Recent Activity Patterns Studies

1) Burmaster, DE. (1998) A lognormal distribution for time spent showering. Risk Anal 18(1):33-35.

2) Field, RW; Smith, BJ; Brus, CP; et al. (1998) Retrospective temporal and spatial mobility of adult Iowa women. Risk Anal 18(5):575-584.

3) Sedman, R; Funk, LM; Fountain, R. (1998) Distribution of residence duration in owner occupied housing. J Expo Anal Environ Epidemiol 8(1):51-58.

Burmaster, DE. (1998) A lognormal distribution for time spent showering. Risk Anal 18(1):33-35.
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In this study, domestic water usage lognormal distribution data previously published by James and Knuiman (1987) has been recast in a parametric form more easily used in Monte Carlo simulations. In their 1987 paper, James and Knuiman used Bayesian methods to quantify the different components of in-house water usage in approximately 3000 households for a 2-week period from July 1981 to June 1982 in Perth, Western Australia. Prior information from a sample of approximately 150 households was also incorporated into the distribution.

James and Knuiman presented data for an individual's time spent showering in one of 2550 households in terms of the following lognormal distribution, where β_1 is their fitted marginal lognormal distribution for time (min/d) spent showering and φ_1 is a fitted marginal lognormal distribution with arithmetic mean = 7.78 and an arithmetic standard deviation = 3.5:

$$\hat{\beta}_1 = 1.23\,\hat{\phi}_1\,0.9 \qquad \text{(Equation 1)}$$

To recast the original lognormal distribution developed by James and Knuiman (Equation 1) in a form more easily used by exposure assessors, it was first expressed as the notation shown in Equation 2, then modified to the final result in Equation 4 as follows:

$$T_s \sim \exp[\mathrm{Normal}[\mu, \sigma]]; \qquad T_s \text{ in min}/d \qquad \text{(Equation 2)}$$

$$\begin{aligned}
T_s &\sim \beta_1; \qquad T_s \text{ in min}/d \qquad \text{(Equation 3)}\\
&\sim 1.23\ \varphi_1\ 0.9\\
&\sim 1.23\ \mathrm{Lognormal}[\mathrm{AMean} = 7.78;\\
&\quad \mathrm{AStdDev} = 3.5]\ 0.9\\
&\sim 1.23\ \exp[\mathrm{Normal}[1.9594, 0.42931]]\ 0.9\\
&\sim \exp[\mathrm{Normal}[0.9 \cdot 1.9594\\
&\quad + \ln[1.23], 0.9 \cdot 0{,}42931]]]
\end{aligned}$$

$$T_s \sim \exp[\mathrm{Normal}[1.9705, 0.3864]]; \qquad T_s \text{ in min}/d \qquad \text{(Equation 4)}$$

Table 1 shows the cumulative frequencies for T_s calculated by the author.

The author states that the results of James and Knuiman re-expressed as a parametric distribution will allow more exposure assessors to model the variability of an individual's time spent showering.

Reference: James, IR; Knuiman, MW. (1987) An application of Bayes methodology to the analysis of diary records from a water use study. J Am Stat Assoc 832(399):705-711.

Table 1. Cumulative Frequency

Shower Duration (min/*d*)	Cumulative Frequency[a]
1	1.695E-07
2	0.0005
3	0.0120
4	0.0653
5	0.1750
6	0.3218
7	0.4747
8	0.6110
9	0.7213
10	0.8050
11	0.8657
12	0.9085
13	0.9380
14	0.9582
15	0.9719
16	0.9811
17	0.9872
18	0.9914
19	0.9941
20	0.9960
21	0.9973
22	0.9981
23	0.9987
24	0.9991
25	0.9993

a Computed from James and Knuiman, 1987.

Source: Burmaster, 1998.

Field, RW; Smith, BJ; Brus, CP; et al. (1998) Retrospective temporal and spatial mobility of adult Iowa women. Risk Anal 18(5):575-584.

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Field et al. (1998) conducted a study to describe the mobility patterns for Iowa females using data from the Iowa Radon Lung Cancer Study (IRLCS). The IRLCS is an epidemiologic case-study which evaluated the association between residential Radon exposure to Iowa women and lung cancer. Individuals were randomly selected for interviews, were required to have no history of malignant lung cancer and to have lived for a minimum of 20 consecutive years in their current residency. The study describes subgroup trends in spatial and mobility patterns within the home, outside the home, and in another building.

