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Respiratory Effects and Pulmonary Functions Related to Wood Dust Exposure among Workers in a Rubber Wood Factory

Chompunuch Supapvanich[1]*, Thanawat Yeekew[2], Ganfre Pechayco[1]

Abstract

This study aimed to determine the effects of wood dust exposure on respiratory symptoms and pulmonary functions in wood dust factory workers and the association between wood dust exposure and pulmonary functions. This cross-sectional study comprised of one hundred workers who answered a self-reported questionnaire. Two factory areas, the production department and the back office, were explored using stationary air sampling. The wood dust concentration was collected using NIOSH Method 0600. Pulmonary function parameters were evaluated through spirometry. A descriptive statistics analysis was done for personal information. Binary logistic regression determined the association between wood dust exposure and respiratory symptoms. The prevalence of respiratory symptoms related to wood dust exposure at work was 49.00 percent. Three major symptoms in the exposed group includes chest pain, shortness of breath, and asthma. The average amount of PM10 in the saw mill area was significantly higher than in the back office (7.23 vs. 1.60 mg/m3). There was a significant difference in forced expiratory capacity between the reference and exposure groups (mean difference = -4.03, p-value = 0.011). The adjusted odd ratio showed that the high wood dust-exposed group had a lower runny nose and dry cough than the reference group. All workers need to consider using personal protective equipment with appropriate specifications in the sawmill area and also the other areas where wood dust levels are high. To control the concentration of respirable particles, resource and pathway control must be applied to reduce the concentration of respirable particles in the workplace.

Keywords: Wood dust, Exposure, Respiratory, Effects, Pulmonary function

* Co-responding author; Email: chompunuch@yala.ac.th, Tel: +66(0)73212863
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[1] Faculty of Public Health and Allied Health Sciences, Praboromarajchanok Institute, 95000, Thailand
[2] Chumphon Provincial Administrative Organization, Chumporn province, 86000, Thailand

Introduction

In 2019, the survey by the Statista research department reported that there were around 14,000 sawmills and wood product factories across Thailand.[1] Sawmills and wood products can produce a large amount of dust particles, particularly PM10.[2] The International Agency for Research on Cancer (IARC) has classified wood dust as a group 1 carcinogen, which can cause cancer in the nasal cavity, paranasal sinuses, and nasopharynx.[3,4] In short-term exposure, health effects were reported, including respiratory irritation, congestion, and eye and skin irritation. In contrast, long-term exposure to wood dust has been found to cause nasopharynx cancer, nasal and sinus cancer, asthma, and lung fibrosis (scarring).[3]

The previous study in Ethiopia assessing dust exposure and chronic respiratory symptoms in 496 woodwork industrial workers found that the chronic respiratory adverse symptoms were 69.75%. Cough was mostly found in 54.60%, followed by phlegm (52.20%), wheezing (44.60%), chest pain (42.90%), and breathlessness (42.10%), respectively. The geometric mean of dust concentration was slightly higher than the standard recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) (10.27 mg/m3 vs. 10.00 mg/m3). Furthermore, the factors included having a history of occupational dust exposure (AOR = 2.09, 95% CI: 1.09–4.01), less than five years of work experience (AOR = 9.18, 95% CI: 5.27–16.00), using bio-fule as energy for cooking (AOR = 2.42, 95% CI: 1.44–4.07), and a lack of occupational safety and health training (AOR = 3.38, 95% CI: 1.20–9.49) having an association with chronic respiratory adverse reactions.(5) Exposure to respirable particles was correlated to the inflammation reactions[6] A study in Iran investigated wood dust exposure and respiratory problems in furniture workers found that force vital capacity (FVC), force expiratory volume in one second (FEV1), and FEV1/FVC were significantly lower in furniture workers than in the reference group.[7] In Denmark, a study investigated the change in pulmonary function and cumulative wood dust concentration exposure. The results found that after adjusting for confounding factors such as smoking, height, and age, a decline in FEV1 was found in exposed females compared to non-exposed or low-exposed females.[8]

