A STUDY OF PREVALENCE RATE AND FACTORS ASSOCIATED WITH SYMPTOMS AND ABNORMAL PULMONARY FUNCTION AMONG FURNITURE WORKERS

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A STUDY OF PREVALENCE RATE AND FACTORS ASSOCIATED WITH SYMPTOMS AND ABNORMAL PULMONARY FUNCTION AMONG FURNITURE WORKERS

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ABSTRACT

This study was a cross sectional study conducted among 120 furniture workers. The objectives were to survey the prevalence rate and factors associated with symptoms and abnormal pulmonary functions. Subjects were divided into 5 groups by type of work such as the cutting or part section, sanding, assembly, coating and finishing, and packing section. Air samples of wood dust were collected for inhalable dust and respirable dust. Vapors were collected only in coating and finishing section. The personal and area sampling technique were used to collect air samples in accordance with the NIOSH methods.

Results of air sampling analysis, showed that the highest average concentration of respirable dust was 0.59 mg/m^3 in sanding section. Results of vapors also showed the highest average concentration of toluene was 9.02 ppm in area and 10.07 ppm in personal sampling. Cutting section had the highest prevalence rate of symptoms (94.28%) of which headache and itching were the most common. Results of abnormal pulmonary functions, revealed that 4 workers had obstructive type (10%), 36 restrictive type (90%) and the prevalence of abnormal pulmonary functions was highest in the cutting section.

Results of factors associated with symptoms were type of work ($p=0.011$) and past respiratory illness ($p=0.010$). A symptom that was associated with respiratory illness was allergy, allergy was associated with cough ($p=0.021$), cough and sputum ($p=0.004$), wheeze ($p=0.001$), nose irritation ($p<0.001$), blocked nose ($p=0.001$), eye irritation ($p=0.035$) and skin irritation ($p=0.002$). Factors associated with abnormal pulmonary function were duration of work ($p=0.047$), concentration of xylene ($p=0.028$) and past respiratory illness ($p=0.042$). A symptom of respiratory illness that was associated with abnormal pulmonary function was allergy ($p=0.015$).

KEYWORDS : WOOD DUST / SOLVENT / PULMONART FUNCTION TEST / WORK RELATED SYMPTOMS / FURNITURE WORKERS

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การศึกษาความชุกและปัจจัยที่สัมพันธ์กับอาการและความผิดปกติของสมรรถภาพปอดในคนงานผลิตเฟอร์นิเจอร์ (A STUDY OF PREVALENCE RATE AND FACTORS ASSOCIATED WITH SYMPTOMS AND ABNORMAL PULMONARY FUNCTION AMONG FURNITURE WORKERS)

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บทคัดย่อ

การศึกษาครั้งนี้เป็นการศึกษาภาคตัดขวาง ในกลุ่มพนักงานผลิตเฟอร์นิเจอร์ จำนวน 120 คน วัตถุประสงค์ของการศึกษาเพื่อสำรวจความชุกและปัจจัยที่สัมพันธ์กับอาการและความผิดปกติของสมรรถภาพปอด โดยแบ่งกลุ่มพนักงานเป็น 5 กลุ่มตามลักษณะงาน ได้แก่ แผนกชิ้นงาน แผนกขัด แผนกประกอบ แผนกพ่นสี และแผนกบรรจุ การเก็บตัวอย่างอนุภาคของฝุ่นไม้จะทำการเก็บตัวอย่างทั้งชนิดฝุ่นรวม (Inhalable dust) และฝุ่นขนาดเล็กที่สามารถเข้าสู่ทางเดินหายใจได้ (Respirable dust) การเก็บตัวอย่างไอระเหยสารเคมี ทำการเก็บเฉพาะในแผนกพ่นสีเท่านั้น การเก็บตัวอย่างอนุภาคฝุ่นไม้และไอระเหยสารเคมี ทำการเก็บตัวอย่างทั้งในแบบพื้นที่และที่ตัวบุคคล ซึ่งปฏิบัติตามวิธีการและมาตรฐานของ NIOSH

ผลการวิเคราะห์ตัวอย่างอากาศ พบว่า ค่าเฉลี่ยความเข้มข้นของฝุ่นขนาดเล็กที่สามารถเข้าสู่ทางเดินหายใจได้ มีปริมาณสูงสุดในแผนกขัด คือ 0.59 มิลลิกรัม/ลูกบาศก์เมตร ส่วนไอระเหยสารเคมี พบว่า โทลูอีนมีปริมาณสูงสุด ทั้งในบริเวณพื้นที่การทำงานและที่ตัวบุคคลคือ 9.02 ppm และ 10.07 ppm ตามลำดับ ผลการศึกษาความชุกของอาการ พบว่า แผนกที่มีอาการมากที่สุดคือแผนกชิ้นงาน (ร้อยละ 94.28) อาการที่พบมากที่สุดคือ ปวดศีรษะและผื่นคันตามผิวหนัง ผลการศึกษาความผิดปกติของสมรรถภาพปอด พบว่า พนักงานมีลักษณะความผิดปกติชนิด Obstructive 4 ราย (ร้อยละ 10) Restrictive 36 ราย (ร้อยละ 90) ซึ่งพบในแผนกชิ้นงานมากที่สุด

