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Influence of Wood Dust Exposure on the Prevalence of Respiratory Symptoms and Spirometric Functional Abnormalities in Parakou in 2024

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Abstract

Introduction: Occupational exposure to wood dust is recognized as an important risk factor for chronic respiratory diseases. **Objective:** The aim of this study was to investigate the relationship between respiratory symptoms and functional measures on the one hand, and exposure to wood dust on the other hand in Parakou in 2024. **Methods:** This was a comparative cross-sectional study with data prospectively collected between June and September 2024. One hundred and eight carpenters (group exposed to wood dust) and 108 administrative agents (group not exposed to wood dust) were included in this study. A questionnaire was used to collect data on the occurrence of respiratory symptoms. A physical examination and pulmonary function testing were performed for each worker. Data were double-entered into Epi Data software version 2.0.7.7.22 and were analyzed using R 3.6.0 software. **Results:** The prevalence of respiratory symptoms occurring in the last 12 months was significantly higher among carpenters (93.52%) compared to administrative agents (55.56%), with a p-value < 0.001. Work-related respiratory symptoms, including rhinorrhea (p < 0.001), epistaxis (p = 0.016), cough (p < 0.001), sputum (p < 0.001), chest tightness (p < 0.001), dyspnoea (p = 0.009), and wheezing (p = 0.002), were significantly higher in carpenters than in administrative workers. Restrictive ventilatory disorders were significantly more common in carpenters than in administrative workers (48.15% vs. 20.37%; p < 0.001). The carpenter profession was significantly associated with the occurrence of respiratory symptoms, after adjustment for work environment, exposure to biomass,

and duration in the profession (aOR = 6.55; 95% CI = 2.72 - 17.7; p-value < 0.001). **Conclusion:** Exposure to wood dust among carpenters adversely affects respiratory function; hence the need to raise awareness among these professionals.

Keywords

Wood Dust, Wood Workers, Administrative Agents, Respiratory Symptoms, Parakou, Benin

1. Introduction

Chronic respiratory conditions are a major public health concern, affecting millions of individuals worldwide [1]. The occupational environment is increasingly implicated in the onset of many of these conditions, such as allergic rhinosinusitis, asthma, extrinsic allergic alveolitis, chronic bronchitis, chronic obstructive pulmonary disease (COPD), bronchopulmonary cancers, and diffuse interstitial lung diseases [2]. Their prevalence continues to rise due to new technical processes, the handling of harmful chemicals or dust particles, and significant-whether short-term or prolonged—exposure to chemicals and wood dust [3].

Wood is one of the most important renewable natural resources in the world, and in Benin in particular. It is a key raw material used in the manufacture of various types of furniture. Wood dust and its constituents enter the respiratory tract through inhalation, causing irritation of the mucous membranes and manifesting as respiratory symptoms in exposed workers [4]. The resulting respiratory diseases frequently lead to increased absenteeism, which can result in reduced productivity or even early retirement [5].

According to the National Institute of Statistics and Demography (INStaD) in Benin, the "carpentry and construction" sector is a branch of the informal economy representing 6.5% of artisanal units, 82% of which take on apprentices [6]. Carpentry plays a significant role in economic activity in Benin, including in Parakou. It is an artisanal trade practiced with limited resources and without adherence to safety or personal protection standards, thereby exposing workers to multiple pathogenic agents.

This study aims to bridge the gap caused by the lack of empirical data in our local context. The general objective of this study was to examine the relationship between respiratory symptoms and functional measurements on the one hand, and wood dust exposure on the other, in Parakou in 2024.

2. Methodology

2.1. Study Setting

This study was conducted in carpentry workshops, banks, the town hall, and the courthouse in the city of Parakou.

2.2. Study Methods

2.2.1. Study Type and Period

This was a comparative cross-sectional study involving prospective data collection. The study took place over a four-month period, from June to September 2024.

2.2.2. Population

1) Exposed Group

The study population comprised two groups: a group exposed to wood dust and a group not exposed to wood dust. The target population consisted of all carpenters working in the city of Parakou. The source population consisted of all carpenters working in the city of Parakou who were accessible, either geographically or after three scheduled appointments.

Inclusion criteria for the exposed group:

Carpenters included in the study were those who:

- were at least 18 years old;
- were non-smokers;
- had provided informed consent;
- were free from any psychiatric condition likely to impair their reasoning;
- had no contraindications for spirometry (stroke within the past 3 months, hospitalization for a cardiac condition, known arterial aneurysm, active pulmonary tuberculosis, recent surgery on the abdomen, thorax, or brain ≤ 3 weeks).

2) Non-Exposed Group

The target population consisted of all administrative staff working in banks, the town hall, and the courthouse in the city of Parakou.

The source population consisted of administrative staff working in banks, the town hall, and the courthouse in the city of Parakou who were accessible, either geographically or after three scheduled appointments.

Inclusion criteria for non-exposed individual:

Individuals included in the study were those who:

- were at least 18 years of age;
- were non-smokers;
- had provided informed consent;
- were free from any psychiatric condition likely to impair their reasoning;
- had no contraindications to undergoing spirometry (see spirometry).

