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Respiratory Symptoms and Pulmonary Function among Workers in a Rubber Wood Sawmill Factory in Thailand

N. Chaiear[1,*], J. Ngoencharee[2], N. Saejiw[3]

[1]Division of Occupational Medicine, Department of Community Medicine, Faculty of Medicine, Khon Kaen University; Thailand
[2]International SOS Thailand, Wittayu Towers, Bangkok, Thailand
[3]Faculty of Science and Industrial Technology, Prince of Songkla University, Surat Thani Campus, Surat Thani, Thailand
*Corresponding author: naesinee@kku.ac.th

Abstract **Objectives**: 1) To determine the prevalence of respiratory symptoms and abnormal pulmonary function among workers exposed to different levels of rubber wood dust (RWD) and 2) to determine the factors which may be associated with the respiratory effects. **Methods**: The study population was 340 workers working in a rubberwood sawmill factory in Nakhon Si Thammarat province, Southern Thailand. Respiratory health questionnaires and spirometric testing according to the ATS 1994 criteria were performed. Workers were classified into three groups by the RWD levels; low RWD (≤ 1.9 mg/m^3); moderate RWD (2.0-4.9 mg/m^3); and high RWD (≥ 5.0 mg/m^3). **Results**: A total of 279 workers (59 male and 220 female) were participated in the study. Their average age and work duration were 36.7 years (SD=8.5) and 6.2 years (SD=4.1), respectively. The prevalence rate of upper and lower respiratory symptoms were 67.0% and 63.1% respectively. The prevalence of abnormal spirometric testing result was 20.6 % (obstructive type 4.4 %, restrictive type 10.5 %, and small airway disease 5.7 %). These prevalence rates were not significantly different according to the RWD level. However, the factors which were significantly associated with the upper respiratory symptoms were being female [OR 2.03 (95%CI 1.10, 3.78)] and being atopy [OR 3.63 (95%CI 1.88, 7.0)]. The factor which was significantly associated with lower respiratory symptoms was a family of asthma [OR 3.95 (95%CI 1.32, 11.7)]. **Conclusion**: Exposure to rubber wood dust is associated with a high prevalence of respiratory illnesses and being atopic person takes a high risk of work related respiratory illnesses.

Keywords: *rubber, wood dust, spirometry, asthma, work related asthma*

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1. Introduction

Wood dust workers are at risk for several occupational diseases ranging from respiratory symptoms, allergy, occupational asthma, or cancers [1,2,3]. Occupational wood dust diseases can occur from various type of woods such as Samba (Obeche, Triplochiton scleroxylon); either small or medium scale enterprises; or either dry or wet wood dust [4,5,6,7]. There are several issues with wood dust occupational exposures. The study from Ethiopia found that 71% of the wood dust enterprises had exceeded wood dust exposure limit [5]. Personal prevention or lack of knowledge increased risk of respiratory symptoms in Thai wood dust workers by 2.26 and 1.83 times, respectively [1].

Similarly to other dusts, wood dust exposures are occupational causes of respiratory symptoms or diseases. Indoor wood dust exposure was a hidden cause of asthma in adults older than 40 years [8]. A meta-analysis found that the risk of asthma increased by 1.5 fold in wood dust workers [9]. In addition, the average expiratory flow rate of 150 male carpenters was significantly lower than healthy control (393 vs 485 L/min; p-value < 0.01) [10]. Even though there are adequate evidences of occupational respiratory diseases caused by wood dust, risk factors for respiratory symptoms/diseases in wood dust workers are limited particularly in Asian setting. Hence, this study aimed at determining the prevalence and risk factors of health effects from rubber wood dust in rubber wood sawmills in southern Thailand where wood dust enterprises are commonly located.

2. Materials and Methods

2.1 Study Design

A cross-sectional study was conducted among employees in a large rubber wood sawmill factory in Nakhon Si Thammarat province, southern Thailand.

