Measurement of Personal Exposure to Environmental Tobacco Smoke in the United States

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A study of personal exposure of non-smokers to environmental tobacco smoke (ETS) has been conducted in 16 cities in the United States. Individual participants wear one of two personal sampling pumps, one each at work and away-from-work. Samples of breathing zone air are collected, and analyzed for both particle- and vapor-phase markers of ETS, including respirable suspended particulate matter, UV-absorbing and fluorescing particulate matter, scopoletin, solanesol, nicotine, 3-ethenyl pyridine, and myosmine. In addition, prior- and post-exposure saliva samples are collected, in order that smoking status can be assessed through cotinine levels. The distribution of subjects among smoking and non-smoking workplaces and homes is such that ca. 54% of the participants worked and lived in non-smoking situations. A comparison of the demographic distribution of the sample population with that of the US non-smoking population indicates that the sample population is more female and of higher socio-economic status.

As the exposure data are segregated according to cells, it is clear that those subjects living and working with smokers are more highly exposed to ETS than those subjects who live and work in predominantly ETS-free environments. However, it is important to note that even the smoke exposures of subjects living and working in smoking venues are low relative to area concentrations of ETS reported in previous studies. For example, 24-hour time averaged median ETS marker levels were 0.84, 1.72, 33.8, and 8.2 ug/m^3 for 3-EP, nicotine, RSP, and FPM, respectively, for those individuals confirmed to be living in smoking homes and working in smoking workplaces, and 0.45, 0.71, 24.9, and 5.53 ug/m^3, respectively, for individuals living in smoking homes, and working in non-smoking workplaces. For individuals living in non-smoking homes, and working in smoking workplaces, 24-hour time weighted average marker levels were 0.13, 0.16, 21.2, and 1.81 ug/m^3, respectively, compared with 0.022, 0.027, 14.9, and 0.52 ug/m^3, for individuals in non-smoking homes and workplaces. It is clear that in general (not considering cell designation), ETS exposure is inversely correlated with household income. Additional data analysis has indicated that although participants perceive their greatest exposures to ETS to occur in the workplace, in fact, exposure to ETS when living with a smoker is demonstrably greater than that received in a smoking workplace. On an individual basis, correlation between salivary cotinine levels and ETS nicotine exposure was non-existent. However, there appears to be significant correlation between the two parameters when participants with measureable exposures are segregated into groups of 25.

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INTRODUCTION

In recent years, many studies attempting to quantify personal exposure to environmental tobacco smoke (ETS) in the US population have had to rely on self-reports of exposure (Jenkins, et al, 1992), or extrapolations from determinations of area measurements of ETS levels in locations where cigarettes are actively being smoked (Oldaker, et al, 1990; Leaderer and Hammond, 1991; Jenkins, et al, 1991; Colett, et al, 1992). Clearly, such is not the same as a direct determination of personal exposure to ETS. While some investigators have attempted to assess personal exposure (Thompson, et al, 1989), such direct determinations have been limited to relatively small study populations. The purpose of the study reported here is to directly determine ETS exposures of more than 1500 US non-smokers.

EXPERIMENTAL

Study Design

The study design involved recruiting approximately 100 individual subjects in each of 16 cities distributed geographically around the United States. To determine personal exposure, each subject wore a sampling pump during the work phase of his/her day, and a second pump to collect samples from which to determine ETS exposure away from work. The sampling systems collected both particulate phase and vapor phase components of ETS. While attempting to create a 2x2 matrix of subjects living in smoking or non-smoking homes and working in smoking or non-smoking workplaces of equal cell population, recruiting subjects living and/or working in smoking environments was difficult, and as a result, the cells were unequally populated. Although all subjects were recruited on the basis of their non-smoking status, salivary cotinine was used to assess actual smoking status.

Subject Recruiting and Itinerary

Nearly all of the subjects were recruited through random telephone dialing or marketing research databases. Less than 10% of the subjects were recruited through shopping mall intercept methods. To be included in the study, individuals had to report themselves as not having used tobacco products in the last six months, nor using any form of nicotine patch or gum, being at least 18 years of age, and working outside the home on a "regular" (ca. 8 am until 5 pm) shift at a minimum of 35 hours per week.

On the evening of the first day of the subject's involvement, the subject arrived at the test coordination site, and was rescreened to verify the accuracy of the questionnaire, which had been administered by telephone. The subject then watched an instructional video with approximately 24 other participants and completed a "first visit" questionnaire concerning his/her lifestyle and details regarding the type of environment in which the subject worked. The subject provided a saliva sample and received his/her sampling systems, after being tested to insure that the subject could actually operate the sampling unit.