In Thailand, a study of para rubber wood exposure found that the exposed group who worked in the production area had high wood dust exposure compared to the unexposed group (0.90 vs. 0.18 mg/m3). Furthermore, the exposed group also had a higher prevalence of respiratory symptoms, including chest tightness (OR =2.79) and shortness of breath (OR = 2.27), compared to the unexposed group.[9] A study in Nakhon Si Thammarat province, Thailand, determined the prevalence and risk factors associated with respiratory symptoms and pulmonary functions in a sawmill factory, found that the prevalence of upper and lower respiratory symptoms was 67.00% and 63.10%, respectively. Moreover, abnormal pulmonary functions were found in 20.60% of patients, including obstructive pulmonary disorder (4.38%), restrictive pulmonary disorder (10.53%), and small airway disorder (5.71%), respectively. However, the prevalence of upper and lower respiratory symptoms were not significantly associated with wood dust exposure.[10]

According to the evidence above, this study aimed to determine how wood dust exposure affects respiratory adverse symptoms and pulmonary function in wood dust factory workers and the association between wood dust exposure and pulmonary functions.

Methods

Population and study samples

This study was a cross-sectional study. The study population consisted of workers at a sawmill factory. Two areas of the saw mill factory are as folows, the saw mill area and the back office, they were studied using a purposive selection. Two hundred twelve workers were working in this factory. Workers who worked at saw mill department and back office were purposive selected. The inclusion criteria were people who has been working in the factory more than 6 months and exclusion criteria were people who had not completed the questionnaire and did not undergo the spirometry. Seventy eight workers who were working at saw mill department (Exposed group) and twenty two back office workers (Reference group) were included in this study.

Research questionnaire

One hundred workers completed the self-reported questionnaire and underwent spirometry. The questionnaire information included personal demographics, symptoms related to wood dust exposure at work, and the use of personal protective equipment (PPE). The validity of the content was validated based on the index of item objective congruence (IOC) by three experts. The content validity of the questionnaire was between 0.60 and 1.00.

Air sampling

The stationary air sampling was performed in two departments, including the saw mill department and the back office. Six air samples were collected using particulates not otherwise regulated by the respirable 0600 method (National Institute for Occupational Safety and Health 1998). The stationary air samples were collected three times for eight hours. The 10 mm nylon cyclone with a 37 mm PVC filter (pore size 5 µm) was loaded on a three-piece cassette to evaluate respirable dust. The flow rate of 1.70 litres per minute (l/min) ran on the portable pump using the SKC Aircheck XR 5000 (Entech, Thailand) for respirable wood dust, according to NIOSH 0600 Method.[11] The respirable dust particles were collected on a filter for analysis. The relative humidity and temperature were measured at the sampling areas. The concentration of respirable particles (mg/m3) was compared with the standard of 5 mg/m3, which was recommended by the Occupational Safety and Health Administration (OSHA).[11] The air sampling pump had been calibrated before and after measurement.

Measurement of pulmonary functions

The pulmonary functions included parameters such as forced expiratory volume in one second (FEV1), forced expiratory capacity (FVC), forced expiratory volume and force expiratory capacity ratio (FEV1/FVC), forced mid-expiratory flow (FEF25–75), FEV1 predicted value, and FVC predicted value. The spirometry (micro medical MicroLab 3500) was performed below the American Thoracic Society (ATS) criteria.[12] The instrument calibration had been done before and after measurement.

Statistical analysis

Descriptive data analysis was performed through personal demographics, respiratory symptoms, and concentration of respirable particles, presenting frequency, percentage, standard deviation, minimum, and maximum. A chi-square test was used to assess respiratory symptoms. An independent t-test was used to compare the pulmonary parameters between the exposure and reference groups. A logistic regression analysis was used to assess the association between wood dust exposure and the prevalence of respiratory symptoms. The confounding factors, including age, gender, smoking, weight, and height, were adjusted for an odd ratio. The data analysis was performed using SPSS Statistics version 21 (Reference ID TH-07-0522, TARA Tech International Co., Ltd.).

