



Chronic respiratory symptoms and lung function parameters in large-scale wood factory workers in Addis Ababa, Ethiopia: a comparative cross-sectional study

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Abstract

Background Occupational wood dust causes chronic respiratory health problems as well as a decline in lung function. However, data on the prevalence of chronic respiratory symptoms and lung function parameters among large-scale wood factories workers in Ethiopia producing furniture are limited. The objective of this study was to determine the prevalence of chronic respiratory symptoms, lung function measures, and associated factors among large-scale wood industry workers in Addis Ababa, Ethiopia.

Methods An institution-based cross-sectional study was conducted among 232 wood workers and 232 controls. Participants for the study were selected using stratified and systematic sampling from soft drink and wood factories. The chronic respiratory symptoms were assessed using a modified American Thoracic Society (ATS) questionnaire, and lung function tests were performed using an Easy on PC spirometer in accordance with the ATS standards for spirometry. The data were imported into Epi-data version 4.4.2 and analyzed with SPSS version 23. Poisson regression, Multivariate linear regression and multivariable logistic regression analysis were used.

Results The prevalence ratio of overall chronic respiratory symptoms was significantly higher among woodworkers (65.7%) compared to controls (23.3%) in this study (PR = 2.17, 95% CI: 1.51–3.12). Current chronic respiratory symptoms were associated with gender, and previous chronic respiratory disease. Woodworkers had significantly lower Forced vital capacity (FVC) and Forced expiratory volume in the first second (FEV1) when compared to controls.

Conclusion Woodworkers had a higher prevalence of chronic respiratory symptoms and lower lung function measures, which lowered lung capacity when compared to controls. To reduce workers' exposure to wood dust, engineering control methods should be implemented.

Keywords Chronic respiratory symptoms · Lung function tests · Wood dust · Workers

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Abbreviations

AAU	Addis Ababa University
AOR	Adjusted odds ratio
ATS	American Thoracic Society
COR	Crude odds ratio
FVC	Forced vital capacity
FEV1	Forced Expiratory Volume in one second
RPD	Respiratory protective device
SPSS	Statistical Packages for Social Science

Introduction

Wood is one of the world's most important renewable natural resources, with an estimated 1700 million m³ of forest extracted for industrial purposes each year (World Health

Organization 1995). Every day, at least 2 million people are exposed to wood dust around the world. Moreover, approximately 3.6 million workers in the European Union are exposed to wood (World Health Organization 1995; Kauppinen et al. 2006).

According to the global estimate of occupational accidents and work-related illness 2017, 2.78 million people die each year from work-related accidents and diseases, including woodworkers around the world (Hämäläinen et al. 2017). Occupational respiratory disorders are a serious global public health problem, accounting for up to 30% of all documented work-related deaths and having a 50% prevalence among employees in high-risk sectors, such as mining, construction, and dust-generating works (Fedotov 2011). Approximately 12,000 people die each year as a result of occupational respiratory diseases in industrialized countries such as the United Kingdom (Health and Safety Executive 2017).

Wood processing from furniture factory caused wood dust and other health hazards. The dust is divided into two groups according to their size: total dust with particle size larger than 10 micron ($PM > 10$), mainly are soft dust (Rosenberg et al. 2002); and respirable dust with particle size smaller than 10 micron ($PM < 10$), mainly from hardwood (Schlünssen et al. 2002). In addition, both hardwoods and softwoods are used in furniture factory (World Health Organization 1995). Wood dust exposure has been linked to nasal adenocarcinoma, chronic bronchitis, lung cancer, nasal obstruction, increased risk of respiratory symptoms, and asthma (Alonso-Sardón et al. 2015; Jacobsen et al. 2009; Vallières et al. 2015; Schlünssen et al. 2002; Wiggans et al. 2016). Furthermore, the International Agency for Research on Cancer has classified wood dust as carcinogenic to humans (Group 1) and causes cancer of the nasal cavity, paranasal sinuses, Nasopharyngeal cancer (World Health Organization 1995).

