

A Respiratory Survey of Cedar Mill Workers

I. Prevalence of Symptoms and Pulmonary Function Abnormalities

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A respiratory-occupational questionnaire and spirometry were used to compare the prevalence of symptoms and pulmonary function abnormalities in 405 workers exposed to red cedar dust and 252 control workers exposed to other wood dusts. Compared with controls, the cedar workers were found to have a significantly higher prevalence of respiratory symptoms, cough, phlegm, wheeze and breathlessness, as well as more rhinitis and conjunctivitis. While, as expected, there was a clear relationship between respiratory symptoms and cigarette smoking, there was also evidence to suggest a synergistic effect between exposure to cedar dust and smoking. There was no difference in the lung function between cedar workers and controls. Sixty-five workers in the control group previously had worked in red cedar mills; they had a higher prevalence of respiratory symptoms than other workers in this group. Red cedar asthma was found in only 1.1% of the cedar workers. This condition usually develops in the early months of exposure, and workers who are affected tend to leave the industry. The probable incidence of red cedar asthma was estimated to be higher, around 4-5%.

Occupational asthma due to exposure to western red cedar (*Thuja plicata*) has been recognized for almost 30 years. It was first described in 1949 by Doig¹ in Britain. A more detailed description of this disease was provided by Milne and Gandevia^{2,3} in Australia. It is a fairly common disease in British Columbia, where a large number of workers are employed in the red cedar lumber industry. To date we have documented over 100 cases, described their clinical picture and diagnostic bronchial challenge tests, and determined the compound responsible for asthma — plicatic acid.^{4,5}

While much is known about the clinical aspects of red cedar asthma, the prevalence of this condition and of other respiratory problems in North American woodworkers exposed to red cedar

is unknown. Ishizaki et al⁶ in Japan surveyed 1,320 furniture workers and found asthma in 3.4%, rhinitis in 9.5%, and conjunctivitis in 9.5%. We have surveyed woodworkers exposed to red cedar in British Columbia to determine the prevalence of respiratory symptoms and lung function abnormalities.

Materials and Methods

Subjects. — Male workers in four red cedar saw and shingle mills, totaling 736, were invited to participate; 441 (59.9%) agreed (Table 1). For controls, 394 male workers in two non-cedar saw-mills (hemlock, Douglas fir, and spruce) were approached; 302 (78.6%) actually participated. The low participation rate among cedar workers was mainly accounted for by the first mill surveyed. In this mill, only 38% of the workers participated; however, while the attendance of the afternoon shift was poor, the attendance of the day shift was 83%. As expected, there was no difference in the personal and employment characteristics of the workers on each shift, since they rotate between the shifts. We have also compared the personal and employment characteristics of the workers in the individual mills and found no differences.

The 302 control workers were divided into two groups. Group 1, comprising 220 (72.8%) workers, had no history of previous exposure to red cedar, while Group 2, comprising 82 (27.2%) workers, had previously worked in red cedar mills and had an average exposure of 8.4 years.

Methods. — *Medical and Occupational Questionnaire.* — Trained interviewers administered questions derived from the British Medical Research Council questionnaire on chronic bronchitis. These questions were supplemented by others relating to the occurrence of certain symptoms such as rhinitis and conjunctivitis, the occurrence of symptoms in relation to working hours, and their improvement on weekends and holidays. In addition, inquiries were made about general health and past personal and family histories of atopy (e.g., asthma, hayfever, or infantile eczema). Questions on occupation were related to the duration of employment in the particular mill, the location and description of the current job, and the description of previous jobs either in the same mill or in other mills or industries.

Spirometric Measurements. — Spirometric measurements were carried out at the work site for cedar and control workers, using a

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Table 1. — Participation Rate.

