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Respiratory effects of work in retail food stores

III. Pulmonary function findings

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WEGMAN DH, EISEN EA, SMITH TJ, GREAVES IA, FINE LJ. Respiratory effects of work in retail food stores: III Pulmonary function findings. *Scand J Work Environ Health* 13 (1987) 213–217. Findings are reported from a prospective morbidity study which examined the effects on pulmonary function associated with the particulate and gaseous air contaminants to which retail food store workers are exposed. A total of 685 supermarket employees (including meat wrappers, meat cutters and store clerks) performed standard ventilatory function tests [forced expiratory volume in 1 s (FEV_{1.0}) and forced vital capacity (FVC)] during a base-line survey. Those available four years later (305) were resurveyed in a similar manner. A suggestive chronic effect on pulmonary function was shown in those with high cumulative exposures and allergic history. Among those workers who had continuous exposure to air contaminants in settings with “hot-wire” plastic wrap film cutters the annual rates of change in FEV_{1.0} and FVC were twice as great as the changes found among comparable workers who were not exposed to fumes from wrapping film. Those who switched from the “hot-wire” to the “cool-rod” cutters during the course of the follow-up had intermediate rates of change in lung function.

Key terms: meat wrapper's asthma, plastic pyrolysis products, polyvinyl chloride.

After the first report of the condition referred to as “meat wrapper's asthma” in 1973 (11), a number of case reports have noted acute symptoms in association with pulmonary function changes among retail food store workers, generally meat wrappers or meat cutters (2, 4, 7, 8, 10, 12). These cases were attributed primarily to fumes from the “hot-wire” cutting of meat wrap film or to fumes from labeling machines which malfunctioned and overheated the label.

A prospective morbidity study was planned to examine the long-term health effects associated with the particulate and gaseous air contaminants to which retail food store workers are exposed. The study was designed to examine the prevalence of respiratory symptoms and to characterize both the cross-sectional status and longitudinal change in pulmonary function associated with employment. The methods and results for respiratory symptoms have been reported separately (13, 14). The findings for pulmonary function are given in the present report.

Methods

Population

Base line. All workers who were over 25 years of age, had been employed for two or more years, and were working in “exposed areas” (the meat, produce, or delicatessen areas) were invited to participate in the study. Workers who met similar basic criteria but who worked in store areas where wrapping was not done were selected as a comparison group. This procedure resulted in 685 subjects drawn from 75 stores in eastern Massachusetts, and the base-line measurements made on this group formed the results of cycle I of the study.

Follow-up. The follow-up of cycle I was done to examine for changes in pulmonary function. The subjects who had participated in cycle I and were still employed at the end of two and four years were resurveyed (cycle II and cycle III, respectively). In cycle II, a survey of a sample of all eligibles (N = 517), 304 subjects were examined, while, in cycle III, an attempt was made to study all subjects still employed (N = 376), 346 (92 %) being tested. A total of 433 subjects were tested two or four years after the base-line measurements of cycle I.

Health effects

Pulmonary function tests. The forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV_{1.0}) were recorded on a spirometer (Collins' Survey Spirometer) according to standard procedures described

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elsewhere (1, 14). The function values were computed for all the subjects who had repeatable measurements (largest and next largest values within 5 % or 200 ml). These results were standardized with equations from the Harvard School of Public Health (HSPH) Six Cities Study of Respiratory Effects of Air Pollution (5). The equations accounted for cigarette smoking, age, sex, height, and race.

Rate of change in ventilatory function. Repeated measures of pulmonary function at two- and/or four-year intervals were used to calculate the rates of change in FEV_{1.0} and FVC. Each subject thus served as his or her own control. The rate of FEV_{1.0} change was estimated for each worker in a separate regression equation if the tests were performed both two and four years after the base line. Otherwise the rate of change was measured as the annualized difference in the measurements made in the two different surveys.

Environmental exposures

The principal exposure variable evaluated in the base-line study was an estimate of the cumulative exposure to emissions from wrapping operations detailed elsewhere (14).

Briefly, an exposure variable, cumulative exposure, was created which summed the hours of work in (direct exposure) or near (indirect exposure) wrapping operations, the type of wrap-cutting machine being accounted for. The cumulative exposure values were subclassified into high and low exposure categories. Since over 90 % of the wrapping time of the entire work force was accumulated in the meat room, the cumulative exposure

in the meat room served as the primary estimate of exposure.

Results

Cross-sectional analysis

In the cross-sectional analysis, the pulmonary function results were expressed both as the percentage of the predicted values and as "normal" versus "abnormal" (abnormal being defined, by common practice, arbitrarily as a percentage of the predicted function of less than 80 % for the FEV_{1.0} and FVC and of less than 70 % for the ratio FEV_{1.0}:FVC).

