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RESEARCH ARTICLE

Assessment of ventilatory disorders in artisans exposed to wood dust

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ABSTRACT

Background: Wood dust is produced at virtually all stages of the wood industry. The most important wood-related risks are chemical hazards with the use of toxic, allergenic, and carcinogenic products which may alter respiratory function. Prevalence rates of ventilatory disorders are heterogeneous and no data are available in Senegal. **Aims and Objectives:** The purpose of our study was to evaluate respiratory function in carpenters. **Materials and Methods:** A cross-sectional study was conducted from February to July 2017 in 70 male carpenters exclusively, from the city of Thiès. Each carpenter received a questionnaire and a spirometry test as a way of establishing a baseline state of all the subjects. The spirometry was subjected to the standardized validation procedure according to the American Thoracic Society/European Respiratory Society criteria. **Results:** The average age is 39 years old. Among these carpenters, 14% are active smokers and 17% are former smokers. Seniority ranged from 1 to 48 years. Spirometry revealed a pure obstructive respiratory disorder in 32.85% of cases. The obstruction is classified as mild in 17.14% and moderate in 7.14% of cases. A pure restrictive syndrome is present in 18.57% and a mixed syndrome in 7.14% of cases. Tobacco potentiates the effects of occupational airborne contaminants because smokers have more obstructive syndrome than ex-smokers 50% versus 33.33% ($P = 0.02$) and more restrictive syndrome than non-smokers 30% versus 14.58% ($P = 0.01$). Negative correlations between the duration of exposure and forced expiratory volume in 1 s (FEV1), FEV1/forced vital capacity, and MEF 25–75% had been found. **Conclusion:** Exposure to wood dust is implicated in the alteration of various respiratory function parameters.

KEY WORDS: Wood Dust; Respiratory Disorder; Spirometry; Ebony Carpenters; Senegal

INTRODUCTION

Wood is one of the most important renewable resources in the world. It is widely used in many activities including the manufacture of handcrafted and industrial furniture. Until the middle of the last century, the only real danger to wood dust was its flammability. The latter being capable, at high concentration in the air, of accidentally causing deadly explosions and fires; it is essentially this risk that has led, in recent decades, to a major effort to reduce atmospheric concentrations of wood dust in workshops. This effort has naturally translated for the workers, into generally lesser exposure, but with the persistence today of exposures to particles often finer than in the past, easily inhalable.[1] Respiratory pathology secondary to the inhalation of wood has been known for about 30 years.[2] In addition, the different products used in the wood industry, the treatments received, and the mold constitutes additional respiratory disease risk factors.[3,4] Several studies have highlighted the link between

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wood dust exposure and ventilatory disorders.[5,6] In fact, studies of respiratory function in carpenters have shown the presence of several types of respiratory functional disorder: Especially obstructive, restrictive, or mixed.[5-7]

In Senegal, no data are available on the importance of respiratory function abnormalities among carpenters, but working conditions in the timber industry are rather degraded and they are working without any awareness of the risk of excessive atmospheric wood dust. The aim of our study was to evaluate ventilatory disorders related to the exposure of inhalable wood dust in ebony carpenters in the informal sector in Thiès (Senegal).

MATERIALS AND METHODS

Type of Study

This is a cross-sectional study that took place only in the city of Thiès from February to July 2017. The study focused on ebony carpenters. A total of 70 ebony carpenters, exclusively male, with at least 1 year of exposure to wood dust in different work sequences, participated in the study.

Study Framework

This study was conducted at the Functional Exploration Department of Thiès Regional Hospital, Senegal. The protocol has been approved by Senegal's National Ethics Committee. All patients were informed of the procedure and objectives of the study and gave their written and informed consent to participate in the study.

Methods

A medical questionnaire was completed by the doctor leading the investigation. It focused on sociological conditions, marital status, smoking habits, and clinical respiratory symptoms (cough, expectorations, dyspnea, asthma, and chronic bronchitis). This questionnaire thus structured allowed us to collect the maximum information from the carpenters. The survey forms were collected 2 weeks before the assessment of the respiratory function. All subjects with active cardiopulmonary pathology, thoracic deformity, or poor cooperation during spirometry were excluded from the study.

