Recent Inhalation Rates Studies

1) Funk, LM; Sedman, R; Beals, JAJ; et al. (1998) Quantifying the distribution of inhalation exposure in human populations: 2. distributions of time spent by adults, adolescents, and children at home, at work, and at school. Risk Anal 18(1):47-56.

Funk, LM; Sedman, R; Beals, JAJ; et al. (1998) Quantifying the distribution of inhalation exposure in human populations: 2. distributions of time spent by adults, adolescents, and children at home, at work, and at school. Risk Anal 18(1):47-56.

Funk et al. (1998) used the California Air Resources Board (CARB) 24-hour recall diary activity and location data, along with ventilation data from a companion study to develop distributions. CARB conducted two studies on human activity patterns between 1987 and 1990. The first study focused on adults and adolescents, and the second study focused on children. Table 1 presents the gender and age groups of the subjects of the CARB human activity pattern studies. Both studies were conducted on different days of the week and during different seasons of the year. CARB determined the distributions of time spent in an activity group by employing the Chi-square, Kolmogorov-Smirnov, and Anderson-Darling goodness-of-fit tests.

Each activity from the CARB studies that occurred at home was assigned to one of three ventilation levels (low, moderate, or high) identified previously by Beals et al. (1996). Table 2 presents the assignments of at-home activities to ventilation levels for adults and adolescents and Table 3 presents the assignment of at-home activities to ventilation levels for children. Most of the activities were assigned to the low or moderate ventilation levels (85 percent). The authors discovered that adults, adolescents, and children spent different amounts of time at low, moderate, and high ventilation levels (Table 4). A significant statistical difference was observed in the mean aggregate time spent in high and moderate activities for male and female adults, while no significant differences were observed for male and female adolescents (Table 5). Mean time spent at home by age and gender for children is presented in Table 6.

Once distinct age and gender populations had been identified, the authors attempted to characterize the data on time spent using known distributions. Lognormal distributions best described the moderate activity group for men, the low activity group for women, and the low and moderate activity groups for adolescents. Gamma distributions best characterized all low and moderate gender-age groups for children. These distributions are shown in Table 7. Two of the adult at-home activity groups (men's low and women's moderate) could not be characterized using known distributions, so the data were described empirically (Table 8).

In addition to time spent at home, selected distributions were also established for time spent at work and at school. Time spent at the workplace was determined using selected CARB activities (work, meals at work, breaks at work, and other activities at work). Unlike the at-home activities, the CARB work-related activities were not assigned to ventilation groups, because explicit information on the physical intensity of the activities performed at work was not solicited. Full time (>30 hrs/wk) workers were used to find the distribution for time spent in the workplace because this worker population was considered to receive the most exposure to air toxicants. There was a significant difference between the time spent at work by men (489.5 min/day) and women (444.4 min/day) (Table 9). Distributions for time spent at school were developed for adolescents and children, using data for students attending school $\geq$240 min/day. The lognormal distributions are shown in Table 10.

The authors acknowledged that an uncertainty with the analyses in the study was the method used to assign each home activity to a particular ventilation level. Limitations are also associated with recall data and with accuracy of time reported. However, the authors noted that since these study results were similar to the results of other time budgeting studies, the uncertainty with this study is believed to be minimal.

Reference: Beals, JAJ; Funk, LM; Fountain, R.; et al. (1996) Quantifying the distribution of inhalation exposure in human populations: distribution of minute volumes in adults and children. Environ Health Perspect 104(9): 974-979.

Table 1. Gender and Age Groups

Gender-age Group	Subgroup	*n*	Age Range
Adults	Men	724	18 years or older
	Women	855	18 years or older
Adolescents	Males	98	12-17 years
	Females	85	12-17 years
Children[a]	Young males	145	6-8 years
	Young females	124	6-8 years
	Old males	156	9-11 years
	Old females	160	9-11 years

[a] Children under the age of 6 are excluded for the present study (too few responses in CARB study).

Source: Funk et al., 1998.