Previous studies from industrial countries have indicated that workers in wood processing sectors exposed to wood dust in their working environment have a greater risk of respiratory complaints than control groups (Bhatti et al. 2011; Jacobsen et al. 2009, 2008; Löfstedt et al. 2017; Neghab et al. 2018; Osman and Pala 2009). A study conducted in Iran showed an increase chronic respiratory symptoms of wheezing, chest tightness, cough, phlegm, dyspnea, and reduced lung function among exposed groups (Neghab et al. 2018). In low- and middle-income countries, including Africa, where there is no effective legislative enforcement to reduce the levels of dust, workers exposed to wood dust might suffer chronic respiratory symptoms, such as persistent cough, sputum, wheezing, chest pain, and associated with a reduction of lung function parameters (Bosan and Okpapi 2004; Ugheoke et al. 2006; Ennin et al. 2015; Tobin et al. 2016). The American Conference of Governmental

Industrial Hygienists (ACGIH) recommends an 8-h time-weighted average (TWA) of 1 mg/m^3 for hard wood dust and 5 mg/m^3 for soft wood dust, while OSHA proposed an 8-h TWA of 1 mg/m^3 for hard wood dust and 5 mg/m^3 for soft wood dust, with the exception of Western red cedar (Martin and Zalk 1997; Scheeper et al. 1995). In addition, the European Union (EU) in 1999, decided the permissible limit for the exposure to inhalable wood dust to be 5 mg/m^3 (Magagnotti et al. 2013), and the European Unions (EU's) Scientific Committee for Occupational Exposure Limits (SCOEL), exposure to wood dust above 0.5 mg/m^3 causes lung function effects (Schulze et al. 2003).

Despite increased furniture production in Ethiopia (Edwards 2010), little is known about worker occupational health and safety (Kumie et al. 2016). Three studies from Ethiopian wood factories were published between 2015 and 2019 (Ayalew et al. 2015; Fentie et al. 2019; Asgedom et al. 2019). The two Ethiopian studies, like most previous studies in wood factories across the world, focused on small-scale wood factories, with one focusing on particleboard companies that used eucalyptus trees as a raw material. A recent study in medium-scale wood factories in Ethiopian found a high level of geometric mean dust exposure ($GM = 10.3 \text{ mg/m}^3$) (Awoke et al. 2021) which was higher than the ACGIH wood dust levels standard. Other studies conducted in Ethiopia among small-scale and particleboard workers investigated the prevalence of chronic respiratory symptoms (Fentie et al. 2019; Asgedom et al. 2019), and personal wood dust concentration level of workers in small-scale and medium wood workers (Ayalew et al. 2015; Awoke et al. 2021).

Previous studies, on the other hand, did not investigate the prevalence of chronic respiratory symptoms, lung function parameters, and associated factors in large-scale wood furniture factories that employ substantial number of people and produce a variety of wood products. The aim of the study was to determine whether respiratory symptoms and lung function among large-scale woodworkers were associated with wood dust exposure in Addis Ababa, Ethiopia.

Materials and methods

Study setting, design and period

The study was carried out in wood factories in Addis Ababa, Ethiopia. There are eight large-scale wood factories in Addis Ababa which produce final goods for instance furniture production, and four of them were included in the study. The wood factories have four operational units. These are the machine operating unit, which generates a significant amount of dust while machining, the carpentry unit, which is responsible for cutting wood into the standard sizes required for further machining using sawing, the sanding unit, which

is responsible for smoothing the surface of wood, and the painting unit, which uses surface treating chemicals. Moreover, in these wood factories, they have used dry wood and other adhesive chemicals.

The study also includes comparison workers from soft drink factories in Addis Ababa. We assumed that workers in soft drink plants were less exposed to dust and used them as a control group. There are three soft drink factories in Addis Ababa, Ethiopia. An institutional-based comparative cross-sectional study was conducted from February to April 2019 among these workers.

