

Work-related sensitization and respiratory symptoms in carpentry apprentices exposed to wood dust and diisocyanates

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Background: Exposure to certain substances in the workplace may lead to sensitization and increased respiratory symptoms.

Objective: To evaluate the frequency of work-related specific sensitization and respiratory symptoms in carpentry apprentices with occupational exposure to wood dust and diisocyanates.

Methods: Apprentices (n = 101) completed an occupational and symptoms questionnaire. Spirometry and skin prick tests to aeroallergens and to a battery of 14 different woods were performed in all the participants. Blood samples were collected for total IgE measurement and detection of specific IgE to diisocyanates.

Results: Half the participants (56%) had work-related respiratory symptoms: 54% due to wood dust, 15% due diisocyanates, and 9% to both. Participants with respiratory symptoms related to wood dust exposure had a significantly lower forced expiratory volume in 1 second compared with symptomatic individuals due to diisocyanates and asymptomatic individuals ($P < .05$). A history of rhinitis or asthma was associated with a 2.1- or 2.8-fold increase, respectively, in the likelihood of having respiratory symptoms due to wood dust exposure. Sensitization to wood was detected in 9% of participants, all of whom were atopic with a history of rhinitis and a high total IgE level ($P < .05$). Sensitization to diisocyanates was detected in 2% of exposed participants.

Conclusions: Work-related respiratory symptoms are common in carpentry apprentices and are more frequently related to exposure to wood dust than to diisocyanates. Symptomatic participants due to wood dust exposure had a lower forced expiratory volume in 1 second. Individuals with a history of rhinitis or asthma had an increased risk of respiratory symptoms. Sensitization to wood was more common in atopic apprentices with a history of rhinitis and a high total IgE level.

Ann Allergy Asthma Immunol. 2010;105:24–30.

INTRODUCTION

Wood is a natural material widely used in construction, for furniture building, and as fuel. In 2002 to 2003, 3.6 million workers in the European Union were occupationally exposed to wood dust. The highest exposure level was in the furniture industry, which employed 20% of exposed workers.¹ There was lower exposure in the construction industry, where 33% of the exposed workers were employed. Diisocyanates are contained in products such as paints, coatings, foams, adhesives, and sealants² and are widely used in numerous industries.

Exposure to wood dust and diisocyanates in the workplace may lead to different types of diseases due to their irritant or toxic effect.³ Accumulation of eosinophils and T-lymphocytes in the lungs after exposure to pinewood dust has been reported in healthy subjects.⁴ Wood dust may also cause allergic diseases, such as rhinitis, and asthma due to sensitization.⁵ Diisocyanates may also have a toxic effect and are the most common sensitizers and cause of occupational asthma in industrialized countries.⁶ The immunologic mechanisms that cause these diseases still remain poorly understood.

Several studies^{7–10} have evaluated the prevalence of respiratory symptoms and risk factors associated with exposure to wood dust. Hessel et al¹¹ studied workers exposed to pine and spruce dust and found that they had a lower forced expiratory volume in 1 second (FEV₁), lower FEV₁/forced vital capacity, and increased respiratory symptoms compared with unexposed controls. Malberg et al¹² reported a 15% frequency of bronchial symptoms in workers exposed to pine dust, and those with symptoms had a lower FEV₁ and increased bronchial hyperresponsiveness. In this group, smoking and atopy were not risk factors for respiratory symptoms. However, another study¹³ showed an increased risk of asthma in atopic workers exposed to pine tree dust compared with nonexposed atopic subjects. Studies^{14,15} of occupational exposure to di-

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Disclosures: Authors have nothing to disclose.

Funding Sources: This study was supported by a grant from the Spanish Ministry of Health (FIS/PI071175), a grant from the Andalusian Health Division, Andalusian Government (PI-0182/2008), and a grant from the Spanish Society of Allergy and the RIRAAF (Red de Investigación de Reacciones Adversas a Alergenos y Farmacos) Network (RD07/0064).