3) Matching Criteria

The matching criteria between the two groups were:

- inclusion of one administrative worker (bank, town hall, or court) for each selected carpenter, *i.e.*, a matching ratio of 1:1;
- age;
- sex.

The participants were not individually matched. There was no matching between each exposed individual and their unexposed counterpart.

2.2.3. Sampling

1) Sampling Technique

A voluntary sampling approach was used for carpenters and administrative workers (bank, town hall, or court) due to the difficulty of obtaining their total population figures.

2) Sample Size

The sample size was calculated using OpenEpi software (https://www.openepi.com/Menu/OE_Menu.htm) via Fleiss's method with a correction factor. Based on a 95% confidence interval, 80% study power, a prevalence of any respiratory symptoms of 24.3% in the unexposed group and 43.2% in the wood-dust-exposed group (as reported in the study by Bislimovska *et al.* [7]), and a matching ratio of 1:1, the calculated sample size was 108 participants in each group (exposed and unexposed), resulting in a total sample size of 216 participants.

2.2.4. Study Variables

1) Dependent Variables

The dependent variable was "presence or absence of respiratory symptoms in the last 12 months." Respiratory symptoms include upper respiratory tract symptoms—namely pharyngeal pain, nasal congestion, nasal obstruction, sneezing, rhinorrhea, and epistaxis—and lower respiratory tract symptoms, such as cough, expectoration, dyspnea, chest tightness, and wheezing.

- Upper respiratory tract symptoms in the last 12 months and their link to work

- Nasal congestion: a binary variable referring to swelling of the nasal mucosa that creates the impression of a nasal voice. It is recorded based on the worker's self-report during the interview. Categories: yes or no.
- Work-related nasal congestion: a binary variable referring to nasal congestion that worsens at the workplace and improves on days off or public holidays. It is recorded based on the worker's self-report during the interview. Categories: yes or no.
- Pharyngeal pain: a binary variable referring to a sore throat exacerbated by swallowing. It is recorded based on the worker's self-report during the interview. Categories: yes or no.
- Work-related pharyngeal pain: a binary variable referring to pharyngeal pain that worsens at the workplace and improves on days off or public holidays. It is recorded based on the worker's self-report during the interview. Categories: yes or no.
- Nasal obstruction: a binary variable recorded for a worker who reports an obstruction to airflow entering and leaving the nose. Categories: yes or no.
- Work-related nasal obstruction: a binary variable referring to any nasal obstruction that worsens at the workplace and improves on days off or public holidays. It is determined based on the worker's statements during questioning. The options are: yes or no.
- Sneezing: binary variable; refers to any sudden, forceful expulsion of air through

the nose and mouth, triggered by irritation of the upper respiratory tract mucosa. It is recorded based on the worker's statements during questioning. Categories: yes or no.

- Work-related sneezing: binary variable; refers to any bout of sneezing that worsens at the workplace, with improvement on days off or public holidays. It is recorded based on the worker's statements during questioning. Categories: yes or no.
- Rhinorrhea: binary variable; recorded for a worker reporting fluid discharge from the nasal passages or sinuses. Categories: yes or no.
- Work-related rhinorrhea: binary variable; refers to rhinorrhea that worsens at the workplace, with improvement on days off or public holidays. It is recorded based on the worker's statements during questioning. Categories: yes or no.
- Epistaxis: binary variable; recorded for a worker reporting bleeding from the nasal passages. Categories: yes or no.
- Work-related epistaxis: binary variable; refers to epistaxis that worsens at the workplace, with improvement on days off or public holidays. It is recorded based on the worker's statements during questioning. Categories: yes or no.

• Lower respiratory tract symptoms in the last 12 months and work-relatedness

- Cough: binary variable; recorded for a worker reporting a sudden, jerky, noisy exhalation lasting several minutes, days, or months, rather than an occasional cough. Categories: yes or no.
- Work-related cough: a binary variable referring to a cough that worsens at the workplace and improves on days off or public holidays. It is determined based on the worker's statements during the interview. The response options are: yes or no.
- Expectoration: a binary variable referring to the presence of bronchial secretions brought up by coughing over a period of minutes, days, or months, rather than transient expectoration. It is determined based on the worker's statements during the interview. The response options are: yes or no.
- Work-related expectoration: a binary variable referring to any expectoration that worsens at the workplace and improves on days off or public holidays. It is identified based on the worker's statements during the interview. Categories: yes or no.
- Paroxysmal dyspnea: a binary variable identified in workers who report periodic episodes of breathing difficulty lasting several minutes or even hours, with symptom-free intervals. Categories: yes or no.
- Work-related paroxysmal dyspnea: a binary variable referring to paroxysmal dyspnea that occurs at the workplace and improves on days off or public holidays. It is identified based on the worker's statements during the interview. Categories: yes or no.
- Chronic dyspnea: a binary variable referring to persistent breathing difficulty—without symptom-free intervals—that typically worsens with exertion and lasts for several months or even years. It is identified based on the worker's state-

ments during the interview. Categories: yes or no.