	Cedar Mills					Control Mills			All Mills
	1	2	3	4	Total	1	2	Total	Total
Total male workers	421	83	114	118	736	189	205	394	1,130
Participants: No.	160	82	91	108	441	130	172	302	743
%	38.0	98.8	79.8	91.5	59.9	68.8	83.9	76.6	65.8

13.5-liter Collin's spirometer. A minimum of three spirometers was obtained on each subject on three separate occasions, viz., Monday morning before the first workshift of the week, Monday afternoon after the first shift of the week, and Friday afternoon after a week's work. The best spirometer was used to obtain the forced expiratory volume in one second (FEV₁), forced vital capacity (FVC), and maximum expiratory flow rate (MMF). Predicted normal values for each measurement respectively were obtained from the reports of Cotes et al,⁷ Goldman and Becklake,⁸ and Leuallen and Fowler.⁹

Statistical Methods. — Much of the data collected in this survey could be summarized in contingency tables for which the chi square was the appropriate statistical test. In some instances, in which one of the classifications involved a natural ordering, for example age, nonparametric measures such as Kendall's tau were used.¹⁰

The risk ratio was used to measure the size of the difference between two proportions. The useful properties of this measure of relative risk are well documented.^{11, 12} Because of the heterogeneity of the data, in particular the difference in mean age between the control and cedar workers, the risk ratio was adjusted.¹³ The method of adjustment used was that introduced by Mantel and Haenszel.¹⁴

For continuous variables such as age and pulmonary function tests, the conventional analysis of variance and linear regression techniques were employed.¹⁵

Results

Characteristics of the Workers. — Between the study groups there were significant differences in age and height. The differences in smoking habits were not statistically significant, although a higher percentage of Group 2 control workers were current smokers compared with Group 1 control and cedar workers. Differences in these characteristics have been taken into account in subsequent analyses. However, in doing so, the numbers in some subgroups became too small to support meaningful analyses. In such instances, only the results pertaining to larger subgroups are reported. The duration of exposure to wood dust was also significantly different in the three groups, the cedar workers being ex-

posed on the average 3.1 and 5.5 years less than Groups 1 and 2, respectively.

It was interesting to note that there were no statistically significant differences between the groups in their self-assessment of health (answer to the question "Are you aware of anything wrong with your health? If yes, specify . . ."). Three-quarters of the workers considered themselves to be healthy. With regard to chest disease, the cedar workers gave an affirmative answer only slightly more frequently than the control groups. With regard to other illnesses, the cedar workers did not consider themselves to be sicker than the controls. Thus, the cedar workers did not appear to be particularly predisposed to respond positively to specific questions about symptoms.

Prevalence of Symptoms. — Cedar workers had a higher prevalence of all symptoms compared with Group 1 controls (Fig 1). Compared with Group 2 controls, cedar workers had more conjunctivitis, cough, phlegm and wheeze. It is of interest to note that Group 2 controls had slightly more rhinitis and breathlessness than the cedar workers; they also had substantially more rhinitis, cough, phlegm and breathlessness than Group 1 controls.

The prevalence of chest symptoms was higher in cedar workers than in controls in each of four age groups, the age gradient being more marked in cedar workers than in controls (Fig 2). As previously noted, the cedar workers were on the average much younger than the control workers. This age difference, therefore, would tend to minimize differences between the groups in the crude frequencies of symptoms.

The prevalence of symptoms according to smoking habit in cedar workers and in Group 1 controls and the age-adjusted risk ratios are shown in Fig 3. Among nonsmokers, conjunctivitis, wheeze and breathlessness were somewhat more common among

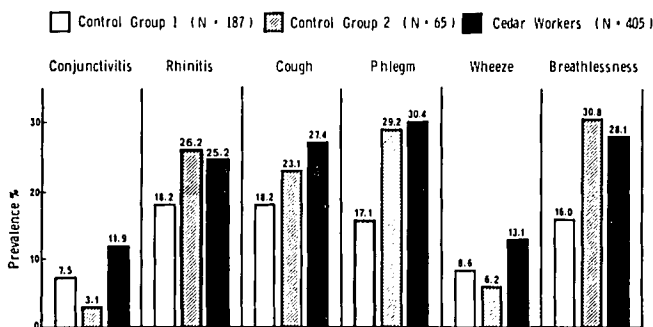


Fig 1. — Prevalence of symptoms in cedar workers and controls.

