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14. ACTIVITY FACTORS

In calculating exposure, a person's average daily dose is determined from a combination of variables including the pollutant concentration, exposure duration, and frequency of exposure (Sexton and Ryan, 1987). These variables can be dependent on human activity patterns and time spent at each activity and/or location. A person's total exposure can be predicted using indirect approaches such as computerized mathematical models. This indirect approach of predicting exposure also requires activity patterns (time use) data. Thus, individual or group activities are important determinants of potential exposure because toxic chemicals introduced into the environment may not cause harm to an individual until an activity is performed subjecting the individual to contact with those contaminants. An individual's choice on how to spend time will vary according to their occupation, hobbies, culture, location, gender, age, and personal preferences. Educational level attained and socioeconomic status also influence chosen activities and their duration.

The purpose of this section is to describe published time use studies that provide information on activities in which various individuals engage, length of time spent performing various activities, locations in which individuals spend time and length of time spent by individuals within those various environments. Information on time spent in specific occupations and residing in specific areas also is included in this section.

This section summarizes data on how much time individuals spend doing various activities and in various microenvironments. These data cover a wide scope of activities and populations. The following table (Table 14-1) should be used as a guide to locating the information relevant to activities and microenvironments of concern. Assessors can consider using these data to develop exposure duration estimates for specific exposure scenarios. Available studies are grouped as key or relevant studies. The classifications of these studies are based on the applicability of their data to exposure assessments. All tables that provide data from these studies are presented at the back of this chapter.

14.1. ACTIVITY PATTERNS

The purpose of this section is to describe published time use studies that provide information on time-activity patterns of the national population and various sub-populations in the U.S. The studies involve survey designs where time diaries were used to collect information on the time spent at various activities and locations for children, adolescents, and adults, and to collect certain demographic and socioeconomic data. Available studies on time-activity data are summarized in the following sections. It should be noted that other site-limited studies, based on small sample sites, are available, but are not presented in this section. The studies presented in this section are ones believed to be the most appropriate for the purpose of the Handbook. Activity pattern studies are presented in Sections 14.1.1 and 14.1.2.

14.1.1. Key Activity Pattern Studies

Timmer et al. - How Children Use Time - Timmer et al. (1985) conducted a study using the data obtained on children's time use from a 1981-1982 Panel study. This study was a follow-up of households from a previous survey conducted in 1975-76. The 922 respondents in the 1981-82 study were those who had completed at least three out of four waves of interview in the 1975 - 1976 survey. Timmer et al. (1985) conducted the survey during February through December 1981, and households were contacted four times during a 3 month interval of the survey period. The first contact was a personal interview, followed by subsequent telephone interviews for most of the respondents. However, families with children were contacted personally and questionnaires were administered to a maximum of three children per household.

The children surveyed were between the ages of 3 and 17 years and were interviewed twice. The questionnaires administered to children had two components: a time diary and a standardized interview. The time diary involved children reporting their activities beginning at 12.00 a.m. the previous night; the duration and location of each activity; the presence of another individual; and whether they were performing other activities at the same time. The standardized interview administered to the children was to gather information about their psychological, intellectual (using reading comprehension tests), and emotional well-being; their hopes and goals; their family environment; and their attitudes and beliefs.

For preschool children, parents provided information about the child's previous day's activities. Children in first through third grades completed the time diary with their parents assistance and, in addition, completed reading tests. Children in fourth grade and above provided their own diary information and participated in the interview. Parents were asked to assess their children's socioemotional and intellectual development. A survey form was sent to a teacher of each school-age child to evaluate each child's

socioemotional and intellectual development. The activity descriptor codes used in this study were developed by Juster et al. (1983). The activity codes and descriptors used for the adult time diaries in both surveys are presented in Appendix Table 14A-1.

The mean time spent performing major activities on weekdays and weekends by age and sex, and type of day is presented in Table 14-2. On weekdays, children spend about 40 percent of their time sleeping, 20 percent in school, and 10 percent eating, washing, dressing, and performing other personal activities (Timmer et al., 1985). The data in Table 14-2 indicates that girls spend more time than boys performing household work and personal care activities, and less time playing sports. Also, children spend most of their free time watching television. Table 14-3 presents the mean time children spend during weekdays and weekends performing major activities by five different age groups. Also, the significant effects of each variable (i.e., age, sex) are shown in Table 14-3. Older children spend more time performing household and market work, studying and watching television, and less time eating, sleeping, and playing. Timmer et al. (1985) estimated that on the average, boys spend 19.4 hours a week watching television and girls spend 17.8 hours per week performing the same activity.

A limitation associated with this study is that the data do not provide overall annual estimates of children's time use since the data were collected only during the time of the year when children attend school and not during school vacation. Another limitation is that a distribution pattern of children's time use was not provided. In addition, the survey was conducted in 1981 so there is a potential that activity patterns in children may have changed significantly from that period to the present. Therefore, application of these data for current exposure situations may bias exposure assessments results. An advantage of this survey is that diary recordings of activity patterns were kept and the data obtained were not based completely on recall. Another advantage is that because parents assisted younger children with keeping their diaries and with interviews, any bias that may have been created by having younger children record their data should have been minimized.

Robinson and Thomas - Time Spent in Activities, Locations, and Microenvironments: A California-National Comparison - Robinson and Thomas (1991) reviewed and compared data from the 1987-88 California Air Resources Board (CARB) time activity study and from a similar 1985 national study, *American's Use of Time*. Data from the national study were recorded similarly to the CARB code categories, in order to make data comparisons (Robinson and Thomas, 1991).

The CARB study involved residents who lived in the state of California. One adult 18 years or older was randomly sampled in each household and was asked to complete a diary with entries for the previous day's activities and the location of each activity. Time use patterns for other individuals 12 years and older in the households contacted were also included in the diaries. Telephone interviews based on the random-digit-dialing (RDD) procedure were conducted for approximately 1,762 respondents in the CARB survey. These interviews were distributed across all days of the week and across different months of the year (between October 1987-August 1988).

In the 1985 National study, single day diaries were collected from over 5,000 respondents across the U.S., 12 years of age and older. The study was conducted during January through December 1985. Three modes of time diary collection were employed for this survey: mailback, telephone interview, and personal interview. Data obtained from the personal interviews were not used in this study (Robinson and Thomas, 1991). The sample population for the mail-back and telephone interview was selected based on a RDD method. The RDD was designed to represent all telephone households in the contiguous United States (Robinson and Thomas, 1991). In addition to estimates of time spent at various activities and locations, the survey design provided information on the employment status, age, education, race, and gender for each member of the respondent’s household. The mail-back procedure was based on a "tomorrow" approach, and the telephone interview was based on recall. In the "tomorrow" approach, respondents know, and agree ahead of time, that they will be keeping a diary (Robinson and Thomas, 1991).

Data comparisons by Robinson and Thomas (1991) were based on 10 major activity categories (100 sub-category codes) and 3 major locations (44 sub-location codes) employed in both the CARB and the 1985 national study. In order to make data comparisons, Robinson and Thomas (1991) excluded responses from individuals of ages 65 years and older and 18 years or younger in both surveys. In addition, only mail-back responses were analyzed for the 1985 national study. The data were then weighted to project both the California and national population in terms of days of the week, region, numbers of respondents per household, and 3 monthly seasons of the year (Robinson and Thomas, 1991).

Table 14-4 shows the mean time spent in the 10 major activities by gender and for all respondents between the ages of 18-64 years (time use data for the individual activities are presented in Appendix Table 14A-2). In both studies respondents spent most of their time (642 mins/day) on personal needs and care (i.e., sleep). Californians spent more time on paid work, education and training, obtaining goods and services, and communication, and less time on household work, child care, organizational activities, entertainment/social activities, and recreation than the national population. The male and female population closely followed the same trends as the general population. Table 14-5 shows the mean time spent at 3 major locations for the CARB and national study grouped by total sample and gender, ages 18-64 years (time use data for the 44 detailed microenvironments are presented in Appendix Table 14A-3). Respondents spent most of their time at home, 892 minutes/day for the CARB and 954 minutes/day for the national study. Californians spent more of their time away from home and traveling compared to the national population.