- Work-related chronic dyspnea: refers to persistent chronic dyspnea that worsens at the workplace and improves on days off or public holidays. It is identified based on the worker's statements during the interview. Categories: yes or no.
- Recurrent wheezing: a binary variable referring to respiratory sounds resembling a cat's meow or bird chirping that occur regularly. It is identified based on the worker's statements during the interview. Categories: yes or no.
- Work-related recurrent wheezing: a binary variable referring to recurrent wheezing that occurs at the workplace and subsides on days off or public holidays. It is determined based on the worker's statements during questioning. The categories are: yes or no.
- Chest tightness: a binary variable referring to an unpleasant sensation of heaviness, pain, or pressure in the chest. It is determined based on the worker's statements during questioning. The categories are: yes or no.
- Work-related chest tightness: a binary variable referring to chest tightness that occurs at the workplace and subsides on days off or public holidays. It is determined based on the worker's statements during questioning. The categories are: yes or no.
- Recurrent lower respiratory tract infections: a binary variable identified in a worker reporting a recurring pattern of cough with expectoration accompanied by fever. The categories are: yes or no.

2) Independent Variables

The independent variables were sociodemographic characteristics (age, sex, ethnicity, marital status, education level) and medical history and lifestyle factors (asthma, pulmonary tuberculosis, hypertension, diabetes, passive smoking status, alcohol consumption and biomass exposure), work-related characteristics (Exposed group: daily working hours, duration of employment, room ventilation, presence of dust extraction systems, dust levels, use of personal protective equipment specific to wood dust; Non-exposed group: daily working hours, duration of employment), social security details, anthropometric characteristics (weight, height, body mass index), the relationship between respiratory symptoms and work, pleuropulmonary examination findings, and spirometry results.

2.2.5. Data Collection

1) Data Collection Equipment

The data collection equipment consisted of:

- A survey questionnaire: this was pre-tested on a sample of ten workers and subsequently revised.
- An electronic scale (STRIDES brand) with a 180 kg capacity and 100 g precision for weighing: the device is first turned on (displaying 0) and placed on a flat surface. The patient then steps onto the scale, and the weight is displayed.
- A stadiometer for measuring participant height: height was measured with participants standing, barefoot with feet flat on the floor and heels together, us-

ing a tape measure placed vertically against a wall, extending from the heels to the top of the head.

- A stethoscope for lung auscultation.
- A Contec SP10 spirometer.
- Spirometer mouthpieces (spirettes) compatible with the device.
- An air quality measuring device: indoor air monitor for PM2.5, PM1.0, and PM10. The measurement was individual.

2) Data Collection Team

The data collection team was led by a seventh-year general medicine student as part of her thesis, with two pulmonologists and an occupational physician serving as supervisors—specifically, the thesis director and co-directors.

3) Data Collection Procedure

The study was proposed to workers at their workplaces. An anonymous individual interview was conducted to gather information on sociodemographic and clinical data, medical history and lifestyle, occupational characteristics, the presence of respiratory symptoms, and the results of pleuropulmonary and ENT examinations. Spirometry was performed after ruling out contraindications (stroke within the previous 3 months, hospitalization for cardiac disease, known arterial aneurysm, active pulmonary tuberculosis, or abdominal, thoracic, or cranial surgery within the previous 3 weeks). A regularly calibrated portable SP10 spirometer was used. Spirometry data were anonymized and interpreted by a pulmonologist. Reference values were determined using the Global Lung Initiative 2012 equations. Dust levels were measured using an outdoor air quality monitor. Measurements were taken during peak dust episodes over a 15-minute period, during which both the operator and the subject wore FFP2-type masks. Based on these measurements, the short-term occupational exposure limit (STEL) was determined. This STEL represents the maximum concentration of a chemical substance in the air, measured or calculated over a maximum period of 15 minutes.

2.2.6. Data Processing and Analysis

Data collected on the survey forms were double-entered into EpiData software (version 2.0.7.7.22) and subsequently analyzed using R software (version 4.4.1). Quantitative variables were described using means (standard deviation) or medians (with interquartile range), depending on whether their distribution was normal or non-normal. Qualitative data were described using frequencies and percentages. Comparisons were made between the two groups regarding the presence of respiratory symptoms and the spirometric measurements obtained. Factors associated with the presence of respiratory symptoms in the past 12 months—including wood dust exposure—were investigated using simple logistic regression. Crude odds ratios (cOR), their 95% confidence intervals, and p-values were determined. Factors that were statistically significant or had a p-value < 0.2 were included in a multiple logistic regression model to determine adjusted odds ratios (aOR), their 95% confidence intervals, and p-values. Subsequently, factors associated with an increased risk of respiratory symptoms specifically among carpen-

ters—based on demographic characteristics, comorbidities, and occupational characteristics—were investigated using the same statistical analysis approach. Pearson's chi-squared and Fisher's exact tests (where applicable) were used. The significance threshold was set at <5%.

3. Results

A total of 216 workers participated in this study, comprising 108 carpenters (representing the group exposed to wood dust) and 108 administrative staff members (from city hall, the courts, and banks) representing the group not exposed to wood dust.