On the morning of Day 2, the subject began sampling with the workplace pump upon his/her arrival at work. The sampling apparatus consisted of a sound-insulated pump (with the strap typically worn over the right shoulder and the pump resting on the left hip) and a sampling head, containing both particulate and vapor collection devices which was worn in the subject's breathing zone. The subject also completed a workplace diary, recording various smells and observations concerning the use of products which may affect indoor air quality (eg., copying machines, correction fluids, coffee, cigarettes, etc.). Subjects were requested to remain at their work station during the lunch period. At the end of the workday, the subject turned off the workplace sampling pump, completed the workplace pump survey, put on the away-from-work pump (which is outfitted with a larger battery pack to afford sampling for a minimum of 18 hours), and returned home, conducting normal activities, such as shopping, dining, etc, on the way. The subject completed an away-from-work

diary on an hourly basis. At bedtime, the subject took off the pump, and set it alongside of his/her bed, while the pump continued to sample. The next morning (Day 3), when the subject arrived at work, the away-from-work pump was turned off, and the home pump survey completed. After work that same day, the subject returned to the test coordination center, completed a last visit survey, provided a second saliva sample, and received a $100 gratuity.

Determination of Exposure Markers

Particulate phase ETS air markers were collected on a Fluoropore membrane filter at a flow of approximately 1.7 L/min, while vapor phase markers were collected on XAD-4 resin cartridges (SKC Inc., Eighty Four, PA) at a flow of approximately 0.5 - 0.7 L/min, using a single air sampling pump (Ogden, et al, 1995). Particulate phase markers included respirable suspended particulate matter (RSP, 3.5 μm cut-off), solanesol, scopoletin, ultraviolet absorbing particulate matter (UVPM), and fluorescing particulate matter (FPM). ETS vapor phase markers included nicotine, 3-ethenylpyridine (3-EP), and myosmine. Briefly, RSP was determined gravimetrically (Conner, et al, 1990), and UVPM and FPM were determined by high performance liquid chromatography (HPLC) with UV and fluorescence detectors(Conner, et al, 1990), respectively. Solanesol and scopoletin were also determined using HPLC (Ogden and Maiolo, 1992; Risner, 1994). All of the vapor phase markers were determined using gas chromatography with thermionic specific (nitrogen selective) detection (Ogden, 1991). Levels of salivary cotinine were determined using radio-immunoassay (Davis and Stiles, 1993).

RESULTS AND DISCUSSION

Samples were collected in 16 urban areas distributed geographically across the 48 contiguous United States between May, 1993 and June, 1994. Cities were chosen based on obtaining a good geographic distribution, weather during the time of year, logistics, lack of pervasive smoking restrictions, and likelihood of high quality field marketing survey research support.

As may be expected for a volunteer subject population recruited by telephone, the group

demographics are slightly different from those of the non-smoking US population as a whole. Differences include somewhat greater median household income, a larger proportion of females and a somewhat higher educational status. Imposing the requirement that subjects work outside the home at least 35 hours per week resulted in very few of the subjects being older than 65 (normal retirement age in the United States). With regards to the occupational distribution, the study contains a lower proportion of individuals in service occupations and those who work in factories. These individuals may have decided not to participate on the basis of safety or appearance concerns for wearing the air sampling pumps. As a result, the study contains a larger proportion of "white collar" workers, who may tend to be more highly paid.

In Table 1 are presented summaries of the 24-hour time weighted average level of ETS markers to which the individuals were exposed. To compile these tables, individual participants were segregated into groups, by those working in smoking and non-smoking locations, and those in away-from-work settings which included either smoking or non-smoking homes. (Except where otherwise noted, all of the data has been corrected by excluding those individuals which we determined to be at least occasional smokers, based on salivary cotinine levels greater than 15 ng/mL.) Note that the measured parameter in this table is the 24-hour time weighted average marker concentration (24-hour TWA). The time averaged concentrations are equal to the sum of the concentration/time products for the workplace and away-from-work sampling systems, divided by the total time of measurement of the two sampling systems (ca. 24 hours).

In Table 1, for clarity, the population has been restricted to those subjects whose self-reports of tobacco product use in their presence during the study period (from the home or work diaries) was consistent with their initial reports of the smoking/non-smoking status of their homes or work places. The rationale for this criterion is that many individuals work in locations where they report smoking occurs, but where no actual tobacco products were observed to have been smoked during the sample collection period. Thus, the assignment of such a facility as a "smoking" workplace, when the participant did not observe smoking taking place, seemed incongruous, and clouds the interpretation of the data. The same argument can be used for assignment to a cell including a smoking home environment. From the data in Table 1, it is clear that those individuals who live and work with

smokers are exposed to substantially higher concentrations of ETS components than those who observe no cigarettes, pipes, or cigars being smoked around them. For example, median airborne nicotine concentrations experienced by participants in Cell 1 (smoking workplaces and an away-from-work categorization which included a smoking home) were more than 60 times greater than concentrations experienced by those who live, work, shop, and commute in truly non-smoking environments (Cell 4 subjects). A subset of the data is presented graphically in Figures 1 and 2. These figures represent the cumulative distribution of the subjects in Cells 1 - 4 for nicotine (vapor phase marker) and scopoletin-PM (particle phase marker). The general pattern of 24- hour TWA levels for Cell 1 subjects being several times greater than those for Cell 2 subjects at any given percent distribution of the subject population, which are in turn several times greater than those of Cell 3 subjects, and so on, is maintained over most of the subject distributions below the 90th percentile. For the most highly exposed individuals (those above the 90th percentile) the relative differences in the levels of ETS components to which the subjects are exposed tend to decrease. However, significant differences still exist. However, most of the levels encountered are much less that those determined in short duration area measurements of ETS constituents (Guerin, et al, 1992)