Study population and selection criteria

Two hundred and thirty two wood factory workers who have worked for at least 1 year at the factory were included in this study. In addition, as a control group, we recruited 232 soft drink industry workers. Due to limited resources, lung function tests were only performed on 104 randomly selected male workers (52 from the wood factory and 52 from the soft drink factory) out of 464 study participants. We included workers, over the age of 18, who have been actively involved in the production of wood and soft drinks for at least one year. Workers with recent abdominal or chest surgery, heart failure, TB, emphysema, and acute illness were all excluded from the lung function test.

Sampling procedure

First, in both the wood and soft drink factories, we divided the work process into production units, assuming that workers in different production units would be exposed to varying levels of dust. The sample was then determined using systematic sampling techniques. The workers' roster was used as a sampling frame. The first study participant was chosen at random from each production unit. Then, every 3rd worker was selected from the workers' rosters in each production unit.

Data collection procedure

Interviews

An interview was conducted to assess chronic respiratory symptoms using American Thoracic society questionnaires (ATS) (Liard and Neukirch 2000). The questionnaire's components included socio-demographic variables, the use of respiratory protective devices while working (yes/no) and the reason for not using respiratory protective devices (RPD). To maintain consistency with the original, the questionnaire was translated from English to Amharic and then back to English using standard translation procedures.

Prior to the actual data collection, the data collection tool was validated. Questions that were difficult for participants to understand were rephrased. The study participant was given a brief explanation about the purpose of the study prior to the interview, and the interview was conducted (face to face) for the selected woodworkers and controls in an office located at their workplaces in private.

Spirometry and anthropometric measurements

The American Thoracic Society-recommended NDD Easy on PC spirometer linked to a laptop was used to evaluate lung function parameters, such as FVC, FEV1, and FEV1/FVC in both woodworkers, and controls in a sitting (Miller et al. 2005). Spirometry was performed early in the morning, before the workers went to work. The technique was demonstrated to each participant prior to the actual lung function testing and supervised throughout the test process. FVC, FEV1, and the FEV1/FVC ratio were the lung function parameters studied. The participants' weight (kg) was measured using a standardized electronic weighing machine while they stood and wore light clothing, and their height (cm) was measured using a stadiometer with portable field survey scales, as recommended by the American Thoracic Society (Miller et al. 2005), and body mass index (BMI) was also calculated using NDD Medical technologies software. In this study, the lung function parameters are presented only in the absolute values because there are no reference equations for the Ethiopia population for obtaining predicted values.

Statistical analysis

During the data collection period, collected data were double-checked for completeness and consistency. We organized and entered the data in Epi-data version 4.4.2 and has been exported to SPSS version 23 for analysis. To summarize the data, descriptive statistics were used. The Pearson's Chi-square test or Fisher's exact test (if the expected value was less than 5) was used to compare categorical responses of the difference between woodworkers and controls, while an independent t test was used to compare means of continuous variables. A Poisson regression model with a robust estimator was used to estimate prevalence ratio (PR) after controlling for confounders; age, education, income, previous respiratory disease, working experience, working hour per week, previous dust exposure, safety training. Prevalence ratio (PR) was chosen instead of prevalence odds ratio (POR) due to the high chronic respiratory symptom prevalence in this study (Tamhane et al. 2016).

Logistic regression analysis was used to determine whether or not exposure variables were significantly associated with respiratory symptom. After adjusted for

confounding variables, such as gender, age, educational status, income, religion, previous respiratory disease, previous dust exposure, and safety training, variables with $p \leq 0.2$ were included in the multivariable analysis. A p value of < 0.05 was considered a significant predictor variable for the current chronic respiratory symptoms. For continuous data, a multivariate linear regression model was used to compare the lung function parameters between woodworkers and controls adjusted for sex, age, and height.

Results

Socio-demographic characteristics

In this study, 230 (99%) of woodworkers and 227 (98%) of controls were included. Two woodworkers and three controls refused to participate, and among controls, one worker was terminated and one was on sick leave. The majority of the study participants were male, accounting for 356 (77.9%), and the (Mean \pm SD) age of woodworkers was 32.9 (9.6), while control workers were 31.5 (7.9). A total of 131 woodworkers (57.0%) and 121 (53.3%) controls were married. A total of 151 (65.7%) of woodworkers and 187 (86.5%) of controls had completed secondary school. Regarding age, educational level, and monthly income, there were significant differences between woodworkers and controls. The two

groups did not differ in terms of gender, religion, or marital status (Table 1).