Data were collected using face-to-face interviews for 619 Iowa females ages 45-84 at time of enrollment in the IRLCS from June of 1993 through December of 1996. Table 1 presents the number of subjects at each age decade for which mobility data at last place of residence were collected. Table 2 presents the population demographics for women enrolled in the IRLCS.

Figure 1 presents the average percent of time women spent at home by age. According to this study, the average time women spend at home across all ages was 72.1%. Figure 2 presents the percent of time college educated women spent at home versus age by total number of children. Figure 3 presents the average percent of time women spent at various locations within one and two story homes with basements. Female subjects who lived in one-story homes spent about 3% more time in their basement as compared to residents of two-story homes (Field et al., 1998).

Figure 4 presents the observed average percent of time women spent in another building, outside, and away from home on business or vacation versus age. The data show that the amount of time women spent outside decreased by age. Figure 5 presents the amount of time college educated women spent in another building versus age by total number of children. On average, women spent 14.4% of their time in another building.

Figure 6 presents the amount of time college educated women spent outside versus age by total number of children. The data show that on average, women spent 8.5% of their time outside. The authors also found that high school educated women spent 0.2% more time outside than college educated women (Table 3). Figure 7 presents the amount of time college educated women spent away from home on vacation or business versus age by the total number of children. On average, women spent 4.9% of their time away from home on business or vacation. Women with three or more children tended to spend less time away from home than those with fewer children.

Results of the study show that Iowa women spent 72.1% of their time in the home, 14.4% in another building, 8.5% outside, and 4.9% away from home on business or vacation. The data for time spent indoors at home ranged from 69.4% for the group aged 50-59 years old to 81.6% for persons 80 years old and older. In 1996, the National Human Activity Patterns Survey (NHAPS) found that females in the U.S. spent an average of 72.5% of their time in the home.

The authors noted the following limitations of the study:

- Study was conducted in a primarily rural midwestern state that is likely not representative of the rest of the United States.

- 20-year residents of their current home are by definition, considerably less mobile than the rest of the highly mobile U.S.

- The accuracy of the historic mobility recall is not quantifiable.

- There are possible secular differences in the relationship of the factors examined by mobility.

The authors also noted that aggregate data such as what was presented in this study are helpful in deriving risk estimates for population subgroups, but does not replace good individual data for determining individual risk.

Reference: U.S. EPA (Environmental Protection Agency). (1996) Analysis of the National Human Activity Pattern Survey (NHAPS) respondents from a standpoint of exposure assessment. Office of Research and Development; Washington, DC; EPA/600/R-96/074.

Table 1. Number of Controls at Each Age Decade for Which Mobility Data at Last Place of Residence were Collected: Note that Participants May Contribute to More than One Decade

Age Decades	*N* (%)
0-19	16 (0.6)
20-29	186 (7.3)
30-39	415 (16.2)
40-49	560 (21.8)
50-59	598 (23.3)
60-69	487 (19.0)
70-79	249 (9.7)
80-89	53 (2.1)

Source: Field et al., 1998

Table 2. Population Demographics for the Female Controls Enrolled in the Iowa Radon and Lung Cancer Study

Demographic Variables	*N* (%)
Total number of participants	619
Age at enrollment	
45-54	52 (8.4)
55-64	183 (29.6)
65-74	257 (41.5)
75-84	127 (20.5)
Number of children	
0	44 (7.1)
1-2	200 (32.3)
3+	375 (60.6)
Location of residence	
Within city limits	444 (71.7)
Outside city limits	175 (28.3)
Highest level of education attained	
Grade school or less	48 (7.8)
High school	298 (48.1)
College or technical school (no degree)	184 (29.7)
College (baccalaureate degree)	61 (9.9)
Graduate school	25 (4.0)
Unknown	3 (0.5)
Smoking status	
Never smokers	418 (67.5)
Previous or current smokers	201 (32.5)

