 21 out of 70 location x activity microenvironments. The missing 49 microenvironments had less than 100 occurrences over the diary days of all the respondents.

Table 6-12. The Overall Weighted Percentage of People Doing (the Doers) Each of 21 Location x Activity Microenvironments on the Diary Day

	Activity **Location**	10. Food Preparation	20. Dishes/ Clean Kitch	30. Housekeeping	40. Bathing	50. Yard/ Mainten.	60. Sports/ Exercise	70. Eating/ Drinking
10	Residential-Indoor	41.24	18.07	19.06	66.91	2.82	3.21	83.89
20	Residential-Outdoor			1.34		10.23	5.94	2.23
30	In Vehicle							
40	Near Vehicle					1.57	4.81	
50	Other Outdoor						5.93	1.62
60	Office/Factory							3.10
70	Mall/Other Store							
80	School/Public Bldg.							4.10
90	Bar/Restaurant							18.70
100	Other Indoor				1.91		2.63	1.47

Note: The missing percentages were for the 49 microenvironments with less than 100 occurrences overall.

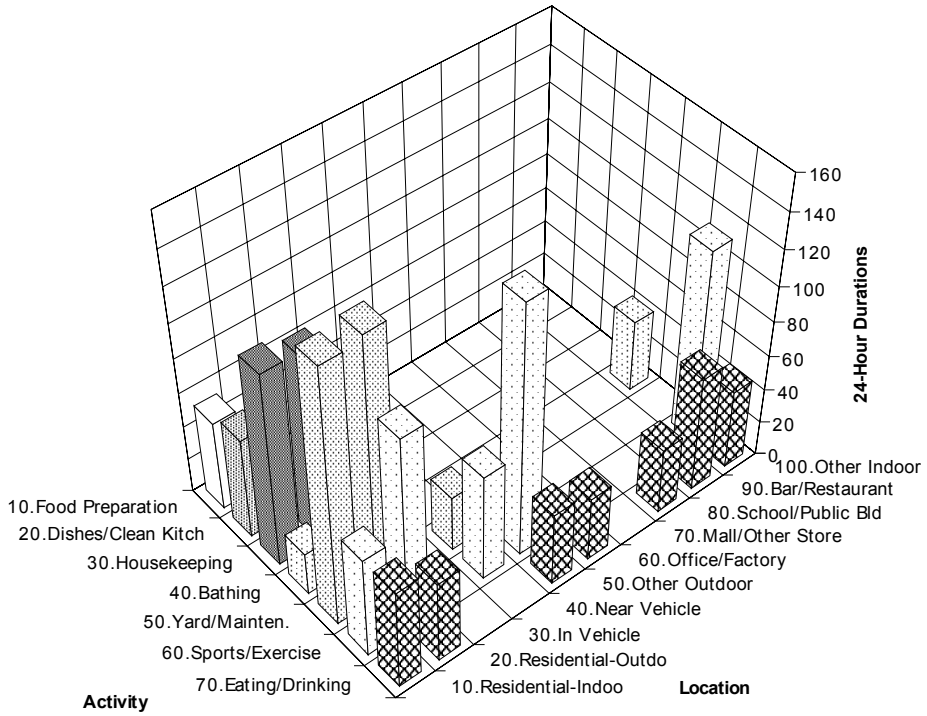


Figure 6-44. 3-D plot of the overall weighted mean 24-hour duration in 21 out of 70 location x activity microenvironments. The missing 49 microenvironments had less than 100 occurrences over the diary days of all the respondents.

Table 6-13. The Overall Weighted Mean 24-Hr Duration in 21 Location x Activity Microenvironments

	Activity **Location**	10. Food Preparation	20. Dishes/ Clean Kitch	30. Housekeeping	40. Bathing	50. Yard/ Mainten.	60. Sports/ Exercise	70. Eating/ Drinking
10	Residential-Indoor	52.19	58.84	112.96	24.82	149.06	58.86	58.71
20	Residential-Outdoor			108.07		151.92	113.44	47.67
30	In Vehicle							
40	Near Vehicle					32.59	62.4	
50	Other Outdoor						145.69	42.5
60	Office/Factory							37.51
70	Mall/Other Store							
80	School/Public Bldg.							38.1
90	Bar/Restaurant							66.96
100	Other Indoor				41.65		111.91	45.77

Note: The missing percentages were for the 49 microenvironments with less than 100 occurrences overall.

all between 30 and 70 min. Although more people experienced Bathing-Residential-Indoor on the diary day than any other microenvironment except Eating/Drinking-Residential-Indoor, since its duration is so small, its overall percentage of time spent is only the fourth largest.

The location x activity microenvironment with the largest mean 24-hr number of occurrences (Figure 6-45 and Table 6-14) for all respondents over the 24-hr diary day was Eating/Drinking-Residential-Indoor (1.9). The other two microenvironments with mean number of occurrences of 1.5 or greater were Food Preparation-Other Indoor (1.6) and Dishes/Laundry/Clean Kitch-Residential-Indoor (1.5). The microenvironments with mean durations between 1.2 and 1.3 were Housekeeping-Residential-Indoor, Bathing-Residential-Indoor, Yardwork/Maintenance-Residential-Indoor, Housekeeping-Residential-Outdoor, Yardwork/Maintenance-Residential-Outdoor, Sports/Exercise-Residential-Outdoor, Sports/Exercise-Other Outdoor, and Eating/Drinking-Bar/Restaurant. The remaining ten microenvironments had mean number of occurrences between 1 and 1.2.

The largest overall percentages of time spent in the Residential-Indoor-Eat/Drink microenvironment were for females respondents (7%), respondents aged 0-4 (6%), and respondents aged 65 and over (5%) (Figure 6-46 and Table 6-15). The percentages of time spent for the other subgroups (males, ages 5-7, ages 18-64, seasons, Census regions, and weekend vs. weekday) ranged between 2.9 and 4%. Of the nine selected microenvironments with the largest percentages of time spent, female respondents and respondents aged 65 and over had the largest percentages of time spent in the Housekeeping-Residential-Indoor (2.4-2.8% vs. 0.4 to 1.8 for the other subgroups), Dishes/Laundry-Residential-Indoor (1.3% vs. 0 to 0.9%), and Residential-Outdoor-Yardwork/Maintenance microenvironments (2.1% vs. 0.1 to 1.6%). Female respondents had the highest percentage of time spent in the Bar/Restaurant-Eating/Drinking (1.7% vs. 0.5 to 1.1% for the other subgroups) and Residential-Indoor-Bathing (2.2% vs. 1 to 1.4%) microenvironments.

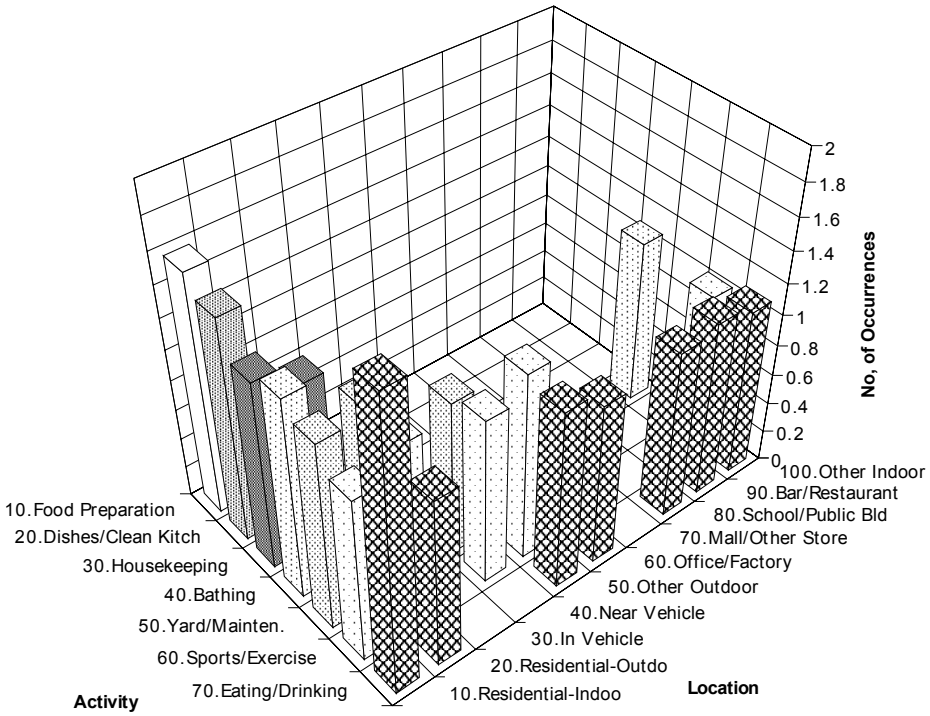


Figure 6-45. 3-D plot of the overall weighted mean 24-hour number of occurrences in 21 out of 70 location x activity microenvironments. The missing 49 microenvironments had less than 100 occurrences over the diary days of all the respondents.

Table 6-14. The Overall Weighted Mean 24-hr No. of Occurrences in 21 Location x Activity Microenvironments

	Activity	10. Food	20. Dishes/	30. Housekeeping	40. Bathing	50. Yard/	60. Sports/	70. Eating/
	Location	Preparation	Clean Kitch			Mainten.	Exercise	Drinking
10	Residential-Indoor	1.57	1.46	1.24	1.32	1.23	1.08	1.89
20	Residential-Outdo			1.08		1.3	1.24	1.11
30	In Vehicle							
40	Near Vehicle					1.02	1.09	
50	Other Outdoor						1.23	1.17
60	Office/Factory							1.06
70	Mall/Other Store							
80	School/Public Bldg.							1.1
90	Bar/Restaurant							1.15
100	Other Indoor				1.08		1.03	1.09

Note: The missing percentages were for the 49 microenvironments with less than 100 occurrences overall.

Table 6-15. The Percentage of Time Spent in Nine Selected Location x Exposure Activity Microenvironments Across Each Subgroup

Location x Activity	Males	Females	0-4	5-17	18-64	65+	Northeast	Midwest	South	West	Weekday	Weekend	Winter	Spring	Summer	Fall
Res.Ind.-Food.Prep.	0.66	0.33	0.14	0.22	1.84	2.40	1.50	1.48	1.48	1.57	1.53	1.43	1.52	1.56	1.40	1.52
Res.Ind.-Dishes	0.18	1.27	0.00	0.11	0.89	1.28	0.80	0.70	0.71	0.74	0.73	0.77	0.80	0.72	0.72	0.68
Res.Ind.-Housekeep.	0.53	2.40	0.14	0.38	1.71	2.80	1.60	1.39	1.45	1.57	1.43	1.68	1.36	1.40	1.48	1.76
Res.Ind.-Bathing	1.09	2.24	1.35	1.10	1.18	0.96	1.15	1.07	1.25	1.13	1.15	1.15	1.24	1.28	1.08	1.04
Res.Ind.-Eat/Drink	3.47	6.67	5.69	3.13	2.92	4.88	3.69	3.40	3.27	3.44	3.30	3.71	3.60	3.36	3.44	3.33
Res.Out.-Yard.Main.	1.54	2.11	0.14	0.27	1.23	2.08	0.95	0.90	1.14	1.37	0.94	1.43	0.52	1.60	1.28	0.88
Res.Out.-Sports/Exer.	0.60	0.35	0.95	1.54	0.16	0.08	0.45	0.29	0.62	0.44	0.38	0.70	0.28	0.64	0.64	0.32
Other.Out.-Sports/Exer.	0.80	0.41	0.27	1.15	0.52	0.40	0.85	0.45	0.51	0.69	0.53	0.77	0.36	0.72	0.92	0.40
Bar/Rest.-Eat/Drink	0.88	1.70	0.54	0.49	1.03	0.88	0.75	1.07	0.77	0.93	0.77	1.08	0.84	0.88	0.84	0.92

Note: The percentage of time spent is over the time spent in all 70 possible location x activity microenvironments. Results are over all respondents (doers + non-doers).

Table 6-16. The 24-Hour Duration (Minutes) of Nine Selected Location x Exposure Activity Microenvironments (the Doers) Across Each Subgroup

Location x Activity	Males	Females	0-4	5-17	18-64	65+	Northeast	Midwest	South	West	Weekday	Weekend	Winter	Spring	Summer	Fall
Res.Ind.-Food.Prep.	34.91	60.47	53.94	20.13	52.71	61.6	51.32	49.98	54.34	52.25	51.46	54.24	50.17	56.27	50.03	52.48
Res.Ind.-Dishes	41.92	62.28	27.47	28.38	59.87	64.24	56.46	58.74	60.99	58.15	56.94	63.82	60.96	62.38	59.48	52.86
Res.Ind.-Housekeep.	101.63	115.67	65.4	60.82	117.22	124.79	108.18	114.44	115.24	112.89	106.05	131.29	111.24	113.78	108.44	117.82
Res.Ind.-Bathing	23.58	25.98	30.13	23.78	24.17	27.09	24.13	23.3	26.04	25.08	24.24	26.36	26.18	26.83	23.11	22.99
Res.Ind.-Eat/Drink	59.32	58.12	84.49	50.83	53.26	77.15	61.16	59.45	56.19	59.69	56.33	64.81	59.73	58.64	59.1	57.32
Res.Out.-Yard.Main.	169.67	122.69	100.13	110.7	155.53	154.73	141.07	147.92	163.75	147.47	145.37	163.81	133.09	159.75	139.19	174.63
Res.Out.-Sports/Exer.	123.08	100.96	119.38	125.73	93.71	62.63	114.44	102.54	117.44	112.97	105.33	127.1	103.19	120.56	128.3	89.82
Other.Out.-Sports/Exer.	152.14	134.98	122.48	128.55	158.4	167.65	168.02	129.7	133.63	153.67	131.73	179.23	155.79	139.24	151.14	137.23
Bar/Rest.-Eat/Drink	63.75	70.41	58.91	50.01	69.98	71.16	69.13	68.91	62.82	68.95	64.17	72.5	69.48	63.98	66.07	68.62

.Note: 24-hour durations were calculated for the doers only.

Table 6-16b. The Weighted Doer Sample Sizes of Nine Selected Location x Exposure Activity Microenvironments Across Each Subgroup

Location x Activity	males	females	0-4	5-17	18-64	65+	Northeast	Midwest	South	West	Weekday	Weekend	Winter	Spring	Summer	Fall
Res.Ind.-Food.Prep.	1229	2563	24.6	240.3	2871.7	655.3	765.9	950.5	1264.1	811.4	2801.8	990.1	990.8	911.7	930.9	958.5
Res.Ind.-Dishes	281.1	1380.6	12.4	88.5	1223.5	337.2	377.6	391.2	543.4	349.5	1203.2	458.5	439	383.5	411	428.2
Res.Ind.-Housekeep.	339	1413.7	24.2	159.5	1202.9	366.2	397.5	395	585.5	374.8	1273.2	479.6	406.2	407.1	448.5	491
Res.Ind.-Bathing	2978.9	3173.9	457.8	1095.5	4023.5	575.9	1235.1	1453.6	2244.1	1220.1	4478.7	1674.1	1592	1558.6	1527.6	1474.6
Res.Ind.-Eat/Drink	3772.2	3942.4	655.5	1492.9	4512.3	1053.9	1603	1844.2	2712.3	1555.2	5549.6	2165	1989.8	1895	1922.1	1907.7
Res.Out.-Yard.Main.	585.1	355.5	11.1	58.1	646.5	224.8	177.8	192.9	321.3	248.6	606.7	333.8	133.8	334.6	305.5	166.7
Res.Out.-Sports/Exer.	308.4	238.2	82	295.2	144.3	25	108.5	94.7	242.5	100.9	343.1	203.5	91.3	179.1	160.7	115.5
Other.Out.-Sports/Exer.	340.4	205.3	18.6	221.5	269	36.7	132	108.8	181.8	123	385.4	160.3	78.3	170.8	202.7	94
Bar/Rest.-Eat/Drink	892.3	826.9	80.8	227.7	1202	208.7	288.1	497.1	564.4	369.6	1144.4	574.9	402.7	463.9	412.7	440

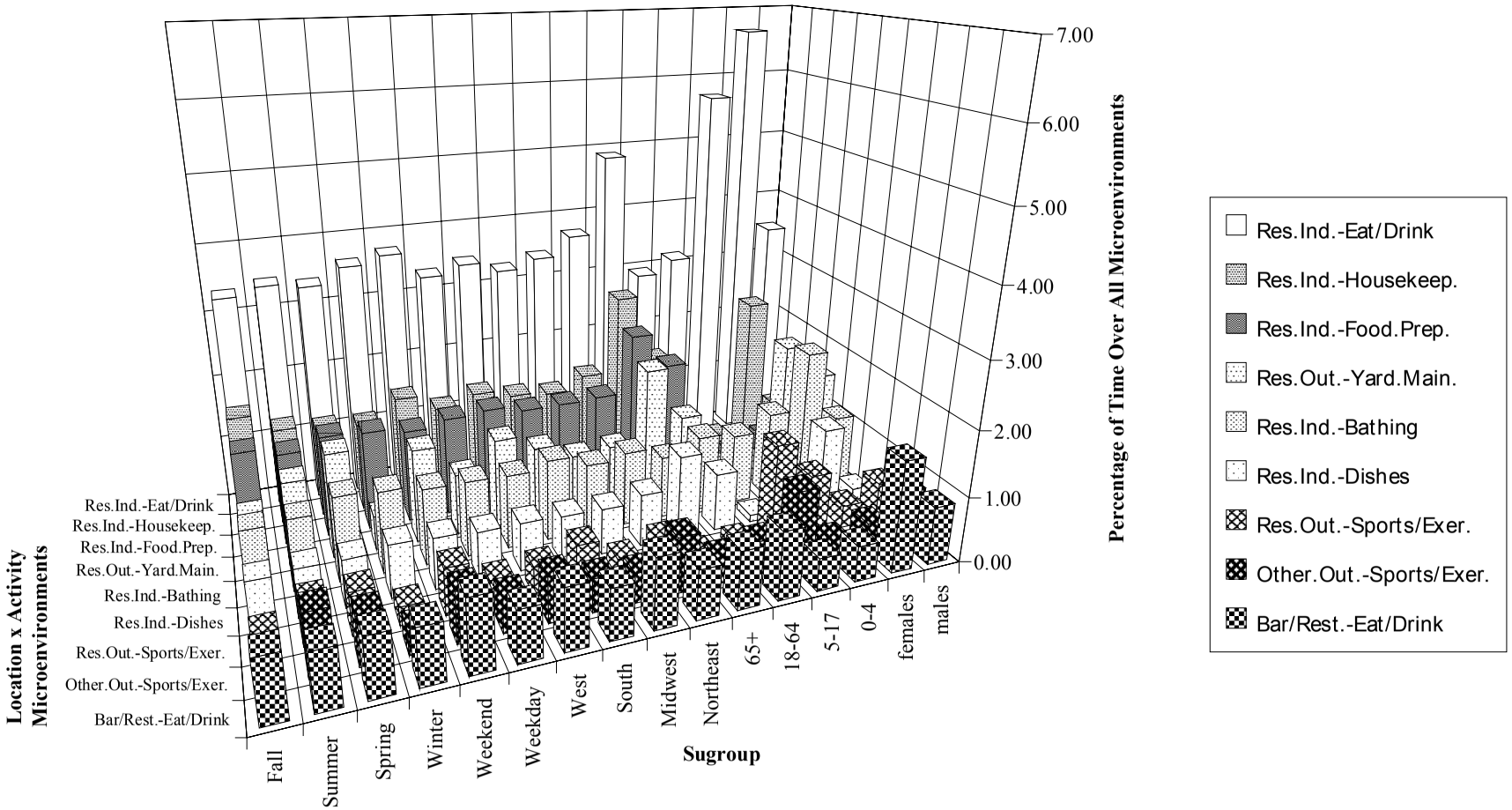


Figure 6-46. 3-D plot of the overall percentage of time spent in nine location x activity microenvironments across each subgroup.

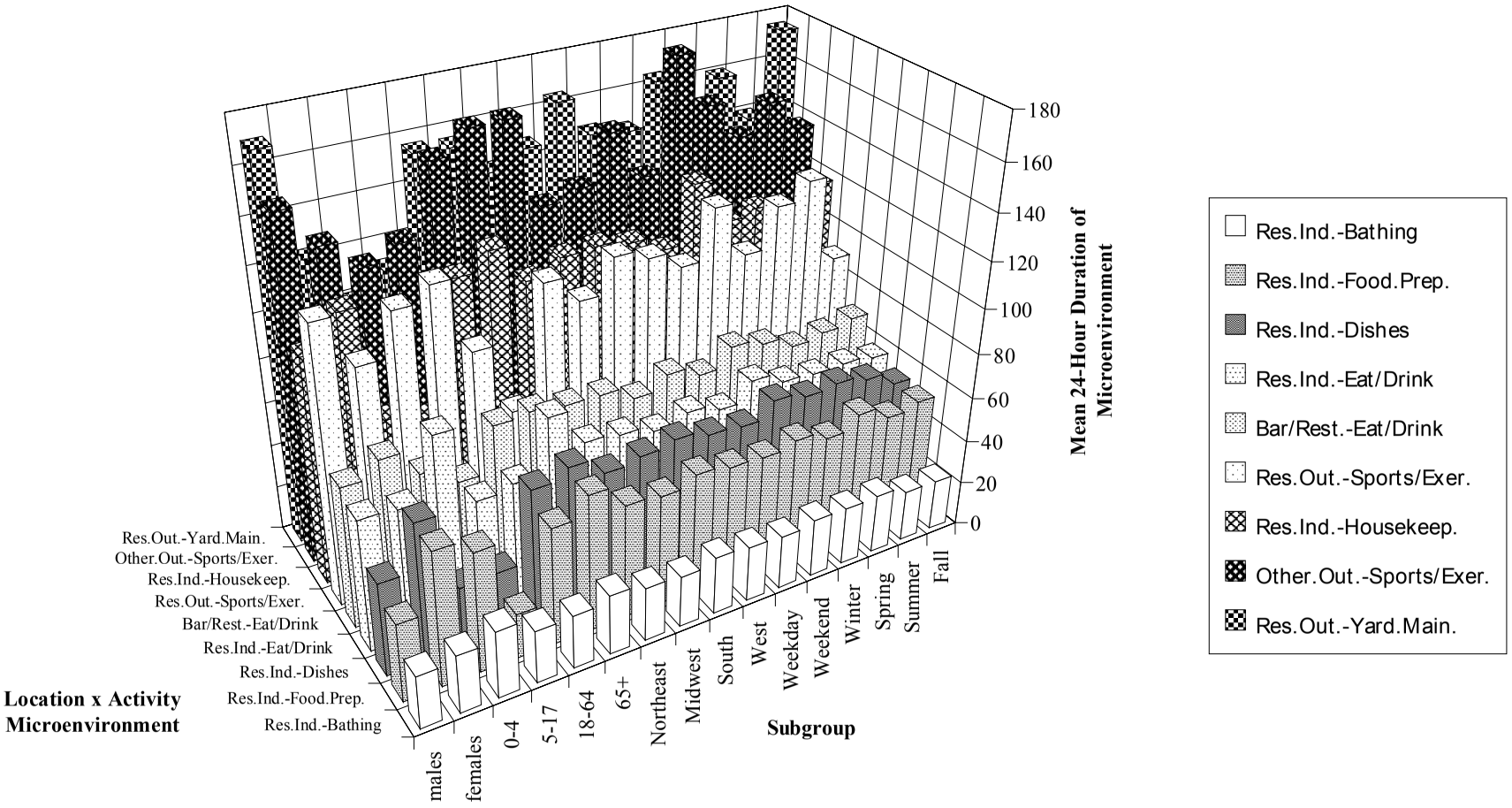


Figure 6-47. 3-D plot of the mean 24-hour duration of nine location x activity microenvironments across each subgroup

Of the nine selected microenvironments with the largest percentages of time spent, the Residential-Indoor-Food-Preparation location x activity microenvironment had the smallest 24-hour mean duration (Figure 6-47 and Table 6-16) for males and respondents aged 5-17 (20-35 min vs. 50-61 min for the other subgroups). Those aged 0-17 had the smallest durations in the Residential-Indoor-Dishes/Laundry (27-28 min vs. 42-64 min), Residential-Indoor-Housekeeping (61-65 min vs. 106-118 min), and Residential-Outdoor-Yardwork/ Maintenance (100-111 min vs. 123-175 min for the other subgroups) microenvironments. Those aged over 65 had the smallest duration in the Residential-Outdoor-Sports/Exercise microenvironment (63 min vs. 94-128 min). Table 6-16b contains the weighted doer sample sizes for the nine microenvironments.

6.6 Summary and Discussion

The percentage of time spent in microenvironments considers both the length of time spent in microenvironments and the number of people entering the microenvironments; and thus, it is a good indicator of the significance of a microenvironment to the entire population and its relative significance between subgroups. However, the duration and frequency of occurrence of microenvironments for the doers -- as calculated in this report -- are more useful in the estimation (modeling) of exposure magnitudes; and they are a better indicator of the potential exposure associated with microenvironments for the specific subgroups that are being exposed. Calculations of human exposure usually give time-averages over minutes, hours, days, etc., and require knowledge of how long and how often microenvironments occur. Assuming characteristics of the locations and the mechanisms of pollutant emission and transport are approximately the same across a population, we can assign exposures based on durations in microenvironments without necessarily knowing the magnitude of exposures.

The Residential-Indoor location is by far the most important overall location with the Eating/Drinking, Food Preparation, and Housekeeping exposure activities taking up the most time. The most time spent being exposed to ETS also occurs in the Residential-Indoor location (females/weekends) -

- followed by the Office/Factory (older males/weekdays) and Bar/Restaurant locations. The next most significant location was Residential-Outdoor which has the most amount of time being spent in the Yard/Maintenance exposure activity followed by Sports/Exercise. Although much time was spent in the In Vehicle location, most of it did not involve specific exposure activities (other than exposure to other vehicles' exhaust fumes). However, after Bar/Restaurant, the In Vehicle location has the next largest amount of time spent exposed to ETS.

Of the microenvironments in the Residential-Indoor location, those with Yardwork/Maintenance and Housekeeping exposure activities have the largest 24-hr durations. Thus, since Housekeeping occurs for a large overall proportion of individuals, it may imply larger potential exposures when considering the entire population; however, those members of the population that spend time in the Yardwork/Maintenance exposure activity may also face significant exposures. Two of the exposure activities in the Residential-Outdoor location with large durations -- Yardwork/Maintenance and Sports/Exercise -- suggest larger exposures to the entire population than Housekeeping, which is more important for specific subgroups -- such as females over 18. The largest 24-hour durations of exposure to ETS occur in the Office/Factory and the Residential-Indoor locations; and these microenvironments occur over large proportions of time for the entire population. Females have more potential exposure in Residential-Indoors while males have more potential exposure in Office/Factory. Persons over 18 have more potential exposure in Office/Factory and those under 5 have more potential exposure in Residential-Home.

6-II. *24-HOUR DIARY RESULTS*: FREQUENCY OF OCCURRENCE FOR SELECTED MICROENVIRONMENTS BY TIME-OF-DAY IN MINUTE TIME SEGMENTS BY DAY-OF-WEEK, SEASON, AND BACKGROUND FACTORS

Besides frequency of occurrence and duration of microenvironments over the entire diary day, the NHAPS human activity pattern data base can be examined by the time-of-day that each microenvironment occurs. Here, we present the fraction of respondents that experienced each location, exposure activity, or smoker-present category over the 24-hour (1440-minute) diary day -- with selected subgroup breakdowns by gender, age, Census region, weekend vs. weekday, or season. There are two kinds of plots presented: (1) stacked area charts of fraction of respondents vs. time of day for direct time-of-day comparisons between each location and exposure activity; and (2) independent plots for precise peak determinations and comparison across subgroups. Sometimes the peaks for different subgroups fall at the approximately the same time so that analysis by time-of-day does not provide any more information than the percentage of time spent over the entire 24-hour day -- as reported in Part I of Section 6. Thus, we have only included those plots where there were significant variations in peak occurrences between subgroups. Since the 24-hour diaries were collected at one-minute time resolution (*i.e.*, every respondent was matched with a microenvironment for every minute of the day) and the plots contain 1440 minutes of data corresponding to every minute of the day, the calculated fraction of microenvironments being experienced for every minute is equal to the fraction of respondents experiencing the microenvironment.

Technical Note: The time of day plots were produced by creating 1440 activity pattern records for each of the 9,386 NHAPS respondents corresponding to each minute of the day, sorting these records by minute and location, activity, and smoker-present category, and calculating the frequency of respondents in each category for each minute of the day. Lastly, the fraction of respondents was obtained by dividing each frequency by the total number of activities (= respondents) for the current minute. The total number of microenvironments for each minute is equal to the total number of respondents (9,386) since the time resolution of the study was one minute. All results presented are weighted.