In addition, Robinson and Thomas (1991) defined a set of 16 microenvironments based on the activity and location codes employed in both studies. The analysis included data for adolescents (12-17 years) and adults (65 years and older) in both the CARB study and the mail-back portion of the 1985 national study (Robinson and Thomas, 1991). The mean duration of time spent in locations for total sample population, 12 years and older, across three types of locations is presented in Table 14-6 for both studies. Respondents spent most of their time indoors, 1255 and 1279 minutes/day for the CARB and national study, respectively.

Table 14-7 presents the mean duration of time and standard mean error for the 16 microenvironments grouped by total sample population and gender. Also included is the mean time spent for respondents ("Doers") who reported participating in each activity. Table 14-7 shows that in both studies men spend more time in autoplaces (garages), automobiles and other vehicles, physical outdoor activities, outdoor sites, and work locations. In contrast, women spend more time cooking, engaging in other kitchen activities, performing other chores, and shopping. The same trends also occur on a per participant basis.

Table 14-8 shows the mean time spent in various microenvironments grouped by type of the day (weekday or weekend) in both studies. Generally, respondents spent most of their time during the weekends in restaurants/bars (CARB study), motor vehicles, outdoor activities, social-cultural settings, leisure/communication activities, and sleeping. Microenvironmental differences by age are presented in Table 14-9. Respondents in the age groups 18-24 years and 25-44 years spent most of their time in restaurants/bars and traveling. The oldest age group, 65 years and older, spent most of their time in the kitchen (cooking and other kitchen related activities) and in communication activities.

Limitations associated with the Robinson and Thomas (1991) study are that the CARB survey was based on recall and the survey was performed in California only. This may somewhat bias the CARB data set. Another limitation is that time distribution patterns (statistical analysis) were not provided for both studies. Also, the data are based on short term studies. An advantage of this study is that the 1985 national study represents the general U.S. population. Also, the 1985 national study provides time estimates by activities, locations, and microenvironments grouped by age, gender, and type of day. Another advantage is that the data were compared and that, overall, both data sets showed similar patterns of activity (Robinson and Thomas, 1991).

California Air Resources Board (CARB) - Study of Children's Activity Patterns - The California children's activity pattern survey design provided time estimates of children (under 12 years old) in various activities and locations (microenvironments) on a typical day (CARB, 1991). The sample population, which consisted of 1,200 respondents (including children under 12 years of age and adult informants residing in the child's household), was selected using Waksberg RDD methods from English-speaking households. One child was selected from each household. If the selected child was 8 years old or less, the adult in the same household who spent the most time with the child responded. However, if the selected child was between 9 and 11 years old, that child responded. The population was also stratified to provide representative estimates for major regions of the state. The survey questionnaire included a time diary which provided information on the children's activity and location patterns based on a 24-hour recall period. In addition, the survey questionnaire included questions about potential exposure to sources of indoor air pollution (i.e., presence of smokers) on the diary day and the socio-demographic characteristics (i.e., age, gender, marital status of adult) of children and adult respondents. The questionnaires and the time diaries were administered via a computer-assisted telephone interviewing (CATI) technology (CARB, 1991). The telephone interviews

were conducted during April 1989 to February 1990 over four seasons: Spring (April-June 1989), Summer (July-September 1989), Fall (October-December 1989), and Winter (January-February 1990).

The data obtained from the survey interviews resulted in ten major activity categories, 113 detailed activity codes, 6 major categories of locations, and 63 detailed location codes. The average time respondents spent during the 10 activity categories for all children are presented in Table 14-10. Also included in this table are the detailed activity, including its code, with the highest mean duration of time; the percentage of respondents who reported participating in any activity (percent doing); and the mean, median, and maximum time duration for "doers." The dominant activity category, personal care (night sleep being the highest contributor), had the highest time expenditure of 794 mins/day (13.2 hours/day). All respondents reported sleeping at night, resulting in a mean daily time per participant of 794 mins/day spent sleeping. The activity category "don't know" had a duration of about 2 mins/day and only 4 percent of the respondents reported missing activity time.

Table 14-11 presents the mean time spent in the 10 activity categories by age and gender. Differences in activity patterns for boys and girls tended to be small. Table 14-12 presents the mean time spent in the 10 activity categories grouped by seasons and California regions. There were seasonal differences for 5 activity categories: personal care, educational activities, social/entertainment, recreation, and communication/ passive leisure. Time expenditure differences in various regions of the State were minimal for childcare, work-related activities, shopping, personal care, education, social life, and recreation.

Table 14-13 presents the distribution of time across six location categories. The participation rates (percent) of respondents, the mean, median, and maximum time for "doers." The detailed location with the highest average time expenditure are also shown. The largest amount of time spent was at home (1,078 minutes/day); 99 percent of respondents spent time at home (1,086 minutes/participant/day). Tables 14-14 and 14-15 show the average time spent in the six locations grouped by age and gender, and season and region, respectively. There are age differences in time expenditure in educational settings for boys and girls (Table 14-14). There are no differences in time expenditure at the six locations by regions, and time spent in school decreased in the summer months compared to other seasons (Table 14-15). Table 14-16 shows the average potential exposure time children spent in proximity to tobacco smoke, gasoline fumes, and gas oven fumes grouped by age and gender. The sampled children spent more time closer to tobacco smoke (77 mins/day) than gasoline fumes (2 mins/day) and gas oven fumes (11 mins/day).

A limitation of this study is that the sampling population was restricted to only English-speaking households; therefore, the data obtained does not represent the diverse population group present in California. Another limitation is that time use values obtained from this survey were based on short-term recall data; therefore, the data set obtained may be biased. Other limitations are: the survey was conducted in California and is not representative of the national population, and the significance of the observed differences in the data obtained (i.e., gender, age, seasons, and regions) were not tested statistically. An advantage of this study is that time expenditure in various activities and locations were presented for children grouped by age, gender, and seasons. Also, potential exposures of respondents to pollutants were explored in the survey. Another advantage is the use of the CATI program in obtaining time diaries, which allows automatic coding of activities and locations onto a computer tape, and allows activities forgotten by respondents to be inserted into its appropriate position during interviewing (CARB, 1991).

U.S. EPA - Dermal Exposure Assessment: Principles and Applications - U.S. EPA (1992) addressed the variables of exposure time, frequency, and duration needed to calculate dermal exposure as related to activity. The reader is referred to the document for a detailed discussion of these variables in relation to soil and water related activities. The suggested values that can be used for dermal exposure are presented in Table 14-17. Limitations of this study are that the values are based on small data sets and a limited number of studies. An advantage is that it presents default values for frequency and duration for use in exposure assessments when specific data are not available.

James and Knuiman - An Application of Bayes Methodology to the Analysis of Diary Records from a Water Use Study - In 1987, James and Knuiman provided a distribution of the amount of time spent showering by individuals in households located in Australia. This distribution was based on diary records of 2,500 households. Using these data, a cumulative frequency distribution was derived and is presented in Table 14-18. Based on these results, the mean shower length is approximately 8 minutes, the median shower length is

approximately 7 minutes and the 90th percentile is approximately 12 minutes.

A limitation of the study is that the data are from households in Australia and may not be representative of U.S. households. An advantage is that it presents cumulative distribution data.

Tsang and Klepeis (1996) - National Human Activity Pattern Survey (NHAPS) - The National Human Activity Pattern Survey was conducted by the U.S. EPA (Tsang and Klepeis, 1996). It is the largest and most current human activity pattern survey available (Tsang and Klepeis, 1996). Data for 9,386 respondents in the 48 contiguous United States were collected via minute-by-minute 24-hour diaries between October 1992 and September 1994. Detailed data were collected for a maximum of 82 different possible locations, and a maximum of 91 different activities. Participants were selected using a Ramdon Digit Dial (RDD) method and Computer Assisted Telephone Interviewing (CATI). The response rate was 63 percent, overall. If the chosen respondent was a child too young to interview, an adult in the household gave a proxy interview. Each participant was asked to recount their entire daily routine from midnight to midnight immediately previous to the day that they were interviewed. The survey collected information on duration and frequency of selected activities and of the time spent in selected microenvironments. In addition, demographic information was collected for each respondent to allow for statistical summaries to be generated according to specific subgroups of the U.S. population (i.e., by gender, age, race, employment status, census region, season, etc.). The participants' responses were weighted according to geographic, socioeconomic, time/season, and other demographic factors to ensure that results were representative of the U.S. population. The weighted sample matches the 1990 U.S. census population for each gender, age group, census region, and the day-of-week and seasonal responses are equally distributed. Saturdays and Sundays were oversampled to ensure an adequate weekend sample.