Previous respiratory disease and behavioral factors

Before starting work in the factory, 47 (20.4%) of woodworkers and 18 (12.3%) of controls had previous chronic respiratory disease confirmed by physicians. About 14 (6.1%) of woodworkers had ever smoked, compared to 16 (7%) of controls. Furthermore, 13 (5.7%) of woodworkers and 22 (9.7%) of controls smoked less than 7 packs of cigarettes per week among ever and current smokers. In this study, only 30 (13.0%) of woodworkers wore RPD while on the job. In terms of previous chronic respiratory disease, and current smoking, there were significant differences between woodworkers and controls (Table 2).

Work-related factors

About 86 (37.4%) of woodworkers had ten years or more of factory experience, while about 84 (37.0%) of controls had between 4 and 5 years of factory experience on the current job. Eighty-two woodworkers (79.1%) and 159 controls (70.0%) worked less than 48 h per week. Before starting the current job, about 55 (23.9%) of woodworkers and 21 (9.3%) of controls had been exposed to coffee dust, cement dust, wood dust and cotton dust. There were

Table 1 Socio-demographic characteristics of woodworkers and controls in Addis Ababa, Ethiopia, 2019

Variables	Woodworkers ($n = 230$), $n\%$	Controls ($n = 227$), $n\%$	p value
<i>Gender</i>			0.077
Male	187 (81.3)	169 (74.4)	
Female	43 (18.7)	58 (25.6)	
<i>Age (in year)</i>			0.040
≤ 29	106 (46.1)	123 (54.2)	
30–39	61 (26.5)	64 (28.2)	
≥ 40	63 (27.4)	40 (17.6)	
<i>Religion</i>			0.316
Orthodox	188 (81.7)	177 (78.0)	
Muslim and others	42 (18.3)	50 (22.0)	
<i>Marital status</i>			0.432
Married	131 (57.0)	121 (53.3)	
Single and others	99 (43.0)	106 (46.7)	
<i>Educational level</i>			0.0001
Primary school and below	79 (34.3)	30 (13.2)	
Secondary school and above	151 (65.7)	197 (86.8)	
<i>Monthly income</i>			0.0001
≤ 2500	81 (35.2)	24 (10.6)	
2501–3500	39 (17.0)	38 (16.7)	
≥ 3501	110 (47.8)	165 (72.7)	

Pearson's chi-square; "n": Number of study participants; p value significant level

Table 2 Previous chronic respiratory disease and behavioral factors of woodworkers and controls in Addis Ababa, Ethiopia, 2019

Variables	Woodworkers (<i>n</i> = 230), <i>n</i> (%)	Controls (<i>n</i> = 227), <i>n</i> (%)	<i>p</i> value
Previous chronic respiratory disease	47 (20.4)	18 (12.30)	0.019
Ever-smoker	14 (6.1)	16 (7.0)	0.678
Current smoker	1 (0.4)	7 (3.1)	0.031
<i>Cigarettes smoked per week for current and ever smokers</i>			0.078
< 7 pack per week	13 (5.7)	22 (9.7)	
≥ 7 pack per week	2 (0.9)	1 (0.4)	

Pearson's chi-square; "n": Number of study participants; *p* value significant level

Table 3 Work-related factors of woodworkers and controls in Addis Ababa, Ethiopia, 2019

Variables	Woodworkers (<i>n</i> = 230), <i>n</i> (%)	Controls (<i>n</i> = 227), <i>n</i> (%)	<i>p</i> value
<i>Working experience</i>			0.02
≤ 4	86 (37.4)	77 (33.9)	
5–9	58 (25.2)	84 (37.0)	
≥ 10	86 (37.4)	66 (29.1)	
<i>Working hours per week</i>			0.026
≤ 48	182 (79.1)	159 (70.0)	
> 48	48 (20.9)	68 (30.0)	
Past dust exposure	55 (23.9)	21 (9.3)	0.0001
Safety training	30 (13.0)	177 (78.0)	0.0001
Energy used at home			0.148
Use biomass fuel	142 (61.7)	125 (55.1)	
Use Electricity	88 (38.3)	102 (44.9)	

Pearson's chi-square; "n": Number of study participants; *p* value significant level

a significant difference between woodworkers and controls in terms of working experience, working hour per week, previous dust exposure, and safety training (Table 3).