Received for publication February 19, 2010; Received in revised form April 14, 2010; Accepted for publication May 2, 2010

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doi:10.1016/j.anai.2010.05.002

isocyanates demonstrated that most individuals with diisocyanate-induced asthma are nonatopic and nonsmokers.

Few studies have analyzed the effect of exposure to both wood dust and diisocyanates. Petsonk et al¹⁶ studied employees of a wood products plant exposed to diisocyanates who reported asthmalike symptoms related to methylene diisocyanate exposure, although the possible summation effect of wood dust exposure was not analyzed.

Specific sensitization caused by plicatic acid in western red cedar wood has been extensively studied,^{17,18} and serum IgE has also been analyzed in individuals exposed to different woods.^{19,20} However, no studies, to our knowledge, report specific sensitization in apprentices exposed to wood dust.

Prospective studies have been conducted in apprentices exposed to different allergens, such as those from laboratory animals,^{21,22} high-molecular-weight substances,²³ latex,²⁴ and diisocyanates.^{25,26} These studies provide valuable information about characteristics of apprentices that may help identify high-risk individuals. The aim of this study was to evaluate prospectively specific sensitization and work-related respiratory symptoms in a group of apprentices exposed to wood dust and diisocyanates. This article presents the initial baseline data corresponding to the first (cross-sectional) evaluation. Although several studies have been performed with diisocyanate-exposed apprentices, to our knowledge, this is the first study to report data about specific sensitization and respiratory symptoms in carpentry apprentices in relation to their exposure to wood dust and to evaluate the possible additional effect of exposure to both wood dust and diisocyanates compared with wood dust alone.

METHODS

Participants were recruited among apprentices attending an occupational school of carpentry in Encinas Reales, Cordoba that specialized in the design and construction of wooden furniture. Participants performed different tasks, such as sawing and sanding the wood. In addition, some participants also spray painted and varnished the furniture. Students were, therefore, exposed to diisocyanates, wood dust, or both 8 hours a day, 5 days a week. Because wood furniture construction is a traditional family business in this area, some of these students had been exposed to diisocyanates or wood dust since childhood. Informed consent was signed by all the apprentices who agreed to participate in the study or by their parents if they were younger than 18 years.

All the participants completed a full medical and occupational questionnaire, modified from the International Union Against Tuberculosis and Lung Disease,²⁷ that recorded information about personal history of rhinitis and asthma symptoms, smoking, length of exposure to wood dust and diisocyanates, types of wood or diisocyanates used, and respiratory symptoms related to exposure to wood dust or diisocyanates: nasal symptoms (itching, sneezing, nasal blockade, and runny nose), bronchial symptoms (chest tightness, dyspnea, cough, and wheezing), and symptoms suggestive of hypersensitivity pneumonitis (dyspnea, cough, fever/

chills, and muscle ache). The questionnaire was administered and supervised by the researchers in 2 separate visits in April and November 2008.

Spirometry was performed using a Spirobank spirometer (RDSM, Hasselt, Belgium) following American Thoracic Society guidelines.²⁸ Skin prick tests (SPTs) with a battery of 10 aeroallergens (ALK-Abello, Madrid) were performed according to European guidelines.²⁹ The battery included pollen (*Lolium*, *Olea europea*, and *Parietaria judaica*), *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae*, *Alternaria alternata*, latex, and cat and dog dander extracts. Extracts of 14 types of wood to which the apprentices are occupationally exposed were prepared in-house with fresh material provided by the school following previously published protocols.³⁰ Briefly, ground whole wood was stirred in 0.1M 5% ammonium bicarbonate for 16 hours, centrifuged at 21,000g, dialyzed, and lyophilized. All the participants underwent SPT at 10 mg/mL with the wood extracts.

Blood samples were collected to measure total IgE and specific IgE to 3 different diisocyanates: hexamethylene diisocyanate, methylene diisocyanate, and toluene diisocyanate (UNICAP; Pharmacia Diagnostics, Uppsala, Sweden).