The data presented are a compilation of 24-hour diary locations, activities, and follow-up exposure questions based on exposure-related events (personal, exposure, household characteristics, medical background) (Tsang and Klepeis, 1996). Data presented are reported in the form of means, percentages of time spent, and percentages of respondent occurrences. The diary data are useful for obtaining national representative distributions of time spent in a large variety of activities and locations in a single day (Tsang and Klepeis, 1996). According to Tsang and Klepeis (1996), the 24-hour diaries in the NHAPS are useful in probabilistic modeling (Monte-Carlo) that provides frequency distributions of exposure. Overall survey results indicate that for time spent in microenvironments, the largest overall percentage of time was spent in residential-indoors (67 percent), followed by time spent outdoors (8 percent), and then time spent in vehicles (5 percent) (Tsang and Klepeis, 1996). NHAPS data on the time spent in selected activities are presented in Tables 14-19 through 14-92. NHAPS data on the time spent in selected microenvironments are presented in Tables 14-93 to 14-139.

Tables 14-19 through 14-30 provide information on the frequency and duration of taking baths, frequency of taking showers, and on the amount of time spent in the shower or bathroom after completion of the activity. Table 14-31 provides the frequency for washing the hand in a day. Tables 14-32 through 14-34 present information on time spent by persons working with or being near foods while being grilled or barbecued, working with or near open flames, and working or being near excessive dust in the air. Tables 14-35 through 14-37 provide data for the number of times a vehicle was started in a garage or carport and started with the door closed, and time spent at a gas station or repair shop. Tables 14-38 through 14-40 present information on the number of times windows and doors were opened and the number of minutes left open at home in a day. Tables 14-41 through 14-45 provide data for time spent in heavy traffic either running, walking, standing, or in a vehicle, and time spent in indoor and outdoor parking lots and garages. Tables 14-46 through 14-48 present information for time spent working for pay and for time spent working outdoors. Tables 14-49 through 14-54 provide information for frequency of performing household tasks such as vacuuming, washing dishes, and clothes in the home. Tables 14-55 through 14-62 present data for frequency and duration on playing in sand, gravel, and dirt; and working in circumstances where one comes in contact with soil such as a garden. Tables 14-63 through 14-65 provide information on the number of times the respondent went swimming in a fresh water pool and the time spent in the water during 1 month.

Tables 14-66 through 14-85 present 24-hour cumulative statistics for time spent in various major categories. They are as follows: Paid Work (main job); Household Work (food preparation and cleanup, cleaning house, clothes care); Child Care (indoor and outdoor playing); Obtaining Goods and Services (car repair); Personal Needs and Care (sleeping/napping); Free Time

and Education (school); and Recreation (active sports, exercise, outdoor recreation).

Tables 14-86 through 14-92 prvide 24-hour cumulative statistics for time spent in various activities that are the results of regrouping/combining activities described in Tables 14-66 through 14-85. They were regrouped into broader categories in order to present categories with a larger number of occurrences in an attempt to create useful exposure activities from the available data (Tsang and Klepeis, 1996).

Tables 14-93 through 14-101 provide statistics for time spent in various indoor microenvironments such as repair shops/gas stations; bar/ night club/bowling alley; and at school. Tables 14-102 through 14-110 present statistical data for time spent in various outdoor locations. These tables include locations such as school grounds/playground; parking lots; construction sites; parks and golf courses; and farms.

Statistics for time spent in various locations in the home are presented in Tables 14-111 through 14-118. Data are presented for the 24-hour cumulative number of minutes spent in the kitchen, bathroom, bedroom, garage, basement, utility room or laundry room, in the outdoor pool or spa; and in the yard or other areas outside the house. Tables 14-119 through 14-128 provide data on time spent traveling and in various types of vehicles, and on time spent walking.

Tables 14-129 through 14-138 present information on locations/microenvironments that have been regrouped/combined based on various data described in Tables 14-93 through 14-128. Tables 14-129 through 14-138 provide statistics for total time spent indoors at home, including all rooms; outdoors at home; traveling inside a vehicle; outdoors near a vehicle; outdoors other than near a residence; in an office or factors; in malls and other stores; in various public buildings, in bars, restaurants, etc.; and outdoor locations such as auto repair shops and laundromats. Table 14-139 provides the statistics for the cumulative number of minutes spent in an activity or microenvironment where a smoker was present.

Advantages of the NHAPS dataset are that it is representative of the U.S. population and it has been adjusted to be balanced geographically, seasonally, and for day/time. Also, it is representative for all ages, gender, and race.

14.1.2. Relevant Activity Pattern Studies

Robinson - Changes in Americans' Use of Time: 1965-1975 - Robinson (1977) compared time use data obtained from two national surveys that were conducted in 1965-1966 and in 1975. Each survey used the time-diary method to collect data. The 1965-66 survey excluded people in the following categories: (a) Non-Standard Metropolitan Statistical Area (non-SMSA) (designation of Census Bureau areas having no city with more than 50,000 population); (b) households where no adult members were in the labor force for at least 10 hours per week; (c) age 65 and over; and (d) farm-related occupations (Robinson, 1977). The 1,244 respondents in the 1965-66 study included either employed men and women or housewives (Robinson, 1977). The survey was conducted between November-December 1965 and March-April 1966. Respondents recorded their daily activities in time diaries by using the "tomorrow" approach. In this approach, diaries were kept on the day following the interviewer's initial contact. The interviewer then made a second call to the respondent to determine if the information in diaries were correct and to obtain additional data. Only one person per household was interviewed. The survey was designed to obtain information on time spent with family members, time spent at various locations during activities, and performing primary and secondary activities.

A similar study was conducted in 1975 from October through December. Unlike the 1965-1966 survey, the 1975 survey included rural areas, farmers, the unemployed, students, and retirees. Time diary data were collected using the "yesterday" approach. In this approach, interviewers made only one contact with respondents (greater than 1500) and the diaries were filled out based on a 24-hour recall (Robinson, 1977). Time diary data were also collected from the respondents' spouses.

In both surveys, the various activities were coded into 96 categories, and then were combined into five major categories. Free-time activities were grouped into 5 sub-categories (Appendix Table 14A-2). In order to compare data obtained from both surveys, Robinson (1977) excluded the same population groups in the 1975 survey that were excluded in the 1965-66 survey (i.e., farmers, rural residents).

Results obtained from the surveys were presented by gender, age, marital and employment status, race, and education. Robinson (1977) reported the data collected in hours/week; however, the method for converting daily activities to hours/week were not presented. Table 14-140 shows the differences in time use by gender, employment, and marital status for five major activity categories and five subcategories for 1965 and 1975. Time spent on work related activities (i.e., work for pay and family care)

was lower in 1975 than in 1965 for employed men and women. Table 14-140 also shows that there was an overall increase in free time activities for all the six groups. The difference in time use in 1965 and 1975 are presented by age, education, and race in Tables 14-141, 14-142, and 14-143, respectively. These tables include data for students and certain employed respondents that were excluded in Table 14-40 (Robinson, 1977). In 1975, the eldest group (ages 56-65 years) showed a decline in paid work, and an increase in family care, personal care and sleep (Table 14-141). Education level comparisons across the ten-year interval indicated that the less educated had a decrease in paid work and an increase in sleep and personal care; the most educated had an increase in work time and a decrease in other leisure (Table 14-142). For racial comparisons, Blacks spent less time at paid work than Whites across the ten-year interval (Table 14-143). Table 14-144 also shows that Blacks spent more time than Whites at free time activities in 1975.

A limitation of the study survey design is that time use data were gathered as social indicators. Therefore, the activity categories presented may not be relevant in exposure assessments. Another limitation is that statistical analysis of the data set was not provided. Additional limitations are that the time use data are old and the data may not reflect recent changes in time use. The 1965 and 1975 data sets excluded certain population groups and, therefore, may not be entirely representative of the U.S. population. Another limitation is that these are short-term studies and may not necessarily represent long-term activity patterns. An advantage of this study is that time use data were presented by age, gender, race, education level, and employment and marital status. Another advantage is that earlier investigations on the study method (24-hr recall) employed in the 1965 study revealed no systematic biases in reported activities (Robinson, 1977). Robinson (1977) also noted that the time-diary method provides a "zero-sum" measure (i.e., since there are only 24 daily hours or 168 weekly hours, if time on one activity increases then time on another activity must decrease).