The pulmonary function was first examined with workers classified according to having worked exclusively in meat preparation areas, produce or delicatessen areas, or in areas distant from wrapping operations (predominantly checkers at the store front). This third group served as the unexposed group in subsequent analyses as well. Although the proportion of subjects with abnormal FEV_{1.0}:FVC ratios was doubled for those who only worked in the meat room (table 1), no other differences are apparent.

These same variables were then examined by level of cumulative exposure to hot-wire wrapping in the meat room. Both the low and high exposure groups showed a doubling for the ratio of FEV_{1.0}:FVC (11 and 12 %, respectively) in comparison with the corresponding ratio of the unexposed group (5 %). The proportion of each exposure group with an abnormal percentage of the predicted FEV_{1.0} was also close to doubled for the high-exposure group when compared

Table 1. Percentage of females, smokers, ex-smokers, and never smokers and the pulmonary function findings of the subjects classified according to major job categories (cycle I).

	Never exposed to wrapping fumes (clerks, etc) ^a (N = 152)			Exposed to wrapping fumes					
	Mean	SE	%	Delicatessen/produce areas ^a (N = 162)			Meat room ^a (N = 260)		
Females	.	.	56	.	.	27	.	.	40
Smokers	.	.	48	.	.	58	.	.	51
Ex-smokers	.	.	21	.	.	20	.	.	20
Never smokers	.	.	31	.	.	22	.	.	26
Pulmonary function ^b									
Percentage of predicted FEV _{1.0}	105	1.5	.	105	1.2	.	103	1.0	.
	(N = 140)			(N = 149)			(N = 244)		
Percentage of predicted FVC	103	1.3	.	103	1.2	.	102	0.9	.
	(N = 141)			(N = 153)			(N = 239)		
Percentage of predicted FEV _{1.0} :FVC ratio	95	0.8	.	96	0.7	.	96	0.6	.
	(N = 137)			(N = 148)			(N = 236)		
Abnormal FEV _{1.0}	.	.	6	.	.	3	.	.	8
	(N = 140)			(N = 149)			(N = 244)		
Abnormal FVC	.	.	5	.	.	4	.	.	6
	(N = 141)			(N = 153)			(N = 239)		
Abnormal FEV _{1.0} :FVC ratio	.	.	5	.	.	4	.	.	10
	(N = 137)			(N = 148)			(N = 236)		

^a Mean age (SE): group never exposed to wrapping fumes 44.5 (1.0) years; group exposed to wrapping fumes in delicatessen and produce areas 41.6 (0.9) years; group exposed to wrapping fumes in the meat room 45.7 (0.6) years.

^b FEV_{1.0} = forced expiratory volume in 1 s, FVC = forced vital capacity, N = number for whom the test was made.

Table 2. Percentage of women, smokers, ex-smokers, and never smokers and the pulmonary function findings of the subjects by cumulative exposure in meat rooms, stratified by history of allergy or asthma (absent or present).

	Meat room											
	Never exposed						Cumulative exposure low					
	Absent ^a			Present ^a			Absent ^a			Present ^a		
	Mean	SE	%	Mean	SE	%	Mean	SE	%	Mean	SE	%
Females	.	.	54	.	.	68	.	.	34	.	.	40
Smokers	.	.	32	.	.	21	.	.	49	.	.	45
Ex-smokers	.	.	18	.	.	37	.	.	26	.	.	15
Never smokers	.	.	50	.	.	42	.	.	25	.	.	40
Pulmonary function ^b												
Percentage of the predicted FEV _{1.0}	105	1.6	.	106	3.4	.	102	1.5	.	103	3.0	.
<80 % of the predicted	(N = 122)		7	(N = 18)		6	(N = 110)		4	(N = 20)		10
Percentage of the predicted FVC	103	1.4	.	107	2.8	.	103	1.4	.	101	2.3	.
<80 % of the predicted FVC	(N = 122)		6	(N = 19)		0	(N = 111)		4	(N = 20)		0
Percentage of the predicted FEV _{1.0} :FVC ratio	97	0.7	.	96	1.5	.	95	0.8	.	97	1.7	.
<70 % of the predicted	(N = 119)		4	(N = 18)		11	(N = 109)		11	(N = 20)		10
FEV _{1.0} :FVC ratio	(N = 119)			(N = 18)			(N = 109)			(N = 20)		

^a Mean age (years): never exposed, absent 44.4 and present 40.2; meat room, cumulative exposure low, absent 40.6 and present 39.5; and meat room, cumulative exposure high, absent 50.5 and present 48.9.