Source: Field et al., 1998

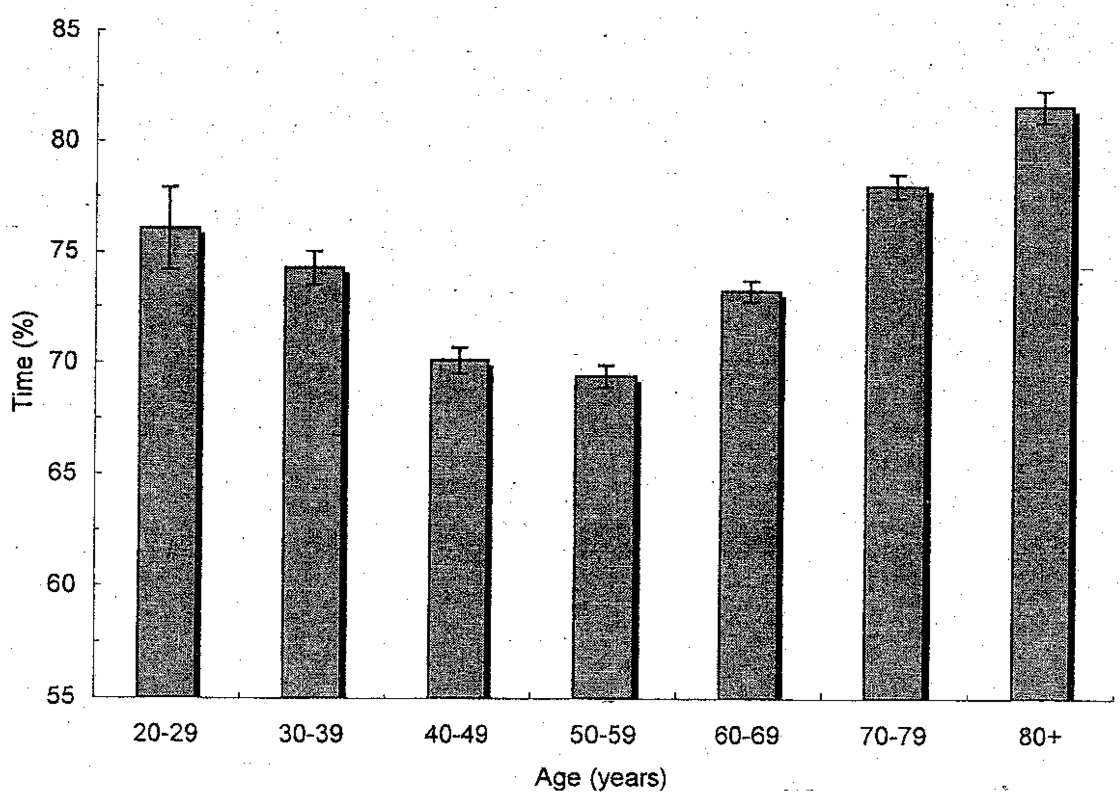

Figure 1. Observed Average Percents and Standard Error Bars for Time Spent At Home vs. Age for All Controls

Source: Field et al., 1998

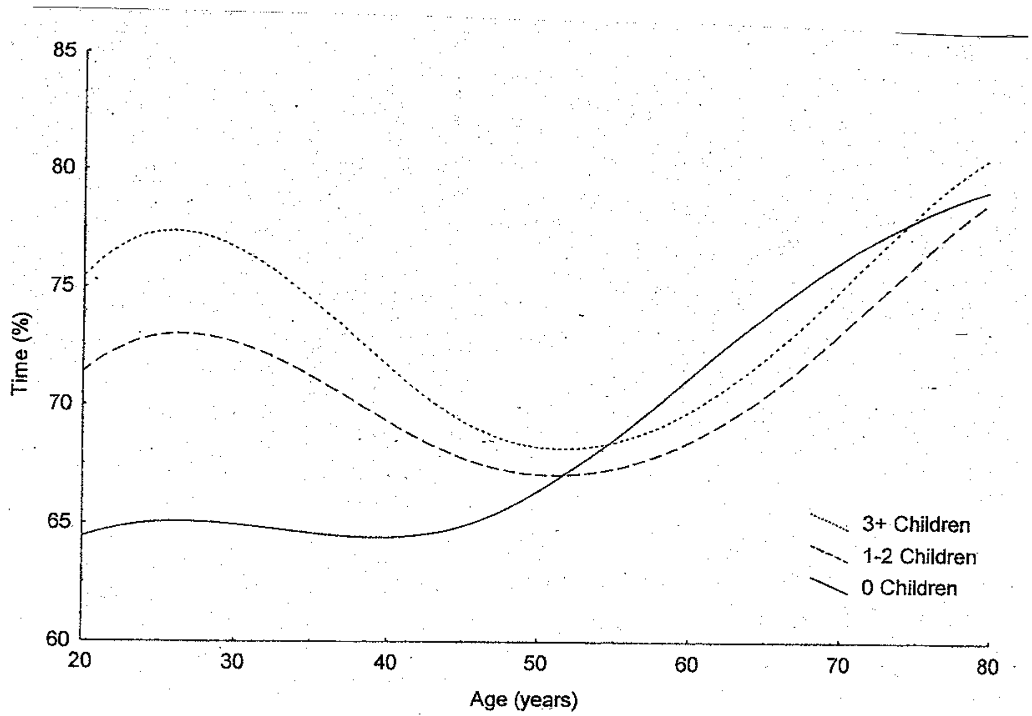

Figure 2. Regression Estimates of the Time Spent at Home vs. Age for College Educated Urban Iowa Women by Total Number of Children