Juster et al. - 1975-1981 Time Use Longitudinal Panel Study - The Time Allocation longitudinal study of the U.S. population began as part of a multinational project with the first survey conducted in 1965-66. A second national time use survey was conducted in 1975-1976 and another in 1981 (Juster et al. 1983). Juster et al. (1983) provided study descriptions of the second and third surveys. The surveys included a probability sample of the adult population (18 years and older) and children between the ages of 3 and 17 years in the United States. In both surveys, time use was measured from 24-hour recall diaries administered to respondents and their spouses. The 1975-1976 survey involved four waves of interview: wave 1, October-November 1975; wave 2, February 1976; wave 3, May-June 1976; wave 4, September 1976. The first wave was a personal interview and the other three waves were telephone interviews. The 1975-1976 survey sample consisted of 2,300 individuals, and of that sample, 1,519 respondents. Four recall diaries (one from each wave of interviews) were obtained from 947 respondents, with data on time use measures for two weekdays, one Saturday and one Sunday. The survey was designed to gather information for: employment status; earnings and other income; "consumption benefits for activities of respondents and their spouses;" health, friendships and associations of the respondents; stock technology available to the household, house repair, and maintenance activities of the family; division of labor in household work and related attitudes; physical characteristics of the respondents housing structure, net worth and housing values; job characteristics; and characteristics of mass media usage on a typical day (Juster et al., 1983).

The 1981 survey was a follow-up of respondents and spouses who had completed at least three waves of interview in the 1975-1976 survey. For the 1981 survey, 920 individuals were eligible. The survey design was similar to the 1975-1976 survey, however in this survey, the adult population was 25 years and older and consisted of 620 respondents. Four waves of interviews were conducted between February - March 1981 (wave 1), May - June 1981 (wave 2), September 1981 (wave 3), and November - December (wave 4). The 1981 survey included the respondents' children between the ages of 3 and 17 years. The survey design for children provided information on time use measures from two time diary reports: one school day and one non-school day. In addition, information for academic achievement measures, school and family life measures, and ratings from the children's teachers were gathered during the survey.

Juster et al. (1983) did not report the time use data obtained for the 1975-1976 survey or the 1981 survey. These data are stored in four tape files and can be obtained from the Inter-university Consortium for Political and Social Research (ICPSR) in Michigan. The response rate for the first wave of interview (1975-76 survey) based on the original sample population was 66 percent, and response rates for the subsequent waves ranged from 42 percent (wave 4) to 50 percent (wave 2). In the 1981 survey, the response rate based on eligible respondents

was 67 percent for the first interview, and ranged from 54 percent (wave 4) to 60 percent (wave 2) in the subsequent interviews (Juster et al., 1985). The 1975-1976 survey included 87 activities. In the 1981 survey, these 87 activities were broken down into smaller components, resulting in 223 activities (Juster et al., 1985). The activity codes and descriptors used for the adult time diaries in both surveys are presented in Appendix Table 14A-3.

A limitation of this study is that the surveys were not designed for exposure assessment purposes. Therefore, the time use data set may be biased. Another limitation is that time use data collected were based on a 24-hour diary recall. This may somewhat bias the data set obtained from this survey. An advantage associated with this survey is that it provides a database of information on various human activities. This information can be used to assess various exposure pathways and scenarios associated with these activities. Also, some of the data from these surveys were used in the studies conducted by Timmer et al. (1985) and Hill (1985). In addition, the activity descriptor codes developed in these studies were used by Timmer et al (1985), Hill (1985), and Robinson and Thomas (1991). These studies are presented in Sections 14.1.1 and 14.1.2. Another advantage of this survey is that the data are based on a national survey and conducted over a one year period, resulting in a seasonally balanced survey and one representative of the U.S. population.

Hill - Patterns of Time Use - Hill (1985) investigated the total amount of time American adults spend in one year performing various activities and the variation in time use across three different dimensions: demographic characteristics, geographical location, and seasonal characteristics. In this study, time estimates were based on data collected from time diaries in four waves (1 per season) of a survey conducted in the fall of 1975 through the fall of 1976 for the 1975-1976 Time Allocation Study. The sampling periods included two weekdays, one Saturday and one Sunday. The 1975-1976 Time Allocation Study provided information on the amount of time spent performing primary activities. The information gathered were responses to the survey question "What were you doing?" The survey also provided information on secondary activities (i.e., respondents performing more than one activity at the same time). Hill (1985) analyzed time estimates for 10 broad categories of activities based on data collected from 87 activities. These estimates included seasonal variation in time use patterns and comparisons of time use patterns for different days of the week. The 10 major categories and ranges of activity codes are listed in Appendix Table 14A-4. Hill (1985) collected data on time use for the major activity patterns in four different age groups (18-24, 25-44, 45-64, and 65 years and older). However, the time use data were summarized in graphs rather than in tables.

Analysis of the 1975-76 survey data revealed very small regional differences in time use among the broad activity patterns (Hill, 1985). The weighted mean hours per week spent performing the 10 major activity categories presented by region are shown in Table 14-144. In all regions, adults spent more time on personal care (included night sleep). Adults in the North Central region of the country spent more time on market work activities than adults in other regions of the country. Adults in the South spent more time on leisure activities (passive and active combined) than adults elsewhere (Table 14-144). Table 14-145 presents the time spent per day, by the day of the week for the 10 major activity categories. Time spent on the 87 activities (components of the 10 major categories) are presented in Appendix Table 14A-5. Adult time use was dominated in descending order by personal care (including sleep), market work, passive leisure, and house work. Collectively, these activities represent about 80 percent of available time (Hill, 1985).

According to Hill (1985), sleep was the single most dominant activity averaging about 56.3 hours per week. Television watching (passive leisure) averaged about 21.8 hours per week, and housework activities averaged about 14.7 hours per week. Weekdays were predominantly market-work oriented. Weekends (Saturday and Sunday) were predominantly devoted to household tasks ("sleeping in," socializing, and active leisure) (Hill, 1985). Table 14-146 presents the mean time spent performing these 10 groups of activities during each wave of interview (fall, winter, spring, and summer). Adjustments were made to the data to assure equal distributions of weekdays, Saturdays, and Sundays (Hill, 1985). The data indicates that the time periods adults spent performing market work, child care, shopping, organizational activities, and active leisure were fairly constant throughout the year (Hill, 1985). The mean hours spent per week in performing the 10 major activity patterns are presented by gender in Table 14-147 (time use patterns for all 87 activities are presented in Appendix Table 14A-6). Table 14-147 indicates that time use patterns determined by data collected for the mid-1970's survey show gender differences. Men spent more time on activities related to labor market work and education, and women spent more time on household work activities.

A limitation associated with this study is that the time data were obtained from an old survey conducted in the mid-1970s. Because of fairly rapid changes in American society, applying these data to current exposure assessments may result in some biases. Another limitation is that time use data were not presented for children. An advantage of this study is that time diaries were kept and data were not based on recall. The former approach may result in a more accurate data set. Another advantage of this study is that the survey is seasonally balanced since it was conducted throughout the year and the data are from a large survey sample.

Sell - The Use of Children's Activity Patterns in the Development of a Strategy for Soil Sampling in West Central Phoenix - In a report prepared for the Arizona Department of Environmental Quality, Sell (1989) investigated the activity patterns of preschool and school age children in the west central portion of Phoenix known as Maryvale. The survey was conducted in two parts: (1) most of the school age children were interviewed personally from May through June, 1989 in three schools; and (2) survey questionnaires were mailed to parents of preschool children.

In the first survey, 15 percent of the total school population (2,008) was sampled with 111 children in grades K-6 participating (response rate of 37 percent). The surveyed population was 53.2 percent male and 46.8 percent female. Of this population, 41 percent were Hispanics, 49.5 percent Anglos, 7.2 percent Blacks, and 1.7 percent Asians. The children interviewed were between the ages of 5 and 13 years. Within each school, the children in grades K-6 were stratified into two groups, primary (grades K-3) and intermediate (grades 4-6), and children were selected randomly from each group. Children in grades K-2 were either interviewed in school or at home in the presence of a parent or an adult care-provider. In the course of the interview, children were asked to identify locations of activity areas, social areas (i.e., places they went with friends), favorite areas, and locations of forts or clubhouses. Aerial photographs were used to mark these areas.