3.1. Socio-Demographic Characteristics

The mean age of the carpenters was 39.66 years ± 11.13 years, ranging from 23 to 68 years. The mean age of the administrative staff was 37.73 years ± 9 years, ranging from 23 to 67 years. There was no significant difference between the mean age of the carpenters and that of the administrative staff ($p = 0.163$). All participants were male. University-level education was found in 89.81% of the administrative staff and 7.41% of the carpenters. Forty-six (42.59%) carpenters had a secondary education. There was a significant difference between the educational level of the carpenters and that of the administrative staff ($p < 0.001$).

3.2. Occupational Characteristics

The mean duration of professional practice was 17.67 years ± 11.9 years (range: 2 - 40 years) for carpenters. For administrative staff, it was 8.49 years ± 6.38 years (range: 2 - 34 years). There was a significant difference in the duration of professional practice between the two groups ($p < 0.001$). The work environment was well-ventilated for all administrative staff and for 73.15% of carpenters. A significant difference existed between the work environments of carpenters and administrative staff ($p < 0.001$). The daily working time was 8 hours or more for 98.15% of workers in both groups surveyed (Table 1).

Table 1. Distribution of carpenters and administrative staff according to occupational characteristics in Parakou in 2024.

	Carpenters (N = 108)		Administrative Staff (N = 108)		
	n	(%)	n	(%)	p-Value
Years of Experience in the Profession					
<15	47	(43.52)	85	(78.70)	**<0.001**
≥15	61	(56.48)	23	(21.30)	**<0.001**
Work Environment					
Airy	79	(73.15)	108	(100)	**0.034**
Confined	29	(26.85)	0	(0.00)	**<0.001**

Continued

Daily Working Time (Hours)					
<8	2	(1.85)	2	(1.85)	>0.999
≥8	106	(98.15)	106	(98.15)	>0.999

3.3. Working Conditions of Carpenters

3.3.1. Types of Wood Used and Dust Levels

The types of wood used were African teak (65.64%), afzelia (63.85%), Senegal mahogany (8.33%), and gmelina (3.70%). The mean dust level was 1.40 mg/m^3 ± 0.61 mg/m^3, ranging from 0.10 to 2.91 mg/m^3 for PM10 particles. For PM2.5 particles, the mean dust level was 1.22 mg/m^3 ± 0.56 mg/m^3, ranging from 0.98 to 2.74 mg/m^3. The mean dust level for PM1.0 particles was 1.15 mg/m^3 ± 0.58 mg/m^3, ranging from 0.16 to 2.34 mg/m^3. Dust levels exceeded 1 mg/m^3 for 73.27% of carpenters regarding PM10 particles. For PM2.5 particles, levels exceeded 1 mg/m^3 for 70.30% of carpenters, and for PM1.0 particles, this figure was 56.44%. Sixty-six carpenters (61.11%) used machinery. Workshop cleaning methods consisted of dry sweeping in 61.11% of cases and the use of a compressor in 4.63% of cases.

3.3.2. Data on Workplace Protection Measures for Carpenters

One hundred carpenters (92.59%) worked in workshops lacking wood dust collection systems. Homemade masks were used as personal protective equipment (PPE) by 107 carpenters (99.07%). Fifty-two carpenters (48.15%) reported using PPE "sometimes."

3.4. Prevalence of Respiratory Symptoms

The prevalence of respiratory symptoms over the past 12 months was 93.52% among carpenters and 55.56% among administrative staff. There was a significant difference in respiratory symptoms between carpenters and administrative staff ($p < 0.001$). Carpenters were 1.68 times more likely to experience respiratory symptoms than administrative staff.

3.4.1. Prevalence of Upper Respiratory Tract Symptoms

All symptoms related to upper respiratory tract involvement—namely sneezing ($p < 0.001$), nasal obstruction ($p < 0.001$), rhinorrhea ($p < 0.001$), nasal congestion ($p < 0.001$), pharyngeal pain ($p < 0.001$), and epistaxis ($p = 0.006$)—were significantly more frequent among carpenters compared to administrative staff. Sneezing, nasal obstruction, and rhinorrhea were observed in carpenters in 76.85%, 65.74%, and 59.26% of cases, respectively. Twelve carpenters (11.11%) reported epistaxis.

3.4.2. Prevalence of Lower Respiratory Tract Symptoms

Symptoms related to lower respiratory tract involvement—such as cough ($p < 0.001$), expectoration ($p < 0.001$), chest tightness ($p < 0.001$), paroxysmal dyspnea

(p = 0.009), and wheezing (p = 0.006)—were significantly more frequent among carpenters compared to administrative staff. Cough, expectoration, chest tightness, and chronic dyspnea were reported by carpenters in 63.69%, 59.26%, 29.63% of cases, and 3.78% of cases, respectively. No administrative staff member reported chronic dyspnea (Table 2).

Table 2. Frequency of lower respiratory tract symptoms over the last 12 months (July 2023 to June 2024) among carpenters and administrative staff in Parakou.