Ethical approval

The study protocol was approved by a research ethics committee from Sirindhorn College of Public Health in Yala Province (Ref.009/2561).

Results

Most participants in this study were female. More than 87.00% of them were Thai. The average age was 41.60 years old. About 88% of the exposure group were smokers, while the reference group found only 12.50%. The use of personal protective equipment was found to be 75.71% in the exposure group and 22.29% in the reference group. There was a significant difference in education level between the exposure and reference groups (p-value <0.001) as shown in Table 1.

Respiratory effects

The prevalence of respiratory symptoms associated with wood dust exposure during work was 49.00% (49/100). Separately, the prevalence of respiratory symptoms was 67.35% in the exposed group, while 32.65% was found in the reference group. Three symptoms found mainly in the exposed group such as chest pain (80.00%), shortness of breath (80.00%), and asthma (75.00%), respectively. Whilst, respiratory symptoms were found in the reference group, includes a runny nose (37.14%), dry cough (34.62%), sneezing (32.14%) and there was significant difference in respiratory symptoms between exposed and reference groups (p-value = 0.012) as shown in Table 2.

Table 1 Personal demographic variables between exposure and reference group

Variable	n (%)		p-value
	Exposure group	Reference group	
Gender			
Male	27 (71.05)	11 (28.95)	0.189
Female	51 (82.25)	11 (28.95)	
Region			
Thai	68 (77.27)	20 (22.73)	1.000[a]
Myanmar	10 (83.33)	2 (16.67)	
Age group (year)			
Lower 35	21 (80.76)	5 (19.23)	0.692
35 over	57 (77.03)	17 (22.97)	
Mean ± SD	39.93 ±9.67	41.95 ±13.15	0.508[b]
Min: Max	17 : 59	20 : 69	
Education level			
Diploma	76 (85.39)	13 (14.61)	<0.001[a]
Bachelor degree and upper	2 (18.18)	9 (81.82)	
Smoking			0.264
No	57 (75.00)	19 (25.00)	
Yes	21 (87.50)	3 (12.50)	
Personal Protective Equipment (PPE)			
No	25 (83.33)	5 (16.67)	0.399
Yes	53 (75.71)	17 (22.29)	

p-value by Chi-square test; [a] p-value by Fisher's exact test, [b] p-value by independent t test

Table 2 Respiratory effects within work between wood dust exposed and reference groups

Symptoms	n (%)		p-value
	Exposed group	Reference group	
All respiratory symptoms			
No	45 (88.24)	6 (11.76)	0.012*
Yes	33 (67.35)	16 (32.65)	
Type of respiratory symptoms (n = 49)			
Asthma	12 (75.00)	4 (25.00)	0.526[a]
Chest tightness	13 (68.42)	6 (31.58)	0.898
Chest pain	12 (80.00)	3 (20.00)	0.324[a]
Shortness of breath	12 (80.00)	3 (20.00)	0.324[a]
Sneezing	19 (67.86)	9 (32.14)	0.930
Runny nose	22 (62.86)	13 (37.14)	0.336
Bronchitis	12 (70.59)	5 (29.41)	1.000
Dry cough	17 (65.38)	9 (34.62)	0.755

p-value by Chi-square test; [a] p-value by Fisher's exact test, * p-value < 0.05

Wood dust exposure and respiratory symptoms

The results showed that the high wood dust exposed group had significantly lower symptoms of a runny nose when compared to the reference group, similarly before and after adjustment for confounding factors. After adjusting for confounding factors, the high wood dust exposed group had significantly lower symptoms of dry cough when compared to the reference group. It revealed that workers who worked in high wood dust concentration had a reduction of 77.40% in the odds of having runny nose and 72.40% in the odd of having dry cough compared to back office workers as shown in Table 3.

