OCCUPATIONAL EXPOSURES AND HEALTH HAZARDS IN PARA RUBBER WOOD SAWMILLS IN TRANG PROVINCE, THAILAND

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A Thesis Submitted in Partial Fulfillment of the Requirements
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การสัมผัสและอันตรายต่อสุขภาพจากการทำงานในโรงเลื่อยไม้ยางพาราในจังหวัดตรัง ประเทศไทย

นายพยงค์ เทพอักษร

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรมหาบัณฑิต
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Thesis Title	OCCUPATIONAL EXPOSURES AND HEALTH HAZARDS IN PARA RUBBER WOOD SAWMILLS IN TRANG PROVINCE, THAILAND
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Field of Study	Public Health
Thesis Advisor	Associate Professor Wattasit Siriwong, Ph.D.
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Accepted by the College of Public Health Sciences, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

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พยงค์ เทพอักษร : การสัมผัสและอันตรายต่อสุขภาพจากการทำงานในโรงเลื่อยไม้ยางพาราในจังหวัดตรัง ประเทศไทย (OCCUPATIONAL EXPOSURES AND HEALTH HAZARDS IN PARA RUBBER WOOD SAWMILLS IN TRANG PROVINCE, THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. ดร.วัฒน์สิทธิ์ ศิริวงศ์, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: Prof. Dr.Akio Koizumi, 77 หน้า.

วัตถุประสงค์ วัตถุประสงค์การศึกษาเพื่อ 1) วิเคราะห์งานเพื่อความปลอดภัยและการบ่งชี้อันตรายจากการสัมผัสในการทำงานและอันตรายต่อสุขภาพสำหรับการป้องกันอันตรายในโรงเลื่อยไม้ยางพาราและ 2) ประเมินความสัมพันธ์ระหว่างอาการทางเดินหายใจและความผิดปกติของสมรรถนะการทำงานปอดของพนักงานโรงเลื่อยไม้ยางพารา

วิธีดำเนินการวิจัย การศึกษาเชิงภาคตัดขวางนี้ (Cross-sectional study) มีการสำรวจเบื้องต้น การวิเคราะห์งานเพื่อความปลอดภัย เก็บตัวอย่างอากาศและวัดระดับเสียง ในระดับบุคคลและสิ่งแวดล้อม และการวัดสมรรถภาพปอด ระหว่างวันที่ 1 ตุลาคม 2558 ถึง 28 กุมภาพันธ์ 2559 ในโรงเลื่อย จำนวน 4 แห่ง ในจังหวัดตรัง ในพนักงานจำนวน 687 คน โดยการสัมภาษณ์รายบุคคล และจำนวนพนักงานส่วนหนึ่งมีการ เก็บตัวอย่างอากาศในระดับบุคคลและสิ่งแวดล้อม และการวัดสมรรถภาพปอด โดยมีการวิเคราะห์การถดถอยโลจิสติก(Logistic Regression Analysis) เพื่อศึกษาปัจจัยที่มีความสัมพันธ์กับความผิดปกติของสมรรถนะการทำงานปอด

ผลการศึกษาและอภิปรายผลปัจจัยเสี่ยงและอันตรายจากการสัมผัสมีความสัมพันธ์กับ 6 ขั้นตอนหลักในการทำงาน ประกอบด้วย ขั้นตอนการตัดท่อนซุง การเลื่อย การเรียงไม้ การอบน้ำยา การเรียงไม้ และการบรรจุและการจัดเก็บ การวิเคราะห์งานเพื่อความปลอดภัยในแต่ละขั้นตอนการทำงานพบว่า พนักงานมีความเสี่ยงต่อการสัมผัสฝุ่นไม้ และเสียงดังอุบัติเหตุและอันตรายต่อมือและขา การสัมผัสสารอบน้ำยาและ สารป้องกันกำจัดเชื้อราและท่าทางในการทำงาน พนักงานสัมผัสเสียงดังสูงสุดในแผนกเลื่อย (Median=92.7 dBA)เละฝุ่นไม้ยางขนาด (0.902 mg/m^3) ในระดับสูงกว่าเปรียบเทียบกับกลุ่มที่ไม่สัมผัส(0.185 mg/m^3) กลุ่มสัมผัสฝุ่นไม้มีความชุกอาการแน่นหน้าอก(OR = 2.79; *p*=0.01) และหายใจขัด(OR = 2.27; *p*=0.04) สูงกว่าอย่างมีนัยสำคัญทางสถิติ ค่าสมรรถการทำงานปอด มีค่าต่ำกว่า (FEV1=2.41, FVC =2.55 L/s) เทียบกับกลุ่มที่ไม่สัมผัส (FEV1=2.91, FVC= 3.01 L/s). ข้อเสนอแนะจากผลการศึกษาควรมีการปรับปรุงการควบคุมเพื่อลดการสัมผัสฝุ่นไม้ยางพาราและเสียงดัง และใช้หลักการทางบริหารจัดการและวิศวกรรมเพื่อควบคุมการสัมผัสเพื่อลดความเสี่ยงจากอันตรายและการสัมผัส ผู้วิจัยเสนอให้พนักงานทุกคนควรใช้อุปกรณ์ป้องกันส่วนบุคคลตลอดระยะเวลาทำงานในทุกขั้นตอนในการทำงาน

สาขาวิชา สาธารณสุขศาสตร์	ลายมือชื่อนิสิต ....
ปีการศึกษา 2559	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
	ลายมือชื่อ อ.ที่ปรึกษาร่วม ....

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KEYWORDS: OCCUPATIONAL EXPOSURE / RISK ASSESSMENT / PULMONARY DYSFUNCTION / WOOD DUST / SAWMILL

PHAYONG THEPAKSORN: OCCUPATIONAL EXPOSURES AND HEALTH HAZARDS IN PARA RUBBER WOOD SAWMILLS IN TRANG PROVINCE, THAILAND. ADVISOR: ASSOC. PROF. DR.WATTASIT SIRIWONG, Ph.D., CO-ADVISOR: PROF. DR.AKIO KOIZUMI, 77 pp.

Objectives: The aims of this study were 1) to identify Job safety analysis (JSA) and hazard identification for occupational health risk exposures and health hazards for work accident prevention in Para rubber wood sawmills and 2) to assess the associations between respiratory symptoms and pulmonary defects of Para rubber sawmill workers.

Materials and Methods: A cross-sectional study was conducted, including a walk-through survey, JSA and personal and environmental wood dust and noise samplings, pulmonary function and spirometry tests between October 2015 and February 28, 2016 at 4 Para rubber wood sawmills in Trang Province. In totall, 687 Para rubber sawmill workers were participating from four sawmills completed questionnaire interviews, and a subset of sawmill workers from four factories participated in spirometric measurements and personal dust samplings. Logistic regression analysis was used to explore risk factors for pulmonary impairments.

Results and Discussion: Potential occupational safety and health hazards associated with six main processes had been evaluated, including logging and cutting, sawing the lumber into sheets, plaining and re-arranging, vacuuming and wood preservation, drying and planks re-arranging, and grading, packing, and storing. JSA and hazard identification on working process in sawmills showed high risk levels of wood dust and noise exposure, occupational accidents on hands and feet, chemicals and fungicide exposure and ergonomics or repetitive works. The workers exposed highest noise levels at sawing department(Median=92.7 dBA).The exposed workers had higher in respirable wood dust exposure (0.902mg/m^3) compared with the unexposed groups (0.185 mg/m^3). The exposed group had significantly higher prevalence than the unexposed group for chest tightness (OR = 2.79; p=0.01) and shortness of breath (OR = 2.27; p=0.04). The ventilatory function values (FEV1 and FVC) were lower for the exposed group compared with the unexposed group (2.41 Vs 2.55 L/s and 2.91 Vs 3.01 L/s, respectively). Results suggest that the sawmills should implement appropriate exposure control measures to reduce wood dust and noise exposure. The authors recommended the administrative controls and engineering controls for minimizing possible accidents and hazardous exposures. All sawmill workers were strongly recommended to use personal protective equipment in any working processes.

Field of Study: Public Health — Student's Signature ....

Academic Year: 2016 — Advisor's Signature ....

Co-Advisor's Signature ....

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I
INTRODUCTION

1.1 Background and Significance

Para rubber wood is one of the most important recycled natural resources in wood industries. Specifically, this wood is one of the most beneficial products in wood products of Thailand and accounts for approximately 75% of wood exported products [1]. It is employed for producing furniture, furniture parts, and wood-based products. These exported products have been significantly contributed to Thai's economy since 1985, approximately 1,000 million US $ per year [1-2]. In Thailand alone, there are 1.55 million ha for Para rubber plantations accounted for 21.6% of world share[3] In addition, Thailand is a leader of wood's log exporter with 1.6 million m^3[1].The factors contributing to a positive of rubber wood include its properties such as light and easy machining and also preserve environments[3].

Originally**,** Para rubber trees are a native South America plant (*Hevea brasiliensis*) [4]. They have been grown in Thailand since 1901[3]. They are an average of 20-30 meters tall and 30 centimeters diameter. After the productive life of the Para rubber tree for rubber production is complete, the trees are harvested. The harvested lumber is processed into wood products and furniture at sawmills. The Para rubber wood is softwood, including light color and easy to cut or transform. The essential components of Para rubber wood are cellulose, polyoses (hemicelluloses), and lignin. Cellulose is a major component (40-50%) of this wood. In addition, it has a higher proportion of mannose and galactose [5].

In the present, Thailand is the leading exporter of natural rubber and related products with 40 percent of the world's production. Southern Thailand is the major area of Para rubber production. It contains one-third of the total rubber production area in Thailand [2]. The productive life of the trees is approximately about 25-30 years. Annually, about 3-4% of total plantation areas are replanted in all of Thailand [2]. The demand for material wood logs is increasing in every year. This is because rubber wood is an important raw material for sawmills and wood product industries

[2]. The rubber wood industry in Thailand has rapidly grown in the last 15 years. According to the Industrial Department, there are approximately 5,000 wood establishments and 130,000 wood workers in Thailand. Approximately 70% of wood working establishments are related to Para rubber wood. These establishments are located in the Central (33.5%), the South (17.4%), the North (16.4%), and the Northeast of Thailand (13.0%) [6].

Previous studies of wood dust exposures have reported health effects and certain work-related risks, including a decline of pulmonary function, alveolitis allergy, asthma, chronic bronchitis, rhinitis, mucous membrane irritation, contact dermatitis and nasal cancer [7-15]. Skin irritation and skin sensitization occur as a result of contact with the wood itself, dust, bark, and wood sap [15]. Wood dust exposure causes effects on the respiratory organs, for example, rhinitis from nasal symptoms, sneezing, eye symptoms as soreness, watering and conjunctivitis, and asthma includes cough, wheeze, and dyspnea [9-10]. Cryptogenic fibrosing alveolitis is one of the interstitial lung diseases that may related to wood dust exposure [16]. In addition, a previous study has reported that wood dust is a potential risk factor for lung cancer [17]. Organic dust toxic syndrome is caused by the biological activity of inhaled dust itself and microbiological components in dust such as fungal spores, endotoxin from gram negative bacteria, etc. These particles will penetrate into lung and or alveoli [18]. Moreover, bioaerosarticles such as endotoxins, bacteria, and fungi, such as *aspergillus spp*., *penicillium spp*., *mucor spp*., and *rhizopus spp*. [19] that were found in wood dusts also induce health related problems in Para rubber workers. The International Agency for Research on Cancer (IARC) classifies wood dust as carcinogenic agent [20].

According to the US Occupational Safety and Health Administration (OSHA), the Permissible Exposure Limit (PEL) for contact to wood dust, including total dust, should not exceed 15 mg/m^3 and the PEL for inhalable dust should not exceed 5mg/m^3[21]. However in Thailand, there is no set standard limit for occupational Para wood dust exposure. Para sawmill workers are at high risk to exposure to borax, noise-induced hearing loss, heat exhaustion, musculoskeletal injuries related to vibration, and respiratory problems due to wood dust[22].

There are 38 Para rubber wood factories in Trang Province. Totally, 4,596 sawmill workers are employed in industries. Two thousand seven hundred and twenty one are male (59.24%) and 1,878 female workers (40.86%) [6]. There were totally 1,646 filed claims for reimbursement for occupational accidents and injuries from Trang Social Security Office between 2010 and 2012. Almost 80% claims were male (77.3%) with age 25-34 years old (37.2%). The employees of small establishments (<200) were found highest occupational accidents and injuries (61.7%). The Para rubber logging and furniture industries were highest claims (26.4) [35]. The most affecting results for occupational accidents and injuries were partial thickness wound (47.7%) with limbs and legs (67.1%) and the cause of struck/injured by object (67.6%). The most injury causes was injured by objects (49.1%). There was statistically significant difference between male and female for job positions ($p < 0.001$), age ($p = 0.003$) and size of establishment ($p < 0.001$) [35].

This study is the health risk assessment on occupational exposures and health hazards among Para rubber sawmills in Trang Province. The main objectives of this study are to investigate occupational health risk exposures and assess the health hazards in sawmill processing factories. A lack of knowledge about this particular topic in Trang Para rubber wood sawmill industry lead to this study as not much is known about occupational health hazards, pulmonary dysfunction, and their prevalence of pulmonary dysfunction. The significance of the study lies in the fact that with advising management on the prevalence of health hazards, including respiratory symptoms and pulmonary dysfunction according to area of work as well as the need for the implementation of specific control measures the progression of respiratory symptoms and pulmonary dysfunction.

1.2 Objectives

The purpose of the study is to describe environmental risk factors, occupational health hazards and risks, respiratory symptoms, pulmonary dysfunction, and the prevalence of pulmonary dysfunction in relation to duration of service and occupation. The aim is to establish whether respiratory symptoms and pulmonary dysfunction, which could be ascribed to excessive exposure to rubber wood dust, are present in exposed workers. Specifically, this study determines occupational health hazards as the following:

1.2.1 To identify environmental potential factors influencing occupational exposure among rubber wood workers in Para rubber wood sawmills in Trang Province.

1.2.2 To investigate occupational exposure to health hazards in Para rubber wood sawmills in Trang Province.

1.2.3 To assess the association between wood dust exposure levels and respiratory symptoms and pulmonary dysfunction.

1.3 Research Hypotheses

1.3.1 Environmental potential factors influencing occupational exposure among rubber wood workers in Para rubber wood sawmills in Trang Province are including job titles, medical history (respiratory symptoms & related diseases), smoking status, personal protection equipment, wood dust levels, work hours a day / a week, year employed, behavioral risks and occupational injuries and illnesses.

1.3.2 Occupational health hazards in Para rubber wood sawmills in Trang Province are including wood dust, heat stress, fungicide agent's use as preservative, repetitive work and poor work conditions.

1.3.3 Wood dust exposed levels are associated with symptoms and abnormal pulmonary function test among Para rubber sawmill workers.

1.4 Scope of Study

This study identified environmental potential factors influencing occupational exposure among rubber wood sawmill workers. The prevalence rate and associated factors with symptoms and abnormal pulmonary function test were assessed among Para rubber sawmill workers.

1.5 Significance of the Study

This study is specific for Para rubber wood workers who are exposed to occupational health hazards in Para rubber wood sawmills. It is hoped that this project had advantages as follows:

1. This study was used in occupational health and safety studies for understanding, managing, controlling, and reducing occupational health risks in Para rubber wood sawmills.

2. This study provided the results as a health promotion and prevention for Para rubber wood establishments in Thailand.

Completion of this study provided the results in a comprehensive assessment of Para rubber wood dust exposure and health hazards, which was not currently well understood. This research provides a better understanding wood dust exposure and lung function in Para rubber wood sawmills. These results provide for designing an intervention for controlling wood dust, other health hazards and protecting workers' health in rubber wood sawmills.

1.6 Conceptual Framework

From the literature reviews of previous studies, the conceptual framework is developed according to the environmental and occupational risk assessment (Figure 1.1).