2.2. Factory Description

This rubber wood sawmill consisted of both green mill and a dry mill. The processes performed in this sawmill include sawing, wood preservation, drying, and dried wood working. Logs cut to the required lengths were transported to the site by truck and then sorted and stored on dry land in a log yard. The logs are cut into manageable sizes using a band saw. Sawing and cutting involved two operators usually working in an open area. Boards were sorted and graded according to their dimensions and quality. Sorted timber was then sent for preservation treatment in a vacuum tank where it was impregnated with fungicide, mainly boric acid and borax. After impregnation, timber was stacked and sent to dry in kilns.

After drying, the stacked and bundled wood was stored in a paved yard for shipping or further processed by cutting, planing, laminating and sanding. Both the green and dry milling processes were conducted in partly enclosed work areas. Machines for processing the wood were equipped with exhaust ventilation systems designed primarily to prevent the accumulation of dust. Cleanup was generally performed at the end of each working day. Compressed air and dry sweeping were used to remove wood dust from machinery, floors and work surfaces.

2.3. Study Population

A total of 340 employees working full time in the rubber wood sawmill were invited to participate in this study. The majority of employees (92.9%) were engaged on the production lines with rest being of the management staff and drivers. All study population was interviewed using a work-related respiratory illnesses questionnaire. The employees who had the positive symptoms related to rubber wood dust were asked to proceed to pulmonary function testing. The participants were classified into three groups according to wood dust exposure levels; 1) low (<2.0 mg/m^3), 2) moderate (2.0-5.0 mg/m^3), and 3) high wood dust exposure (> 5.0 mg/m^3).

The low exposure group served as the reference group. The high exposure group consisted of employees working in sawing green lumber, boiler operation, cutting of dry lumber, sorting, grading and stacking of green lumber and shaving of dry lumber. The moderate exposure group included cutting of finished product, sorting, stacking, ripping of dry lumber, pellet makers, cleaning, colour grading from rip saw machine, four side shaving, laminating with machine, manual laminating, recovery of waste, joint makers, stacking of dried wood, finger makers and sanding. The low exposure group (reference group) were involved in two side planning, packing, maintenance workers, forklift driver, stacking of wet- preserved wood, office workers, and vacuum tanks operators.

2.4. Measurement Methods

2.4.1. Dust Measurement

A total of 27 job titles and 9 working areas were identified and ambient air sampling conducted by both personal and static techniques. Personal exposure measurements were undertaken for 340 workers. Three repeated inhalable dust measurements were undertaken for 199 workers. The remaining 141 workers were sampled at least once. Finally, 742 inhalable, 241 respirable personal dust samples and 55 total inhalable, 30 respirable static samples were analyzed. The majority of samples were representative of an eight hours shift. Inhalable dust sampling was performed by the Institute of Occupational Medicine or IOM (SKC Inc, Eighty Four, PA, USA) inhalable dust samplers. IOM was used for sampling both inhalable dust and respirable dust simultaneously. This sampling methodology was in accordance with the method for determination of hazardous substances: General methods for the sampling and gravimetric analysis of respirable and inhalable dust (MDHS 14/3). Detail of samplings and the results of measurement were reported elsewhere [11]. The results of dust measurement were used to classify the categories of worker exposure to rubber wood dust.

2.4.2. Particle Size Determination

An eight stage non-viable impactor (Model **20-800 Mark II**, Thermo Electron Corporation Inc., Atlanta, USA) with a vacuum pump, using a flow rate of 28.3 L/min, was used as the static sampler to obtain the size distribution concentration of wood dust from different machines. Air samples were collected at breathing zone and distance 1 m from machines. The stainless steel particle collection substrates were coated with silicone spray (Dow Corning, USA) to prevent particle bounce. A glass fibre filter was positioned after the last impaction stage to collect particles with aerodynamic diameters smaller than the last stage cut point diameter. Before they were weighed, the impaction plates and the filters were desiccated. The stage specific effective cut off diameter (ECD) values as given by manufacturer were used in this study. The upper limit of ECD was taken as 30 µm for the first stage and 0.08 µm at the final filter stage. Detail of samplings and the results of measurement were reported elsewhere [11].