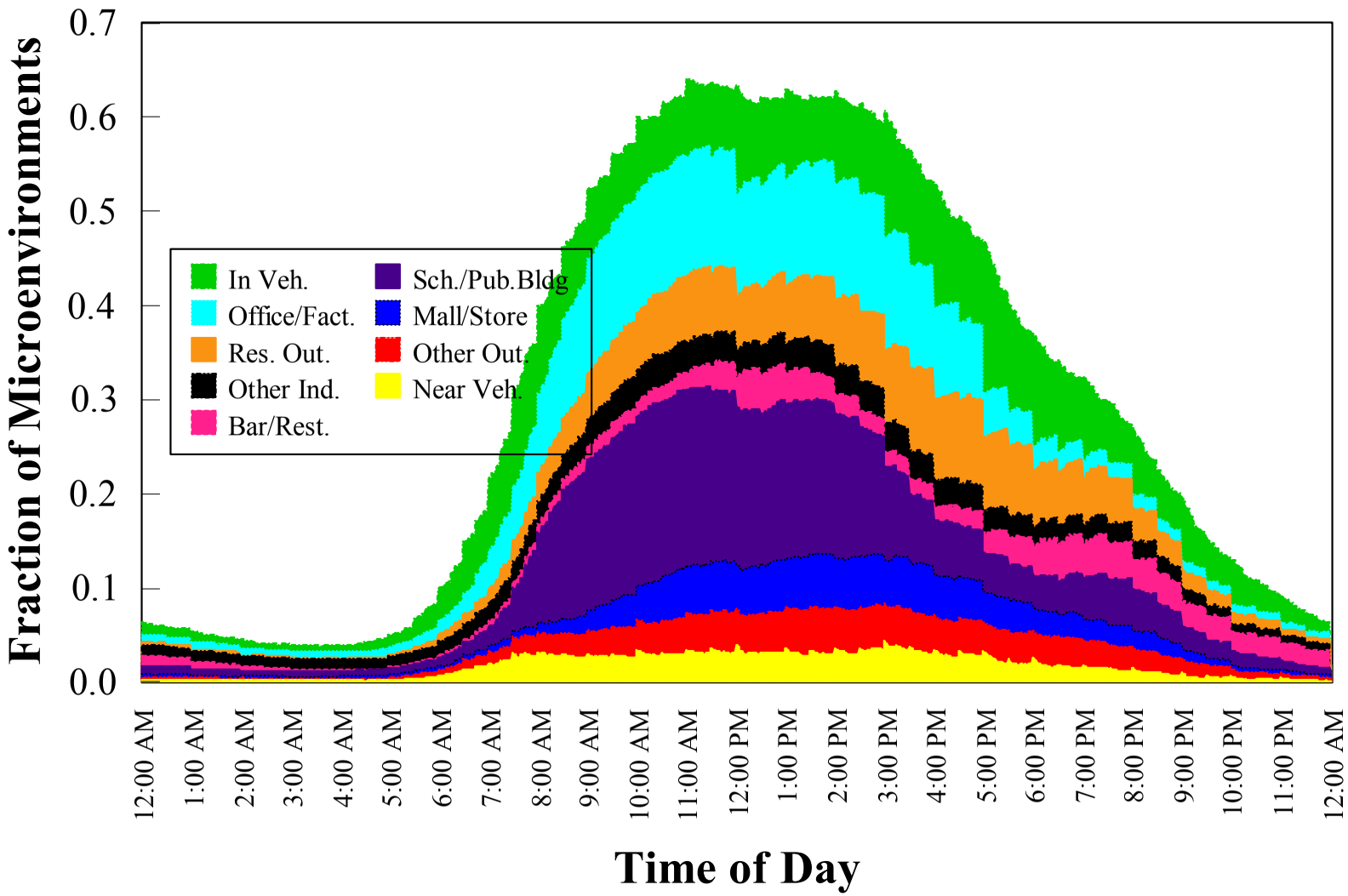
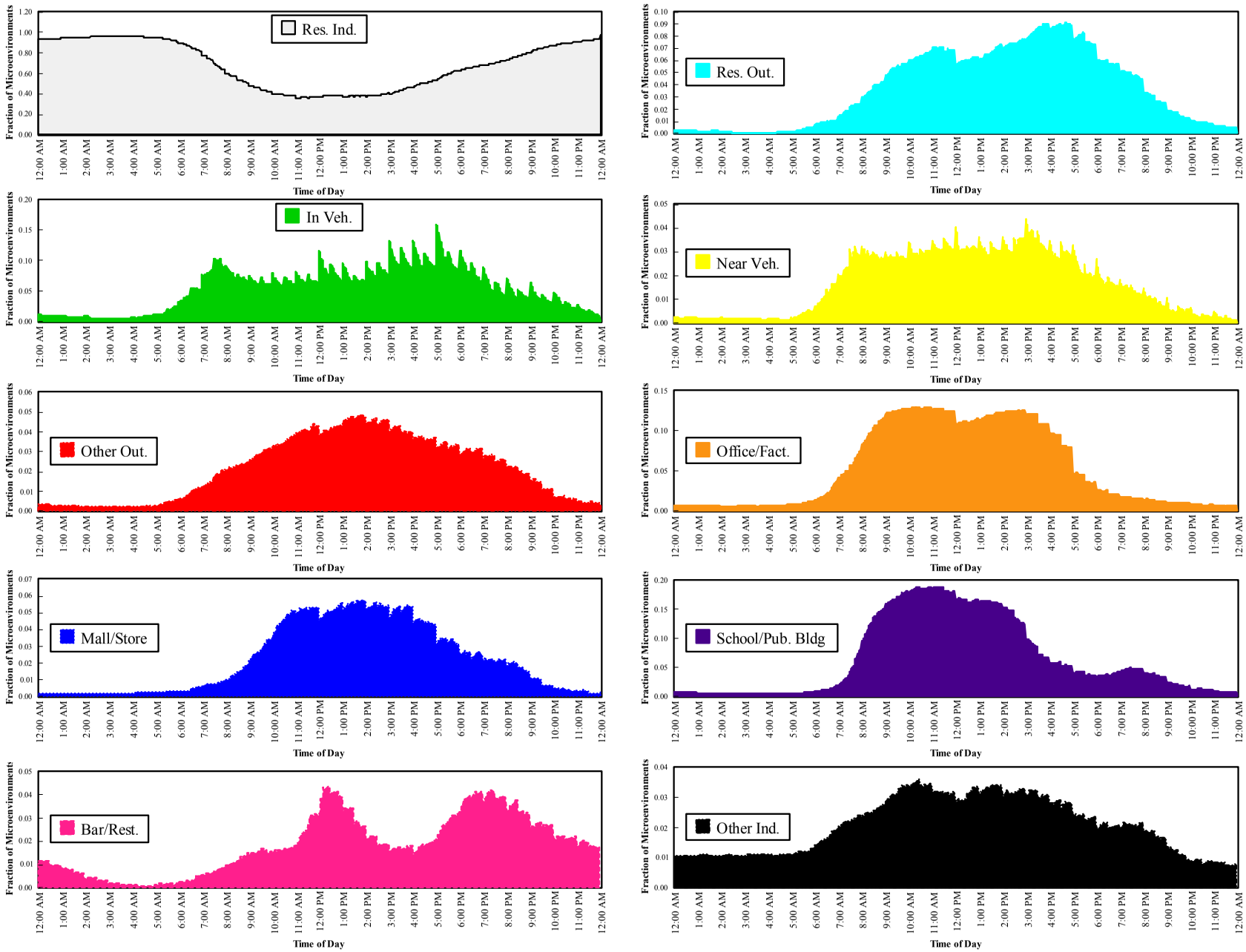


Figure 6-48. Stacked overall fraction of respondents in each location by time-of-day. The Residential-Indoor location accounts for the fraction not shown (white space). The time scale is from midnight to midnight on the diary day. Since all respondents are in some location at any given minute the fraction of microenvironments is equal to the fraction of respondents.

6.7 Locations

By following a straight vertical line in Figure 6-48 corresponding to a particular minute of the day, we are able to examine the relative fraction of the NHAPS respondents that spent the current minute in each of nine locations (see Section 5) -- Residential (Indoor), which takes up the largest fraction throughout the day, accounts for the remaining time: (1) Residential-Outdoors; (2) In Vehicle; (3) Near Vehicle (walking near roadway, bicycling, motorcycling, etc.); (4) Other Outdoor (park, campground, etc.); (5) Office/Factory; (6) Mall/Other Store; (7) School/Church/Other Public Building; (8) Bar/Restaurant; and (9) Other Indoor (hotel/motel, health club, repair shop, etc.). Except for the middle of the day between 9:00 AM and 5:00 PM the majority of the respondents (more than 50%) are in the Residential-Indoor location. Between 9:00 AM and 5:00 PM between 50% and 65% of respondents are outside of the Residential-Indoor location. The four locations with the highest fraction between 9:00 AM and 5:00 PM are the Residential-Outdoor, In Vehicle, Office/Factory, and School/Church/Public Building locations with the Office/Factory and School/Church/Public Building being the larger of the four until about 4:00 PM. Towards 5:00 PM most people are returning from school and work by car so the frequency of the In Vehicle location becomes larger and more people may be spending time outside at their homes so the frequency in the Residential (Outdoors) location also becomes larger. The Bar/Restaurant location replaces Office/Factory in the top four locations after 5:00 PM.

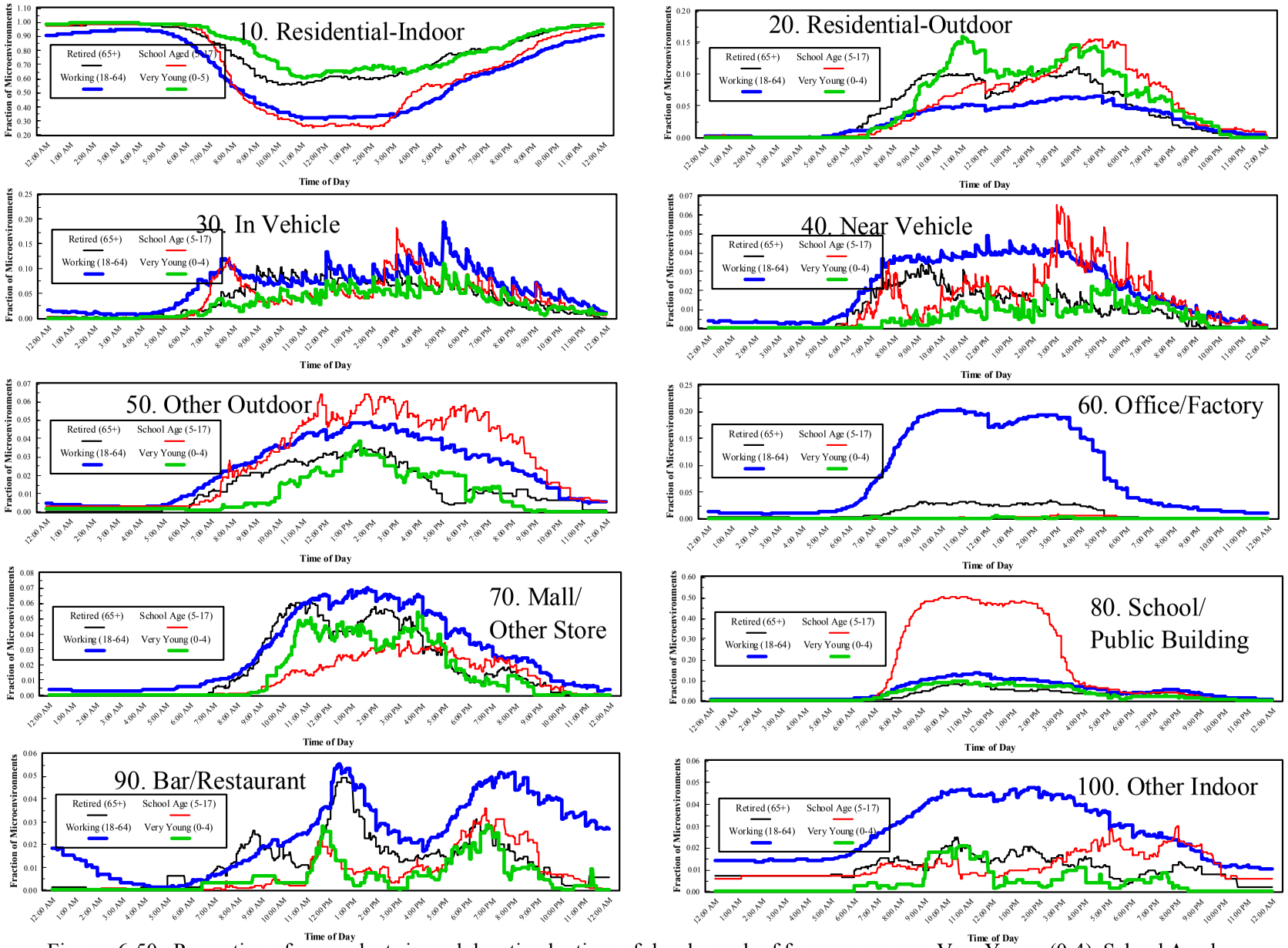
The Office/Factory and School/Public Bldg. locations each have double peaks of occurrence in the middle of the day corresponding to the before and after lunch waves (Figure 6-49). The first broad peak falls between 9:00 AM and 12:00 PM (about 13% of respondents) for Office Factory and between 10:00 and 11:00 AM (almost 20%) for School/Public Bldg. The second peak occurs at about 2:30 PM (just over 12%) for Office/Factory and about 1:00 PM (about 17%) for School/Public Bldg. The School/Public Bldg. location also has a third peak at about 7:30 PM probably corresponding to night school (about 5% of respondents). The Residential-Outdoor location has two peaks, one just before



Figures 6-49. Overall fraction of respondents in each location by time-of-day in separate plots. The stacked plot is in Figure 6-48.

noon (about 7%) and another slightly higher one between 4:00 and 5:00 PM (about 9%). Single broad peaks occur between morning and evening for the Other Outdoor (6:00 AM to midnight, high of 5%), Mall/Other Store (6:00 AM to 10:00 PM, high of about 6%), and Other Indoor (6:00 AM to 10:00 PM, about 3.5%). About 1% of respondents are in the Other Indoor location between 11:00 PM and 6:00 AM. The most striking peaks occur for the Bar/Restaurant location at about 12-12:30 PM for lunch time (4.5%) and 7:00 PM for dinnertime (just over 4%). The occurrences of Bar/Restaurant extend into the night -- trailing off at about 3:00 AM. The In Vehicle and Near Vehicle locations display a jagged pattern that probably arises because their durations are fairly brief and respondents tend to round their diary beginning and ending times to the nearest hour or half-hour. The smoothest, broadest peak for In Vehicle occurs during morning traffic between 7:00 AM and 8:00 AM (about 10%) with the highest peak occurring just after 5:00 PM for the rush-hour commute home (17-18%). The number of respondents in the Near Vehicle location is a fairly even plateau between 7:30 AM and 3:00 PM (3-4%).

The Very Young (0-4) and Retired (65+) age groups have two distinct peaks each about five hours long -- one in the late morning and one in the afternoon -- for the Residential-Outdoor location (Figure 6-50). The Very Young peaks are delayed about an hour after those for the Retired. The Working (18-64) and School Aged (5-17) age groups each have steadily rising occurrences with peaks at about 5:00 PM. The School Aged and Working account for the In Vehicle peak at 7:00-8:00 AM. The peak for School Age in the afternoon occurs at 3:00 PM while peaks for the Working are at noon and 5:00 PM. While the peak for the Working in the Near Vehicle location is a broad plateau during the day, the School Aged have one peak near 8:00 AM and another near 3:00 PM. The School Aged have the largest fraction of respondents in the Other Outdoor location after 5:00 PM. As expected from our study of percentages of time spent over the entire diary day of all respondents, the Working has the largest fraction of respondents in the Office/Factory location for the entire day and the School Aged has the largest fraction in the School/Public Bldg. location for the entire day. The Working also have the largest



Figures 6-50. Proportion of respondents in each location by time-of-day by each of four age groups: Very Young (0-4), School Aged (5-17), Working (18-64), and Retired (65+). The time scales run from midnight to midnight on the diary day.

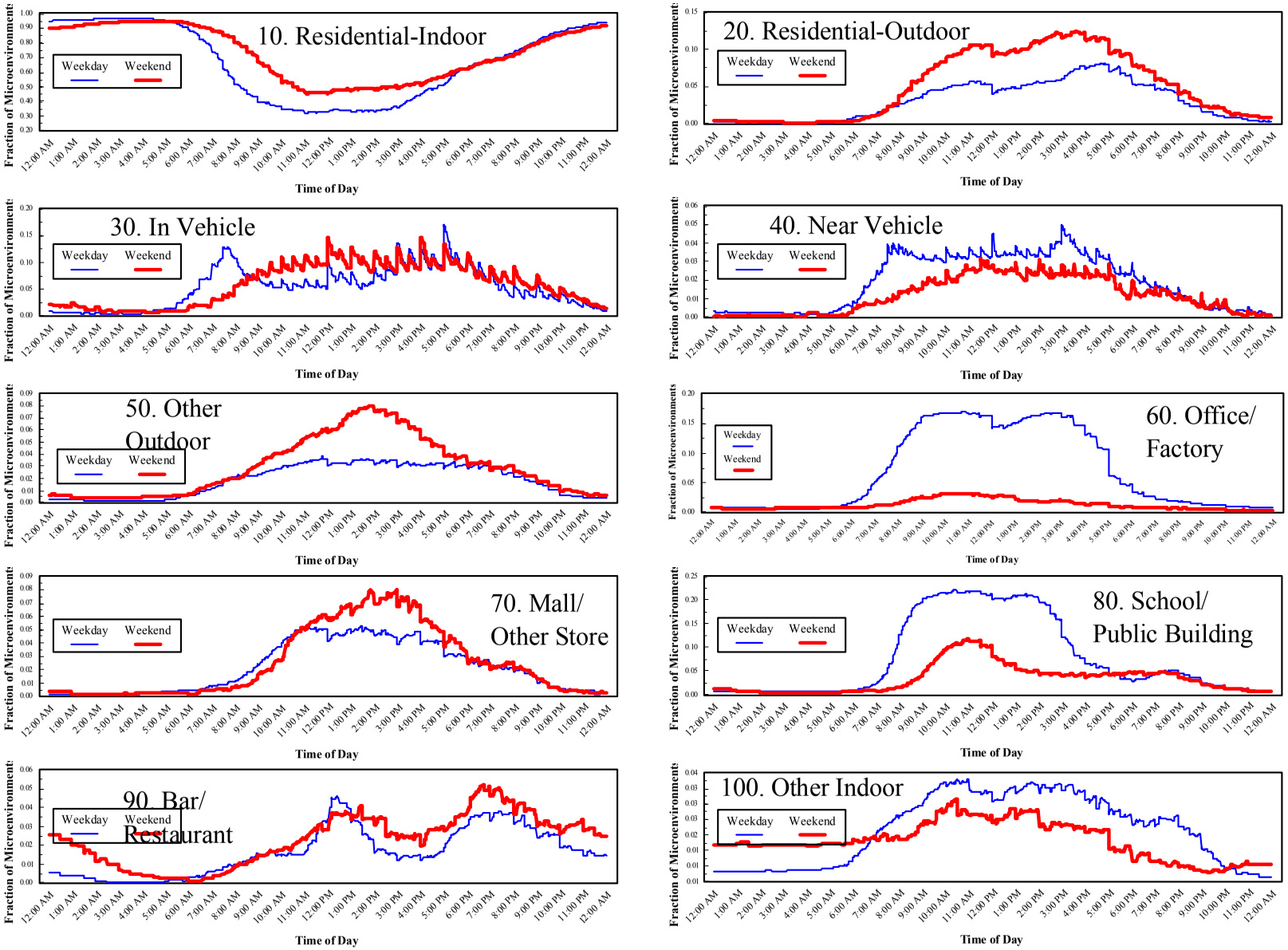
fraction of respondents in the Other Indoor location from midnight until about 7:30 PM. The School Aged and Very Young age groups have the most respondents in the Bar/Restaurant location at about 11:30 AM and 6:30-7:00 PM, while the Working have the most respondents in the Bar/Restaurant location at about 12:30 PM and 7:30-8:00 PM. The Retired have the most respondents in Bar/Restaurant at 12:30 PM to match the Working, but their peak at just after 6:00 PM is close to that for the School Aged and the Very Young.

On weekends more respondents were in the Residential-Indoor location between 6:00 AM and 5:30 PM than on weekdays (Figure 6-51). There were slightly fewer respondents on weekends in Residential-Indoor from midnight to about 4:00 AM. The peaks of occurrence of In Vehicle are distinct for the morning and evening commutes on weekdays, but on weekends the fraction of respondents in In Vehicle is fairly even (2.5% to 10%) between 8:00 AM and 10:00 PM. The fraction of respondents is greater on weekends in Other Outdoor between 8:30 AM and 6:00 PM, in Mall/Other Store between 11:00 AM and 6:00 PM, in Bar/Restaurant from 10:00 PM to 5:00 AM, and in Other Indoor between 10:30 PM and 7:00 AM. In contrast to the double peaks (before and after lunch) on weekdays, on weekends there is a small, broad peak at about 10:30 AM in Office/Factory and a peak at about 11:00 AM for School/Public Bldg., which decays gradually until 8:00 PM.

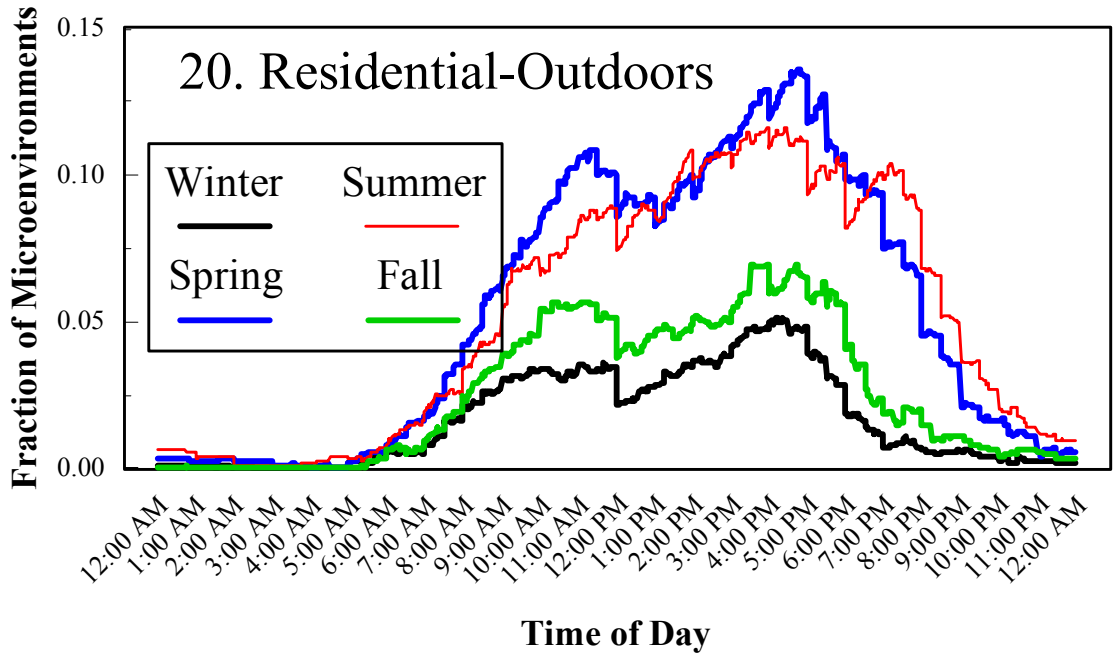
The fraction of respondents were similar during the Winter and Fall seasons and during the Spring and Summer seasons (Figure 6-52). The fractions of respondents in the Residential-Outdoors and Other Outdoor locations were greater during most of the diary day in Spring/Summer with the peak in summer extending until about 7:00 PM.

6.8 Exposure Activities

At any time during the diary day, between 0% and about 35% of the NHAPS respondents (Figure 6-53) were occupied in seven exposure activities that are related to exposure to chemical pollutants by the air, water, dermal, or food pathway (see Section 5): (1) Food Preparation, (2) Do Dishes/Do



Figures 6-51. Proportion of respondents in each location by time-of-day by weekday vs. weekend. The time scales run from midnight to midnight on the diary day.



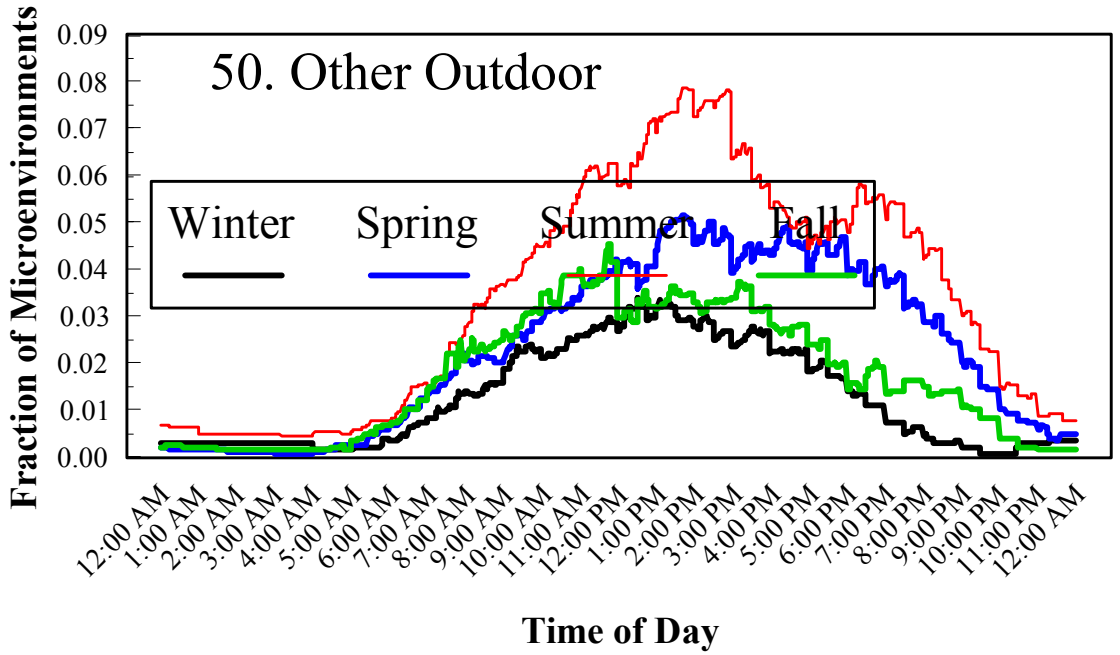


Figure 6-52. The fraction of respondents in the Residential-Outdoor and Other Outdoor locations by time of day for the four seasons. The time scales run from midnight to midnight on the diary day. Since all respondents are in some location at any given minute, the fraction of microenvironments is equal to the fraction of respondents.

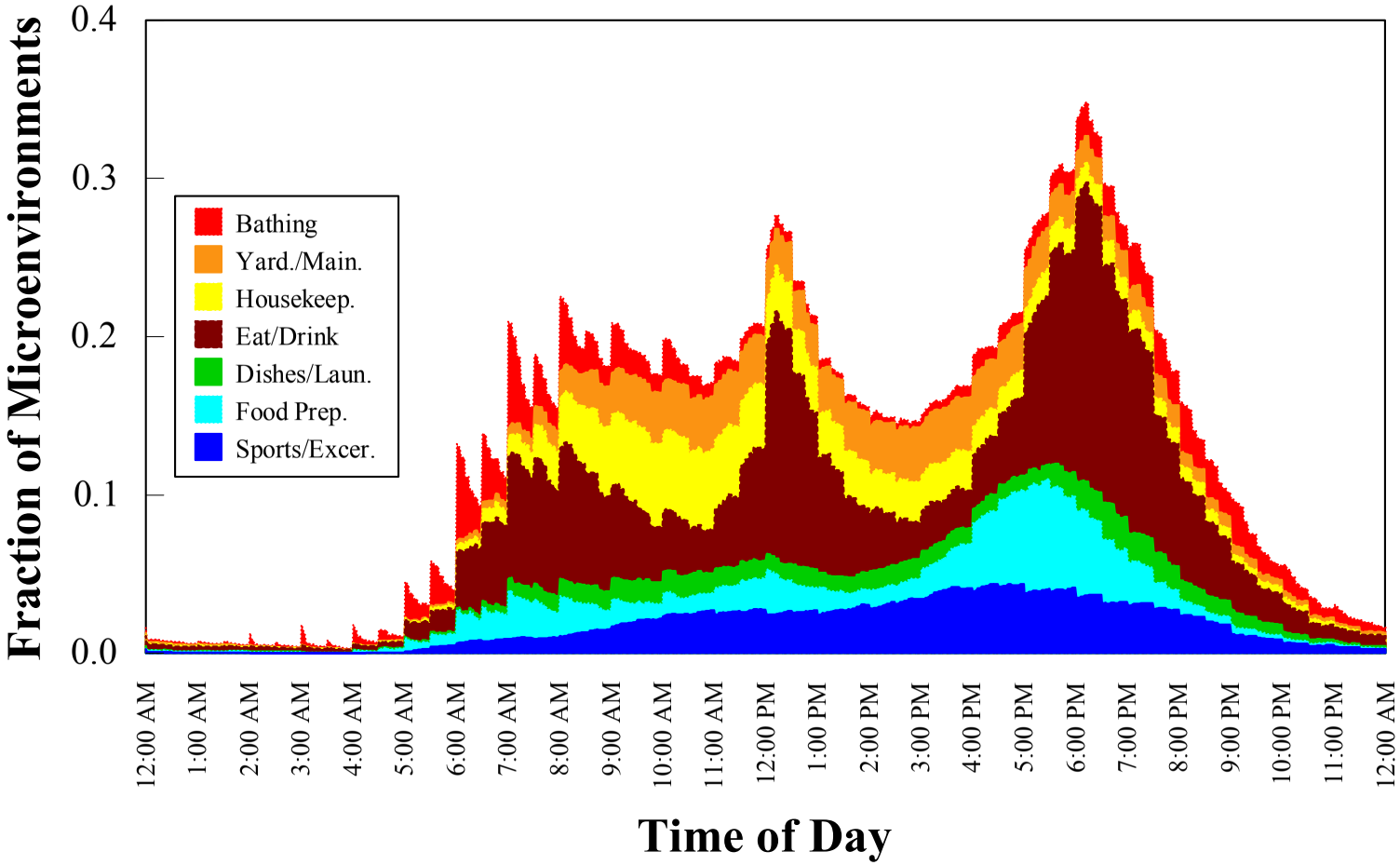
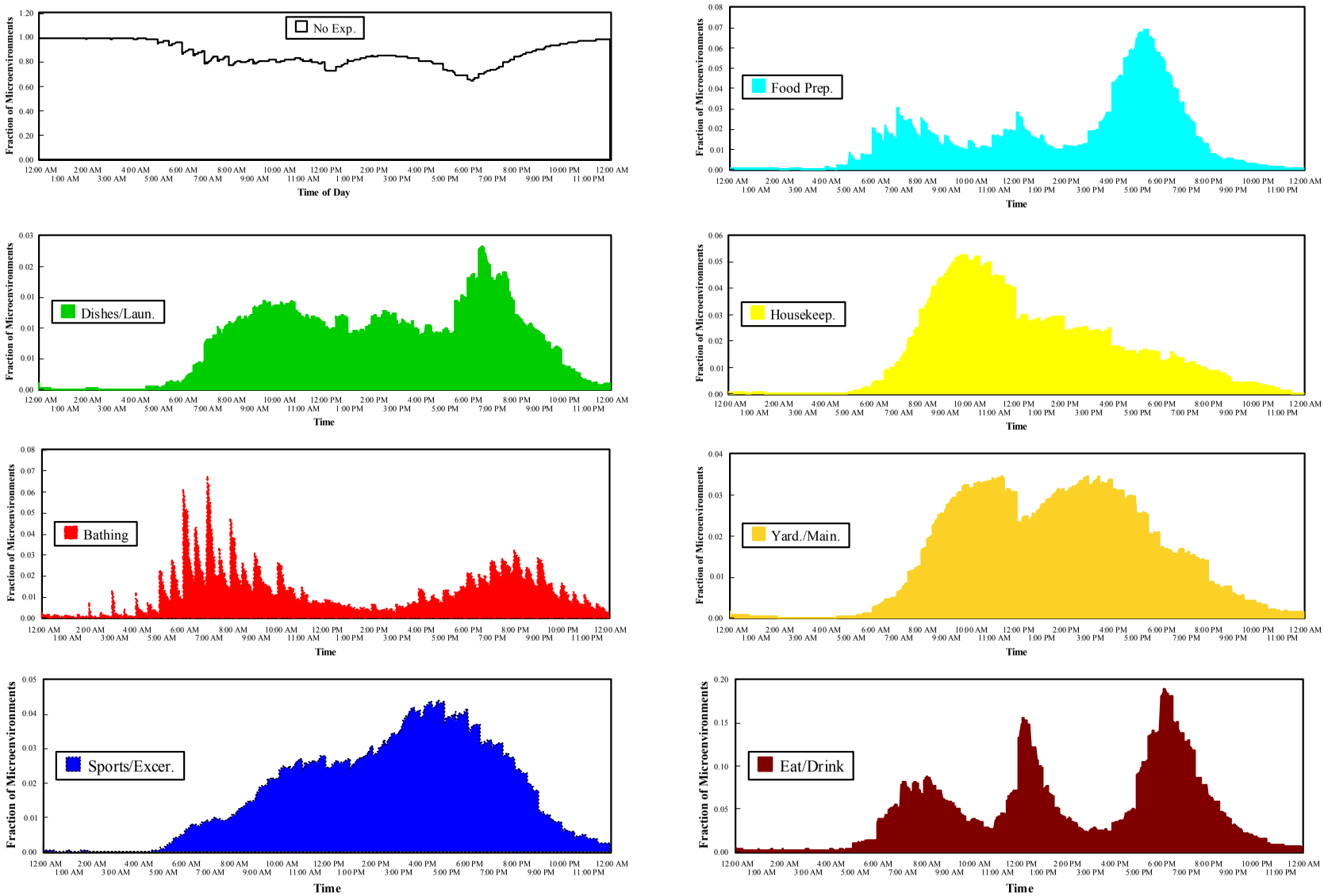


Figure 6-53. Stacked overall fraction of respondents in each exposure activity by time-of-day. The No Exposure category accounts for the fraction not shown (white space). The time scale is from midnight to midnight on the diary day. Since all respondents are in some exposure activity at any given minute, the fraction of microenvironments that include a given exposure activity is equal to the number of respondents in that exposure activity.

Laundry/Clean Kitchen, (3) Housekeeping, (4) Giving or Taking a Bath or Shower, (5) Yardwork/Gardening/Maintenance, (6) Sports/Exercise, and (7) Eating/Drinking. The peak fraction of respondents in exposure activities (about 65%) occurs at about 6:00 PM when people are returning home to make dinner. Close to 100% of the respondents are involved in non-exposure activities from midnight to about 5:00 AM when most people are sleeping. Examples of other non-exposure related activities are watching TV, dressing, traveling for goods and services, or traveling to and from work (see Table 5-7 in Section 5). By following a straight vertical line in Figure 6-53 corresponding to a particular minute of the day, we are able to examine the relative fractions of respondents in the seven defined exposure activities. At midday and the early evening, Eating/Drinking takes up the major portion of time, with Cooking/Food Preparation at night also taking up a substantial fraction. From 2:30 to 4:30 PM Yardwork and Sports/Exercise seem to be the predominant activities, while between 9:30 and 11:30 AM Housekeeping occurs in the largest proportion.