Table 4 Adjusted prevalence ratio of chronic respiratory symptoms among woodworkers and controls in Addis Ababa, Ethiopia, 2019

Variables	Woodworkers, <i>N</i> = 230 <i>n</i> (%)	Controls, <i>N</i> = 227 <i>n</i> (%)	Prevalance ratio, 95% CI	<i>p</i> value
Respiratory symptoms				
Cough	81 (35.2)	23 (10.1)	2.18 (1.16–4.08)	0.015
Phlegm	102 (44.3)	26 (11.5)	2.48 (1.42–4.34)	0.001
Wheezing	68 (29.6)	27 (11.9)	2.05 (1.09–3.86)	0.027
Breathlessness	92 (40.0)	25 (11.0)	2.64 (1.47–4.78)	0.001
Chest pain	86 (37.4)	18 (7.9)	3.89 (2.05–7.38)	0.0001
At least one respiratory symptom	151 (65.7)	53 (23.3)	2.17 (1.51–3.12)	0.0001

Poisson regression model to compare the prevalence ratio of chronic respiratory symptoms between woodworkers and controls when adjusting for age, education, income, previous respiratory disease, working experience, working hour per week, previous dust exposure, safety training; *N* = number of workers in the groups; *n* = number of workers with symptom; *CI* confidence interval; *p* value: significance level

Prevalence of chronic respiratory symptoms

After adjusting for age, education, income, previous respiratory disease, working experience, working hour per week, previous dust exposure, and safety training, woodworkers had a significantly higher prevalence of chronic respiratory symptoms than controls (65.7% vs 23.3%). The prevalence ratio of all respiratory symptoms was significantly higher in woodworkers than in controls, parameters are cough (PR 2.18, 95% CI 1.6–4.08), sputum (PR 2.48, 95% CI 1.42–4.34), wheezing (PR 2.05, 95% CI 1.09–3.86), breathlessness (PR 2.64, 95% CI 1.47–4.78), and chest tightness (PR = 3.89, 95% CI 2.05–7.38). Because the number of smokers was small, the analysis was undertaken both including and excluding smokers. However, the outcome stayed the same (Table 4).

Factors associated with chronic respiratory symptoms

A multivariable logistic regression model was used to identify independent predictor variables for current chronic respiratory symptoms. Variables with a significant association at the bi-variate level, *p* value ≤ 0.2 were added to a multivariable logistic regression model. In this study, male participants had 1.9 times the odds of having current chronic

respiratory symptoms as compared to female participants (AOR 1.9, 95% CI 1.09–3.30).

Previous respiratory disease was another factor that was found to be significantly associated with the current chronic respiratory symptoms. The odds of current chronic respiratory symptoms among workers who had previous respiratory disease were 3.9 times that of the workers who had no previous respiratory disease (AOR 3.9, 95% CI: 2.08–7.19). Moreover, we have performed analysis on previous dust exposure, use of RPD and safety training within the woodworker's only. But we did not found significant association with current respiratory symptoms (Table 5).

Anthropometric measurements

The anthropometric parameters of woodworkers and controls were compared using an independent t test. In terms of weight and height, we found significant differences between groups (Table 6).