Differences between groups were compared using the *t* test for continuous variables and the χ^2 test for categorical variables. The method of multiple comparisons for percentages was verified based on the Holm method. A multivariate logistic regression analysis was performed to determine whether respiratory symptoms related to exposure to wood dust or diisocyanates were associated with baseline risk factors, such as atopy, smoking, time of exposure, history of rhinitis or asthma, total IgE level, and FEV₁. A *P* < .05 was considered statistically significant. Statistical analyses were performed using a software package (SPSS for Windows version 12; SPSS Inc, Chicago, Illinois). This study was approved by the ethics committee of Carlos Haya Hospital, Malaga, Spain.

RESULTS

Clinical Characteristics

The demographic and clinical characteristics of 101 apprentices (97 men and 4 women; mean [SD] age, 19.5 [2.7] years) are summarized in Table 1. Almost half of the apprentices were active smokers (46%). The mean period of exposure at the time of the evaluation was 39.9 months for wood dust (range, 3-200 months) and 27.8 months (range, 0-96 months) for diisocyanates. Participants were questioned about their history of nasal and bronchial symptoms; 18% had a history of asthma/airway hyperreactivity, and 40% reported previous nasal symptoms. Forty-six participants were exposed to both diisocyanates and wood dust, and 55 to wood dust only. The mean total IgE level was 69.2 IU/mL (3-1,340 IU/mL), and the mean FEV₁ was 4.08 ± 0.48 L (95.9% of predicted). Half of the participants (n = 49) had a positive SPT reaction to at least 1 of the aeroallergens in the battery. Specific sensitization to wood was detected in 9 of 101 participants (9%), and

Table 1. Demographic and Clinical Characteristics of the 101 Apprentices

Characteristic	Value
Age, mean (SD), y	19.5 (2.7)
Sex, M/F, No.	97/4
Smoking status, %	
Current smokers	46
Nonsmokers	48
Former smokers	6
Exposure to wood dust, mean (range), mo	39.9 (3-200)
Exposure to diisocyanates, mean (range), mo	27.8 (0-96)
History of rhinitis, No.	
No	61
Yes	40
History of asthma, No.	
No	83
Yes	18
Total IgE, mean (range), IU/mL	69.2 (3-1,340)
FEV ₁ , mean (SD), L	4.08 (0.48)
FEV ₁ , mean (SD), % of predicted	95.9
Positive SPTs to aeroallergens, No.	49
Positive SPTs to wood, No.	9
Work-related respiratory symptoms, No.	57
Due to wood dust exposure	54
Due to diisocyanate exposure	7
Due to wood dust and diisocyanate exposure	4

Abbreviations: FEV₁, forced expiratory volume in 1 second; SPT, skin prick test.

sensitization to diisocyanates was detected in 1 of 46 participants (2%). Fifty-seven participants (56%) reported some kind of work-related respiratory symptoms, 54 (of 101) associated with exposure to wood dust (54%), 7 (of 46) to diisocyanates (15%), and 4 (of 46) to both (9%). No cases suggestive of hypersensitivity pneumonitis by either wood dust or diisocyanates were detected. Forty-four participants reported no symptoms associated with exposure to any substance.

Demographic Characteristics of Participants Exposed to Diisocyanates and Wood Dust vs Those Exposed to Wood Dust Only