The individual time of day plots in Figures 6-54 illustrate how the number of respondents in each exposure activity fluctuates during the day. The Food Preparation and Eating/Drinking exposure activities display three distinct peaks in frequency corresponding to the three typical meals of the day (breakfast, lunch, and dinner). The majority of Food Preparation takes place in the evening at approximately 5:30 PM (about 7% of respondents). The peaks for breakfast at 7:00 AM and lunch at noon (both about 3%) are substantially smaller, probably because more people are eating out or skipping those meals. Likewise, the breakfast peak (about 9% of respondents) for Eating/Drinking is much smaller than the peaks for lunch at 12:30 PM (15%) and dinner at 6:00 PM (about 19%). Notice how the dinner and breakfast peaks are more spread out than the lunch peak suggesting that Americans adhere to the noon lunch hour more than any specific breakfast or dinner hour. Additionally, the Eating/Drinking peaks are about a half-hour delayed from the Food Preparation peaks, and the frequency of Eating/Drinking is much higher during the entire day than the frequency for Cooking/Food Preparation

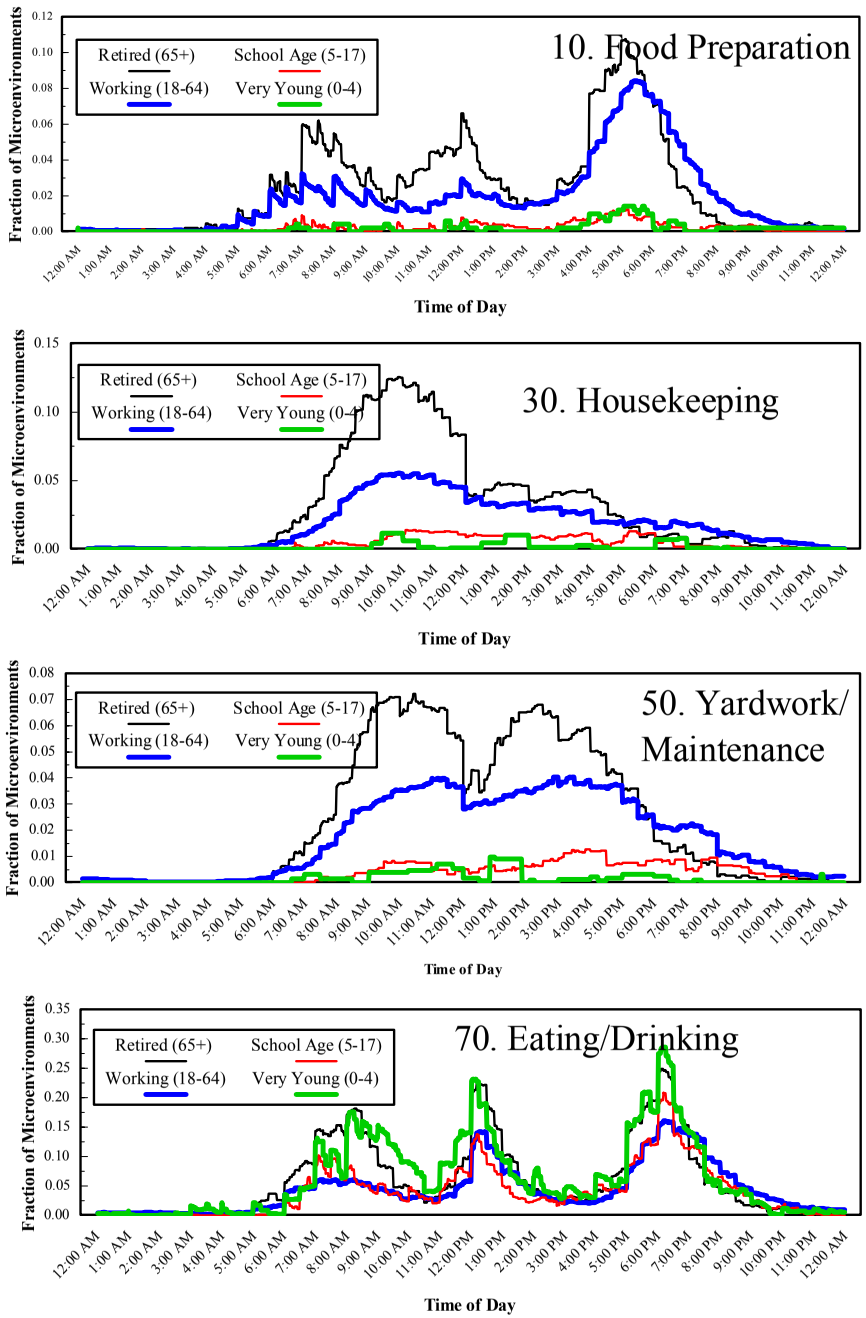


Figures 6-54. Overall fraction of respondents in each exposure activity by time-of-day in separate plots. The stacked plot is in Figure 6-53.

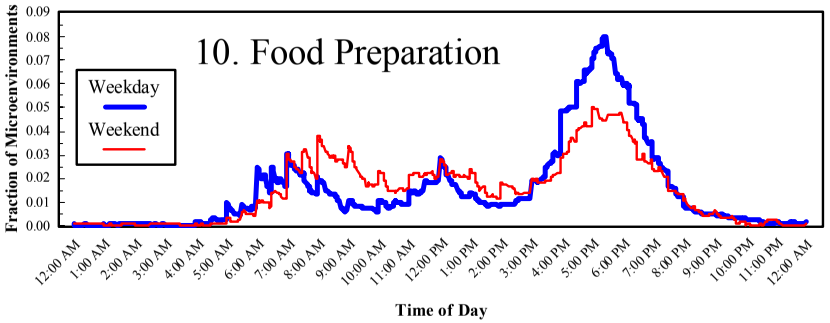
since more people are (1) eating only, or (2) both eating and cooking, rather than (3) cooking only. The Dishes/Clean Kitchen/Laundry exposure activity has lower frequencies than both the Cooking/Food Preparation or Eating/Drinking exposure activities, and the peaks are spread out more evenly throughout the entire day -- except for the peak at about 6:30 PM which is delayed about a half hour after the Eating/Drinking dinner peak. The Housekeeping exposure activity fraction of respondents rises steadily from 5:00 AM until its peak at about 9:30 AM (about 5.5% of respondents); it then falls abruptly at noon before decreasing steadily until midnight. Like the In Vehicle location the Giving/Taking a Bath/Shower exposure activity displays sharp peaks every hour and half-hour. The two major areas of high frequency are in the morning at about 6:00-8:00 AM (a high of 7% of respondents), and the other in the evening centered at approximately 8:00 PM (about 3%). Both peaks span 5-7 hours and jagged sub-peaks occur throughout each of them. For the Yardwork/Maintenance exposure activity there is a peak in the morning at about 10:30 AM (3.5%), an abrupt drop-off in the fraction of respondents at noon, and another peak at about 3:00 PM (3.5%). The fraction of respondents in the Sports/Exercise exposure activity rises from 5:00 AM, levels off between 10:00 AM and 1:00 PM (about 2.5% of respondents), and reaches a peak at about 4:30 PM (4.5%).

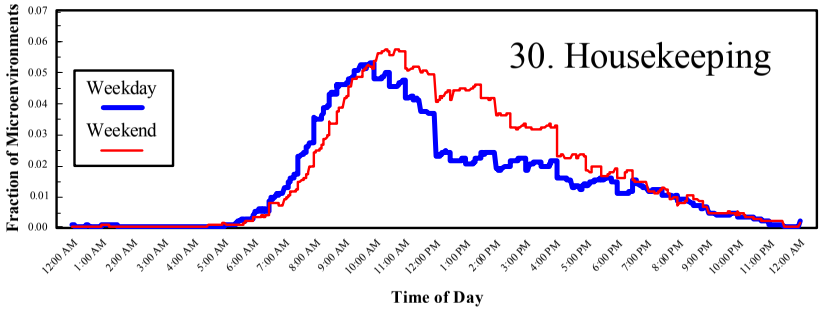
For respondents in the Retired age group, the dinner peak for Food Preparation is about one half-hour ahead (5:00 PM) of the same peak for those in the Working age group (5:30 PM) (Figure 6-55). In the Food Preparation, Dishes/Laundry, Housekeeping, and Yardwork/Maintenance exposure activities, the fraction of respondents in the Retired age group is larger than the other age groups for most of the day. However, for the Sports/Exercise exposure activity, the School Aged take up the largest fraction for most of the day, and for Eating/Drinking, the Very Young have approximately the same fraction as the Retired throughout the day.

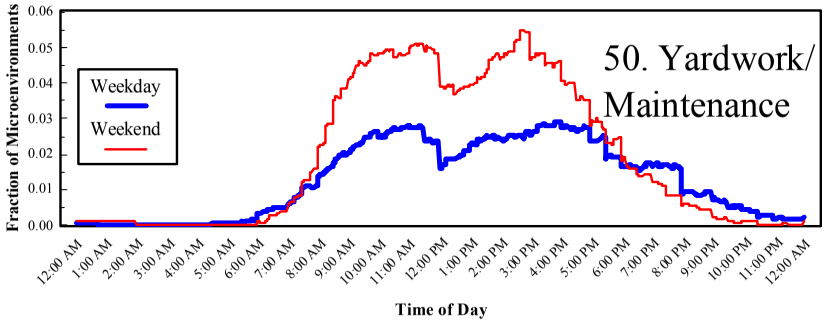
For Food Preparation, Dishes/Laundry, Housekeeping, Bathing, and Eating/Drinking, the peaks in the morning are consistently earlier on weekdays than on weekends; but the peaks later in the day

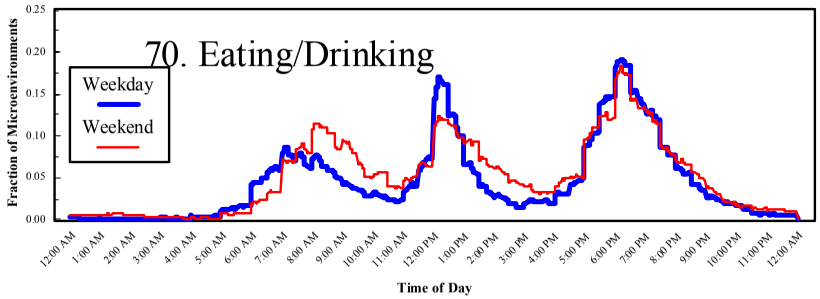


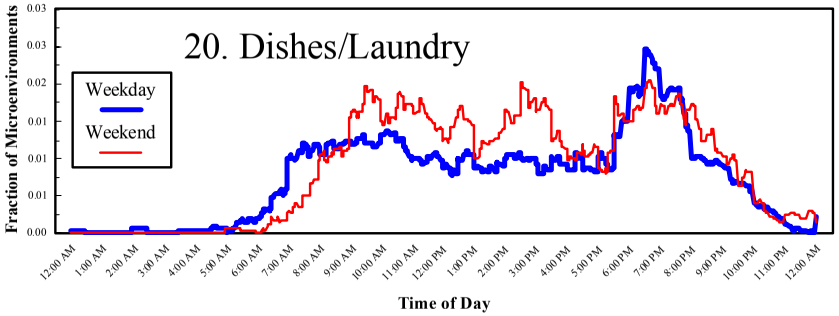
Figures 6-55. Proportion of respondents in each exposure activity by time-of-day by each of four age groups: Very Young (0-4); School Aged (5-17); Working (18-64); and Retired (65+). The time scales run from midnight to midnight on the diary day.

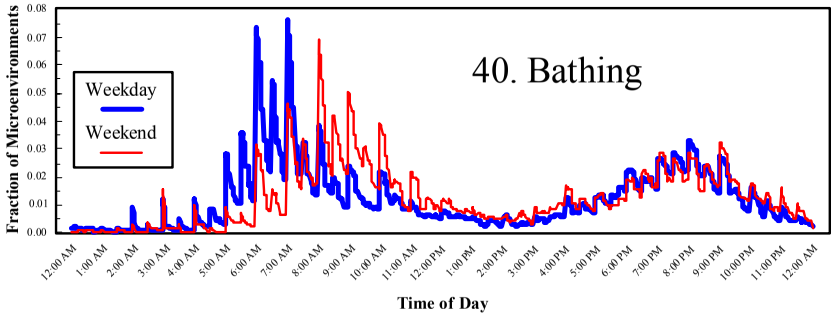


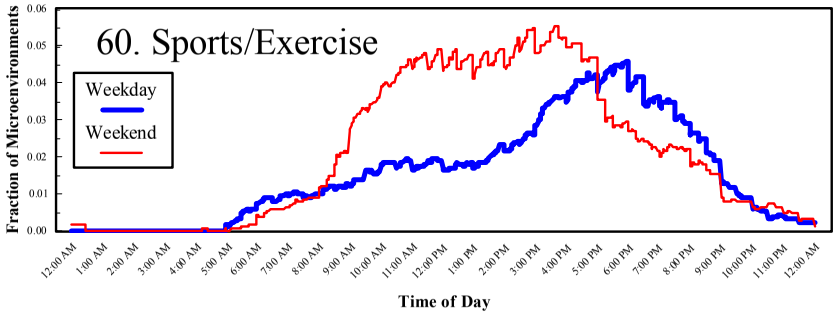




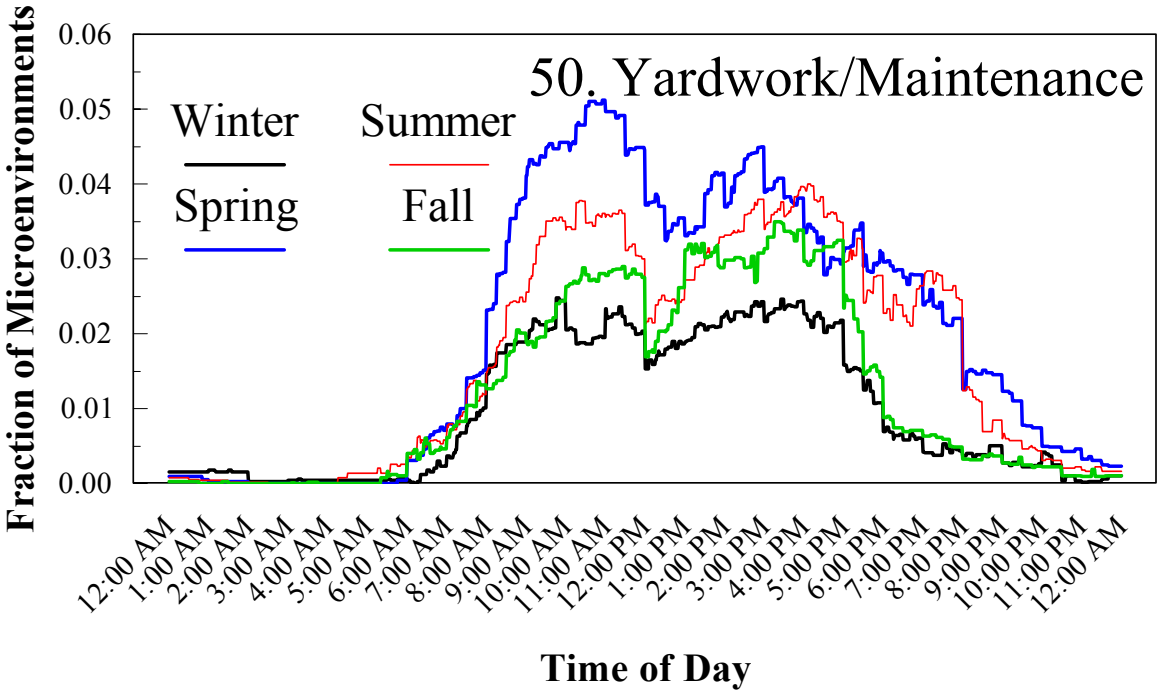








Figures 6-56. Proportion of respondents in each exposure activity by time-of-day for weekdays vs. weekends. The time scales run from midnight to midnight on the diary day.



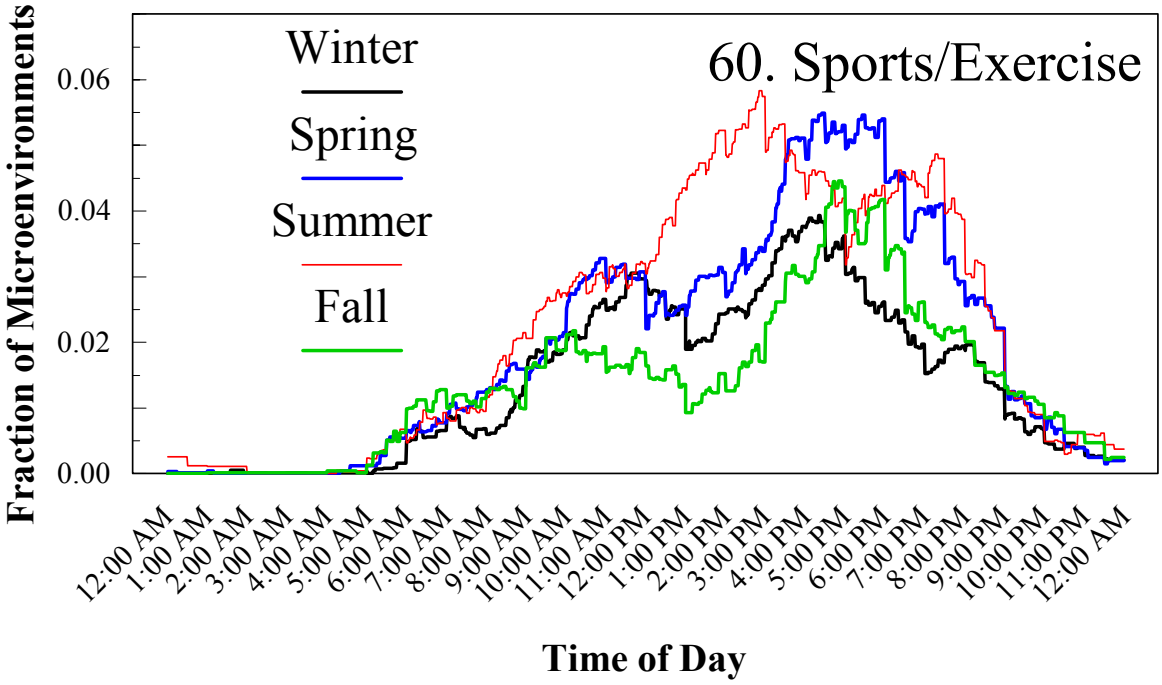


Figure 6-57. The fraction of respondents in the Yardwork/Maintenance and Sports/Exercise exposure activities by time of day for the four seasons. The time scales run from midnight to midnight on the diary day. Since all respondents are in one exposure activity at any given minute, the fraction of microenvironments is equal to the fraction of respondents.

occur at approximately the same times for weekdays and weekends (Figure 6-56). On weekends Sports/Exercise has the largest fraction of respondents in the middle of the day between 10:00 AM and 5:00 PM, whereas on weekdays the largest fraction occurs at about 6:00 PM.

Throughout the morning and early afternoon, the highest fraction of respondents in the Yardwork/Maintenance exposure activity occurs in the Spring (Figure 6-57). For Spring/Summer the fractions are larger than those in Winter/Fall from 5:00 PM to 10:00 PM. Summer has the largest fraction of respondents (3-6% of respondents) in the middle of the day (noon to 3:00 PM) for Sports/Exercise, while in Spring the fraction of respondents becomes large (5%) from about 3:30 to 6:00 PM. In both Spring and Summer the fraction of respondents in Sports/Exercise remains larger than Winter/Fall until 9:00 PM.

6.9 Smoker-Present Categories

The fraction of respondents exposed to environmental tobacco smoke (ETS) has its largest peak (Figure 6-58) just before 9:00 PM (about 18% of respondents). The fraction falls towards midnight but remains between 5 and 8% until it reaches a low of 2.5% at 4:00 AM. For most of the work day (11:00 AM to 7:00 PM) about 15-16% of the respondents are exposed.

Males are exposed in larger fractions than females for the entire day (a high of 20% vs. a high of 15%), and the Working are substantially more exposed than any other age group between 7:00 AM and 11:00 PM (a peak difference of more than 10% at about 2:00 PM). Between noon and 9:00 PM a smaller fraction of respondents in the West are exposed to ETS than any other region (10-15% vs. 15-20%). Between noon and 4:30 AM the fraction is larger on weekends than on weekdays, and in the Fall there are slightly more respondents exposed to ETS between about 8:00 AM and 5:00 PM than in the other seasons.

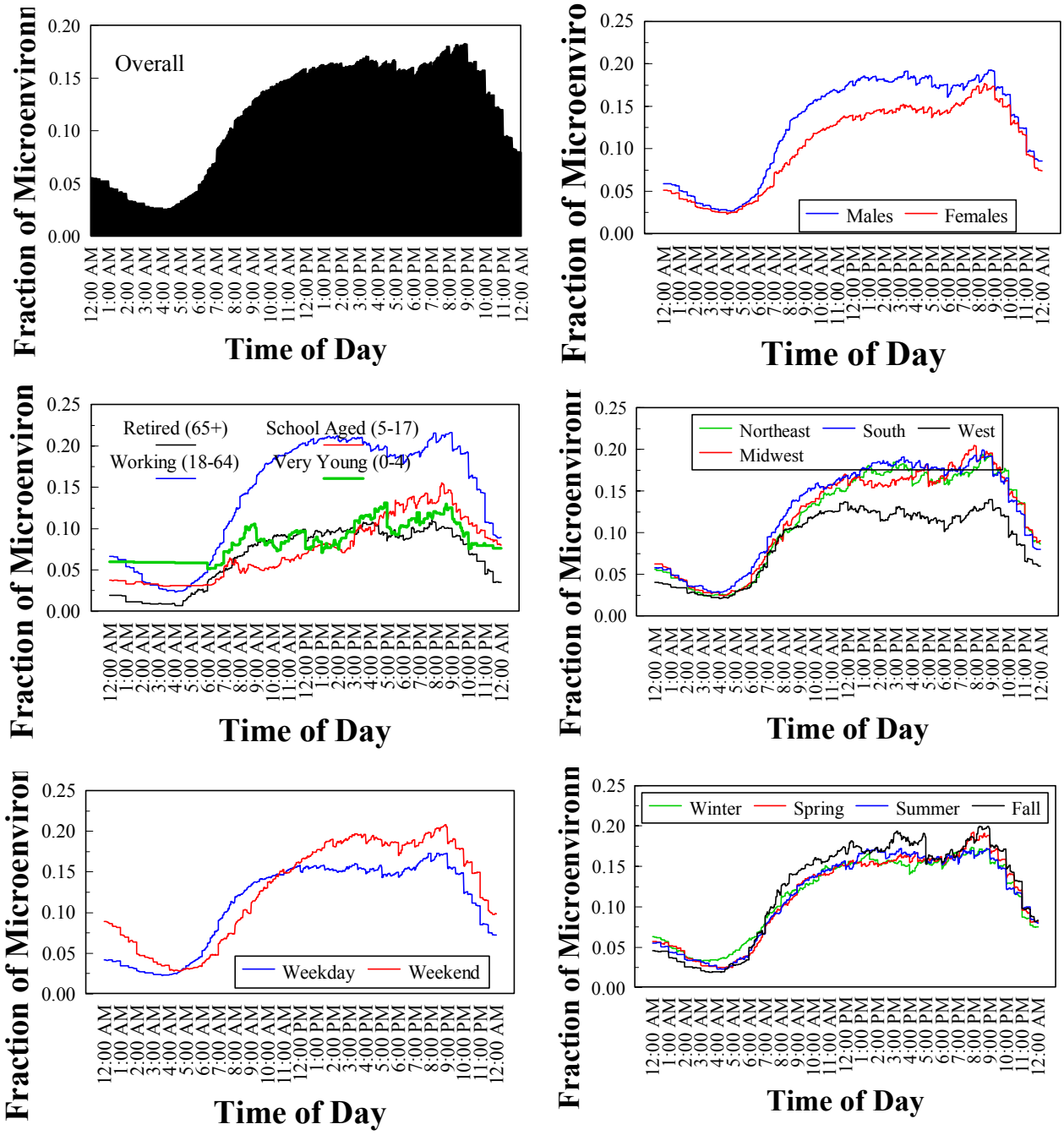


Figure 6-58. Fraction of respondents exposed to ETS by time-of-day: overall; by gender; by age; by Census region; by weekday vs. weekend; and by season. Those that were unexposed to ETS account for the remaining fraction (white space). Those who answered "don't know" concerning ETS exposure were omitted from calculations. The time scale is from midnight to midnight on the diary day. Since all respondents are in one microenvironment at any given minute, the fraction of microenvironments is equal to the fraction of respondents.

6-III. *24-HOUR DIARY RESULTS*: OVERALL DURATION AND PROPORTION OF RESPONDENTS IN SELECTED MICROENVIRONMENTS BY TIME-OF-DAY IN 3-HOUR TIME SEGMENTS

To study the duration of microenvironments at different times of the day, we broke the diary day into eight 3-hour time segments and calculated the mean total duration -- across all respondents -- of microenvironments (location, exposure activity, and smoker-present categories) whose beginning times originated in each time segment. The entire length of the microenvironment was considered regardless of whether the ending time extended beyond the rightmost boundary of the 3-hour segment; and for each respondent, durations of all occurrences of a microenvironment in a time segment were summed to obtain the total duration. Thus, the mean total duration can exceed three hours (=180 minutes). No comparisons were made across subgroups.

The percentage of respondents initiating a microenvironment in each location for each of the 3-hour segments (Table 6-17 and Figure 6-59) was greatest for the Residential-Indoor location for all eight time segments. The location with the second highest percentage of respondents initiating a microenvironment over all time segments was Residential-Outdoor. The longest mean duration (over all occurrences) of any location was 408 minutes between 12:00 AM and 3:00 AM in Residential-Indoors (Table 6-18 and Figure 6-60). The next five longest durations were Mall/Store between 3:00 AM and 6:00 AM (400 min), Other Indoor between 12:00 AM and 3:00 AM (392 min), Office/Factory between 3:00 AM and 6:00 AM (382 min), Office/Factory between 6:00 AM and 9:00 AM (368 min), and School/Public Bldg between 3:00 AM and 6:00 AM (343 min). The peak duration for In Vehicle occurred between 3:00 AM and 6:00 AM (54 min).

The percentage of respondents initiating a microenvironment in each exposure activity -- excluding the No Exposure category -- for each of the 3-hour segments (Table 6-19 and Figure 6-61) was greatest for the Eat/Drink exposure activity between 6:00 AM and 9:00 PM (23% to 26%). The Bathing exposure activity had the largest percentage between 12:00 AM and 3:00 AM (1.7%), between

Table 6-17. Weighted Percentage of Respondents Who Entered a Location Beginning in Each of Eight Consecutive 3-Hour Time Segments

	Sample Size	Res. Ind.	In Veh.	Res.Out.	Near Veh.	Other Out.	Office/Fact.	Mall/Store	Sch./Pub.Bldg.	Bar/Rest.	Other Ind.
12am-3am	9685.2	91.33	0.37	3.22	0.43	0.36	0.88	0.23	0.90	1.15	1.13
3am-6am	2833.7	68.50	2.88	16.84	2.71	1.55	2.89	0.80	1.32	0.96	1.54
6am-9am	15875.2	43.19	4.21	23.63	6.26	2.01	6.58	1.34	9.32	1.31	2.15
9am-12pm	11631.1	35.88	7.02	22.96	5.78	3.37	3.88	6.31	8.57	3.67	2.57
12pm-3pm	13793.5	32.74	7.17	25.22	6.52	3.57	5.46	6.15	6.26	4.62	2.30
3pm-6pm	16080.2	39.68	7.74	29.03	6.74	2.46	1.65	4.50	3.43	2.87	1.90
6pm-9pm	13785.3	52.96	5.41	22.41	4.44	1.87	0.60	3.11	3.16	4.46	1.58
9pm-12am	9835.2	73.38	1.67	16.54	2.78	0.47	0.52	0.87	0.87	2.19	0.71

Note: The total weighted sample size is 9,196 (see Section 4). The total sample size of respondents entering locations in each 3-hour can exceed 9,196 since respondents may enter more than one location in any given 3-hour segment.

Table 6-18. Weighted Cumulative Durations (Minutes) of Locations Originating in Eight Consecutive 3-Hour Time Segments

	Res. Ind.	Res.Out.	In Veh.	Near Veh.	Other Out.	Office/Fact.	Mall/Store	Sch./Pub.Bldg.	Bar/Rest.	Other Ind.
12am-3am	408.54	140.14	69.4	217.13	338.5	308.46	335.53	281.16	124.69	391.65
3am-6am	135.3	100.69	54.41	122.94	231.85	382.45	400.22	343.1	165.07	285.62
6am-9am	111.7	134.85	36.66	81.34	211.92	368.44	217.88	303.17	144.26	233.99
9am-12pm	141.62	116.17	39.86	44.58	151.74	178.46	111.66	147.71	85.07	120.35
12pm-3pm	154.06	126.03	37.77	47.86	126.58	194.44	93.36	143.72	63.38	135.83
3pm-6pm	132.59	84.96	35.33	29.43	118.15	118.52	68.91	105.53	106.91	105.83
6pm-9pm	191.32	72.16	32.33	26.63	108.92	120.67	53.87	120.73	85.34	100.77
9pm-12am	128.73	39.93	26.39	14.39	63.63	65.69	29.26	88.64	78.88	93.26

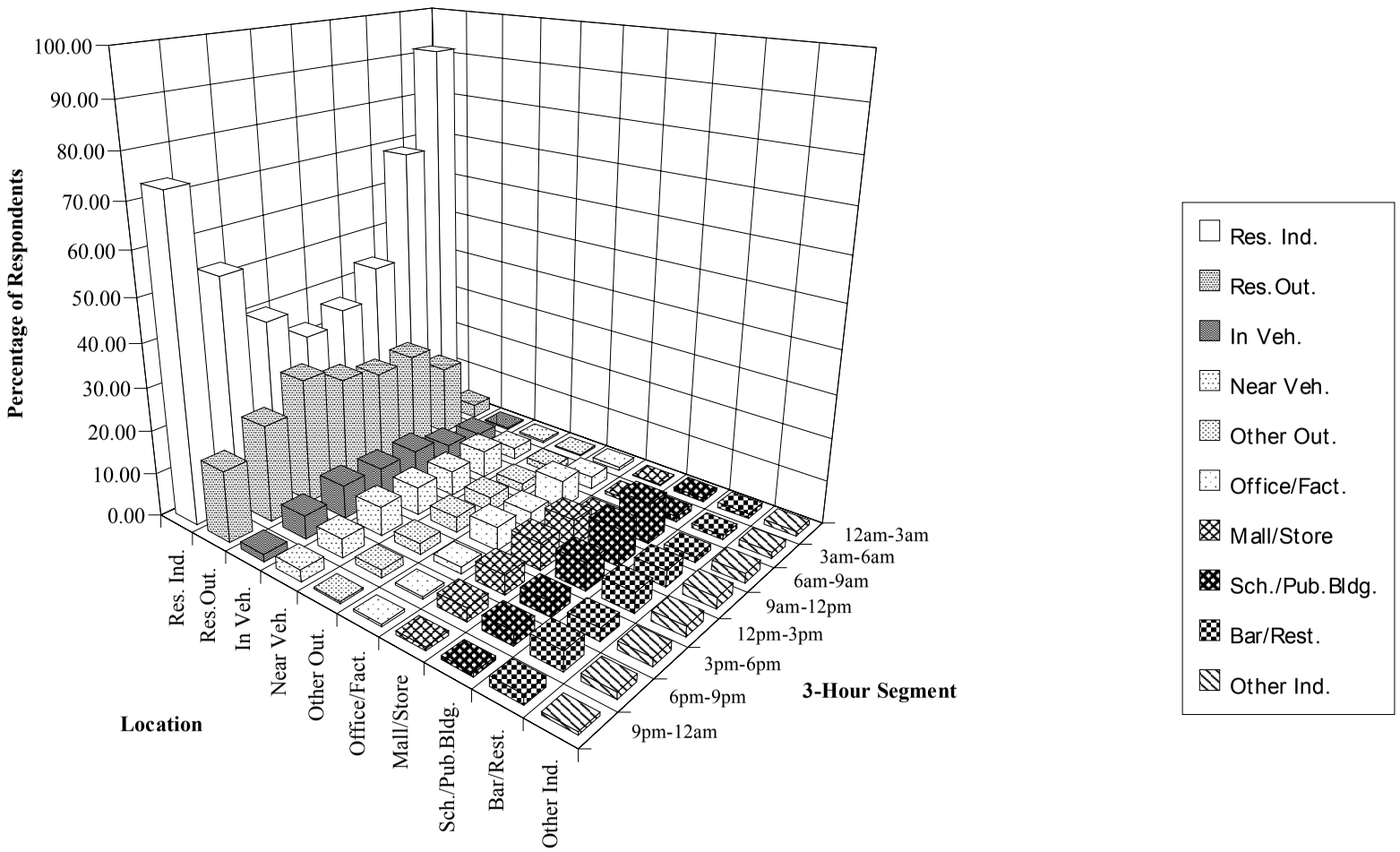


Figure 6-59. 3-D plot of the weighted percentage of respondents initiating a microenvironment in each of the eight 3-hour time segment for each location throughout the 24-hour diary day (see Table 6-17). Notice that the fractions in each time segment can add up to greater than 1 since a respondent can enter more than 1 location in any given 3-hour time segment.