Source: Field et al., 1998

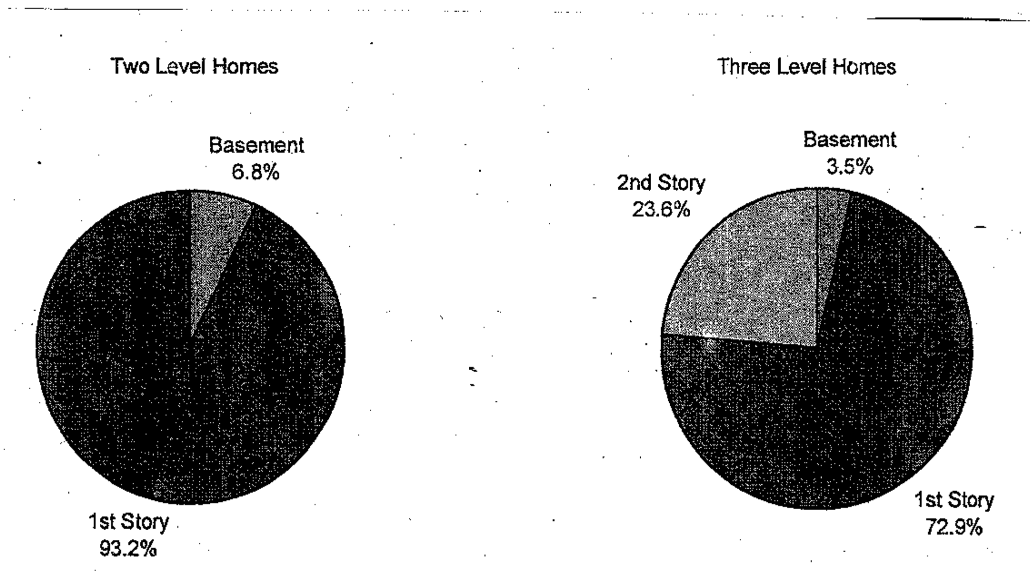

Figure 3. Observed Average Percent of Time Spent at Various Locations Within One (n = 294) and Two (n = 259) Story Homes with Basements