In Table 2 are presented exposures (8-hour or 16-hour time weighted average levels multiplied by the duration of exposure) to each of the ETS components determined in this study for three groups of individuals: those who reported observing tobacco products being smoked during their workday, those who reported tobacco products being smoked around them at any time while away from work, and those who reported tobacco products being smoked inside their residence. (Note that individuals in the Away-from-work category could have observed tobacco products being used anywhere outside of work - but not necessarily in the home-, but that subjects in the "Home" category had to have observed tobacco products being used inside the home.) For virtually all of the comparisons, exposures in the away-from-work environment, where the home is the primary source of exposure, is greater than the workplace exposure by a factor of two or more. For example, for the 3-ethenyl pyridine, the median and 80th percentile exposures for the subjects exposed inside the home are 6.33 and 22.4 μg-hr/m^3, respectively, in contrast to the workplace exposures of 1.28 and 7.02 μg-hr/m^3. For the particulate-associated markers for ETS, such as the scopoletin-PM, the differences are similar, but somewhat greater in magnitude.

Table 1

Comparison of Concentrations of Environmental Tobacco Smoke Markers to which Individuals have been Exposed

Among Cells Classified by Screening Questionnaire and Diary Observations of Tobacco Products

Cell[1]	Away From Work Environment	Work Environment	Number of Participants		24-hr Time Averaged Airborne Concentrations, µg/m³ [2]									
					3-EP	Nicotine	Myosmine	RSP	UVPM	FPM	Solanesol	Scopoletin	Scopoletin-PM	Solanesol-PM
1	Smoking	Smoking	122	**Median:**	**0.839**	**1.72**	**0.185**	**33.8**	**13.0**	**8.22**	**0.122**	**6.13**	**4.61**	**4.01**
				Mean:	1.29	3.27	0.290	47.0	25.1	18.9	0.508	19.0	14.3	16.8
				80th %ile:	1.96	3.94	0.359	66.7	34.9	26.8	0.726	28.4	21.4	24.0
				95th %ile:	3.75	9.08	0.717	117	88.0	68.7	1.89	81.4	61.2	62.4
2	Smoking	Non-Smoking	149	**Median:**	**0.448**	**0.711**	**0.074**	**24.9**	**7.24**	**5.53**	**0.047**	**1.90**	**1.43**	**1.55**
				Mean:	0.708	1.41	0.126	33.0	13.7	9.99	0.236	6.39	4.80	7.80
				80th %ile:	1.07	2.00	0.182	44.6	20.1	15.8	0.368	9.63	7.24	12.1
				95th %ile:	2.30	4.39	0.389	76.3	40.4	29.6	0.799	26.0	19.6	26.4
3	Non-Smoking	Smoking	154	**Median:**	**0.131**	**0.161**	**0.021**	**21.2**	**2.91**	**1.81**	**0.005**	**0.262**	**0.197**	**0.166**
				Mean:	0.305	0.686	0.070	28.7	7.01	4.89	0.090	3.33	2.50	2.98
				80th %ile:	0.400	0.922	0.094	34.4	9.53	6.83	0.069	3.35	2.52	2.27
				95th %ile:	1.17	2.10	0.210	75.0	24.8	18.3	0.402	13.2	9.90	13.3
4	Non-Smoking	Non-Smoking	555	**Median:**	**0.022**	**0.027**	**0.004**	**14.9**	**1.03**	**0.516**	**0.003[3]**	**0.037**	**0.028**	**0.093[3]**
				Mean:	0.049	0.055	0.008	18.1	1.65	1.10	0.003[3]	0.131	0.098	0.088
				80th %ile:	0.056	0.070	0.012	21.8	1.87	1.15	0.003[3]	0.143	0.107	0.093[3]
				95th %ile:	0.182	0.173	0.031	41.5	4.68	3.14	0.010	0.385	0.289	0.338

[1]Cell assignments determined from responses on the screening questionnaire and confirmed by reporting of tobacco product observations in the Diaries.

[2]Analytical blank-corrected µg/sample/(Sampling time x Flow rate) = µg/m³ per sample; [(µg/m³, Away from work sample x Hours, Away from work sample) + (µg/m³, work sample x Hours, work sample)]/(Hours, Away from work sample + Hours, Work sample) = Time Averaged µg/m³; Scopoletin is in ng/m³.