2.4.3. Questionnaire

A modified respiratory questionnaire in Thai was used. This was based on one developed by Chaiear et al [12] and it included 1) personal characteristics, 2) health information including work-related respiratory symptoms and underlying disease, 3) smoking habits, 4) history of allergic symptoms including atopy and 5) job history and work task performed.

2.4.4. Lung Function

A portable spirometer (Pony graphic version 4.0, precision ± 2%) was used to assess individual pulmonary function. The quality control of the equipment followed the American Thoracic Society (ATS) 1994 in which three traces with measurements were varying by less than 5%. The equipment was calibrated in the day prior to using. The pulmonary function results were assessed by using Thai pulmonary function standard values.

2.5. Outcome Assessment

The outcomes were self-reported respiratory symptoms, pulmonary function results, and a diagnosis of occupational asthma.

Respiratory symptoms were grouped into upper and lower respiratory tract symptoms (URTS and LRTS, respectively). URTS defined as eye irritations, rhinorhea or nasal decongestion during working hours and not related to upper respiratory tract infection. Symptoms such as dyspnea, chest discomfort, wheezing, or cough related to working hours were defined as LRTS.

The criteria for diagnosing wood dust induced asthma (WDA) was by having 1. a history of wood dust exposure, 2. developing symptoms after wood dust exposure or a duration of at least two weeks such as cough, dyspnea, wheezing while working and improving after work, and 3. having reversible obstructive airway disease by pulmonary function test or a positive methocholine challenge test.

We classified the diagnosis of asthma by clinical criteria and severity as suggestive, possible, probable and definite asthma. Suggestive WDA defined as one who had a history of wood dust exposure, one of LRTS with improvement after days off and symptoms developing after wood dust exposure, persisting for at least two weeks. Possible WDA defined as LRTS or obstructive airway pattern shown by pulmonary function test. Probable WDA was who developed LRTS plus obstructive airway pattern by pulmonary function test.

2.6. Statistical Analysis

Study variables were baseline characteristics, work history, smoking history, history of wood dust exposure and preventive measures at the workplace, and a personal or family history of asthma, atopic or allergic diseases.

Baseline characteristics of all participants were summarized using descriptive statistics. Univariate and multivariate logistic analysis were used to assess the likelihood of having URTS, LRTS and WDA. Crude and adjusted odds ratio were also reported. All data analyses were performed using SPSS-PC software version 15.0.

2.7. Ethical Consideration

All workers were invited to participate in the study on the voluntary basis. Ethical approval was obtained from the Institutional Review Board of Faculty of Medicine, Chulalongkorn University, Bangkok (No. 034/2007).

3. Results

There were 340 workers participated during the study period. Of those, 279 (82.1%) workers completed the questionnaire. The female: male ratio was 4:1 and the mean age (S.D.) was 36.7 (8.5) years. The mean (S.D.) duration of employment was 6.2 (4.1) years. The current smoker and second hand smoker rate was 16.5% and 40.5%, respectively (Table 1).

Approximately half of workers (52.7%) were exposed to moderate level of wood dust and 85% of workers wore cloth masks while working. About 50% of workers felt uncomfortably wearing cloth masks and one-fourth reported the absence of local air ventilation (Table 1). A history of metal allergy was found in 67% of workers, while history of atopic disease, allergic disease, and asthma were reported in 99 workers (33.7%), 7 workers (2.5%), and 4 workers (1.4%), respectively.

The prevalence rate of URTS and LRTS were 67.0% (187 workers) and 63.1% (176 workers), respectively. There were 228 workers completed spirometry, and abnormal findings were detected in 47 workers (20.6%) classified as 10 (4.4%) obstructive type, 24 (10.5%) restrictive type, and 13 (5.7%) small airway diseases. Possible and probable asthma were found in 179 (64.2%) and 7 (2.5%) workers, respectively.

