Respiratory Illness in the Construction Industry*

Airflow Obstruction Among Painters

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To assess the potential respiratory effects of exposure to paint products, the pulmonary function of 118 construction painters was compared to construction workers unexposed to paints (314 sheet metal workers). When compared to sheet metal workers, painters reported significant excess symptoms of cough ($p<0.05$), wheezing ($p<0.001$), and dyspnea ($p<0.0001$). Nonsmoking painters working at least 15 years in the trade had significant decrements in percent predicted forced expiratory volume in one second ($\%FEV_1$) ($p<0.025$) and in the percent predicted ratio of the forced expiratory volume in one second to the forced vital capacity ($\%FVC_1$/FVC) ($p<0.025$). Current smoking painters working less than 15 years in the trade demonstrated significant decrements in $\%FEV_1$ ($p<0.05$) and $\%FEV_1$/FVC ($p<0.05$). Restricting the analysis to painters, and controlling for smoking, we observed a significant relationship between years of exposure to paint products and airflow obstruction. Painters may be at risk for developing airflow obstruction and these changes appear to be related to the duration of exposure to paint products. Painters who smoke may be at risk of developing this obstructive process earlier than nonsmokers.

Pulmonary hazards among construction workers vary from the well-recognized effects of asbestos and silica to more recently-described illnesses from isocyanates[1] and epoxy compounds.[2] Although indirectly exposed to asbestos, painters have much lower exposure to this agent than other construction workers, such as insulation workers[3] and pipefitters.[4] In contrast, painters, particularly spray painters, have potentially high exposure to a variety of chemical substances with poorly characterized pulmonary toxicity. Painters are exposed to solvent fumes and aerosols containing various concentrations of pigments (chromates), binders (alkyl, epoxy and urethane resins), fillers (talc) and chemically reactive monomers (isocyanates). Specific components in paint, such as isocyanates and dimethyl ethanolamine, are capable of inducing acute[5,6] and chronic[1] forms of airflow obstruction. Although lacquer painters have demonstrated excess respiratory symptoms[7] and an uncontrolled study of 1,000 painters found significant airflow obstruction in 26 percent of the nonsmokers,[8] an excess of respiratory deaths was not observed among paint fabricators.[9]

Our study sought to explore the proposed hypothesis that painters may be at increased risk of developing respiratory impairment. We studied the respiratory status of painters by comparing their pulmonary function to a previously-tested population of sheet metal workers.

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Methods

Subjects

In April 1984, the Boston district council of the International Brotherhood of Painters and Allied Trades offered a union-sponsored medical evaluation to all of its active and retired members who were covered under the Union Health and Welfare Plan ($n=409$); 118 painters participated. Assessment of selection bias was accomplished by mail questionnaire to nonparticipants and showed reasonable comparability between participants and nonparticipants.[10] For comparison purposes, data from a published study of 314 construction sheet metal workers tested in 1981[11] were reanalyzed. Sheet metal workers have been exposed to variable concentrations of asbestos during installation[12] and removal[13] procedures and also from contamination of the general work environment.[14] As members of the construction trades, both painters and sheet metal workers have somewhat similar job duties and demographic characteristics.

Health Evaluation and Assessment

All participants completed an occupational history and an American Thoracic Society (ATS) questionnaire.[15] Pulmonary function tests were performed in the seated position without employing nose clips. Results were recorded on a Collins' Stead-Wells survey spirometer. Five trials were required for inclusion and ATS guidelines were used to determine acceptability.[16] Percent-predicted forced expiratory volume in one second ($\%FEV_1$) was calculated by applying equations of Knudson et al[17] to the average of the two largest acceptable measurements of the forced expiratory volume in one second. The percent predicted ratio of the forced expiratory volume in one second to the forced vital capacity ($\%FEV_1$/FVC) was calculated by dividing the observed FEV_1/FVC ratio by the predicted FEV_1/FVC ratio and then multiplying by 100.

Chest roentgenograms were performed in the posterioanterior projection and interpreted by two certified "B" readers who used the International Labor Organization (ILO) 1971 Classification of Radiographs of Pneumoconioses[18] and were blinded to the exposure

Table 1—*Population Characteristics by Percentage for Painters and Sheet Metal Workers*

Characteristic	Painters	Sheet Metal Workers
No. of subjects	(118)	(314)
Age, yr*	42.3 ± 11.8	46.9 ± 11.5
Union participation	28.9	22.2
Years in trade		
1-14	42.1	21.4
15+	57.9	78.6
Smoking Status		
Nonsmoker	25.4	17.5
Ex-smoker	29.8	40.4
Current smoker	44.7	41.1
Spirometry acceptibility	99.1	99.4
Chest roentgenogram performed	90.7	95.2
Work-related exposures		
Asbestos	26.3	100.0
Berryllium	0.0	1.0
Cotton dust	0.9	0.3
Farming	4.4	4.0
Sand blasting	27.2	2.0
Sheet metal dust	0.9	100.0
Spray paint	72.8	8.0
Welding fumes	2.6	64.9
Wood dust	5.3	14.7

*Mean ± standard deviation.

history of the screened individuals as well as the objectives of the study.