Smokers were individualized as smokers, former smokers, and non-smokers. Subjects were considered smokers if they recognized that they regularly smoked at least one cigarette a day and for at least 1 year. Non-smokers were those who had never smoked regularly at least one cigarette a day or who had smoked one or more cigarettes a day for less than a year. Ex-smokers who had smoked regularly a cigarette a day or more for at least a year in the past but who had abandoned this for at least a year.[8]

Functional breathing tests were performed using a regularly calibrated spirometer type "*Jaeger pneumo care fusion"* connected to a DELL brand computer which served us as a monitor. For all subjects, a single spirometry examination with three successive trials of ventilatory maneuvers was performed. The best of the three was selected taking into account the degree of cooperation of the subject.[9-11]

The recording measured spirometry parameters and their rate of change. These were forced vital capacity (FVC), forced expiratory volume in 1 s (FEV 1), FEV1/FVC (Tiffeneau index), and maximal expiratory flow at 25–75% of vital capacity (MEF 25–75%). Pulmonary function tests were performed according to the criteria of the American Thoracic Society and the European Respiratory Society (criteria 2005).[9-11] The analysis of the modifications of the different quantities measured made it possible to individualize:

The obstructive syndrome which was defined on the basis of:

- Total obstruction: Decrease in FEV1, FEV1/FVC, and MEF 25–75% <80% of predicted value
- Proximal obstruction: FEV1/FVC <80% of the predicted value
- Distal obstruction: MEF 25–75% <80% of the predicted value.[12]

Restrictive syndrome was defined based on a decrease in FVC of <80% of the predicted value with a normal FEV1/FVC ratio (>80%).

The severity of the obstruction was analyzed according to FEV1: Mild between 70% and 80%, moderate between 50% and 70%, severe between 30% and 50%, and very severe inferior of 30% of the predicted value.[9]

Statistical Analysis

The data were collected from the spirometry interpretation sheet into the Excel 2013 software. Statistical analysis was performed using STATA software version 11.0. The results were expressed as mean ± standard deviation and as a percentage. The Chi-squared test was used for comparing percentages. The Pearson correlation test was used to search for a link between parameters. The threshold of statistical significance was set at $P < 0.05$.

RESULTS

Sociodemographic Data

The demographic data are shown in Table 1. The analysis of the results shows that the average age of the subjects to be 39.7 ± 11.4 years with extremes ranging from 18 to 65 years. Those aged 30–50 accounted for 57.14% of the study population.

Table 1: Characteristics of the studied population

Characteristics	Average value	Standard deviation	Minimum	Maximum
Age (years)	39.7	11.4	18	65
Height (cm)	179.67	6.8	167	195
Weight (kg)	71.21	13	45	107
BMI (kg/m^2)	22.67	3.4	16.4	31.4
Longevity in the professional activity (years)	22.2	11.7	1	48

BMI: Body mass index

The body mass index of our subjects was on average normal with rare cases of obesity at 4%. Average tenure in the profession was 22 ± 11.7 years. The majority of the subjects had wood dust exposure duration of >10 years (85.72%) and 34.29% had an exposure duration of ≥30 years ($P < 0.0001$).

Active smokers accounted for 14% of the population and 17% were former smokers.

Spirometry Data

Our results showed that the most ventilatory disorders found were of the pure obstructive type 32.85% of the subjects [Table 2]. These disorders were mainly localized in the distal bronchi (17.14%). The obstructive disorders found of a mild defect type were 17.14% and moderate at 7.14%.

In addition, 18.57% of the subjects had pure restrictive ventilatory disorders.

In 7.14% of the subjects, the respiratory functional exploration had shown a mixed ventilatory disorder.

Ventilatory disorders were found in smokers, former smokers, and non-smokers. Obstruction was significantly more common in smokers than in ex-smokers ($P = 0.02$). Restrictive ventilatory disorders were also significantly more frequent in smokers than non-smokers ($P = 0.01$) [Figure 1].

A negative correlation was found between certain spirometry parameters such as the MEF 25–75% [Figure 2], the Tiffeneau index [Figure 3], and the FEV1 [Figure 4] with the seniority at the workstation ($r = -0.2804$; $P = 0.0187$, $r = -0.3411$; $P = 0.0039$, and $r = 0.3072$; $P = 0.0097$, respectively).

DISCUSSION

Our study took place over a period of 5 months (from February 2017 to July 2017) and involved 70 ebony carpenters. The main observation of this study is the effect of exposure to wood dust generated during various carpentry operations on the respiratory risks of carpenters in the informal economy.

The majority of our study population consisted of adults. These results are close to those observed by Belabed[7] who found an average age of 39.11 years. By cons, average age

Table 2: Distribution of subjects according to ventilatory disorders

Ventilatory disorders	Effective *n* (%)
Pure OVD	
Total obstruction	7 (10)
Proximal obstruction	4 (5.71)
Distal obstruction	12 (17.14)
Pure RVD	13 (18.57)
Mixed ventilatory disorders	5 (7.14)
No trouble	29 (41.42)

OVDs: Obstructive ventilatory disorders, RVDs: Restrictive ventilatory disorders

in our study (39.7 years) is higher compared to other African studies: 27 years old[13] and 34.2 years old.[14] This is no doubt linked to the current high levels of school enrollment of young people, which tends to diminish more and more the population of the young and active found in all sectors of activity in developing countries.