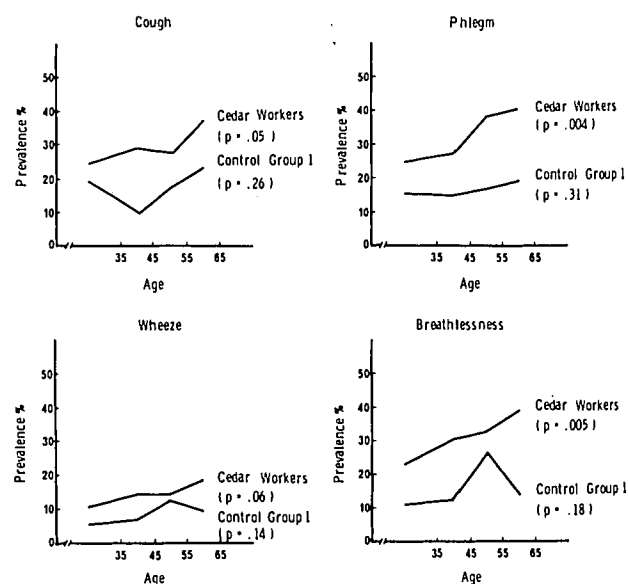


Fig 2. — Prevalence of chest symptoms by age.

	Cedar Workers (N = 405)		Controls	
			Group 1 (N = 187)	Group 2 (N = 65)
Age in years (mean $\pm$ s.d.)†	36.8	$\pm$ 13.7	43.1	$\pm$ 13.8
Height in cm (mean $\pm$ s.d.)*	177.4	$\pm$ 6.4	175.9	$\pm$ 6.4
Duration of work in mill in years (mean $\pm$ s.d.)†	10.6	$\pm$ 10.4	16.1	$\pm$ 10.7
Smoking habits				
Nonsmoker	67	(16.6)	30	(16.0)
Exsmoker	120	(29.6)	56	(35.3)
Current smoker‡	218	(53.8)	91	(48.7)
Self-assessment of health				
Healthily	313	(77.3)	143	(76.5)
Asthma, bronchitis, chest disease	34	(8.4)	10	(5.3)
Other illnesses	58	(14.3)	34	(18.2)

† and * indicate that differences between the groups are significant at the 1% and 5% confidence levels respectively.
‡ Among current workers there were no statistically significant differences between the groups in either the type of smoker or daily amount smoked.
Figures in brackets represent percentages.

cedar workers, while rhinitis, cough and phlegm were more common among the controls. None of the risk ratios was statistically significant. Among exsmokers, cedar workers had higher frequencies of all symptoms than the controls, the risk ratios being statistically significant for rhinitis and phlegm. In both the control and cedar groups, current smokers had the highest frequencies of chest symptoms. Furthermore, among current smokers cedar workers had higher frequencies of all symptoms than did controls, the risk ratios being statistically significant for cough, phlegm and breathlessness.

Cedar and Group 1 control workers were also compared with regard to the frequencies of workers reporting either no chest symptoms (cough, phlegm, wheeze and breathlessness) or one or more of these symptoms (Fig 4). Among nonsmokers, the proportions of workers in cedar mills and control mills having no chest symptoms were similar, and the mean symptom scores (mean number of symptoms per person) were identical (0.40). Among current smokers, only 36.2% of cedar workers reported no chest symptoms, compared to 58.2% of the controls. In addition, more of the smoking cedar workers had multiple chest symptoms compared with the smoking controls, the mean symptom scores being 1.31 and 0.78 respectively.

The overall risk ratios for symptoms after adjustment for age and smoking habits are shown in Table 3. For cedar workers compared with either control group, the risk ratios for all symptoms exceed-

ed unity, and for cedar workers compared with Group 1 controls, the ratios were statistically significant for rhinitis, cough, phlegm, and breathlessness. For Group 2 control workers compared with Group 1 controls, the risk ratios exceeded unity for rhinitis, cough, phlegm and breathlessness, the latter ratio also being statistically significant.