Source: Field et al., 1998

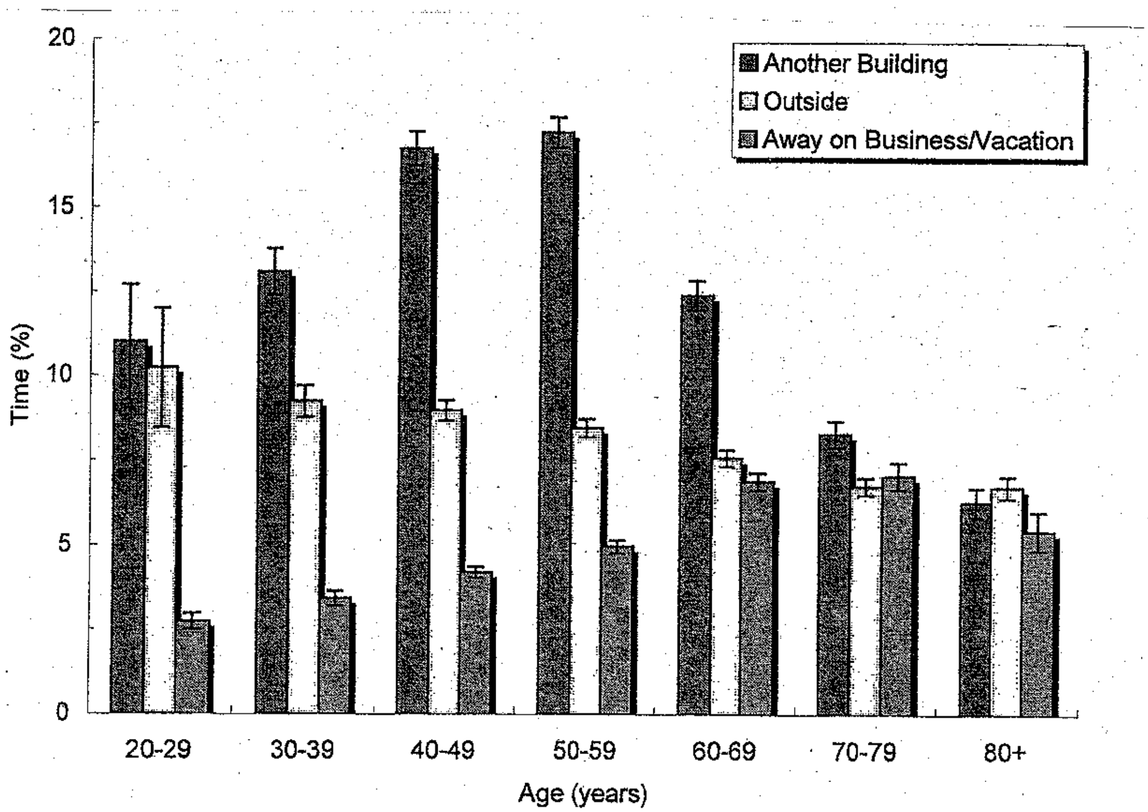

Figure 4. Observed Average Percents and Standard Error Bars for Time Spent in Another Building, Outside, and Away vs. Age for All Participants

Source: Field et al., 1998

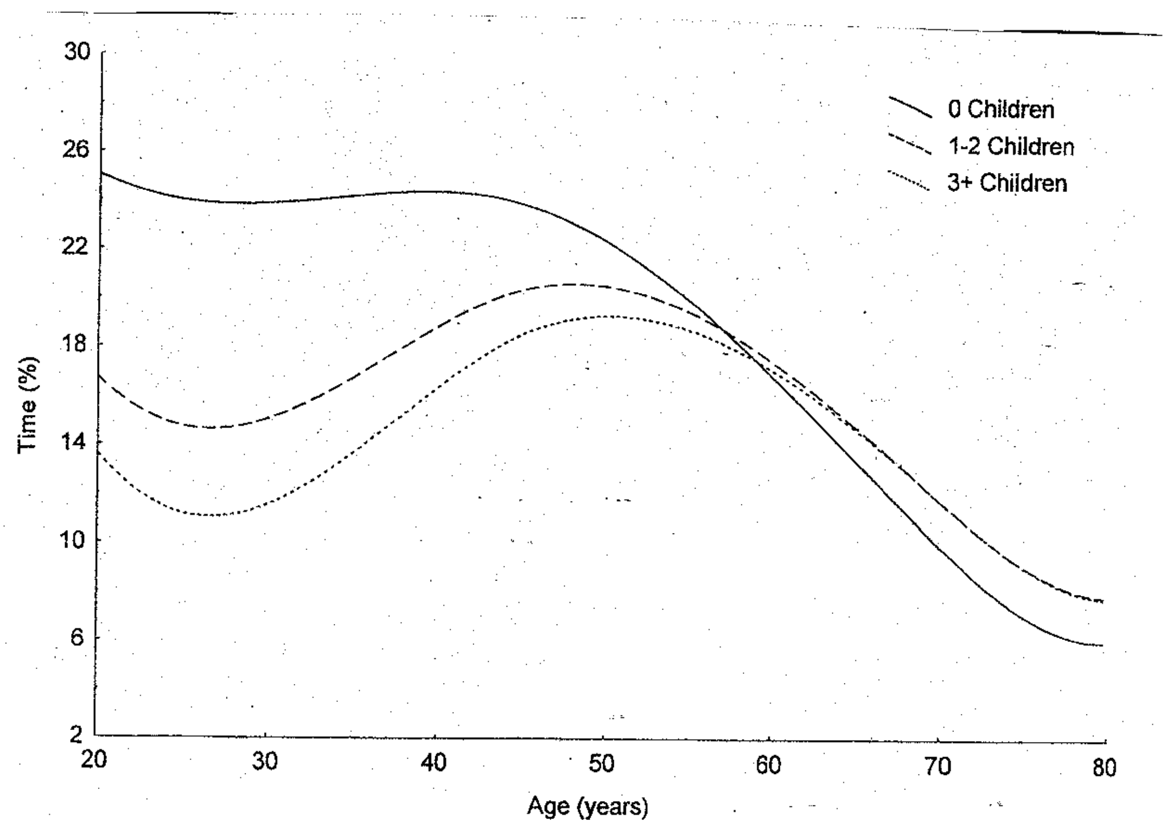

Figure 5. Regression Estimates of the Time Spent in Another Building vs. Age for College Educated Urban Iowa Women by Total Number of Children