[3]Actual value was non-detectable; one half of the limit of detection, in µg, an average flow rate, and a 24-hour time were used.

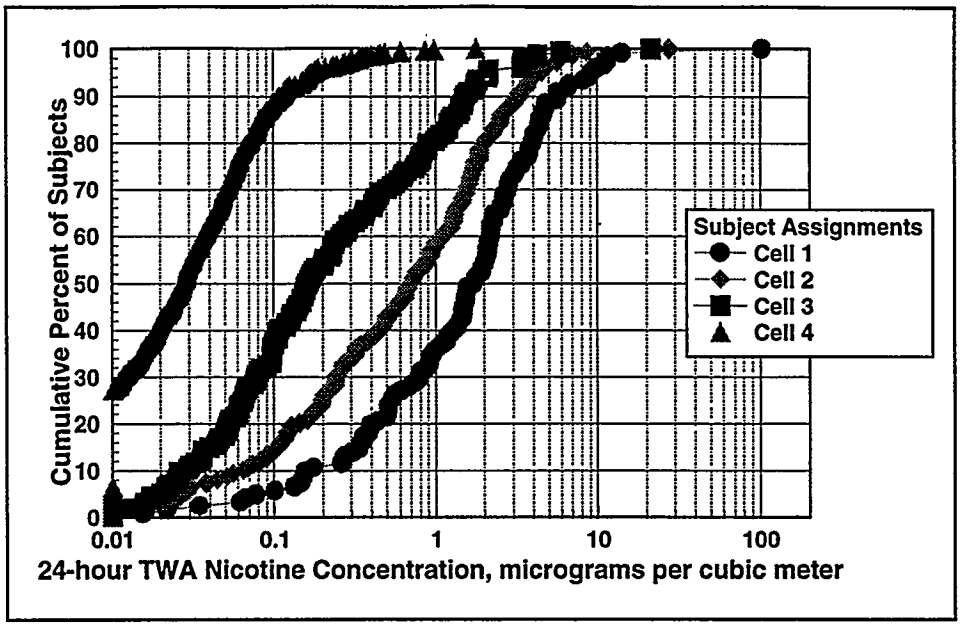

Figure 1. Cumulative distribution of study subjects (with salivary cotinine <15 ng/mL or no report) as a function of nicotine 24-hour time weighted average concentration. Note log scale on horizontal axis.

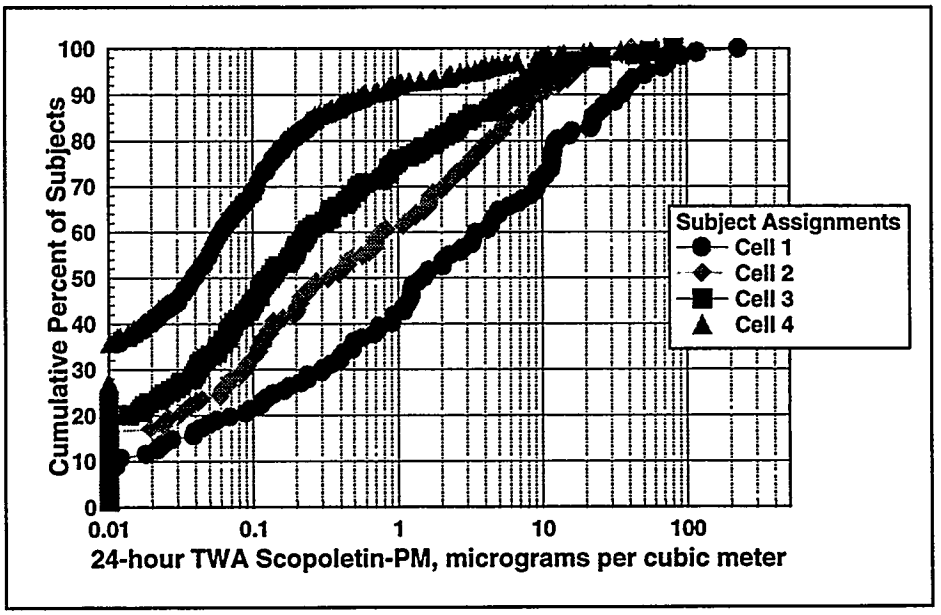

Figure 2. Cumulative distribution of study subjects (with salivary cotinine <15 ng/mL or no report) as a function of scopoletin-related particulate matter 24-hour time weighted average concentration. Note log scale on horizontal axis.

For example, median and 80th percentile scopoletin-PM exposures for those exposed inside the home were 16.1 and 142 μg-hr/m^3, respectively, compared with those in the workplace of 2.26 and 37.6 μg-hr/m^3.