The apprentices were exposed to 14 types of wood: alder (*Alnus serrulata*), cedar (*Cedrus*), cherry tree, European beech (*Fagus silvatica*), iroko (*Chlorophora excelsa*), kotibe, walnut tree (*Juglans major*), olive tree (*Olea europaea*), obeche (*Triplochiton scleroxylon*), 3 types of pine tree (*Pinus*), oak tree (*Quercus*), and sapelly. No significant associations were found between exposure to a specific type of wood dust and respiratory symptoms (either nasal or bronchial) (data not shown). Exposure to diisocyanates was mostly to hexamethylene diisocyanate from spray painting the furniture. A comparison of the demographic and clinical characteristics of the participants based on type of exposure is given in Table 2. Forty-six participants were exposed to both diisocyanates and wood dust and 55 to wood dust only. Age,

sex, smoking status, time of exposure to wood dust, history of rhinitis or asthma, total IgE level, FEV₁, atopy status, and frequency of respiratory symptoms were compared between the 2 groups, but no significant differences were found. Frequency of specific sensitization to wood was higher in individuals exposed to wood dust alone, although the difference was not significant.

Respiratory Symptoms Related to Exposure to Diisocyanates and Wood Dust

Work-related respiratory symptoms were more frequent in relation to exposure to wood dust compared with diisocyanates (54% vs 15% of exposed). Characteristics of these symptomatic participants were compared according to the cause of the symptoms, either wood dust (n = 54) or diisocyanates (n = 3) exposure only, and also compared with participants without work-related respiratory symptoms (asymptomatic individuals) (Table 3). When symptomatic and asymptomatic participants were compared, we found no significant differences in terms of age, sex, smoking status, or atopy. Total time of exposure to wood dust was lower in

Table 2. Demographic and Clinical Characteristics of Apprentices by Type of Substance Exposure

Characteristic	Diisocyanate and wood dust exposure (n = 46)	Wood dust exposure (n = 55)
Age, mean (SD), y	19.57 (2.7)	19.38 (2.7)
Sex, M/F, No.	44/2	53/2
Smoking status, No. (%)		
Nonsmokers	25 (54)	23 (42)
Current smokers	17 (37)	30 (55)
Former smokers	4 (9)	2 (4)
Exposure, mean, mo		
Wood dust	41.37	29.44
Diisocyanates	27.8	0
History of rhinitis, No. (%)		
No	28 (61)	33 (60)
Yes	18 (39)	22 (40)
History of asthma, No. (%)		
No	38 (83)	45 (82)
Yes	8 (17)	10 (18)
Total IgE, mean, IU/mL	246.49	166.4
FEV ₁ , mean, L	4.09	4.08
FEV ₁ , mean, % of predicted	95.8	96.9
SPT to inhalants, No. (%)		
Negative	26 (57)	26 (47)
Positive	20 (43)	29 (53)
SPT to wood, No. (%)		
Negative	44 (96)	48 (87)
Positive	2 (4)	7 (13)
Respiratory symptoms, No. (%)		
No	18 (39)	26 (47)
Yes	28 (61)	29 (53)

Abbreviations: FEV₁, forced expiratory volume in 1 second; SPT, skin prick test.

Table 3. Comparison of the Clinical Characteristics of Apprentices With Respiratory Symptoms Due to Exposure to Wood Dust or Diisocyanates and Asymptomatic Apprentices

Characteristic	Respiratory symptoms with wood dust exposure (n = 54)	Respiratory symptoms with diisocyanate exposure (n = 3)	Asymptomatic (n = 44)
Age, mean, y	18.93	18.67	20.18
Sex, M/F, No.	51/3	3/0	43/1
Smoking status, No. (%)			
Nonsmokers	28 (52)	3 (100)	17 (39)
Current smokers	24 (44)	0	23 (52)
Former smokers	2 (4)	0	4 (9)
Exposure to wood dust, mean, mo	35.12	24	35.5
History of rhinitis, No. (%)			
No	28 (52)	1 (33)	32 (73)
Yes	26 (48) ^a	2 (67)	12 (27)
History of asthma No. (%)			
No	40 (74)	3 (100)	40 (91)
Yes	14 (26) ^a	0	4 (9)
Total IgE, mean, IU/mL	259.79	672 ^c	127.51
FEV ₁ , mean, L	3.92 ^{a,b}	4.46	4.26
FEV ₁ , mean, % of predicted	94.32 ^{a,b}	108.33	98.23
SPT to inhalants, No. (%)			
Negative	27 (50)	1 (33)	20 (45)
Positive	27 (50)	2 (67)	24 (55)

Abbreviations: FEV₁, forced expiratory volume in 1 second; SPT, skin prick test.