Table 6 Anthropometric measurements of woodworkers and controls in Addis Ababa, Ethiopia, 2019

Variables	Wood workers (n = 50)	Control workers (n = 50)	p value
Age (in year): AM (SD)	33.6 (11.7)	30.1 (8.0)	0.088 ^a
Weight (kg): AM (SD)	59.2 (8.5)	62.7 (6.70)	0.026 ^a
Height (cm): AM (SD)	163 (0.06)	166 (0.05)	0.002 ^a
BMI (kg/m ²): AM (SD)	22.33 (2.9)	22.62 (2.4)	0.582 ^a

AM arithmetic mean, SD standard deviation, BMI body mass index, n number of study participants, p value significance level

^aIndependent t test

Table 5 Multivariable models of factors associated with respiratory symptoms among woodworkers and controls in Addis Ababa, Ethiopia, 2019

Variables	Respiratory symptoms		COR (95% CI)	AOR (95% CI)
	Yes	No		
<i>Sex</i>				
Male	168 (82.4)	188 (74.3)	1.6 (1.02–2.55)	1.9 (1.09–3.30)*
Female	36 (17.6)	65 (25.7)	1.00	1.00
<i>Age (in year)</i>				
≤ 29	96 (47.1)	133 (52.6)	1.00	1.00
30–39	51 (25.0)	74 (29.2)	0.9 (0.61–1.49)	0.8 (0.48–1.43)
≥ 40	57 (27.9)	46 (18.2)	1.7 (1.07–2.74)	1.1 (0.63–2.12)
<i>Religion</i>				
Orthodox	174 (85.3.)	191 (75.5)	1.9 (1.16–3.05)	1.9 (0.93–3.47)
Muslim and others	30 (14.7)	62 (24.5)	1.00	1.00
<i>Educational level</i>				
Primary school and below	65 (31.9)	191 (75.5)	1.9 (1.16–3.05)	1.3 (0.78–2.32)
Secondary school and above	139 (68.1)	62 (24.5)	1.00	1.00
<i>Monthly income</i>				
≤ 2500	64 (31.4)	41 (16.2)	2.5 (1.59–4.00)	1.6 (0.90–2.97)
2501–3500	36 (17.2)	42 (16.6)	1.3 (0.81–2.25)	0.9 (0.43–2.29)
≥ 3501	105 (51.5)	170 (67.2)	1.00	1.00
<i>Previous respiratory disease</i>				
Yes	53 (26.0)	22 (8.7)	3.7 (2.15–6.31)	3.8 (2.08–7.19)**
No	151 (74.0)	231 (91.3)	1.00	1.00
<i>Previous dust exposure</i>				
Yes	47 (61.8)	29 (38.2)	2.3 (1.39–3.83)	1.7 (0.98–3.19)
No	157 (41.2)	224 (58.8)	1.00	1.00
<i>Safety training</i>				
Yes	59 (28.9)	148 (58.5)	1.00	1.00
No	145 (71.1)	105 (41.5)	3.5 (2.34–5.13)	1.2 (0.68–2.26)

A multivariable logistic regression model when adjusted for gender, age, educational status, income, religion, previous respiratory disease, previous dust exposure, and safety training, *p value < 0.05, **p value < 0.001, 1: reference value, COR: crude odds ratio, AOR: adjusted odds ratio

Lung function test

We tested the lung function of 104 male workers (52 from the woodworkers and 52 from controls). We excluded four spirometer results (two from woodworkers and two from controls) from the analysis due to unacceptable readings. Lung functions (FVC, and FEV1/FVC) between the woodworkers and the controls were significantly different (p = when adjusted for sex, age and height using multivariate regression). However, the ratio of FEV1/FVC was not significantly difference between woodworkers and controls (Table 7).

Discussion

The current study found that the prevalence of chronic respiratory symptoms was higher among woodworkers than in the control group, including cough (35.2% vs 10.1%), phlegm (44.3% vs 11.5%), wheezing (29.6% vs 11.9%), breathlessness (40.0% vs 11.0%), and chest tightness (37.4% vs 7.9%). Furthermore, gender, and previous respiratory disease were found to be independent predictors of the current chronic respiratory symptoms. When compared to controls, woodworkers had significantly lower FVC and FEV1.