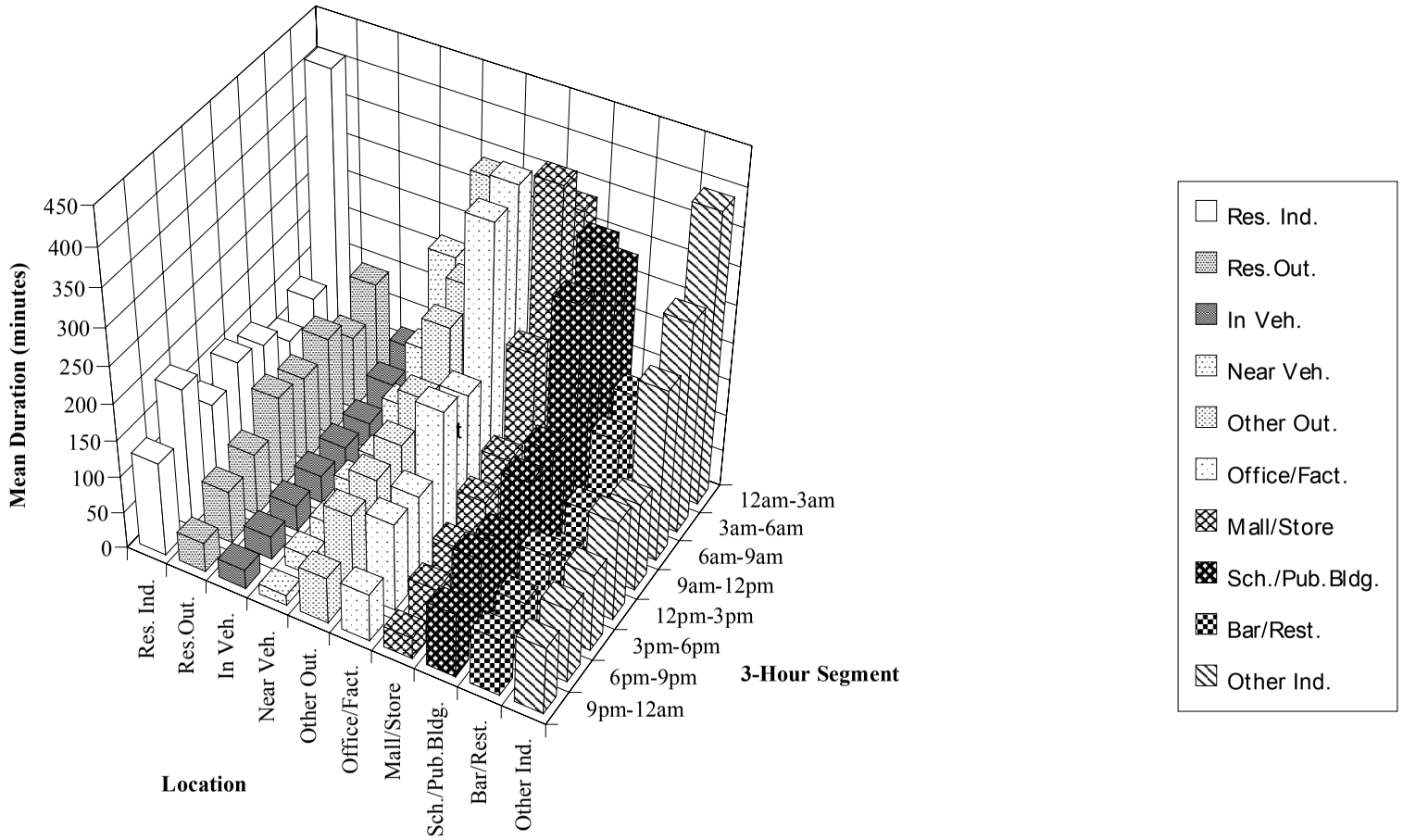


Figure 6-60. 3-D plot of the weighted mean duration in each location for each of the eight 3-hour time segments. The beginning times of the microenvironments originate in each time segment the durations are assigned to, but the ending times of the microenvironments may occur in a later time segment.

Table 6-19. Weighted Percentage of Respondents Who Entered an Exposure Activity Beginning in Each of Eight Consecutive 3-Hour Time Segments

	Sample Size	No Exp.	Food Prep.	Dishes/Laund.	Housekeep.	Bathing	Yard./Maint.	Sports/Exerc.	Eat/Drink
12am-3am	9507.4	96.56	0.24	0.05	0.14	1.70	0.11	0.10	1.10
3am-6am	3588.3	51.56	8.19	0.84	0.98	23.83	0.46	1.48	12.66
6am-9am	16530.5	41.63	9.03	2.02	3.70	16.75	1.92	1.75	23.19
9am-12pm	10883.8	49.26	6.10	3.08	5.24	9.08	3.06	3.54	20.63
12pm-3pm	12122.6	53.35	5.52	2.64	2.82	2.69	3.26	3.77	25.95
3pm-6pm	14312.2	50.79	11.54	2.67	2.21	4.66	2.68	4.80	20.67
6pm-9pm	16039.3	49.25	5.59	4.73	1.77	9.20	1.26	2.66	25.53
9pm-12am	9392.7	79.47	1.39	1.44	0.80	9.28	0.41	0.89	6.32

Note: The total weighted sample size is 9,196 (see Section 4). The total sample size of respondents entering exposure activity in each 3-hour can exceed 9,196 since respondents may enter more than one exposure activity in any given 3-hour segment.

Table 6-20. Weighted Cumulative Durations (Minutes) of Exposure Activities Originating in Each of Eight Consecutive 3-Hour Time Segments

	No Exposure	Food Prep.	Dishes/Laund.	Housekeep.	Bathing	Yard./Maint.	Sports/Exerc.	Eat/Drink
12am-3am	410.02	66.98	70.17	55.19	16.07	97.95	62.02	51.66
3am-6am	184.58	19.93	31.23	96.22	15.33	109.13	140.92	27.87
6am-9am	256.12	23.77	59.9	120.08	17.05	161.08	98.21	29.61
9am-12pm	181.57	34.07	54.54	111.17	22.83	126.2	109.77	35.12
12pm-3pm	182.95	38.29	62.64	105.47	28.12	132.53	112.44	35.72
3pm-6pm	147.18	48.61	39.47	67.35	24.04	79.43	91.41	40.84
6pm-9pm	182.1	34.5	33.91	50.05	24.22	78.39	77.24	39.3
9pm-12am	130.26	20.14	33.35	39.36	19.1	36.57	53.01	29.44

3:00 AM to 6:00 AM (24%), and between 9:00 PM and 12:00 AM (9.3%). Bathing also had the largest percentage besides Eat/Drink between 6:00 AM and 9:00 AM (17%), 9:00 AM and 12:00 PM (9%), and 6:00 PM to 9:00 PM (9%). Besides the No Exposure category, the longest mean total duration occurred for Yardwork/Maintenance between 6:00 AM and 9:00 AM (161 min) (Table 6-20 and Figure 6-62). The two next largest mean durations occurred for Sports/Exercise between 3:00 AM and 6:00 AM (141 min) and Housekeeping between 6:00 AM and 9:00 AM (120 min). During the 12:00 AM to 3:00 AM time segment, the greatest mean total duration occurred for the Eat/Drink (52 min), Dishes Laundry (70 min), and Food Preparation (67 min) exposure activities. The 12:00 AM to 3:00 AM time segments also have the smallest percentages of respondents initiating these exposure activities, so that only a small portion of the population is contributing to the long durations.

The largest percentage of respondents initiating a microenvironment where they were exposed to environmental tobacco smoke (ETS) occurred in the 3:00 PM to 6:00 PM (20%) and 6:00 PM to 9:00 PM time segments (21%) (Table 6-21 and Figure 6-63). The longest mean total duration of microenvironments where ETS exposure was initiated was in the 12:00 AM to 3:00 AM time segment (235 min), followed by the 6:00 AM to 9:00 AM (206 min) and 3:00 AM to 6:00 AM (183 min) time segments. The long mean durations between 12:00 AM and 6:00 AM are due to a small segment of the population since only 3-6% of the population is starting to experience ETS exposure during these times versus 10 to 21% for the other time segments.

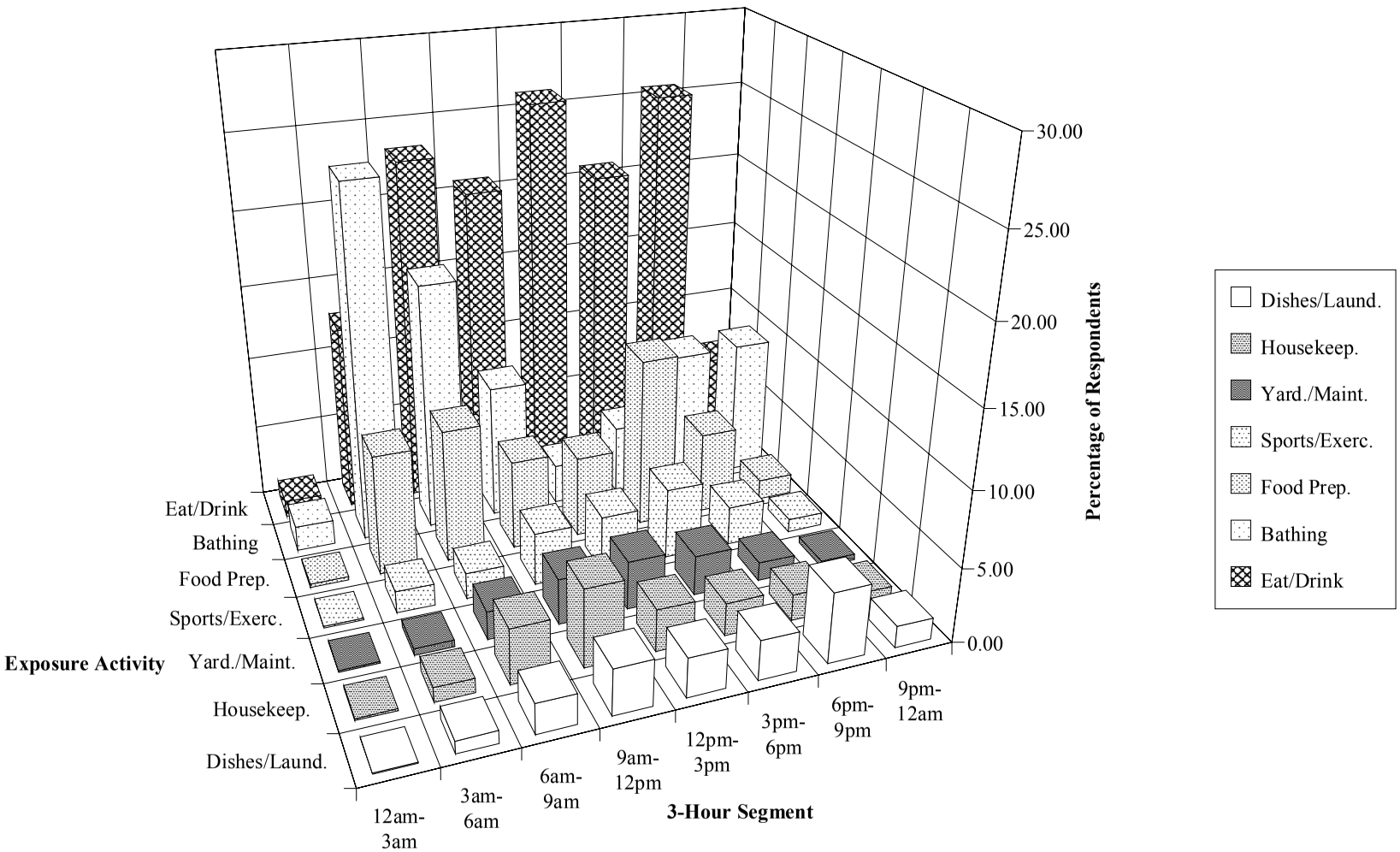


Figure 6-61. 3-D plot of the weighted percentage of respondents initiating a microenvironment in each of the eight 3-hour time segments by exposure activity throughout the 24-hour diary day (see Table 6-19). Notice that the percentages can sum to greater than 100 since a respondent can be in more than one microenvironment for any given 3-hour time segment.

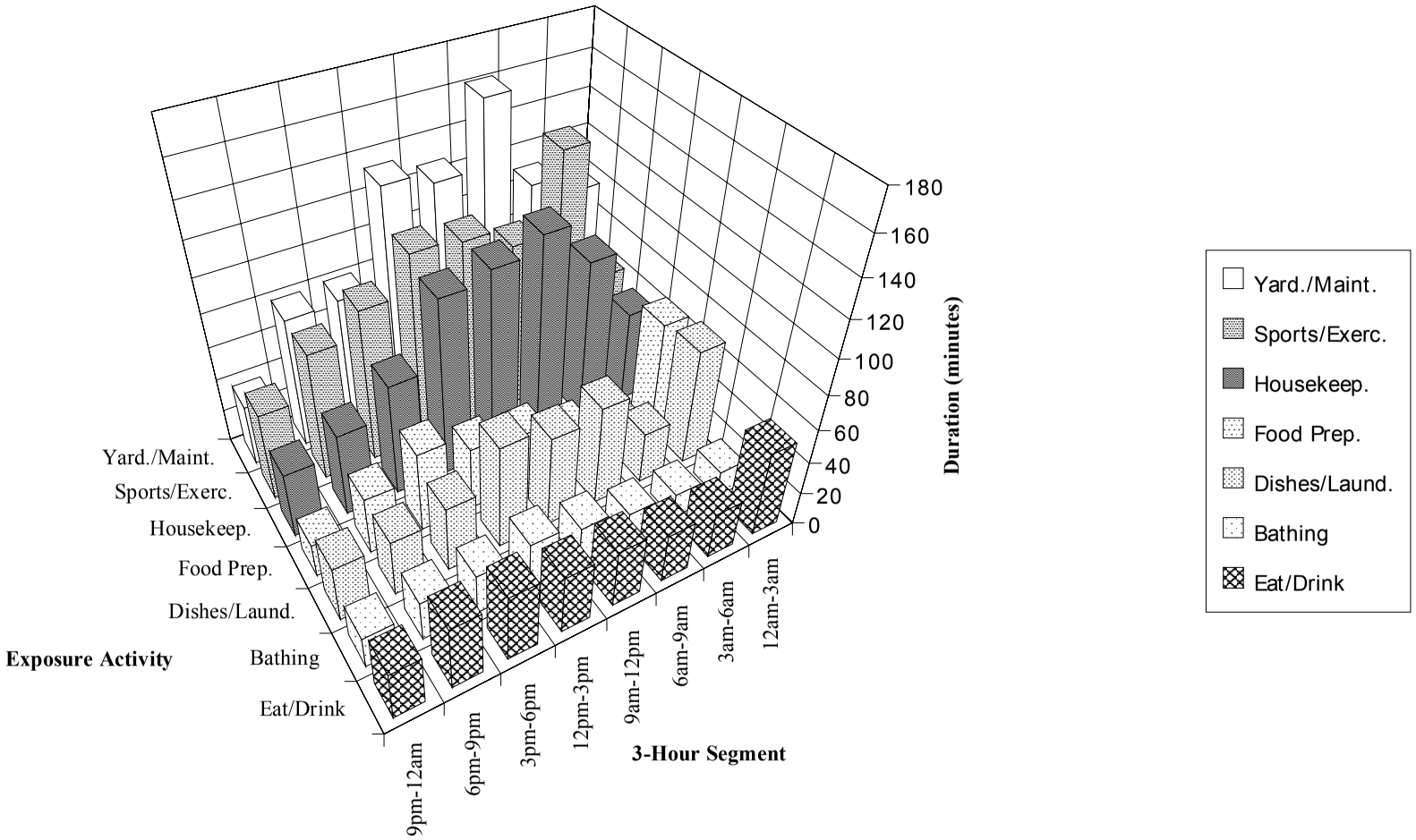


Figure 6-62. 3-D plot of the weighted mean duration in each exposure activity for each of the eight 3-hour time segments. The beginning times of the microenvironments originate in each time segment the durations are assigned to, but the ending times of the microenvironments may occur in a later time segment.

Table 6-21. Cumulative Weighted Duration and Weighted Percentage of Respondents for ETS Exposures Originating in Each of Eight 3-Hour Time Segments

	Percentage	**Duration**
12am-3am	5.94	235.6
3am-6am	3.15	182.86
6am-9am	16.86	205.92
9am-12pm	13.83	159.35
12pm-3pm	17.30	149.43
3pm-6pm	19.89	127.76
6pm-9pm	20.81	144.31
9pm-12am	9.87	88.86

Note: The Percentage column is the number of respondents who began an ETS exposure episode in each 3-hour segment divided by the weighted total sample size of persons who were exposed vs. persons who were never exposed (4025.9 + 4951.5 = 8977.4).

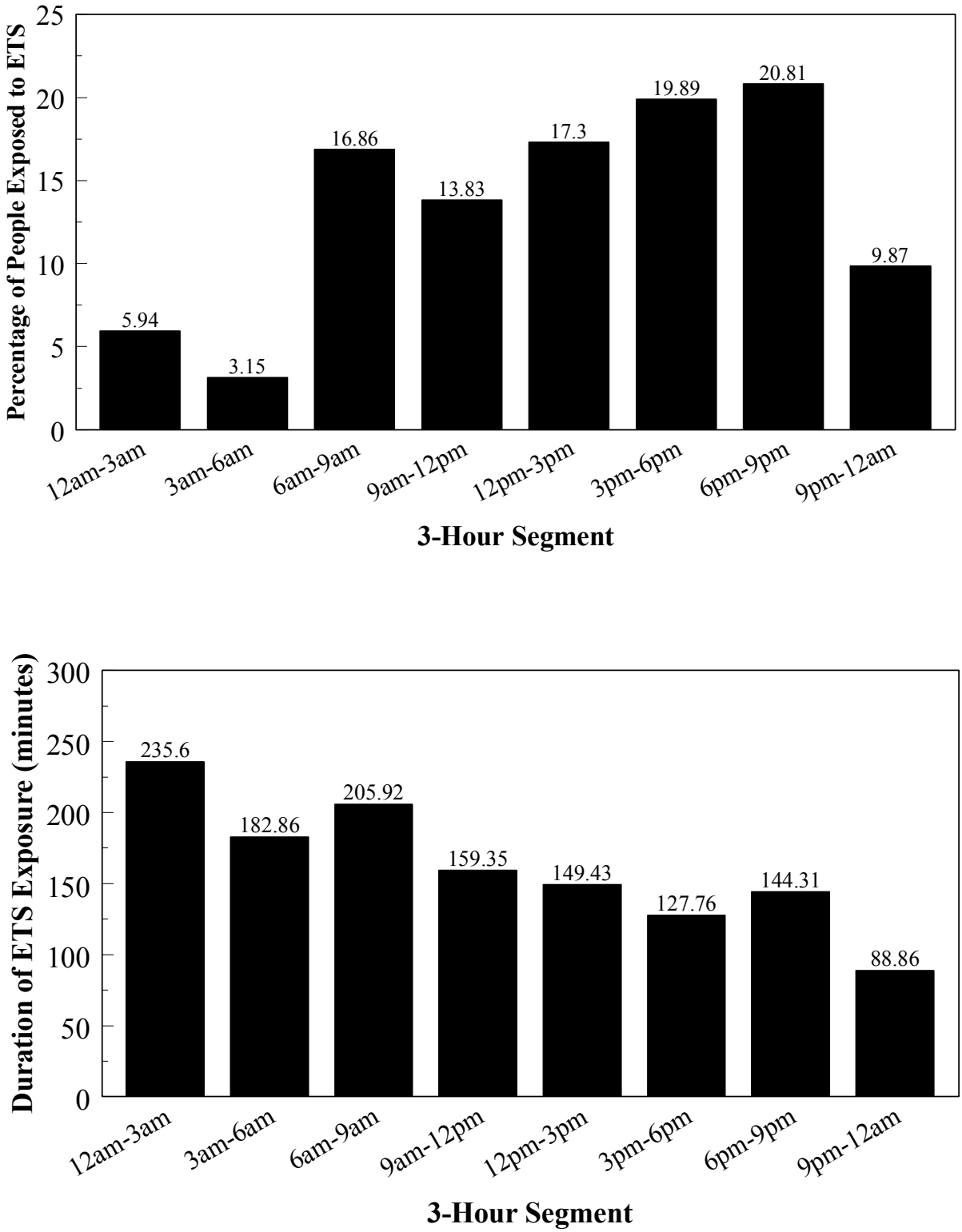


Figure 6-63. Bar charts of the weighted percentage of respondents exposed to ETS and the weighted mean duration of exposure to ETS (in minutes) for each of the eight 3-hour segments in the 24-hour diary day (see Table 6-21). The beginning times of the microenvironments originate in each time segment the durations are assigned to, but the ending times of the microenvironments may occur in a later time segment.

7. RESULTS OF FOLLOW-UP QUESTIONS ON PERSONAL EXPOSURE

Although the 24-hour diary data -- analyzed in Section 6 -- provides the most accurate frequencies and durations of specific exposure-related microenvironments, specific exposure-related background activities are not represented. For example, the general areas of Food Preparation and Housekeeping were not broken down into smaller classifications such as "Frying" or "Waxing the Floor". Similarly, while the diary data contain variables for the presence of a smoker in every microenvironment, direct smoking or the type of smoke source is not addressed. The 175 follow-up questions presented here were designed to retrieve specific exposure information for typical household pollutant sources such as dish detergent, floor wax, paints, glue, pesticides, engine exhaust, wood smoke, gas ovens, air fresheners, etc., and indirect and direct exposure to tobacco smoke. Unfortunately, however, many of the follow-up questions contain a substantial number of missing values or were coded in a way that makes them difficult to analyze.

To shorten the length of each interview, the follow-up questions were split into two groups. Some were placed on the A questionnaire, some on the B questionnaire, and some on both. Of the 9,386 total respondents, 4,723 were given the A questionnaire and 4,663 were given the B questionnaire. Both questionnaires were asked of respondents that were evenly distributed throughout the United States.

The TEAM studies[22-26] give the higher-than-outdoor kinds and levels of pollutants that are found in typical indoor microenvironments. Since the NHAPS follow-up questions mostly queried respondents on the activity portion of microenvironments, they have been grouped into ten categories of exposure based on the type of activity and assigned a unique two-letter code (Table 7-1). All tobacco smoke-related questions were placed into the TB group. Questions related to water exposure pathways were placed in the groups for Taking (and/or giving) a Bath, Showering, and Swimming (BA), Eating or Drinking (ED), and Washing (WA). Many of the air exposure pathway questions concerning a variety of combustion sources (other than tobacco smoke) such as fires, heating systems, and engine exhaust

Table 7-1. The Ten NHAPS Follow-Up Question Categories with Example Activities and Associated Chemicals

	Category Name/Description	Code	Examples of Activities	[a]Associated Chemicals
1	Bathing/Showering/Swimming	BA	Giving/Taking a Bath or Shower	Chloroform, ...
2	Miscellaneous Chemical Exposure	CE	Pesticides, Solvents, ...	Pesticides, VOCs, ...
3	Miscellaneous Combustion Sources	CS	Heating, Engine Exhaust, ...	Particles, CO, PAH, benzene, VOCs, NO_2, ...
4	Dust/Soil	DS	On Grass, Sand, In Garden, ...	Particles, Heavy Metals, ...
5	Eating/Drinking	ED	Water Drank, Seafood Eaten, ...	Pesticides, Heavy Metals, ...
6	Miscellaneous Home Characteristics	HC	Carpets, Windows Open, ...	
7	Medical Background	MB	Angina, Asthma, ...	
8	Some Other Category	OC	Microwave Use, Walking Outside, ...	
9	Tobacco Smoke Exposure	TB	Indirect/Direct Smoking	Particles, PAH, CO, benzene, VOCs, ...
10	Washing	WA	Laundry, Dishes, ...	Chloroform, ...

[a]CO = Carbon Monoxide; VOC = Volatile Organic Chemical; NO_2 = Nitrogen Dioxide; PAH = Polycyclic Aromatic Hydrocarbons; Heavy Metals include Lead, Mercury, and Cadmium. Measured particles typically consist of matter with diameters of 10 microns or less (PM_{10}).

Table 7-2. The Categorized NHAPS Follow-up Variables, If They Are on the A or the B Questionnaire, If They Are a Categorical Variable, and the Number of Missing, Refused, and "Don't Know" Responses (9386 total for A+B with 4723 for A and 4663 for B)

No.	Variable Name	Cat.	Variable Label	A	B	Type	% Y/N or Mean	Missing	Refused	DK
1.	BATH	BA	DID YOU TAKE OR GIVE ANY BATH YESTERDAY		B	C		1021 (21.9)		
2.	BATH#	BA	MINUTES RES SPEND TAKING SHOWERS	1	B			44	51	17
3.	BATHP	BA	DID YOU TAKE BATH YESTERDAY		B	C		4213 (90.3)		1
4.	KBASTAY	BA	MINUTES RES STAY B-RM RIGHT AFTER BATH		B	C		8	3617 (77.6)	28
5.	KBATH1	BA	DID RES TAKE OR BE GIVEN BATH YESTERDAY	1	B	C		4137 (88.7)		5
6.	KBATH1#	BA	# OF BATH RES Took OR Gave	1	B			6		69
7.	KBATH1M	BA	# OF MINUTES RES SPEND IN TAKE-GIVEN BATH		B			7	3617 (77.6)	20
8.	KBAWIN	BA	WAS WINDOW OPEN OR EXAUST FAN ON		B			7	3617 (77.6)	8
9.	KBDOOR	BA	WAS BATH ROOM DOOR CLOSED		B	C		7	3617 (77.6)	15
10.	KIDSWIM	BA	# OF TIMES SWIMMING	1	B			6		5
11.	KSWIM	BA	DID KID SWIM IN SWIMMING POOL LAST MONTH	1	B	C	14/86	3		22
12.	KSWM	BA	MINUTES RES IN WATER WHEN SWIMMING		B		14/86	6	4004 (85.9)	13
13.	SHBAST#	BA	HOW LONG RES STAY B-RM RIGHT AFTER BATH	A				6	430 (9.1)	101 (2.1)
14.	SHDOOR	BA	WAS B-RM DOOR CLOSED WHEN RES SHOWERED		B	C		43	1030 (22.1)	70
15.	SHOWBA	BA	DID RES TAKE SHOWER OR BATH YESTERDAY	1 A		C	91/8	32		17
16.	SHOWBA#	BA	HOW LONG FOR SHOWER OR BATH	1 A				4	430 (9.1)	37
17.	SHOWER	BA	DID RES TAKE A SHOWER YESTERDAY	1	B	C	77/22	38		10
18.	SHOWER#	BA	# OF TIMES RES TOOK SHOWER	1	B			40		15
19.	SHROOM	BA	MINUTE RES STAY B-RM RIGHT AFTER SHOWER		B			44	1030 (22.1)	55
20.	SHWIND	BA	WAS BATH-RM WINDOW OPEN OR EXAUST FAN ON		B	C		43	1030 (22.1)	20
21.	AEROSAL	CE	DID SM USE AEROSOL SPRAY PRODUCTS	1 A		C	32/67	36		32
22.	AEROSAL#	CE	ABOUT HOW MANY TIMES	1 A				39		40
23.	AGENT	CE	EXPOSED TO CLEANING AGENTS-POWERS-AMMOMIA	1 A		C	20/80	26		18
24.	AGENT#	CE	ABOUT HOW MANY MINUTES	A				7	3795 (80.4)	16
25.	DEODORT	CE	TOILET-BOWL DEODORIZERS USED AT HOME	1 A		C	44/56			35
26.	FLOORWAX	CE	EXPOSED TO FLOOR-FURNITURE WAX	1 A		C	7/92	24	1	14
27.	FLOORWAX #	CE	ABOUT HOW MANY MINUTES	A				7	4385 (92.8)	5
28.	FRESHNER	CE	are AIR FRESHeNERS USED AT HOME	1 A		C	64/36			14
29.	GLUE	CE	EXPOSED TO GLUES-ADHESIVES	1 A		C	6/93	22	1	31
30.	GLUE#	CE	ABOUT HOW MANY MINUTES	A				7	4416 (93.5)	5
31.	GLUEUSE	CE			B	C		5	4219 (90.5)	35
32.	GSTATIO#	CE		A				7	3739 (79.2)	10
33.	GSTATION	CE	ABOUT HOW MANY MINUTES ALTOGETHER	1 A			21/78	29		15
34.	IPAINT	CE	INDOOR PAINTING	1	B	C	25/74	4		15
35.	LAWN	CE	LAWNMOWERS-OTHER DEVICES STORED AT HOME	1 A	B	C	26/73			31
36.	MOTHBALL	CE	MOTHBALLS-CRYSTALS-CAKES USED AT HOME	1 A		C	14/85			48
37.	NPOLISH	CE	USE NAIL POLISH YESTERDAY	1 A		C	5/87	364 (7.7)		8
38.	OTHPUMP	CE	DID SM PUMP GAS WHILE RES IN CAR	A		C		3746 (79.3)		5
39.	PAINT	CE	PAINTS-VARNISHES STORED AT HOME	1 A	B	C	44/55			82
40.	PAINTAP#	CE	ABOUT HOW MANY MINUTES	A				7	4436	3
41.	PAINTAPP	CE	EXPOSED TO APPLIED PAINT-OPEN PAINT CAN	1 A		C	6/93	17		19
42.	PERFUME	CE	USE COLOGNE-PERFUME-AFTERSHAVE-FRAGRANCE	1 A		C	47/45	364 (7.7)		18
43.	PERFUME#	CE	HOW MANY TIMES	1 A				369 (7.8)		22
44.	PERSPEST	CE	# OF TIMES P-CIDES APPLIED PERSONALLY		B			5	2712 (58.2)	29
45.	PEST	CE	ANY PESTICIDES USED TO GET RID OF PESTS?	1	?	C	42/58			37
46.	PEST1	CE	EXPOSED TO PESTICIDES-BUG SPRAYS	1 A		C	6/94	24	1	15
47.	PEST1#	CE	ABOUT HOW MANY MINUTES	A				7	4451 (94.2)	7