^a Respiratory symptoms with wood dust exposure vs asymptomatic, $P < .05$.

^b Respiratory symptoms with wood dust exposure vs respiratory symptoms with diisocyanate exposure, $P < .05$.

^c Respiratory symptoms with diisocyanate exposure vs asymptomatic, $P < .05$.

individuals with co-exposure to wood, although the differences were not significant. Total IgE levels were higher in symptomatic participants, although not significantly. Significant differences were detected, however, when IgE levels were compared in those with symptoms related to diisocyanates and asymptomatic individuals (672 vs 127.5 IU/L, $P = .002$). Apprentices who reported respiratory symptoms due to exposure to wood dust had a significantly lower FEV₁ compared with participants with symptoms due to diisocyanates and with asymptomatic participants ($P < .05$). Of apprentices with a history of asthma or rhinitis, respiratory symptoms related to exposure to wood dust were significantly higher ($P = .03$ and $P = .04$, respectively). Apprentices with respiratory symptoms due to diisocyanate exposure exclusively (n = 3) showed no other significant differences with any variable analyzed compared with the asymptomatic group or the group with wood-related symptoms.

Logistic regression analysis using forward and backward approaches for stepwise variable selection retained or selected a history of rhinitis and a history of asthma as the only variables associated with the presence of respiratory symptoms related to exposure to wood dust. A history of rhinitis or asthma was associated with 2.1- or 2.8-fold increases in the likelihood of having respiratory symptoms related to exposure to wood dust. None of the remaining variables was associated with the presence of such work-related symptoms (data not shown).

Upper vs Lower Airway Symptoms in Symptomatic Participants Related to Exposure to Wood Dust

Participants with respiratory symptoms related to wood dust exposure were selected and further analyzed to examine possible differences between those with upper (n = 38) vs lower (n = 16) airway respiratory symptoms (Table 4). Apprentices with work-related upper airway respiratory symptoms had a lower mean age ($P = .008$) and a higher mean level of IgE (210 vs 163 IU/mL) compared with asymptomatic participants, although the latter was not significant. Participants with a history of asthma showed more nasal symptoms related to exposure to wood dust. Symptomatic participants also had a lower FEV₁ compared with asymptomatic apprentices. Participants with lower airway symptoms had a longer exposure period (47.25 vs 34.8 months) and a higher total IgE level (320 vs 163 IU/mL) compared with asymptomatic individuals, although the differences were not statistically significant. Participants with a history of rhinitis and asthma showed a higher frequency of lower respiratory symptoms due to wood dust exposure compared with asymptomatic participants ($P = .01$ and $P = .03$, respectively). The FEV₁ values were significantly lower in participants with work-related bronchial symptoms ($P = .01$ and $.02$, respectively). Frequency of positive SPT results showed no differences between groups. There were no significant differences between participants who showed nasal vs bronchial symptoms related to any of the study variables.

Table 4. Comparison of Apprentices With Wood-Related Upper and Lower Airway Symptoms vs Asymptomatic Apprentices