^b FEV_{1.0} = forced expiratory volume in 1 s, FVC = forced vital capacity, N = number for whom the test was made.

with that of both the low-exposure group and the unexposed group.

In an analysis of respiratory symptoms reported elsewhere (13), evidence was shown of an association between work in the vicinity of wrapping operations and symptoms of episodic airway narrowing, particularly in those with a history of allergy or asthma. As a result, the relationship between pulmonary function and exposures was compared between those with and those without a history of allergy or asthma. Subjects were identified as having a positive history if they reported being told by a physician either that they were allergic to inhaled allergens or that they had asthma. For those without a history of allergy or asthma, table 2 indicates a difference for both exposed groups only in the proportion with an abnormal FEV_{1.0}:FVC ratio.

When those with an allergic or asthmatic history were examined separately, however, a clear trend was present for the percentage of predicted FEV_{1.0} and FVC. Those with high cumulative exposure and allergy had the lowest values. In addition, the high exposure group had the highest proportion of abnormal FEV_{1.0} and FVC values. The FEV_{1.0}:FVC ratios were similar across the groups, except for a slight decrease in the proportion of abnormals in the high exposure group.

In a logistic regression model for abnormal FEV_{1.0} (table 3), a history of allergy or asthma had a significantly increased odds ratio of 2.22 ($P < 0.05$), while total cumulative exposure was of borderline significance ($P = 0.09$). When only cumulative exposure in the meat room was considered, the number of subjects was reduced, but similar odds ratios were found, none being significant. No evidence of interaction between

Table 3. Odds ratios from two logistic regression models with <80 % of predicted forced expiratory volume in 1 s as the outcome.

Independent variables	Model 1	Model 2
Allergic history (yes, no)	2.22**	1.95
Cumulative exposure in meat room (high, never)	.	1.70
Total cumulative exposure (high, never)	1.74*	.

* $P < 0.10$, ** $P < 0.05$.

allergic or asthmatic history and exposure was found in either model.

Multiple linear regression was used also to evaluate the association between the percentage of predicted FEV_{1.0}, a history of allergy or asthma, cumulative exposure, and the interactions between allergy/asthma and cumulative exposure. In these models neither the main effects of exposure nor those of allergy/asthma were significant, but the interaction of the two variables was.

Follow-up analysis

The evaluation of changes in pulmonary function during the follow-up period required further consideration of the exposure classification. A prospective "current" exposure classification was created according to the type of cutting instrument to which each subject was exposed either directly or indirectly. The following four exposure categories were created for the follow-up interval: hot wire for cycle I through cycle II or III (depending on last cycle tested), hot wire at the start but cool rod at the end, cool rod throughout, and no exposure throughout.

Table 4. Slope of ventilatory function (milliliter/year) by cumulative exposures in the meat room up to cycle 1. (FEV_{1.0} = forced expiratory volume in 1 s, FVC = forced vital capacity).

Total cumulative exposure	FEV _{1.0} slope			FVC slope		
	Number	Mean	SE	Number	Mean	SE
High	84	-42	7.6	82	-41	9.4
Low	91	-49	8.0	90	-30	9.5
None	79	-42	11.4	77	-42	10.7

Table 5. Slope of forced expiratory volume in 1 s (FEV_{1.0}) (milliliters/year) by current exposure group classified over the four years of the study.

Current exposure category	Number of subjects	Percentage of predicted FEV _{1.0} in cycle 1		Asthma/allergy history (%)
		Mean	SE	
Hot-wire cutting exposure (direct or indirect) throughout	34	-68	14.1	9
Hot-wire exposure changed to cool-rod or mechanical exposure (direct or indirect)	28	-54	14.2	18
Cool-rod or mechanical cutting exposure (direct or indirect) throughout	200	-35	5.4	19
Never exposed throughout	71	-44	12.6	11

Table 6. Multiple regression analysis for the slope of the forced expiratory volume in 1 s (FEV_{1.0}) for the nonsmokers.^a

Variable		T	Prob > T
Intercept	-464.8	-1.91	0.06
Interval exposure group ^b	-47.9	-1.98	0.05
Gender ^c	52.4	2.01	0.05
Allergic history ^d	-8.8	-0.43	0.67
Total cumulative exposure ^e	-4.1	0.21	0.83
Height (cm)	-2.8	-2.00	0.05

^a Outcome: FEV_{1.0} slope (ml/year); R-square = 0.13; N = 80.

^b Interval exposure group: 0 = cool or never, 1 = hot during follow-up study.

^c Gender: 0 = male, 1 = female.