48.	PESTLOC	CE	WHERE WERE PESTICIDES USED			B	C		5	2712 (58.2)	7
49.	PROPEST	CE	# TIMES P-CIDES APPLIED BY PROFESSIONAL			B			5	2712 (58.2)	23
50.	PUMPGAS	CE	DID YOU PUMP GAS AT GAS STATION		A		C		142	3739	8
51.	SOLV	CE	EXPOSED TO SOLVENTS-FUMES	1	A		C		22	1	25
52.	SOLV#	CE	ABOUT HOW MANY MINUTES		A				7	4217 (89.3)	3
53.	SOLVENT	CE	WOODWORKING SOLVENTS-ADHESIVES AT HOME	1		B	C				87
54.	STAIN	CE	EXPOSED TO STAIN OR SPOT REMOVERS	1	A		C		27		12
55.	STAIN#	CE	ABOUT HOW MANY MINUTES		A				7	4605 (97.5)	2
56.	AGAR#	CS	# OF TIMES car was started		A	B			7	2859 (60.5)	27
57.	AGARC#	CS	# OF TIMES car started w. G-DOOR CLOSED		A	B			48	5643 (60.1)	33
58.	AUTOGAR	CS	ANY AUTO STARTED IN GARAGE YESTERDAY		A	B	C		8	5643 (60.1)	15
59.	ESPAHEAT	CS	ANY RM HEATED WITH ELECTRIC SPACE HEATER		A		C		3	2813 (59.6)	4
60.	FIREHEAT	CS	ANY RM HEATED WITH FIREPLACE		?		C		3	2813 (59.6)	1
61.	FIREPLAC	CS	DO YOU USE A FIREPLACE	1		B	C	10/89	4		43
62.	FLAMES	CS	EXPOSED TO OPEN FLAMES	1			C	10/89	19	1	9
63.	FUEL	CS	MAIN TYPE OF FUEL USED IN THIS SYSTEM	1		B	C		1		296
64.	FUELY	CS	WHAT KIND FUEL USED IN CENTRAL FURNACE		A		C		386	2813 (59.6)	65
65.	FURNY	CS	WAS CENTRAL FURNACE TURNED ON		A		C		3	2813 (59.6)	25
66.	GASCAN	CS	GASOLINE-KEROSENE STORED AT HOME	1	A	B	C	19/80			57
67.	GASQUIP	CS	EXPOSED TO GAS-DIESEL POWERED EQUIPMENT	1	A		C	8/91	24		15
68.	GASQUIP#	CS	ABOUT HOW MANY MINUTES		A				6	4322 (91.5)	5
69.	HEAT	CS	MAIN TYPE OF HEATING SYSTEM USED AT HOME	1		B	C		1		160
70.	HEATY	CS	WAS ANY HEAT TURNED ON AT HOME YESTERDAY	1	A		C	40/58	34	18	31
71.	HEAVYT#	CS	FOR HOW MANY MINUTES ALTOGETHER		A				6	3503 (74.2)	17
72.	HEAVYTRF	CS	WAS RES IN CAR-VAN-TRUCK IN HEAVY TRAFFIC	1	A		C	26/73	43		24
73.	INDGAR	CS	WAS RES IN GARAGE-INDOOR PARKING LOT	1	A		C	6/92	44		17
74.	INDGAR#	CS	FOR HOW MANY MINUTES ALTOGETHER		A				7	4418 (93.5)	4
75.	KERHEAT2	CS	ANY RM HEATED WITH KEROSENE SPACE HEATER		A		C		3	2813 (59.6)	2
76.	KEROHEAT	CS	DO YOU USE A KEROSENE SPACE HEATER	1		B	C	2/97	4		44
77.	OFUEL	CS	ANY OTHERS		A		C		452 (9.6)	4103 (86.9)	12
78.	OTHEAT	CS	ANY OTHER SOURCES OF HEATING	1		B	C	22/77	1		49
79.	OTHEATD	CS	ANY OTHER HEAT SOURCES?	1		B	C	3/96	4		43
80.	OTHHEAT	CS	ANY RM HEATED WITH ANY OTHER HEAT SOURCE		A		C		3	2813 (59.6)	2
81.	OVENHEAT	CS	DID YOU USE GAS RANGE-OVEN TO HEAT HOME		A		C		8	3668 (77.7)	1
82.	OVENON	CS	WAS RES AT HOME WHEN GAS OVEN USED		A		C		6	2934 (62.1)	10
83.	OVENON#	CS	HOW LONG RES AT HOME WHEN OVEN WAS ON		A				7	3668 (77.7)	22
84.	OVHEAT#	CS	ABOUT HOW MANY NIMUTES		A				7	4687 (99.2)	6
85.	RUNHEAV	CS	DID RES RUN-WALK ON HEAVY TRAFFIC RD	1	A		C	9/90	43		21
86.	RUNHEAV#	CS	FOR HOW MANY MINUTES ALTOGETHER		A				7	4310 (91.3)	5
87.	SPILOT	CS	DOES RANGE-OVEN HAVE BURNING PILOT LIGHT		A	B	C	27/72	11	5782 (61.6)	103
88.	STOVE	CS	DO YOU HAVE A GAS RANGE OR OVEN	1	A	B	C	38/61	28		61
89.	WOODSTOV	CS	DO YOU USE A WOOD STOVE	1		B	C	6/93	4		43
90.	WSTOVE	CS	ANY ROOM HEATED WITH WOOD STOVE		A		C		3	2813 (59.6)	1
91.	DIRT#	DS	HOW MANY MINUTES ON DIRT		A	B			5699 (60.7)	2987 (31.8)	53
92.	DUST	DS	EXPOSED TO EXCESSIVE DUST IN THE AIR	1	A		C	15/83	26	57	
93.	DUST#	DS	ABOUT HOW MANY MINUTES		A				6	4015 (85)	23
94.	GRASS#	DS	HOW MANY MINUTES ON GRASS		A	B			5699 (60.7)	2987 (31.8)	43
95.	GROUND	DS	DID KID PLAY ON SAND-GRAVEL-DIRT-GRASS		A	B	C		5699 (60.7)	2800 (29.8)	12
96.	KIDFLOOR	DS	DID KID CRAWL-LIE-PLAY ON FLOOR AT HOME		A	B	C		5699 (60.7)	2114 (22.5)	17
97.	KIDOUT	DS	DID KID SPEND TIME PLAYING OUTDOORS		A	B	C		5699 (60.7)	2114 (22.5)	30

98.	MAT	DS	ANY WELCOME MATS FOR WIPING FEET	1		B	C	88/12			5
99.	SAND#	DS	HOW MANY MINUTES SPENT ON SAND OR GRAVEL		A	B			5707 (60.8)	2987 (31.8)	33
100.	SOILHR	DS	HOURS RES WORKED IN GARDEN-WITH SOIL	1		B			3		88
101.	VACUUM	DS	FREQ OF SWEEPING-VACUUMING FLOORS	1		B					25
102.	VACUUMD	DS	# OF DAYS SINCE THAT AREA SWEPT-VACUUMED		A	B			5699 (60.7)	2413 (25.7)	11
103.	BOTTWAT	ED	IS BOTTLED WATER EVER USED IN YOUR HOME	1		B	C	43/57			7+1
104.	CHAR#	ED	# OF SERVINGS OF CHARRED FOOD	1		B			5		100
105.	CHARCOAL	ED	DID RES EAT any FOOD BLACKENED-CHARRED		A	B	C		4723 (50.3)	1	83
106.	FRIED	ED	EXPOSED TO FOOD BEING FRIED-GRILLED	1	A		C	23/76	19	1	22
107.	FRIED#	ED	ABOUT HOW MANY MINUTES		A				6	3641 (77.1)	20
108.	GLASS#	ED	GLASSES TAP WATER RES DRANK YESTERDAY	1		B			31		138
109.	JUICE#	ED	GLASSES JUICE WITH TAP WATER RES DRANK	1		B			34		66
110.	SEACP	ED	WAS SEAFOOD PURCHASED OR CAUGHT			B	C		2	1884 (40.4)	39
111.	SEAFOOD	ED	DID RES EAT SEAFOOD LAST MONTH	1		B	C	60/39			72
112.	SEAFOOD#	ED	OF SERVINGS RES ATE SEADFOOD	1		B			1		136 (2.9)
113.	SODA	ED	CAN-BOTTLE CARBONATED DRINKS RES DRANK	1		B			35		27
114.	ATGARAGE	HC	DO YOU HAVE AN ATTACHED GARAGE OR CARPORT		A	B	C		1650 (17.6)	4	8
115.	BASEMNT	HC	IS THERE A BASEMENT IN YOUR BUILDING	1	A	B	C	43/55	2		125
116.	CARP	HC	# OF ROOMS BEING CARPETED	1	A	B			4		161 (1.7)
117.	CARPORT	HC	LAYING CARPET	1		B	C	9/90	4		15
118.	DOOROUT	HC	ANY HOME DOORS OPEN DIRECTLY TO OUTSIDE	1	A		C	84/15	36	18	12
119.	DOPENTI	HC	HOW MANY TIMES AN OUTSIDE DOOR OPENED		A				7	3529 (74.7)	55
120.	DROPEN	HC	ANY OUTSIDE DOORS LEFT OPEN YESTERDAY		A		C		2	768 (16.3)	19
121.	DROPEN#	HC	HOW LONG OUTSIDE DOORS LEFT OPEN		A				7	3529 (74.7)	17
122.	ELECHEAT	HC	DO YOU USE AN ELECTRONIC HEATER	1		B	C	8/91	4		45
123.	FLAME#	HC	ABOUT HOW MANY MINUTES		A				6	4227 (89.5)	10
124.	FLOOR	HC	REFINISHING FLOORS	1		B	C	5/95	4		16
125.	FLOORCAR	HC	IS THAT FLOOR AREA CARPETED		A	B	C		5699 (60.7)		
126.	GAL#	HC	#OF GALLONS OF WATER USED PER WEEK			B			2	2655 (56.9)	70
127.	HOUSING	HC	HOUSING TYPE	1	A	B	C		1+1		98
128.	HUMI	HC	IS A PORTABLE HUMIDIFIER USED AT HOME	1	A	B	C	21/79	1		22
129.	HUMID	HC	FREQ OF USING HUMIDIFIER			B			5	3610 (77.4)	24
130.	HUMIDR	HC	TYPES OF HUMIDIFIER		A		C		5	3785 (80.1)	84
131.	RENOVA	HC	WAS HOUSE RENOVATED	1		B	C	31/69			13
132.	ROOM	HC	ADDING ROOMS TO THE HOUSE	1		B	C	4/96	4		16
133.	ROOMS	HC	# OF ROOMS IN HOME	1	A	B					
134.	STORIES	HC	# OF FLOORS IN HOME OR BUILDING	1	A	B					
135.	STORWORK	HC	# OF STORIES WORK BUILDING		A				893 (18.9)	1373 (29.1)	164
136.	WATER	HC	WHERE DO YOU GET WATER FOR HOUSEHOLD USE	1		B	C				46
137.	WINDMIN	HC	AMOUNT OF TIME WINDOWS LEFT OPEN		A				25	2712 (57.4)	26
138.	WINDY	HC	WERE WINDOWS LEFT OPEN WHEN RES AT HOME	1	A		C	43/56	35	18	35
139.	WINDY#	HC	# OF WINDOWS LEFT OPEN	1	A				40	18	55
140.	YEARHOME	HC	YEAR OF MOVING INTO HOME	1	A	B		1984			262
141.	ANGIN	MB	DOES RES HAVE ANGINA	1	A	B	C	3/97			75
142.	ASTHMA	MB	DOES RES HAVE ASTHMA	1	A	B	C	7/92		1	60
143.	EMPHYS	MB	DOES RES HAVE BRONCHITIS OR EMPhYSEMA	1	A	B	C	5/95			71
144.	PREGNANT	MB	IS RES PREGNANT	1	A	B	C				
145.	MICRO	OC	DID RES USE A MICROWAVE YESTERDAY	1	A		C	49/42	366 (7.7)		45
146.	MICRO#	OC	ABOUT HOW MANY MINUTES		A				7	2384 (50.5)	32
147.	OTHOUT	OC	DID RES SPEND OTHER TIME RUN-WALK OUTSIDE	1	A		C	27/70	89		28
148.	OTHOUT#	OC	FOR HOW MANY MINUTES ALTOGETHER	1	A				??		
149.	SLEEP	OC	WHERE DID YOU SLEEP WHILE RENOVATING			B	C		4	3210 (68.8)	5

150.	WALKCAR	OC	DID RES WALK OUTSIDE TO CAR IN DRIVEWAY	1	A		C		44		22
151.	WALKCAR#	OC	FOR HOW MANY MINUTES ALTOGETHER		A				6	1363 (28.9)	51
152.	CIGAR	TB	DID YOU SMOKE CIGARS-TOBACCO YESTERDAY		A	B	C		1045 (11.1)	1	4
153.	CIGARMIN	TB	FOR ABOUT HOW MANY MINUTES		A	B			527 (5.6)	4619 (49.2)	7
154.	OTHSMO	TB	DID SB SMOKE CIGARETTES AT R'S HOME		A		C		897 (19)		17
155.	OTHSMO#	TB	# OF CIGARETTES THEY SMOKED		A				901 (19.1)		85
156.	SMOAWAY#	TB	# OF CIGARETTES RES SMOKED OUTSIDE HOME		A				519 (11)		37
157.	SMOHO	TB	IS SMOKING ALLOWED IN YOUR HOME		A	B	C		1382 (14.7)		28
158.	SMOHO#	TB	#OF HOUSEHOLD MEMBERS WHO SMOKE AT HOME			B			2782 (59.7)		3+1+1
159.	SMOKE#	TB	# OF CIGARETTES SMOKED AT HOME TOTAL		A				3826 (81)	18	17
160.	SMOKE1	TB	MINUTES SPENT SMOKING	1	A	B		382	0=????		
161.	SMOKEHO	TB	DID ANYONE SMOKE CIGARETTES AT R'S HOME		A		C		3824 (81)	18	3
162.	SMOKEHOA	TB	# OF CIGARETTES RES SMOKED AT HOME		A				519 (11)		23
163.	SMOKES#	TB	# OF CIGARETTES YOU SMOKED YESTERDAY			B			533 (11.4)		10
164.	SMOY	TB	DID YOU SMOKE CIGARETTES YESTERDAY		A	B	C		1045 (11.1)		
165.	DHAND	WA	FREQ RES WASH-RINSE DISHES BY HAND			B			1	998 (21.4)	12
166.	DISH	WA	DO YOU HAVE A DISHWASHER AT HOME	1		B	C	57/43			14
167.	DISH#	WA	FREQ RES USed DISHWASHER			B			4	2025 (43.4)	46
168.	DISHHAND	WA	DOES RES WASH-RINSE DISHES BY HAND	1		B	C	79/17	206 (4.4)		16
169.	DISHWASH	WA	WAS DISHWASHER USED WHEN RES AT HOME	1	A		C	21/77	33	18	32
170.	LAUNDRY	WA	ARE CLOTHES DONE AT HOME OR AT LAUNDROMAT	1		B	C				21
171.	WASHAH	WA	WAS WASHING MACHINE USED WHEN RES AT HOME	1	A		C	?	33	18	49
172.	WASHK	WA	# OF TIMES KID WASHED HANDS YESTERDAY	1		B			38		189 (4.1)
173.	WASHLOAD	WA	# OF LOADS OF LAUNDRY DONE WHEN RES HOME	1	A				39	18	87
174.	WASHMACH	WA	WHERE IS YOUR WASHING MACHINE LOCATED			B	C		1	746 (16)	6
175.	WMACH#	WA	FREQ RES WASH CLOTHES IN MACHINE	1		B			368	35	37

Note: The numbers in parentheses are percentages of the total number: 9386 for A+B, 4723 for A, and 4663 for B. Shaded rows designate variables that have more than 10% missing, refused or "don't know" responses.

were placed in the CS group. Any question on chemical or solvent exposure via either air or dermal contact was placed in the CE group. The general questions on housing characteristics such as renovations, number of carpets, number of windows left open, water sources, etc. were put in the HC group. Any question not easily placed in one of the above categories was put into the OC group.

The follow-up variables that contain the NHAPS respondents' answers to each of the 175 follow-up exposure questions are listed in Table 7-2. The variables are listed alphabetically under each of the groups described above. Thirty-four of the follow-up questions were asked of all 9,386 NHAPS respondents, 77 of them were asked of 4,723 respondents on the A Questionnaire, and 60 of them were asked of 4,663 respondents on the B Questionnaire. The columns in Table 7-2 contain: the variable number, the variable name, the category name (see Table 7-1), the variable label, the questionnaire (A or B), the variable type (either categorical or numeric), either the overall % answered yes or no (categorical) or the overall mean (numeric), the number of missing values, the number of refused values, and the number of "don't know" answers. Categorical variables can have two values (yes/no) or multiple values (*e.g.*, for housing type). Either the percent answered yes/no or the mean is included for variables with enough actual data.

Unfortunately, many of the NHAPS follow-up variables contain substantial numbers of missing, "refused to answer", or "don't know" responses, especially the variables containing numeric or interval data (an exact number) that attempt to measure frequencies of occurrence ("how many times...") or durations ("how many minutes...") of exposure events. Some of these missing values arise because the variables are dependent on yes/no questions where most of the responses were "no". However, in addition, most of these variables were coded with **both** interval and categorical data types, which makes them difficult to analyze.

The yes/no variables with less than 10% overall invalid responses were analyzed by the percentage of "yes" responses out of the total number of "yes" and "no" answers (missing values, "don't know", or

"refused" responses were omitted). The results were broken down by the exposure categories in Table 7-1. The ten yes/no follow-up variables asked of 9,386 combined respondents on both questionnaire A and B that contain enough useful information are ANGIN, ASTHMA, BASEMNT, CARP, EMPHYS, GASCAN, HUMI, LAWN, PAINT, and STOVE. There are 28 yes/no variables on questionnaire A and 21 on questionnaire B that had adequate amounts of valid data. There were 14 variables analyzed for the Chemical Exposure (CE) category (Figures 7-1 and 7-2; Table 7-3), 10 for the Combustion Sources (CS) category (Figure 7-3; Table 7-4), 8 for the combined Washing and Bathing (WA./BA) categories (Figure 7-4; Table 7-5), 4 for the Medical Background (MB) category (Figure 7-5; Table 7-6), 9 for the Housing Characteristics (HC) category (Figure 7-6; Table 7-7), and 8 for other categories (OC, DS, ED) (Figure 7-7; Table 7-8). The percentage of "yes" answers to exposure questions were used to assign relative amounts of exposure across the different subgroups.

The highest absolute percentages of "yes" answers can be used to determine which exposures are the most significant both overall and within each subgroup. Overall percentages of "yes" answers over 50% occurred for exposure to air fresheners, the use of dish washers, taking a shower, washing dishes by hand, giving/taking a bath, children swimming, having a door leading directly outdoors, use of a microwave, running/walking outdoors, walking to a car in the driveway, and the use of a welcome mat.

Females had more exposures to nail polish, floor wax, spot/stain removers, cleaning agents, aerosols, and air fresheners, while males had more exposures to applied paint, glue, solvents, stored lawn mowers, and stored paint (Figures 7-1 and 7-2; Table 7-3). Respondents aged 5-17 had the most exposure to glue, stored paint, stored lawn mowers, and air fresheners, while those aged 18-64 had the most exposure to every other item in the CE category except mothballs and deodorant, which were highest for those aged 65 and older. There was more exposure to pesticides in the summer than in any other season, and exposure to glue occurred the most in the fall.

Table 7-3. Percentage of "Yes" Responses for Follow-Up Questions on Chemical Exposure (CE)

Variable	AGENT	AEROSOL	DEODORT	FLOORWAX	FRESHNER	GLUE	MOTHBALL	NPOLISH	PAINTAPP	PEST1	SOLV	STAIN	LAWN	PAINT
Overall	18.99	33.33	45.62	7.21	65.01	8.28	12.87	4.85	6.06	5.54	10.92	2.65	29.73	46.70
Males	13.01	26.53	48.82	4.34	63.26	9.88	12.85	0.66	7.19	5.75	12.94	2.21	32.67	48.58
Females	24.63	39.76	42.63	9.93	66.66	6.77	12.88	8.79	4.99	5.34	9.00	3.05	26.94	44.90
0-4	10.29	17.42	42.12	6.05	60.44	4.46	4.57	0.00	2.74	2.37	2.40	0.62	29.47	46.06
5-17	10.18	31.06	43.15	5.83	67.15	13.46	11.43	4.71	4.68	5.07	8.27	1.26	32.36	52.69
18-64	22.01	37.35	45.87	8.14	66.47	8.58	11.96	5.25	7.21	6.10	14.16	3.52	30.61	46.98
65+	20.97	24.93	49.83	5.16	57.34	1.78	24.09	3.04	4.08	5.16	3.14	1.33	21.73	36.82
Northeast	20.85	30.66	45.88	6.99	63.33	8.59	17.51	3.97	5.95	3.71	13.06	2.56	26.02	51.81
Midwest	16.12	33.88	41.86	8.23	63.50	8.58	10.57	4.13	6.18	5.57	11.40	2.12	32.88	54.59
South	18.51	37.10	51.99	7.80	69.07	7.27	15.61	4.71	5.54	6.54	9.20	2.75	30.75	37.61
West	21.60	28.67	38.85	5.16	61.41	9.37	6.55	6.83	6.87	5.49	11.29	3.19	27.85	48.02
Weekday	18.56	33.03	45.23	6.78	64.04	9.37	12.98	4.47	6.99	5.85	11.73	2.61	29.71	46.77
Weekend	20.08	34.07	46.61	8.31	67.44	5.54	12.59	5.82	3.72	4.77	8.87	2.73	29.79	46.52
Winter	19.60	31.99	45.24	8.80	63.40	7.59	12.97	4.40	4.84	2.59	12.04	2.13	29.66	46.53
Spring	17.07	33.51	43.01	6.57	64.39	6.85	12.24	5.97	6.36	6.54	9.93	3.07	29.64	48.10
Summer	19.29	32.67	46.26	6.08	65.04	6.79	13.82	4.53	6.79	9.12	12.22	3.67	28.16	43.09
Fall	19.98	35.05	47.89	7.42	67.09	11.70	12.46	4.51	6.21	3.95	9.59	1.73	31.49	49.06

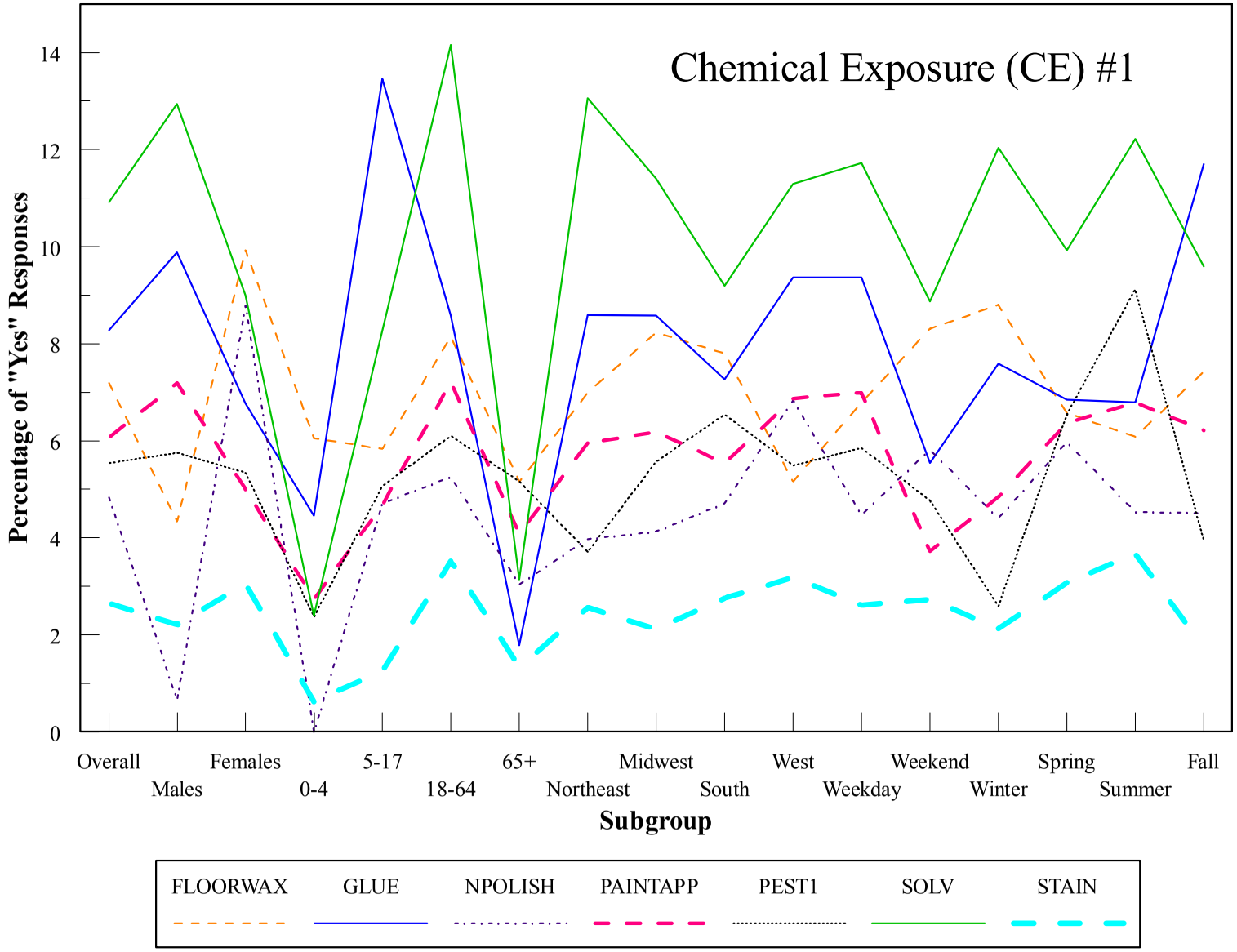


Figure 7-1. The weighted percentage of respondents that answered "yes" to questions on chemical exposure: floor wax, glue, nail polish, applied paint or open paint cans, pesticides/bug sprays, solvents/fumes, stain/spot removers.

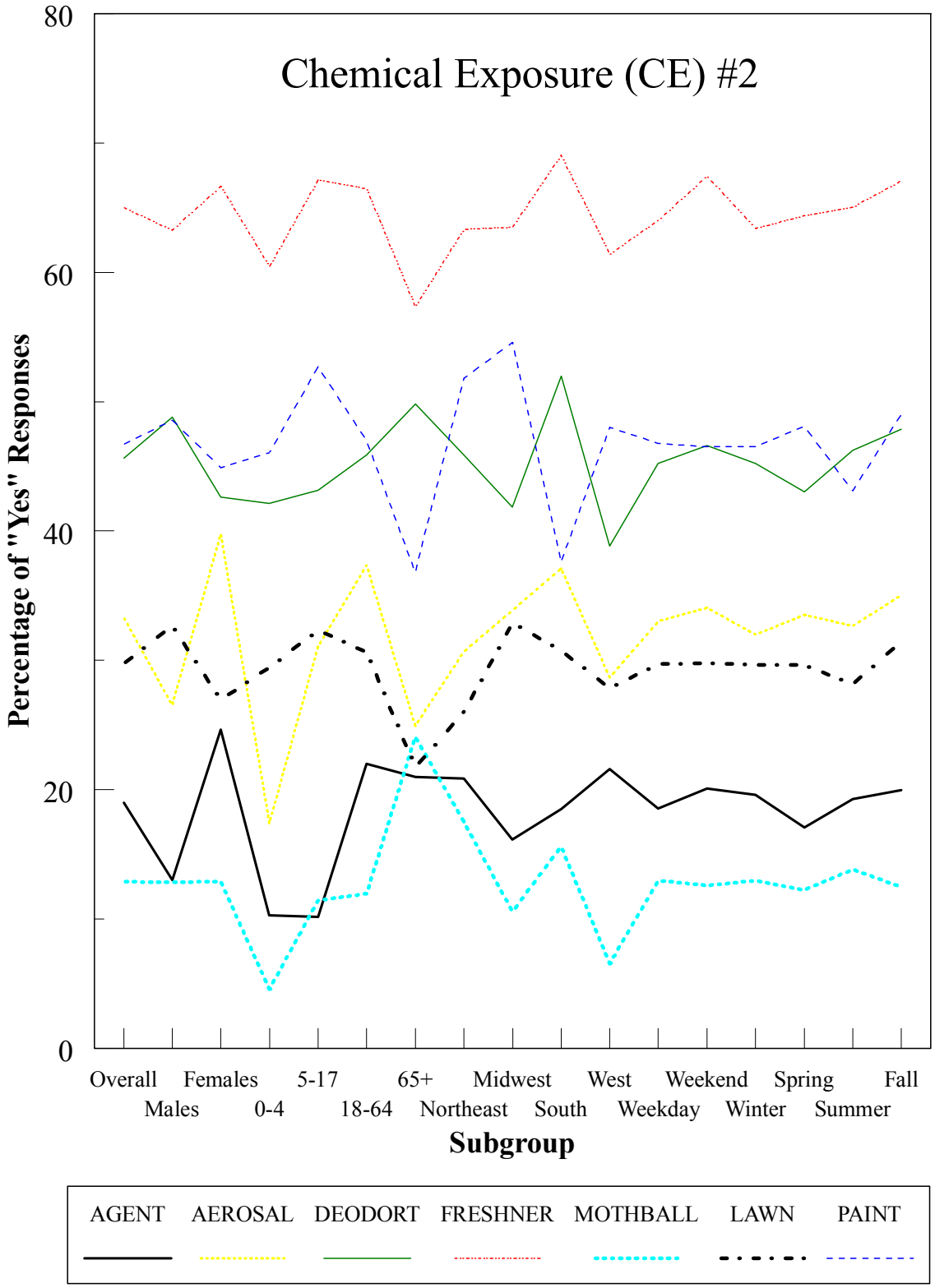


Figure 7-2. The weighted percentage of respondents that answered "yes" to additional questions on chemical exposure: cleaning agents, aerosols, deodorants, air fresheners, mothballs, stored lawn mowers, or stored paints/varnishes.