Table 3 Association between group of workers and respiratory symptoms before and after control confounding factors (n = 100)

Variables	n (%)		Crude OR (95% CI)	Adj. OR (95% CI)[a]
	Exposed gr	Reference gr		
Asthma				
No	21 (63.64)	12 (36.36)	1	1
yes	12 (75.00)	4 (25.00)	0.81 (0.23 – 2.84)	0.69 (0.18-2.62)
Chest tightness				
No	20 (66.67)	10 (33.33)	1	1
yes	13 (68.42)	6 (31.58)	0.55 (0.17 – 1.62)	0.57 (0.16-1.99)
Chest pain				
No	21 (63.64)	13 (36.36)	1	1
yes	12 (80.00)	3 (20.00)	1.15 (0.29 – 4.50)	1.09 (0.25-4.63)
Shortness of breath				
No	21 (61.67)	13 (38.24)	1	1
yes	12 (80.00)	3 (20.00)	1.15 (0.29 – 4.50)	0.93 (0.20-4.21)
Sneezing				
No	14 (66.67)	7 (33.33)	1	1
yes	19 (67.86)	9 (32.14)	0.46 (0.17-1.25)	0.45 (0.15 – 1.36)
Runny nose				
No	11 (78.57)	3 (21.43)	1	1
yes	22 (62.86)	13 (37.14)	0.27 (0.10-0.72)**	0.22 (0.07-0.68)**
Bronchitis				
No	21 (65.63)	11 (34.37)	1	1
yes	12 (70.59)	5 (29.41)	0.61 (0.19-1.99)	0.59 (0.16 – 2.20)
Dry cough				
No	16 (69.57)	7 (30.43)	1	1
yes	17 (65.38)	9 (34.62)	0.40 (0.14-1.10)	0.27 (0.08-0.90)*

[a] Adjusted for confounding factors: age, gender, smoke, body weight and height, **p-value <0.01

Wood dust concentrations

Air samples were collected in two departments, including the sawmill area and the back office. The average amount of PM10 at the sawmill area was 7.23 mg/m3, and the back office was found to be 1.60 mg/m3. Comparing the sawmill area with the standard of respirable aerosol by the Occupational Safety and Health Administration (OSHA), the concentration of PM10 in the sawmill area was higher than the standard. The PM10 concentration between the sawmill and the back office area showed that the sawmill had a higher PM10 concentration than the back office (p -value< 0.001) as shown in Table 4.

Table 4 Average concentration of PM10 between saw mill area and back office

Department	Day 1	Day2	Day3	Average level	Mean difference	p-value
Back office	1.88	1.25	1.67	1.60	5.63	<0.001
Saw mill	7.40	7.09	7.19	7.23		

p-value calculated by independent t test, standard of respirable dust particle by OSHA = 5 mg/m3

Measurement of pulmonary functions

The result of pulmonary function showed a significant difference between FEV1/FVC between the exposure and reference groups (p-value = 0.011), while other pulmonary functions were not significantly different between both groups as shown in Table 5.

Table 5 Comparison of pulmonary functions between exposure and reference groups

Parameters	Exposed gr	Reference gr	S.E	Mean Diff	95% CI	p-value
FEV1	2.42	2.37	0.16	-0.04	-0.33 to 0.27	0.772
FVC	2.73	2.77	0.18	0.04	-0.33 to 0.41	0.826
FEV1/FVC	89.21	84.90	1.65	-4.30	-0.75 to -1.01	0.011*
FEF25 - 75	117.16	100.00	8.01	-17.15	-33.11 to -1.20	0.035
FEV1 predicted	97.51	97.20	5.97	3.84	-8.04 to 15.72	0.522
FVC predicted	91.21	95.05	5.83	-0.30	-11.91 to 11.30	0.958