The second survey involved only preschool children. Parents completed questionnaires which provided information on the amount of time their children spent outdoors, outdoor play locations, favorite places, digging areas, use of park or playgrounds, and swimming or wading locations. This survey was conducted between June-July 1989. One thousand (1,000) parents were sampled, but only 211 questionnaires were usable out of 886 questionnaires received resulting in a response rate for the preschool's survey of about 24 percent. The sample population consisted of children 1 month and up to preschool age. Of this population, 53 percent were Anglos, 18 percent Hispanics, 2 percent Blacks, and 3 percent Asians.

The survey design considered the kinds of activities children engaged in, but not the amount of time children spent in each activity. Therefore, Sell (1989) presented the data obtained from the survey in terms of percent of respondents who engaged in specific activities or locations. A summary of percent responses of the preschool and school-age children's activities at various locations in the Maryvale study areas are presented in Table 14-148. Also included in this table is a ranking of children's play locations based on other existing research works. Based on the survey data, Sell (1989) reported that the median time preschool children spent outdoors on weekdays was 1-2 hours, and on weekends the median time spent outdoors was 2-5 hours. Most of these children played outside in their own yards, and some played in other people's yards or parks and playgrounds (Sell, 1989).

Limitations associated with this study are that the survey design did not report the time spent in various activities or locations and the response rates obtained from the surveys were low and, therefore, may result in biased data. In addition, because the survey was conducted in Arizona, the surveyed population does not represent the children's population on a national basis. Advantages of this study are that it provides data on various activities children engage in and locations of these activities, and provides for time spent outdoors. This information is useful in determining exposure pathways to toxic pollutants for children.

Tarshis - The Average American Book - Tarshis (1981) compiled a book addressing the habits, tastes, lifestyles, and attitudes of the American people in which he reported data on time spent in personal grooming. The data presented are gathered from small surveys, the Newspaper Advertising Bureau, and magazines. Tarshis reported frequency and percentage data by gender and age for grooming activities such as showering and bathing as follows:

- 90 percent take some sort of a bath in an average 24-hour period;
- 5 percent average more than 1 shower or bath a day;
- 75 percent of men shower, 25 percent take baths;

- 50 percent of women take showers, 50 percent take baths;
- 65 percent of teenage girls 16-19 shower daily;
- 55 percent of teenage girls take at least one bath a week;
- 50 percent of women use an additive in their bath every time they bathe;
- People are more likely to shower than bathe if they are young and have higher income; and
- Showering is more popular than bathing in large cities.

Limitations of this study are that the data are compiled from other sources, and that the data are old; it is possible that these data may not reflect the current trends of the general population. An advantage of the study is that it presents frequency data that are useful in exposure assessment, especially concerning volatilization of chemicals from water.

AIHC (1994) - Exposure Factors Sourcebook - The activity factors data presented in the Sourcebook are similar to that in this handbook. The AIHC Sourcebook uses tenure data from the Bureau of Labor Statistics (1987), while this handbook uses more recent data (Carey, 1988) and provides general and specific recommendations for various age groups. Distributions were derived using data presented in U.S. EPA (1989) version of this handbook, he Bureau of Labor Statistics (1984), and various other references. Distribution data and/or recommendations are presented for time in one residence, residential occupancy, time spent indoors/outdoors, hours at home/away from home for adults and children, hours at work for adults, working tenure, and shower duration. For each distribution, the @Risk formula is provided for direct use in the @Risk software (Palisade, 1992). The Sourcebook has been classified as a relevant rather than a key study becuase it is not the primary source for the data used to make recommendations. It is a relevant source of alterntive information.

14.2. OCCUPATIONAL MOBILITY

14.2.1. Background

The amount of time spent in different types of occupations may affect the duration and/or magnitude of exposures to contaminants specific to those occupations. For example, an individual who spends an entire lifetime as a farmer may experience a longer duration of exposure to certain contaminants, especially pesticides, than individuals who leave farming for indoor occupations. Also, individual exposures to specific chemicals in the work place may be significantly reduced when individuals change jobs. Work place exposures among women may be of shorter duration than among men because women's careers may be interrupted by home and family responsibilities. The key studies presented in the following section provide occupational tenure for workers grouped by age, race, gender, and employment status.

14.2.2. Key Occupational Mobility Studies

Carey (1988) - Occupational Tenure in 1987: Many Workers Have Remained in Their Fields - Carey (1988) presented median occupational and employer tenure for different age groups, gender, earnings, ethnicity, and educational attainment. Occupational tenure was defined as "the cumulative number of years a person worked in his or her current occupation, regardless of number of employers, interruptions in employment, or time spent in other occupations" (Carey, 1988). The information presented was obtained from supplemental data to the January 1987 Current Population Study, a U.S. Bureau of the Census publication. Carey (1988) did not present information on the survey design.

The median occupational tenure by age and gender, ethnicity, and employment status are presented in Tables 14-149, 14-150, and 14-151, respectively. The median occupational tenure of the working population (109.1 million people) 16 years of age and older in January of 1987, was 6.6 years (Table 14-149). Table 14-149 also shows that median occupational tenure increased from 1.9 years for workers ages 16-24 to 21.9 for workers 70 years and older. The median occupational tenure for men 16 years and older was higher (7.9 years) than for women of the same age group (5.4 years). Table 14-150 indicates that whites had longer occupational tenure (6.7 years) than blacks (5.8 years), and Hispanics (4.5 years). Full-time workers had more occupational tenure than part-time workers 7.2 years and 3.1 years, respectively (Table 14-151).

Table 14-152 presents the median occupational tenure among major occupational groups. The median tenure ranged from 4.1 years for service workers to 10.4 years for people employed in farming, forestry, and fishing. In addition, median occupational tenure among detailed occupations ranged from 24.8 years for barbers to 1.5 years for food counter and fountain workers (Appendix Table 14A-7).

The strength of an individual's attachment to a specific occupation has been attributed to the individual's investment in education (Carey, 1988). Carey (1988) reported the median occupational tenure for the surveyed

working population by age and educational level. Workers with 5 or more years of college had the highest median occupational tenure of 10.1 years. Workers that were 65 years and older with 5 or more years of college had the highest occupational tenure level of 33.8 years. The median occupational tenure was 10.6 years for self-employed workers and 6.2 years for wage and salary workers (Carey, 1988).

A limitation associated with this study is that the survey design employed in the data collection was not presented. Therefore, the validity and accuracy of the data set cannot be determined. Another limitation is that only median values were reported in the study. An advantage of this study is that occupational tenure (years spent in a specific occupation) was obtained for various age groups by gender, ethnicity, employment status, and educational level. Another advantage of this study is that the data were based on a survey population which appears to represent the general U.S. population.

Carey - Occupational Tenure, Employer Tenure, and Occupational Mobility - Carey (1990) conducted another study that was similar in scope to the study of Carey (1988). The January 1987 Current Population Study (CPS) was used. This study provided data on occupational mobility and employer tenure in addition to occupational tenure. Occupational tenure was defined in Carey (1988) as the "the cumulative number of years a person worked in his or her current occupation, regardless of number of employees, interruptions in employment, or time spent in other locations." Employer tenure was defined as "the length of time a worker has been with the same employer," while occupational mobility was defined as "the number of workers who change from one occupation to another" (Carey, 1990). Occupational mobility was measured by asking individuals who were employed in both January 1986 and January 1987 if they were doing the same kind of work in each of these months (Carey, 1990). Carey (1990) further analyzed the occupational mobility data and obtained information on entry and exit rates for occupations. These rates were defined as "the percentage of persons employed in an occupation who had voluntarily entered it from another occupation" and an exit rate was defined as "the percentage of persons employed in an occupation who had voluntarily left for a new occupation" (Carey, 1990).