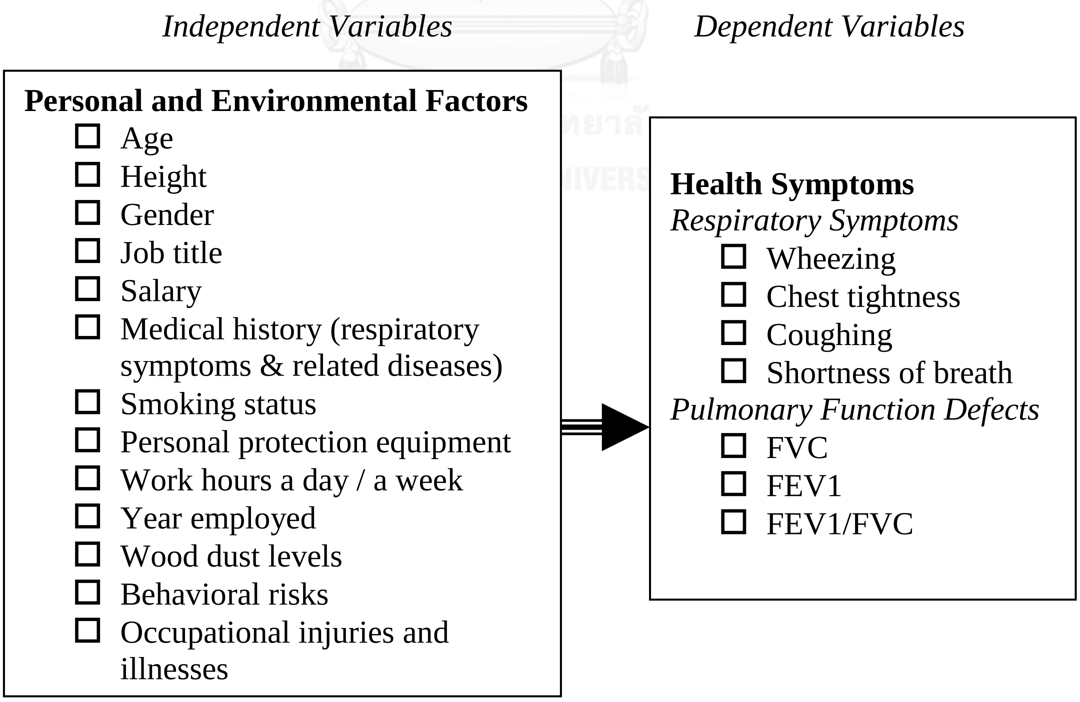

Figure 1.1 Conceptual framework of this study

1.7 Term Terminology

1. Rubber wood processing industry: All establishments that are involved with Para rubber wood.
2. Para rubber Wood Dust: A complex mixture of dust generated when Para rubber wood log or timber was processed in sawmill, e.g., debarking, sawing, drying, pressing, etc.
3. Sawmills: Establishments that perform processing of wood. In this study sawmill performed sawmilling, sawn wood preservation, drying of sawn wood and woodworking.
4. Occupational exposure hazards: The act or the condition of being subjected and was quantified by personal exposure to wood dust, fungi , noise, heat, vibration, chemicals, slips, trips and falls in the specific processes of sawmill.
5. Inhalable dust (Inhalable particulate matter; IPM): The fraction of particles defined in terms of a probability as a function of particle aerodynamic diameter, which is aspirated through the nose and/or mouth during breathing. This is equivalent to the aspiration efficiency of the human head (diameter 1-100 μm).
6. Respirable dust (Respirable particulate matter; RPM): The fraction of inhaled particles, defined in terms of a probability as a function of particle aerodynamic diameter, which passes down to the alveolar or gas exchange region of the lung (diameter < 4 μm).
7. Job: Work at specified machine or process.
8. FVC (Forced Vital Capacity): This is the total volume of air expired after a full inspiration. Patients with obstructive lung disease usually have a normal or only slightly decreased vital capacity. Patients with restrictive lung disease have a decreased vital capacity.
9. FEV1 (Forced Expiratory Volume in 1 Second): This is the volume of air expired in the first second during maximal expiratory effort. The FEV1 is reduced in both obstructive and restrictive lung disease. The FEV1 is reduced in obstructive lung disease because of increased airway resistance. It is reduced in restrictive lung disease because of the low vital capacity.

10. FEV1/FVC: This is the percentage of the vital capacity which is expired in the first second of maximal expiration. In healthy patients the FEV1/FVC is usually around 70%. In patients with obstructive lung disease FEV1/FVC decreases and can be as low as 20-30% in severe obstructive airway disease. Restrictive disorders have a near normal FEV1/FVC (Figure 1.2).

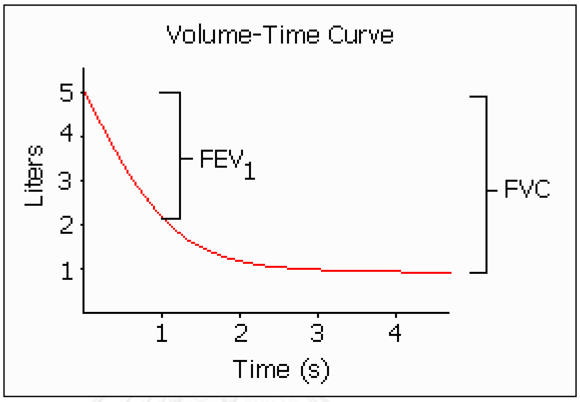

Figure 1.2 The amount of air expired from the lungs as a function of time

1.8 Ethical Considerations

Human Subject Approval:

This study was approved by the ethical committee of Chulalongkorn University Review Board (COA No.237/2558; research project 210.1/58).

Ethical Considerations and Misconduct Management

All workers were sign an informed consent form. Several mechanisms are used to ensure anonymity of participants. Each participant was given a number. Since this study procedure has relative low risks to sawmill workers, the risk-benefit is considered and no risk to the participants such as physical or psychological harm or loss of privacy existed. The sawmill workers have the right to withdraw from this research project at any time as they wish without given any reasons. This withdrawal was not have any negative harm to them such as less paid, change job position, dismissal from work, etc.

CHAPTER II
LITERATURE REVIEW

This chapter described the descriptive relevant reviews related to occupational risks and hazards in sawmills. The details are including 1) wood sawmill processing and working process in Para rubber wood sawmills, 2) potential hazardous exposure in sawmills, 3) wood dust and Para rubber dust exposure in sawmills, 4) health effects from wood dust exposure, 5) occupational noise exposure and health effects in sawmills, 6) chemical exposure and health effects, and 7) occupational accidents and injuries in Trang Province.

2.1 Wood Sawmill Processing

Working process in Para rubber wood sawmills

From a walk-through survey of one sawmill, this sawmill consists of a green mill and a dry mill. In rubber wood sawmill industries, the major process consists of four main activities: 1) lumber cutting and preparation; 2) debarking and sawing the lumber into sheets; 3) drying, pressing, and gluing; and 4) finishing including grading, stacking, banding, and stock and sale [Figure 2.1-2.3][3]. Briefly, logs were cut into the required length and then sorted and stored in dry area. In cutting process, the logs were cut into boards by a band saw. Next, sorted sheets were sent to a vacuum tank for preservative treatment where they were impregnated with fungicide, mainly boric and borax. After impregnation, the sheets were stored to dry before shipping or further processing including cutting, planning, laminating, and sanding. In these working areas, exhaust ventilation systems were provided to primarily prevent the accumulation of wood dust and air pollutants. Finally, cleaned up process was performed at the end of each day, including compressed air and dry sweeping to remove wood dust.

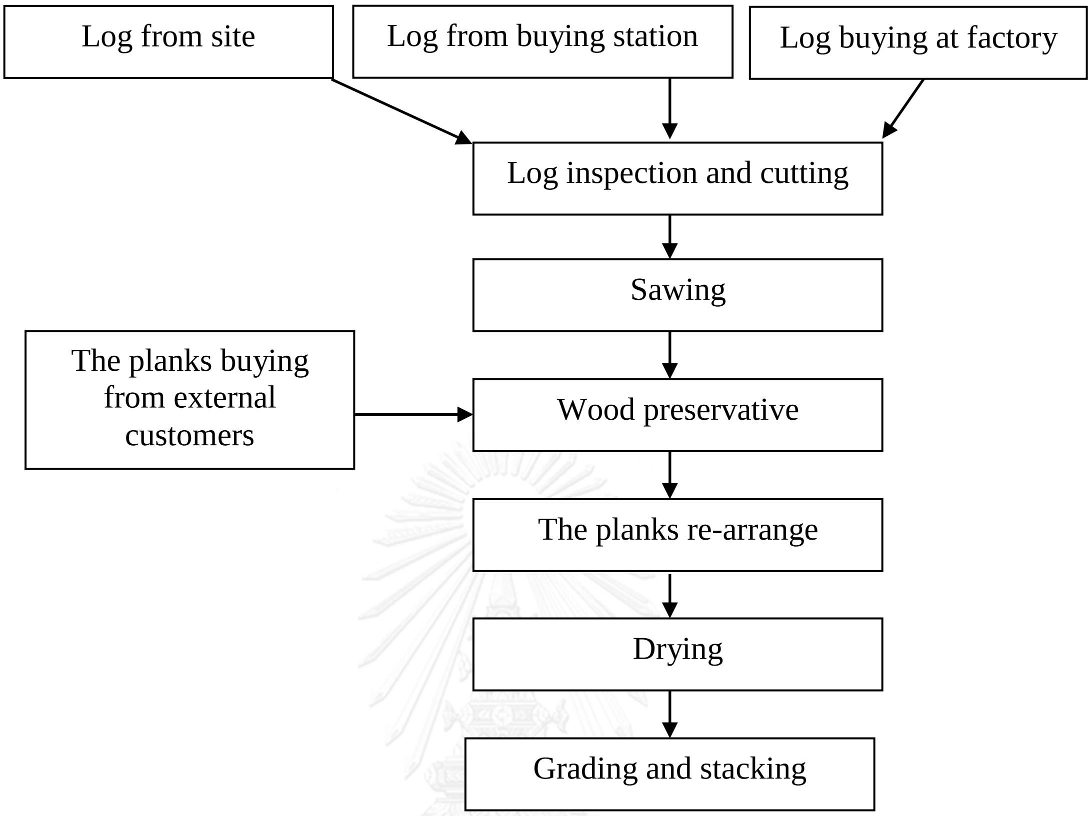

Figure 2.1 Para rubber wood sawmill processing

Figure 2.2 Sawing process

Figure 2.3 The planks were put into a vacuum tank for preservative

2.2 Potential Hazardous Exposure in Sawmills

Occupational exposure to wood dust in Para rubber sawmill

From several processes, workers are exposed to airborne dust of different particle sizes, concentrations, and compositions. The most Para rubber wood dust comes from sawing process.

The essential components of wood are cellulose, polyoses (hemicelluloses), and lignin. Cellulose is a major component (40-50%) of both hardwood and softwood. However, the proportion and composition of lignin and polyose differ in softwood and hardwood. Softwood has a higher proportion of mannose and galactose, whereas hardwood has a higher proportion of xylose units [5].

The wood dust particle consists of macromolecules such as cellulose, hemi-cellulose, and lignin and micro-molecules, such as ternene and terpenoid, lipid and wax, phenol compounds (para-hydroxybenzoic acid, tannin, flavonoid, quinine, and lignan), proteins and amino acids, and inorganic compounds, such as potassium, calcium, magnesium and silicon[5,19].

Table 2.1 Production activities and source of occupational exposure to rubber wood products in rubber wood sawmill

Production Station and Activities	Description of Processing	Main Products	Health Hazards	Source of Occupational Exposure
Log inspection and cutting	-Cutting -Grading(size of log)	-Logs	-Milk sap -Work related musculoskeletal stress and vibration -Heat stress -Job stress -Ergonomic hazards-slips and trips	-Skin contact with rubber milk or sap -Inhalation of wood dust
Sawing	-Sawing	-Planks	-Wood dust -Milk sap -Work related musculoskeletal stress and vibration -Heat stress -Job stress -Ergonomic hazards-slips and trips	-Skin contact with wood dust -Inhalation of wood dust -Inhalation of bioaerosol such as fungi, bacteria, and endotoxins
Laminating and finger jointing	-Laminating	-Laminating board	-Wood dust -Job stress -Ergonomic hazards-repetitive work	-Skin contact with wood dust
Four side planing	-Planing	-Four side planed timber	-Wood dust -Job stress -Ergonomic hazards-repetitive work	-Skin contact with wood dust
Wood preservative	-Using fungicide preservative in a vacuum tank	-Preservative planks	-Wood dust -Chemical-borax, boric and chlorine -Job stress -Ergonomic hazards-repetitive work	-Inhalation of wood preservative such as fungicide
Drying	-Drying process or kiln drying	-Drying planks	Wood dust -Chemical-borax, boric and chlorine -Job stress -Ergonomic hazards-repetitive work	-Inhalation of wood dust -Inhalation of bioaerosol such as fungi, bacteria, and endotoxins
Grading and stacking	-Cutting and grading -Stacking	-Cupboards -Finger joints -Chips	Wood dust -Job stress -Ergonomic hazards-repetitive work	-Skin contact with wood -Inhalation of bioaerosol such as fungi, bacteria, and endotoxins

2.3 Permissible Exposure Limit for Wood Dust Exposure

According to the US Occupational Safety and Health Administration (OSHA), the Permissible Exposure Limit (PEL) for contact to wood dust, including total dust, should not exceed 15 mg/m^3 and the PEL for respirable dust should not exceed 5mg/m^3. But in Thailand, there is no set standard limit for occupational Para wood dust exposure [21].

Several public agencies have set standards or given recommendation for wood dust exposure at the workplace. OSHA, NIOSH, ACGIH and IARC proposed the standard level and guideline (Table 2.2).

Table 2.2 Permissible exposure limit for wood dust exposure [20-22, 24]

Agency	Standard Level
OSHA PEL	15 mg/m^3 as total dust
NIOSH REL	1 mg/m^3 as total dust
ACGIH TLVs (2014) : A1	
Certain hardwoods such as beech and oak	TWA 1 mg/m^3
Softwood	TWA 1 mg/m^3, STEL 10 mg/m3
ACGIH TLVs (2014) : A1	
Hardwoods and softwoods(non-allergic): A4	TWA 1 mg/m^3
Beach and oak: SEN:A1	TWA 1 mg/m^3
Birch, mahogany, teak, walnut (allergic): SEN;A4	TWA 1 mg/m^3
Western red cedar: SEN; A4	TWA 0.5 mg/m^3
Ministry of Interior, Thailand	
Respirable dust; size less than 10 µm	TWA 5 mg/m^3
Total dust	TWA 15 mg/m^3

In Thailand, Para sawmill workers are at high risk to exposure to borax, noise-induced hearing loss, heat exhaustion, musculoskeletal injuries related to vibration, and respiratory problems due to wood dust(Table 2.3).

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Table 2.3 Major hazards, causative agents, and associated health effect in rubber wood sawmill [22-27],

Major Hazards	Causative Agents	Health Effects
Physical hazards	-Noise and vibration -Heat	-Noise-induced hearing loss -Heat stress
Chemical hazards	-Fungicide agents use as preservative -Volatile components of wood -Formaldehyde	-Respiratory diseases- asthma, chronic obstructive pulmonary disease(COPD), pneumonitis -Skin irritation and contact dermatits -Possible sino-nasal
Biological hazards	-Para rubber wood dust -Moulds in wood dust -Bacteria in wood dust including endotoxin	-Respiratory diseases- asthma, chronic obstructive pulmonary disease(COPD), allergic alveolitis
Ergonomic hazard	-Slips, trips, and fall -Repetitive work	-Work related musculoskeletal disorder such as low back pain, strain,
Psychological hazards	-Poor work conditions	-Job stress

2.4 Wood Dust and Para rubber Dust Exposures

Saejew N. (2008) conducted occupational dust exposures at one of the largest Para rubber wood sawmills. The personal inhalable dust and respirable dust were assessed using NIOSH method. Totally, there were 742 personal inhalable dust samples and 241 respirable dust, 323 inhalable fungi and 212 respirable fungi samples. The personal inhalable dust levels were high ranging between 0.2 to 59.4 mg/m^3 and GM of 4.7 mg/m^3. The highest GM inhalable dust exposure levels were found in the sawing green lumber (12.8 mg/m^3) and the cutting of dry lumber (7.3 mg/m^3). However, the personal respirable dust concentrations were generally low in the range of 0.1 to 6.0 mg/m^3 with GM 0.3 mg/m^3. The high exposure groups were presented on job positions, green lumber sawing, boiler operators, dry lumber cutting, sorting, grading and stacking of dry lumber, planning and ripping dry lumber and planning of dry lumber. The significant determinants of personal inhalable dust exposure were the wood processed, job groups and type of machine used [25].

Alwis KU & Mandrylk J (1999) conducted study of occupational exposure to wood dust in joineries. From several processes, workers are exposed to airborne dust of different particle sizes, concentrations, and compositions. The essential components of wood are cellulose, polyoses (hemicelluloses), and lignin. Cellulose is a major component (40-50%) of both hardwood and softwood. However, the proportion and composition of lignin and polyose differ in softwood and hardwood. Softwood has a higher proportion of mannose and galactose, whereas hardwood has a higher proportion of xylose units [5]. The wood dust particle consists of macromolecules such as cellulose, hemi-cellulose, and lignin and micro-molecules, such as ternene and terpenoid, lipid and wax, phenol compounds (para-hydroxybenzoic acid, tannin, flavonoid, quinine, and lignan), proteins and amino acids, and inorganic compounds, such as potassium, calcium, magnesium and silicon[5,19].

Mandrylk et al. (2000) conducted study at three green mills and two dry mills. The results showed the levels of endotoxin, (1-->3)-beta-D-glucan, bacteria and fungi were high in green mills compared with dry mills. Significant positive correlations were found among endotoxin and Gram (-)ve bacteria, (1-->3)-beta-D-glucan and fungi, and endotoxin and (1-->3)-beta-D-glucan exposure levels [25].

Thetkathuek et al (2010) conducted occupational exposure at the wood furniture industry in the Chonburi and Rayung provinces of eastern Thailand. Wood dust exposure levels were 4.08 mg/m3 (SD = 1.42, range: 1.15-11.17 mg/m3) [26].

2.5 Health Effects from Wood Dust Exposures

The Health Effects of Occupational Exposure to Wood Dust

Several studies of wood dust exposures have shown certain work-related symptoms, including a decline of lung function, allergic alveolitis, asthma, chronic bronchitis, rhinitis, mucous membrane irritation, contact dermatitis and nasal cancer [7-13]. Skin irritation and skin sensitization occur as a result of contact with the wood itself, dust, bark, and sap. Sensitization dermatitis is usually caused by fine dust. Inhalation of wood dust also causes effects on the respiratory organs. For example, respiratory symptoms include rhinitis from nasal symptoms, sneezing, and nose bleeding, eye symptoms as soreness, watering and conjunctivitis, and asthma includes cough, wheeze, and dyspnea [9-10].

The chemical exposures in sawmills are pentachlorophenol, formaldehyde, and solvent. The chemical exposure are fungicides and insecticides such as borax, pentachlorophenol, solvent such as methyl alcohol, aromatic hydrocarbons—toluene, xylene, and ketone, kerosene, turpentine, aliphatic hydrocarbon [22].

Pulmonary Effects and Dysfunction

Pulmonary function tests provide measures of airflow, lung volumes, gas exchange, response to bronchodilators, and respiratory muscle function. Basic pulmonary function tests available in the ambulatory setting include spirometry and pulse oximetry; these tests provide physiologic measures of pulmonary function and can be used to quickly narrow a differential diagnosis and suggest a subsequent strategy of additional testing or therapy. Spirometry is used to establish baseline lung function, evaluate dyspnea, detect pulmonary disease, monitor effects of therapies used to treat respiratory disease, evaluate respiratory impairment, evaluate operative risk, and performs surveillance for occupational-related lung disease.

