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A PERSONAL MONITORING STUDY TO ASSESS WORKPLACE EXPOSURE TO ENVIRONMENTAL TOBACCO SMOKE

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ABSTRACT

Because the workplace may be the major or only site of exposure to environmental tobacco smoke (ETS) for some adults, we enrolled 15 nonsmoking volunteers to determine the feasibility of measuring personal exposure to ETS at work and to begin to characterize workplace exposures. We obtained exposure questionnaires, saliva, urine, and personal air particle samples during one workshift. Salivary and urinary cotinine was quantitated by a double antibody radioimmunoassay. Respirable particle and nicotine concentrations were determined from the personal air samples. The average duration of the workshift and of the personal monitoring was 6.5 hours (SD ± 2.0), with a mean reported hours of exposure of 3.4 (SD ± 2.1). Respirable particle and nicotine concentrations varied widely with the reported number of smokers and hours of exposure. As was observed for the atmospheric markers, the post-workshift urinary and salivary cotinine levels varied widely with self-reported exposure. We conclude that personal monitoring for tobacco smoke components could be accomplished in the workplace, and that personal RSP and nicotine, and urinary and salivary cotinine varied widely with self-reported exposure to ETS at work, but on average increased with increasing exposure.

INTRODUCTION

Passive smoking refers to the involuntary exposure of nonsmokers to the combination of tobacco combustion products released by the burning cigarette and smoke components exhaled by the active smoker (DHHS 1986; NRC 1986). Health effects of passive smoking on children and adults have been established, but the principal source of exposure investigated to date has been environmental tobacco smoke in the home. Exposure in the workplace has received little investigation and health effects of environmental tobacco smoke (ETS) in the workplace remain controversial.

Because the workplace may be the major or only site of exposure to ETS for some adults, we enrolled 15 nonsmoking adults to determine the feasibility of measuring personal exposure to ETS at work and to begin to characterize workplace exposures. Markers of exposure included questionnaires, personal respirable particles (RSP), and nicotine, and urinary and salivary cotinine were measured during a workday for each subject.

METHODS

Sample Selection

Between October 1986 and May 1987, 15 nonsmoking volunteers, 18 years of age and older, were recruited from the Albuquerque area to participate in a study of exposure to ETS at work.

Data Collection

We obtained exposure questionnaires, saliva, urine, and personal air particle samples during one workshift. From the questionnaires, we determined the reported number of smokers and number of hours that the subjects were exposed during their workshift. The saliva and urine specimens were obtained before and after the workshift.

Cotinine Assay

Cotinine was quantitated by a double antibody radioimmunoassay, as described by Langone et al. (1973). A specific antiserum produced in rabbits was supplied by Dr. Helen Van Vunakis. The saliva and urine samples were diluted 1:5 and 1:4 for the assay, respectively. The sensitivity of the assays in our hands was 0.20 ng/ml of saliva, and 0.78 ng/ml of urine. Urine creatinine concentrations were determined by the Jaffe reaction (Faulkner and King 1976), and the urine cotinine concentrations were standardized to the creatinine concentrations. Assays were performed without knowledge of questionnaire responses.

Particle Measurements

During the workshift, each subject wore a personal monitoring pump with a 10 mm nylon cyclone clipped to the shirt collar (Turner et al. 1979). RSP samples (2.5 μm cutpoint) were collected on 37 mm filters and nicotine was collected on a glass fiber backup filter treated with sodium bisulfate to minimize volatilization. After extraction from the filter, analysis for nicotine was done on a gas chromatograph with a flame ionization detector. The nicotine collection and extraction procedure is a modification of that described by Hammond et al. (1987). The recovery of nicotine by this procedure has been shown to be 98% efficient.

Data Analysis

The questionnaire responses, respirable particle and nicotine concentrations, and urinary and salivary cotinine levels were assessed with univariate analyses. From the questionnaires the measures of exposure included the total number of cigarette smokers and total number of hours exposed during the workshift.

To describe the relationships among the measures of ETS exposure, Spearman correlations were calculated. Data analysis was performed with standard programs (SAS Institute 1985).