	Carpenters (N =108)		Administrative Staff (N = 108)		
	n	(%)	n	(%)	p-Value
Cough	69	(63.69)	15	(13.89)	**<0.001**
Sputum production	64	(59.26)	3	(2.78)	**<0.001**
Chest tightness	32	(29.63)	3	(2.78)	**<0.001**
Paroxysmal dyspnea	19	(17.59)	6	(5.56)	**0.009**
Wheezing	12	(11.11)	2	(1.85)	**0.006**
Recurrent lower respiratory tract infections	5	(4.63)	1	(0.93)	0.125
Chronic dyspnea	3	(3.78)	0	(0.00)	0.125

3.4.3. Prevalence of Work-Related Respiratory Symptoms

Of the 108 carpenters presenting with respiratory symptoms, 99 (91.67%) reported that they were work-related. Among the 108 administrative staff members who reported respiratory symptoms, 21 (19.44%) stated that these symptoms were work-related. There was a significant difference regarding work-related respiratory symptoms between carpenters and administrative staff (p < 0.001). Carpenters were 4.71 times more likely to experience work-related respiratory symptoms than administrative staff.

3.4.4. Prevalence of Work-Related Upper Respiratory Tract Symptoms

All symptoms associated with upper respiratory tract involvement—namely sneezing (p < 0.001), rhinorrhea (p < 0.001), nasal obstruction (p < 0.001), nasal congestion (p < 0.001), pharyngeal pain (p < 0.001), and epistaxis (p = 0.016)—were significantly more frequent among carpenters compared to administrative staff. Sneezing, nasal obstruction, rhinorrhea, and epistaxis were reported by carpenters as being work-related in 75.93%, 61.11%, 54.63%, and 5.56% of cases, respectively (Table 3).

3.4.5. Prevalence of Work-Related Lower Respiratory Tract Symptoms

Work-related lower respiratory tract symptoms—such as cough (p < 0.001), sputum production (p < 0.001), chest tightness (p < 0.001), paroxysmal dyspnea (p = 0.009), and wheezing (p = 0.002)—were significantly more frequent among carpenters compared to administrative staff. Cough and sputum production occurring at the workplace were reported by 63 carpenters (58.33%). Among adminis-

trative staff, only cough was reported as work-related, representing a proportion of 1.85% (Table 4).

Table 3. Frequency of work-related upper respiratory tract symptoms over the past 12 months (July 2023 to June 2024) among carpenters and administrative staff in Parakou.

	Carpenters (N = 108)		Administrative Staff (N = 108)		
	n	(%)	n	(%)	p-Value
Sneezing	82	(75.93)	17	(15.74)	**<0.001**
Nasal obstruction	66	(61.11)	10	(9.26)	**<0.001**
Rhinorrhea	59	(54.63)	8	(7.41)	**<0.001**
Nasal congestion	46	(42.59)	4	(3.70)	**<0.001**
Pharyngeal pain	37	(34.26)	1	(0.93)	**<0.001**
Epistaxis	6	(5.56)	0	(0.00)	**0.016**

Table 4. Frequency of work-related lower respiratory tract symptoms over the past 12 months (July 2023 to June 2024) among carpenters and administrative staff in Parakou.

	Carpenters N = 108		Administrative Staff N = 108		
	n	(%)	n	(%)	p-Value
Cough	63	(58.33)	2	(1.85)	**<0.001**
Sputum production	63	(58.33)	0	(0.00)	**<0.001**
Chest tightness	31	(28.70)	0	(0.00)	**<0.001**
Paroxysmal dyspnea	18	(16.67)	0	(0.00)	**<0.001**
Wheezing	10	(9.26)	0	(0.00)	**0.002**
Chronic dyspnea	3	(2.78)	0	(0.00)	0.123

3.5. Spirometry Results

Spirometry was performed on all 216 participants.

Restrictive ventilatory defects were significantly more common among carpenters compared to administrative staff ($p < 0.001$). Fifty-two (48.15%) carpenters presented with a restrictive ventilatory defect. One carpenter (0.93%) presented with an obstructive ventilatory defect (Table 5).

3.6. Factors Associated with the Occurrence of Respiratory Symptoms among Carpenters and Administrative Staff

3.6.1. Bivariate Analysis Using Simple Logistic Regression among Carpenters and Administrative Staff

1) Association between the occurrence of respiratory symptoms and age and occupation

Table 5. Distribution of spirometric functional abnormalities among carpenters and administrative staff in Parakou in 2024.

	Carpenters (N = 108)		Administrative Staff (N = 108)		p-Value
	n	(%)	n	(%)	
Spirometry Results					
Normal spirometry	55	(50.93)	86	(79.63)	**0.009**
Restrictive ventilatory defect	52	(48.15)	22	(20.37)	**<0.001**
Obstructive ventilatory defect	1	(0.93)	0	(0.00)	0.500

In the bivariate analysis, the occupation of carpenter (ORb = 11.54; p < 0.001) was associated with the occurrence of respiratory symptoms.

2) Association between the occurrence of respiratory symptoms and medical history

In the bivariate analysis, reported medical history was not associated with the occurrence of respiratory symptoms.

3.6.2. Factors Associated with Respiratory Symptoms among Carpenters and Administrative Staff via Multivariate Analysis Using Multiple Logistic Regression

Being a carpenter increases the risk of experiencing respiratory symptoms (ORa = 6.55; p < 0.001) after adjusting for work environment, biomass exposure, and duration of employment in the profession (Table 6).