Characteristic	Upper airway symptoms (n = 38)	Lower airway symptoms (n = 16)	Asymptomatic (n = 47)
Age, mean, y	18.5 ^a	20	20.1
Sex, M/F, No.	36/2	15/1	46/1
Smoking status, No. (%)			
Nonsmoker	21 (55)	7 (44)	20 (43)
Current smoker	16 (42)	8 (50)	23 (49)
Former smoker	1 (3)	1 (6)	4 (8)
Exposure to wood dust, mean, mo	29.8	47.25	34.8
History of rhinitis, No. (%)			
No	22 (58)	6 (38)	33 (70)
Yes	16 (42) ^a	10 (62) ^b	14 (30)
History of asthma No. (%)			
No	29 (76)	11 (68)	43 (92)
Yes	9 (24) ^a	5 (32) ^b	4 (8)
Total IgE, mean, IU/mL	210	320	163
FEV ₁ , mean, L	3.9 ^a	3.9 ^b	4.28
FEV ₁ , mean, % of predicted	95.4	91.4 ^b	98.9
SPT, No. (%)			
Negative	17 (45)	10 (63)	25 (53)
Positive	21 (55)	6 (37)	22 (47)

Abbreviations: FEV₁, forced expiratory volume in 1 second; SPT, skin prick test.

^a Upper respiratory symptoms with wood dust exposure vs asymptomatic, $P < .05$.

^b Lower respiratory symptoms with wood dust exposure vs asymptomatic, $P < .05$.

Work-Related Respiratory Symptoms and Sensitization

Forty-nine percent of the apprentices had a positive SPT reaction to at least 1 of the aeroallergens in the battery, with 33% sensitized to pollen, 20% to dust mites, and 8% to cat or dog dander. Participants who reported work-related symptoms showed similar results compared with asymptomatic apprentices. No significant differences were found when symptomatic participants were stratified according to the occurrence of upper or lower symptoms. No significant associations were found regarding positivity to any aeroallergen or to pollen, dander, or dust mites when respiratory symptoms were used as the dependent variable in logistic regression analysis. Neither were any significant differences observed when data were stratified according to the number of positive SPT results (0-2 vs ≥ 3) (data not shown).

Specific sensitization to wood was detected in 9% of exposed participants. Seven participants showed a positive SPT reaction to olive tree wood, 1 to obeche wood, and 1 to pine tree wood. Participants with sensitization to wood were all atopic, had a history of rhinitis, and had higher total IgE levels (Table 5). Three participants reported respiratory symptoms due to exposure to wood dust: 2 had nasal symptoms and 1 had nasal and bronchial symptoms. There were no

significant differences in terms of frequency of work-related respiratory symptoms, age, exposure time, FEV₁, smoking, or history of asthma between participants with positive vs negative SPT reactions to wood.

In vitro sensitization to diisocyanates was detected in only 1 participant (2%) (positive IgE to hexamethylene diisocyanate and toluene diisocyanate), an atopic apprentice with clear nasal symptoms while varnishing furniture after 2 years of exposure. This positive result represents 15% (1 of 7) of positive results among those who reported symptoms due to exposure to diisocyanates.

DISCUSSION

Wood dust is a substance capable of producing various effects on health due to a carcinogenic effect or as an irritant, toxic agent, or sensitizer,^{30,31} although the immunologic mechanisms are not fully understood. Wood dust may affect several organs, specially the upper and lower airways and skin, with several reports of dermatitis³² and lower FEV₁ and increased respiratory symptoms.^{11,12} A recent meta-analysis³³ of 19 studies showed a pooled relative risk of asthma in workers exposed to wood dust of 1.53 (95% confidence interval [CI], 1.25-1.87): 1.59 (95% CI, 1.26-2.00) in white populations and 1.15 (95% CI, 0.92-1.44) in Asian populations.

Whether atopy is a risk factor for respiratory symptoms related to wood dust exposure is unclear,^{12,13} and other factors

Table 5. Characteristics of Participants Based on the Results of SPTs to Wood

Characteristic	Positive (n = 9)	Negative (n = 92)
Age, mean, y	19.1	19.5
Smoking status, No. (%)		
Nonsmokers	5 (56)	43 (47)
Current smokers	4 (44)	43 (47)
Former smokers	0	6 (6)
Exposure to wood dust, mean, mo	36.3	34.7
History of rhinitis No. (%)		
No	0	61 (66)
Yes	9 (100) ^a	31 (34)
History of asthma, No. (%)		
No	7 (78)	76 (83)
Yes	2 (22)	16 (17)
Total IgE, mean, IU/mL	439.6 ^a	178.1
FEV ₁ , mean, L	4.06	4.09
FEV ₁ , mean, % of predicted	97.3	96.3
SPT, No. (%)		
Negative	0	52 (57)
Positive	9 (100) ^a	40 (43)
Work-related respiratory symptoms, No. (%)		
No	5 (56)	39 (42)
Yes	4 (44)	53 (58)

Abbreviations: FEV₁, forced expiratory volume in 1 second; SPT, skin prick test.