RESULTS

Of the 15 volunteers, there were eight males and seven females working in a variety of occupations. The mean age of all participants was 44.8 years (Table 1). The average du-

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TABLE 1

Description of Participants in a Personal Monitoring Study of Exposure to Environmental Tobacco Smoke at Work, New Mexico, 1986–7

Sex	Age (years)	Occupation/Workplace	Workshift Duration (hours)
Males			
1	30	Physician/Hospital	6
2	34	Social Worker/Office	8
3	33	Stock Broker/Office	8
4	41	Bus Boy/Restaurant	8
5	49	Maintenance Worker/Retail Store	8
6	52	Barber/Barber Shop	8
7	52	Barber/Barber Shop	8
8	70	Volunteer/Hospital	4
Females			
9	25	Interviewer/Public Transportation	3
10	31	Travel Agent/Office	8
11	36	Travel Agent/Office	6
12	34	Attorney/Office	8
13	63	Volunteer/Hospital	4
14	60	Volunteer/Hospital	4
15	62	Volunteer/Hospital	4

TABLE 2

Spearman Correlations Between Various Measures of Environmental Tobacco Smoke at Work, New Mexico, 1986–7

Correlated Measures	N	r
RSP ($\mu g/m^3$) with:		
Nicotine	15	0.57*
Total number of smokers	15	0.44
Total hours of exposure	15	0.53*
Postshift urine cotinine	14	0.05
Postshift saliva cotinine	11	−0.07
Nicotine ($\mu g/m^3$) with:		
Total number of smokers	15	0.62*
Total hours of exposure	15	0.54*
Postshift urine cotinine	14	0.60*
Postshift saliva cotinine	11	0.46
Postshift urine cotinine (ng/mg Cr) with:		
Total number of smokers	14	0.39
Total hours of exposure	14	0.57*
Postshift saliva cotinine (ng/ml) with:		
Total number of smokers	11	0.63*
Total hours of exposure	11	0.45

*$p < 0.05$

ration of the workshift and of the personal monitoring was 6.5 hours (SD ± 2.0).

Exposure to cigarette smokers at work was reported by 13 of the 15 participants. Of the 13 reporting exposure, two reported exposure to crowds of smokers during their workshift and the remaining 11 encountered a mean of 8.8 smokers (SD ± 6.7). The mean reported hours of exposure was 3.4 (SD ± 2.1).

Respirable particle and nicotine concentrations varied widely with the reported number of smokers and hours of exposure (Figures 1 through 4). The mean concentrations for RSP and nicotine were 63.9 $\mu g/m^3$ (SD ± 41.5) and 20.4 $\mu g/m^3$ (SD ± 20.6), respectively. Correlations between the atmospheric markers and the questionnaire measures of exposure to ETS were moderate (Table 2).

As was observed for the atmospheric markers, the postworkshift urinary and salivary cotinine levels varied widely with self-reported exposure. In comparison with pre-workshift levels, post-workshift levels were not consistently increased. The mean pre-workshift urinary and salivary cotinine concentrations were 31.8 ng/mg Cr (SD ± 67.6) and 2.9 ng/ml (SD ± 5.0), respectively. For the post-workshift levels, the corresponding values were 19.7 ng/mg Cr (SD ± 43.2) and 3.5 ng/ml (SD ± 5.9).

To examine the relationships among the questionnaire variables, the atmospheric markers, and urinary and salivary cotinine, the authors calculated Spearman correlations (Table 2). Moderate correlations were obtained for self-reports and cotinine levels, and nicotine levels and cotinine levels. However, there was no correlation between RSP levels and cotinine concentrations.

DISCUSSION/CONCLUSIONS

In a group of 15 nonsmoking volunteers, it was found that personal RSP and nicotine, and urinary and salivary cotinine varied widely with self-reported exposure to ETS at work but on average increased with increasing exposure. Personal monitoring for tobacco smoke components could be accomplished in the workplace. However, many people approached for participation refused because of concern about potential responses from the employer or coworkers.

We observed moderate correlations among the questionnaire measures, the results of personal monitoring for RSP and nicotine, and measurements of urinary cotinine. Each of these types of measures provides a differing index of exposure to ETS. The questionnaire measures that were used assess source strength, but concentrations of ETS are also influenced by room volume and ventilation. Nicotine is a specific marker of exposure to ETS, whereas RSP is nonspecific. Cotinine levels reflect nicotine exposure, but are also determined by individual differences in uptake and metabolism. Thus, tight concordance among the broad indicators of exposure used in this study would not be anticipated. The authors consider these approaches to be complementary for measurement of exposure to ETS.