Table 7-4. Percentage of "Yes" Responses for Follow-Up Questions on Combustion Sources (CS)

Variables	FIREPLAC	KEROHEAT	OTHEAT	OTHEATD	WOODSTOV	FLAMES	HEATY	HEAVYTRF	INDGAR	RUNHEAV
Overall	11.25	2.03	24.11	3.21	6.42	10.08	41.74	26.08	6.05	8.48
Males	11.97	1.94	24.38	3.06	6.89	11.54	42.11	26.15	6.63	8.92
Females	10.56	2.10	23.86	3.35	5.98	8.70	41.39	26.01	5.49	8.06
0-4	8.67	1.93	22.11	2.16	6.88	5.18	41.52	17.12	4.05	4.26
5-17	12.91	2.94	28.35	4.73	7.60	7.39	42.71	18.97	4.95	7.93
18-64	11.52	1.93	23.43	3.04	6.23	12.29	40.55	29.48	7.25	9.67
65+	9.06	1.14	22.24	2.37	5.32	5.45	46.53	23.86	2.63	5.62
Northeast	8.81	1.81	23.14	3.65	7.88	12.88	48.71	22.33	5.40	11.71
Midwest	9.43	2.06	21.91	2.97	6.18	11.12	48.70	24.44	5.12	7.52
South	12.15	2.91	22.20	2.49	3.83	8.54	34.64	27.09	4.93	6.84
West	14.34	0.67	30.98	4.28	9.72	8.83	38.81	29.86	9.70	9.45
Weekday	11.33	1.79	24.50	2.96	6.38	9.27	42.07	28.77	6.17	9.72
Weekend	11.07	2.62	23.16	3.80	6.52	12.10	40.92	19.26	5.73	5.34
Winter	11.71	1.83	28.14	3.41	8.09	12.11	81.50	24.11	5.47	8.06
Spring	12.45	1.97	23.93	2.69	6.90	9.89	22.64	27.62	6.07	9.66
Summer	8.87	1.54	19.68	3.25	4.84	9.69	2.59	23.79	6.49	7.94
Fall	12.03	2.80	24.68	3.50	5.82	8.71	60.08	28.60	6.15	8.24

Table 7-5. Percentage of "Yes" Responses for Follow-Up Questions on Washing and Bathing (WA and WA)

Variable Category	DISH WA	DISHHAND WA	WASHAH WA	DISHWASH WA	KBATH BA	KSWIM BA	SHOWER BA	SHOWBA BA
Overall	58.07	79.49	42.43	23.66	61.93	15.51	75.46	91.79
Males	59.23	72.58	37.16	24.78	60.03	14.69	77.43	91.59
Females	56.97	86.04	47.35	22.60	63.94	16.30	73.58	91.98
0-4	54.15	22.53	50.81	28.89	73.46	25.60	16.98	84.50
5-17	60.35	56.25	43.94	23.39	49.82	24.53	58.50	83.19
18-64	59.58	87.92	43.06	23.85		13.55	89.99	95.84
65+	49.59	86.80	32.49	20.09		5.38	66.18	87.57
Northeast	53.80	78.47	42.11	21.30	53.13	15.14	78.51	91.17
Midwest	52.82	78.82	42.77	23.63	51.67	12.35	71.03	90.87
South	60.37	77.94	42.77	24.25	73.90	17.18	76.80	93.49
West	64.62	84.03	41.73	24.88	61.29	16.72	75.20	90.57
Weekday	57.50	79.76	42.33	22.20	58.33	15.35	76.33	91.94
Weekend	59.48	78.82	42.69	27.36	70.59	15.90	73.31	91.41
Winter	57.61	81.09	41.43	23.62	55.97	5.20	72.86	90.23
Spring	59.20	79.71	43.69	23.12	65.75	17.81	76.08	93.11
Summer	58.32	78.71	42.52	21.86	64.14	32.14	76.53	92.77

Fall	57.13	78.32	42.08	25.90	62.49	6.53	76.48	91.07

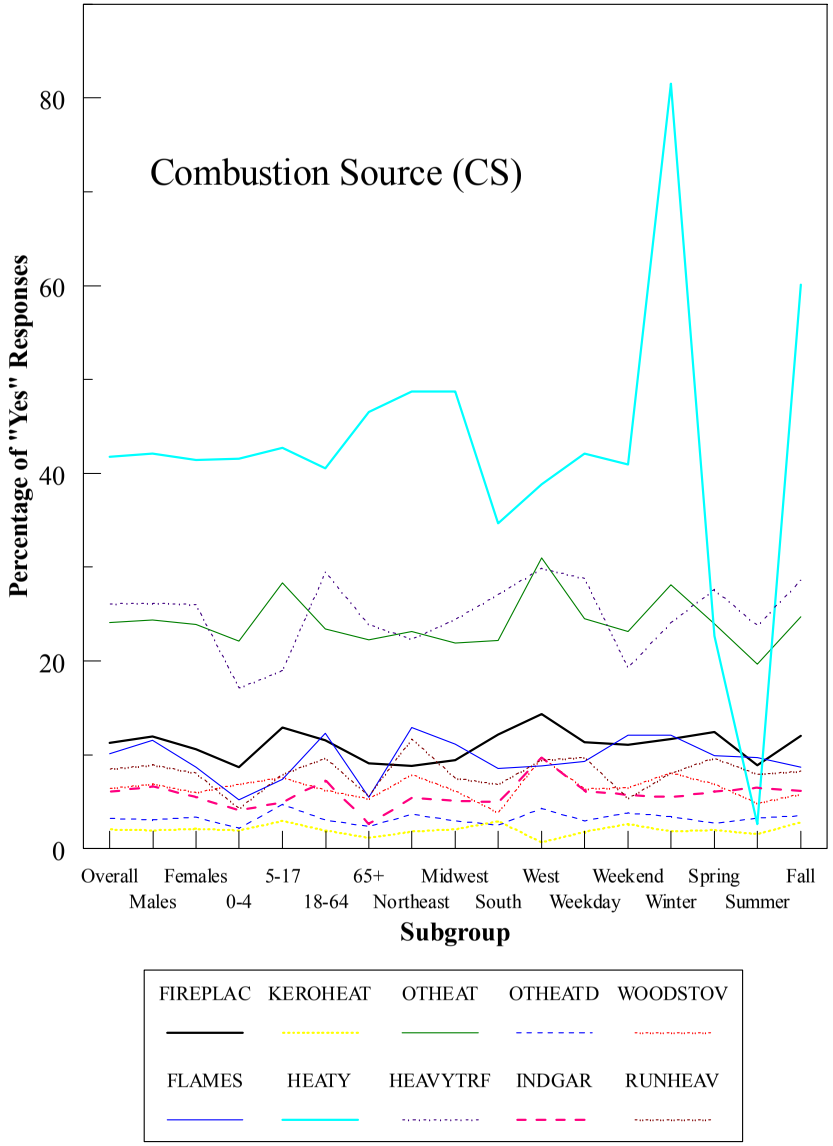


Figure 7-3. The weighted percentage of respondents that answered "yes" to questions on exposure to combustion sources: a fireplace, kerosene heater, wood stove, open flames, other heat sources, if heat was turned on (HEATY), heavy traffic, indoor garages, or running in heavy traffic.

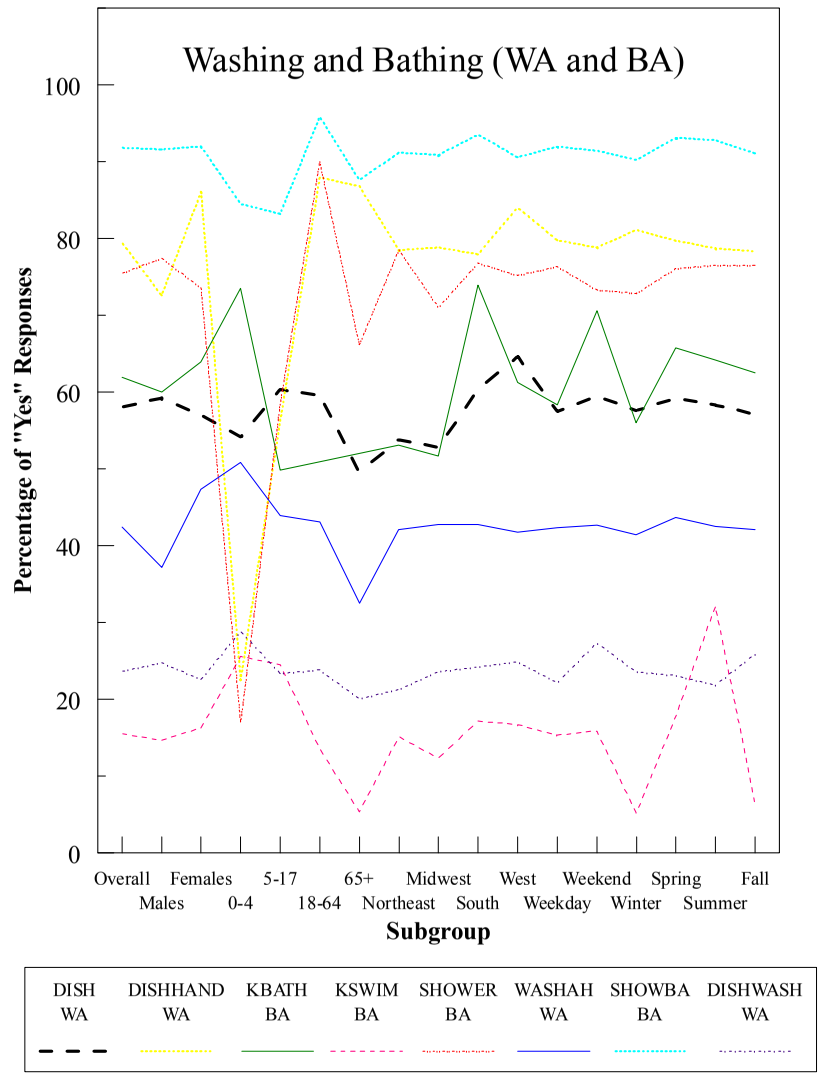


Figure 7-4. The weighted percentage of respondents that answered "yes" to questions concerning washing and bathing: dish-washing machine present (DISH), dish-washer used (DISHWASH), dishes hand-washed (DISHHAND), clothes-washing machine used (WASHAH), a bath given or taken (KBATH), child swam (KSWIM), a shower/bath taken (SHOWBA).

Table 7-6. Percentage of "Yes" Responses for Follow-Up Questions on Medical Background (MB)

Variable	ANGINA	ASTHMA	EMPHYS	PREGNANT
Overall	2.26	7.41	4.27	2.94
Males	2.17	6.67	4.11	0.00
Females	2.35	8.11	4.41	2.95
0-4	0.00	8.72	1.62	0.00
5-17	0.66	10.40	2.84	1.18
18-64	1.53	6.90	3.88	3.04
65+	9.59	4.81	9.85	0.00
Northeast	1.98	7.10	3.63	3.69
Midwest	2.37	7.48	3.41	3.03
South	2.57	7.41	5.69	2.49
West	1.87	7.65	3.45	2.88
Weekday	2.12	6.97	3.85	2.66
Weekend	2.60	8.51	5.31	3.63
Winter	2.45	6.60	3.73	2.33
Spring	2.06	7.70	4.20	3.57
Summer	1.96	7.63	4.25	3.60
Fall	2.57	7.73	4.89	2.28

Table 7-7 Percentage of "Yes" Responses for Follow-Up Questions on Housing Characteristics (HC)

Variable	BASEMNT	HUMI	DOOROUT	WINDY	CARPORT	ELECHEAT	FLOOR	RENOVA	ROOM
Overall	44.41	24.06	84.93	41.90	9.92	8.98	4.99	34.21	3.94
Males	44.48	22.63	85.29	41.27	9.01	9.38	5.28	34.38	3.91
Females	44.35	25.42	84.60	42.50	10.79	8.59	4.71	34.05	3.96
0-4	43.95	38.92	84.37	37.69	8.91	11.57	5.45	37.80	6.38
5-17	45.81	25.51	85.39	41.96	10.56	9.00	6.61	40.16	5.03
18-64	44.26	22.75	85.00	42.13	10.61	8.27	4.90	34.92	3.71
65+	43.40	19.65	84.25	43.02	6.16	10.78	2.68	19.38	1.92
Northeast	79.84	27.38	79.51	48.46	9.99	8.46	6.53	41.13	3.97
Midwest	71.87	33.34	82.42	35.47	12.64	9.02	3.56	37.19	3.86
South	18.80	19.03	87.42	32.71	8.38	7.20	5.54	29.88	3.97
West	21.14	18.39	88.82	59.50	9.31	12.52	4.12	31.08	3.96
Weekday	44.14	23.70	84.52	41.13	9.89	9.31	5.26	34.13	3.71
Weekend	45.10	24.97	85.97	43.85	10.00	8.15	4.32	34.40	4.52
Winter	45.31	26.84	86.82	25.49	10.04	10.88	5.99	31.82	4.41
Spring	44.90	22.27	86.49	54.60	9.32	8.26	4.17	32.02	3.31
Summer	43.50	22.11	84.26	54.31	8.26	6.82	4.93	34.49	3.07
Fall	43.96	25.04	82.32	33.44	12.18	9.95	4.82	38.78	5.02

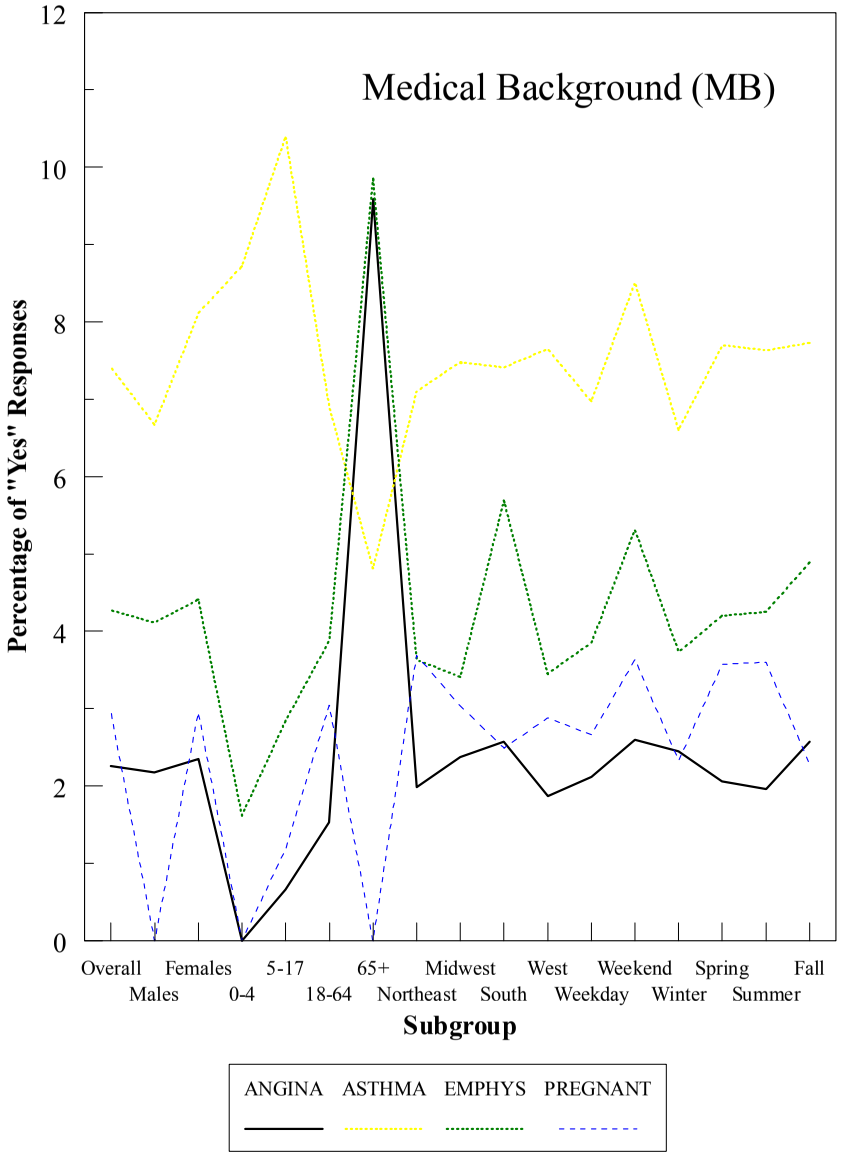


Figure 7-5. The weighted percentage of respondents that answered "yes" to questions on their medical background: does the respondent have angina, asthma, bronchitis/emphysema (EMPHYS), or is the respondent pregnant.

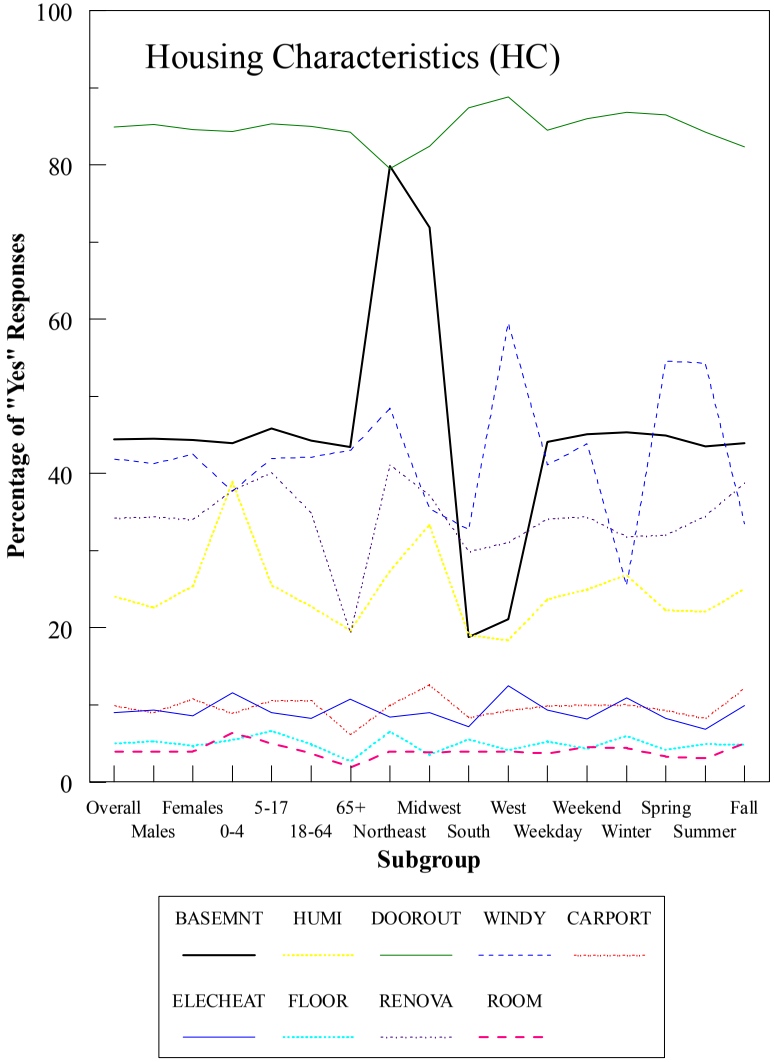


Figure 7-6. The weighted percentage of respondents that answered "yes" to questions on the characteristics of their housing: a basement (BASEMNT), humidifier (HUMID), or electric heater (ELECHEAT); if the windows were left open (WINDY), rooms being added (ROOM), house being renovated (RENOVA), floors being refinished (FLOOR), carpet being laid (CARPORT), or doors open directly to the outside (DOOROUT).

Table 7-8 Percentage of "Yes" Responses for Follow-Up Questions for Other Categories (DS, ED, OC)

Variable Category	DUST DS	FRIED ED	MICRO OC	OTHOUT OC	WALKCAR OC	BOTTWAT ED	MAT DS	SEASFOD ED
Overall	16.23	23.99	55.06	28.46	72.47	42.96	89.33	59.25
Males	17.31	23.33	51.36	29.93	73.35	41.61	89.59	60.97
Females	15.21	24.62	58.52	27.07	71.64	44.25	89.09	57.62
0-4	10.67	12.80	100.00	39.52	57.29	50.93	86.13	41.53
5-17	18.99	27.03	38.87	42.72	71.87	39.79	90.24	45.50
18-64	18.17	25.73	58.30	24.97	76.92	46.89	89.83	65.57
65+	5.64	17.27	58.09	21.18	59.37	23.35	87.52	59.87
Northeast	14.69	20.95	49.03	25.63	71.09	46.40	88.72	61.63
Midwest	16.09	25.02	55.10	28.77	73.50	36.58	88.51	52.83
South	15.17	25.86	57.11	27.90	71.38	42.79	90.28	62.82
West	19.63	22.34	57.05	31.68	74.37	47.20	89.28	58.21
Weekday	16.72	22.92	55.77	28.21	72.09	43.32	89.37	58.60
Weekend	14.99	26.69	53.28	29.11	73.42	42.08	89.22	60.86
Winter	14.60	24.11	59.01	26.17	70.95	43.82	88.39	61.88
Spring	15.97	25.37	53.45	33.57	74.38	43.43	88.46	58.98
Summer	17.62	23.70	50.51	34.08	74.94	45.54	89.70	57.52
Fall	16.69	22.84	57.23	20.45	69.69	38.80	90.87	58.57

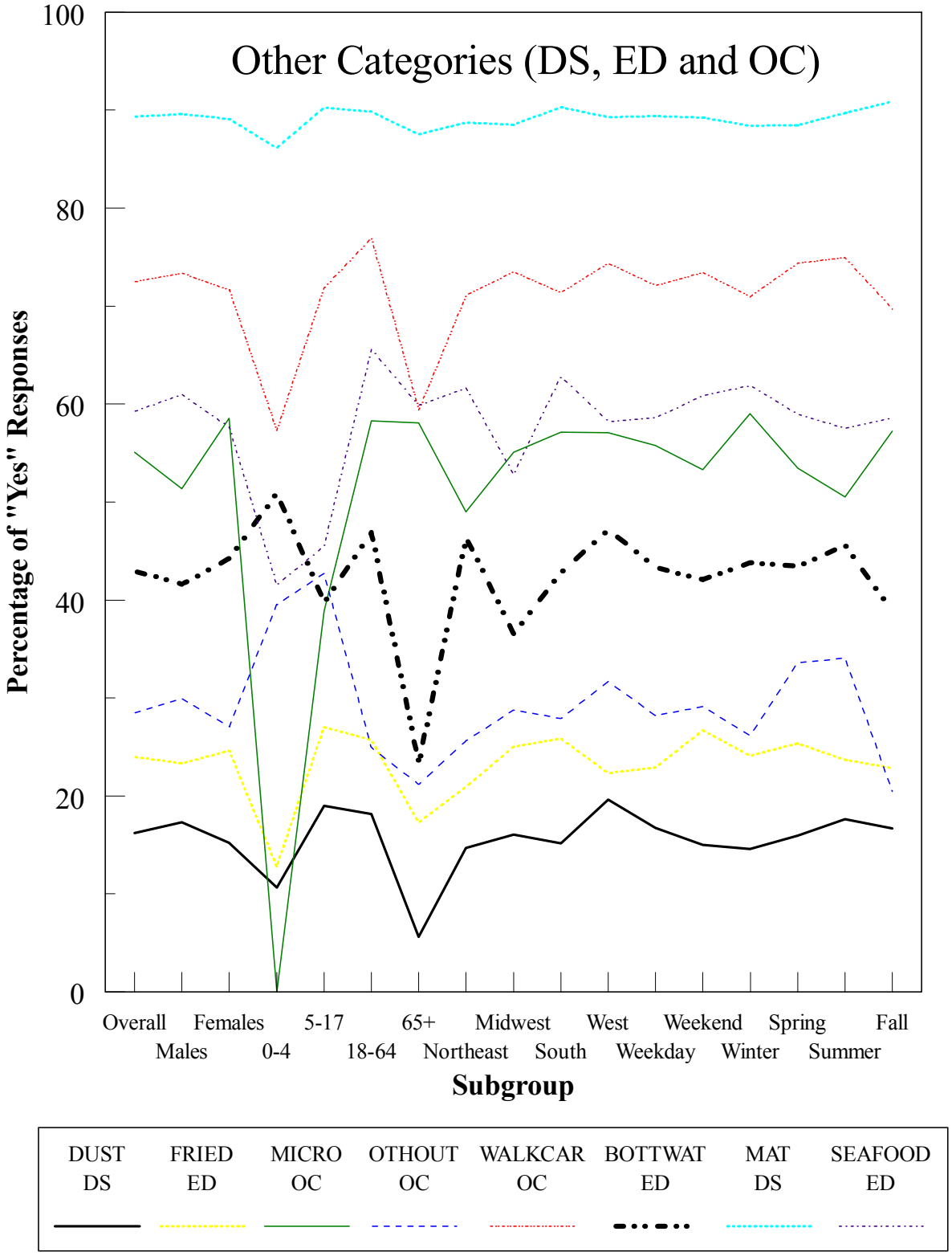


Figure 7-7. The weighted percentage of respondents that answered "yes" to questions concerning other exposure categories: dust/dirt (DUST), welcome mat used (MAT), foods eaten (SEAFOOD), food fried or grilled (FRIED), microwave used (MICRO), running/walking outdoors (OTHOUT), or walking to car in the driveway (WALKCAR).

The only three exposures in the CS category that were greater than 15% were the use of heat yesterday, and the use of other heat sources besides fireplace, kerosene, wood stove, etc. (Figure 7-3; Table 7-4). As expected, the Northeast and the Midwest had the most use of heat and the Winter/Fall seasons had much more exposure than Spring/Summer.

Those respondents aged 0-4 had the lowest number of exposures to washing dishes by hand and taking a shower, but they had the highest exposures for giving/taking a bath and using a clothes-washing machine or dish-washing machine (Figure 7-4; Table 7-5). Respondents aged 18-64 had the highest number of exposures from taking a shower.

The most respondents with angina and bronchitis or emphysema were by far in the 65+ age group (Figure 7-5; Table 7-6). Females had slightly more cases of these ailments and asthma than males. The most occurrences of asthma were for the 5-17 age group. Curiously, angina and emphysema also occur most frequently in the South.

Humidifiers were used most often by respondents aged 0-4 and by respondents in the Midwest (Figure 7-6; Table 7-7). Respondents in the Northeast had both the largest number of basements and the fewest number of doors leading directly outdoors, while the West had the largest number of doors left open.

8. CONCLUSIONS, RECOMMENDATIONS, AND FUTURE WORK

This report has presented analyses of time spent (duration **D**) and number of occurrences (of people **N** and microenvironments **O**) for selected location, activity, smoker-present, location x activity, and location x smoker-present microenvironments by selected geographic, socioeconomic, and time factors. These analyses were based on the minute-by-minute 24-hour diary day data collected in the National Human Activity Pattern Survey (NHAPS). Analyses of exposure-related follow-up questions were also presented but these took the form of the percentage of "yes" responses concerning exposure events occurring on the day before the diary day or some other time frame (such as the previous month or 6 months) for each subgroup. The 24-hour diary results are more desirable for probabilistic modeling of population exposure and, unlike the follow up questions, they provide detailed time information (time-of-day, day-of-week) and allow for accurate determinations of frequency of occurrence and duration of microenvironments. See Table 8-1 for a comparison of diary data and follow-up question data.

The follow-up questions are, in general, not conducive to classification by specific microenvironments (beginning and ending time with a specified location, activity and/or background activity), but since they reveal the occurrence or non-occurrence of selected exposure events for different subgroups, some follow-up questions will provide more accurate information than the diaries. For example, some respondents might forget they went to the gas station on the way to work and could be reminded by a follow-up question. However, these responses could possibly be incorporated back into the minute-by-minute diary format.

While the location categories in the NHAPS diaries were very detailed and acceptable for use in exposure modeling, most of the exposure activity categories in the 24-hour diaries were very general (the FACT diary variable contained more specific, verbatim descriptions of the exposure activity, but was recorded inconsistently) and sociologically-based; and so their usefulness in exposure modeling

Table 8-1. Comparison of the NHAPS 24-Hour Minute-by-Minute Diaries and the NHAPS Follow-Up Questions

Data Type	Pros	Cons
24-Hour Diaries	1. Complete time-of-day information 2. The most accurate way to obtain exposure information 3. Complete human activity pattern data (the beginning and ending times of locations, activities, background activities, etc.) 4. Flexible data format for analysis by any combination of microenvironmental factors (location, activity, smoker-present) and any combination of demographic factors 5. Useful in probabilistic modeling of human exposure	1. Bulky data base 2. Can sometimes miss exposure events caught by the follow-up questions, but these can be added to the minute-by-minute diaries afterward
Follow-Up Questions	1. Obtain answers to questions on personal exposure in specific microenvironments for different demographic subgroups 2. Catch exposure events that might be missed in diaries 3. Relatively small data base	1. No time of day information 2. Responses may not be as accurate as 24-hour diaries with many missing values since the questions may be difficult for respondents to answer; many questions on the duration or frequency of occurrence of specific microenvironments were not answered by many respondents or were coded in a mixed-type format, making the data unusable or difficult to use. 3. Inflexible and/or incomplete and/or imprecise data that is difficult or impossible to analyze across different microenvironments (both location **and** activity); usually only contain information on one specific exposure activity (*e.g.*, the use of an appliance or other household/personal products) with no specified location. 4. May not be useful in modeling of human exposure

may be limited. For example, there were very few specific breakdowns for exposure activities involving smoking, housing characteristics, food preparation, housekeeping, maintenance (house or automobile), and yardwork. The use of more detailed exposure activity categories in the 24-hour diaries instead of in the follow-up questions would probably not require any more interview time and would allow for the detail in the limited format of the follow-up questions to be used in the more flexible diary format. Future human activity pattern (HAP) studies should collect 24-hour diaries that explicitly categorize exposure categories such as baking, frying, cold food preparation, vacuuming, waxing the floor, and general tidying (Table 8-2), which correspond to different sources (or a lack of sources) of chemical pollutants. Studies that target more specific kinds of exposure could utilize even more finely split categories such as baking with a gas stove versus an electric stove. For these finer categories to be useful, the sample size of the study must be large enough to provide a sufficient number of occurrences for each exposure activity. These studies will probably be focused on much smaller geographic areas than the entire nation such as states, counties, or cities. In addition, future HAP studies that sample the same respondents on more than one day would give accurate estimates of the how the duration and frequencies of occurrence of microenvironments vary by time factors such as day-of-week, month, season, and year.

The NHAPS 24-hour diary data should be used in the future for many different kinds of exposure assessments -- most importantly for the probabilistic modeling of human exposures for different populations in the United States. The raw data can be used to obtain minute-by-minute 24-hour diaries for many subgroups, *e.g.*, female respondents aged 5-11 in Texas. The NHAPS data should also be systematically compared to previous national studies (*e.g.*, the American's Use of Time Study[4,18] and the California Activity Pattern Survey (CAP) [1-3]) by the amounts of time people spend in different microenvironments. Additionally, NHAPS can be used to determine commuting patterns and transition probabilities between microenvironments.

Table 8-2. Suggested Specific Exposure Activity Categories for Microenvironments in the Minute-by-Minute 24-hour Diaries for Future HAP Studies

General Exposure Activity	Examples of More Detailed 24-Hour Categories
Smoking	Number of Cigarettes Smoked, Smoking Time of Each Cigarette
Housing Characteristics	Was Window Open, Was Fireplace Going, Was Gas Heat On
Food Preparation	Baking, Frying, Grilling, Cold Food Preparation, Using a Microwave
Housekeeping	Sweeping Bare Floor, Vacuuming Carpet, Dusting, Waxing the Floor, General Tidying, Using Air Freshener
Car Maintenance	Changing Oil, Cleaning Engine, Washing the Car, Waxing the Car, Tune-up
Home Maintenance	Painting, Varnishing, Removing Paint or Varnish, Sanding, Carpentry, Electrical Repair
Yardwork	Mowing the Lawn, Gardening, Trimming Trees, Applying Pesticide
Sports/Exercise	Running, Biking, Hiking, Swimming, Football, Basketball

Note: Many of these more detailed 24-hour diary exposure activity categories are the same as those contained in the follow-up question part of the interview (see Section 7).

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APPENDIX A: CONCEPTUAL METHODOLOGY AND BACKGROUND

A1. Total Human Exposure, Human Activity Patterns, and the Generalized Microenvironment

The study of human exposure to pollutants has recently been focused away from the traditional sources (industrial waste, factory emissions, etc.) and onto the non-traditional sources (consumer products, building materials, etc.) with which a person typically comes into personal contact during their daily routine. With the recognition that most exposure sources are associated with personal activities and consumer products,[7,22-26] the concept of total human exposure (THE) was introduced to consider all possible routes of exposure by which a pollutant reaches a human target. Ott[21] defines exposure as the confluence of two events in space and time: (1) person i is present at location x,y,z at time t; and (2) pollutant concentration c is present at location x,y,z at time t.

With the individual human being -- and his or her movement though space and time -- placed at the center of attention, the most important part of THE studies has been the human activity pattern (HAP), which includes all exposure-relevant information about a person's behavior (locations, activities, etc.) over time. Human activity patterns do not describe the mechanisms of exposure or the flow of pollutants from sources; these topics are left to mass-flow modeling or monitoring surveys. Instead, HAP's describe a person's activities or activities occurring nearby that person, and the type of location in which those activities are occurring. The six most basic exposure-related questions one might ask in human activity pattern studies -- along with their measured or calculated NHAPS quantities in parentheses -- are (Figure A-1): "What are people doing (activities, background activities)?"; "Where are they doing it (locations)?"; "Who are they (demographics)?"; "How long were they doing it (duration)?"; "How often were they doing it (frequency of occurrence)?"; and "When were they doing it (time of day, season, day of week)?".

Most generally, person i's position over time is given by $[x(t), y(t), z(t)]_i$ for any spatial and temporal resolution of interest. However, since (1) it may not be possible to determine either human activity patterns or pollutant concentrations $c(x,y,z,t)$ with fine spatial or temporal resolution, and (2)

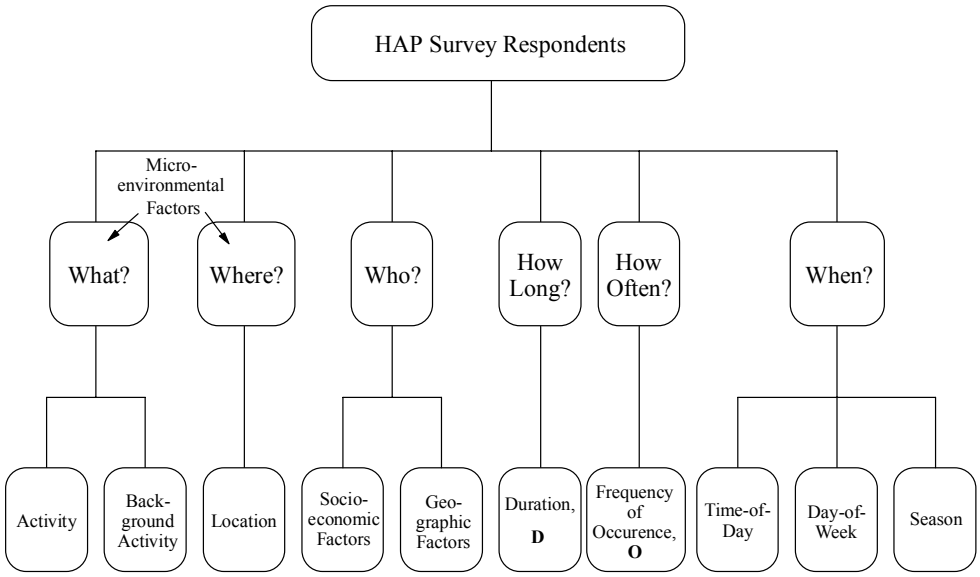


Figure A-1. The most basic questions posed in human activity pattern (HAP) analysis: The What? and Where? questions specify the microenvironmental factors, Who? and When? determine the background (gender, age, census region) and time (time-of-day, day-of-week, season) factors, respectively, and How Long? and How Often? determine the duration **D** and frequency of occurrence **O** of the microenvironments, respectively.

pollutant concentrations may be homogeneous in certain locations, a "discrete model" for exposure to air pollution was proposed,[19-21] using the microenvironment concept in which a person is exposed to a uniform air pollutant concentration *c* in a certain location and block of time. Ott[21] defines a microenvironment as a *discrete event* that "denotes a clearly defined air pollution problem and a unique class of activities". Similarly, Duan[20] defines a microenvironment as "a location of homogeneous pollutant concentration that a person occupies for some finite period of time". Only Behar *et al.*[12] describe a microenvironment as a combination of a location **and** an activity.