p-value by Independent t test, *p-value < 0.05

Discussion

The overall prevalence of respiratory symptoms associated with wood dust exposure in this sawmill factory was 49.00%. This prevalence was lower than in the previous studies, as reported between 63.00 and 69.80 percent.[5,10] However, when compared to the respiratory symptoms between sawmill workers (Exposed group) and back office workers (Reference group), the exposed group had a higher respiratory symptoms than the reference group (67.35% vs. 32.65%). Furthermore, three symptoms were primarily found in exposed groups, including chest pain, shortness of breath, and asthma, while the reference group had a runny nose, dry cough, and sneezing. These means that the exposed group had higher exposure to wood dust at working area as the average concentration of PM10 is higher than the standard. As the PM10 are small particulate matters when they enter through the respiratory system, they can induce the respiratory symptoms such as wheezing, asthma attack, shortness of breath or chest tightness.[7] The other study in Thailand found that more than half of the workers in a rubber wood sawmill factory in Nakhon Si Thammarat province, Southern Thailand, had 67% upper respiratory symptoms and 63.1% lower respiratory symptoms.[10] Chronic respiratory adverse reactions had been reported at 69.80%.[5] Types of respiratory symptoms related to wood dust exposure included cough (36.00 - 90.00%), phlegm (52.20%), chest tightness (20.50 - 78.60%), chronic coughs (63.60%), wheezing (6.00 - 80.00%), breathlessness (32.00 - 72.70%), runny nose (12.90%) asthma (80.00%), sneezing (25.00 - 43.00%), and chest pain (42.90%). (5,7,13,14)

Pulmonary functions related to wood dust exposure showed that the reference group had lower FEV1/FVC than the exposed group, while others did not significantly differ. An interesting point of this study was the exposed group had not difference pulmonary function when compared to the reference group. Because the exposed group may have considered health prevention and also, more wood dust was found in the working area, so the workers may have used personal protective equipment during work. Furthermore, workers with health problems may be more concerned about wood dust exposure than

other workers without symptoms. This may explain why there was a healthy worker effect. A previous study in Denmark found an association between cumulative wood dust exposure and the percent annual decline in FEV1 in female workers at a furniture factory.[8] Similarly, a study in Iran found a decrease in pulmonary functions, including FEV1, FEV1/FVC, in the exposed group compared to the reference group.[7] Moreover, a study in Nigeria found the reduction of predicted FEV1 and predicted ratio of FEV1/FVC in a high exposed group, while normal pulmonary functions were found in low exposed group.[14] On the other hand, a study in Poland determining pulmonary functions and wood dust exposure at work, found that, there were no reduction of FEV1 FVC and FEV1/FVC ratio in workers at wood processing.[15]

The concentration of wood dust in the sawmill and back office areas showed that the wood dust level, particularly PM10, in the sawmill area was high when compared to the back office (7.23 vs. 1.60 mg/m3). Furthermore, the concentration of PM10 in the sawmill area was higher than the standard recommended by NIOSH.[11] As well as, a previous study in southern Thailand determining the wood dust exposure in wooden toy industry found the concentration of respirable dust and total dust at 1.11 mg/m3 and 0.45 mg/m3, respectively.[16] This was lower respirable dust concentration when compared with our study. Moreover, the concentration of total wood dust in wooden frames factory had been found in the range of 0.49 to 18.20 mg/m3.[15]

This cross-sectional study has limitations in the exposure and the health effects were measured at the same time, so the temporal link between exposure and health effects could not be determined, and the causal factors could not be confirmed. Moreover, the effect on healthy worker was also found in this study because the risk group had lower symptoms when compared with the reference group. By the way, we have assumed from our results that back office workers may had exposed to wood dust when they went outside their office without using any protection as the area of saw mill had high level of respirable dust. On the other hand, the saw mill workers had already known the risk and they may have use the protection during worked. Furthermore, the saw mill area was opened then the wood dust may distribute everywhere.

Conclusion

A high concentration of PM10 was found in the sawmill area. This showed that the factory should educate the workers about work safety, particularly those working in the processing area and back office, and also provide them with personal protective equipment. The factory must spread precaution in high risk area. Furthermore, the workplace should have guidelines for wood dust exposure to reduce the risk of respiratory problems.

Recommendation

The further study should be involved the protective behaviors of the workers separating each position and individual personal air sampling should also measure to evaluate the concentration of PM2.5 exposure at each worker in each department.