The absence of women in this carpentry sector could be explained by sociocultural factors. In addition to her role as a mother where she must ensure the sustainability of the offspring, the woman is responsible for the execution of domestic and fieldwork.

Numerous studies have shown that occupational exposure to wood dust is involved in the alteration of various respiratory function parameters, apart from asthmatic manifestations.[15,16] In our cross-sectional study, 58.56% of the subjects exposed to wood dust have respiratory abnormalities, of which 32.85% are an obstructive syndrome, but we found mainly, only the mild and moderate types. Spirometry abnormalities observed during exposure to wood dust have been reported by several authors.[16,17] Eriksson *et al*.[18] found a significant decrease in FEV1, CV, and Tiffeneau's ratio in 38 exposed subjects. Our results remain superior to the Belabed series[7] and NDE[5] who found 5.1% and 6.20%, respectively, of obstructive ventilatory disorders, but they are in agreement with those of Laraqui[14] who finds 30% of obstructive syndrome. This difference may be due to regulated limits to exposure.[1] Vedal *et al*.[19] showed that the FVC and FEV 1 are decreased with a concentration of dust >2 mg/m^3. In the carpentry workshops of our subjects, there is an absence of dust extraction

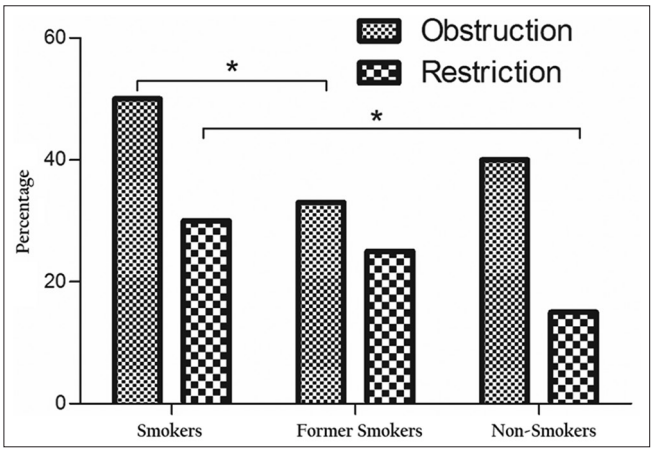

Figure 1: Prevalence of ventilatory disorders according to smoking

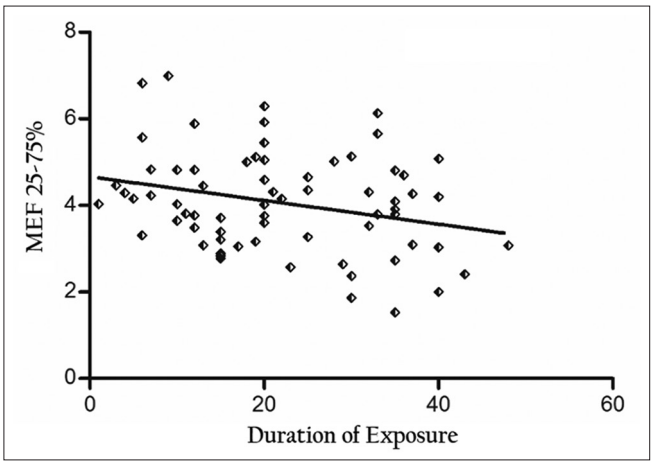

Figure 2: Relationship between MES 25–75 and the duration of exposure to wood dust

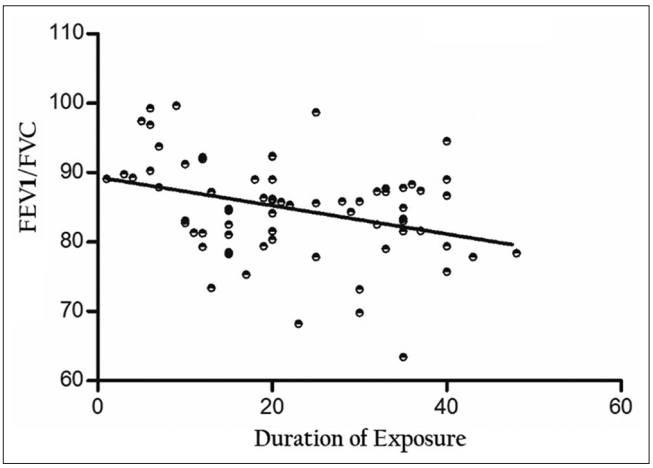

Figure 3: Relationship between forced expiratory volume in 1 s/ forced vital capacity and duration at exposure to dust