Mandryk et al. (1999) conducted occupational exposure to wood dust at four sawmills and five joineries in Australia. They revealed significant associations between percentage cross-shift decrease in FVC and regular phlegm and blocked nose among sawmill and chip mill workers. Both joinery workers and sawmill and chip mill workers showed significant relationships between percentage predicted lung function (FVC, FEV1, FEV1/FVC, FEF25-75%) and respiratory symptoms. They suggested that wood dust and biohazards associated with wood dust are potential health hazards and should be controlled [13].

Anamai et al (2010) conducted factors affecting pulmonary dysfunction among 685 workers in rubber wood furniture industry. The mean percent of predicted forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and FEV1/FVC values were 84 % (SD = 13.41), 86 % (SD = 14.40), and 99% (SD = 10.42), respectively. Significant negative correlations were found between mean dust exposure levels and FVC ($p = 0.0008$), and FEV1/FVC% ($p < 0.001$), but not FEV1 ($p = 0.074$). An association between decline in lung function and wood dust levels among wood workers suggests that rubber wood dust exposure negatively affects lung function [26].

Sripaiboonkij et al (2009) conducted occupational exposure and potential health effects related to rubber wood dust among 103 workers in a rubber tree furniture factory and 76 office workers in four factories. The results showed that the workers increased risk of wheezing, nasal symptoms and asthma compared to office workers. Significantly increased risks of nasal symptoms (OR= 3.67) and asthma

(OR=8.41) were detected in the low exposure category. There was dose-dependent reduction in spirometric lung function with wood dust level. This study provides evidence that workers exposed to wood dust increased risk of nasal symptoms, wheeze, and asthma and skin symptoms [27].

Schlunssen et al (2002) showed the results of pulmonary function and respiratory symptoms from a survey of 2,423 wood workers from 54 furniture factories and three control factories. They found woodworkers had increased frequency of coughing with negative interaction between dust exposure and smoking. A dose-response relationship was seen between dust exposure and asthma symptoms, and a positive interaction for asthma was seen between female gender and dust exposure. Increased frequency of wheezing and a cross-shift decrease in forced expiratory volume in 1 second among workers using pinewood was seen. They suggested that wood dust exposure might cause respiratory symptoms, despite relatively low exposure levels [28].

Douwes et al (2006) conducted association between pine dust exposure and asthma symptoms of 772 pine sawmill workers. Pulmonary function and atopy was determined using spirometry and skin-prick tests, respectively. Exposed workers to dry but not to green dust were associated with asthma symptoms. In addition, green dust was associated with atopic sensitization, particularly against outdoor allergens. However, no association was found for dry dust. FVC, FEV1 and peak expiratory flow were significantly lower in pine workers exposed to high levels of green dust and dry dust. These associations were observed both in workers with and without asthma symptoms. No associations with cross-shift changes in pulmonary function were found. This study suggested exposure to green pine sawdust may be a risk factor for atopy. Both green and dry dust was associated with obstructive as well as restrictive pulmonary effects [29].

Osman and Pala (2009) performed occupational exposure to wood dust at furniture factory. The results showed the mean FEV1 and FVC values of both smokers and non-smokers, were significantly low, although the FEV1/FVC value was high ($p < 0.05$). An increase both in FEV1 and FVC values was detected who had a working period less than 10 years and were exposed to wood dust at levels over 4 mg/m^3 compared to the workers who were exposed to wood dust at less than 4 mg/m^3

($p < 0.05$). They suggested that the exposed workers adversely influenced their pulmonary dysfunctions [30].

2.6 Noise Exposure and Health Effects

Exposure to high levels of noise can cause permanent hearing loss. Neither surgery nor a hearing aid can help correct this type of hearing loss. Short term exposure to loud noise can also cause a temporary change in hearing or tinnitus. These short-term problems may go away within a few minutes or hours after leaving the noise. However, repeated exposures to loud noise can lead to permanent tinnitus and/or hearing loss. In addition, loud noise can create physical and psychological stress, reduce productivity, interfere with communication and concentration, and contribute to workplace accidents and injuries by making it difficult to hear warning signals. The effects of noise induced hearing loss can be profound, limiting your ability to hear high frequency sounds, understand speech, and seriously impairing your ability to communicate.

Aurajananon K et al. (2006) conducted noise exposure and risk perceptions of noise exposure among sawmill workers (n= 98) in Chiangmai Province. They revealed that 57.1 percent of workers who worked in all departments: saw line, cut line, and wood planning line had exposed to noise exceeding 85 dB(A) during an 8-hour workday (range 85.1-103.0), specifically 83.3% for saw line department. For risk perceptions of noise exposure, about 64-68 percent of workers had perceived risks at a moderate level and 13-15 percent of workers had perceived risks at a low level [31].

Robinson (2009) conducted the prevalence of occupational NIHL among wood workers in Nepal. One hundred and twenty five participants were recruited in this study (89 carpenters and 36 log cutters). Prevalence of NIHL was 26.5% (95% confidence interval (CI): 20.4–33.6) and 43.8% (95% CI: 32.3–55.9) among carpenters and log cutters respectively. Equivalent noise levels ranged from 71.2–93.3 dBA and 74.9–93.9 dBA for the respective groups. Age and time were significant predictors for NIHL ($p=0.002$ and $p=0.014$ respectively). They are at a substantial risk of occupational NIHL [32].

2.7 Chemical Exposure and Health Effects

Tuntiseranee and Chongsuvivatwong (1998) conducted a survey for chemical exposures in sawmills are pentachlorophenol, formaldehyde, and solvent. The chemical exposure are fungicides and insecticides such as borax, pentachlorophenol (PCP), solvent such as methyl alcohol, aromatic hydrocarbons—toluene, xylene, and ketone, kerosene, turpentine, aliphatic hydrocarbon [22].

Borax is a form of boric acid chemically known as sodium tetraborate decahydrate or simply sodium borate decahydrate. It is a common insecticide, herbicide, fungicide and fire retardant. Borax is immediately irritant. Long-term contact can result in toxicity. Dermal toxicity is considered boric acid to be moderately acutely toxic and may cause skin irritation. Acute respiratory irritation such as dryness of the mouth, nose or throat, dry cough, nose bleeds, sore throat, productive cough, shortness of breath and chest tightness in borax workers who participated in the study.

Pentachlorophenol (PCP) is a man-made chemical that is used as a pesticide and wood preservative. PCP exposure can have many symptoms. If inhaled, it can cause coughing, dizziness, headache, difficulty breathing, and sore throat. If absorbed, it can cause redness, blisters, or chloracne. If ingested, it can cause stomach cramps, diarrhea, nausea, vomiting, weakness, and unconsciousness [32].

Toluene is used as a solvent. Exposure to toluene may occur from breathing ambient or indoor air affected by such sources. Symptoms of toluene exposure include: irritation of the eyes and nose; weakness, exhaustion, confusion, euphoria, dizziness, headache; dilated pupils, lacrimation (discharge of tears); anxiety, muscle fatigue, insomnia; numbness or tingling of the skin; dermatitis. Toluene exposure may cause liver and kidney damage. Toluene affects the central nervous system, eyes, skin, respiratory system, liver, kidneys. Breathing high levels of toluene during pregnancy has been shown to result in children with birth defects and to retard mental abilities and growth. Long term and repeated workplace exposure to toluene affect the central nervous system [33].

Xylene is an aromatic hydrocarbon widely used in industry and medical technology as a solvent. Exposure to xylene can occur via inhalation, ingestion, eye or skin contact. The main effect of inhaling xylene vapor is depression of the central nervous system, with symptoms such as headache, dizziness, nausea and vomiting. The effects listed below can begin to occur with exposure to air levels of about 100 ppm [34].

2.8 Occupational Accidents and Injuries in Trang Province

Thepaksorn et al (2013) conducted study of factors affecting occupational accidents and injuries of establishments in Trang Province between 2010 and 2012. There were totally 1,646 filed claims for reimbursement. One thousand two hundred and seventy two were male (77.3%) with age 25-34 years old (37.2%). The employees of small establishments (<200) were found highest occupational accidents and injuries (61.7%). The logging and furniture industries were highest claims (26.4%), followed by construction, metal and machinery industries (16.3%). The most affecting results were partial thickness wound (47.7%) with limbs and legs (67.1%) and the cause of struck/injured by object (67.6%). The most injury causes was injured by objects (49.1%). There was statistically significant difference between male and female for job positions ($p < 0.001$), age ($p= 0.003$) and size of establishment ($p < 0.001$). There was statistically significant difference between sex and cause of injuries ($p < 0.001$), affecting factors ($p =0.001$) and affecting results ($p < 0.001$), respectively. There was statistically significant difference between age group and part of body affected ($p =0.001$), size of establishment ($p =0.015$), cause of injuries ($p < 0.001$), affecting factors ($p < 0.001$) and affecting results ($p = 0.032$), respectively. Job positions were also correlated to part of body affected ($p< 0.001$), causes ($p< 0.001$), affecting factors ($p < 0.001$), and affecting results ($p=0.003$), respectively. The study recommendations that should be included conduct educational training for occupational health and safety, for example, exhibition and display, study visit, using personal protective equipment (PPEs), and providing statistical accident board. Specifically, the high risk group of mechanic employees should be seriously practicing and concerns following occupational health and safety rules [35].

CHAPTER III
MATHODOLOGY

This study aimed to describe environmental risk factors, occupational health hazards, respiratory symptoms, pulmonary dysfunction, and the prevalence of pulmonary dysfunction in relation to duration of service and occupation. A job safety analysis (JSA) was conducted for identifying existing and potential health hazards in each working procedure. The aim was to establish whether respiratory symptoms and pulmonary dysfunction, which could be ascribed to excessive exposure to rubber wood dust, are present in exposed workers.

3.1 Study Design

This study was conducted including a walk-through survey, questionnaire interviews, JSA, personal and environmental samplings, physical exams and spirometry measurements. Specifically, this study examined the observed effects on health effects and occupational hazards, including lung function of wood sawmill workers.

Subject Recruitment:

This study recruited in total 687 sawmill workers from 4 sawmill factories in Trang Province. The invitation letters were sent to the managers of the participated factories. The researcher team had investigated and site visited for assessment based on similar characteristics of work settings and work environment, number of workers, working procedures, size of factories, etc. The worker recruitment includes asking permission for participation in this study and their employers to administer questionnaire interview and pulmonary function test.

Inclusion Criteria

The inclusion criteria for participants were workers between 20-60 years old, having worked at least 6 months, and no previous diagnosed as asthma, tuberculosis, and respiratory symptoms. The occupational nurse reviewed records of physical exams for screening the participated workers. Then, the participants were asked to confirm for diagnosed diseases. The factories were recruited based on similar characteristics in terms of working procedure, number of workers, equipment uses, working hours, etc.

Exclusion Criteria

The exclusion criteria for participants were migrant workers and minority workers. The migrant workers or alienate workers were workers who legally are employed under Labor Act, B.E.2551 and registered with approval for work permit.

Sample Size Calculation and Selection:

The sample size was calculated based on Kelsey et al, 1996. The proportion of unexposed to expose in sample is 0.15. The ratio of sample size (non-exposed/exposed group is 0.30 and odds ratio is 2. Six hundred forty seven workers (n= 647) are required for this study. They were interviewed and had their lung function tests [36]. However, to prevent the dropout rates, 6% additional participants were recruited. Therefore, the total of 687 sawmill workers were interviewed in this study.

$$n = \frac{NZ^2_{\alpha/2} * p(1-p)}{\left[e^2(N-1)\right] + \left[Z^2_{\alpha/2} * p(1-p)\right]}$$

n = Sample size

N = Total number of sawmill workers in Trang Province (N=4,596)

$Z_{\alpha/2}$ = Confidential level (1.96)

p = Degree of variability and proportion of abnormal respiratory symptoms and pulmonary dysfunction for Para rubber wood dust exposure (0.25) [26]

e^2 = Precision level at 0.05

3.2 Study and Sampling Methods

Study Population and Settings

A cross-sectional study was conducted at sawmill factories in Trang Province. A walk-through survey was conducted for a preliminary assessment and sampling plan arrangement during October, 2015. This employed the survey template of the Ministry of Labor [23]. Face-to faces for questionnaire interviews and JSA were conducted on January 15-30, 2016 at the factories. The records of physical exams were also reviewed. Spirometry measurements were conducted for each participant on February 15-30, 2016 at the factories by mobile unit of Thungsong Laboratory Co. Ltd.

Questionnaire interviews containing 28 questions were used in the study. The questionnaires included questions relating to the workers' demographic data, smoking status, medical history, occupational background, personal protective equipment usage status and complaints about work. The questionnaires were filled during face-to-face interviews (Fig. 3.1).

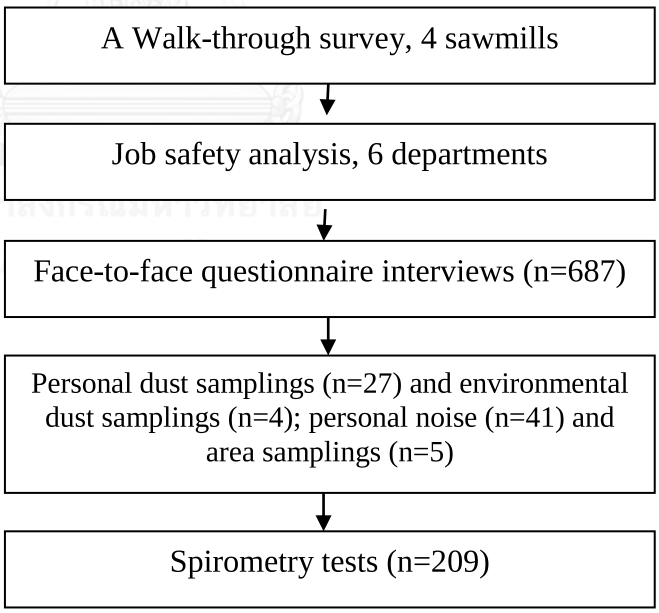


Figure 3.1 Flowchart of study and sampling technique

Identify Exposure and Non-Exposure Group

Exposure group was selected from workers in different departments and types of job titles [23]. Approximately 80% of workers and exposed to respirable dust at level >1mg/m^3. In non-exposure group or reference group was selected from non-exposure group such as office workers, maintenance workers, drivers and workers who are exposed to wood dust at low level <1mg/m^3. The ratio for exposed and exposed groups was approximately 2:1.

Questionnaire Interviews and Data Validation

The questionnaire was developed by modifying the questionnaires from the American Thoracic Society Division of Lung Diseases [41]. The questionnaires were tested and some corrections were made prior to use for interviewing. Pulmonary function testing followed the guidelines given by the Thoracic Society of Thailand to measure forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), FEV1/FVC, forced expiratory flow between 25% and 75% of vital capacity (FEF25–75%) and peak expiratory flow (PEF) using a spirometer (Spirolab II; MIR Medical International Research, Waukesha, WI, USA). The questionnaire interviews were tested for content validity by three experts from Central Chest Institute of Thailand, Burapa University, and Trang Hospital. The questionnaire interviews were revised and tested for reliability by tryout at one sawmill for 35 samples. The coefficient Alpha (Cronbach) was 0.7208(COA No.237/2558; research project 210.1/58).

Pulmonary Function Test by Spirometry

Pulmonary function tests were performed by trained occupational nurse at least three times for each subject in a sitting position with closed nostrils using MIR — Spirobank G (Italy) spirometer and with a different mouthpiece for each subject. A practical presentation about the test and the way it was done is performed for the subjects before the test. The tests were performed according to the test procedure of The European Respiratory Society [37]. FEV_1, FVC, FEV_1/FVC and FEF_{25-75} values were measured three times and the best result of the three measurements was recorded.

Wood Dust Measurement

Wood dust samplings were conducted by well-trained and certified occupational industrial hygienist. Portable Aircheck 2000 (SKC Inc, Aircheck 2000, Valley View Road, PA USA) pump was used for collecting airborne wood dust sample from the workplaces. NIOSH Method 0500, Gravimetric measurement method was used in dust measurements [38]. The following formula recommended in NIOSH Method 0500 is used to estimate wood dust level in the atmosphere whereas respirable dust using tared 5-PVC membrane with aluminum cyclone (NIOSH method 0600):

$$C = \frac{(W2-W1)-(B2-B1)\times 103}{V} \quad mg/m^3$$

Where:

C	=	Total dust concentration,
W_1	=	Empty filter weight before dust collection process (mg),
W_2	=	Filter weight after dust collection process (mg),
B_1	=	Average Empty filter weight (mg),
B_2	=	Average filter weight after dust collection process (mg),
V	=	Volume (L).

A PVC 37 mm dia. filter (SKC Inc., 5.0 µm) was used to collect wood dust. To collect the sample, a pump is placed on a worker working in a randomly selected point at the workplace and the flow rate was set at 2 L/min [38]. Samples were collected from wherever the worker went during 8 hours without interruption. The dust amount for this randomly selected worker was assumed to be the same for all workers working at the same workplace and factory. Dust collection apparatus were calibrated after each three measurements. The filters were weighted with the help of a GecAvery (Model VA 304–x0.0001) balance with a precision of 0.0001 g before and after dust collection process.

Noise Measurements and Samplings

Noise exposure - samplings were conducted between January 10, 2016 and January 30, 2016. Area noise measurements were performed to monitor noise levels as the equivalent continuous noise exposure level (Leq) using a sound level meter (NL-21; Rion , Inc., Kyoto, Japan). Personal noise measurements were conducted using noise dosimeters (Casella, Cel320; Casella CEL, Inc., NY, USA). A total of 41 personal noise measurements were conducted by randomization in each department.