Table 2. Assignments of At-Home Activities to Ventilation Levels for Adults and Adolescents

Low	Moderate	High
Night sleep	Food preparation	Outdoor cleaning
Naps/resting	Food clean-up	
Doing homework	Cleaning house	
Radio use	Clothes care	
TV use	Car care	
Records/tapes	Household repairs	
Read books	Plant care	
Read magazines	Animal care	
Read newspaper	Other household	
Writing/paperwork	Baby care	
Other passive leisure	Child care	
	Helping/teaching	
	Talking/reading	
	Indoor playing	
	Outdoor playing	
	Medical child care	
	Washing	
	Medical care	
	Help and care	
	Meals at home	
	Dressing/grooming	
	Not ascertained	
	Visiting at home	
	Hobbies	
	Domestic crafts	
	Art	
	Music/drama/dance	
	Games	
	Computer use	
	Conversations	

Source: Funk et al., 1998.

Table 3. Assignment of At-Home Activities to Ventilation Levels for Children

Low	Moderate	High
Watching child care	Outdoor cleaning	
Night sleep	Food preparation	
Watch personal care	Meal clean-up	
Homework	Cleaning house	
Radio use	Clothes care	
TV use	Car/boat repair	
Records/tapes	Home repair	
Reading books	Plant care	
Reading magazines	Other household	
Reading newspaper	Pet care	
Letters/writing	Baby care	
Other leisure	Child care	
Homework/watch TB	Helping/teaching	
Reading/TV	Talking/reading	
Reading/listen music	Indoor playing	
Paperwork	Outdoor playing	
	Medical child care	
	Washing, hygiene	
	Medical care	
	Help and care	
	Meals at home	
	Dressing	
	Visiting at home	
	Hobbies	
	Domestic crafts	
	Art	
	Music/dance/drama	
	Indoor games	
	Conversations	
	Painting room/home	
	Building fire	
	Washing/dressing	
	Outdoor play	
	Playing/eating	
	Playing/talking	
	Playing/watch TV	
	TV/eating	
	TV/something else	
	Reading book/eating	
	Read magazine/eat	
	Read newspaper/eat	

Note: Activities were not assigned to the high ventilation level catetgory.

Source: Funk et al., 1998.

Table 4. Aggregate Time Spent At-Home in Activity Groups by Adults, Adolescents, and Children[a]

Activity Group	Adults		Adolescents		Children	
	Mean	SD	Mean	SD	Mean	SD
Low	702	214	789[b]	230	823	153
Moderate	257	183	197[b]	131	241[c]	136
High	9	38	1[b]	11	3	17
$High_{Participants}$ [d]	92	83	43	72	58	47

[a] Time spent engaging in all activities embodied by ventilation level category (minutes/day).
[b] Significantly different from adults ($p < 0.05$).
[c] Significantly different from adolescents ($p < 0.05$).
[d] Represents time spent at-home by individuals participating in high ventilation level activities.

Source: Funk et al., 1998.

Table 5. Comparison of Mean Time Spent At-Home by Gender[a]

Activity Group	Male		Female	
	Mean (min)	SD	Mean (min)	SD
Adults				
Low	691	226	714	200
Moderate	190	150	323[b]	189
High	14	50	4[b]	18
$High_{Participants}$ [d]	109	97	59[b]	40
Adolescents				
Low	775	206	804	253
Moderate	181	126	214	134
High	2	16	0	0

[a] Time in minutes/day.
[b] Significantly different from male ($p < 0.05$).
[c] Participates in high ventilation level activities.

Source: Funk et al., 1998.

Table 6. Comparison of Mean Time Spent At-Home by Gender and Age for Children[a]

Activity Group	Males				Females			
	6-8 Years		9-11 Years		6-8 Years		9-11 Years	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Low	806	134	860	157	828	155	803	162
Moderate	259	135	198	111	256	141	247	146
High	3	17	7	27	1	9	2	10
$High_{Participants}$ [b]	77	59	70	54	68	11	30	23

[a] Time in minutes/day.
[b] Participates in high ventilation level activities.