Typically, human activity patterns such as NHAPS are analyzed and incorporated into exposure studies through the microenvironment concept.[5,6,11-13,19-21,27-29] In broadening the original definition, we propose the *generalized n-factor microenvironment*, which: (1) in addition to <u>location</u>s includes specific pollutant-generating <u>activities</u> in the definition of a microenvironment to make full use of detailed HAP surveys like NHAPS; (2) expands and generalizes the microenvironment concept for estimation of exposures from any pollutant source and through any pathway; (3) is not limited to air pollutants that are

homogeneously distributed; and (4) mathematically formalizes the microenvironment concept for use in scientific estimates of total human exposure. As the foundation of our definition, we establish the following three ideas:

1. Whereas the term "environment" encompasses **all** factors that influence an individual life, a microenvironment is some **fraction** of all possible *discrete events* (or *episodes*) that occur during a defined **portion of time** in an individual life.
2. A *microenvironmental factor* is a discrete event related to human behavior such as a location, an activity, some other simultaneous activity, or a background activity.
3. Microenvironments are fully characterized by a single microenvironmental factor or combination of any number *n* of microenvironmental factors and the corresponding time in which each microenvironmental factor or combination of factors occurs.

Examples of microenvironmental factors are: (1) bedroom, office, automobile, etc. for locations; (2) cleaning the floor, watching TV, mowing the lawn, etc. for activities; (3) using air freshener while watching TV, smoking a cigarette while cleaning the floor, applying pesticides while mowing the lawn, etc. for simultaneous activities that the respondent is doing directly; and (4) presence of a smoker, washing machine running, kerosene heater on, etc. for possible background activities that the respondent is not directly controlling. Any one of these microenvironmental factors or any conceivable combination of them may comprise the *n-factor* portion of our generalized microenvironment definition. In this report we present results for all location, activity, and smoker-present categories and location x activity and location x smoker-present microenvironments. Section 5 of this report presents the location x activity and location x smoker-present microenvironments that were used.

Once the microenvironment factor(s) of interest has(have) been specified, the characterization of the microenvironment is completed by assigning the appropriate starting and ending times for which the microenvironmental factor(s) occurs(occur) over the desired time period. A specific occurrence of a microenvironment -- some combination of microenvironmental factors, a beginning time, and an ending time -- is called an *episode*. In this report human microenvironment patterns are analyzed by their

beginning and ending times (by episodes) and in increments of one minute over one 24-hour diary day (by time-of-day).

A microenvironment is an abstract notion whose exact definition depends on the relevant microenvironmental factors and the time frames of interest. The microenvironment is a "window of exposure" during which human exposure to any pollutant source (exhaust, paints/solvents, aerosol sprays, etc.), via any pathway (air, water, soil, food), and in any locale (home, automobile, playground, etc.), can occur. The detailed mechanisms of exposure for each microenvironment, which follow from the relevant microenvironmental factors, are experimentally and/or theoretically characterized by scientists. For example, once a person is determined to be inside a large room with multiple cigarette smokers, a physical mass flow model can be applied to calculate the typical exposure that a person will receive.[35]

A2. A Mathematical Formalism for Microenvironments

Our generalized n-factor microenvironment M is a relation between the set of n combined microenvironmental factors $\boldsymbol{F} = F_1 \text{ x } F_2 \text{ x } \ldots \text{ x } F_n$ and the set $\boldsymbol{T}$ of their corresponding beginning times ($B_1 \ldots B_n$) and ending times ($E_1 \ldots E_n$):

$$
\begin{aligned}
&M: \boldsymbol{T} \rightarrow \boldsymbol{F} \\
&\boldsymbol{F} = F_1 \times F_2 \times F_3 \times \ldots \times F_n \\
&\boldsymbol{T} = \{B_1, \ldots B_n, E_1, \ldots, E_n\}
\end{aligned} \tag{1}
$$

where
$\boldsymbol{F}$ = the set of n combined microenvironmental factors
$\boldsymbol{T}$ = the set of corresponding beginning and ending times

The microenvironmental factor portion is the same for any microenvironment formulation, but the formulation may change depending on the time period or time scale of interest. For example, if researchers wish to study occurrences of exposure events on an absolute scale of small fixed-length intervals over a 24-hour period -- as in a time-of-day study -- then a different formulation is required (the *time-of-day formulation*) than if researchers simply desire a tabulation of starting times, durations, or number of

occurrences of exposure events over a day, week, month, or year (using the *episodic formulation*). An *episode* is an unspecified occurrence of an exposure event -- with beginning and ending times -- that is classified according to the microenvironment concept.

Microenvironmental Factors

Each combined microenvironmental factor can correspond to multiple beginning and ending times. Each microenvironmental factor F_k has a_k elements, and there are a_1 x a_2 x,..., x a_n possible combinations of microenvironmental factors denoted by $F_{k_1,k_2,\ldots,k_n}$:

(2) $$F_{k_1,k_2,\ldots,k_n} \in \boldsymbol{F}$$

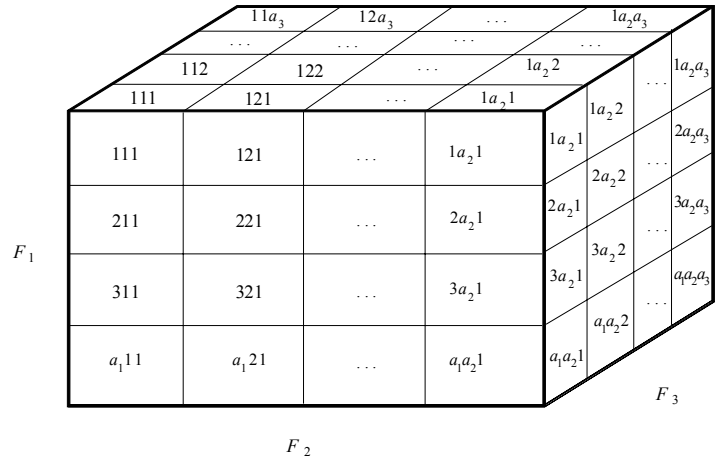
where
$$k_1 \in \{1,2,\ldots a_1\}, k_2 \in \{1,2,\ldots a_2\}, \ldots, k_n \in \{1,2,\ldots a_n\}$$

For one-factor microenvironments the $\boldsymbol{F}$ portion of M consists of a single microenvironmental factor (location, activity, background activity, etc.). For two-factor microenvironments, $\boldsymbol{F}$ consists of the set of all possible combinations of the two microenvironmental factors F_1 and F_2 (location and activity, location and background activity, etc.)

(3) $$F_1 x\, F_2 = \begin{Bmatrix} F_{1,1} & F_{1,2} & \cdots & F_{1,a_2} \\ F_{2,1} & F_{2,2} & \cdots & F_{2,a_2} \\ \vdots & \vdots & F_{k_1,k_2} & \vdots \\ F_{a_1,2} & F_{a_1,2} & \cdots & F_{a_1,a_2} \end{Bmatrix} = \boldsymbol{F}$$

where
F_1 = microenvironmental factor #1
F_2 = microenvironmental factor #2
a_1 = number of elements in F_1
a_2 = number of elements in F_2

Likewise, the $\boldsymbol{F}$ portion of M for three-factor microenvironments consists of all combinations of F_1, F_2, and F_3 and can be represented as follows (each cell contains the appropriate F subscript only):



The Episodic Formulation

The most condensed format for human microenvironment data -- which we call the *episodic formulation* -- contains the combined microenvironmental factors linked with the times that they begin and end. It is most useful for storing the data and for calculations of exposure-event duration and frequency of occurrence over a 24-hour period (or week, month, year, etc.). The NHAPS data is stored in this format by a simple list of each beginning and ending time and multiple variables that specify each microenvironmental factor (location, activity, and presence of a smoker).

Mathematically, we write the episodic formulation of the set of all generalized n-factor microenvironments M_e (the e subscript stands for episodic) for person i and episode j as follows:

(4) $$M_e(i, j; k_1, \ldots, k_n)$$

where

$i \in \{1,2,\ldots N\}$

N = number of individuals

$j \in \{1,2,3,\ldots, J_i\}$

J_i = number of episodes for person i

each with beginning time B_j and ending time E_j

$k_1, \ldots, k_n$ = subscripts of the combined microenvironmental factors $F_{k_1,\ldots,k_n}$

$k_1 \in \{1,2,\ldots a_1\}, k_2 \in \{1,2,\ldots a_2\}, \ldots, k_n \in \{1,2,\ldots a_n\}$

$a_1, \ldots, a_n$ = number of elements in each microenvironmental factor

The Time-of-Day Formulation

In exposure modeling, we need a microenvironment formulation that allows us to conduct time-of-day comparisons of human exposure across arbitrary time periods. Instead of studying exposure events by episodic "chunks", we create an absolute time scale that provides a homogeneous base for comparisons. For example, by assigning exposure events -- combinations of microenvironmental factors -- to every minute of the day, we may calculate a time series of exposure for each person and subsequently derive hourly, 8-hour, 12-hour, or 24-hour exposures which can be compared across the population.

This *time-of-day formulation* of the generalized *n*-factor microenvironment consists of sequential time intervals of fixed length over a given time period. While the episodic formulation contains only beginning and ending times mapped to each combined microenvironmental factor, this formulation is a mapping of each combined microenvironmental factor $F_{k_1,k_2,\ldots,k_n}$ to each time interval j. Different time intervals j can point to the same $F_{k_1,k_2,\ldots,k_n}$. For each person i, the set of all generalized n-factor microenvironments M_t (the subscript t stands for time-of-day) in the time-of-day formulation is:

(5) $$M_t(i, j; k_1, \ldots, k_n)$$

where

$i \in \{1,2,\ldots N\}$

N = number of individuals

$j \in \{1,2,3,\ldots, J\}$

J = number of time intervals in time period, *e.g.* 1440 minutes in 24 - hours

$k_1, \ldots, k_n$ = subscripts of the combined microenvironmental factors $F_{k_1,\ldots,k_n}$

$k_1 \in \{1,2,\ldots a_1\}, k_2 \in \{1,2,\ldots a_2\}, \ldots, k_n \in \{1,2,\ldots a_n\}$

$a_1, \ldots, a_n$ = number of elements in each microenvironmental factor

M_t is an expansion of M_e from a relation that links each existing microenvironmental factor with its starting and ending times to an onto mapping from the time segments to the microenvironmental factors. As long as the length of the fixed time segments in M_t are at the same time resolution as the starting and ending times specified in M_e, then the set M_t has $2+n$ dimensions which fully describes the human microenvironmental patterns of a population of N people by retaining all the information stored in M_e, and

the time-of-day formulation can be converted back to the episodic formulation since every beginning and ending time corresponds to some time interval. However, if the time intervals j (typically one minute) are of greater resolution than the durations of each microenvironment, then duration information is destroyed within each time interval for each episode whose ending time exceeds a time interval's right boundary.

This formalism is helpful in efforts that apply human microenvironmental patterns to exposure modeling, especially when $n \geq 2$. It can be used to develop computer algorithms to calculate total human exposure for populations.

A3. The Microenvironment Calculations in This Report

In this report we calculate for all 9,386 NHAPS respondents: (1) durations **D** and frequencies of occurrence **O** of microenvironments for the 24-hour diary day using the episodic formulation of microenvironments, and (2) frequencies of occurrences **O** of microenvironments for each minute and each 3-hour segment of the 24-hour diary day using the time-of-day formulation of microenvironments. For episodic calculations, the episodes for each person are sorted according to microenvironmental factor combinations $F_{k_1,k_2,\ldots,k_n}$. Since each episode is sorted together with its beginning and ending times, we do not need strict knowledge of their sequence (*i.e.* time-of-day). The **cumulative** 24-hour duration $\hat{\mathbf{D}}(i,k_1,\ldots,k_n)$ (distinguished from the single-episode durations by the ^ symbol) over episodes j with the combined microenvironmental factor subscripts $k_1,\ldots,k_n$ for person i is:

(6)
$$\hat{\mathbf{D}}(i,k_1,\ldots,k_n) = \sum_{j}^{J} E_j - B_j$$

(for episodes j with microenvironmental factor subscripts $k_1,\ldots,k_n$ only)
where
E_j = the ending time for episode j
B_j = the beginning time for episode j
J = the total number of episodes for person i

The frequency of occurrence $\mathbf{O}(i,k_1,\ldots,k_n)$ for person i is a running count of episodes j -- over the 24-hour period -- that have the $k_1,\ldots,k_n$ subscripts. The mean of **D** and **O** were calculated for each person in

the population. The percentage of time spent in each microenvironement was calculated using $\hat{\mathbf{D}}$ over the entire population.

Whereas episodic calculations use episodes with many different beginning and ending times sorted in any order, time-of-day calculations require a constant number of defined episodic occurrences (*e.g.* 1440 minutes over a 24-hour day) with fixed-length segments sorted in sequential order and by the subscripts $k_1,...,k_n$. During time units of one minute (the time resolution of the study) each person experiences one microenvironment (one subscript $k_1,...,k_n$). The total frequency of occurrence $\mathbf{O}(j,k_1,...,k_n)$ for minute j is a count over all the persons N that have the subscripts $k_1,...,k_n$. The percentage of persons in each microenvironment can then be calculated for every minute j in the time series (*e.g.* the 1440 minutes in a 24-hour day).

Example

Suppose we are studying a population of $N = 10$ people over a period of 12 hours and our single microenvironmental factor is location, which has two possible elements: indoors ($k = 1$) and outdoors ($k = 2$). The number of microenvironments J_i for each of the ten people is in the set $\{5,5,3,1,2,5,2,3,1,3\}$. Thus, our episodic formulation of the set of all microenvironments is:

(7) $$M_e(i,j;k_1,\ldots,k_n)$$

where

$$i \in \{1,\ldots,10\}$$
$$j \in \{1,\ldots,J_i\}$$
$$J_i \in \{5,5,3,1,2,5,2,3,1,3\}$$
$$B_j \in \{12{:}00am,\ldots,11{:}59am\}, E_j \in \{12{:}01am,\ldots,12{:}00pm\}$$
$$k \in \{1,2\}$$

We can represent the series of episodes including beginning times B_j, ending times E_j, and location codes ($k = 1$ for indoors and $k = 2$ for outdoors) in a table with a variable number of records per person:

Table A-1. Episodic Formulation of Ten Persons in Indoor (k=1) and Outdoor (k=2) Microenvironments Over a 12-hr Period

Person #1			*Person #2*			*Person #3*			*Person #4*			*Person #5*		
B_j	E_j	k	B_j	E_j	k	B_j	E_j	k	B_j	E_j	k	B_j	E_j	k
12:00 a	8:00 a	1	12:00 a	5:30 a	1	12:00 a	8:30 a	1	12:00 a	12:00 p	1	12:00 a	11:00 a	1
8:01 a	8:30 a	2	5:31 a	9:30 a	2	8:31 a	10:45 a	2				11:01 a	12:00 p	2
8:31 a	10:30 a	1	9:31 a	10:00 a	1	10:46 a	12:00 p	1						
10:31 a	11:00 a	2	10:01 a	11:00 a	2									
11:01 a	12:00 p	1	11:01 a	12:00 p	1									

Person #6			*Person #7*			*Person #8*			*Person #9*			*Person #10*		
B_j	E_j	k	B_j	E_j	k	B_j	E_j	k	B_j	E_j	k	B_j	E_j	k
12:00 a	3:30 a	2	12:00 a	4:30 a	2	12:00 a	6:30 a	1	12:00 a	12:00 p	1	12:00 a	10:45 a	1
3:31 a	4:00 a	1	4:31 a	12:00 p	1	6:31 a	11:45 a	2				10:46 a	11:00 a	2
4:01 a	6:30 a	2				11:46 a	12:00 p	1				11:01 a	12:00 p	1
6:31 a	11:30 a	1												
11:31 a	12:00 p	2												

The cumulative duration (in minutes) and frequency of occurrence for outdoors and indoors for the ten people over the 12-hour period -- calculated after the people are sorted by location -- are $\hat{\mathbf{D}}(i,1) \in \{660, 420, 585, 720, 660, 330, 450, 405, 720, 705\}$ for time indoors, $\hat{\mathbf{D}}(i,2) \in \{60, 300, 135, 0, 60, 390, 270, 315, 0, 15\}$ for time outdoors, $\mathbf{O}(i,1) \in \{3,3,2,1,1,2,1,2,1,2\}$ for occurrences indoors, and $\mathbf{O}(i,2) \in \{2,2,1,0,1,3,1,1,0,1\}$ for occurrences outdoors. The average durations are 566 minutes for indoors and 155 minutes for outdoors, and average frequencies of occurrence are 1.8 for indoors and 1.2 for outdoors. By adding up all the time spent in the indoor (5,655 minutes) vs. outdoor (1,545 minutes) microenvironments (10 people x 720 minutes = 7,200 total minutes), we determine that for the population of ten people, 79% of the time was spent indoors.

To calculate the proportion of microenvironmental factor occurrences across the population for each half-hour, the microenvironments for the ten people are converted into the time-of-day formulation at one-minute resolution (Table A-2). Notice that whereas the episodic formulation requires only 30 set elements (10 people x 3 variables), the time-of-day formulation requires 10 people x 24 time segments = 240 set elements. Also notice that we lose exact duration information by choosing half-hour time units, which are less than the one-minute time resolution of the beginning and ending times. The frequencies of indoor and outdoor microenvironments in half-hour increments over all ten people (Table A-2) can be converted into percentages and plotted to present the movement of the population in and out of doors over

the 12-hour study period (Figure A-2). For most of the morning, 80% of the people are indoors, with between 60 and 80% indoors from 8:00 am to noon.

A4. Modeling Human Exposure

Since exposure is usually reported in pollutant concentrations c_j, before total human exposure can be estimated for a population, we require knowledge of the pollutant concentration in each microenvironment j. Concentrations are either measured directly using personal monitoring surveys, or predicted with validated microenvironmental exposure models that incorporate mass balance descriptions of pollutant flow.[33-36]

Duan[20] has proposed a model that expresses the integrated exposure E_i for a population of N people's exposure to air pollutants over a specified time period T:

(8) $$E_i = \sum_{j=1}^{J} c_j t_{ij}$$

where

E_i = the integrated pollutant exposure of person i
$i = 1,2,3,\ldots,N$ people
c_j = the pollutant concentration encountered in microenvironment j
t_{ij} = the time spent by person i in microenvironment j
J = the number of microenvironments visited

Table A-2. Time-of-Day Formulation for Ten People (i=1..10) With Frequencies of Indoor (k=1) vs. Outdoor (k=2) Microenvironments Over 12-Hours in Half-Hour Increments

Time j =	12:00 am	12:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00	5:30	6:00	6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30 am
i =1	k=1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	1
2	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1	2	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
6	2	2	2	2	2	2	2	2	1	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
7	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1
O(j,1)=	8	8	8	8	8	8	8	8	9	8	9	9	8	8	8	8	8	7	7	7	8	8	6	8
O(j,2)=	2	2	2	2	2	2	2	2	1	2	1	1	2	2	2	2	2	3	3	3	2	2	4	2

Note: **O**(j,1) = Frequency of Being Indoors (k = 1) for half-hour increment j. **O**(i,1) = Frequency of Being Outdoors (k = 2) for half-hour increment j..

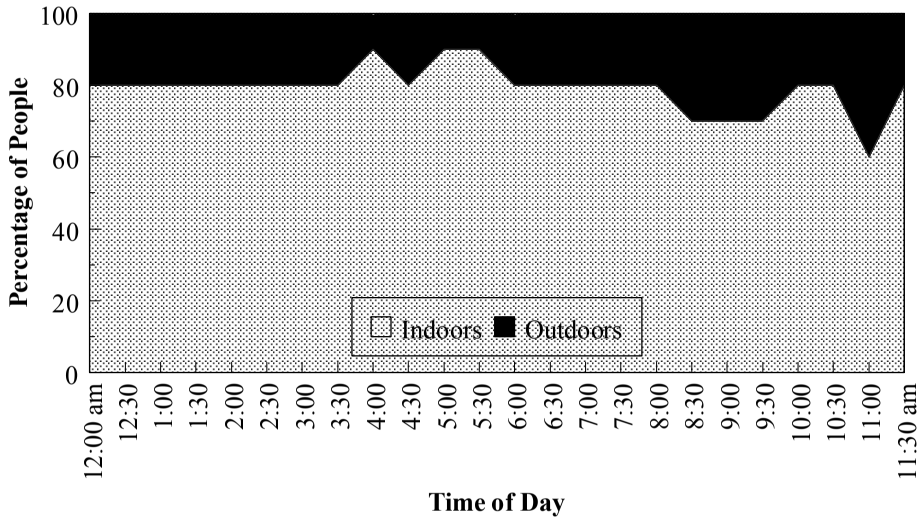


Figure A-2. Percentage of people in indoor vs. outdoor microenvironments by time-of-day in half-hour increments over a 12-hour period.

Person i's integrated exposure over all microenvironments j is computed by multiplying the pollutant concentration c_i by the microenvironment's duration t_{ij}. The average exposure of person i over the time period T is E_i/T. This model -- based on the episodic formulation of microenvironments -- does not explicitly incorporate a time sequence of microenvironments or a generalized microenvironmental definition that accounts for all kinds of simultaneous exposure.

Klepeis, Ott, and Switzer[13] have presented a framework for using microenvironmental data in modeling human exposure to particles on personal computers -- based on the time-of-day formulation of microenvironments -- that constructs 1440-minute arrays containing location, activity, and smoker-present codes for each person over a 24-hour period: the Total Human Exposure Model (THEM). The exposure $E(i,j)$ of an individual i at any minute j is a function of **L**, **A**, and **S** arrays, which contain location, activity, and smoker-present codes, respectively:

(9) $$E(i, j) = f[\mathbf{L}(i, j),\ \mathbf{A}(i, j),\ \mathbf{S}(i, j)]$$

Each different kind of exposure to particles (tobacco smoke, wood smoke, cooking, cleaning, etc.) is calculated by a subprogram ($TS(i,j)$, $WS(i,j)$, $CK(i,j)$, $CL(i,j)$, etc.) that depends on the microenvironment that each person i visits during a series of minutes j. The total exposure $E(i,j)$ is the sum of all of these different kinds of exposure according to the "superposition hypothesis".[27,28] Such a framework is very versatile for calculations of average total exposure over any time period (hourly, 8-hour, 24-hour) since it contains minute-by-minute exposure information. It can be improved by generalizing the kinds of exposure to any kind of simultaneous microenvironments (including exposure to ambient pollutant sources) as we have done above with the generalized microenvironment M.

Building on the time-of-day microenvironmental formulation we have developed above, total human exposure $E(i,j)$ is a function of the generalized set of microenvironments M for person i and time intervals j (minutes):

(10) $$E(i, j) = f[M(i, j; k_1, \ldots, k_n)]$$

M can be decomposed into microenvironmental factors **F** for person i and time interval j:

$$
\begin{aligned}
&M(i,j;k_1,\ldots,k_n) = M\left(i,j;F_{k_1,\ldots,k_n}\right) \\
(11)\quad &\in M(i,j;\mathbf{F}) = \bigcup_{k_1=1,\ldots k_n=1}^{a_1,\ldots,a_n} M\left(i,j;F_{k_1,\ldots,k_n}\right) = M\left(i,j;F_{1,\ldots,1}\right) \cup M\left(i,j;F_{1,\ldots,2}\right) \cup \ldots \cup M\left(i,j;F_{a_1,\ldots,a_n}\right)
\end{aligned}
$$

Example

Consider a two-factor location x smoker-present microenvironments each with two elements ($k_1 = 1$ for indoors, $k_1 = 2$ for outdoors, $k_2 = 1$ for no-smoker-present, and $k_2 = 2$ for smoker-present):

$$
\begin{aligned}
&M(i,j;k_1,k_n) = M\left(i,j;F_{k_1,k_n}\right) \\
(12)\quad &\in M(i,j;\mathbf{F}) = \bigcup_{k_1=1,k_2=1}^{a_1=2,a_2=2} M\left(i,j;F_{k_1,k_2}\right) = M\left(i,j;F_{1,1}\right) \cup M\left(i,j;F_{1,2}\right) \cup M\left(i,j;F_{2,1}\right) \cup M\left(i,j;F_{2,2}\right)
\end{aligned}
$$

M is based on the union of each combination of microenvironmental factors (Table A-3 illustrates $M(i,j;\mathbf{F})$ for person #1 from the example in Table A-2). The set $M(1,j;F_{1,1})$ corresponding to "no smokers indoors" for person #1 (Table A-3) contains the most elements (14) with $M(1,j;F_{1,2})$ for "smoker present indoors" having the next highest number of elements (6).

To determine exposures for each combination of location and smoker-present categories for person i at minute j, the corresponding exposure array element $E(i,j)$ is filled in using appropriate exposure subprograms that operate on each element of $M(i,j;\mathbf{F})$ (f_{11} for indoors/no-smoker-present, f_{12} for indoors/smoker-present, f_{21} for outdoors/no-smoker-present, and f_{22} for outdoors/smoker-present) -- assigning null values if no exposure has taken place. The total human exposure $E(i,j)$ for person i over the time intervals j is the union of the resulting exposures $e(i,j;\mathrm{F}_{k1,k2})$ (Table A-3):

$$
\begin{aligned}
(13)\quad E(i,j) &= f_{11}\left[M\left(i,j;F_{1,1}\right)\right] \cup f_{12}\left[M\left(i,j;F_{1,2}\right)\right] \cup f_{21}\left[M\left(i,j;F_{2,1}\right)\right] \cup f_{22}\left[M\left(i,j;F_{2,2}\right)\right] \\
&= e\left(i,j;F_{1,1}\right) \cup e\left(i,j;F_{1,2}\right) \cup e\left(i,j;F_{2,1}\right) \cup e\left(i,j;F_{2,2}\right)
\end{aligned}
$$

Table A-3. Example (n=2) Breakdown of the Time-of-Day Formulation of the Generalized n-Factor Microenvironment $M(i,j;\ \mathrm{F} = F_{k1,k2})$ for Person i = 1, and Location (Indoor/Outdoor) and Smoker-Present Microenvironmental Factors (k_1 = 1 for indoors, k_1 = 2 for outdoors, k_2 = 1 for smoker-present, k_2 = 2 for no-smoker-present)

$M(1,j;\ F_{k1,k2})$				=	$M(1,j;\ F_{1,1})$				∪	$M(1,j;\ F_{1,2})$				∪	$M(1,j;\ F_{2,1})$				∪	$M(1,j;\ F_{2,2})$			
i	j	k_1	k_2		i	j	k_1	k_2		i	j	k_1	k_2		i	j	k_1	k_2		i	j	k_1	k_2
1	1	1	1		1	1	1	1															
1	2	1	1		1	2	1	1															
1	3	1	1		1	3	1	1															
1	4	1	1		1	4	1	1															
1	5	1	1		1	5	1	1															
1	6	1	1		1	6	1	1															
1	7	1	1		1	7	1	1															
1	8	1	1		1	8	1	1															
1	9	1	1		1	9	1	1															
1	10	1	1		1	10	1	1															
1	11	1	1		1	11	1	1															
1	12	1	1		1	12	1	1															
1	13	1	2							1	13	1	2										
1	14	1	2							1	14	1	2										
1	15	1	2							1	15	1	2										
1	16	1	2							1	16	1	2										
1	17	2	2																	1	1	2	2
1	18	2	2																	1	1	2	2
1	19	1	1		1	19	1	1															
1	20	1	2							1	20	1	2										
1	21	1	2							1	21	1	2										
1	22	2	1												1	22	2	1					
1	23	2	1												1	23	2	1					
1	24	1	1		1	24	1	1															

Table A-4. Breakdown of the 12-Hour (24 half-hour intervals j) Total Exposure Array E(i,j) for Person i = 1 into the Exposure Arrays $e(i,j;\ F_{k1,k2})$ Containing Hypothetical Exposure Concentrations c_i (µg/m^3) Calculated from Exposure Subprograms $f_{11}, f_{12}, f_{21}, f_{22}$ for Each Different Combination of Microenvironmental Factors (k_1 = 1 for indoors, k_1 = 2 for outdoors, k_2 = 1 for no-smoker-present, and k_1=2, for smoker-present)

$E(1,j)$ =			$e(1,j;F_{11})$			$e(1,j;F_{12})$			$e(1,j;F_{21})$			$e(1,j;F_{22})$		
i	j	c_i	i	j	c_i	i	j	c_i	i	j	c_i	i	j	c_i
1	1	0	1	1	0									
1	2	0	1	2	0									
1	3	0	1	3	0									
1	4	0	1	4	0									
1	5	0	1	5	0									
1	6	0	1	6	0									
1	7	0	1	7	0									
1	8	0	1	8	0									
1	9	0	1	9	0									
1	10	0	1	10	0									
1	11	0	1	11	0									
1	12	0	1	12	0									
1	13	20				1	1	20						
1	14	20				1	1	20						
1	15	140				1	1	140						
1	16	0				1	1	120						
1	17	40										1	1	40
1	18	50										1	1	50
1	19	0	1	19	0									
1	20	130				1	2	130						
1	21	140				1	2	140						
1	22	0							1	22	0			
1	23	0							1	23	0			
1	24	0	1	24	0									

Note: Instead of containing location or smoker-present codes the exposure arrays $e(i,j;F_{k1,k2})$ contain exposure concentrations in µg/m^3. Microenvironments that contain multiple-simultaneous exposures (*e.g.* smoker-present, dust, car exhaust, etc.) are treated by each exposure subprogram ($f_{11}, f_{12}, f_{21}, f_{22}$), by branching to cigarette, dust, or other exposure submodels -- that account for pollutant cross-effects or assume simple superposition of exposures -- or by sampling from distributions of typical exposures. Each possible combination of exposure factors can theoretically give a different kind of exposure.

In Table A-4 the elements of the exposures $e(1,j;\ F_{1,1})$ and $e(1,j;\ F_{2,1})$ for person #1 all contain exposures of 0 μg/m^3 since there is no smoker present, while the elements of $e(1,j;\ F_{1,2})$ and $e(1,j;\ F_{2,2})$ contain indoor and outdoor smoking exposures calculated from the f_{12} and f_{22} subprograms, respectively -- note that these are hypothetical values.

In general, the exposure subprograms can either be physical submodels that predict exposures based on microenvironment characteristics (air flow, pollutant source strength, etc.)[33-36] or probabilistic submodels that randomly sample typical exposures from monitoring data (using the Monte-Carlo method). The same subprogram can be used for different elements of $M(i,j;\ \mathbf{F})$, and some subprograms (*e.g.* f_{11}, f_{21}) may simply function to fill in every element in the exposure array with values of zero. For microenvironments that incorporate simultaneous exposures (*e.g.*, exposure to particles from both a smoker and someone vacuuming carpet), exposure values are summed to give the total exposure (by the superposition principle).