Table 14-153 shows the voluntary occupational mobility rates in January 1987 for workers 16 years and older. For all workers, the overall voluntary occupational mobility rate was 5.3 percent. These data also show that younger workers left occupations at a higher rate than older workers. Carey (1990) reported that 10 million of the 100.1 million individuals employed in January 1986 and in January 1987 had changed occupations during that period, resulting in an overall mobility rate of 9.9 percent. Executive, administrative, and managerial occupations had the highest entry rate of 5.3 percent, followed by administrative support (including clerical) at 4.9 percent. Sales had the highest exit rate of 5.3 percent and service had the second highest exit rate of 4.8 percent (Carey, 1990). In January 1987, the median employer tenure for all workers was 4.2 years. The median employee tenure was 12.4 years for those workers that were 65 years of age and older (Carey, 1990).

Because the study was conducted by Carey (1990) in a manner similar to that of the previous study (Carey, 1988), the same advantages and disadvantages associated with Carey (1988) also apply to this data set.

14.3. POPULATION MOBILITY

14.3.1. Background

An assessment of population mobility can assist in determining the length of time a household is exposed in a particular location. For example, the duration of exposure to site-specific contamination, such as a polluted stream from which a family fishes or contaminated soil on which children play or vegetables are grown, will be directly related to the period of time residents live near the contaminated site.

Information regarding population mobility is compiled and published by the U.S. Bureau of the Census (BOC). Banks, insurance companies, credit card companies, real estate and housing associations use residence history information. However, usually this information is confidential. Information compiled by the BOC provides information about population mobility; however, it is difficult to determine the average residence time of a homeowner or apartment dweller from this information. Census data provide representations of a cross-section of the population at specific points in time, but the surveys are not designed to follow individual families through time. The most current BOC information about annual geographical mobility and mobility by State is summarized in Appendix 14B. Figure 14-1 graphically displays the distribution of movers by type of move.

Available information was provided by the Oxford Development Corporation, the National Association of Realtors (NAR), and the BOC. According to Oxford Development Corporation, a property management firm, the typical residence time for an apartment dweller for their corporation has been estimated to range from 18 to

Figure 14-1. Distribution of Individuals Moving by Type of Move: 1991-92.

Source: U.S Bureau of the Census, 1993

30 months (S. Cameron Hendricks, Sales Department, Oxford Development Corporation, Gaithersburg, MD, personal communication with P. Wood (Versar) August 10, 1992).

14.3.2. Key Population Mobility Studies

Israeli and Nelson (1992) - Distribution and Expected Time of Residence for U.S. Households - In risk assessments, the average current residence time (time since moving into current residence) has often been used as a substitute for the average total residence time (time between moving into and out of a residence) (Israeli and Nelson, 1992). Israeli and Nelson (1992) have estimated distributions of expected time of residence for U.S. households. Distributions and averages for both current and total residence times were calculated for several housing categories using the 1985 and 1987 BOC housing survey data. The total residence time distribution was estimated from current residence time data by modeling the moving process (Israeli and Nelson, 1992). Israeli and Nelson (1992) estimated the average total residence time for a household to be approximately 4.6 years or 1/6 of the expected life span (see Table 14-154). The maximal total residence time that a given fraction of households will live in the same residence is presented in Table 14-155. For example, only 5 percent of the individuals in the "All Households" category will live in the same residence for 23 years and 95 percent will move in less than 23 years.

The authors note that the data presented are for the expected time a household will stay in the same residence. The data do not predict the expected residence time for each member of the household, which is generally expected to be smaller (Israeli and Nelson, 1992). These values are more realistic estimates for the individual total residence time, than the average time a household has been living at its current residence. The expected total residence time for a household is consistently less than the average current residence time. This is the result of greater weighting of short residence time when calculating the average total residence time than when calculating the average current residence time (Israeli and Nelson, 1992).

When averaging total residence over a time interval, frequent movers may appear several times, but when averaging current residence times, each household appears only once (Israeli and Nelson, 1992). According to Israeli and Nelson (1992), the residence time distribution developed by the model is skewed and the median values are considerably less than the means (T), which are less than the average current residence times.

U.S. Bureau of the Census (1993) - American Housing Survey for the United States in 1991 - This survey is a national sample of 55,000 interviews in which collected data were presented owners, renters, Black householders, and Hispanic householders. The data reflect the number of years a unit has been occupied and represent all occupied housing units that the residents' rented or owned at the time of the survey.

The results of the survey pertaining to residence time of owner/renter occupied units in the U.S. are presented in Table 14-156. Using the data in Table 14-156, the percentages of householders living in houses for specified time ranges were determined and are presented in Table 14-157. Based on the BOC data in Table 14-156, the 50th percentile and the 90th percentile values were calculated for the number of years lived in the householder's current house. These values were calculated by apportioning the total sample size (93,147 households) to the indicated percentile associated with the applicable range of years lived in the current home. Assuming an even distribution within the appropriate range, the 50th and 90th percentile values for years living in current home were determined to be 9.1 and 32.7 years, respectively. These were then rounded to 9 and 33 years. Based on the above data, the range of 9 to 33 years is assumed to best represent a central tendency estimate of length of residence and upper percentile estimate of residence time, respectively.

A limitation associated with the above analysis is the assumption that there is an even distribution within the different ranges. As a result, the 50th and 90th percentile values may be biased.

Johnson and Capel (1992) - A Monte Carlo Approach to Simulating Residential Occupancy Periods and It's Application to the General U.S. Population - Johnson and Capel developed a methodology to estimate the distribution of the residential occupancy period (ROP) in the national population. ROP denotes the time (years) between a person moving into a residence and the time the person moves out or dies. The methodology used a Monte Carlo approach to simulate a distribution of ROP for 500,000 persons using data on population, mobility, and mortality.

The methodology consisted of six steps. The first step defined the population of interest and categorized them by location, gender, age, sex, and race. Next the demographic groups were selected and the fraction of the specified population that fell into each group was developed using U.S. BOC data. A mobility table was developed based on census data, which provided the probability that a person with specified demographics did not move during the previous year. The fifth step used data on vital statistics published by the National Center for Health Statistics and developed a mortality table which provided the probability that individuals with specific demographic characteristics would die during the upcoming year. As a final step, a computer based algorithm was used to apply a Monte Carlo approach to a series of persons selected at random from the population being analyzed.

Table 14-158 presents the results for residential occupancy periods for the total population, by gender. The estimated mean ROP for the total population was 11.7 years. The distribution was skewed (Johnson and Capel, 1992): the 25th, 50th, and 75th percentiles were 4, 9, and 16 years, respectively. The 90th, 95th, and 99th percentiles were 26, 33, and 47 years, respectively. The mean ROP was 11.1 years for males and 12.3 years for females, and the median value was 8 years for males and 9 years for females.

Descriptive statistics for subgroups defined by current ages were also calculated. These data, presented by gender, are shown in Table 14-159. The mean ROP increases from age 3 to age 12 and there is a noticeable decrease at age 24. However, there is a steady increase from age 24 through age 81.

There are a few biases within this methodology that have been noted by the authors. The probability of not moving is estimated as a function only of gender and age. The Monte Carlo process assumes that this probability is independent of (1) the calendar year to which it is applied, and (2) the past history of the person being simulated. These assumptions, according to Johnson and Capel (1992), are not entirely correct. They believe that extreme values are a function of sample size and will, for the most part, increase as the number of simulated persons increases.

14.3.3. Relevant Population Mobility Studies

National Association of Realtors (NAR) (1993) The Home Buying and Selling Process - The NAR survey was

conducted by mailing a questionnaire to 15,000 home buyers throughout the U.S. who purchased homes during the second half of 1993. The survey was conducted in December 1993 and 1,763 usable responses were received, equaling a response rate of 12 percent. Of the respondents, forty-one percent were first time buyers. Home buyer names and addresses were obtained from Dataman Information Services (DIS). DIS compiles information on residential real estate transactions from more than 600 counties throughout the United States using courthouse deed records. Most of the 250 Metropolitan Statistical Areas are also covered in the DIS data compilation.

The home buyers were questioned on the length of time they owned their previous home. A typical repeat buyer was found to have lived in their previous home between four and seven years. The survey results indicate that the average tenure of home buyers is 7.1 years based on an overall residence history of the respondents. These results are presented in Table 14-160. In addition, the median length of residence in respondents' previous homes was found to be 6 years (see Table 14-161).