While numerous subjects observed individuals smoking in and around their workplaces, in fact, many of the workplaces had some form of smoking restrictions imposed. Such would tend to lower the ETS exposure of subjects occupying those areas. In order to compare exposures of subjects occupying workplaces where smoking was not restricted, with away-from-work exposures where spousal smoking was unrestricted, we segregated subsets of the subjects. Exposures of subjects who worked in areas in which there were no smoking restrictions, and who reported tobacco products being used around them in the workplace, have been compared to exposures of subjects who live in homes where they report that their spouses smoke anywhere within the home, and also reported tobacco products being used around them in the home. That data is compiled for all of the ETS constituents and summarized in Table 3.

While the exposure differences are not as large as in the comparisons which permitted inclusion of subjects working in workplaces where smoking was restricted, the exposure levels are still greater for the away-from-work venue, when compared with the workplace, for the vast majority of the subjects included in this comparison. For example, the median 3-ethenyl pyridine exposures are about 3.3 times greater away from work than in the workplace. The median scopoletin exposures are about 3.7 times greater away from work. The differences between exposures in the two venues do decrease with the more highly exposed subjects in each group. For example, in Figures 3 and 4 are presented cumulative subject distributions as a function of exposure level to 3-EP and scopoletin. As suggested by the tabular presentation of the data, the relative differences in the away-from-work and workplace exposures are maintained across much of the distributions of the 100+ subjects in each of these subgroups. For example, at the 70th percentile for 3-EP exposures, the away-from-work exposures are still ca. 2.5 times greater than those incurred in the workplace. However, the differences appear to be minimized for those most highly exposed individuals in the study. In other words, for perhaps 85 - 90% of those individuals who work in locations where no smoking restrictions exist, exposures to ETS constituents are a factor of 1.5 - 2.5 less than those of subjects

Table 2

Comparison of Exposures to ETS Constituents of Individuals

Recording Tobacco Product Observations in Different Venues

8 or 16 hour Exposures (Concentration x Time)

Venue	Number of Participants		3-EP $\mu g \cdot hr/m^3$	Nicotine $\mu g \cdot hr/m^3$	Myosmine $\mu g \cdot hr/m^3$	RSP $\mu g \cdot hr/m^3$	UVPM $\mu g \cdot hr/m^3$	FPM $\mu g \cdot hr/m^3$	Solanesol-PM $\mu g \cdot hr/m^3$	Scopoletin-PM $\mu g \cdot hr/m^3$
Home (16-hr Sample)	415	**Median**	**6.33**	**10.1**	**1.32**	**377**	**109**	**71.1**	**14.7**	**16.1**
		Mean	14.0	32.3	2.78	566	267	199	171	124
		80th %ile	22.4	40.6	3.84	816	426	290	224	142
		95th %ile	50.9	106	8.97	1543	1053	726	765	513
Away-From-Work (16-hr Sample)	545	**Median**	**3.88**	**5.18**	**0.728**	**337**	**61.8**	**40.6**	**6.30**	**6.73**
		Mean	11.5	26.2	2.30	514	222	164	137	101
		80th %ile	18.7	33.4	3.26	732	332	227	155	110
		95th %ile	48.1	96.3	8.24	1419	871	636	679	480
Work (8-hr Sample)	520	**Median**	**1.28**	**1.68**	**0.254**	**185**	**28.4**	**17.5**	**1.12[1]**	**2.26**
		Mean	5.52	13.2	1.26	316	119	86.9	61.4	55.4
		80th %ile	7.02	17.8	1.62	409	144	100	32.9	37.6
		95th %ile	25.5	64.2	5.98	898	554	435	336	303

Home: Noted tobacco product observations *while inside the home* on the Home diary

Away From Work: Noted tobacco products observations in any location on the Home diary

Work: Noted tobacco product observations on the Work diary

[1]Actual value was non-detectable; one half of the limit of detection, in µg, an average flow rate, and an 8 or 16-hour time were used. For the Sleep Corrected Potential Inhaled Quantity, the light activity ventilation rate and 8 hour time were used for the Work sample; for the Away From Work and Home samples, 8 hours at the light activity ventilation rate and 8 hours at the resting ventilation rate were used.

Table 3

Comparison of Exposures to Selected ETS Markers in Unrestricted Smoking Environments
8-hour Exposures in Workplaces with No Restrictions vs. 16-hour Exposures, Away from Work
in Homes Where the Spouse Smokes Anywhere