Source: Field et al., 1998

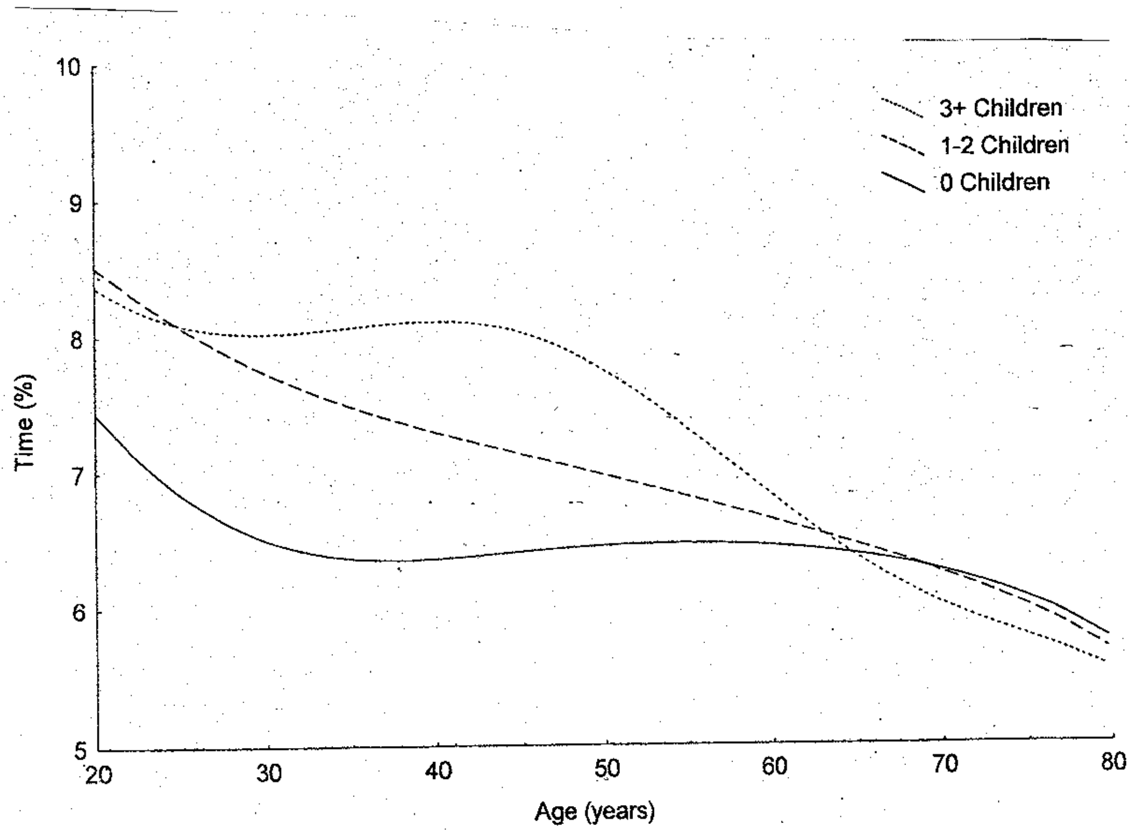

Figure 6. Regression Estimates of the Time Spent Outside vs. Age for College Educated Urban Iowa Women by Total Number of Children