Job Safety Analysis

This study was conducting job safety analysis (JSA) by identifying, analyzing and recording as the following steps, including 1) the steps involved in performing a specific task and job title, 2) the existing or potential safety and health hazards associated with each step, and 3) the recommended actions at each procedure that will be eliminated or minimized these hazards and the risk of a workplace injury or illness [51]. Before performing JSA, the researchers considered the potential hazards, types or suspected effects when completing a JSA, including impact with a falling or flying object, penetration of sharp objects, caught in or between a stationary/moving object, falls from an elevated work platform, ladders or stairs, excessive lifting, twisting, pushing, pulling, reaching, or bending, exposure to vibrating power tools, excessive noise, heat, or harmful levels of gases, vapors, fungicide, fumes, and wood dusts, repetitive motion, electrical hazards, light, water, etc.

Measuring and Calculating Risk Levels

In this study, the authors had a walk-through survey and then inspection for each working procedures throughout the factories for JSA and hazard identification using an application of risk assessment and what if analysis [51]. JSA methodology was adapted from Job Hazard Analysis, OSHA Publication 3071 [52]. Risk levels were assessed as the following steps, including 1) an operational issue or occupational health problem has been inspected, reported and recorded, which required the attention of occupational safety personnel and the managers of each factory, 2) the researchers and occupational safety personnel analyzed the nature of the work procedures necessary to carry out the repair or minimize occupational hazards and risks, 3) all potential hazards were identified, including physical, chemical, biological, ergonomic, psychosocial hazards, possible mechanisms of injury and possible damage to others and/or equipment, 4) if potential hazards were identified, it was necessary to calculate a “Total Score” was calculated using risks by chance and event [51]. Calculating the total scores, the authors employed the matrix of occupational risk by chance and event severity of the incident (Table 3.1) and then convert into the total score [51] (Table 3.2). The total score is the multiplication of the level (risks by chance) and level (event severity).

Table 3.1 Levels of risks by chance and event severity

Level (degree)	Description Criteria for Occupational Risks by Chance	Description Criteria for Event Severity
1	Rare(very low incidence rate)	Incident or accident can be managed by a first aid (minimal risk)
2	Low(once for 5-10 years)	Incident or accident can be treated by medical treatment and healthcare team (moderate risk)
3	Moderate(once per year)	Incident or accident causes severe and illnesses (high risk)
4	High(once per month)	Incident or accident causes death or life threatening

The total scores have been quantified by multiplication of the level according to risks by chance and rating event severity into minimal risk (score 1-2), acceptable risk needs to review working procedure and control (score 3-7), high risk needs to manage and control (score 8-11), and no acceptable any risk levels or tolerance and needs to stop and provide a control method or procedure (score 12-16) (Table 3.2).

Table 3.2 Definition of total scores

Total Score [a]	Description Criteria for Risk Level
1-2	Minimal risk
3-7	Acceptable risk needs to review working procedure and control
8-11	High risk needs to manage and control
12-16	No acceptable any risk levels or tolerance and needs to stop and provide a control method or procedure

[a] The multiplication of the level (risks by chance) and level (rating event severity).

3.3 Statistical Analysis

1. Sample size estimation and power calculation.

2. Data analysis. Descriptive and interferential statistics were used to analyze the data by using SPSS version 20(SPSS Inc., IL, USA).

2.1 Descriptive data such as numbers and percentages were used to describe characteristics of samples.

2.2 Prevalence of wood dust exposure related to respiratory symptoms and lung function test was calculated by Chi-square test. Two-sided *P-value* < 0.05 was considered as statically significant. For comparing between wood dust exposure group and non-exposure group in terms of relative risks, odds ratio (OR) with 95% confidential interval, gender, age, height, and smoking, were adjusted by logistic regression model.

2.3 The correlations between personal and hygiene factors (age, gender, smoking, etc.) and pulmonary function test were analyzed. Similar to personal and hygiene factors, the correlations between environmental and work related factors (job title, wood dust exposure level, etc.) and pulmonary function tests were also determined.

2.4 The correlations between respiratory symptoms and pulmonary function test (% cross-shift change in pulmonary function) by adjusting age, gender, height, and smoking by linear regression analysis at p-value< 0.05.

CHAPTER IV
RESULTS

The key findings of this study have been disseminated into two sessions. The outline of the results has been presented following the conceptual framework of the study. The results have been presented in the order of specific aims and the original articles, including 1) job safety analysis and hazard identification for work accident prevention in Para rubber wood sawmills, and 2) respiratory symptoms and ventilatory function defects among Para rubber wood sawmill workers.

4.1: job safety analysis and hazard identification for work accident prevention in Para rubber wood sawmills [53]

Occupational risks were falling logs, hands stabbing to splinter of wood chips, fungicide exposure, repetitive work and heavy lifting. Identifying and assessing all actual or potential occupational safety and health hazards associated with each task had been conducted, including work procedure, activities and health risks and hazards (Table 4.1). Occupational safety and health hazards assessment at working procedures of six Para rubber sawmills were including 1) logging and cutting, 2) sawing the lumber into sheets, 3) plaining and re-arranging, 4) vacuuming and wood preservation, 5) drying and planks-rearranging, and 6) grading, packing and storing. Two additional involving in wood processing were blade sharpening and boiling. The authors made a summary based on the similar synthesis the results presented.

Table 4.1 Occupational health risks and hazards assessment after evaluation in working procedures in Para rubber sawmills

Working Procedure/ area	Task	Identified Hazard and Risk	Definitions	Risks by Chance	Rating (event severity)	Total Score	Risk Level
Logging and cutting	Re-arrange log into palate	Logs	Falling objects(logs) to feet and hands	4	1	4	Acceptable
			Slippery and fall caused head injury	4	1	4	Acceptable
		Hook	Body parts injured by hook	4	1	4	Acceptable
		Wood dust	Wood dust inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High
		Fungi	Fungicide exposure caused respiratory symptoms and irritation and allergy	4	1	4	Acceptable
		Wet floor	Fall and slippery	3	1	3	Acceptable
		High heat	Heat exhaustion and faintness	4	1	4	Acceptable
		Ergonomics or repetitive work	Repetitive work caused musculoskeletal disorders	3	1	3	Acceptable
		Urgent on demand work	Work stress and caused occupational injury and accident	3	1	3	Acceptable
		Truck	Accident on car crash	2	2	4	Acceptable
		Forklift	Accident on forklift hit or crash	3	3	9	High
		Heavy lifting	Heavy and repetitive work caused musculoskeletal disorders	3	2	6	Acceptable
Sawing the lumber into sheets*		Saw blade	Hands and arms injuries caused by saw blade	3	3	9	High
			Lack belt caused body parts injured	2	3	6	Acceptable
		Logs	Falling logs to feet, hands, and shoulder, slippery and fall caused head injury	4	1	4	Acceptable
		Sliver and chip wood	Splashed in eyes caused irritation and eye injury	4	2	8	High
		Wood dust	Wood dust inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High
		Planks	Falling planks caused feet injury	4	1	4	Acceptable
		Splinter of wood	Hands stabbing by splinter	4	1	4	Acceptable
		Fungi	Fungicide exposure caused respiratory symptoms and irritation and allergy	4	1	4	Acceptable
		Noise	Hearing defects and noise-induced hearing loss	3	3	9	High
		Ergonomics or repetitive work	Repetitive work caused musculoskeletal disorders	3	1	3	Acceptable
		Heavy lifting	Heavy and repetitive work caused musculoskeletal disorders	4	1	4	Acceptable
		Electricity	Short circuit caused fire	1	4	4	Acceptable
		Fire	Planks and wood dust caused fire	1	4	4	Acceptable
		Urgent on demand work	Work stress and caused occupational injury and accident	3	1	3	Acceptable
Plaining and re-arranging*	Planks/sheets plaining before vacuum/wood preservative						
		Planks	Falling planks caused feet injury	4	1	4	Acceptable
		Wood dust	Wood dust inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High
		Splinter of wood	Hands stabbing by splinter	4	1	4	Acceptable
		Noise	Hearing defects and noise-induced hearing loss	3	3	9	High
		Forklift	Accident on forklift hit or crash	3	3	9	High
		Ergonomics or repetitive work	Repetitive work caused musculoskeletal disorders	3	1	3	Acceptable
		Fire	Planks and wood dust caused fire	1	4	4	Acceptable
	Planks/sheets plaining after vacuum/wood preservative						
		Chemicals	Skin rash and irritations	4	1	4	Acceptable
		Splinter of wood	Hands stabbing by splinter	4	1	4	Acceptable

Table 4.1 Occupational health risks and hazards assessment after evaluation in working procedures in Para rubber sawmills (cont.)

Working Procedure/ area	Task	Identified Hazard and Risk	Definitions	Risks by Chance	Rating (event severity)	Total Score	Risk Level
		Sheet pile	Falling planks/sheets caused feet and hands injury	3	1	3	Acceptable
		Forklift	Accident on forklift hit or crash	3	3	9	High
		Ergonomics or repetitive work	Repetitive work caused musculoskeletal disorders	3	1	3	Acceptable
		Fire	Planks and wood dust caused fire	1	4	4	Acceptable
	Planks/ sheets plaining after drying	Splinter of wood	Hands stabbing by splinter	4	1	4	Acceptable
		Wood dust	Wood dust inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High
Plaining and re-arranging*		Light	Dim and dark by eye focusing caused eye pain and dizziness	3	1	3	Acceptable
		Forklift	Accident on forklift hit or crash	3	3	9	High
		Sheet pile	Falling planks/sheets caused feet and hands injury	3	1	3	Acceptable
Vacuuming and wood preservation	Chemical mixing	Chemicals	Chemical inhalation caused respiratory symptoms, nausea and vomiting	4	2	8	High
			Skin rash and irritations	4	1	4	Acceptable
			Eye irritation and pain	4	1	4	Acceptable
		Wet floor	Fall and slippery	4	1	4	Acceptable
		Electricity	Short circuit caused fire	1	4	4	Acceptable
		Fire	Planks and wood dust caused fire	1	4	4	Acceptable
Drying and planks re-arranging	Transfer wood chip to stove	Sheet pile	Falling planks/sheets caused feet and hands injury	3	1	3	Acceptable
		High heat	Body dehydration and faint	2	1	2	Minimal
Grading, packing and storing	Packing	Sheet pile	Falling planks/sheets caused feet and hands injury	3	1	3	Acceptable
		Splinter of wood	Hands stabbing by splinter	4	1	4	Acceptable
		Light	Dim and dark by eye focusing caused eye pain and dizziness	3	1	3	Acceptable
		Ergonomics or repetitive work	Repetitive work caused musculoskeletal disorders	3	1	3	Acceptable
		Forklift	Accident on forklift hit or crash	3	3	9	High
	Storage	Sheet pile	Falling planks/sheets caused feet and hands injury	3	1	3	Acceptable
		Fire	Planks and wood dust caused fire	1	4	4	Acceptable
Blade sharpening	Sharpening	Blade	Hands and arms injury	3	3	9	High
		Splash from blade sharpening	Eye irritation, pain and may cause blindness	4	1	4	Acceptable
Blade sharpening	Sharpening	Noise	Hearing defects and noise-induced hearing loss	3	3	9	High
		Fume/mist	Inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High
		Electricity	Short circuit caused fire	1	4	4	Acceptable
		Fire	Splash from blade sharpening caused fire	1	4	4	Acceptable

Table 4.1 Occupational health risks and hazards assessment after evaluation in working procedures in Para rubber sawmills (cont.)

Working Procedure/ area	Task	Identified Hazard and Risk	Definitions	Risks by Chance	Rating (event severity)	Total Score	Risk Level
Boiling (boiler)	Transferring wood chip as fuel	Splinter of wood	Hands stabbing by splinter	4	1	4	Acceptable
		High heat	Heat exhaustion and faintness	4	1	4	Acceptable
		Total dust and smog	Total dust and smog inhalation and exposed through upper respiratory system caused respiratory symptoms	4	2	8	High
	Controlling boiler	Ball valve obstruction	Water decreasing caused explosion	1	4	4	Acceptable
		Valve defect	High pressure caused valve defect and explosion	1	4	4	Acceptable
		Controlling meter defect	Water decreasing and valve controlling controller caused explosion	1	4	4	Acceptable
		Gage/switch defect	Boiler controlling system failure caused explosion	1	4	4	Acceptable
		Crack pipe/leakage	High pressure and decreasing high heat may cause explosion	1	4	4	Acceptable

Logging and Cutting

In logging and cutting procedures, the working processes consist of log re-ararranging and drying, log transportation, and log weighing. The occupational safety and health hazards were associated with log and lumber, hooker, wood dust, fungi and molds, wetting floor, high heat, ergonomics, traffic injury from fork lift hitting and heavy lifting. The sawmill workers were exposed to wood dust at maximum levels of 2.500 mg/m^3 for respirable dust and 2.083 mg/m^3 for total dust, respectively. The high risk levels were wood dust exposure (score = 8) and traffic injury from forklift (score= 9) (Table 4.2). It was one case report for the forklift hit.

Table 4.2 Para rubber wood dust exposure level in Para rubber wood sawmills

Department	Total dust (mg/m^3)*				Respirable (dust mg/m^3)*			
	Median	SD	Max	Min	Median	SD	Max	Min
Sawing the lumber into sheets (n= 5)	1.458	0.439	2.083	1.111	1.670	0.918	2.500	0.556
Plaining and re-arranging(n= 4)	-	-	-	-	0.453	0.263	0.556	ND
Vacuuming and wood preservation(n= 4)	-	-	-	-	ND	ND	ND	ND
Drying and planks re-arranging(n= 4)	-	-	-	-	1.111	0.000	1.111	1.111
Grading, packing and storing(n= 4)	-	-	-	-	0.681	0.786	1.111	ND
Maintenance/forklift (n= 2)	-	-	-	-	0.412	0.393	0.556	ND
Office(n= 4)	-	-	-	-	ND	ND	ND	ND

*ACGIH= American Conference of Governmental Industrial Hygienists, 2011; ND =No detection

Sawing the Lumber into Sheets

At sawing the lumber into sheets process, occupational safety and health hazards showed including blade, log, scraps of wood, splinter, wood dust, fungi and molds, noise, ergonomics, heavy lifting, electricity and fire. Hands and arms injuries caused by saw blade were relative at high risk level (score = 9). Sliver and chip wood exposures by splashed into eyes caused irritation and eye injuries were also at high risk level (score = 8). In addition, high noise exposures were detected at maximum of 94.4 dBA (score = 9) (Table 4.1& 4.3). There were occupational accidents and injuries for wood chips splashing into eyes (3 cases) and hands and arms injured at sawing (5 cases) in each year and noise hearing defects (6 cases) within two years, respectively [44-45].

Table 4.3 Noise level measurements in Para rubber wood sawmills

Department	Area sampling (dBA)*	Personal sampling (dBA)**			
		Median	SD	Max	Min
Sawing the lumber into sheets (n= 16)	88.4	92.7	1.5	94.4	89.2
Drying and planks re-arranging(n= 12)	87.8	90.2	0.8	91.1	89.1
Vacuuming and wood preservation(n= 4)	86.4	88.6	0.2	88.9	88.4
Grading, packing and storing(n= 4)	86.0	88.9	0.4	89.4	88.4
Blade sharpening/ maintenance/forklift(n= 5)	87.2	92.4	4.5	93.0	82.5

*area sampling using sound level meter, a single measurement
**personal sampling using noise dosimeter

Plaining and Re-arranging

In plaining and pre-vacuum rubber sheet processing, consisted of plaining, plaining pre-vacuum, and plainining after wood preservative, occupational safety and health hazards were determined, including wood sheet, scraps of wood, splinter, noise, light, fork lift, ergonomics, fire, and stacks. Tasks at high risk level of exposures were wood dust (score = 8), high noise and accidents from hitting (score = 9) and crashing by forklift (score = 9) (Table 4.3). It was one case report for the forklift hit [45].

Vacuuming and Wood Preservation

For vacuuming and wood preservation procedure that were including wood preservation and chemical and fungicide mixing, occupational safety and health hazardous concerns were chemical exposure, slippery at mixing areas, climbing up ladder to tank, wetting floor, electricity shock, high heat, repetitive work, and explosion. Tasks at risk level were exposure to chemical mixing for wood preservation among fungicide and chemical uses (score = 8) (Table 4.1).

Drying and the Planks Re-arranging

At drying process and the planks re-arranging, the planks or sheets were prepared for drying. Occupational safety and health hazards were stacks and wood plank injuries and high heat exposure. The risk level was acceptable (Table 4.1).

Grading, Packing and Storing

At warehouse, packing and storaging, the work procedures were grading, stacking, packing, and storing. Occupational safety and health hazards were repeating work, packing, splinter flying, and explosion. Task at high risk level was hitting by forklift (score = 9) (Table 4.1).

Blade Sharpening

For blade sharpening, occupational safety and health hazards showed blade injuries, fume exposure from sharpening, noise, electricity, and explosion. Hands and arm injuries from blade cutting (score = 9), inhalation of fume and mist (score=8) and high level of noise exposure at maximum level of 93.0 dBA (score=9) were at high risk level (Table 4.1& 4.3).

Boiling

For controlling the boiler--boiler controlling, heat controlling, and fuel materials, occupational safety and health hazards were associated with flying splinter, high heat, dust and smoke exposure, gage control and switch, pump and hot water. Total dust from fume and dust using wood chips were at high risk level (score =8) (Table 4.1).

4.2: respiratory symptoms and ventilatory function defects among Para rubber wood sawmill workers [47].

Five hundred and ninety nine exposed sawmill workers and 88 unexposed participants were included in this study. Male exposed workers had slightly more than female workers (304 Vs 295), but unexposed workers were predominantly by female workers (24 Vs 64). The mean age of exposed and unexposed group was 33.5 years old on average. The mean height of exposed group was insignificantly slightly lower from unexposed group whereas the mean weight of exposed workers was slightly lower than unexposed group. Most of the exposed group had had education level (71%) less than secondary whereas most of unexposed had a college degree. Most of exposed workers had 4.47 years in working experiences on average (Max = 16 years) whereas unexposed group had higher 5.69 years in working experiences on average (Max = 16 years). Smoking was significantly higher among workers compared with unexposed workers (p=0.01). Almost 30 % of exposed workers were current smokers. About 61% of exposed workers and 5% unexposed workers were never trained for personal protective equipment (PPEs) and more than half of them rarely wearing dust mask while they are working (Table 4.4).