	Number of Participants		3-EP., $\mu g\text{-}hr/m^3$	Nicotine, $\mu g\text{-}hr/m^3$	Myosmine, $\mu g\text{-}hr/m^3$	RSP, $\mu g\text{-}hr/m^3$	UVPM, $\mu g\text{-}hr/m^3$	FPM, $\mu g\text{-}hr/m^3$	Solanesol, $\mu g\text{-}hr/m^3$	Scopoletin, $ng\text{-}hr/m^3$
Home	113*	**Median**	**14.7**	**22.9**	**2.52**	**516**	**199**	**142**	**2.28**	**78.2**
		Mean	18.5	38.2	3.37	720.	355	266	7.13	232
		80th Percentile	29.1	57.8	5.45	1050	573	462	11.3	353
		95th Percentile	51.3	122	8.98	1930	1210	930	30.2	977
Workplace	136*	**Median**	**4.51**	**9.15**	**1.16**	**366**	**92.1**	**59.5**	**0.26**	**20.9**
		Mean	12.9	30.1	2.57	552	257	194	4.38	173
		80th Percentile	15.9	41.0	3.71	669	302	212	3.86	1522
		95th Percentile	53.9	133	10.1	1620	1010	790	23.8	873

* To be included in this compilation, subjects had to report observations of tobacco products being used in the particular venue, and that the venue had no smoking restrictions

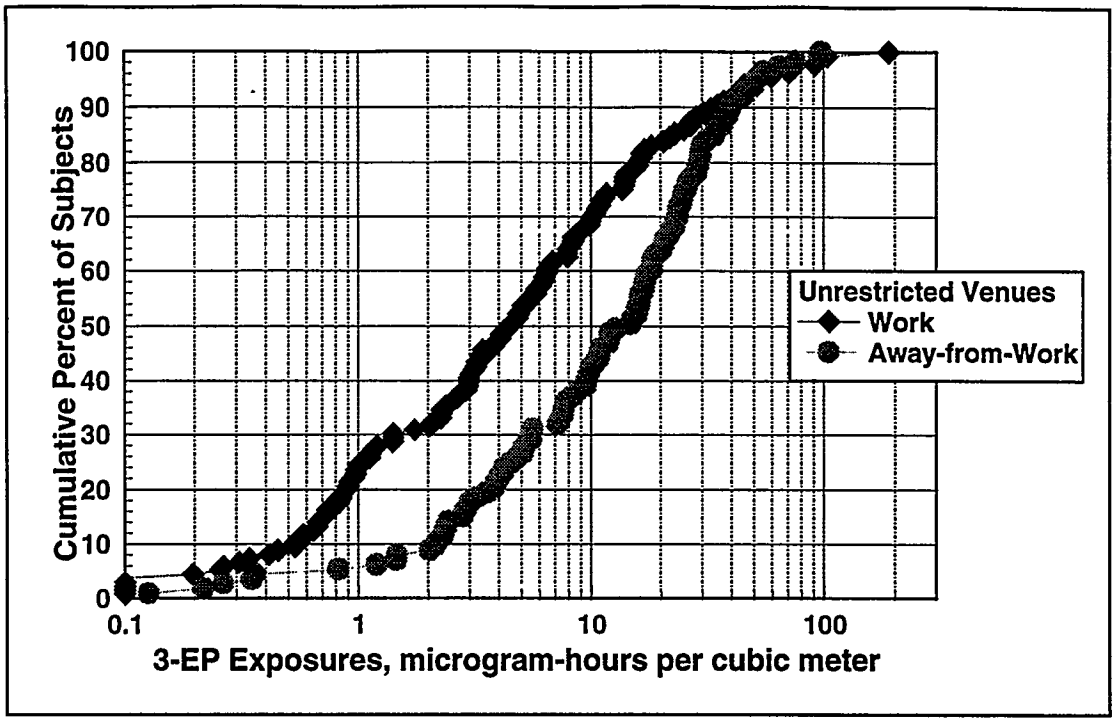

Figure 3. Cumulative distribution of study subjects in unrestricted venues where smoking was observed (with salivary cotinine <15 ng/mL or no report) as a function of 3-ethenyl pyridine exposure. Note log scale on horizontal axis.