Source: Field et al., 1998

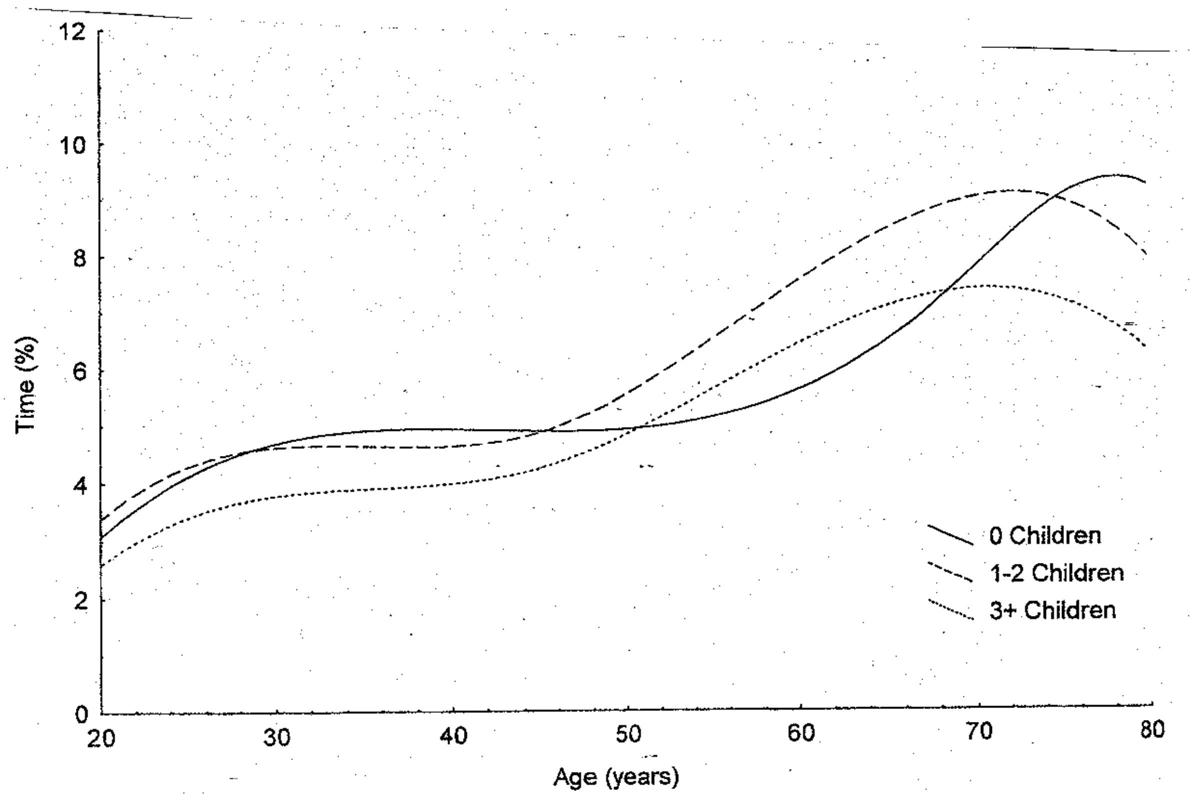

Figure 7. Regression Estimates of the Time Spent Away vs. Age for College Educated Urban Iowa Women by Total Number of Children

Source: Field et al., 1998

Sedman, R; Funk, LM; Fountain, R. (1998) Distribution of residence duration in owner occupied housing. J Expo Anal Environ Epidemiol 8(1):51-58.

Sedman et al. (1998) estimated residence duration by using the transfer of property title as an indicator of occupancy to establish the distribution of residence duration for owner-occupied housing units. The data were taken from a sample of tax records in Multnomah County, Oregon. Residence duration was established in a randomly selected sample of households by using the interval between two of the most recent changes in ownership. Tax records on 151,110 parcels of property for residential properties that had transferred title in the years 1990-1991 (n=20,192) and 1993-1994 (n=37,100) were selected for the study.

A total of 517 single-family residential units were included in the sample (260 properties from years 1990-1991; 257 from years 1993-1994). Of these, 347 met the selection criteria of being owner-occupied. Residence duration was determined for residences whose most recent title transfer occurred by subtracting the previous date of acquisition from the most recent date of acquisition. Chi-square and Kolmogorov-Smirnov goodness-of-fit tests were performed to determine whether residence duration could be characterized using known distributions. A z-test for independent samples was also performed to determine whether there was a significant difference between residence duration in records based on 1990-1991 as opposed to 1993-1994 records.

Mean residence duration, taken as the time interval between the two most recent transfers, was estimated to range from 12.0 to 15.8 years with a mean of 13.6 years (Table 1). Residence duration was observed to be consistent with an exponential distribution. Figure 1 shows the distribution of residency duration for households whose titles were transferred in 1990 through 1994. Significant differences were observed between the mean residence duration for titles transferred during 1990-1991 compared to those transferred in 1993-1994 (Table 2). This was attributed to possible differences in economic activity or changes in the unemployment rates. As shown in Table 3, the results of this study were similar to mean residency duration determined by other investigators.

A limitation associated with this study is that the data are for a single county in Oregon, and possible differences in residence duration between urban and rural areas were not determined. In addition, all owners may not occupy their residence during the precise time period that they hold title to their property. Other limitations noted by the authors were: (1) transfer of the title could be associated with changes in marital status or death that would not necessarily result in the property being vacated; (2) children would not be expected to remain in the same unit as long as adults; and (3) the method used in this study did not identify age and gender differences.