The current study showed a higher prevalence of phlegm among woodworkers than the controls. This result is consistent with a study conducted in Iran among woodworkers and controls (Hosseini et al. 2020). But the prevalence of phlegm in this study is higher than previous studies done among woodworkers and controls in Iran (Neghab et al. 2018), South South of Nigeria (Tobin et al. 2016), Macedonia (Bislimovska et al. 2015), and Ethiopia (Fentie et al. 2019; Asgedom et al. 2019). The possible reasons for the difference might be due to the difference in uses of RPD which only 13.0% woodworkers were used in the present study. The findings of this study are consistent with those of a study conducted among woodworkers in Benin City, Nigeria, and Ethiopia, which found a high prevalence of chronic cough compared to controls (Ugheoke et al. 2006; Asgedom et al. 2019). All of these studies reported that woodworkers had a high prevalence of chronic cough compared to controls. But the present study showed a lower prevalence of chronic

cough compared to the study done among woodworkers and controls in Iran and Southwest Ethiopia (Hosseini et al. 2020; Fentie et al. 2019). The observed difference could also be due to the difference by the study setting in which the study was done.

Similarly, the increased prevalence of wheezing among woodworkers in our study was also consistent with the findings among woodworkers in Iran (Hosseini et al. 2020). But the prevalence of wheezing in our study is higher than the studies done among woodworkers and controls in South of Thailand, Macedonia, Benin City, Nigeria, and Southwest Ethiopia (Thepaksorn et al. 2017; Bislimovska et al. 2015; Ugheoke et al. 2006; Fentie et al. 2019). Woodworkers working in wood factory had an increased risk of chest tightness compared to office workers (Hosseini et al. 2020), which is also consistent with our study. But the increasing prevalence of chest tightness in the present study is higher than previous studies done among woodworkers and controls in Iran, South of Thailand, Macedonia, Benin, City Nigeria, and Southwest Ethiopia (Neghab et al. 2018; Thepaksorn et al. 2017; Bislimovska et al. 2015; Ugheoke et al. 2006; Fentie et al. 2019). But the prevalence of chest tightness in this study is lower than the study in South South Nigeria (Tobin et al. 2016). The observed difference could also be explained by the difference in the ventilation system.

Regarding associated factors with the current chronic respiratory symptoms, only gender was independently associated with the current chronic respiratory symptoms from socio-demographic factors when added in the multivariable analysis model. Men were 1.90 times more likely than women to have current chronic respiratory symptoms (AOR 1.9, 95% CI 1.09–3.30). This finding contradicts a study conducted in Thailand, which found a link between being a female worker and the current chronic respiratory symptoms (Chaiear et al. 2018). Furthermore, a longitudinal study conducted in Danish also found a link between wood dust exposure and chronic respiratory symptoms in female woodworkers (Jacobsen et al. 2009). This could be due to the fact that women were assigned to areas with reduced wood dust exposure.

Previous respiratory disease was also associated with the current respiratory symptoms in this study. Workers who had the previous respiratory disease were 3.9 times (AOR

Table 7 Lung function parameters in woodworkers and controls in Addis Ababa, Ethiopia, 2019

Lung function Parameters	Woodworkers ($n=50$)	Controls ($n=50$)	B (SE)	p value
FVC (L) – AM (SD)	3.82 (0.64)	4.34 (0.68)	5.96 (0.42)	0.002*
FEV1 (L/s) – AM (SD)	3.19 (0.57)	3.65 (0.59)	5.03 (0.36)	0.006*
FEV1/FVC \times 100 – AM (SD)	83.44 (0.06)	84.37 (0.05)	0.86 (0.04)	0.426

Multivariate linear regression between wood workers and controls when adjusting for sex, age, and height B unstandardized beta coefficient, SE standard error, p value significance level, “ n ” number of study participants, AM arithmetic mean, SD standard deviation

3.9, 95% CI 2.08–7.19) higher odds of current chronic respiratory symptoms compared to those who were free of previous respiratory disease. This study is similar to a study conducted in Thailand, which stated that workers who had family history of asthma were 3.95 times more likely to have current chronic respiratory health symptoms than workers who had no family history of asthma (Chaiear et al. 2018). This underlines the importance of previous respiratory disease on the current respiratory symptoms. In the present study, no use of RPD was not associated with current chronic respiratory symptoms among woodworkers. This finding contradicts with a study conducted in Northeast Thailand, which stated that woodworkers who did not use RPD were 2.26 times more odds of current chronic respiratory health symptoms than woodworkers who had use respiratory protective devices while working (Soongkhang and Laohasirivong 2015). This evidenced that, to avoid dust exposure, a respiratory protective device is required. This difference could be attributed to differences in the types of dust produced, and the amount of dust each worker exposed to. The observed difference might also be explained by ventilation systems. Furthermore, the present study did not also find a significant association between education and the current chronic respiratory symptoms. This might be education alone and is not enough in areas where the ventilation system is limited as observed.