Table 1. Participant characteristics of all participated subjects (279 subjects)

Variables	**Number (%) or Mean (Standard deviation.)**
Male	59 (21.1)
Age (years)	
< 29	63 (22.6)
30-39	110 (39.4)
> 40	106 (38.0)
Current smokers	46 (16.5)
Male	42 (15.1)
Second hand smokers	113 (40.5)
Male	42 (15.1)
Working related variables	
Mean working hours/day	8.0 (0.5)
Mean working hours/week	6.0 (0.2)
Mean numbers of working overtime (days)	1.9 (2.0)
Mean numbers of working overtime (hours)	1.5 (1.4)
Mean working employment (years)	6.2 (4.1)
Duration of employment (years)	
< 4	133 (47.7)
5-9	82 (29.4)
> 10	64 (23.0)
Exposure to wood dust level	
Low (≤ 1.9 mg/m^3)	37 (13.3)
Moderate (2.0 – 4.9 mg/m^3)	147 (52.7)
High (≥ 5.0 mg/m^3)	95 (34.0)
Occupational hazard related variables	
Recognition of occupational hazards	232 (83.2)
Using face mask while working	238 (85.3)
Uncomfortable feeling while wearing mask	155 (55.6)
Absence of local air ventilation	66 (23.6)
Personal and family illnesses history	
History of food allergy	20 (7.2)
History of wool allergy	35 (12.5)
History of metal allergy	92 (67.0)
History of asthma	4 (1.4)
History of allergic disease	7 (2.5)
History of atopic disease	94 (33.7)
Family history of asthma	27 (9.7)
Family history of allergic disease	39 (14.0)

By univariate analysis (Table 2), being female, age more than 30 years, having 5-9 years of employment, history of using cloth mask, uncomfortable feeling with cloth mask, history of wool allergy, history of metal allergy, history of allergy, history of atopic disease, and family history of asthma had significant positive association with URTS. The current and second hand smokers were negatively associated with URTS. Only female gender and history of atopic disease were significantly related to URTS in the multivariate logistic regression analysis (Table 4).

Table 2. Crude odds ratio in specific variables for having upper and lower respiratory tract symptoms (URTS & LRTS)

Variables	URTS (N = 187)		LRTS (N = 176)	
	N	ORs (95%CI)	N	ORs (95%CI)
Female	157	2.4 (2.0-2.9)	145	1.8 (1.5-2.1)
Age (years)				
< 29	38	1.0	38	1.0
30-39	80	1.8 (1.5-2.0)	71	1.2 (1.0-1.4)
> 40	69	1.2 (1.0-1.5)	67	1.1 (0.9-1.4)
Current smokers	23	0.4 (0.3-0.5)	26	0.7 (0.6-0.9)
Second hand smokers	72	0.8 (0.7-0.9)	72	1.1 (0.9-1.2)
Duration of employment (years)				
< 4	63	1.0	64	1.0
5-9	83	1.7 (1.5-1.9)	77	1.3 (1.1-1.4)
> 10	41	1.1 (0.9-1.3)	35	0.7 (0.5-0.9)
Exposure to wood dust level				
Low	24	1.0	24	1.0
Moderate	99	1.1 (0.5-2.5)	89	0.8 (0.4-1.9)
High	64	1.1 (0.5-2.7)	63	1.1 (0.4-2.5)
Dust size $\leq$ 9 micron	111	1.2 (0.7-100)	103	1.2 (0.7-1.9)
Potential risk				
Recognition of hazards	155	1.0 (0.8-1.2)	144	0.8 (0.6-1.0)
Using face mask	162	1.4 (1.1-1.7)	150	1.0 (0.8-1.3)
Uncomfortable feeling with wearing mask	110	1.5 (1.3-1.7)	104	1.5 (1.3-1.7)
Absence of local air ventilation	40	1.5 (0.8-2.6)	40	1.2 (0.6-2.0)
Personal & family illnesses history				
History of food allergy	14	1.2 (0.7-1.9)	14	1.4 (0.9-2.3)
History of wool allergy	28	2.1 (1.5-3.2)	27	2.2 (1.5-3.1)
History of metal allergy	71	2.1 (1.8-2.5)	55	0.8 (0.7-0.9)
History of allergy	7	16 (1.6-160)	6	3.6 (0.4-36)
History of atopic disease	80	4.2 (3.4-5.1)	66	1.6 (1.4-1.9)
Family history of asthma	25	6.9 (1.7-61)	23	3.7 (2.0-6.9)
Family history of allergy	27	1.1 (0.9-1.5)	28	1.6 (1.2-2.1)