Table 6. Factors associated with the occurrence of symptoms following multiple logistic regression among carpenters and administrative staff in Parakou in 2024.

	aOR	95% CI	p-Value
Profession			
Administrative staff	1		
Carpenters	6.55	2.72 - 17.7	**<0.001**
Work Environment			
Well-ventilated	1		
Confined	0.67	0.19 - 2.76	0.6
Biomass Exposure			
No	1		
Yes	2.72	0.92 - 10	0.09
Years in the Profession	1	0.96 - 1.04	>0.9

3.7. Factors Associated with Respiratory Symptoms among Carpenters

3.7.1. Bivariate Analysis Using Simple Logistic Regression among Carpenters

Association with age, weight status, and lifestyle:

In the bivariate analysis, age, weight status, and passive smoking were not associated with the occurrence of respiratory symptoms among carpenters (Table 7).

Table 7. Simple logistic regression between the worksite and the occurrence of respiratory symptoms among carpenters in Parakou in 2024.

	n/N	%	ORc	95% CI	p-Value
Age (Years)	-	-	0.98	0.93 - 1.04	0.5
Weight Status					
Normal	69/73	(94.52)	1		
Undernutrition	2/4	(50)	0.058	0.02 - 0.64	0.3
Overweight	23/24	(95.83)	1.33	0.48 - 54	0.3
Obesity	6/7	(85.71)	0.74	0.11 - 14.9	0.8
Passive Smoking					
No	86/92	(93.48)	1		
Yes	15/16	(93.75)	2.04	0.35 - 38.6	0.5

ORc: Crude odds ratio; 95% CI: 95% confidence interval.

3.7.2. Association between the Occurrence of Respiratory Symptoms, Duration of Employment, and Work Environment

In the bivariate analysis, duration of employment and work environment were not associated with the occurrence of respiratory symptoms among carpenters (Table 8).

Table 8. Simple logistic regression between duration of employment, work environment, and the occurrence of respiratory symptoms among carpenters in Parakou in 2024.

	n/N	%	ORc	95% CI	p-Value
Duration of Professional Practice	-	-	0.98	0.92 - 1.03	0.4
Work Environment					
Well-ventilated	74/79	(93.67)	1		
Confined	26/29	(89.66)	0.59	0.20 - 2.82	0.6

ORc: Crude odds ratio; 95% CI: 95% confidence interval.

4. Discussion

4.1. Socio-Demographic Data

The majority of our study population consisted of adults, with a mean age of 39.66 years ± 11.13 years for carpenters and 37.73 years ± 9 years for administrative staff; there was no significant difference between the two groups. These results are similar to those reported by Ennin *et al.* in Ghana in 2023, who found a mean age of 37.36 years for woodworkers and 37.92 years for the control group (p = 0.713) [8]. Similarly, Massoud *et al.* in Iran (2018) found a mean age of 37.41 years among carpenters compared to 40.42 years among non-carpenters (p = 0.07) [9]. Indeed,

young adults constitute the most active segment of the population in any country, which likely explains the mean age and the lack of significant difference observed in most studies.

Education levels were significantly higher among administrative staff than among carpenters. Generally, employment in public or private administration requires at least a secondary education, whereas this is not the case for the carpentry profession.

4.2. Lifestyle

Exposure to biomass smoke and secondhand smoke was more common among carpenters than among administrative staff ($p < 0.001$). This exposure is likely attributable in part to the less favorable socioeconomic conditions of most carpenters, who often still rely on wood or charcoal fires for cooking. Furthermore, challenging working conditions may encourage tobacco use among some individuals—or those around them—as a means of boosting physical stamina to increase productivity.

4.3. Professional Characteristics

The mean duration of professional practice was 17.67 years ± 11.9 years for carpenters and 8.49 years ± 6.38 years for administrative staff, a significant difference. Assessments of the duration of practice in trades such as carpentry often include the apprenticeship period, whereas in administration, it is calculated from the date of taking office. This could explain the longer mean duration observed among carpenters. In 2009, Beladed *et al.* also found a mean duration of professional practice of 17.75 years ± 0.98 years for carpenters in Algeria [10].

Administrative staff reported working in well-ventilated environments more frequently than carpenters ($p < 0.001$). This result reflects the stark contrast between working conditions in administration—a formal sector—and carpentry, which remains part of the informal economy in Benin. Much remains to be done to properly structure this sector and ensure an adequate working environment for woodworkers.

4.4. Analysis of Working Conditions for Carpenters

In this study, carpenters were exposed to wood dust from various species, notably afzelia, African teak, Senegal mahogany, and gmelina. Mean dust concentration levels were 1.397 mg/m^3 ± 0.61 mg/m^3 for PM10 particles, 1.221 mg/m^3 ± 0.56 mg/m^3 for PM2.5 particles, and 1.153 mg/m^3 ± 0.58 mg/m^3 for PM1.0 particles. Most carpenters were exposed to dust levels exceeding 1 mg/m^3—the wood dust exposure limit established in the Labor Code under Decree No. 2003-1254 of December 23, 2003, as defined by the National Research and Safety Institute (INRS) [11]. These results are comparable to those reported by Tobin *et al.*, who found a mean dust level of 1.39 mg/m^3 ± 0.28 mg/m^3 in woodworking workshops in Nigeria in 2016 [12]. In 2018, Massoud *et al.* found an even higher mean dust level

of 2.44 mg/m^3 ± 0.66 mg/m^3 in carpentry workshops in Iran [9]. The high concentration of wood dust in carpentry workshops can be attributed to the absence of dust collection systems and poor ventilation. Furthermore, there is no effective policy for regulating or monitoring the carpentry profession in Benin at either the local or national level, as the sector remains largely informal.