Table 4.4 Descriptive characteristics of the exposed and unexposed sawmill workers

Characteristics	Exposed [c]	Unexposed	Total	*p* value [a]
Sex (%) (n=687)	599(87.20)	88(12.80)	687(100.00)	<0.01*
Male	304 (50.75)	24(27.27)	328(47.74)	
Female	295(49.24)	64(72.72)	359(52.26)	
Age (years), mean (SD)	33.50(10.46)	33.50(8.30)	33.51(10.16)	0.01 [b] *
Height(cm), mean (SD)	159.53(9.85)	160.01(7.73)	159.66(9.65)	0.46
Weight(kg), mean (SD)	58.95(12.49)	59.21(16.32)	59.09(13.08)	0.06
Education (%)(n=531)	469(88.32)	62(11.68)	531(100.00)	<0.01*
Primary	158(33.69)	4(6.45)	162(30.51)	
Secondary	197(42.00)	9(14.52)	206(38.79)	
Higher	114(24.31)	49(79.03)	163(30.70)	

[a] Chi-square test; [b] Independent Student's *t*-test; [c] Exposed group (high exposed: sawing, planer mill and wood preservative; low exposed: maintenance, packing & storing; unexposed: office).
[*] Significant at a p value of < 0.05

Table 4.4 Descriptive characteristics of the exposed and unexposed sawmill workers (cont.)

Characteristics	Exposed [c]	Unexposed	Total	*p* value [a]
Tenure (years), mean (SD)	4.47(3.55)	5.69(4.75)	4.62(3.74)	<0.01 [b] *
Smoking (%)(n=504)	445(88.29)	59(11.71)	504(100.00)	0.01*
Never	309(69.44)	53(89.83)	362(71.83)	
Current	136(30.56)	6(10.17)	142(28.17)	
PPE training(n=533)	472(88.56)	61(11.44)	533(100.00)	0.01*
Yes	147(31.14)	32(52.46)	179(33.58)	
No	325(68.86)	29(47.54)	354(66.42)	
PPE use(n=533)	471(88.37)	62(11.63)	533(100.00)	0.03*
All the time	165(35.03)	14(22.58)	179(33.58)	
Sometime/rare	232(49.26)	31(50.00)	263(49.34)	
Never	74(15.71)	17(27.42)	91(17.07)	

[a] Chi-square test; [b] Independent Student's *t*-test; [c] Exposed group (high exposed: sawing, planer mill and wood preservative; low exposed: maintenance, packing & storing; unexposed: office).
[*] Significant at a p value of < 0.05

The exposed group had a significantly higher prevalence than the unexposed group for chest tightness (OR= 2.79) and shortness of breath (OR = 2.27), but an insignificantly for wheezing and coughing after adjustment for age, duration of employment, smoking, and education (Table 4.5).

Table 4.5 Prevalence of respiratory symptoms in the exposed and unexposed sawmill workers

Symptoms	Exposed (n=599)	Unexposed (n=88)	OR[b]	95%CI	*p* value [a]
Wheezing	81(15.52%)	7(7.95%)	1.65	0.73-3.76	0.23
Chest tightness	109(18.19%)	6(6.81%)	2.79	1.17-6.67	0.01*
Shortness of breath	105(17.52%)	7(7.95%)	2.27	1.01-5.13	0.04*
Coughing	145(24.21%)	21(23.86%)	0.87	0.49-1.53	0.62

[a] Analyzed using logistic regression adjusting for age, tenure, smoking and education.
[b] OR= normal group (%FEV1 >80) compared with mild (%FEV1 =66-80) combined moderate(%FEV1
=50-65) and severe groups (%FEV1 <50).
[*] Significant at a p value of < 0.05

The exposed group had similar prevalence of normal pulmonary function compared with the control group. The unexposed group had slightly higher mild pulmonary impairment than the exposed group (Table 4.6).

Table 4.6 Patterns of pulmonary dysfunction in the exposed and unexposed sawmill workers

Pulmonary function [c]	Total (n=206)	Exposed (n = 169)	Unexposed (n = 37)	OR [b]	95%CI	*p* value [a]
Normal	182(88.3%)	149(88.2%)	33(89.2%)	0.90	0.28-2.81	0.56
Mild	17(8.3%)	13(7.7%)	4(10.8%)			
Moderate	5(2.4%)	5(2.9%)	0			
Severe	2(0.9%)	2(1.2%)	0			

[a] Analyzed using Fisher's exact test.
[b] OR= normal group compared with mild combined moderate and severe groups.
[c] Pulmonary functions 1) normal (%FEV1 >80), 2) mild (%FEV1 =66-80), 3) moderate (%FEV1 =50-65), and severe (%FEV1 <50).
[*] Significant at a *p* value of <0.05.

The estimated ventilatory function values (FEV1 and FVC) were significantly lower for the exposed group compared with the unexposed group whereas the exposed FEV1/FVC % had slightly higher for low exposed group (Table 4.7).

Table 4.7 Estimated ventilatory function values (FEV1, FVC, and FEV1/FVC) for exposed and unexposed sawmill workers

Characteristics	Exposed(n = 169)		Unexposed (n = 37)	Total (n=206)	*p* value [a]
	High (n = 113)	Low (n = 56)			
FEV1 (L/s), mean (SD)	2.40±0.62	2.86±0.66	2.55±0.53	2.55±0.65	<0.01*
FVC (L), mean (SD)	2.91±0.74	3.33±0.79	3.01±0.67	3.04±0.76	0.01*
FEV1/FVC (%), mean (SD)	82.89±8.31	85.92±8.31	82.80±6.63	83.72±7.63	0.03*

[a] Chi-square test (combined high and low exposure).
*Significant at a *p* value of <0.05.

The estimated ventilatory function values (FEV1) and FEV1/FVC for cigarette smoking were significantly lower for never smokers for high exposed group and similar for current, and ex-smoker of the exposed group compared with the unexposed group. There were insignificantly different FVC between both groups (Table 4.8).

Table 4.8 Ventilatory function values (stratifying cigarette smoking habits) for exposed and unexposed sawmill workers

Characteristics	Smoking status	Exposed(n = 169)		Unexposed (n = 37)	Total (n=206)	*P* value[a]
		High (n = 113)	Low (n = 56)			
FEV1 (L/s), mean (SD)	Never(n=141)	2.21±0.55	2.54±0.58	2.39±0.46	2.32±0.56	0.01*
	Current(n=57)	2.96±0.52	3.30±0.50	3.07±0.42	3.12±0.53	0.74
	Ex-smoker(n=8)	2.78±0.30	2.82±0.12	2.84±0.22	2.79±0.25	0.98
FVC (L), mean (SD)	Never (n=141)	2.64±0.60	2.98±0.79	2.77±0.58	2.75±0.66	0.47
	Current (n=57)	3.64±0.63	3.81±0.48	3.74±0.37	3.73±0.54	0.55
	Ex-smoker(n=8)	3.62±0.58	3.26±0.41	3.55±0.27	3.56±0.49	0.85
FEV1/FVC (%), mean (SD)	Never (n=141)	83.77±8.33	85.97±6.35	83.37±6.14	84.19±7.56	0.03*
	Current (n=57)	81.08±7.66	86.00±6.56	81.37±8.62	83.14±7.62	0.06
	Ex-smoker (n=8)	77.40±8.96	86.00±2.16	79.05±2.62	78.85±7.98	0.70

[a] Chi-square test (combined high and low exposure).
*Significant at a *p* value of <0.05.

The exposed workers had a higher respirable wood dust exposure than the unexposed groups. The sawing and planer mill had highest concentration of respirable wood dust exposure (0.902±0.879 mg/m ^{3}) and office workers had exposed to respirable wood dust at low level of 0.085 mg/m^3 on average. The total dust exposure was found at level of 1.458 mg/m^3 on average (Table 4.9).

Table 4.9 Total dust and respirable dust levels and spirometry results for sawmill workers

Descriptive characteristics	No.collected samples	Median	SD	Max	Min	*p* value [b]
Total dust levels(mg/m ^{3}) [a]						
High exposed	4	1.458	0.439	2.083	1.111	
Respirable dust levels(mg/m ^{3}) [a]						
High exposed	14	1.012	0.879	2.500	0.001	0.13
Low exposed	13	0.444	0.271	0.556	0.001	
Unexposed	4	0.095	0.321	0.556	0.001	

[a] Exposed group (high exposed: sawing, planer mill and wood preservative; low exposed: maintenance, packing & storing; unexposed: office).
[b] ANOVA analysis adjusting for age and sex; significant at a *p* value of <0.05.

The mean FEV1, FVC, and FEV1/FVC levels of 114 high exposed group were 2.40 L, 2.91 L, and 82.89%, respectively whereas unexposed group (n=36) were 2.56 L, 2.91 L, and 82.81%respectively (Table 4.10). Multiple linear regression analysis between high and low respirable dust exposures adjusted with age and gender showed significance association of dust levels with FEV1 (L), FVC (L) and FEV1 (L-), but there was indifferent between high and unexposed or low and unexposed workers (Table 4.10).

Table 4.10 Comparing mean of respirable dust levels and spirometry results among sawmill worker groups

Pulmonary function tests [a]	No. Subj.	Mean	SD	Max	Min	Pulmonary function tests*		
						High exposed	Low exposed	Unexposed
FEV1								
High exposed	114	2.40	0.62	4.28	0.92	-	<0.01*	0.43
Low exposed	56	2.86	0.66	4.30	1.63	-	-	0.07
Unexposed	36	2.56	0.53	3.60	1.58	-	-	-
FVC								
High exposed	114	2.91	0.75	4.98	1.48	-	0.01*	0.77
Low exposed	56	3.33	0.79	4.72	1.85	-	-	0.15
Unexposed	36	3.02	0.67	4.45	2.00	-	-	-
FEV1/FVC								
High exposed	114	82.89	8.31	98.00	43.00	-	0.04*	0.99
Low exposed	56	85.98	6.32	99.00	72.00	-	-	0.14
Unexposed	36	82.81	6.63	92.00	67.00	-	-	-

[a] Exposed group (high exposed: sawing, planer mill and wood preservative; low exposed: maintenance, packing & storing; unexposed: office).
[b] ANOVA analysis adjusting for age and sex
*Significant at a *p* value of <0.05.

The decrease in pulmonary function was modeled as the outcome in a linear regression model that included covariates for age and gender (Table 4.11). There were significant in FEV1, FVC, and FEV1/FVC when the high respirable dust level–exposed workers were compared with low respirable dust level–exposed workers. There seemed to be a dose-dependent reduction in spirometric lung function according to the level of respirable dust.

Table 4.11 Model results for dose-response of pulmonary function and respirable dust levels among sawmill workers

Variable [a]	B	β	t	*p* value [b]
FEV1				
Age	-0.95	-0.73	-18.48	<0.01*
Gender	-0.02	-0.32	-8.12	<0.01*
FVC				
Age	-1.16	-0.76	-18.43	<0.01*
Gender	-0.06	-0.23	-5.44	<0.01*
FEV1/FVC				
Age	1.31	0.08	1.28	0.20
Gender	-0.19	-0.28	-4.15	<0.01*

[a] Exposed group (high exposed: sawing, planer mill and wood preservative; low exposed: maintenance, packing & storing; unexposed: office).
[b] ANOVA analysis adjusting for age and sex
*Significant at a *p* value of <0.05.

CHAPTER V
DISCUSSIONS

This chapter presents discussion of the findings, limitations of the study, and conclusion, implication, and future research needs. The outline of discussion is focused on the outputs and key findings of the study. This study aims to discuss on 1) job safety analysis and hazard identification for work accident prevention in Para rubber wood sawmills and 2) respiratory symptoms and ventilatory function defects among Para rubber wood sawmill workers.

5.1: job safety analysis and hazard identification for work accident prevention in Para rubber wood sawmills

The results from this study of sawmills in the South of Thailand demonstrated that the workers in sawmills were exposed to wood dust and noise above permissible exposure limits, especially in process of sawing the lumber into sheets and plaining and re-arranging, respectively (Table 4.2-4.3). The large majority of workers in sawmills were exposed to noise equal or exceed an 8-hour time-weighted average sound level (TWA) of 85 dBA. The employer shall administer a continuing, effective hearing conservation program, as described in the law regulations. Sawmill wood dust exposure levels were detected exceeded the limit for inhalable wood dust exposure, especially in process of sawing the lumber into sheets and plaining and re-arranging, respectively. These detections were found similar to the previous studies [27, 42], but it should be noted that these studies were conducted at the Para rubber furniture factories. This study found similar as the study of Aurajananon [31] and Koehncke et al.[43]. The results of our study demonstrate the need for further occupational wood dust exposure, noise management and efforts to minimize hazardous exposures through the implementation of control measures among sawmill workers.

The authors and occupational health safety personnel of four sawmills conducted JSA and hazard identifications for each work procedure for the purpose of establishing proper task procedures to minimize or eliminate the occupational hazards. Previous studies showed utilizing JSA for improving task procedures in sawmills can reduce costs and related unnecessary expenses resulting from lower occupational injury rates, employee absenteeism and workers’ compensation, and can also lead to increased performance and productivity [18-19)].

At logging and cutting procedure as raw material and log loading areas, tasks at high risk level were wood dust exposure and traffic injuries by forklift hits. Wood dust inhalation and exposure through upper respiratory system due to respiratory symptoms and also accidents on forklift hit or crash were reported [44-45]. From our review on occupational accident records, the incidence of forklift hits showed on average two cases each year of four factories. The authors recommended the safety officer to make a better commuted drive way for transferring sheets by using sign and lay out of the drive way with the luminous line and reflective paint. The luminous line and reflective paint costs should be included for occupational health and safety in year plan activity and timeline. Wood dust exposure should be protected for inhalation using personal mask and implemented hood duct for a better ventilation system.

For sawing the lumber into sheets procedure, tasks at high risk level were hands and arms injured and eye injury due to chip or sliver splash into eyes and high noise level exposure. From reviewing occupational accidents and injuries and annual reports, the occupational accidents by saw blade caused hands and arms injured showed one case on average [44-45]. Almost half of sawmill workers did not use and rarely use gloves since they felt uncomfortable for carrying log into saw chain and may cause slippery [46-47]. The authors strongly recommend for using gloves. Wood chips splashing into eyes caused eye irritation and injuries [44-45]. We recommended using goggles for eye protection. Noise levels were presently at relatively high level of 92.1±1.5 dBA on average in sawing the lumber into sheets process (Table 5). Less than half of workers regularly wore ear plugs or any kinds of earing protectors [46-47]. Hearing defects and noise-induced hearing loss were reported [44-45]. Using ear protector is still strongly recommended.

In plaining and re-arranging before vacuuming wood preservation procedure, high levels of wood dust exposure, high noise levels, and accidents by forklift hit or crash were concerned. As same as planks and sheets plaining before vacuum wood preservative procedure, the authors recommended for risk management and plan for minimizing occupational risks and degree of severity. The authors suggested that improving a better commuted drive way, personal mask and hood duct, and hearing protection.

In vacuuming and wood preservation procedure, chemical mixings using mainly fungicide and other diluents were at high risk level of employees' exposure. Fungicide and chemicals use can cause respiratory symptoms, nausea and vomiting, skin and eye irritations [22]. We suggest the workers using both mask protection and chemical resistant gloves.

Drying and the planks-rearranging procedure is also contributed to incidence of falling planks and sheets which caused feet and hands injuries from transferring wood chip to the stove. Even though we found the relative low risk for high heat exposure (Table 4.1), high heat exposed workers may become body dehydration and then faint.

At grading, packing and storing procedure, the most vulnerable incidence at packing and storage areas is accidents from traffic injuries by forklift crashing. All of regular commuted logs and sheets are performed unsafe sign and routes.

For two additional sections involving blade sharpening and boiling, the authors suggest for occupational safety and health hazards that should be concerned. At blade sharpening section, at high risk levels were hands and arms injury and hearing defect from high noise levels. Splash from blade sharpening can cause eye irritation and pain. Fume and mist exposure may cause respiratory symptoms [16]. At boiler station, tasks at high risk level were total dust and smog inhalation and exposure through upper respiratory system caused respiratory symptoms.

Other occupational safety and health hazards could be prevented for falling planks, hands stabbing by wood splinter, repetative works, and fire accidents. The incidences should be concerned including falling planks or sheets caused feet and hand injuries or even hand stabling by wood splinter. Repetitive work can cause musculoskeletal disorders and dim areas can cause eye pain and dizziness. Identified hazards were including hands stabling by wood splinter while workers transfer wood chip into stove and also high heat exposure can cause heat exhaustion and faintness. For controlling boiler and maintaining system, ball valve obstruction caused water decreasing and leaded to explosion, valve and meter control defected, and gage and switch can cause high pressure and explosion.

In conclusion, occupational health risk assessment and risk identification in working processes found high levels of wood dust and noise exposure needed to be controlled as provision guidelines, using local ventilation system and reducing noise transmission. The risk assessment should address priorities for action plan. JSA and hazard identification on working process in sawmills such as occuaptional acidents on hands and feet by the cause of struck or injured by lumber at plaining section, high wood dust exposure caused respiratory symptoms at sawing the lumber into sheets process, and ergonomics from repetative works caused musculoskeletal symptoms. At vacuuming and wood preservative section, workers exposed chemicals and fungicide uses caused skin irritations. In addition, they should wear gloves and goggles for protection their eyes and hands from sharpen saws. They should also wear ear plugs for prevention noise-induced hearing loss. All workers were strongly recommended to use personal protective equipment in any working processes. In addition, risk perception plays a crucial role for sawmill workers as a main predictor for PPE use, and suggests opportunities for increasing the effectiveness of PPE training programs, though it should be noted that other strategies from the hierarchy of controls, including the use of engineering and administrative controls, are needed in addition to PPE-based interventions. The findings of our study could assist policy recommendations that focus on improving risk recognition and risk perception for sawmill workers. Further study could provide a critical analysis of risk perception factors and theories to determine which are most salient for reducing risk tolerance and encouraging safer behavior.