Table 3. Crude odds ratio in specific variables for having possible asthma and probable asthma

Variables	Possible asthma (N = 179)		Probable asthma (N = 7)	
	N	ORs (95%CI)	N	ORs (95%CI)
Female	126	1.9 (1.0-3.9)	7	NA
Age (years)				
< 29	28	1.0	1	1.0
30-39	64	1.7 (0.7-3.7)	3	1.6 (0.1-85)
> 40	61	1.4 (0.6-3.3)	3	1.6 (0.1-84)
Current smokers	22	0.6 (0.3-1.4)	0	NA
Second hand smokers	65	1.0 (0.6-1.4)	3	(0.1-6.1)
Duration of employment (years)				
< 4	54	1.0	3	1.0
5-9	68	1.0 (0.5-2.0)	1	1.0 (0.5-2.0)
> 10	31	0.6 (0.3-1.3)	3	1.4 (0.7-3.0)
Exposure to wood dust level				
Low	22	1.0	0	1.0
Moderate	73	0.6 (0.2-1.5)	4	NA
High	58	0.7 (0.2-2.0)	3	NA
Dust size $\leq$ 9 micron	83	0.8 (0.4-1.4)	4	1.0 (0.2-7.3)
Occupational hazards				
Recognition of hazards	124	0.9 (0.4-1.9)	4	0.3 (0.1-2.0)
Using cloth masks	130	1.1 (0.5-2.4)	6	1.1 (0.1-51)
Uncomfortable feeling with mask	86	1.3 (0.7-2.4)	3	0.6 (0.1-3.8)
Absence of local air ventilation	27	0.05 (0.0-0.1)	6	1.3 (0.2-62)
Personal & family illnesses history				
food allergy	9	0.7 (0.2-2.6)	0	0 (0.0-8.0)
wool allergy	26	2.0 (0.8-5.7)	2	2.5 (0.2-15)
metal allergy	49	0.9 (0.5-1.7)	2	0.8 (0.1-5.1)
asthma	4	1.3 (0.2-9.0)	1	12 (0.2-174)
allergy	6	3.2 (0.4-140)	1	6.0 (0.1-63)
History of atopic diseases	59	1.4 (0.8-2.7)	5	0.8 (0.5-1.5)
Family history of asthma	18	3.2 (0.9-27)	2	4.3 (0.4-27)
Family history of allergy	18	2.5 (0.9-6.8)	5	1.2 (0.1-10.3)

NA: not applicable.

Table 4. Adjusted odds ratio in specific variables for having upper and lower respiratory tract symptoms (URTS and LRTS)

Variables	URTS (N = 187)		LRTS (N = 176)	
	ORs	95%CI	ORs	95%CI
Female	2.0	1.1-3.8	NA	NA
Exposure to wood dust level				
Low	1.0	NA	1.0	NA
Moderate	0.8	0.3-2.0	0.6	0.3-1.6
High	0.9	0.4-2.2	0.8	0.3-2.3
Dust size $\leq$ 9 micron	1.3	0.7-2.3	1.2	0.7-2.0
Absence of local air ventilation	1.6	0.8-3.3	1.6	1.0-2.6
History of atopic disease	3.6	1.9-7.0	NA	NA
Family history of asthma	NA	NA	4.0	1.3-11.9

NA: not applicable.