4.5. Prevalence of Respiratory Symptoms over the Past 12 Months

The presence of at least one respiratory symptom over the past 12 months was reported significantly more often by almost all carpenters compared to nearly half of the administrative staff ($p < 0.001$). Several authors have obtained results similar to ours. Indeed, in a 2016 study in Nigeria involving 227 woodworkers and 227 workers from a water bottling plant, Tobin *et al.* reported a respiratory symptom prevalence of 68% among woodworkers compared to 10% in the comparison group ($p < 0.001$) [12]. In a 2015 study in Cameroon involving 194 carpenters and 122 office workers, Nde *et al.* found a prevalence of 51% among carpenters compared to 26.2% in the control group ($p = 0.01$) [13]. These differences in prevalence could be explained by the methodologies employed by these authors. Specifically, both Tobin *et al.* and Nde *et al.* considered only lower respiratory tract symptoms. Furthermore, in the study by Tobin *et al.*, respiratory symptoms were assessed over a period of only three months.

The high prevalence of respiratory symptoms among carpenters is likely linked to wood dust generated during sawing and sanding operations; this dust is inhaled and deposited throughout the respiratory tract (nose, bronchi, and lungs). In most of the workshops where the study was conducted, more than three-quarters of the carpenters used machines that produce ultrafine dust capable of remaining airborne for several hours, thereby exposing them to excessive dust levels. Additionally, some carpenters worked in confined environments (26.85%). All these factors could be responsible for the irritative and allergic symptoms affecting the respiratory tract.

4.5.1. Analysis of the Prevalence of Work-Related Upper Respiratory Tract Symptoms

All symptoms associated with upper respiratory tract involvement—namely sneezing, rhinorrhea, nasal obstruction, nasal congestion, pharyngeal pain, and epistaxis—were significantly more frequent among carpenters than administrative staff. The most common symptoms were sneezing (75.95% vs. 15.74%; $p < 0.001$), nasal obstruction (61.11% vs. 9.26%; $p < 0.001$), and rhinorrhea (54.63% vs. 7.41%; $p < 0.001$). These results corroborate findings from other authors in the literature. For instance, in a 2024 study conducted in Ghana involving 104 woodworkers and a control group, Ennin *et al.* also reported a prevalence of sneezing (58% vs. 4%; $p < 0.01$) and rhinorrhea (61% vs. 1%; $p < 0.01$) among woodworkers [8]. Similarly, in a 2009 study in Türkiye involving 328 carpenters and 328 controls, Osman *et al.* found a predominance of sneezing (53.7% vs. 0%; $p < 0.001$) and rhinorrhea (23.8% vs. 0%; $p < 0.001$) [14]. This difference in prevalence between carpenters and other

worker groups could be explained by the fact that wood dust exposure reduces nasal patency due to the involvement of various allergic, irritant, or toxic factors [15]. Ahman *et al.*, while investigating inflammatory markers in nasal secretions, discovered the existence of inflammatory effects on the nasal mucosa associated with wood dust [16]. The intensity and extent of these symptoms vary and depend on dust concentrations, wood hardness and type, handling methods, associated chemicals, and whether or not collective and personal protective equipment is used.

Although the prevalence of epistaxis was relatively low, its occurrence also indicates irritation and inflammation of the nasal mucosa; recurrent episodes should prompt an investigation for sinonasal cancer.

4.5.2. Analysis of the Prevalence of Work-Related Lower Respiratory Tract Symptoms

The frequency of cough was significantly higher among carpenters than among administrative staff ($p < 0.001$). Other work-related lower respiratory tract symptoms were reported only by carpenters and were dominated by expectoration (58.33%), chest tightness (28.70%), and wheezing (9.26%). These results are consistent with data from the literature [7] [14] [17]-[19]. Tobin *et al.* in Nigeria reported the main respiratory symptoms as cough (41.2% vs. 4.5%; $p < 0.001$), expectoration (37.4% vs. 0%; $p < 0.001$), paroxysmal dyspnea (2.6% vs. 0%; $p < 0.001$), and chest tightness (2% vs. 0%; $p < 0.001$) [12]. Meanwhile, in a 2019 study in Ethiopia involving 70 carpenters and 70 traders, Demissie *et al.* found cough (41.4% vs. 10.00%; $p < 0.001$), expectoration (34.3% vs. 14.3%; $p = 0.01$), chest tightness (32.9% vs. 17.1%; $p = 0.032$), paroxysmal dyspnea (21.25% vs. 14.30%; $p = 0.41$), and wheezing (12.4% vs. 8.6%; $p = 0.02$) [20]. The high prevalence of these symptoms among carpenters attests to the harmful effects of wood dust on the respiratory tract, particularly the bronchi. Composed of cellulose and other soluble chemicals—including acetic acid and resins—this dust consists largely of fibers that irritate cough receptors in the trachea and cause mucus stasis in the lower respiratory tract, thereby explaining the prevalence of coughing and expectoration. Working conditions—specifically confined environments, a lack of individual and collective protective measures, and various wood-processing methods—further account for the high frequency of these symptoms among carpenters.