Table 1. Single Residence Owner Occupied Residency Duration (year)

Year	n	Mean	Median	Minimum	Maximum	SD
1990	83	14.94	12	2	42	10.83
1991	86	15.77	12	2	62	12.85
1993	83	11.92	8	2	63	11.12
1994	95	12.02	8	1	53	11.84
All Years	347	13.62	9	1	63	11.78

Source: Sedman et al., 1998.

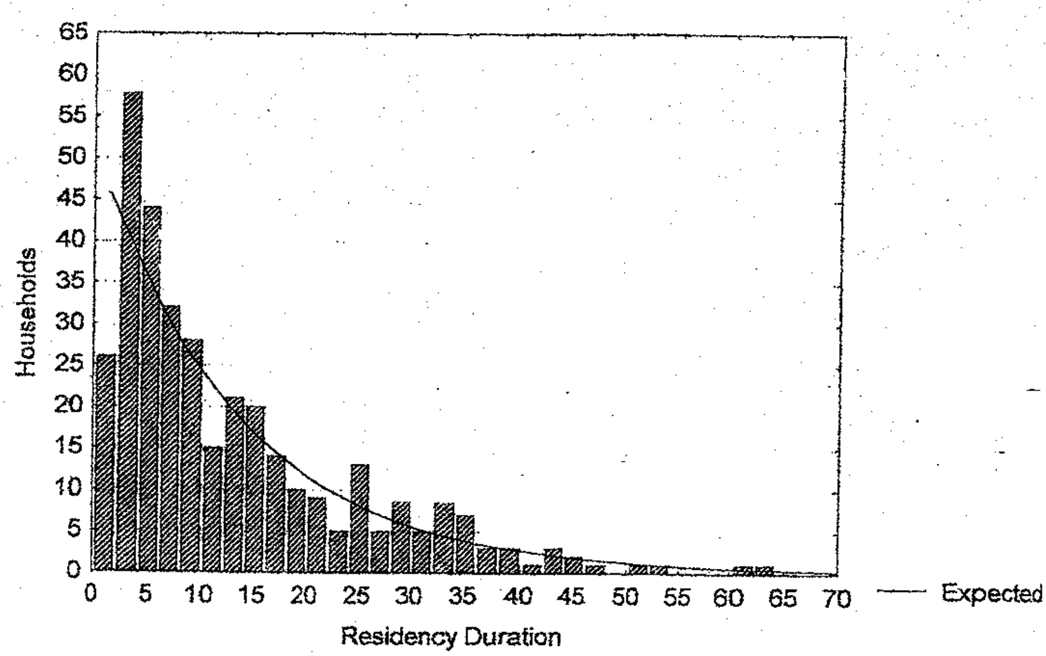

Figure 1. Distribution of Residency Duration for Households Whose Titles Were Transferred in 1990, 1991, 1993, and 1994.

Source: Sedman et al., 1998.

Table 2. Distributions of Single Residence Owner Occupied Residency Duration

Time Period	Distribution	*p*-Value
1990-1991	Exponential ($\lambda = .065$)	0.22
1993-1994	Exponential ($\lambda = .084$)	0.66
All Years (1990-1994)	Exponential ($\lambda = .073$)	0.40

Source: Sedman et al., 1998.

Table 3. Comparison of Residential Duration from Various Investigators

	Residency Duration (years)			
	Mult. CO.	EPA[a]	Price et al.[b]	Israeli/Nelson[c]
Mean	13.6	11.7	11	11.4
5th Percentile	2	2		
10th Percentile	3	2		
25th Percentile	5	4		1.4
50th Percentile	9	9	7	5.2
75th Percentile	19	16		17.1
90th Percentile	32	26		32
95th Percentile	36	33	36	41.4
98th Percentile	45	41		
99th Percentile	55	47		
99.5th Percentile	62	51		
99.8th Percentile	63	55		
99.9th Percentile	63	59		
Maximum Value	63	87		

[a] U.S. EPA (Environmental Protection Agency). (1992) A Monte Carlo approach to simulating residential occupancy period and its application to the general U.S. population. Washington, DC; EPA/450/3-92/011.

[b] Price, PS; Sample, J; Strieter, R. (1992) Determination of less-than-lifetime exposures to point source emissions. Risk Anal 12(3):367-382.

[c] Israeli, M; Nelson, CB. (1992) Distribution and expected time of residence for U.S. households. Risk Anal 12(1):65-72.