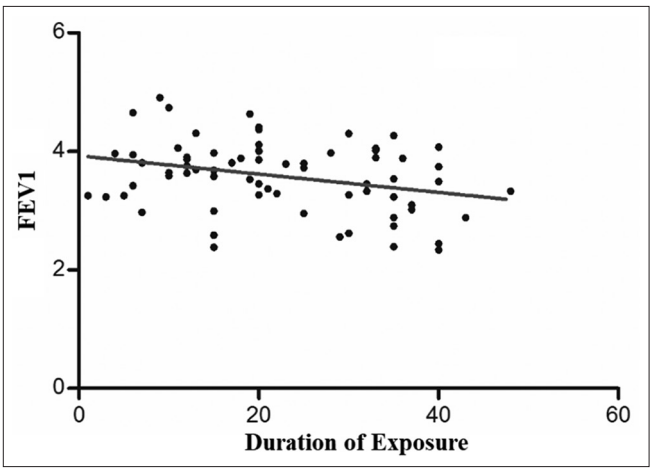

Figure 4: Relationship between forced expiratory volume in 1 s and duration at exposure to dust

device at the source, appropriate breathing masks and effective cleaning of dusts and chips resulting in wood dust concentrations probably very high in workplace atmospheres. Another hypothesis is linked to the composition or types of wood used, which varies according to geographical origin.[20] Our results as well as those reported by Mandryk *et al*.[21] show a decrease in MEF 25–75%. In addition, the study by Whitehead *et al*.[22] shows that MEF is 2–4 times lower with exposure to softwood or hardwood dust at >10 mg-years/m^3.

Our study showed in 18.57 of the subjects restrictive ventilatory disorders. Boskabady *et al*.[23] found a similar reduction in FVC that decreases with exposure to wood dust. These findings may indicate the presence of restrictive lung disease in carpenters. This finding is supported by other earlier studies conducted by Rastogi *et al*.[24] by showing low levels of FVC. Reducing the median, maximum throughout could be secondary to ventilatory obstructive disorders,[23] or carpentry work can lead to a mixed ventilatory disorder.

Wood dust is a very composite substance whose constituents depend on the kind of wood that causes the dust and the treatments received (fungi, bacteria, preservatives, varnishes, waxes, paints, and glue). Activities carpenter produce easily inhalable fine particles that play an important role in the genesis of respiratory disorders, especially during sanding operations.[1]

In the etiology of these pathologies, the mechanical irritations of wood dust, the toxic mechanism attributed to the action of various chemical substances and the immunoallergic mechanism by the intervention of various allergens (molds, isocyanates, plicatic acid, and formaldehyde) is often associated.[14] The nature of the woods handled is an important risk factor.[7]

In this work, negative correlations were found between seniority at the workplace and a few variables such as FEV1, Tiffeneau's index, and MEF 25–75. These results could suggest an increase in the tone of the bronchial muscle, leading to a certain degree of bronchoconstriction related to an irritating effect by exposure to wood dust.[8,25]

Like other authors, we find a synergistic deleterious effect of tobacco that potentiates the effects of professional air contaminants;[7,14] indeed, we found in our study more

obstructive ventilatory disorders in smokers than in non-smokers.

Practitioners the carpentry artisanal in Senegalese are part of the informal sector, and they work without any awareness of the risk of excessive atmospheric dusting which is responsible for irritative and allergic symptoms on the airway tract. Respiratory abnormalities can be sustained if no preventive measures are taken. Prevention must be technical, collective, and individual. Prevention in the workplace is mainly focused on the fight against dusting with respect to the average exposure values (installation of suction systems and wearing of personal protective equipment), favoring the installation of water point. Information, education, and communication actions on the risks involved (components of treatments applied to wood) and on tobacco control will complete the preventive approach. The urgent implementation of an occupational health system for the benefit of these workers, the easy access to care by an occupational doctor who must systematically seek a professional etiology but also the adoption of a table of occupational diseases related to wood.

CONCLUSION

The activities of ebony carpenters working in bad work conditions with significant risk of ventilatory disorders in developing countries including Senegal. The activities are carried out in unsuitable and poorly adapted premises, a polluted environment, and the workers' lack of information on the professional nuisances. Smoking and longevity in the trade increase the risks associated with dust inhalation. Exposure to high atmospheric concentrations of wood dust is considered the primary risk factor.[16,17]

In our country, the wood sector mainly employs artisans in small businesses. This is where prevention efforts should focus. Regulatory provisions need to be developed and supported by preventive measures.

Wood-related occupational pathology can be repaired in Senegal as part of Table 2 of the French General Regime, which deals with occupational respiratory diseases caused by wood.

However, more studies in the future with much larger cohorts would be needed to better confirm our results.

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