The distances the respondents moved to their new homes were typically short distances. Data presented in Table 14-162 indicate that the median distances range from 11 miles for new home buyers and repeat buyers to 8 years for first time buyers and existing home buyers. Seventeen (17) percent of respondents purchased homes over 100 miles from their previous homes and 49 percent purchased homes less than 10 miles away.

Lehman - Homeowners Relocating at Faster Pace - Lehman (1994) presents data gathered by the Chicago Title and Trust Family Insurers. The data indicate that, in 1993, average U.S. homeowners moved every 12 years. In 1992, homeowners moved every 13.4 years and in 1991, every 14.3 years. Data from the U.S. Bureau of the Census indicate that 7 percent of the owner population moved in 1991. Based on this information, Lehman has concluded that it would take 12 years for 100 percent of owners to move. According to Lehman, Bill Harriett of the U.S. Bureau of the Census has been said that 14 years is a closer estimate for the time required for 100 percent of home owners to move. An advantage of this study is that it provides percentile data for the residential occupancy period.

14.4. RECOMMENDATIONS

Assessors are commonly interested in a number of specific types of time use data including time/frequencies for bathing, showering, gardening, residence time, indoor versus outdoor time, swimming, occupational tenure, and population mobility. Recommendations for each of these are discussed below.

14.4.1. Recommendations for Activity Patterns

Following are recommendations for selected activities known to increase an individual's exposure to certain chemicals. These activities are time spent indoors versus outdoors and gardening, bathing and showering, swimming, residential time spent indoors and outdoors, and traveling inside a vehicle.

Time Spent Indoors Versus Outdoors and Gardening - Assessors often require knowledge of time individuals spend indoors versus outdoors. Ideally, this issue would be addressed on a site-specific basis since the times are likely to vary considerably depending on the climate, residential setting (i.e., rural versus urban), personal traits (i.e., age, health) and personal habits. The following general recommendation is offered in lieu of site-specific information. The key study by Robinson and Thomas (1991) compares the time use values derived in the CARB and National Studies; data are presented only for persons 12 years and older. The time use values did not differ significantly between the two studies and were averaged to provide the following recommended values. These values are applicable to individuals 12 years and older. Approximately 21 hrs/day are spent indoors; 1.5 hrs/day are spent outdoors, and 1.5 hrs/day are spent in a vehicle.

Activities can vary significantly with differences in age. Special attention should be given to the activities of populations under the age of 12 years. Timmer et al. (1985) presented data on time spent in various activities for boys and girls ages 3-11 years. The study focused on activities performed indoors such as household work, personal care, eating, sleeping, school, studying, attending church, watching television, and engaging in household conversations. The average times spent in each indoor activity (and half the times spent in each activity which could have occurred indoors or outdoors) were summed. This procedure resulted in the following recommendations:

- Indoor activities accounted for about 78 percent of the total time in weekdays and 70 percent total time in weekend days. The corresponding times spent indoors are 19 hrs/day for weekdays and 17 hrs/day on weekends.

- Outdoor activities accounted for about 22 percent of children's time during weekdays and 30 percent during the weekend. The corresponding times spent outdoors are 5 hrs/day for weekdays and 7 hrs/day on weekends.

Assessors evaluating soil exposures are commonly interested in data on gardening times and frequencies. No data specific to time spent gardening could be found; thus, no firm recommendation could be made. However, two sets of data were found which indirectly relate to this issue which the assessor can consider in deriving time estimates for gardening:

- Robinson and Thomas (1991) estimated the time spent in "other outdoor activities" (Table 14-8) as 1 hr/day. These data apply to populations 12 years and older.

- Hill (1985) estimated that time spent in "house work and/or yard work" (Table 14-144) as 2 hr/day. These data apply to adult populations.

U.S. EPA's Dermal Exposure Assessment Document (1992) recommends, on the basis of judgement, an event frequency for the adult gardener, working outside: 1 to 2 events/week during warmer months or about 40 events/year.

Baths and Showers - In the NHAPS study, 649 (~ 7 percent) of the total participants indicated either taking or giving at least one bath in a day. Those 649 respondents were subsequently asked the number of times they took or gave a bath in one day. The majority, 459 of 649 respondents, recorded taking or giving one bath in a day. These results are presented in Table 14-22. The recommended bathing duration is 20 minutes. This is a 50th percentile value based on the NHAPS distribution shown on Table 14-24; the reported 90th percentile value is 45 minutes.

The recommended shower frequency of one shower per day is based on the NHAPS data summarized in Table 14-19. This table showed that 3,594 of the 9,386 total participants indicated taking at least one shower the previous day. When asked the number of actual showers taken the previous day, the reported results ranged from one to ten showers; a majority (76 percent), of those 3,549 responsents, reported taking one shower the previous day. The NHAPS data shown on Table 14-19, Table 14-22, and Table 14-24 provide information grouped according to gender, age, race, employment, education, day of the week, seasonal conditions, and health conditions such as asthma, angina, and bronchitis/emphysema.

Recommendations for showering duration are based on the key study conducted by James and Knuiman (1987). Although the study pertains to showering activities of the Australian population, it is assumed that bathing activities are similar in the U.S. population. The recommended average showering time is 8 minutes per day and 12 minutes per day is the reported 90th percentile value. A complete set of percentiles are listed in Table 14-18 and recommended for deriving distributions of showering time.

Swimming - Data for swimming frequency is taken from the NHAPS Study (Tsang ad Klepeis, 1996). Of 9,386 participants, 653 (about 7 percent), answered yes to the question "in the past month, did you swim in a freshwater pool?". The results to this question are summarized in Table 14-63. The recorded number of times respondents swam in the past month ranged from 1 to 60 with the greatest number of respondents, 147 (23 percent), reporting they swam one time per month. Thus, the recommended swimming frequency is one event/ month for the general population. The recommended swimming duration, 60 minutes per swimming event, is based on the NHAPS distribution shown on Table 14-65. Sixty minutes is based on the 50th percentile value and the 90th percentile value is 180 minutes per swimming event.

In addition, users can obtain frequency and duration data grouped according to gender, age, race, employment, education, day of the week, and season. Frequency and duration data is also available in Table 14-63 and Table 14-65, for swimmer respondents reporting health conditions such as asthma, angina, and bronchitis/ emphysema.

Residential Time Spent Indoors and Outdoors - The recommendations for time spent indoors at one's residence is 16.4 hours/day. This is based on the NHAPS data summarized in Table 14-129 which records the 50th percentile value of 985.0 minutes per day (16.4 hours/day) and 90th percentile value of 1,395 minutes per day (23.3 hours/day).

The recommended value for time spent outdoors at one's residence is 2 hours per day based on Table 14-100 (generated by the NHAPS data). Values of 105 minutes per day for the 50th percentile and 362 minutes per day for the 90th percentile are shown in Table 14-100.

Traveling Inside a Vehicle - The recommendation for time spent in a vehicle is 1 hour and 20 minutes per day. This recommendation is based on two studies and (1) Robinson and Thomas (1991) and (2) The NHAPS data. The Robinson and Thomas study evaluated two independent studies, the CARB and the National Study. They respectively reported mean durations for time spent in a vehicle as 98 and 87 minutes per day which averages to 92 minutes per day or about 1.5 hours per day. The NHAPS data, as summarized on Table 14-131, provide a 50th percentile value of 70 minutes per day (or 1 hour and 10 minutes) and a 90th percentile value of 190 minutes per day. Thus, the averaged value from these two studies is about 1 hour and 20 minutes. NHAPS data is grouped according to gender, race, age, employment status, census region, day of the week, season, and health condition of respondents.

14.4.2. Recommendations: Occupational Mobility

The median occupational tenure of the working population (109.1 million people) ages 16 years of age and older in January 1987 was 6.6 years (Carey, 1988). Since the occupational tenure varies significantly according to age it is recommended to use the age dependent values presented in Carey's 1988 study (Table 14-149). When age cannot be determined, it is recommended to use the median tenure value of 6.6 years for working men and women 16 years and older. For persons 70 years and older, a tenure value of 21.9 years is recommended for a working lifetime. A value of 30.5 years and 18.8 years is recommended for men and women, respectively. Part-time employment, race and the position held are important to consider in determining occupational tenure. The ratings indicating confidence in the occupational mobility recommendations are presented in Table 14-164.