Woodworkers had significantly lower FVC and FEV1 compared to controls in this study. This finding indicated that occupational exposure to wood dust may cause a decrease in lower FVC and FEV1, as found in previous studies conducted in Turkey, Sulaimani, Iraq, South of Thailand, and Norway (Osman and Pala 2009; Mahmood et al. 2016; Færden et al. 2014; Thepaksorn et al. 2017). Similar with our findings, a study done in South South Nigeria showed a significant reduction of FVC and FEV1 among woodworkers when compared with the control groups (Tobin et al. 2016). However, the result of our study is inconsistent with study done in Ethiopia among particleboard workers, which showed an insignificant difference in lung function between exposed and control groups (Asgedom et al. 2019). This might be due to the difference in dust control mechanisms and the use of RPD.

Despite the fact that woodworkers were exposed to wood dust, as evidenced by the workplace survey, there was no significant difference in ratio of FEV1/FVC reduction between woodworkers and controls in this study. Our result agrees with results in Norway, Sulaimani, Iraq (Færden et al. 2014; Mahmood et al. 2016), which showed an insignificant difference in FEV1/FVC ratio reduction between woodworkers and controls. But the results of the this study contradict with other previous studies conducted in Iran (Neghab et al. 2018; Badirdast et al. 2017), South Thailand (Thepaksorn et al. 2017), India (Kacha et al. 2014), Macedonia (Bislimovska

et al. 2015), Turkey (Osman and Pala 2009), and Nigeria (Omole et al. 2018; Tobin et al. 2016). All of these studies found that woodworkers had a significant FEV1/FVC ratio reduction than control groups. The possible reason for the difference might be due to the amount of wood dust each worker is exposed to and the type of dust control mechanisms.

Limitations of the study

The study relies on a cross-sectional design and a cause-and-effect relationship could not be established from this study. The amount of wood dust each worker is exposed to during their work time was not measured in this study. The workers may have a recall bias in the respiratory symptom assessment because symptoms are not always easy to remember and the study may also have risk of section bias of the workers. In addition, workers with respiratory health problem might have left their job so a healthy worker effect cannot be excluded.

Conclusion

When compared to controls, woodworkers exposed to wood dust had a significantly higher prevalence of chronic respiratory symptoms and lower FVC and FEV1. Furthermore, gender, and previous respiratory disease were associated with current chronic respiratory symptoms. This study found that woodworkers have lower lung function measures, which lowered lung capacity when compared to controls.

Therefore, engineering control methods should be implemented to reduce workers' exposure to wood dust and, it is preferable to conduct a prospective cohort study that focuses on dust exposure of each woodworker on large-scale wood factories.

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Author contributions BJ designed the study, conducted fieldwork, analyze the data, interpret the data, and wrote the manuscript SW supervised the development of the proposal, data analysis, and procedure of spirometer measurement and ZA contributed to the interpretation and reviewing of results and drafting the manuscript. All authors read the manuscript and agreed to its content.

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Data availability The data used to support the results of this study are available from the corresponding author upon request.

Declarations

Conflict of interest All authors declare no conflicts of interest.

Ethical approval and consent We conduct the study after having an ethical clearance from the Institutional Review Board of the College of Health Sciences of Addis Ababa University. In addition, permission to conduct the study was also obtained from the factory managers. Before performing the lung function tests, written informed consent was obtained from each participant, and participants were informed that they have full right to refuse and withdraw at any time in the study. The study participants with lung function impairments were advised and linked to the nearest health facility.

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