References

1. Statista Research Department. Thailand: number of sawmills and wood product plants by type 2019. [Internet]. 2022. [Cited in 9 March, 2023] Available from: https://www.statista.com/statistics/1121791/thailand-number-of-sawmills-and-wood-product-factories-by-type/).
2. Bruschweiler E, Danuser B, Huynh C, Wild P, Schüpfer P, Vernez D, Boiteux P, Hopf N. Generation of polycyclic aromatic hydrocarbons (PAH) during woodworking operations. Front Onco 2012; 2:148.
3. Cancer Council. Occupational cancer risk series: wood products. [Internet]. 2019. [Cited in 22 February, 2023] Available from: https://www.cancer.org.au/assets/pdf/occupational-cancer-risk-series-wood-products.
4. Government of New South Wales. Wood dust - health hazards and control: fact sheet. [Internet]. 2011. [Cited in 9 March, 2023]. Available from: https://www.safework.nsw.gov.au/resource-library/manufacturing/wood-safety-kit/wood-dust-health-hazards-and-control.

5. Awoke, TY, Abera KT, Worku TM, Samson WA, Yifokire TZ, Embay AA, and Bezayit GA. Assessment of dust exposure and chronic respiratory symptoms among workers in medium scale woodwork factories in Ethiopia; a cross sectional study. BMC Public Health 2021; 21:309.
6. Westberg H, Elihn K, Andersson E, Persson B, Andersson L, Bryngelsson I-L, Karlsson C, Sjögren B. Inflammatory markers and exposure to airborne particles among workers in a swedish pulp and paper mill. Int Arch Occup Environ Health 2016; 89: 813–22.
7. Kargar-Shouroki F, Dehghan Banadkuki M R, Jambarsang S, Emami A. The association between wood dust exposure and respiratory disorders and oxidative stress among furniture workers. Wien Klin Wochenschr 2022.; 134: 529–37.
8. Jacobsen G, Schlünssen V, Schaumburg I, Taudorf E, Sigsgaard T. Longitudinal lung function decline and wood dust exposure in the furniture industry. Euro Res J 2008; 31: 334–42.
9. Thepaksorn P, Fadrilan-Camacho VFF, Siriwong W. Respiratory symptoms and ventilatory function defects among para rubber wood sawmill workers in the south of Thailand. Hum Ecol Risk Assess 2017; 23: 788-97.
10. Chaiear N, Ngoencharee J, Saejiw N. Respiratory symptoms and pulmonary function among workers in a rubber wood sawmill factory in Thailand. Am J Public Health Res 2018; 6: 65-71
11. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods (NMAM) method 0600 particulates not otherwise regulated respirable. [Internet]. 1998. [Cited in 21 January, 2021]. Available from: https://www.cdc.gov/niosh/docs/2003-154/pdfs/0600.pdf.
12. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. Eur Respir J 2005; 26: 319-338.
13. Mogal, Md R, Islam Md D, Hasan Md I, Junayed A, Sompa SA, Mahmod Md R, Akter A, Abedin Md. Z, Sikder Md A. The impact of wood dust on pulmonary function and blood Immunoglobulin E, erythrocyte sedimentation rate, and C- reactive protein: a cross-sectional study among sawmill workers in Tangail, Bangladesh. Health Sci Rep 2022; 5: e646.
14. Wali NY. Influence of varying degree of wood dust exposure on pulmonary function and respiratory symptoms among wood workers in Kano, North Western Nigeria. Niger J Physiol Sci 2020; 35: 161–65.
15. Baran S, Swietlik K, and Teul I. Lung function: occupational exposure to wood dust. Eur J Med Res 2009; 14:14.
16. Thepaksorn P, Thongjerm S, Siriwong W, Ponprasit P. Occupational Hazard Exposures and Health Risks at Wooden Toys Industry in Southern Thailand. Hum Ecol Risk Assess 2020; 26: 2162–72.