Table 5. Adjusted odds ratio in specific variables for having possible and probable asthma

Variables	Possible asthma (N = 179)		Probable asthma (N = 7)	
	ORs	95%CI	ORs	95%CI
Exposure to wood dust level				
Low	1.0	NA	NA	NA
Moderate	0.4	0.1-1.3	NA	NA
High	0.5	0.1-1.8	NA	NA
Dust size $\leq$ 9 micron	0.9	0.5-1.8	0.5	0.1-2.7
Absence of local air ventilation	1.5	0.6-3.6	0.6	0.1-6.5

NA: not applicable.

For LRTS outcome, the significant positive factors were female gender, 5-9 years of employment, uncomfortable feeling with cloth mask, history of wool allergy, history of atopic disease, and family history of asthma and allergy (Table 2). A family history of asthma was a significant risk factor with adjusted odds ratio of 4.0 (Table 4). No significant factor associated with possible or probable asthma by both univariate and multivariate logistic analysis (Table 3 and Table 5). Workers with a history of atopic disease have a higher chance of developing respiratory disease. Therefore, we did subgroup analyses by history of atopic disease with multivariate logistic regression analysis.

For those who did not have atopic disease, factor with positive correlation with URTS was female gender [OR 3.3 (95%CI: 1.5, 7.5)], while age more than 40 years [OR 0.3 (95%CI: 0.1, 0.8)] and being second hand smokers [OR 0.5 (95%CI: 0.3, 1.0)] were negative association with URTS. Being female was also positively associated with LRTS and possible asthma with adjusted odds ratio of 2.1 (95%CI: 1.1, 4.2) and [OR 3.2 (95%CI 1.5, 7.1)], respectively.

Subgroup analyses by having atopic disease showed that age between 30-39 years and more than 40 years were significantly associated with URTS [OR 7.9 (95%CI: 1.4, 43.7) and OR 10.9 (95%CI: 1.8, 65.5), respectively]. A family history of asthma was positively related with LRTS and possible asthma [OR 9.7 (95%CI: 1.2, 77.6), OR 9.7 (95%CI: 1.2, 77.7), respectively]. There was no factor related to the category possible asthma in either subgroup.

4. Discussion

This study represents the respiratory symptoms of rubber wood dust exposure in terms of various levels of wood dust exposure and particle sizes. The prevalence of upper and lower respiratory tract symptoms and possible asthma were high (Table 2). Almost 70% of workers had either upper or lower respiratory symptoms or possible asthma regardless of wood dust level or dust sizes. This finding may be due to a possible fact that in these types of factories such as sawmill and furniture factories, wood dust arose from the work processes generally presented with higher concentration. Some studies showed the concentration as higher than 5 mg/m^3 [11,13] and such concentrations can cause a high prevalence of both upper and lower respiratory symptoms.

However, there was no dose-dependent relation between having respiratory symptoms and wood dust levels in this study. The TLV limits for dusts of less than 2 mg/m^3 may not be appropriate for wood dust. Sripaiboonkij et al reported that an exposure to rubber tree dust in furniture factory increased the risk of respiratory symptoms including asthma by 8.41 times [14]. These findings were comparable with the current study except there was dose dependent in having wheeze and skin symptoms and the prevalence was quite lower. The differences of both studies are due to both studies used the different control groups, level of dust, and hazardous agents. The current study had three level of wood dust exposure (low, moderate, and high) and the low exposure group was used as reference. The geometric mean of wood dust concentration in the current study was 4.7 mg/m^3 (range 0.2-59.4), while most study area of the previous study had the inhalable dust concentration of less than 2 mg/m^3 [14]. In addition, the operations in the factory of the current study had only wood dust works unlike in the previous study that may contain other chemical substance exposures such as organic solvents. However, the prevalence of respiratory symptoms in the previous study was lower than the current study. Therefore, the wood dust may be a strong factor for the development of respiratory symptoms.