Pulmonary Function Tests. — For cedar workers and Group 1 controls, the mean values of the initial pulmonary function tests (FEV₁, FVC, MMF) expressed as percentage of predicted, and the percentages of workers with abnormal tests (less than 80% of predicted) according to smoking habits are shown in Fig 5. The influence of smoking on pulmonary function is clear. For all workers there was a marked gradient for each test, from the highest means in the nonsmokers to the lowest means in the current smokers. These gradients were steepest for MMF. Within the smoking categories, however, there was little consistent difference between the exposure groups. Despite the clear preponderance of symptoms among cedar workers, there was no evidence of significantly

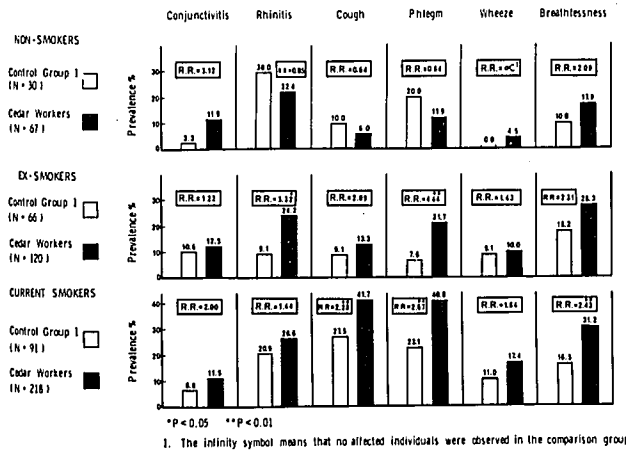


Fig 3. — Prevalence of symptoms in Group 1 controls and cedar workers by smoking habit and age-adjusted risk ratios (cedar/control).

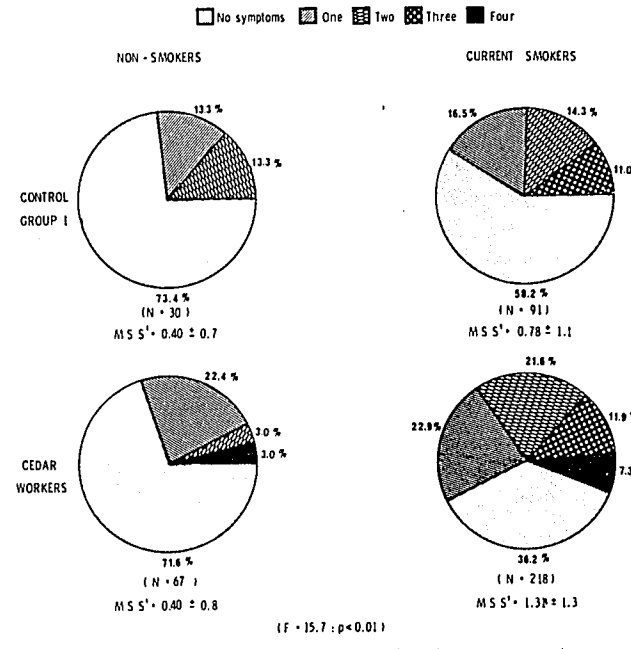


Fig 4. — Concurrence of chest symptoms.