APPENDIX B: DETAILED EXAMPLES OF THE METHODOLOGY USED FOR CALCULATIONS IN THIS REPORT (WITH SAS[31] COMPUTER CODE)

B1. Episodic: Duration and Frequency of Occurrence of Microenvironments

The episodic formulation of microenvironments (beginning and ending times with matched microenvironment codes for each record) is useful for calculations of the percentage of time spent, mean 24-hour durations, and mean 24-hour frequencies of occurrence for microenvironments occurring throughout the diary day. An example of the episodic format, which is the native NHAPS format, is found in Table B-1. Each record contains the beginning and ending times of each episode with the corresponding original NHAPS microenvironment variables (FACT, RACT, WHR, SMK) and the recoded variables (NEWACT, REGACT, and NEWLOC). The episode duration is also included (ETOA). There is a new record (= microenvironment) every time the respondent entered a new location, activity, or smoker-present category. Counts of the number of records containing each location or each activity can greatly overestimate their 24-hour frequency of occurrence because: (1) the same location can occur consecutively when the respondent experiences different activities and vice versa; and (2) after the original microenvironment codes were recoded, it was possible for the identical microenvironment to occur in two consecutive records, although this phenomena seems to occur mostly when REGACT = 0. The two columns in Table B-2 compare the 24-hour frequency computed by simply counting the consecutive occurrences only versus counting records with the same consecutive locations, activities, etc. only once, *i.e.*, merging these records. The 24-hour duration of each microenvironment and the percentage of time spent in each microenvironment is calculated for Person ID#1.1 (Table B-2). The mean 24-hour duration and 24-hour frequency of occurrence of each microenvironment over the NHAPS respondents were obtained by averaging each individual's 24-hour duration (SAS code in Figure B-1). The percentage time spent in each microenvironment over all respondents was obtained by dividing the amount of time everyone spent in each microenvironment (calculated with the SAS code in Figure B-1)

Table B-1. Example 24-Hour Diary File in the Episodic Format for Person ID# 1.1 Containing Beginning & Ending Times, Original Codes, Regrouped Codes, and Durations of 22 Microenvironments Visited on the Diary Day (see Section 5 for code explanations).

No.	ID	START	END	FACT	RACT	NEWACT	REGACT	WHR	NEWLOC	SMK	ETOA
1	1.1	0:00	1:45	at night club1	77	0	0	405	90	1	105
2	1.1	1:45	2:00	traveled home after night club	79		0	301	30	0	15
3	1.1	2:00	11:00	Sleeping or Napping	45	0	0	105	10	0	540
*4	1.1	11:00	11:05	brushed teeth	44	31	40	104	10	0	5
*5	1.1	11:05	11:15	Preparing Meals or Snacks	10	10	10	101	10	0	10
*6	1.1	11:15	11:25	Eating Meals or Snacks	43	15	70	102	10	0	10
7	1.1	11:25	11:30	Dressing or Personal Grooming	47	0	0	102	10	0	5
8	1.1	11:30	11:37	traveled to play football	89	0	0	306	40	0	7
*9	1.1	11:37	13:37	playing flag football	80	60	60	507	50	0	120
*10	1.1	13:37	13:44	travel to a bar	79	0	0	306	40	0	7
*11	1.1	13:44	13:54	Preparing Meals or Snacks	10	10	10	201	10	0	10
12	1.1	13:54	13:57	travel from bar	79	0	0	301	30	0	3
13	1.1	13:57	15:30	at bar	77	0	0	405	90	1	93
14	1.1	15:30	15:33	travel from bar	79	0	0	301	30	0	3
15	1.1	15:33	16:30	Watching TV	91	0	0	102	10	0	57
*16	1.1	16:30	17:00	Bathing or Showering	40	30	40	104	10	0	30
17	1.1	17:00	19:00	Watching TV	91	0	0	102	10	0	120
18	1.1	19:00	19:10	travel to shopping	39	0	0	301	30	0	10
19	1.1	19:10	19:25	shopping for food	30	0	0	414	90	0	15
20	1.1	19:25	19:35	travel related to shopping for food	39	0	0	301	30	0	10
21	1.1	19:35	21:00	Watching TV	91	0	0	102	10	0	85
22	1.1	21:00	24:00	studied	54	0	0	102	10	0	180

Note 1: The shaded records with an asterix (*) beside their number designate location x activity microenvironments that were classified as exposure-related -- based on the exposure activity, *i.e.*, microenvironments with REGACT = 0 are not shaded. Exposure could be occurring in the other microenvironments, but it must be determined based on locations alone, *e.g.*, exposure to automobile exhaust in vehicles, since the exposure activity classifications lack detailed information.
Note 2: FACT = verbatim activity description; RACT = original NHAPS activity code; NEWACT = recoded activity #1 (16 categories); REGACT = recoded activity #2 (8 categories); WHR = original NHAPS location code; NEWLOC = recoded location (10 categories); SMK = original smoker-present code; ETOA = duration of microenvironment (in minutes). The respondent with Person ID# 1.1 was an Hispanic male from Connecticut between 18 and 24 who was interviewed on a weekend in the fall.

Table B-2. Example Microenvironment Calculations of Percentage of Time Spent, 24-Hour Duration, and 24-Hour Frequency of Occurrence Using Person ID# 1.1

	Percentage of Time Spent	24-Hour Duration (minutes)	24-Hour Frequency	Merged 24-Hour Frequency
Locations				
10. Res. Ind.	73.06	1052	11	4
20. Res. Out.	-	-	-	-
30. In Veh.	2.85	41	5	5
40. Near Veh.	0.97	14	2	2
50. Other Out.	8.33	120	1	1
60. Office/Fact.	-	-	-	-
70. Mall/Store	-	-	-	-
80. Public Bldg.	-	-	-	-
90. Bar/Rest.	14.79	213	3	3
100. Other Ind.	-	-	-	-
Activities				
00. Non-Exposure	87.15	1,255	16	5
10. Food Prepar.	1.39	20	2	2
20. Dishes/Laundry	-	-	-	-
30. Housekeeping	-	-	-	-
40. Bathing/Hygiene	2.43	35	2	2
50. Yard./Mainten.	-	-	-	-
60. Sports/Exercise	8.33	120	1	1
70. Eating/Drinking	0.69	10	1	1
Smoker-Present				
Smoker-Present	13.75	198	2	2
No-Smoker Present	86.25	1,242	20	2
Location x Activity				
10-40	2.43	35	2	2
10-10	1.39	20	2	2
10-70	0.69	10	1	1
50-60	8.33	120	1	1
Location x Smoker-Present				
90-01	13.75	198	2	2

Note: The respondent with Person ID# 1.1 was an Hispanic male from Connecticut between 18 and 24 who was interviewed on a weekend in the fall. Percentages of time spent over multiple respondents were done by taking the total amount of time spent in a microenvironment and dividing by the total time = 1440 x 9,386 respondents. Mean 24-hour durations were obtained by averaging over multiple respondents. There is a "consecutive error" that arises when consecutive microenvironments have the same location, activity, or smoker-present category. The merged 24-hour frequencies of occurrence (column 5) do not count locations, activities, or smoker-present categories more than once if they occur consecutively in different location x activity x smoker-present microenvironments. In this report 24-hour frequencies of occurrence were only presented for location x activity and location x smoker-present microenvironments.

```
libname n2'e:\s2dt';run;
options ps=66 ls=120;
proc sort data=n2.timres2 out=n2.timloc; by fid newloc ;
run;
data n2.timloc; set n2.timloc; by fid newloc ;
if first.newloc then do;
   ctimloc=0;
   cnumloc=0;
  end;
  ctimloc+etoa;
  cnumloc+1;
if last.newloc then output;
run;
proc tabulate data=n2.timloc;
  class newloc;
  var ctimloc;
  table all*ctimloc*(n*f=5.0 sum*f=8.0 pctsum*f=6.2 mean*f=6.2
 std*f=6.2) ,newloc  all;run;
proc tabulate data=n2.timloc;
  class newloc;
  var cnumloc;
  table all*cnumloc*(n*f=5.0 sum*f=8.0 pctsum*f=6.2 mean*f=6.2
 std*f=6.2) ,newloc  all;run;
proc tabulate data=n2.timloc;
  class newloc;
  var ctimloc;  weight weight4;
  table all*ctimloc*(sumwgt*f=6.1 sum*f=8.0 pctsum*f=6.2 mean*f=6.2
 std*f=6.2) ,newloc  all;run;
proc tabulate data=n2.timloc;
  class newloc;
  var cnumloc;  weight weight4;
  table all*cnumloc*(sumwgt*f=6.1 sum*f=8.0 pctsum*f=6.2 mean*f=6.2
 std*f=6.2) ,newloc  all;run;
```

Figure B-1. The SAS code for calculating total time spent, 24-hour durations, and 24-hour frequencies of occurrence of microenvironments using the episodic formulation.

by the total amount of time spent over the entire diary day by all respondents (9,386 x 1440 min = 13,515,840 min, unweighted) or a subgroup of the respondents (by age, gender, etc.).

B2. Time-of-Day I: Fraction of Respondents in Each Microenvironment by Minute

The time-of-day formulation of microenvironments (sequential fixed-length time segments matched with microenvironment codes) is used for calculations of the fraction of respondents experiencing each microenvironment during every minute of the diary day. The original episodic data storage format was converted into a one-minute fixed time length format so that each record of the data base specified the microenvironments that a person entered in each hour of the day and for which of the 60 minutes he/she was there (see SAS code in Figure B-2 and example output in Table B-3).

Format Conversion

In the conversion process from episodic to time-of-day formats, the input file containing the original episode and demographic information for all respondents was `N1.TIMRES2`. The output data files containing the one-minute fixed time length format for each hour of the diary day were `N1.SUMACT0`, `N1.SUMACT1`, ..., `N1.SUMACT23` with `N1.SUMACT` containing all 24 hours concatenated into one large data set (see SAS code in Figure B-3). In the episodic data format, the variables `STRMINU` and `ENDMINU` store the beginning and ending times of each episode over the diary day with values ranging from 0 to 1440 minutes. Note that the value of `STRMINU` has been considered exclusively and the value of the `ENDMINU` has been considered inclusively. For example, an episode with `STRMINU` = 0 and `ENDMINU` = 25 occurred at a particular location and activity between 00:01:00 AM and 01:25:00 AM on the diary day.

At the heart of the algorithm is the assignment of a "1" (designated by ▓ in Table B-3) for every minute of each one-hour time block that the respondent is in the corresponding microenvironment and a missing value (designated by ▒ in Table B-3) whenever the respondent is not in the corresponding microenvironment. The respondent must be in at least one microenvironment over the 60 minutes of

```
libname n1'E:\S2DT' ;
PROC SORT DATA=N1.TIMRES2; BY FID ACTNO;RUN;
*time from 1 to 60;
data n1.sumact0 ; set N1.TIMRES2;
KEEP H FID  NEWLOC REGACT SMK ENDMINU STRTMINU REGIONC--smkexp TI1--
TI60;
H=0;
a=(H*60)+1;
b=a+60;
if a gt strtminu then strtpt=a;
else if a=strtminu then strtpt=strtminu+1;
else if a lt strtminu then strtpt=strtminu+1;
if b gt endminu then endpt=endminu;
else if b = endminu then endpt=endminu;
else if b lt endminu then endpt=b;
array time{61} ti1-ti61;
do i= strtpt-(a-1) to endpt-(a-1);
   time{i}=1;
  end;
IF SUM(OF TI1-TI60) THEN OUTPUT;
run;
```

Repeat for every hour, H = 1, 2, 3, 4,...,23

Figure B-2. The SAS code for converting the 24-hour diary data from its episodic format into the time-of-day format. Only the code for the first hour is shown (H = 0, output file = `sumact0`). For subsequent hours the values of H range from 1 to 23 and the output files are `sumact1`,..., `sumact23`.

```
LIBNAME NE'F:\S2DT';RUN;
DATA NE.SUMACT;
SET N1.SUMACT0 N1.SUMACT1 N1.SUMACT2 N1.SUMACT3 N1.SUMACT4 N1.SUMACT5
N1.SUMACT6 N1.SUMACT7 N1.SUMACT8  N1.SUMACT9
N1.SUMACT10 N1.SUMACT11 N1.SUMACT12 N1.SUMACT13 N1.SUMACT14
N1.SUMACT15 N1.SUMACT16 N1.SUMACT17 N1.SUMACT18 N1.SUMACT19
N1.SUMACT20 N1.SUMACT21 N1.SUMACT22 N1.SUMACT23;
RUN;
```

Figure B-3. The SAS code used to concatenate the 24 files containing the time-of-day formulation for each hour of the diary day. The resulting output file containing all 24 hours for all 9,386 respondents is `SUMACT` which took up approximately 240 MB of hard disk space.

Table B-3. Example Time-of-Day Format for Person ID# 1.1, ▓ = Person in Corresponding Location x Activity x Smoker-Present Microenvironment at the Specified Hour and Minute, ▒ = Person Not in Corresponding Microenvironment at Specified Hour and Minute

							Minute																							
FID	NEWLOC	REGACT	SMK	STRTMINU	ENDMINU	HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	HOUR
1.1	90	0	1	0	105	0	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	0
1.1	90	0	1	0	105	1	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	1
1.1	30	0	0	105	120	1	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	1
1.1	10	0	0	120	660	2	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	2
1.1	10	0	0	120	660	3	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	3
1.1	10	0	0	120	660	4	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	4
1.1	10	0	0	120	660	5	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	5
1.1	10	0	0	120	660	6	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	6
1.1	10	0	0	120	660	7	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	7
1.1	10	0	0	120	660	8	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	8
1.1	10	0	0	120	660	9	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	9
1.1	10	0	0	120	660	10	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	10
1.1	10	40	0	660	665	11	▓	▓	▓	▓	▓	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	11
1.1	10	10	0	665	675	11	▒	▒	▒	▒	▒	▓	▓	▓	▓	▓	▓	▓	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	11
1.1	10	70	0	675	685	11	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▓	▓	▓	▓	▓	▓	▓	▓	11
1.1	10	0	0	685	690	11	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	11
1.1	40	0	0	690	697	11	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	11
1.1	50	60	0	697	817	11	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	11
1.1	50	60	0	697	817	12	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	12
1.1	50	60	0	697	817	13	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	13
1.1	40	0	0	817	824	13	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	13
1.1	10	10	0	824	834	13	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	13
1.1	30	0	0	834	837	13	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	13
1.1	90	0	1	837	930	13	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	13
1.1	90	0	1	837	930	14	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	14
1.1	90	0	1	837	930	15	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	15
1.1	30	0	0	930	933	15	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	15
1.1	10	0	0	933	990	15	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	15
1.1	10	0	0	933	990	16	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	16
1.1	10	40	0	990	1020	16	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	16
1.1	10	0	0	1020	1140	17	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	17
1.1	10	0	0	1020	1140	18	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	18
1.1	30	0	0	1140	1150	19	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	19
1.1	90	0	0	1150	1165	19	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	19
1.1	30	0	0	1165	1175	19	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	19
1.1	10	0	0	1175	1260	19	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	19
1.1	10	0	0	1175	1260	20	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	20
1.1	10	0	0	1260	1440	21	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	21
1.1	10	0	0	1260	1440	22	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	22
1.1	10	0	0	1260	1440	23	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	23

Note: See Section 5 for an explanation of the microenvironmental variable codes (NEWLOC, RAGACT, SMK). STRMINU and ENDMINU are the starting and ending minutes of each hour (HOUR).

Table B-3. Continued.

HOUR	Minute 24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	HOUR
0	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	0
1	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	1
1	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	1
2	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	2
3	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	3
4	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	4
5	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	5
6	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	6
7	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	7
8	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	8
9	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	9
10	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	10
11	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	11
11	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	11
11	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	11
11	▒	▒	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	11
11	▒	▒	▒	▒	▒	▒	▒	■	■	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	11
11	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	11
12	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	12
13	■	■	■	■	■	■	■	■	■	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	13
13	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	■	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	13
13	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	■	■	■	■	■	■	■	■	■	▒	▒	▒	▒	▒	▒	13
13	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	■	■	▒	▒	▒	13
13	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	■	■	13
14	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	14
15	■	■	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	15
15	▒	▒	▒	▒	▒	▒	▒	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	15
15	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	15
16	■	■	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	16
16	▒	▒	▒	▒	▒	▒	▒	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	16
17	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	17
18	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	18
19	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	19
19	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	19
19	▒	▒	■	■	■	■	■	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	19
19	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	19
20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	20
21	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	21
22	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	22
23	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	23

every hour, but can conceivably be in up to 60 different microenvironments in that hour so that 60 different time-of-day records would be necessary to describe their microenvironments by time-of-day -- one record for each different microenvironment. Each record would have one "1" for the minute they were in the corresponding microenvironment and the remaining minutes would be filled with missing values. However, more typically, each respondent is in much fewer than 60 different microenvironments in any given hour. For example, in Table B-3 there are two records for hour #1 corresponding to the Bar/Restaurant-No-Exposure-Activity-Smoker-Present (90-0-1 = NEWLOC-REGACT-SMK) and In-Vehicle-No-Exposure-Activity-No-Smoker-Present (30-0-1) microenvironments. The first microenvironment -- in the second record -- occurs from minute 1 through minute 45 (designated by ▓'s with ▒'s inserted afterward) with the second microenvironment -- in the third record -- occurring from minute 46 to minute 60 (designated by ▓'s with ▒'s inserted previously).

The time-of-day format consists of 24 one-hour time blocks (0,...,23) specified by the variable `H` with each of the 60 minutes in each one-hour time block corresponding to a microenvironment. The variable `a` is the starting time of this one hour time block in the 1440-minute scale (*i.e.* 1, 61,121,...) and `b` is the ending time of the one-hour time block in the 1440-minute scale (*i.e.* 60, 120,...). The code in Figure B-2 must be repeated for all 24 one-hour time blocks. The "1" flags that show whether the respondent is present in a microenvironment for a particular minute (t1, t2,...) are stored in the array `tij`. The elements of the array are assigned by determining the starting point `strtpt` and ending point `endpt` of the microenvironment within the limits of each one-hour time block beginning at `a` and ending at `b`, and filling in "1"'s whenever the microenvironment occurs. The microenvironment starting time `STRMINU` may occur before `a`, at `a`, or after `a`, and the microenvironment ending time `ENDMINU` may occur before `b`, at `b`, or after `b`.

```
libname n2'f:\s2dt';run;
filename ou1 'c:\tlocall.lst';
filename ou2 'c:\tlocsex.lst';
options ls=120 ps=72 nocenter;
```

Overall.

Unweighted:

```
proc printto print=ou1;
title'Activity Study by every minute unweighted loc';
proc tabulate data=n2.sumact;
class  H newloc;
var ti1-ti60;
table H*(ti1  ti2 ti3 ti4 ti5 ti6 ti7 ti8 ti9 ti10
           ti11  ti12 ti13 ti14 ti15 ti16 ti17 ti18 ti19 ti20
           ti21  ti22 ti23 ti24 ti25 ti26 ti27 ti28 ti29 ti30
           ti31  ti32 ti33 ti34 ti35 ti36 ti37 ti38 ti39 ti40
           ti41  ti42 ti43 ti44 ti45 ti46 ti47 ti48 ti49 ti50
           ti51  ti52 ti53 ti54 ti55 ti56 ti57 ti58 ti59 ti60
         )*(n*f=6.0),newloc all;
run;
```

Weighted:

```
title'Activity Study by every minute weighted loc';
proc tabulate data=n2.sumact;
class  H newloc;
var ti1-ti60;      weight weight4;
table H*(ti1  ti2 ti3 ti4 ti5 ti6 ti7 ti8 ti9 ti10
           ti11  ti12 ti13 ti14 ti15 ti16 ti17 ti18 ti19 ti20
           ti21  ti22 ti23 ti24 ti25 ti26 ti27 ti28 ti29 ti30
           ti31  ti32 ti33 ti34 ti35 ti36 ti37 ti38 ti39 ti40
           ti41  ti42 ti43 ti44 ti45 ti46 ti47 ti48 ti49 ti50
           ti51  ti52 ti53 ti54 ti55 ti56 ti57 ti58 ti59 ti60
         )*(sumwgt*f=6.1),newloc all;
run;
```

By Gender.

Unweighted:

```
proc printto print=ou2;
title'Activity Study by every minute unweighted loc';
proc tabulate data=n2.sumact;
class rsex H newloc;
var ti1-ti60;
table rsex*H*(ti1  ti2 ti3 ti4 ti5 ti6 ti7 ti8 ti9 ti10
           ti11  ti12 ti13 ti14 ti15 ti16 ti17 ti18 ti19 ti20
           ti21  ti22 ti23 ti24 ti25 ti26 ti27 ti28 ti29 ti30
           ti31  ti32 ti33 ti34 ti35 ti36 ti37 ti38 ti39 ti40
           ti41  ti42 ti43 ti44 ti45 ti46 ti47 ti48 ti49 ti50
           ti51  ti52 ti53 ti54 ti55 ti56 ti57 ti58 ti59 ti60
         )*(n*f=6.0),newloc all;
run;
```

Weighted:

```
title'Activity Study by every minute weighted loc';
proc tabulate data=n2.sumact;
class rsex H newloc;
var ti1-ti60;      weight weight4;
table rsex*H*(ti1  ti2 ti3 ti4 ti5 ti6 ti7 ti8 ti9 ti10
           ti11  ti12 ti13 ti14 ti15 ti16 ti17 ti18 ti19 ti20
           ti21  ti22 ti23 ti24 ti25 ti26 ti27 ti28 ti29 ti30
           ti31  ti32 ti33 ti34 ti35 ti36 ti37 ti38 ti39 ti40
           ti41  ti42 ti43 ti44 ti45 ti46 ti47 ti48 ti49 ti50
           ti51  ti52 ti53 ti54 ti55 ti56 ti57 ti58 ti59 ti60
         )*(sumwgt*f=6.1),newloc all;
run;
```

The unweighted and weighted analyses were repeated for the other subroups: age, region, weekday vs weekend, & season.

Figure B-4. The SAS code used to calculate the unweighted and weighted (using WEIGHT4) numbers of respondents (= fraction of microenvironments at the one-minute time resolution of the study) in each location (NEWLOC category) for every minute of the 24-hour diary day, overall and for males and females (RSEX). The same code was changed slightly to do analyses by exposure activities, smoker-present categories, and by age, region, weekday vs. weekend, and season.

Table B-4. An Example Output Data File Containing the Overall Weighted Fraction of Respondents in Each Location (NEWLOC category) for Every Minute of the Diary Day Calculated Using the Time-of-Day Formulation of Microenvironments (see Section 5 for code explanations)

		NEWLOC Code									
Minute	**Time**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	12:01 AM	0.937	0.003	0.012	0.002	0.004	0.009	0.002	0.009	0.011	0.011
2	12:02 AM	0.937	0.003	0.012	0.002	0.004	0.009	0.002	0.009	0.011	0.011
3	12:03 AM	0.937	0.003	0.012	0.002	0.004	0.009	0.002	0.009	0.011	0.011
4	12:04 AM	0.937	0.003	0.012	0.002	0.004	0.009	0.002	0.009	0.011	0.011
5	12:05 AM	0.937	0.003	0.012	0.002	0.004	0.009	0.002	0.009	0.011	0.011
6	12:06 AM	0.937	0.003	0.012	0.002	0.004	0.009	0.002	0.009	0.011	0.011
7	12:07 AM	0.937	0.003	0.012	0.002	0.004	0.009	0.002	0.009	0.011	0.011
8	12:08 AM	0.937	0.003	0.012	0.002	0.004	0.009	0.002	0.009	0.011	0.011
9	12:09 AM	0.937	0.003	0.012	0.002	0.004	0.009	0.002	0.009	0.011	0.011
10	12:10 AM	0.937	0.003	0.012	0.002	0.004	0.009	0.002	0.009	0.011	0.011
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
710	11:50 AM	0.367	0.069	0.067	0.032	0.044	0.125	0.053	0.179	0.031	0.031
711	11:51 AM	0.369	0.069	0.067	0.031	0.043	0.125	0.053	0.179	0.032	0.031
712	11:52 AM	0.369	0.069	0.067	0.031	0.043	0.125	0.053	0.179	0.032	0.031
713	11:53 AM	0.369	0.069	0.067	0.031	0.043	0.125	0.053	0.179	0.032	0.031
714	11:54 AM	0.369	0.069	0.067	0.030	0.043	0.125	0.053	0.180	0.032	0.031
715	11:55 AM	0.369	0.069	0.067	0.030	0.043	0.125	0.053	0.180	0.032	0.031
716	11:56 AM	0.370	0.069	0.064	0.031	0.044	0.125	0.053	0.181	0.031	0.032
717	11:57 AM	0.370	0.069	0.064	0.031	0.044	0.125	0.053	0.181	0.031	0.032
718	11:58 AM	0.370	0.069	0.064	0.031	0.044	0.125	0.053	0.181	0.031	0.032
719	11:59 AM	0.370	0.069	0.064	0.031	0.044	0.125	0.053	0.181	0.031	0.032
720	12:00 PM	0.370	0.069	0.064	0.031	0.044	0.125	0.053	0.181	0.031	0.032
721	12:01 PM	0.365	0.055	0.116	0.040	0.038	0.110	0.046	0.168	0.032	0.029
722	12:02 PM	0.365	0.055	0.116	0.040	0.038	0.110	0.046	0.168	0.032	0.029
723	12:03 PM	0.367	0.055	0.115	0.039	0.039	0.110	0.047	0.168	0.032	0.029
724	12:04 PM	0.368	0.055	0.113	0.038	0.039	0.110	0.047	0.168	0.033	0.029
725	12:05 PM	0.367	0.056	0.113	0.038	0.039	0.110	0.047	0.168	0.033	0.029
726	12:06 PM	0.374	0.057	0.102	0.033	0.039	0.110	0.047	0.169	0.039	0.029
727	12:07 PM	0.374	0.057	0.102	0.033	0.039	0.110	0.047	0.169	0.039	0.029
728	12:08 PM	0.375	0.057	0.102	0.033	0.039	0.110	0.047	0.169	0.039	0.029
729	12:09 PM	0.375	0.057	0.101	0.033	0.039	0.110	0.047	0.169	0.039	0.029
730	12:10 PM	0.375	0.057	0.101	0.033	0.040	0.110	0.047	0.169	0.039	0.029
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
1430	11:50 PM	0.934	0.005	0.012	0.002	0.005	0.007	0.002	0.007	0.018	0.008
1431	11:51 PM	0.935	0.005	0.012	0.002	0.005	0.007	0.002	0.007	0.017	0.008
1432	11:52 PM	0.935	0.005	0.012	0.002	0.005	0.007	0.002	0.007	0.017	0.008
1433	11:53 PM	0.935	0.005	0.012	0.002	0.005	0.007	0.002	0.007	0.017	0.008
1434	11:54 PM	0.935	0.005	0.012	0.002	0.005	0.007	0.002	0.007	0.017	0.008
1435	11:55 PM	0.935	0.005	0.012	0.002	0.005	0.007	0.002	0.007	0.017	0.008
1436	11:56 PM	0.936	0.005	0.010	0.002	0.005	0.007	0.002	0.007	0.018	0.008
1437	11:57 PM	0.936	0.005	0.010	0.002	0.005	0.007	0.002	0.008	0.018	0.008
1438	11:58 PM	0.936	0.005	0.010	0.002	0.005	0.007	0.002	0.008	0.018	0.008
1439	11:59 PM	0.936	0.005	0.010	0.002	0.005	0.007	0.002	0.008	0.018	0.008
1440	12:00 AM	0.936	0.005	0.011	0.002	0.005	0.007	0.002	0.008	0.018	0.008

The Fraction of Respondents Experiencing Each Microenvironment During Each Minute

From the concatenated file `N1.SUMACT` containing the 24-hour time-of-day format for all 9,386 respondents, the number of times a microenvironment occurred during each minute of the day was tabulated (see SAS code in Figure B-4). These frequencies were then divided by the total number of microenvironments occurring in each minute to convert them into fractions (see example in Table B-4). Since the episodic format had a resolution of one minute, our 1440-minute time-of-day format contains all the information in the episodic format, and each microenvironment's fraction of the total microenvironments occurring in each minute is equal to the fraction of respondents experiencing that microenvironment during that minute.

Time and Hardware Requirements

The complete conversion from the episodic to the time-of-day format (for all 24 hours and all 9,386 respondents) was accomplished with less than 60 minutes of CPU time on a 486 IBM-compatible personal computer. Each hour of the time-of-day formulation required nearly 10 MB of hard disk space -- with approximately 10 demographic variables for each respondent -- for a total of almost 240 MB over all 24 hours (concatenated file). Thus, a total of almost 0.5 GB is required for the calculation since the concatenated file must coexist on the hard disk with the hourly files. Overall calculations of the number of respondents in each microenvironment for each of the 1440 minutes on the diary day each took approximately 15-20 minutes on a 486 IBM-compatible personal computer. Slightly more time was required for subgroup calculations (divisions by age, gender, region, etc.).

B3. Time-of-Day II: Duration of Microenvironments by Eight 3-Hour Segments

Since duration information was destroyed within each time unit of the time-of-day format by minute, the time unit was increased to 3-hours, giving eight segments over the 24-hour diary day: (1) midnight-3 AM; (2) 3 AM-6 AM; (3) 6 AM-9 AM; (4) 9 AM-noon; (5) noon-3 AM; (6) 3 PM-6 PM; (7) 6 PM-9 PM; and (8) 9 PM-midnight. The durations of microenvironments originating in each of the eight 3-hour segments that comprise the 24-hour diary day were calculated in the same way as 24-hour durations were calculated

(see SAS code in Figure B-5) except that the entire duration of each microenvironment was used even if its ending time extended beyond the 3-hour segment. For example, the ninth microenvironment for the NHAPS respondent with Person ID# 1.1 (Sports/Exercise in the Other Outdoor location) began at 11:37 AM (in the fourth 3-hour segment) and continued until 1:37 PM (in the fifth 3-hour segment). This microenvironment would be attached to the fourth 3-hour segment -- its time segment of origin -- and assigned a duration of two hours even though it lasted 1 hour and 37 minutes into the fifth 3-hour segment.

```
libname n2'e:\s2dt';run;
options ps=66 ls=120;
data timres2;set n2.timres2;
```

Overall.

```
gsthr=floor(sthr/3);
proc sort data=timres2 out=n2.timtloc; by gsthr fid newloc ;
run;
data n2.timtloc; set n2.timtloc; by gsthr fid newloc ;
if first.newloc then do;
   ctimloc=0;
   cnumloc=0;
  end;
  ctimloc+etoa;
  cnumloc+1;
if last.newloc then output;
run;
```

Unweighted:

```
proc tabulate data=n2.timtloc;
  class newloc;
  var ctimloc;
  table all*ctimloc*(n*f=5.0 sum*f=8.0 pctsum*f=6.2 mean*f=6.2
 std*f=6.2) ,newloc  all;run;
```

Weighted:

```
proc tabulate data=n2.timtloc;
  class newloc;
  var ctimloc;  weight weight4;
  table all*ctimloc*(sumwgt*f=6.1 sum*f=8.0 pctsum*f=6.2 mean*f=6.2
 std*f=6.2) ,newloc  all;run;
```

By gender.

Unweighted:

```
options ls=146 ps=56 nocenter;
proc tabulate data=n2.timtloc;
  class rsex newloc gsthr;
  label gsthr='t'
        rsex='sex';
  var ctimloc;
  table rsex*gsthr*ctimloc*(n*f=5.0 sum*f=8.0 pctsum*f=6.2 mean*f=6.2
 std*f=6.2) all*ctimloc*(n*f=5.0 sum*f=8.0 pctsum*f=6.2 mean*f=6.2
 std*f=6.2),
     newloc  all/rts=2;
keylabel pctsum='%sm'
         sum='sm'
         ;
run;
```

Weighted:

```
proc tabulate data=n2.timtloc;
  class rsex newloc gsthr;
label gsthr='t'
      rsex='sex';
  var ctimloc;  weight weight4;
  table rsex*gsthr*ctimloc*(sumwgt*f=6.1 sum*f=8.0 pctsum*f=6.2 mean*f=6.2
 std*f=6.2) all*ctimloc*(sumwgt*f=6.1 sum*f=8.0 pctsum*f=6.2 mean*f=6.2
 std*f=6.2),
      newloc  all/rts=2;
keylabel sumwgt='wsm'
         sum='sm'
         pctsum='%sm';
run;
```

Figure B-5. The SAS code used to calculate weighted and unweighted overall mean durations in each of the 8 three-hour segments (GSTHR) in the 24-hour diary day, overall and by gender. Similar code was used in analyses for the other subgroups.