14.4.3. Recommendations: Population Mobility

There are three key studies from which the population mobility recommendations were derived: Israeli and Nelson (1992), U.S. Bureau of the Census (1993) - and Johnson and Capel (1992). Each study used a unique approach to estimate the length of time a person resides in a household. The respective approaches were to (1) average current and total residence time; (2) model current residence time; and (3) determine the residential occupancy period. Below is a summary of the approaches used and values recommended by each of these studies.

Study	Value	Method
Israeli and Nelson, 1992	4.6 yr (averge) 1/6 a person's lifetime (70 yr) = 11.7 (modeled)	Average of current and total residence times
US Bureau of the Census, 1993	9 yr (50th percentile) 33 yr (90th percentile)	Current residence time
Johnson and Capel, 1992	26 yr (90th percentile) 33 yr (95th percentile) 47 yr (99th percentile) 12 yr (mean)	Residential occupancy period

The three studies provide residence time estimates that are very similar to the 9 year (50th percentile) and 30 year (95th percentile). Tables 14-154 and 14-155 show residence times for different types of residences and are recommended where assessors are interested in specific types of residences. The ratings indicating confidence in the population mobility recommendations is presented in Table 14-165.

14.4.4. Summary of Recommended Activity Factors

Table 14-166 includes a summation of the recommended activity pattern factors presented in this section and the studies which provided data on the specific activities. The type of activities include indoor activities, outdoor activities, time inside a vehicle, taking a bath or shower, swimming, working at a specific occupation, and residing in a particular location.

14.5. REFERENCES FOR CHAPTER 1

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Table 14-1. Time Use Table Locator Guide

Percentile	Basis	Population	Application	Study	Table
Averages	Activity	Children 3-17 yrs	National	Timmer et al., 1985	14-2
Distribution	Activity	Children and Teens	National	Timmer et al., 1985	14-3
Averages	Activity	Adults 18-64 yrs	National	Robinson and Thomas, 1991	14-4
Averages	Activity	Adults 18-64 yrs	Regional-CA	Robinson and Thomas, 1991	14-5
Averages	Microenvironment	Adults 18-64 yrs	National/Regional-CA	Robinson and Thomas, 1991	14-6
Averages	Microenvironment	Children and Adult	Regional-California	Robinson and Thomas, 1991	14-6 to 14-9
Averages	Microenvironment	Children and Adults	National	Robinson and Thomas, 1991	14-6 to 14-9
Averages	Activity	Infants and Children	Regional-California	CARB, 1991	14-10
Distribution	Activity	Infants and Children	Regional-California	CARB, 1991	14-11
Averages	Activity by season	Infants and Children	Regional-California	CARB, 1991	14-12
Averages	Microenvironment	Infants and Children	Regional-California	CARB, 1991	14-13
Distribution	Microenvironment	Infant and Children	Regional-California	CARB, 1991	14-14
Averages	Microenvironment by season	Infants and Children	Regional-California	CARB, 1991	14-15
Distribution	Microenvironment near pollutant	Infant and Children	Regional-California	CARB, 1991	14-16
Averages	Bathing and swimming	Adults	Regional-National	USEPA, 1992 Tsang and Klepeis, 1996	14-17 14-22, 14-63
Distribution	Showering	Adults	Foreign-Australia	James and Knuiman, 1987 Tsang and Klepeis, 1996	14-18 14-24
Average	Activity by employment	Adults	National	Robinson, 1977	14-19
Averages	Occupational Tenure by race and gender	Teens and Adults	National	Carey, 1988	14-29
Averages	Occupational Tenure by employment and gender	Teens and Adults	National	Carey, 1988	14-30
Distribution	Occupational Tenure by employment	Teens and Adults	National	Carey, 1988	14-31
Distribution	Occupational Mobility by age	Teens and Adults	National	Carey, 1990	14-32
Distribution	Population Mobility by locale	All ages	National	Census, 1993	Figure 14-1
Averages	Residence Time by region, setting	All ages	National	Israeli and Nelson, 1992	14-33
Distribution	Residence Time by region, setting	All ages	National	Israeli and Nelson, 1992	14-34
Distribution	Residence Time by year moved in	All ages	National	Census, 1993	14-35
Distribution	Residence Time by years in current home	All ages	National	Census, 1993	14-36
Distribution	Residence Time by gender	All ages	National	Johnson and Capel, 1992	14-37
Distribution	Residence Time by age	All ages	National	Johnson and Capel, 1992	14-38
Distribution	Residence Time by years in previous house	All ages	National	NAR, 1993	14-39
Distribution	Residence Time by tenure in previous home	All ages	National	NAR, 1993	14-40
Distribution	Relocation Distance	All ages	National	NAR, 1993	14-41

Table 14-2. Mean Time Spent (Minutes) Performing Major Activities Grouped by Age, Sex and Type of Day

Activity	Age (3-11 years)				Age (12-17 years)			
	Duration of Time (mins/day)				Duration of Time (mins/day)			
	Weekdays		Weekends		Weekdays		Weekends	
	Boys (n = 118)	Girls (n = 111)	Boys (n = 118)	Girls (n = 111)	Boys (n = 77)	Girls (n = 83)	Boys (n = 77)	Girls (n = 83)
Market Work	16	0	7	4	23	21	58	25
Household Work	17	21	32	43	16	40	46	89
Personal Care	43	44	42	50	48	71	35	76
Eating	81	78	78	84	73	65	58	75
Sleeping	584	590	625	619	504	478	550	612
School	252	259	--	--	314	342	--	--
Studying	14	19	4	9	29	37	25	25
Church	7	4	53	61	3	7	40	36
Visiting	16	9	23	37	17	25	46	53
Sports	25	12	33	23	52	37	65	26
Outdoors	10	7	30	23	10	10	36	19
Hobbies	3	1	3	4	7	4	4	7
Art Activities	4	4	4	4	12	6	11	9
Playing	137	115	177	166	37	13	35	24
TV	117	128	181	122	143	108	187	140
Reading	9	7	12	10	10	13	12	19
Household Conversations	10	11	14	9	21	30	24	30
Other Passive Leisure	9	14	16	17	21	14	43	33
NA[a]	22	25	20	29	14	17	10	4
Percent of Time Accounted for by Activities Above	94%	92%	93%	89%	93%	92%	88%	89%

[a] NA = Unknown
Source: Timmer et al., 1985.

Table 14-3. Mean Time Spent in Major Activities Grouped by Type of Day for Five Different Age Groups

	Time Duration (mins)										Significant Effects[a]
	Weekday					Weekend					
Age (years)	3-5	6-8	9-11	12-14	15-17	3-5	6-8	9-11	12-14	15-17	
Activities											
Market Work	--	14	8	14	28	--	4	10	29	48	
Personal Care	41	49	40	56	60	47	45	44	60	51	A,S,AxS (F > M)
Household Work	14	15	18	27	34	17	27	51	72	60	A,S, AxS (F > M)
Eating	82	81	73	69	67	81	80	78	68	65	A
Sleeping	630	595	548	473	499	634	641	596	604	562	A
School	137	292	315	344	314	--	--	--	--	--	
Studying	2	8	29	33	33	1	2	12	15	30	A
Church	4	9	9	9	3	55	56	53	32	37	A
Visiting	14	15	10	21	20	10	8	13	22	56	A (Weekend only)
Sports	5	24	21	40	46	3	30	42	51	37	A,S (M > F)
Outdoor activities	4	9	8	7	11	8	23	39	25	26	
Hobbies	0	2	2	4	6	1	5	3	8	3	
Art Activities	5	4	3	3	12	4	4	4	7	10	
Other Passive Leisure	9	1	2	6	4	6	10	7	10	18	A
Playing	218	111	65	31	14	267	180	92	35	21	A,S (M > F)
TV	111	99	146	142	108	122	136	185	169	157	A,S, AxS (M > F)
Reading	5	5	9	10	12	4	9	10	10	18	A
Being read to	2	2	0	0	0	3	2	0	0	0	A
NA	30	14	23	25	7	52	7	14	4	9	A

[a] Effects are significant for weekdays and weekends, unless otherwise specified A = age effect, $P < 0.05$, for both weekdays and weekend activities; S = sex effect $P < 0.05$, F > M, M > F = females spend more time than males, or vice versa; and AxS = age by sex interaction, $P < 0.05$.

Source: Timmer et al., 1985.