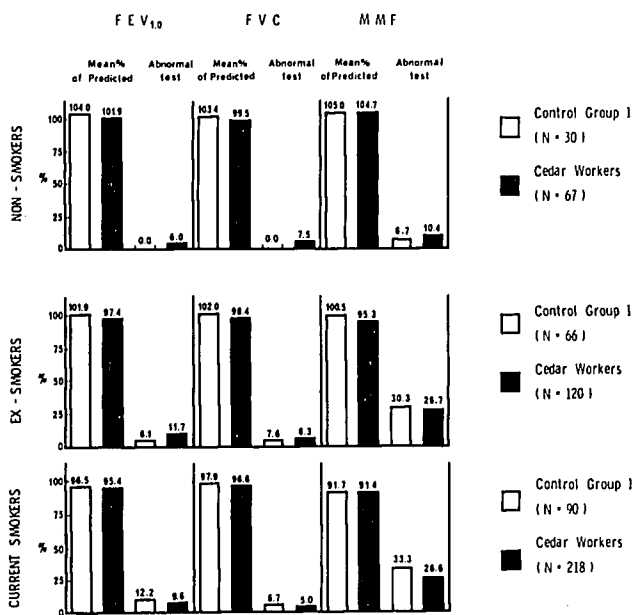


Fig 5. — Initial pulmonary function: mean percentage of predicted values and percentage of abnormal tests.

lower mean pulmonary function or of consistently higher percentages of abnormal findings in this group, particularly in exsmokers and current smokers. In the nonsmokers, there was a suggestion of a mild adverse effect associated with cedar exposure. In current smokers and exsmokers, the effect of smoking on pulmonary function is greater than the effect of exposure to cedar. The synergistic effect suggested between smoking and cedar exposure with regard to symptoms was not reflected in this analysis of pulmonary function.

Prevalence of Red Cedar Asthma. — Five workers (1.1%) in the cedar mills gave a typical history of red cedar asthma. We were only able to study two of them subsequently with inhalation provocation tests, using an extract of red cedar; the diagnosis was confirmed in both workers. Four workers (4.9%) in the Group 2 controls had been diagnosed as suffering from red cedar asthma in the past and had had to leave the cedar mills to take up employment in non-cedar mills. They improved considerably after leaving the cedar industry. In the two-year period prior to the survey, we also encountered in our clinic three patients with red cedar asthma who were employees of cedar mills we later surveyed. Moreover, we are aware of two other workers from these cedar mills who developed red cedar asthma within a year of the survey.

Discussion

In this study, we compared the frequency of symptoms and

lung function abnormalities among workers exposed to red cedar dust with that seen in workers exposed to other wood dusts. We have obtained unequivocal evidence that cough, phlegm, wheeze, breathlessness, rhinitis and conjunctivitis occur with greater frequency among workers exposed to red cedar. Our findings in this regard are similar to the Japanese survey,⁶ the prevalence of conjunctivitis and rhinitis being somewhat higher in our survey.

This study, like many other industrial surveys, suffered from certain shortcomings. The most important of these was our inability to find a completely suitable control group. For controls, we selected workers exposed to other wood dusts, but it cannot be assumed that inhalation of these dusts is harmless. It is pertinent to compare findings in our controls with data obtained in population surveys in this province. Such a comparison, of course, is not completely accurate, but it provides suggestive evidence that the prevalence of chest symptoms among the Group 1 controls is similar to that found in the general male population. The prevalence of cough and sputum among the Group 1 controls was around 10% in nonsmokers and around 25% in current smokers. Anderson and co-workers²¹ in the Chilliwack respiratory survey in 1963 found, in similar age groups, that the prevalence of "chronic bronchitis" was 7.2% in nonsmokers and 19-32% in current smokers, depending on the amount smoked.

There were differences between cedar workers and controls in age, duration of exposure and smoking habits, the first two being statistically significant. Fortunately, the differences in age and duration of exposure would tend to underestimate the crude frequency of symptoms in red cedar workers. The controls as a group were older, and, as expected and shown in this study, symptoms occurred more frequently in older than in younger workers. The shorter duration of exposure in cedar workers would again tend to underestimate the harmful effects of inhalation of the dust. We adjusted statistically for the differences related to age and smoking, and after these adjustments there was a significantly higher prevalence of symptoms among cedar workers than controls.