5.2 respiratory symptoms and ventilatory function defects among Para rubber wood sawmill workers

For synthesis with previous findings, the health effects that have been related to wood dust exposure in different industries employing wood sawmill workers, carpenters and furniture workers with different species of wood types and showed respiratory and skin effects [9-10, 16-17, 25, 27, 28, 48-50]. However, the Para rubber sawmills in this study, the respiratory health effects and pulmonary defects of which have not been previously studied according to a PubMed database and online search engine [26, 42].

In this study of sawmill factory workers exposed to Para rubber wood dust, 599 sawmill workers experienced significantly increased risk of chest tightness (*p* = 0.01) and shortness of breath (*p* = 0.04) compared to unexposed office workers. There seemed to be an increase in the risk in relation to increasing dust level (Table 4.5 & 4.9). Our results are partly in agreement with previous studies of Sripaiboonkij et.al. (2009) [27] and Sriproed et al. (2013) [42] for the wood furniture factories, which showed significant associations between wood dust exposure levels and respiratory symptoms, including wheezing, coughing, chest tightness, and shortness of breath, phlegm production and nasal symptoms [27,42]. Due to the methodological conducts of cross-sectional studies, the need for additional explore for testify a causal relationship.

We previously performed a walk-through survey and occupational exposure risk and job safety analysis and assessment based both on job tasks and on measurements of total and inhalable dust in different working procedures. We also used information and data records on occupational exposures and safety issues in each factory. The wood dust measurements allowed us to determine and categorize the workers into low and high dust exposure categories for exposed workers and office workers as a reference for unexposed group. Therefore, we believe that our assessment reflects current homogenous group of exposure for four participated factories.

In Thailand, no standard occupational exposure limit (OEL) has been set for wood dust exposure. The NIOSH, US has established a recommended OEL for wood dust from all woods, but except for western red cedar of 0.5 mg/m^3 (ACGIH 2014). The concentrations of Para rubber wood dust in high exposure areas at maximum level exceeded this limit for inhalable wood dust (2.500 mg/m^3), including sawing, drying and storing and packing, but below OEL in areas on average. These detections were found similar to the study of Sripaiboonkij et al, 2009 (1.34–2.93 mg/m^3) and Sriproed S et al, 2013 (0.07-12.16 mg/m^3), but these studies were conducted at the furniture factories [27, 42].

The results of patterns of pulmonary dysfunction in the exposed and unexposed sawmill workers showed the ventilatory function between normal lower than mild to severe pulmonary functions (OR=0.90) (Table 4.6). The results found that exposure to rubber wood dust were significantly associated with decreased pulmonary function, FVC, FEV1 and FEV 1/FVC. The insignificant reductions in ventilatory function values in exposed sawmill workers in this study were in agreement with similar studies of Sripaiboonkij et al, 2009 and Sriproed S et al, 2013 [27, 42]. This study demonstrated the casual relationship between Para rubber wood dust exposure and pulmonary reductions in FEV1, FVC, and FEV1/FVC%, respectively (Table 4.7). However, this study could not clearly confirm the causal relationship between Para rubber wood dust exposure and pulmonary reductions and impairments in FVC for stratifying smoking status (Table 4.8). Mandryk and colleagues conducted cross-shift changes in pulmonary dysfunction in eucalyptus tree sawmill workers in Australia and found a significant cross-shift decrement in vital capacity (VC) and FEF25–75% among wet mill workers related to inhalable dust concentrations [25]. Sriproed et al. (2013) [42] conducted a simple comparison of predicted versus pre-shift PFT values and found a significant decrement in PEF values for the high rubber wood dust level–exposed workers. This same group also had significant decrements in post shift PFT versus predicted values for FVC, FEV1, and PEF measurements. Sripaiboonkij and colleagues also found lower% predicted FEV1 and FVC in higher rubberwood dust level–exposed workers but the effect was not statistically significant. This may be because the levels of dust exposure were lower (0.38 to 2.93 mg/m^3) than in this study (0.07 to 12.16 mg/m^3) [27]. Thetkathuek and colleagues found a significant decrease in the% predicted FVC and FEV1/FVC related to rubberwood dust exposure after controlling for age, height, and gender. The dust concentrations in the study reported here were similar to those reported in the Thetkathuek study (1.15 to 11.17 mg/m^3) [26].

Multiple linear regression analysis between high and low respirable dust exposures adjusted with age and gender showed significance association of dust levels with FEV1 (L), FVC (L) and FEV1 (L-), but there was indifferent between high and unexposed or low and unexposed workers (Table 4.10). The decrease in pulmonary function was modeled as the outcome in a linear regression model that included covariates for age and gender (Table 4.11). There were significant in FEV1, FVC, and FEV1/FVC when the high respirable dust level–exposed workers were compared with low respirable dust level–exposed workers. There seemed to be a dose-dependent reduction in spirometric lung function according to the level of respirable dust.

The insignificant findings may be due to a number of reasons. The effect of wood dust exposure and effects on pulmonary dysfunction was probably not strongly correlated by low tenure, because the workers had maintained their work just a short period of time (average 4.47 years) and relative young (average = 33.5 years old). It would be related to gender disparity since exposed workers are mostly men and they are working at sawing department while women are working in the office as classified as unexposed workers. Generally, men workers have higher FEV1, FVC and FEV1/FVC than women. From our findings in this study, the relationship between Para rubber wood dust exposure and pulmonary dysfunctions may be occurred the healthy worker effect by the exposed sawmill workers switched their jobs often, so they were not exposed for long enough to initiate health effects.

In this study the small number of wood dust samplings per department probably yielded an inadequate result for reliable generalization to the entire department. However, the working procedures and work environment were similar according to a walk-through survey. As a result, a relatively robust association between measured and estimated exposure and pulmonary function tests, the results must be considered preliminary. The authors suggest more following up the pulmonary function tests. In addition, the authors suggest that the respiratory health of sawmill workers should be protected. Since more than half of them are rarely used PPEs such as mask protection, thus, they are still at high risk of wood dust exposure. The use of proper PPEs while at work would help to protect them from developing more severe chronic respiratory diseases in the future.

Our study had some limitations that warrant discussion. First, our data are based on a cross-sectional study. Sampling bias was occurred due to a non-random sample of a population since we recruited for only agreed to participate in this study. In addition, the following up spirometry and pulmonary measurements can give the stronger correlation of wood dust exposure and pulmonary defects. Second, the healthy worker effect may be occurred. Lastly, there was no reconstruction of exposure dose levels for each worker based on past job history assessment.This study recommends additional studies on this topic with a larger number of participants and measurements.

The findings also have practical implications for further implementations. These study results showed the association of wood dust exposure posed significantly correlated with the job and working procedures. One important note of these respects concerns of occupational and environmental settings in Trang sawmills was the implementation for occupational safety trainings since about 66% of workers have not had PPE trainings and applying the regulations for compliance of PPE uses all the time for sawmill workers. It is strongly recommended to regularly wood dust measurements, spirometry and audiometry measurement and record all test results for providing the evidence base and claims for pulmonary dysfunctions associated with work history.

In conclusion, this study provides new evidence that sawmill workers exposed to Para rubber wood dust experience an increased risk of chest tightness and shortness of breath symptoms and reduced spirometric lung function. The results suggest that the owners and occupational health personnel of sawmill factories using Para rubber tree wood should implement appropriate exposure control measures to reduce wood dust exposure to protect their employees.

REFERENCES

[1] Balsiger J, Bahdon J, Whiteman A. The utilization, processing and demand for rubberwood as a source of wood supply. Forestry Policy and Planning Division, Rome, Regional office for Asia and the Pacific, Bangkok. (2000).

[2] Rubber Estate Organization, Ministry of Agriculture and Cooperative. Accessed [Online].2015. Available from: http://www.reothai.co.th/Para1.htm. [2015 August , 22]

[3] Department of Agriculture, Ministry of Agriculture and Cooperative. Accessed [Online].2015. Available from: http://www.doa.go.th/th/.[2015, Agust 22];

[4] National Center for Biotechnology Information (NCBI). *Hevea brasiliensis* Accessed [Online].2014. Available from: http://www.ncbi.nlm.nih.gov/Taxonomy. [2015, August 22]

[5] Alwis KU, Mandryk, J, Hocking AD, Lee J, Mayhew T, Baker W. Dust exposures in wood processing industry. Am Ind Hyg Assoc J. 60(1999):641-6.

[6] Department of Industry, Ministry of Industry. Name of Industries in 2013. Accessed [Online].2015. Available from: http://www.diw.go.th/data_fac/cl034.zip. [2015, August 22]

[7] Demers PA, Teschke K, Kennedy SM. What to do about softwood dust? A review of respiratory effects and recommendations regarding exposure limits. Am J Ind Med. 31(1997): 385-398.

[8] De Zotti R, Gubian F. Asthma and rhinitis in wooding workers. Aller Asthma Proc. 17(1996):199-203.

[9] Enarson DA, Chan-Yeung M: Characterization of health effects of wood dust exposures. Am J Ind Med. 17(19900: 33-38.

[10] Goldsmith DF, Shy CM. Respiratory health effects from occupational exposure to wood dusts. Scand J Work Environ Health. 14*(*1988):1-15.

[11] Hedenstierna G, Alexandersson R, Wimander K, Rosen G. Exposure to terpenes: Effects on pulmonary function. Int Arch Occup Environ Health. 51(1983): 191-198.

[12] Malmberg PO, Rask-Andersen A, Larsson KA, Stjernberg N, Sundblad BM, Eriksson K. Increased bronchial responsiveness in workers sawing Scots pine. Am J Respir Crit Care Med. 153(1996): 948- 952.

[13] Mandryk J, Alwis KU, Hocking AD. Work-related symptoms and dose-response relationships for personal exposures and pulmonary function among woodworkers. Am J Ind Med. 35(1999): 481-490.

[14] Binkley H, Schroyer T, Catalfano J. Latex Allergies. A Review of Recognition, Evaluation, Management, Prevention, Education, and Alternative Product Use. Journal of Athletic Training. 38(2003):133-40.

[15] Mark BJ, Slavin RG. Allergic contact dermatitis. Med Clin North Am. 90(2006):169-85.

[16] Hubbard R. Occupational dust exposure and the aetiology of cryptogenic fibrosing alveolitis. Eur Respir J Suppl. 32(2001):119s-21s.

[17] Barcenas CH, Delclos GL, El-Zein R, Tortolero-Luna G, Whitehead LW, Spitz MR. Wood Dust Exposure and the Association with Lung Cancer Risk. Am J Ind Med. 47(2005): 349-357.

[18] Donham KJ, Thorne PS. Agents in organic dust: criteria for a causal relationship. Am. J. Ind. Med. (1994): 33-39.

[19] Land CJ, Hult K, Fuchs R, Hagelberg S, Lundstrom H. Tremorgenic mycotoxins from Aspergillus fumigatus as a possible occupational health problem in sawmills. Appl Environ Microbiol. 53(1987):787-90.

[20] International Association Research on Cancer (IARC). Wood dust is carcinogenic to humans (Group 1). 1995. Accessed [Online].2015. Available from: http://www-cie.iarc.fr/htdocs/monographs/vol62/wood.html. [2015, November 22]

[21] Health Safety and Environment (HSE). Wood Dust. Accessed [Online].2002. Available from:http://www.hse.gov.uk/woodworking/wooddust.htm. [2014, November 22]

[22] Tuntiseranee P, Chongsuvivatwong V. A survey into process and worker's characteristics in the wood furniture industry in Songkhla Province, southern region of Thailand. SE Asian J Trop Med PH. 29(1998):814-20.

[23] Saejiw N, Chaiear N, Sadhra S. Exposure to wood dust and its particle size distribution in a rubberwood sawmill in Thailand. J Occup Environ Hyg. 6(2009):483–490.

[24] The National Institute for Occupational Safety and Health (NIOSH). Wood dust. Accessed [Online].2005 [Available from: http://www.cdc.gov/niosh/pel88/wooddust.html [2005, December 5]

[25] Mandryk J, Alwais KU, Hocking AD. Effect of personal exposures on pulmonary function and among sawmill workers. Ann J Occup Hyg.44(2000):281–289.

[26] Thetkathuek A, Yingratanasuk T, Demers PA, Thepaksorn P,Saowakhontha S, Kiefer MC. Rubberwood dust and lung function among Thai furniture factory workers. Int J Occup Environ Health.16(2010):69–74.

[27] Sripaiboonkij P, Phanprasit W, Jaakkola MS. Respiratory and skin effects of exposure to wood dust from the rubber tree Hevea brasiliensis. Occup Environ Med. 66(2009):442–447.

[28] Schlunssen V, Schaumburg I, Taudorf E, Mikkelsen AB, Sigsgaard T. Respiratory symptoms and lung function among Danish woodworkers. J Occup Environ Med. 44(2002):82–98.

[29] Douwes J, McLean D, Slater T, Travier N, Cheng S, Pearce N, Pine dust, atopy and lung function: a cross-sectional study in sawmill workers. Eur Respir J. 28(2006):791–798.

[30] Osman E, Pala K. Occupational exposures to wood dust and health effects on the respiratory system in a minor industrial estate in Bursa, Turkey. Int J of Occ Med Env Health. 22(2009):43 – 50.

[31] Aurajananon K, Chanprasit C, Songkham W. Noise Exposure and Risk Perception of Noise Exposure Among Workers in Large Lumber Mill. Thesis. Chiangmai University, (2004).

[32] Robinson T. Noise-induced hearing loss in the wood industry: A cross-sectional prevalence study based in Kaski District, Nepal. Thesis. College of Medical and Dental Sciences, University of Birmingham, UK (2012).

[33] The Environmental Protection Agency (EPA) a recommended standard: Occupational exposure to toluene. Accessed [Online] 1975. Available from: http://www.epa.gov/ttnatw01/hlthef/toluene.html. [2014, December 4]

[34] National Institute for Occupational Safety and Health (NIOSH) criteria for a recommended standard: Occupational exposure to xylene. Accessed [Online] 1975. Available from: http://www.cdc.gov/niosh/75-168.html. [2014, December 4]

[35] Thepaksorn P, Jaijong S,Tohtuptiang K, Rakthong C. Occupational Accidents and Injuries of Insured Workers in Trang Province, Thailand. The 29th Annual Conference of Asia Pacific Occupation Safety & Health Organization, BKK, July 2-6, (2014).

[36] Fleiss JL, Levin B, Cho Paik M. Statistical Methods for Rates and Proportions. John Wiley & Sons, 69-73. Accessed [Online] 2003 Available from: http://www.openepi.com/SampleSize/SSCohort.htm. [2014, December 4]

[37] Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of Spirometry. Eur Respir J 26(2005):319–38.

[38] NIOSH Manual of Analytical Methods (NMAM). Particulates Not Otherwise Regulated, Total: Method 0500. Accessed [Online] 1994 Available from: http://www.cdc.gov/NIOSH/nmam/pdfs/0500.pdf. [2015, January 8]

[39] Deepreecha K. Prevalence rate and associated factors of work-related respiratory diseases among wood workers at Wang-Numyen co-operation Sa Kaew province [thesis]. Bangkok: Chulalongkorn University. (2004).

[40] Chaiear N, Sadhra S, Jones M, Cullinan P, Foulds IS, Burge PS. Sensitisation to natural rubber latex: an epidemiological study of workers exposed during tapping and glove manufacture in Thailand. Occup Environ Med. 58(2001):386-91.

[41] National Institute for Occupational Safety and Health (NIOSH). American Thoracic Society Adult Questionnaire. Accessed [Online] 1978. Available from: http://www.cdc.gov/niosh/atspage.html. [2015, April 18];

[42] Sriproed S, Osiri P, Sujirarat D, Chantanakul S, Harncharoen K, Ong-artborirak P, Woskie SR. Respiratory effects among rubberwood furniture factory workers in Thailand. Arch Environ Occup Health. 68(20130:87-94.

[43] Koehncke N, Taylor M, Talyor C, Harman LP, Beaulne P, Guidotti T. An investigation of noise levels in Alberta sawmills. Am J Ind Med. 43(2003):154–164.

[44] Occupational Health and Safety Department. Woodwork Co.,Ltd. Annual report. (2015).

[45] Administrative and Human Resource Section. Asia Pacific Parawood Co.,Ltd. Annual report. (2014).

[46] Trang Research Center for Occupational Health. Occupational health and safety hazards from a walk-through survey of four sawmills in Trang Province report. Sirindhorn College of Public Health, Trang. (2016).

[47] Thepaksorn P, Fadrilan-Camacho V, Siriwong W. Respiratory symptoms and ventilatory function defects among Para rubber wood sawmill workers in the South of Thailand (in press). Hum. Ecol. Risk Assess. (2017).

[48] Bosan IB, Okpapi JU. Respiratory symptoms and ventilatory function impairment among wood workers in the Savannah belt of Northern Nigeria. Ann Afr Med 3(2004):22–7.

[49] Talini D, Monteverdi A, Benvenuti A, et al. Asthma like symptoms, atopy and bronchial responsiveness in furniture workers. Occup Environ Med 55(1998):786–91.

[50] Borm PJ, Jetten M, Hidayat S, et al. Respiratory symptoms, lung function, and nasal cellularity in Indonesian wood workers: a dose-response analysis. Occup Environ Med
59(2002):338–44.