4.6. Functional Spirometric Abnormalities

Spirometry results differed significantly between carpenters and administrative staff ($p < 0.001$). Spirometric abnormalities were predominantly characterized by restrictive ventilatory impairment, affecting nearly half of the carpenters (48.15%) and less than a quarter of the administrative staff. In a 2001 study conducted in Morocco involving 242 carpenters and 121 subjects unexposed to wood dust, Laraqui *et al.* found a restrictive ventilatory impairment prevalence of 30.1% among carpenters and 12.5% among unexposed subjects, a significant difference between the two groups ($p < 0.001$) [21]. Similarly, a 2023 study by Ekman *et al.* in Ghana found a high prevalence of restrictive ventilatory impairment—43.8% among car-

penters versus 19% among those unexposed to wood dust (p = 0.008) [22]. In contrast, Nde *et al.* found a lower frequency of restrictive ventilatory impairment in Cameroon in 2015 (17% of carpenters versus 11.5% of office workers), with no significant difference between the groups (p = 0.152). These results demonstrate that wood dust exposure progressively impairs the lung function of exposed workers. Indeed, the presence of fine dust particles in the airways and lungs leads to increased oxidative stress and inflammatory reactions, heightened airway constriction, and reduced lung tissue elasticity [23]. This results in increased airway resistance and a loss of lung compliance, followed by a decrease in FVC and FEV1 [23]. The high frequency of restrictive ventilatory disorders observed in our study may point to a loss of lung compliance, which can eventually lead to pulmonary fibrosis. Exposure to wood dust has been implicated in the development of pulmonary fibrosis due to increased inflammation [24].

4.7. Factors Associated with Respiratory Symptoms

Following bivariate and subsequent multivariate analysis, the occupation of carpenter was significantly associated with the occurrence of respiratory symptoms (aOR = 6.55; p < 0.001) after adjusting for other factors. A 2024 study by Abateneth *et al.* in Ethiopia also found that wood dust exposure was associated with the occurrence of respiratory symptoms (aOR = 14.36; CI = 7.6 - 27.0; p = 0.01) [25]. In our study, we did not find an association between age or duration of employment and the occurrence of respiratory symptoms among carpenters. Similar findings were reported by Nde *et al.* in Cameroon in 2015 [13]. Indeed, these results indicate that the occurrence of respiratory symptoms among carpenters appears to stem exclusively from wood dust exposure, regardless of the level of exposure, wood type, processing methods, or protective measures used. This risk is further heightened by prolonged exposure and the presence of other factors contributing to chronic bronchial inflammation, such as smoking [10].

4.8. Practical Implications and Scope for Future Research

Workers exhibiting ventilatory disorders were referred to specialized pulmonology and occupational health consultations. This study indicated that workplace air pollution is the primary cause of increased respiratory symptoms and reduced lung function among carpenters. Wood dust is the main pathogenic factor. Consequently, measures must be implemented to minimize the adverse effects of wood dust on carpenters and improve workplace safety. In addition to wood dust exposure, carpenters are heavily exposed to a variety of chemicals, fungi, and bacteria present on fresh wood. Consequently, the decline in lung function reported in this study could also be—at least in part—attributable to these factors. It is important to further investigate the interplay of all the mechanisms contributing to this decline in lung function among these professionals.

5. Conclusion

This study demonstrated that exposure to wood dust significantly increases the

risk of developing most respiratory symptoms—affecting both the upper and lower respiratory tracts—thereby highlighting the pathogenic effects of inhaling it. It constitutes a risk factor for the development of these symptoms, even after adjusting for other variables such as workplace ventilation, exposure to biomass, and duration of employment in the trade. Respiratory functional abnormalities—predominantly restrictive defects—are significantly more prevalent among carpenters than among administrative staff. Harmful dust levels exceeding 1 mg/m^3 were identified. The working conditions of these carpenters are characterized by poorly ventilated environments, the use of toxic substances, and a lack of collective and individual protective measures.

Author Contributions

Ibrahim Mama Cissé: Study design and implementation, data analysis and interpretation, and writing; **Mênonli Adjobimey:** Management, data analysis and interpretation, and manuscript revision; **Josiane Patricia Mapto Fopoussi:** Data preparation, collection, management, analysis, and interpretation; **Mariano Efio:** Data collection, analysis, and writing; **Serge Ade:** Data collection, analysis, and writing; **Ahouménou Paul Ayélo:** Manuscript revision and approval.

Ethical Considerations

The study was conducted with the approval of the Local Ethics Committee for Biomedical Research at the University of Parakou. Informed consent was obtained from participants beforehand. Data confidentiality was maintained.

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Conflicts of Interest

The authors declare no conflicts of interest regarding this article. The manuscript has not been published, in whole or in part, in any medical or scientific journal—whether in French or another language—nor is it currently under consideration elsewhere.

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