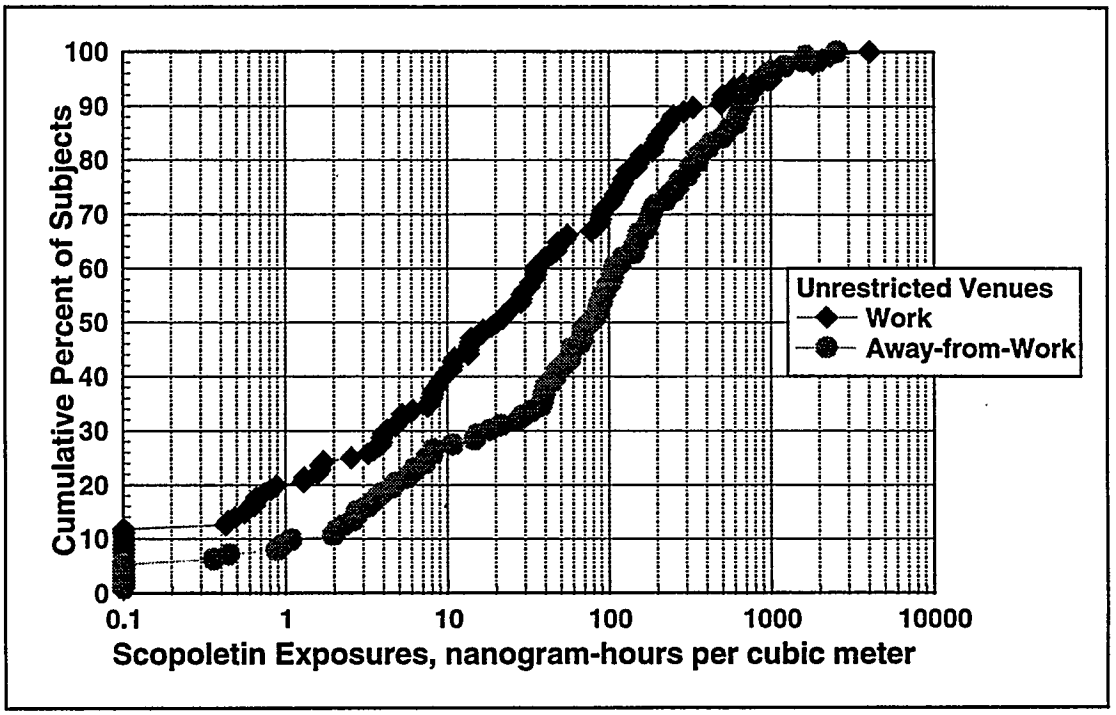

Figure 4. Cumulative distribution of study subjects in unrestricted venues where smoking was observed (with salivary cotinine <15 ng/mL or no report) as a function of scopoletin exposure level. Note log scale on horizontal axis.

living in homes where there spouses smoke anywhere within the home. For the most highly exposed 10% or so of these groups, exposures in the workplace are comparable to those incurred away from work.

In Figure 5 are presented individual comparisons between salivary cotinine and 24-hour TWA nicotine levels for those subjects whose nicotine levels and salivary cotinine levels are greater than the one-tailed 95% confidence interval above the mean limit of detection for each of the two constituents. As can be seen from Figure 5, there was virtually no correlation between these two indicators of exposure on an individual basis. For the regression of salivary cotinine on nicotine, $R^2 = 0.00595$. Presumably, the impact of individual differences in metabolism contribute to the lack of correlation. The correlation improves considerably if the subjects are clustered in groups, and the median salivary cotinine levels are compared with the median 24-hour TWA nicotine levels for the group. (Note that for the cluster analysis, subjects with salivary cotinine levels as great as 100 ng/mL were included, since the absolute values would not affect the median levels of each group.) For groups of 10, $R^2 = 0.515$. When the group size is increased to 25, the correlation between the median cotinine and nicotine levels in each group is increased as well, to $R^2 = 0.833$. In Table 4 are presented data regarding the relationship between the median average salivary cotinine level and the median 24-hour time weighted average level of nicotine to which the subjects were exposed as a function of cell designation. (Note that for this comparison, the cell assignments were based both on the response to the screening questionnaire and on diary observation confirmation of the presence/absence of smoking products in the venue in question.) For relatively large groups such as this, the correlation is very high ($R^2 = 0.992$). These data indicate that on an individual basis, salivary cotinine level cannot be used for individual exposure assessment. However, clustering subjects into groups large enough to mask individual differences in metabolism may provide an approach to using salivary cotinine as a semi-quantitative indicator of ETS exposure for the group as a whole.

Table 4

Comparison of Salivary Cotinine Levels and 24-hour Time Weighted Average Nicotine Levels Among Cells Classified by Screening Questionnaire and Diary Observations of Tobacco Products

Cell	Away-From-Work Environment	Work Environment	Number of Participants	Median Cotinine, ng/mL [1]	Median 24-hour TWA Nicotine Level, $\mu g/m^3$
1	Smoking	Smoking	100	1.94	2.00
2	Smoking	Non-Smoking	138	0.879	0.73
3	Non-Smoking	Smoking	144	0.446	0.16
4	Non-Smoking	Non-Smoking	545	0.163	0.03

[1]Cotinine results used in this calculation are the **mean** of Start and End determinations.