[51] Occupational Safety & Health Administration (OSHA) U.S. Department of Labor. Accessed [Online] 1995. [Available from: URL: https://www.osha.gov/Publications/osha3071.html. [2015, Setember 10]

[52] Canadian Centre for Occupational Health and Safety (CCOHS). Accessed [Online] 2015 Available from: URL: https://www.ccohs.ca/oshanswers/hsprograms/job-haz.html. [2015 November, 8]

[53] Thepaksorn, P. Thongjerm S, Incharoen S, Siriwong W, Harada K, Koizumi A. Job safety analysis and hazard identification for work accident prevention in Rubber wood sawmills in Trang Province, Thailand. J Occ Health. (2017) (under revision).

APPENDIX

APPENDIX A

Walk-Through Survey Report

Section I Administrative Information

1.1 General Information

Name of Establishment	....
Type of Establishment	....
Address	....
Product types	....
Year of business start	....
Total no. employees	....
Number of work shift	....
Does this factory have worker union?	☐ Yes ☐ No

Location and Address in Brief

Establishment Layout of Roofing Tiles Fiber-Cement Manufacturing Process

1.2 Facilities Supports & Benefits

Items	Available	N/A
1. Clean drinking water ( )		
2. Canteen or clean area for lunch and break If YES, it is located outside or separate from work environment? ( ) 1 Yes ( )2 No		
3. Zink (4 points)		
4. Bathroom		
5. Toilet		
6. Changing clothes or uniform		
7. Changing room/storage		
8. Common room If YES, please specify…………………………		
( ) 1 inside the factory ( )2 outside the factory		

1.3 Health Care Services

Items	Available	N/A
1. Medicine and supplies		
2. First aid room		
3. Occupational physician or occupational nurse		
4. Work hour of physician…-… hrs/day and ….-…..day/ week		
5. Work hour of nurse …-… hrs/day and …..-…..day/ week		
6. Employees pass first aid training course		
7. Registered hospital for medical service If YES, please specify ………..		
8. Provided hospital under workmen compensation fund If YES, please specify ………………………..		
9. Provided medical insurance and related Life insurance If YES, please specify ……………………………		
10. Physical examination for new employees and if they are recruited to new job/position ( )1 Yes ( )2 No		
If YES, medical examination is: ……………. Ears …………….Blood ……………. Eyes …………….Urine ……… ….. Chest X-ray …………. Pulmonary function test ……………. Other, please specify………………………………………………		
11. Follow up and fiscal physical examination If YES, medical examination is: ……………. Ears …………….Blood ……………. Eyes ……………Urine …………… Chest X-ray …………….Pulmonary function test ……………. Other, please specify….EKG/ BUN Cholesterol Liver and Kidney function		

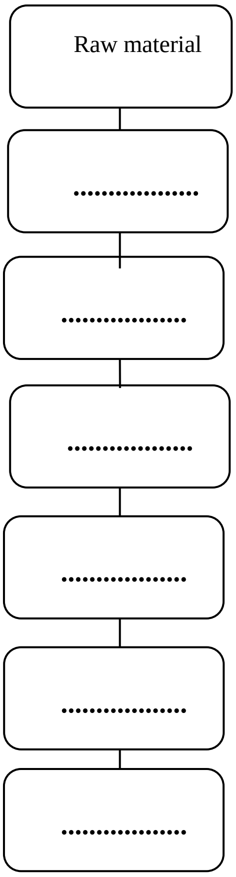
1.3 Health Care Services (cont.)

Items	Available	N/A
12. Rehabilitation in case employee has occupational injuries and illnesses If YES, please specify (how)..		
13. Employment disability employees who have occupational injuries and illnesses to new job or position		
14. Medical examination record (If YES, please provided)		

1.4 Occupational Health and Safety **Yes** **No**

Items	Available	N/A
1. Providing personal protective equipment (PPE) If YES, provided PPE is: ( )1 Hard hat ( ) 6 Shoes (Boots) ( )2 Eye goggle ( )7 Gloves ( )3 Mask ( ) 8 apron ( )4 Ear muffs ( )9 Insulator clothes ( )5 Ear plugs ( )10 Other, please specify Safety belt etc. If YES, please specify ( )1 Provided, please specify... ( )2 Employee paid a half, please specify …….......... ( )3 Employee paid full, please specify........................ ( )4 Other, please specify... If YES, how often, specify…………..………………..……………		
2. Occupational safety personnel (one occupational hygienist)		
3. Occupational health and safety training		
4. Providing occupational health and safety in factory, i.e., poster, morning talk, etc.		
5. Occupational health and safety promotion activities, i.e., occupational health and safety such as occupational health and safety week		

Section II: Production process and raw material uses)figure(

Production Process and Procedure	**Production Process**	**Raw Material and Chemical Uses**
		

Section III: Environmental and Occupational Hazards

Section	Process	No. Workers Exposed to Environmental and Occupational Hazards					
		Dust	Chemical Agent	Noise	Heat	Light	Other, please specify
	1..................................	....	....	....	....	....	....
	2..................................	....	....	....	....	....	....
	3..................................	....	....	....	....	....	....
	4..................................	....	....	....	....	....	....
	5.................................	....	....	....	....	....	....
	1..................................	....	....	....	....	....	....
	2..................................	....	....	....	....	....	....
	3..................................	....	....	....	....	....	....
	4..................................	....	....	....	....	....	....
	5.................................	....	....	....	....	....	....
	1..................................	....	....	....	....	....	....
	2..................................	....	....	....	....	....	....
	3..................................	....	....	....	....	....	....
	4..................................	....	....	....	....	....	....
	5.................................	....	....	....	....	....	....
	1..................................	....	....	....	....	....	....
	2..................................	....	....	....	....	....	....
	3..................................	....	....	....	....	....	....
	4..................................	....	....	....	....	....	....
	5.................................	....	....	....	....	....	....

Section IV: Environmental Survey

Item	Process/Procedure	Section	Section	Criteria
1. Environmental health hazards	1. Dust levels in production process and procedure			0- Low dust levels 1- Dust levels in the air, but not in the floor 2- Dust levels in the air and high levels in the floor
	2. Chemical or organic volatile levels in production process, e.g., Toluene, benzene, etc.			0- No smell of chemical or organic volatile 1- Smell of chemical or organic volatile under ventilation control system 2- Smell of chemical or organic volatile without ventilation control system
	3. Carbon monoxide (CO) levels in production process			0- Open with high ceiling with ventilation system such as fan 1- Open with high ceiling with ventilation system such as fan but does not operate 2- Close without ventilation system
	4. Noise level in production process			0- Less than 85 dB(A) 1- 85-90 dB(A) 2- > 90 dB(A)
	5. Light levels at work station			0- > 200 Lux 1- 51-199 Lux 2- < 50 Lux
	6. Light levels in building			0- > 20 Lux 1- 10-19 Lux 2- < 10 Lux
	7. Heat			0- Open air building/ventilation system 1- No ventilation system or have ventilation system but doesn't operate 2- No ventilation system
	8. Mechanical and equipment safety ( ) No safety protection for mechanical and equipment available (i.e., cut, press, rotate, etc.) ( ) Work station unsafe or in secured ( ) Mechanical and equipment in worn out or poor maintenance ( ) Mechanical and equipment in worn out or poor maintenance but still in use ( ) Other, please specify…			0- Not found 1- Meet only one item and could be correct 2- Meet one or more items without correction

Item	Process/Procedure	Section	Section	Criteria
	9. Unsafe operation/working ( ) Tease while working ( ) Use mechanical or equipment incorrect and unsafe ( ) Inappropriate wearing clothes ( ) Not use PPE or use with inappropriate ( ) Use inappropriate PPE ( ) Smoking and eating while working ( ) Other, please specify…			0- No found 1- Meet only one item 2- Meet more than one items
2. Prevention and control	10. Local ventilation system			0- Operated ventilation system 1- Few operated ventilation system or insufficient ventilation system 2- No ventilation system
	11. General ventilation system			0- Open area < 1/10 of total area and ceiling level > 3.5 m 1- Open area < 1/10 of total area or ceiling level > 3.5 m 2- Close or ventilation system less than 1/10 and ceiling < 3.5 m
	12. Noise control level system in production process			0- < 90 dB(A) 1- > 90 dB(A) with using PPD in some occasion or insufficient 2- > 90 dB(A) without appropriate control system
	13. Fire protection ( ) Distinguished fire equipment) 1 unit/ 100 sqm (and promptly use ( ) Distinguished fire equipment has been checked and ready to use ( ) Fire exit door without any obstruction or locked ( ) Explosive and flammable substance are storage with ventilation system ( ) Explosive and flammable substance waste disposal management ( ) Plug and switch have been checked ( ) Other, please specify....................................			0- Every items has been checked 1- No more than 2 items are needed to correct 2- More than 2 items are needed to correct

Item	Process/Procedure	Section	Section	Criteria
	14. Mechanical hazards ( ) Providing protective equipment or shield for OSH protection ( ) Mechanical equipment maintenance (i.e., inspection, clean-up, lubricant, etc) ( ) Mechanical equipment has been signed for area permission ( ) Other, please specify…			0- Every items has been checked 1- No more than 2 items are needed to correct 2- More than 2 items are needed to correct
	15. Personal protective equipment (PPE)			0- Appropriate and adequate PPE use 1- Inappropriate or inadequate PPE use 2- No PPE
	16. Sign			0- Poster and sign have been placed appropriately 1- Poster and sign have been placed inappropriately with lack of maintenance 2- No poster and sign
	17. Occupational health and safety training			0- Orientation program at the beginning related to mechanical uses, procedure and production process and health hazards 1- Orientation program while working related to mechanical uses, procedure and production process and health hazards 2- No orientation program related to mechanical uses, procedure and production process and health hazards
	18. Food & beverage and smoking policy			0- No food and beverage or smoking permission sign has been placed in work settings and canteen with area providing 1- No food and beverage or smoking permission sign has been placed in work settings and canteen without area providing 2- No food and beverage or smoking permission sign
	19. Well management and cleaning up			0- Well maintenance with clean-up chemicals & equipment 1- Fairly maintenance with clean-up chemicals & equipment 2- Poor maintenance and clean-up chemicals & equip.

<table>
<tr><th>Item</th><th>Process/Procedure</th><th>Section</th><th>Section</th><th>Criteria</th></tr>
<tr><td>3. Welfare and benefits</td><td>20. Bathroom and utilities</td><td></td><td></td><td>0- Clean bathroom(shower) with clean water supply
1- Not enough clean bathroom(shower) or enough but not clean
2- Not enough and clean bathroom(shower) available
Criteria:
1-80 workers/toilet If > 80 workers, add one more toilet</td></tr>
<tr><td></td><td>21. Restroom and utilities</td><td></td><td></td><td>0- Clean toilet with clean water supply and hygiene condition
1- Not enough clean toilet or enough but not clean
2- Not enough and clean toilet available
Criteria:<table><tr><th>No. worker</th><th>Required toilet</th></tr><tr><td>1-15
16-40
41-80</td><td>1
2
3</td></tr></table>1-80 workers/restroom If > 80 workers, add one more toilet</td></tr>
<tr><td></td><td>22. Sink</td><td></td><td></td><td>0- Clean and enough sink with soap available
1- Not enough or unclean sink available
2- Not enough and unclean sink available
Criteria:<table><tr><th>No. worker</th><th>Required sink</th></tr><tr><td>1-15
16-40
41-80</td><td>1
2
3</td></tr></table>1-80 workers/sink If > 80 workers, add one more sink</td></tr>
<tr><td></td><td>23. Drinking water</td><td></td><td></td><td>0- Clean drinking water supply
1- Clean drinking water in enough or enough but unlearned
2- In enough and un-cleaned
Criteria:<table><tr><th>No.worker</th><th>Required drinking water</th></tr><tr><td>1-40
41-80</td><td>1
2</td></tr></table>1-80 workers/drinking water unit If > 80 workers, add one more sink</td></tr>
</table>

Item	Process/Procedure	Section	Section	Criteria
	24. First aid			0- Enough medicine and medical supplies available 1- In enough medicine or medical supplies available 2- No medicine and medical supplies available
	25. Health insurance benefits			0- Health insurance coverage under registered hospital 1- Health insurance coverage with conditional approve 2- No health insurance coverage
	26. Physical examination 26.1 Fiscal physical examination 26.2 Follow-up physical examination (i.e., 6-moth)			0- Fiscal physical examination (full) 1- Fiscal physical examination 2- No fiscal physical examination before and leave the job

Section V Post Assessment of a Walk-Through Survey

Assessor Name..
Establishment Name...
Type of Establishment…..

Priority Needs Improvement (List Items)	Department (Section)	Comments & Recommendations
1. Need improvement....... .... 2. Additional required improvement	....	....

Results...
....
....

Section VI Environmental and Occupational Health Hazards Results

Department (Section)	Air monitoring			Noise dB(A)	Light)Lux(	Heat WBGT (˚C)	Other
	Dust/airborne	Name	Conc.)ppm)				

APPENDIX B

Sampling Methods and Protocols

Particulates not otherwise regulated, Total dust

DEFINITION: total aerosol mass
METHOD: 0500
OSHA: 15 mg/m^3
NIOSH: no REL
ACGIH: 10mg/m^3, total dust less than 1% quartz

SAMPLING
  SAMPLER: FILTER (tared 37-mm, 5-µm PVC filter)
  FLOW RATE: 1 to 2 L/min
  VOL -MIN: 7 L @ 15 mg/m^3
  -MAX: 133L @ 15 mg/m^3

SHIPMENT: routine

SAMPLE
  BLANKS: 2 to 10 field blanks per set
  BULK SAMPLE: none required

MEASUREMENT
  TECHNIQUE: GRAVIMETRIC (FILTER WEIGHT)
  ANALYTE: airborne particulate material

EQUIPMENT:

1. Sampler: 37-mm PVC, 2- to 5-µm pore size membrane or equivalent hydrophobic filter and supporting pad in 37-mm cassette filter holder.
2. Personal sampling pump, 1 to 2 L/min, with flexible connecting tubing.
3. Microbalance, capable of weighing to 0.001 mg.
4. Static neutralizer: e.g., Po-210; replace nine months after the production date.
5. Forceps (preferably nylon).
6. Environmental chamber or room for balance (e.g., 20 °C ± 1 °C and 50% ± 5% RH).

MEASUREMENT:

Weigh each filter, including field blanks. Record the post-sampling weight, (mg). Record anything remarkable about a filter (e.g., overload, leakage, wet, torn, etc.)

Source: NIOSH Manual of Analytical Methods (NMAM), Fourth Edition

Particulates not otherwise regulated, Respirable 600

DEFINITION: aerosol collected by sampler with 4-µm median cut point

METHOD: 0600
OSHA: 5 mg/m^3
NIOSH: no REL
ACGIH: 3mg/m^3
SAMPLING
SAMPLER: CYCLONE + FILTER (10-mm nylon cyclone, Higgins-Dewell [HD] cyclone, or aluminum cyclone + tared 5-µm PVC membrane)
FLOW RATE: nylon cyclone:1.7 L/min,HD cyclone:2.2 L/min,Al cyclone:2.5 L/m
VOL -MIN: 20 L @ 5 mg/m^3
-MAX: 400 L
SHIPMENT: routine
SAMPLE
BLANKS: 2 to 10 field blanks per set
MEASUREMENT
TECHNIQUE: GRAVIMETRIC (FILTER WEIGHT)
ANALYTE: airborne particulate material
EQUIPMENT:

1. Sampler: a.Filter: 5.0-µm pore size, polyvinyl chloride filter or equivalent hydrophobic membrane filter supported by a cassette filter holder (preferably conductive). b. Cyclone: 10-mm nylon (Mine Safety Appliance Co., Instrument Division, P. O. Box 427, Pittsburgh, PA 15230), Higgins-Dewell (BGI Inc., 58 Guinan St., Waltham, MA 02154) [7], aluminum cyclone (SKC Inc., 863 Valley View Road, Eighty Four, PA 15330), or equivalent.
2. Personal sampling pump, 1.7 L/min ± 5% for nylon cyclone, 2.2 L/min ± 5% for HD cyclone, or 2.5 L/min ± 5% for the Al cyclone with flexible connecting tubing.
3. Balance, analytical, with sensitivity of 0.001 mg.
4. Weights, NIST Class S-1.1, or ASTM Class 1.
5. Static neutralizer, e.g., Po-210; replace nine months after the production date.
6. Forceps (preferably nylon).
7. Environmental chamber or room for balance, e.g., 20 °C ± 1 °C and 50% ± 5% RH.

MEASUREMENT:
Weigh each filter, including field blanks. Record the post-sampling weight, (mg). Record anything remarkable about a filter (e.g., overload, leakage, wet, torn, etc.)

Source: NIOSH Manual of Analytical Methods (NMAM), Fourth Edition

APPENDIX C

แบบสอบถามสำหรับพนักงานประเภทกิจการโรงเลื่อยและแปรรูปไม้

คำชี้แจง : แบบสัมภาษณ์ฉบับนี้ ประกอบด้วย คำถาม 3 ส่วน คือ

(1) ข้อมูลทั่วไป

(2) (2) ข้อมูลการทำงานและประเมินความเสี่ยงจากการทำงาน

(3) ข้อมูลสุขภาพส่วนตัวและข้อมูลการตรวจร่างกาย

กรุณาตอบแบบสัมภาษณ์ให้ครบทุกส่วน

****

ข้อมูลที่ได้จะเก็บเป็นความลับไม่เปิดเผย

คำชี้แจง โปรดทำเครื่องหมาย ✓ ลงในช่อง ☐ หรือเติมข้อความให้สมบูรณ์

	สำหรับเจ้าหน้าที่
เลขที่แบบสอบถาม………	ID……………………
วันที่ตอบ...	Date………………
ส่วนที่ 1 ข้อมูลทั่วไป	
รหัสโรงงาน..	FacCode…………….
1.เพศ ☐ 1.ชาย ☐ 2.หญิง	Sex………..........
2. อายุ จำนวน...............................ปี (นับถึงวันที่ตอบแบบสอบถาม)	Age………………
3. น้ำหนัก ……………………กิโลกรัม	BW………………..
4. ส่วนสูง…………………………เซนติเมตร	Height……………
5. สถานภาพสมรส ☐1. โสด ☐2. สมรสแล้ว ☐3. ม่าย ☐4. หย่า ☐ 5.แยกกันอยู่	Status…………..…
6. ท่านมีรายได้เท่าใดต่อเดือน ☐1. < 9,000 บาท ☐2. 9,000-15,000 บาท ☐3. >15,000 บาท	Salary……………..
7. ระดับการศึกษา ☐ 1.ประถมศึกษา ☐2. มัธยมศึกษา ☐3. อนุปริญญา ☐ 4.ปริญญาตรี ☐ 5. สูงกว่าปริญญาตรี ☐6. อื่นๆ....................	Edu……….