^a $P < .05$.

may affect the development of respiratory symptoms. In a recent study,³⁴ 1,377 woodworkers (1,137 men and 240 women) with low exposure participated in a 6-year follow-up study. Results showed that female woodworkers had an increased incidence of coughing and bronchitis, whereas no association with wood dust exposure was seen in male woodworkers.³⁴ Diisocyanate-induced symptoms seem to be higher in nonatopic, nonsmoking individuals.^{14,15} However, risk factors have not been well-defined.

In the present study, we report the results of the baseline data for a group of carpentry apprentices exposed to diisocyanates, wood dust, or both. Because of the important tradition in furniture construction, this group of apprentices had a high average exposure period to wood dust (39.9 months) and diisocyanates (27.8 months) at the time of evaluation, mainly because most of them had worked in their family businesses before starting their studies. However, although this question was clearly addressed in the questionnaire and the apprentices were asked specifically, it was still not possible to obtain complete data about the latency period (time from beginning of exposure until the development of symptoms). We also detected a high proportion of individuals with a history of asthma and previous nasal symptoms in the study group. The frequency of atopy was also high (49%). A nonexposed control group matched for age and sex is necessary in future studies.

Work-related respiratory symptoms were found in 56% of participants, more frequently in relation to wood dust (54%) than to diisocyanates (15%). No cases suggestive of hypersensitivity pneumonitis were identified. Several variables, such as sex, smoking status, atopy, and total time of exposure to any substance, did not seem to affect the frequency of respiratory symptoms. Apprentices reporting respiratory symptoms had significantly lower FEV₁ values. These results agree with those of other studies of wood-exposed subjects,^{9,10} although in the future, a control population should be recruited for further comparisons. The measurement of non-specific airway hyperresponsiveness is also an important variable that is missing in this study due to technical difficulties. Because this was a baseline evaluation, we did not find many substantial differences between individuals exposed to diisocyanates and wood dust vs those exposed to wood dust alone. Prospective follow-up should detect any differences and a possible increase in the frequency of respiratory symptoms. Symptomatic apprentices with a history of asthma or rhinitis also had more respiratory symptoms and an increased risk of respiratory symptoms due to wood exposure. There was no effect of atopy on the occurrence of respiratory symptoms.

Sensitization to wood evaluated by means of SPTs was found in 9% of participants. All the sensitized participants were atopic, with high IgE levels and a history of rhinitis. Several articles^{5,19,20,30} have demonstrated that proteins contained in wood may cause IgE-mediated sensitization, demonstrated by SPT and by different in vitro tests. However, most of these proteins are not well characterized and need

further investigation. In vitro sensitization to diisocyanates was detected in 2% of exposed individuals.

In conclusion, respiratory symptoms were reported frequently in wood dust-exposed subjects compared with those exposed to diisocyanates. Participants who were symptomatic due to exposure to wood dust had a lower FEV₁ compared with asymptomatic participants, and there was an increased risk of work-related respiratory symptoms among participants with a history of either rhinitis or asthma. Sensitization to wood was more common in atopic apprentices with a history of rhinitis and a high total IgE level.

ACKNOWLEDGMENTS

We thank Mrs Arias and Mr García-Montes, staff, and students from CEMER School (Cordoba, Spain) for their support and collaboration in this study and Ian Johnstone for his help with the final English version of the manuscript.

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