A worker was considered to have evidence of a parenchymal abnormality if the degree of profusion was observed to be at least 1/0, which represents a clearly abnormal degree of fibrosis in the ILO classification system.[18] Pleural disease was defined as the presence of at least one of the three following characteristics: (1) bilateral pleural thickening of the chest walls and/or diaphragm of extent 1, 2, or 3; (2) bilateral pleural calcification of the chest walls and/or diaphragm of extent 1 or 2; or (3) bilateral pleural plaques (uncalcified).

Characterization of Smoking History

Participants were classified as "nonsmokers" (less than 20 packs of lifetime cigarettes and no cigarettes in the month prior to medical screening), "current smokers" (smoked within one month of the medical screening) and "ex-smokers" (more than 20 lifetime packs of cigarettes but stopped more than one month prior to medical screening).

Statistical Analysis

A chi-square test with Yates' correction factor[19] was employed to test differences in the prevalence of categoric variables, such as respiratory symptoms and roentgenographic abnormalities between painters and sheet metal workers. Student's two-tailed *t*-test[19] was used to compare mean $\%FEV_1$ and $\%FEV_1/FVC$ between the two groups of workers. All spirometric comparisons were stratified by years of work in the trade and smoking history. Relative risks were calculated in the standard fashion for a cohort study, and Taylor's method was used to calculate 95 percent confidence intervals.[20]

Results

Population Characteristics

Painters and sheet metal workers were found to represent comparable working populations with similar levels of union participation (Table 1). Although both groups were of similar age, sheet metal workers tended to be working in their trade longer than painters. Painters were more often nonsmokers. Prevalent work-related exposures for painters included spray paint, silica, and asbestos. Sheet metal workers were most often exposed to asbestos, sheet metal dust, and welding fumes. Pulmonary function test acceptability and chest roentgenogram acquisition were similar in both working populations.

Table 2—*Respiratory Characteristics by Percentage for Painters and Sheet Metal Workers*

Characteristic	Painter (N = 118)	Sheet Metal Worker (N = 299)
Prior diagnosis		
Bronchitis	7.9	11.4
Asthma	1.8	5.0
Emphysema	1.8	4.3
Symptoms		
Cough*	34.2	23.7
Sputum production	18.4	21.7
Wheezing†	34.2	9.0
Dyspnea†	40.4	7.4

*$p<0.05$.
†$p<0.0001$.

Medical Characteristics

Prior respiratory system diagnoses (bronchitis, asthma, and emphysema) were reported more frequently among sheet metal workers; however, painters noted excess symptoms of cough ($p<0.05$), wheezing ($p<0.0001$), and dyspnea ($p<0.0001$) (Table 2).

Pulmonary Function Tests

When compared to sheet metal workers, nonsmoking painters working at least 15 years in the trade, demonstrated significant decrements in $\%FEV_1$ ($p<0.025$) (Table 3) and $\%FEV_1/FVC$ ($p<0.025$) (Table 4). Painters with fewer than 15 years in the trade who were current smokers demonstrated significant decrements in $\%FEV_1$ ($p<0.05$) (Table 3) and $\%FEV_1/FVC$

Table 3—*Comparison of $\%FEV_1$* Between Painters and Sheet Metal Workers*

Employment Duration	Smoking Status	$\%FEV_1$ (Mean ± SD) (N) Painters	(N) Sheet Metal Workers
1-14	Nonsmoker	(13) 92.8 ± 7.2	(15) 98.3 ± 15.0
	Ex-smoker	(12) 97.1 ± 15.0	(16) 101.1 ± 12.0
	Current smoker†	(25) 87.4 ± 12.6	(35) 94.9 ± 18.4
≥15	Nonsmoker‡	(17) 91.1 ± 24.7	(40) 104.6 ± 21.0
	Ex-smoker	(23) 96.3 ± 15.6	(111) 94.0 ± 20.0
	Current smoker	(27) 84.9 ± 16.9	(94) 88.1 ± 18.1

*Percent predicted forced expiratory volume in one second (after Knudson et al[17]).
†$p<0.05$.
‡$p<0.025$.