ส่วนที่ 2 ข้อมูลการทำงานและประเมินความเสี่ยงจากการทำงาน	
8. ระยะเวลาทำงาน จำนวน ....ปี...........................เดือน	Year………… Month………..
8.1 ลักษณะงาน ☐1. ทำงานในเวลาปกติ ☐ 2.ทำงานเข้ากะ จำนวน................ชม.ต่อกะ	Worktype………. Hr………………
9. ท่านทำงานล่วงเวลาหรือไม่ ☐1. ทำ เฉลี่ยสัปดาห์ละ..................ชั่วโมง ☐2. ไม่ทำ	OT………… OT_Hr………
10. ตำแหน่งงาน ☐ 1.หัวหน้างาน ☐ 2. ผู้ปฏิบัติงาน	JD………………
11.ท่านทำงานใน**<u>แผนก</u>**ใด (เลือกแผนกที่ท่านทำงานในช่วงวันมากที่สุด) ☐1. เลื่อยไม้ ☐5. แพคคิ้ง ☐2. เรียงไม้ ☐6. ออฟฟิส ☐3. อบน้ำยา ☐4. ซ่อมบำรุง/โฟล์คลิฟท์	DEP…………….
12. ท่านคิดว่าขณะนี้ตนเองมีร่างกายสมบูรณ์แข็งแรงระดับใด ☐ 1. แข็งแรงดีมาก ☐ 2. แข็งแรงดี ☐ 3.พอใช้ ☐ 4. ไม่ดี	Health……………
13. ท่านเคยได้รับการอบรมถึงวิธีการป้องกันอันตรายจากการทำงานหรือไม่? ☐1. เคย ☐2. ไม่เคย	Train………………
14.ท่านปฏิบัติงานในขณะที่ทำงานดังต่อไปนี้หรือไม่?	
14.1 ปฏิบัติตามกฎความปลอดภัยในการทำงาน ☐1. ทุกครั้ง ☐2. บ่อยมาก ☐3. บางครั้ง ☐4. น้อยมาก ☐5. ไม่เลย	Safe…………………
14.2 สวมหน้ากากปิดจมูกขณะทำงาน ☐1. ทุกครั้ง ☐2. บ่อยมาก ☐3. บางครั้ง ☐4. น้อยมาก ☐5. ไม่เลย	Mask………………..
14.3 สูบบุหรี่ขณะทำงาน ☐1. ทุกครั้ง ☐2. บ่อยมาก ☐3. บางครั้ง ☐4. น้อยมาก ☐5. ไม่เลย	SmokeW………..
14.4 ท่านเคยได้รับ**<u>การอบรม</u>**ให้ใช้หน้ากากปิดจมูกป้องกันสารเคมี, ฝุ่นละออง และฝุ่นไม้หรือไม่? ☐1. เคย ☐2. ไม่เคย	TrainMask……….
14.5 ขณะที่ใช้ท่านใช้**<u>หน้ากากปิดจมูก</u>** ป้องกันสารเคมี, ฝุ่นละออง และฝุ่นไม้ ท่านมีอาการผิดปกติหรือรู้สึกไม่สบายจากการใช้งานหรือไม่? ☐1. ใช่ ☐2. ไม่ใช่	Wear……………….

ส่วนที่ 3 ข้อมูลสุขภาพส่วนตัวและข้อมูลการตรวจร่างกาย

ประเมินความเสี่ยงต่อระบบสุขภาพและระบบทางเดินหายใจ	สำหรับเจ้าหน้าที่
16. ท่านเคยมี อาการ**หายใจเสียงหวีด** ในระยะ 12 เดือนที่ผ่านมาหรือไม่ ☐1. มี ☐2. ไม่มี(กรุณาข้ามไปตอบข้อ 17) ถ้ามี กรุณาตอบคำถามทั้งหมด ต่อไปนี้ ในช่วงวันหยุดพักผ่อน 2-3 วันติดต่อกัน อาการ**หายใจเสียงหวีด** เป็นอย่างไร? ☐1. ดีขึ้นกว่าในช่วงปฏิบัติงาน ☐2. ไม่เปลี่ยนแปลง ☐3. แย่ลงกว่าขณะที่ปฏิบัติงาน ถ้าท่านมี อาการ**หายใจเสียงหวีด** อาการนั้นเกิดขึ้น ครั้งแรกเมื่อใด เดือน...................... ปี (พ.ศ.) .... ท่านมี อาการ**หายใจเสียงดังหวีด ๆ** บ่อยแค่ไหน? ☐1. ทุกวัน ☐2. ทุกอาทิตย์ ☐3. ทุกเดือน ☐ 4. นาน ๆ ครั้ง	Wheezing……………. WheezingR……….. Month……..Yr……… WheezingF…………
17. ท่านเคยมี อาการ**แน่นหน้าอก** (อาการหายใจไม่ทั่วท้อง) ในระยะ 12 เดือนที่ผ่านมาหรือไม่ ☐1. มี ☐2. ไม่มี (กรุณาข้ามไปตอบข้อ 18) ถ้ามี กรุณาตอบคำถามทั้งหมด ต่อไปนี้ ในช่วงวันหยุดพักผ่อน 2-3 วันติดต่อกัน อาการ**แน่นหน้าอก** เป็นอย่างไร? ☐1. ดีขึ้นกว่าในช่วงปฏิบัติงาน ☐2. ไม่เปลี่ยนแปลง ☐3. แย่ลงกว่าขณะที่ปฏิบัติงาน ถ้าท่านมี อาการ**แน่นหน้าอก** อาการนั้นเกิดขึ้น ครั้งแรกเมื่อใด เดือน...................... ปี (พ.ศ.) .... ท่านมี อาการ**แน่นหน้าอก** บ่อยแค่ไหน? ☐1. ทุกวัน ☐2. ทุกอาทิตย์ ☐3. ทุกเดือน ☐4. นาน ๆ ครั้ง	Chest………………….. ChestR……..…… Month….Yr……… ChestF………….
18. ท่านมี **อาการหายใจไม่อิ่ม** (อาการที่หายใจไม่สะดวก เหนื่อยง่ายเมื่อเร่งรีบในการเดินหรือเดินขึ้นเนิน)ในระยะ 12 เดือนที่ผ่านมาหรือไม่ ☐1. มี ☐2. ไม่มี (กรุณาข้ามไปตอบข้อ 19) ถ้ามี กรุณาตอบคำถามทั้งหมด ต่อไปนี้ ในช่วงวันหยุดพักผ่อน 2-3 วันติดต่อกัน **อาการหายใจไม่อิ่ม** ของท่านเป็นอย่างไร? ☐1. ดีขึ้นกว่าในช่วงปฏิบัติงาน ☐2. ไม่เปลี่ยนแปลง ☐ 3. แย่ลงกว่าขณะที่ปฏิบัติงาน ท่านมี **อาการหายใจไม่อิ่ม** ครั้งแรกเมื่อใด เดือน...................... ปี (พ.ศ.) .... ท่านมี **อาการหายใจไม่อิ่ม** บ่อยแค่ไหน ☐ 1. ทุกวัน ☐2. ทุกอาทิตย์ ☐3. ทุกเดือน ☐ 4. นาน ๆ ครั้ง	Shortbreath………. ShortbreathR………. Month….Yr……… ShortbreathF…….

19.ท่านเคยมี **<u>อาการไอ</u>** ในระยะ 12 เดือนที่ผ่านมาหรือไม่ ☐1. มี ☐2. ไม่มี (กรุณาข้ามไปตอบข้อ 20) ถ้ามี กรุณาตอบคำถามทั้งหมด ต่อไปนี้ ในช่วงที่ท่านหยุดพักผ่อน 2-3 วันติดต่อกัน **<u>อาการไอ</u>** ของท่านเป็นอย่างไร? ☐1. ดีขึ้นกว่าในช่วงปฏิบัติงาน ☐2. ไม่เปลี่ยนแปลง ☐3. แย่ลงกว่าขณะที่ปฏิบัติงาน ท่านมี **<u>อาการไอ</u>** ครั้งแรกเมื่อใด เดือน.............. ปี (พ.ศ.) .... ท่านมี **<u>อาการไอ</u>** บ่อยแค่ไหน ☐1. ทุกวัน ☐2. ทุกอาทิตย์ ☐3. ทุกเดือน ☐ 4. นาน ๆ ครั้ง	Cough………….. CoughR……….. Month…….Yr……. CoughF…………
20. ท่านสูบบุหรี่ ยาสูบใบจาก อย่างน้อย 1 มวน ต่อวัน ติดต่อกันเป็นเวลาอย่างน้อย 1 ปี ☐1. ใช่ ☐2. ไม่ใช่ (กรุณาข้ามไปทำข้อ 21) ท่านสูบบุหรี่เฉลี่ย กี่มวนต่อวัน... ท่านสูบบุหรี่ติดต่อกันมานานเท่าใด ....ปี	Smoke…………… SmokeNo…….. SmokeYR………
21. ท่านดื่มสุรา เบียร์ หรือเครื่องดื่มแอลกอฮอล์บ้างหรือไม่? ☐1. ไม่ดื่ม ☐2. ดื่มน้อยกว่า 1 ครั้งต่อสัปดาห์ ☐3. ดื่ม 2-3 ครั้งต่อสัปดาห์ ☐4. ดื่มมากกว่า 3 ครั้งต่อสัปดาห์ ☐5. เคยดื่มแต่เลิกแล้ว ระยะเวลาที่เคยดื่มนาน.................ปี	Alcohol…………… QuitYR…………..
22.ถ้าท่านทำการตรวจสุขภาพประจำปี ผลการตรวจเป็นอย่างไร? ครั้งล่าสุดเมื่อวันที่ เดือน ปี ระบุ .... ☐1. ปกติ ☐2. ผิดปกติ ระบุ......................................	Latest date……….. Phyexam……….. Other………………
23.ท่านได้เคยการตรวจการได้ยินหรือไม่? ☐1. เคย (ถ้าเคย ตอบข้อ 24) ☐2. ไม่เคย (ถ้าไม่เคย ตอบข้อ 25)	Noise……………….
24.ผลตรวจการได้ยินเป็นอย่างไร? ☐1. ปกติ ☐2. ผิดปกติ ระบุ.....................................	NoiseRes……………
25.ท่านเคยได้รับการตรวจสมรรถภาพปอดมาก่อนหรือไม่? ☐1. เคย (ถ้าเคย ตอบข้อ 26) ☐2. ไม่เคย (ถ้าไม่เคย ตอบข้อ 27)	Lung……………..
26.ผลการตรวจสมรรถภาพปอดเป็นอย่างไร? ☐1. ปกติ ☐2. ผิดปกติ ระบุ.....................................	LungRes……………
27.ท่านเคยเป็นโรคดังต่อไปนี้ หรือไม่? (*จากประวัติการตรวจของแพทย์* ตอบได้มากกว่า 1 ข้อ) ☐1. วัณโรค ☐2. หอบหืด ☐3. มะเร็งปอด	TB………………….. Asth………………… LungC……………… HP…………………… ALLER……………..

☐4. ภาวะความดันโลหิตสูง ☐5. ภูมิแพ้ ☐6. เบาหวาน ☐7. ไขมันในเลือดสูง ☐8. ปวดหลัง ☐9. อื่น ๆ (กรุณาระบุ)...	DIAB……………..… HighChol……...... Backpain………. Other…………….
28. ท่านเคยประสบอุบัติเหตุจากการทำงานหรือไม่ ☐ 1. ไม่เคย ☐ 2. เคย จำนวน..........ครั้ง และจำเป็นต้องหยุดงาน..........วัน ลักษณะการบาดเจ็บ... ชนิดและอวัยวะที่ได้รับการบาดเจ็บระบุ...	Acc……… AccTime…….. AccType….. AccOr………

IRB Approval

AF 01-12

คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย
254 อาคารจามจุรี 1 ชั้น 2 ถนนพญาไท เขตปทุมวัน กรุงเทพฯ 10330
โทรศัพท์/โทรสาร: 0-2218-3202 E-mail: eccu@chula.ac.th

COA No. 237/2558

ใบรับรองโครงการวิจัย

โครงการวิจัยที่ 210.1/58 : การสัมผัสและอันตรายต่อสุขภาพจากการทำงานในโรงเลื่อยไม้ยางพารา ในจังหวัดตรัง

ผู้วิจัยหลัก : นายพยงค์ เทพอักษร

หน่วยงาน : วิทยาลัยวิทยาศาสตร์สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย

คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย ได้พิจารณา โดยใช้หลัก ของ The International Conference on Harmonization – Good Clinical Practice (ICH-GCP) อนุมัติให้ดำเนินการศึกษาวิจัยเรื่องดังกล่าวได้

ลงนาม..
(รองศาสตราจารย์ นายแพทย์ปรีดา ทัศนประดิษฐ)
ประธาน

ลงนาม..
(ผู้ช่วยศาสตราจารย์ ดร.นันทรี ชัยชนะวงศาโรจน์)
กรรมการและเลขานุการ

วันที่รับรอง : 28 ธันวาคม 2558 **วันหมดอายุ** : 27 ธันวาคม 2559

เอกสารที่คณะกรรมการรับรอง

1) โครงการวิจัย
2) ข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัยและใบยินยอมของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย
3) ผู้วิจัย 210.1/58
4) แบบสอบถาม

Publications and submitted papers

[1] Thepaksorn P, Fadrilan-Camacho V, Siriwong W. Respiratory symptoms and ventilatory function defects among Para rubber wood sawmill workers in the South of Thailand. (In press). *Human and Ecological Risk Assessment*.2017. http://dx.doi.org/10.1080/10807039.2017.1285221

[2] Thepaksorn, P. Thongjerm S, Incharoen S, Siriwong W, Harada K, Koizumi A. Job safety analysis and hazard identification for work accident prevention in Rubber wood sawmills in Trang Province, Thailand. *Journal of Occupational Health*. 2017(under revision).

[3] Thepaksorn P, Siriwong W, Somrongthong R, Neitzel RL,Techasrivichien T. Risk recognitions and risk perceptions affecting protection utilizations among Southern Thailand sawmill workers. *Journal of Safe Health at Work*. 2017 (under revision).

[4] Thepaksorn P, Koizumi a, Harada K, Siriwong W, Neitzel RL. Occupational noise exposure and hearing defects among sawmill workers in the South of Thailand. Submitted to the *Archives of Environmental and Occupational Health*.2017.

Publications related to lab trainings

[5] Shiwaku Y, Lee P, Thepaksorn P, Zheng B, Koizumi A, Harada KH. Spatial and temporal trends in perfluorooctanoic and perfluorohexanoic acid in well, surface, and tap water around a fluoropolymer plant in Osaka, Japan. Chemosphere. 2016; 164: 603-610.

[6] Lee P, Shiwaku Y, Thepaksorn P, Zheng B, Harada KH., Koizumi A. Formation and Degradability of Perfluorinated Chemicals in River Soils around a Fluoropolymer Plant in Osaka, Japan. Submitted to Journal of Environmental Sciences & Technology Letter. 2017.

Poster presentation

[7] Thepaksorn P, Koizumi a, Harada K, Siriwong W, Neitzel RL. Occupational noise exposure and hearing defects among sawmill workers in the South of Thailand. 2016 *Kyoto Global Health Conference for Rising Public Health Researchers*, Kyoto, Japan December 14-15, 2016.

[8] Thepaksorn P, Siriwong W, Koizumi A, Somrongthong R. Occupational exposures and health hazards in Para rubber wood sawmills in the South of Thailand. *The American Industrial Hygiene Conference & Exposition (AIHce)*, Seattle, WA, USA June 4-7, 2017.

VITA

Mr.Phayong Thepaksorn was born in 1973 in Trang Province. He earned a degree of Bachelor of Science in Pharmaceutical Sciences from Prince of Songkla University in 1996. He has been appointed as a senior lecturer at Sirindhorn College of Public Health, Trang since 1996 until present. He also received Master of Public Health degree from Mahidol University in 2001.

He received both degrees of Master of Public Health in Environmental and Occupational Health and Master of Sciences in Occupational and Environmental Exposure Science from the University of Washington, USA in 2009 (the Royal Thai Scholarship). His research thesis entitled "Occupational injuries and accidents in Thailand" and "Measurement of atmospheric trace gases using ultraviolet differential optical absorption spectroscopy (UV-DOAS)" He earned his Ph.D. at College of Public Health Sciences, Chulalongkorn University in 2012. His research dissertation entitled "Developing health impact assessment tools: a case study of cement factory in Nakhon Si Thammarat Province, Thailand" (the Royal Thai Scholarship and International Fogarty Scholarship, USA).

He also continued to pursue his Master double degrees at School of Public Health, Kyoto University Graduate School of Medicine and College of Public Health Sciences, Chulalongkorn University in 2015-2017. His research projects are "Occupational exposures and health hazards in Para rubber wood sawmills in Trang Province, Thailand" and "Occupational noise exposure and risk perceptions among Para rubber wood workers in Trang sawmills,Thailand". He also got fellowship training on A Genetic Risk Assessment of Environmental Risk Factors and Familial Aggregation of Disease: Applications to the Study of Genetic Epidemiology. Mr.Thepaksorn was supported by a scholarship from the ASEAN University Network (AUN) – Kyoto University (KU) Student Mobility Program toward Human Security Development.