As anticipated, the nicotine measurements were correlated with the cotinine values, whereas the RSP measurements were not. We conclude that personal sampling for nicotine represents a specific approach for assessing ETS exposure in the workplace. However, because of the small sample size and the limited assessment of self-reported exposure, additional research is warranted to further characterize the relationships among these various markers of exposure to ETS in the workplace.

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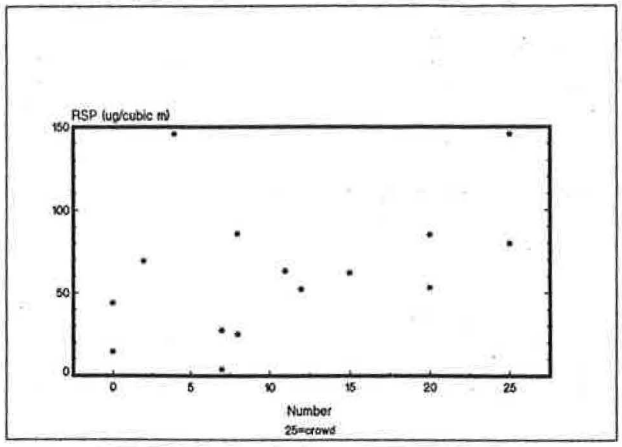

Figure 1 *Personal RSP concentrations vs. the self-reported number of cigarette smokers exposed to at work*

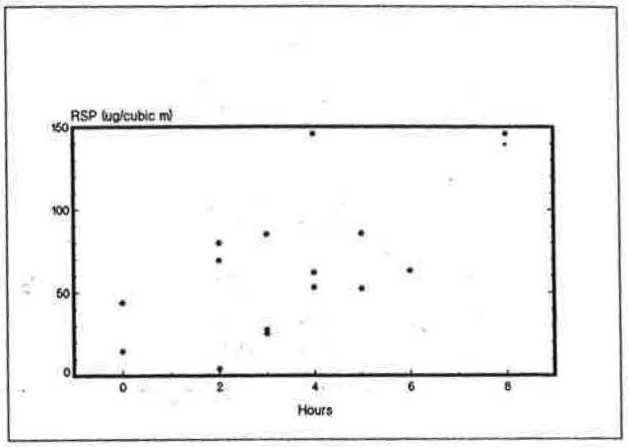

Figure 2 *Personal RSP concentrations vs. the self-reported hours of exposure to cigarette smokers at work*

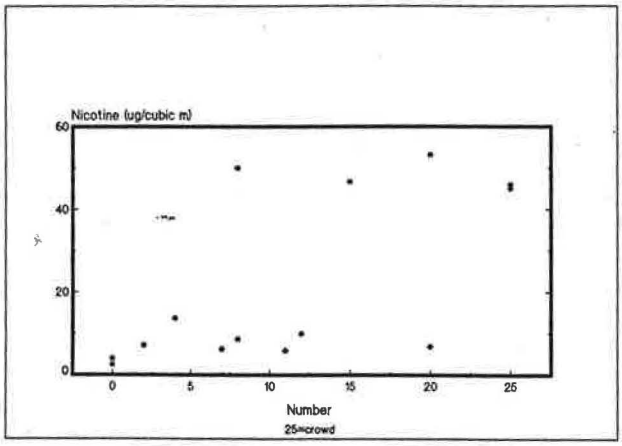

Figure 3 *Personal nicotine concentrations vs. the self-reported number of cigarette smokers exposed to at work*

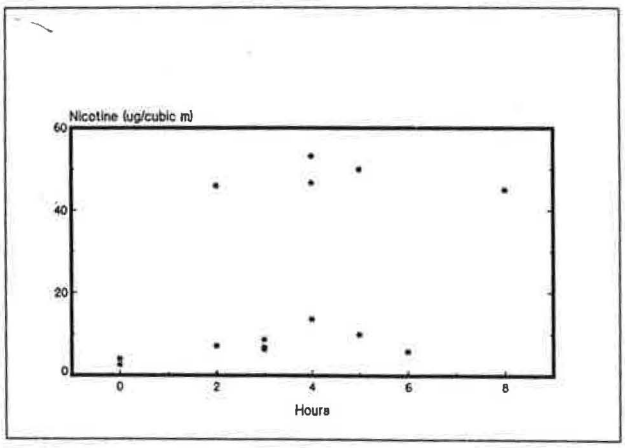

Figure 4 *Personal nicotine concentrations vs. the self-reported hours of exposure to cigarette smokers at work*