Despite the higher prevalence of respiratory symptoms among cedar workers, we were unable to demonstrate any significant increase in lung function abnormalities among them when compared with the controls. The mean pulmonary function and the percentage of workers with abnormal findings were similar in cedar workers and in controls. We were able to show, however, that lung function declined more rapidly with length of exposure in cedar workers who were current smokers compared with controls.²⁰

Chronic bronchitis and emphysema develop more commonly in smokers than in nonsmokers. The effects of cigarette smoke on the prevalence of respiratory disease have been demonstrated in a

Table 3. — Risk Ratios of Symptoms in Cedar Workers and Controls Adjusted for Differences in Age and Smoking Habits.

		Conjunctivitis	Rhinitis	Cough	Phlegm	Wheeze	Breathlessness
Cedar workers (N = 405)							
vs.	Risk ratio	1.75	1.61	2.02	2.43	1.82	2.34
Control Group 1 (N = 187)	p value	0.11	0.04	0.005	0.0002	0.07	0.0002
Cedar workers (N = 405)							
vs.	Risk ratio	4.57	1.18	1.64	1.35	2.82	1.06
Control Group 2 (N = 65)	p value	0.03	0.73	0.20	0.42	0.089	0.96
Control Group 2 (N = 65)							
vs.	Risk ratio	0.52	1.32	1.24	1.77	0.75	2.34
Control Group 1 (N = 187)	p value	0.55	0.56	0.70	0.13	0.80	0.02

number of industrial surveys.^{22 23 24} The detrimental effects of smoking are also clearly shown in this study. The frequency of all symptoms was greater among smokers than nonsmokers in both cedar and control mills. This detrimental effect of smoking was confirmed by pulmonary function tests, as current smokers in both cedar and control mills had lower pulmonary function than nonsmokers. While nonsmokers in the cedar and control groups experienced similar risks of respiratory symptoms, current smokers exposed to red cedar dust had higher risks than did the corresponding controls. Furthermore, the decline in lung function with duration of exposure was most rapid in those cedar workers who were also current smokers.²⁰ These findings suggest that there may be a synergistic effect between cigarette smoking and cedar dust exposure.

One of the unexpected but important findings in this study was the demonstration of a higher prevalence of symptoms among control workers who were previously exposed to red cedar compared to controls with no previous exposure, even after adjusting for differences in age and smoking habits between the groups. This finding suggests that previous exposure to red cedar may have altered the airways, rendering the workers more prone to develop symptoms. It is also possible that some of these individuals left the cedar mills because of symptoms resulting from red cedar exposure. Indeed, four workers from this group had been diagnosed previously as suffering from red cedar asthma.

During the past six years, we have diagnosed over 100 patients with red cedar asthma in our respiratory clinic. During the present survey, we found only five patients with red cedar asthma, giving a low prevalence rate of 1.1%. This is not really surprising, as our clinical studies have shown that the majority of patients with red cedar asthma develop this disease within two years of employment, while the average duration of employment of cedar workers in this survey was 10.6 years. We are dealing, therefore, with a selected population; workers who developed red cedar asthma had left the industry because their symptoms were disabling. As already pointed out, in the preceding two years we had diagnosed three patients with red cedar asthma who were employees of the cedar mills we subsequently surveyed, and all three had left the industry by the time of the survey. Furthermore, the prevalence of red cedar asthma among control workers who were previously exposed to this wood was 4.9% (four cases among 82 workers). To determine the incidence of this condition, it would be necessary to conduct a prospective study of all new entrants into the industry or to study those individuals who left the industry for health reasons. However, the above considerations suggest that the incidence of red cedar asthma is likely to be around 4-5%.

In conclusion, we found that workers exposed to red cedar dust have a higher prevalence of symptoms than those exposed to other wood dusts. The most disabling condition arising from red cedar exposure is occupational asthma. The prevalence of this condition in cedar mills is low (1.1%), as the majority of workers who develop it leave the industry. Cedar workers, particularly those who smoke, develop chronic bronchitis more readily than corresponding controls; they also show a more rapid decline in lung function than controls.²⁰ In addition, cedar workers have more conjunctivitis and rhinitis. These conditions, while annoying,

are not disabling enough to influence the workers to leave the industry.

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