Another hypothesis that may explain non dose dependent effect of wood dust level and the occurrence of respiratory symptoms may be due to some other specific agents like natural rubber latex (NRL) which cannot be excluded. The purified allergen from raw NRL, which is a 58 kDA protein, can induce allergic reactions in the nanogram exposure range [15]. In addition, the explanation can be pointed to irritation mechanisms as only few workers exposed to wood dust were detected with specific IgE against pine wood [16].

The prevalence of URTS was marginally higher than LRTS (67.0 versus 63.1%, respectively). The exposure to dust size less than 9 micron was found in 111 of 187 workers (59.4%) and 103 of 176 workers (58.5%) in workers who had URTS and LRTS, respectively (Table 2). Considering probable asthma, it revealed quite as low as 2.5% among rubber sawmill workers. Due to our cross-sectional study design, we did not have baseline or pre-working pulmonary function results. The drop in forced expiratory volume might indicate some abnormal changes in the airways. The current study showed the prevalence of asthma close to the study by Borm, et al. that showed the prevalence of 4.1% among Meranti wood workers in Indonesia [17]. The lower prevalence asthma found in the current study may be explained by the fact that the current study is a cross-sectional study and that a healthy worker effect might have been contributed to bias. In addition, there may be some definite asthmatic workers related to rubber wood dust, however, due to their afraid of losing their job, they did not participate to the pulmonary function test. Other possibilities to be considered to explain this finding is that particle size found in the rubber wood sawmill shown to be in the size of inhalable fraction [11] therefore URTS would have been seen more LRTS i.e. asthma, bronchitis.

Regarding risk factors for URTS and LRTS, only female sex and history of atopic disease were independently associated with URTS (Table 4), while only family history of asthma had significant adjusted odds ratio for LRTS (Table 4). As previously reported, female sex had higher risk for development of rhinitis and upper respiratory tract infection particularly acute and chronic sinusitis, tonsillitis, and otitis externa [18,19]. Exposure to wood dust may aggravate these infections causing more URTS. Atopic disease associated with perennial allergic rhinitis [20] or asthma resulting in higher risk for URTS; and also aggravated by wood dust exposures. While, family history of asthma also increases risk for asthma up to 26% and LRTS when exposed to wood dusts [21]. There was no definite case of WDA and also no definite risk factors for possible or probable asthma in this study (Table 5). These results may explain from limitation of not using the methacholine test in pulmonary function test in this study.

Due to the very high prevalence of respiratory symptoms, we recommend to have a follow-up study in rubber wood sawmill factory with methacholine test and a pre-work pulmonary function test program for new workers. The prevention by law with the 8 hours time weighted averages (TWA) of wood dust in Thailand should be considered as the international recommendation (8 hrs-TWA less than 5 mg/m^3) [11].

5. Conclusion

The strengths of this study included using low wood dust exposure as reference and three levels of wood dust exposure. Even though there was no differences of respiratory symptoms by levels of wood dust exposure, the prevalence of respiratory symptoms were still high (82.1%). Additionally, the response rate was quite high. The main limitation of the study was that the cross-sectional study design. It is difficult to demonstrate the causal effect of wood dust. Long term follow up should be done to evaluate the chance of development of occupational asthma from wood dust. This information is limited and needs a cohort study to show this hypothesis. In addition, a healthy worker effect might be one of Among other explanation since a cross-sectional study normally showed this bias especially in the occupational health researches.

In conclusion, wood dust exposure had high prevalence of respiratory symptoms and possible asthma. Workers with history of allergic rhinitis and a family history of asthma should be closely monitored or advised to avoid wood dust exposure. Further cohort study is required to confirm the causal effect of wood dust for occupational asthma.

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