Table 4—*Comparison of %FEV_1/FVC* Between Painters and Sheet Metal Workers*

Employment Duration	Smoking Status	%FEV_1/FVC (Mean ± SD) (N) Painters	(N) Sheet Metal Workers
1-14	Nonsmoker	(13) 77.8 ± 3.5	(15) 77.7 ± 11.0
	Ex-smoker‡	(12) 77.8 ± 4.5	(16) 82.4 ± 3.4
	Current smoker†	(25) 74.1 ± 6.7	(35) 77.2 ± 5.6
≥15	Nonsmoker‡	(17) 75.6 ± 7.8	(40) 80.0 ± 6.3
	Ex-smoker	(23) 75.3 ± 7.5	(111) 76.4 ± 9.4
	Current smoker	(27) 70.5 ± 10.5	(69) 72.0 ± 10.6

*Ratio of the observed FEV_1/FVC divided by the predicted FEV_1/FVC and then multiplied by 100.
†$p<0.05$.
‡$p<0.025$.

Table 5—*Relative Risk for Airflow Obstruction* Among Painters*

Employment Duration	Smoking Status	%FEV_1/FVC <70%	%FEV_1/FVC ≥70%	Relative Risk (95% CI)
1-14	Not current	1	24	1.0
	Current smoker	5	20	5.0 (0.6, 39.8)
≥15	Not current	7	33	4.4 (0.6, 33.7)
	Current smoker	9	18	8.3 (1.1, 60.9)

*Defined as %FEV_1/FVC <70%.
†Relative risk was calculated by comparing each subgroup to not current smokers with less than 15 years of paint experience. The 95% percent confidence interval (95% CI) was calculated using Taylor's method.[20]

($p<0.05$) (Table 4) when compared to similarly stratified sheet metal workers.

To examine the relationship between the duration of exposure to paint products and changes in pulmonary function, we restricted our analysis to painters. For the purposes of this analysis, ex-smokers and nonsmokers were grouped in one smoking category (not current smokers). Using a %FEV_1/FVC of less than 70 percent as an indication of airflow obstruction and comparing each category to not current smokers with less than 15 years in the trade, we observed a significant relationship between years of exposure to paint products and airflow obstruction (Table 5). Current smokers with less than 15 years in the trade and not current smokers with more than 15 years in the trade had similar relative risks (RR = 5.0, 95 percent confidence interval 0.6, 39.8 and RR = 4.4, 95 percent confidence interval 0.6, 33.7, respectively), while current smokers with more than 15 years in the trade had a higher risk of airflow obstruction (RR = 8.3, 95 percent confidence interval 1.1, 60.9). These results suggest that among painters, an additive relationship may exist between years of exposure to paint products and cigarette smoke in their effect on the airflow rate.

Chest Roentgenograms

Although the prevalence of parenchymal disease was similar between both working populations (3.7 percent in painters and 3.3 percent in sheet metal workers), pleural abnormalities were observed much more commonly among sheet metal workers (17.8 percent in painters and 50.8 percent in sheet metal workers; $p<0.0001$).

Discussion

Results from our study indicate that painters may be at increased risk of developing airflow obstruction and that these changes appear to be related to the duration of exposure to paint products and are independent of the effects of cigarette smoking. These findings are consistent with a previous uncontrolled study which reported airflow obstruction among 26 percent of the nonsmoking painters.[3]

Although sheet metal workers were exposed to higher levels of asbestos, we found that painters had far more respiratory complaints (cough, wheezing, and dyspnea). Compared to sheet metal workers, painters who were nonsmokers manifested decrements in %FEV_1 and %FEV_1/FVC after 15 years of work exposure while patients who were smokers demonstrated decrements in %FEV_1 and %FEV_1/FVC within the first 15 years of work experience. Among painters, a significant relationship was observed between years of exposure to paint products and airflow obstruction.

Agents other than paint could be responsible for these observations. Most union painting occurs in and around active construction. Twenty-seven percent of our painters were exposed to silica. Other respiratory toxins such as asbestos dust and welding fumes alone or in combination with paint may be responsible for our findings.

Several aspects of the design of this study limit the interpretation of our results. A self-selected population of workers chose to participate in each of the health screenings. Despite similar medical evaluation techniques for both worker groups, painters may have different health concerns than sheet metal workers leading to noncomparable results. This effect could explain our findings only if painters were more concerned with their respiratory status than sheet metal workers. Given the exposure of sheet metal workers to asbestos, this form of selection bias is unlikely to have been important. Although self-selection may account for differences between screened painters and all painters, it probably does not account for the differences observed between screened painters and screened sheet metal workers.

Our results should be viewed as preliminary findings within a self-selected group of workers. It is clear, however, from the results of our investigation that additional studies are needed to better characterize

the extent and etiology of respiratory impairment among painters.

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