Source: Funk et al., 1998.

Table 7. Distributions Which Best Describe Aggregate Time Spent in At-Home Activity Groups

At-Home Activity Group	Distribution	X^2 p-value[a]
Adults		
Men		
Low	empirical	
Moderate	lognormal (4.99, 0.57)[b]	0.21
High	discrete [0.13[c]; lognormal (6.66, 0.10)[b]]	0.74
Women		
Low	lognormal (6.53, 0.08)[b]	0.10
Moderate	empirical	
High	discrete [0.07[c]; lognormal (6.56, 0.06)[b]]	
Adolescents		
Low	lognormal (6.63, 0.08)[b]	0.80
Moderate	lognormal (5.07, 0.51)[b]	0.29
High	discrete [0.02, 42.75[d]]	0.41
Children		
Low		
Male, 6-8 yrs.	gamma[e] (0.05, 39.36)[f]	0.00
Female, 6-8 yrs.	gamma[e] (0.04, 30.50)[f]	0.08
Male, 9-11 yrs.	gamma[e] (0.03, 29.22)[f]	0.14
Female, 9-11 yrs.	gamma[e] (0.03, 25.28)[f]	0.74
Moderate		
Male, 6-8 yrs.	gamma[e] (0.01, 3.17)[f]	0.50
Female, 6-8 yrs.	gamma[e] (0.01, 3.37)[f]	0.56
Male, 9-11 yrs.	gamma[e] (0.01, 2.90)[f]	0.91
Female, 9-11 yrs.	gamma[e] (0.01, 2.97)[f]	0.00
High	discrete [0.05[c]; lognormal (6.71, 0.04)[b]]	0.18

[a] Kolmogorov-Smirnov p-values not significant for all activity groups.

[b] Mean and standard deviation of log of aggregate time in ventilation level level.

[c] Probability of participating in high ventilation level activities.

[d] Mean time spent in the activity group.

[e] $f(x) = \frac{1}{\Gamma(\alpha)\,\beta^{\alpha}} x^{\alpha-1} e^{-x/\beta}$, Γ = gamma function, β = scale parameter, α = shape parameter.

[f] Scale parameter, shape parameter.

Source: Funk et al., 1998.

Table 8. Statistical Description of Empirical Distributions Associated with Adult At-Home Activities[a]

Statistic	At-Home	
	Men (low)	Women (moderate)
Mean	691	323
Median	675	290
Minimum	0	15
Maximum	1,440	900
Lower quartile	540	170
Upper quartile	805	450
Range	1,440	885
Standard deviation	226	189
Skewness	0.5	0.6
Kurtosis	1.0	-0.2

[a] Time in minutes/day.

Source: Funk et al., 1998.

Table 9. At-Work Empirical Distributions[a]

Statistic	At-Work	
	Men	Women
Mean	489.5	444.4
Median	510.0	486.0
Minimum	15.0	15.0
Maximum	945.0	814.0
Lower quartile	435.0	415.0
Upper quartile	570.0	530.0
Range	930.0	799.0
Standard deviation	154.1	140.7
Skewness	-0.9	-1.2
Kurtosis	1.8	1.3

[a] Time in minutes/day.

Source: Funk et al., 1998.

Table 10. Distributions Which Best Describe Away-from-Home Activity Groups

Activity Group	Distribution	x^2 *p*-value
Work		
Men	Empirical	
Women	Empirical	
School		
Adolescent males	Lognormal (5.84, 0.03)[b]	0.50
Adolescent females	Lognormal (5.98, 0.01)[b]	0.63
Male children	Lognormal (5.77, 0.02)[b]	0.33
Female children	Lognormal (5.84, 0.02)[b]	0.11

[a] Kolmogorov-Smirnov *p*-values not significant for all activity groups.
[b] Mean and standard deviation of log of aggregate time.

Source: Funk et al., 1998.