^d Allergic history: 0 = no, 1 = yes.

^e Total cumulative exposure: 0 = none, 1 = high.

Table 4 shows the association of cumulative exposure with the rate of decrement in lung function. No differences in the rate of change in FEV_{1.0} or FVC were seen. The rates of change were of the same order of magnitude as those determined in other follow-up investigations (3). When exposure was grouped according to "current" exposure, a trend was apparent (table 5). The employees who had worked continuously in the vicinity of hot-wire wrapping operations had a significantly greater rate of loss of FEV_{1.0} and FVC than the employees who had never been exposed to wrapping operations or than those who had worked, during the follow-up interval, only with cool rods or mechanical cutters.

There are a variety of covariates which might have affected this trend, including height, sex, cigarette smoking, cumulative exposure, and allergic or asthmatic history. To account simultaneously for these variables, we again used multiple regression analysis. The results for nonsmokers are shown in table 6. The significant effect of current hot-wire exposure on the slope of the FEV_{1.0} can be seen in the presence of all the covariates. When all the subjects, including smokers, were examined, the results were essentially the same, except for the addition of a pack-years smoking effect (data not shown).

Discussion

The present findings from a cross-sectional evaluation of retail food store workers suggest a possible chronic effect on pulmonary function attributable to the work environment. This effect is shown in the measure of obstruction represented by an increased proportion of subjects with an abnormal ratio of FEV_{1.0}:FVC (<70 %) among the workers with the highest cumulative exposure.

When the population was subdivided into those with and those without an allergic or asthmatic history, the evidence for a work-related effect was stronger. In a stratified analysis those with a history of allergic disorders or asthma had greater work-related effects on pulmonary function than did workers without such a history. Work-related impairments in lung function were probably not substantial enough to be present as disability in this population, but they were consistent with our findings of symptoms reflecting episodic airway narrowing in relation to cumulative exposure (13). When examined further by multivariate modeling, the abnormalities in lung function showed an interaction between an allergic or asthmatic history, and cumulative exposure to wrapping operations was responsible for the associations noted.

In the follow-up study, annual changes in lung function were not associated with cumulative exposure. Significant relationships between lung function decline and workplace exposures were noted, however, when the subjects were categorized according to type of equipment used to cut wrapping film during the follow-up interval. Because the type of equipment (hot wire or cool rod) determined the intensity of the exposures to the fumes from wrapping film, the relationship between lung function decline and the type of equipment indicates that excessive lung function declines were related to high interim exposures.

Among those workers who had continuous exposure to air contaminants in settings with hot-wire cutters, the annual rates of change in FEV_{1.0} and FVC were 1.5 times greater than the changes found among comparable workers who were not exposed to wrapping fumes. It is interesting to note that those who switched from the hot-wire to the cool-rod cutters during the course of the follow-up had intermediate rates of change

in lung function. Finally, the importance of current versus cumulative exposures with respect to the rate of lung function decline is shown by the multiple linear regressions of the rate of change in FEV_{1.0} on cumulative and current exposures in that there was a significant effect only for the current type of exposure (table 6).

Three previous epidemiologic studies have considered pulmonary function among employees in supermarkets (4, 6, 9). Each of these studies considered relatively small numbers of employees, and two of the studies (4, 9) included many of the same subjects. No abnormalities in lung function were found in relation to meat wrapping. However, the groups of "unexposed" subjects used for comparison purposes (office personnel or store clerks) differed from the meat wrappers in the proportions of nonsmokers and women in all three studies, and subjects who may have been exposed "indirectly" to wrapping fumes (eg, meat cutters) were included among the unexposed comparison groups in one study (6). Furthermore, many stores had replaced hot-wire cutting with mechanical cutters several years before this latter study (6). No previous study had attempted to quantify exposures to emissions from wrapping film. With these limitations and the relatively small numbers of meat wrappers studied previously in mind, it is perhaps not surprising that lung function changes associated with fumes from wrapping film were not observed.

The findings from the present study appear to be the first to relate estimates of exposure to fumes from wrapping film with lung function. Our findings indicate that significant decreases in FEV_{1.0} and FVC were related to high cumulative exposures and to a history of allergy or asthma. The rate of decline in FEV_{1.0} was associated with continuing exposures to emissions from hot-wire cutting. Synergism between a history of allergy or asthma and ongoing exposure to fumes from wrapping film was present for the rate of decline in FEV_{1.0}.

On the basis of these findings, we suggest that exposure to relatively high levels of wrapping fumes (such

as occur with hot-wire cutting) is related to airway effects that are the most marked in workers who have a history of allergy or asthma.

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