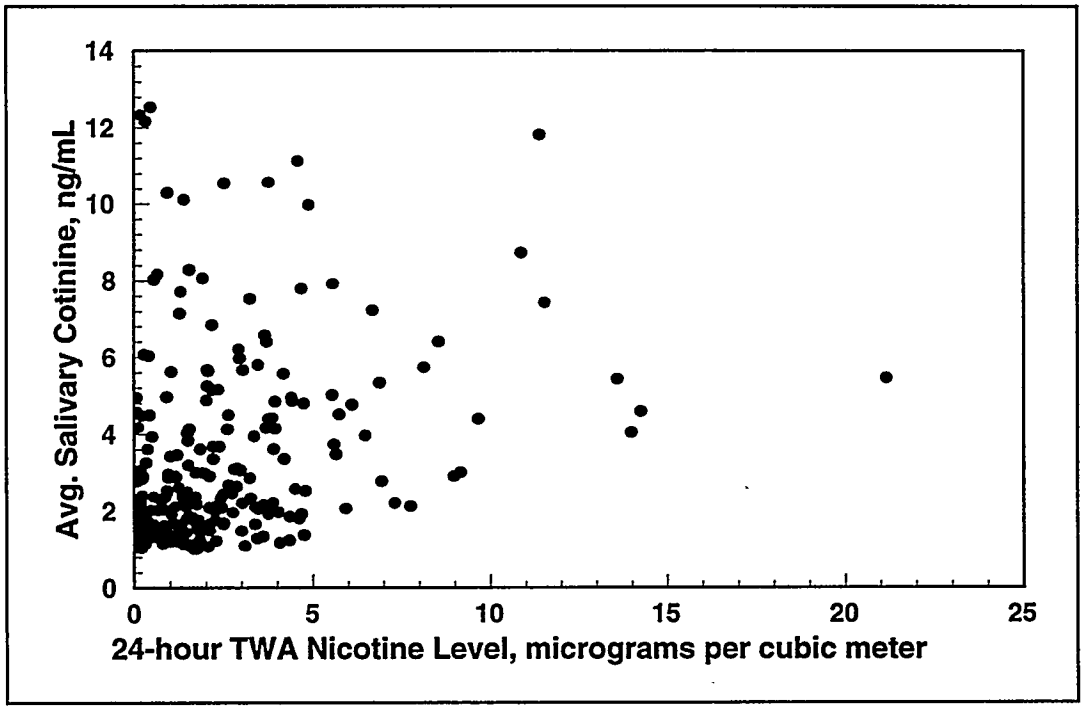

Figure 5. Comparison of individual average salivary cotinine levels with 24-hour time weighted average nicotine levels to which subjects were exposed.

CONCLUSIONS

Results of a study to determine the exposure of more than 1500 non-smoking subjects to ETS in the United states indicate that actual personal exposures to ETS are low, relative to that which might be estimated from short duration area measurements reported in previous studies. The levels of ETS components to which subjects were exposed decrease with decreasing time spent in the presence of smokers. For the majority of the study population, exposures (concentration multiplied by time) in the workplace are not comparable to those received outside the workplace. When comparing environments where smoking is not restricted, 80% of the subjects were exposed to twice as much (or more) ETS away from work than in the workplace. And while salivary cotinine levels may have some utility for classifying exposures of large groups of non-smokers, such is clearly not useful for quantitative determination of individual ETS nicotine exposures.

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Measurement of Personal Exposure to Environmental Tobacco Smoke in the United States

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A study of personal exposure of non-smokers to environmental tobacco smoke (ETS) has been conducted in 16 cities in the United States. Individual participants wear one of two personal sampling pumps, one each at work and away-from-work. Samples of breathing zone air are collected, and analyzed for both particle- and vapor-phase markers of ETS, including respirable suspended particulate matter, UV-absorbing and fluorescing particulate matter, scopoletin, solanesol, nicotine, 3-ethenyl pyridine, and myosmine. In addition, prior- and post-exposure saliva samples are collected, in order that smoking status can be assessed through cotinine levels. The distribution of subjects among smoking and non-smoking workplaces and homes is such that ca. 54% of the participants worked and lived in non-smoking situations. A comparison of the demographic distribution of the sample population with that of the US non-smoking population indicates that the sample population is more female and of higher socio-economic status.

As the exposure data are segregated according to cells, it is clear that those subjects living and working with smokers are more highly exposed to ETS than those subjects who live and work in predominantly ETS-free environments. However, it is important to note that even the smoke exposures of subjects living and working in smoking venues are low relative to area concentrations of ETS reported in previous studies. For example, 24-hour time averaged median ETS marker levels were 0.84, 1.72, 33.8, and 8.2 ug/m^3 for 3-EP, nicotine, RSP, and FPM, respectively, for those individuals confirmed to be living in smoking homes and working in smoking workplaces, and 0.45, 0.71, 24.9, and 5.53 ug/m^3, respectively, for individuals living in smoking homes, and working in non-smoking workplaces. For individuals living in non-smoking homes, and working in smoking workplaces, 24-hour time weighted average marker levels were 0.13, 0.16, 21.2, and 1.81 ug/m^3, respectively, compared with 0.022, 0.027, 14.9, and 0.52 ug/m^3, for individuals in non-smoking homes and workplaces. It is clear that in general (not considering cell designation), ETS exposure is inversely correlated with household income. Additional data analysis has indicated that although participants perceive their greatest exposures to ETS to occur in the workplace, in fact, exposure to ETS when living with a smoker is demonstrably greater than that received in a smoking workplace. On an individual basis, correlation between salivary cotinine levels and ETS nicotine exposure was non-existent. However, there appears to be significant correlation between the two parameters when participants with measureable exposures are segregated into groups of 25.

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