ผลการศึกษาความสัมพันธ์ของปัจจัยต่าง ๆ กับอาการ พบว่า ลักษณะงานและการเจ็บป่วยของทางเดินหายใจในอดีตมีความสัมพันธ์กับอาการต่าง ๆ ($p = 0.011$ และ $p = 0.010$ ตามลำดับ) การเจ็บป่วยของทางเดินหายใจในอดีตที่มีความสัมพันธ์กับอาการคือ โรคภูมิแพ้ โดยมีความสัมพันธ์กับอาการไอ ($p=0.021$), ไอและมีเสมหะ ($p=0.004$), หายใจมีเสียงหวีด ($p=0.001$), ระคายเคืองจมูก ($p<0.001$), คัดจมูก ($p=0.001$), ระคายเคืองตา ($p=0.035$) และระคายเคืองผิวหนัง ($p=0.002$) ส่วนปัจจัยที่สัมพันธ์กับความผิดปกติของสมรรถภาพปอด คือ ระยะเวลาการทำงาน ($p=0.047$), ปริมาณความเข้มข้นของไซลีน ($p=0.028$) และการเจ็บป่วยของทางเดินหายใจในอดีต ($p=0.042$) ซึ่งโรคที่สัมพันธ์กับความผิดปกติของสมรรถภาพปอด คือ โรคภูมิแพ้ ($p=0.015$)

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CHAPTER I
INTRODUCTION

1.1 Background and Rational (1,2,3,4)

Many industrial in Thailand used materials from woods throughout country. Wood products are significantly important export of Thailand, especially wood furnitures and decorations, which export into Asian countries, Europe and United States. In many years, wood furniture industry of Thailand have more rapidly develop in qualities and designs. When the wood furniture more favored than any furniture, so the production is increased which leaded to increase more employment.

Furniture workers may be exposed to potential hazards that have harmful to health effects such as wood dust, noise, accidents, vibration, chemical and ergonomics. Furniture workers may be exposed to wood dust during the milling process, shaped, planed and sanded. Although many processes are used by machines but in many steps such as join or assembly need to do by hand. Wood dust from these processes may be small size to be inhaled into the lung.

Effects to respiratory system from exposure to wood dust include decreased lung capacity, allergic reaction in the lung as hypersensitivity pneumonitis and occupation asthma. Many studies have shown that exposure to wood dust can cause many health problems, such as irritate to the eyes, nose and throat. Wood dust contaminate with the skin can also cause contact dermatitis. In addition, the International Agency for Research on Cancer (IARC) has classified wood dust as carcinogenic to human. In 1965, there is large number of furniture workers and other workers exposed to wood dust in England developed a nasal cancer (adenocarcinoma) which is rare cancer.

There are many chemicals from painting or finishing processes such as solvents that include varnishes, painting medium, lacquer, thinners, shellac and vanish removers. These solvents contain toxic chemicals such as benzene (benzol), toluene, xylene or methyl alcohol (methanol). Toxicity of solvents can cause dried skin, blistering and cracking ; irritated to respiratory system cause breathlessness ; compress the central nervous system which can cause acute effects such as dizzy or headaches and chronic effects as pallid ; tired and anaemia. Furthermore, there is a confirm benzene that can cause leukemia.

Wood dust and solvents have more health problems to furniture workers, especially, effect to the eyes, nose, skin and respiratory system. This study has surveyed work related symptoms, pulmonary function and factors associated with these symptoms of furniture workers. The studied results will be used to prevention and control risk factors. The studied results can be used also for disease surveillance of furniture workers.

1.2 Objectives

1.2.1 General Objectives

To survey health conditions and health effects of workers who had exposed to wood dust and chemicals in furniture factory.

1.2.2 Specific Objectives

1. To study the prevalence rate of symptoms and pulmonary function among furniture factory workers.
2. To study factors associated with symptoms and pulmonary function among furniture factory workers.

1.3 Research Hypothesis

1.3.1 Concentration of wood dust and chemical vapor associated with symptoms and abnormal pulmonary function test among furniture workers.

1.3.2 The workers who worked in each processes associated with and abnormal pulmonary function test.

1.3.3 The workers who work more than 2 years will be have symptoms and abnormal pulmonary function test more than the workers who work less than 2 years.

1.3.4 Extraneous variables associated with symptoms and abnormal pulmonary function test among furniture workers.

1.4 Research Variables

1.4.1 Independence variables

1. Concentration of wood dust to consist of
    - 1.1 Inhalable dust
    - 1.2 Respirable dust
2. Concentration of chemical vapors to consist of
    - 2.1 benzene
    - 2.2 toluene
    - 2.3 xylene
3. Type of work to divided 5 section
    - 3.1 Part section
    - 3.2 Sanding section
    - 3.3 Assembly section
    - 3.4 Coating and finishing section
    - 3.5 Packing section
4. Duration of work

1.4.2 Dependence variables

1. Symptoms
2. Abnormal pulmonary function test

1.4.3 Extraneous variables

1. Age
2. Sex
3. Body Mass Index (BMI)
4. Smoking
5. Wearing personal protective equipment
6. Past respiratory illness

1.5 Scope of the study

This thesis study the prevalence rate and factors associated with symptoms and abnormal pulmonary function test among furniture workers. Wood dust and vapor chemicals, which consist of benzene, toluene and xylene. Type of work divided by the following :

1.5.1 Part section : This process consist of sawed and other machined into the shape of the final part such as table leg. The wood stock moves pass to various machines such as rough planer, cutoff saw, rip saw or finish planer.

1.5.2 Sanding section : The part finished will be assembling to furnitures but those wood parts are not smooth and splinters. Thus, wood parts must to sanding to ensure a smooth surface and no splinters.

1.5.3 Assembly section : Furniture made of irregularly shaped components is usually assembled and finished. The assembly process usually involved the use of adhesives (both synthetic and natural) in conjunction with other joining method, such as nailing, followed by the application of veneers.

1.5.4 Coating and finishing section : These processes are applied after the product is assembled. Normally, coating methods include fillers, stains, glazes, sealers, lacquers, paints and vanishes. The coating may be applied by brush, pad, dip, roller or flow-coating machine.

1.5.5 Packing section : The finished furnitures will be packed in a carton through the sized of products for shipping to consumers.

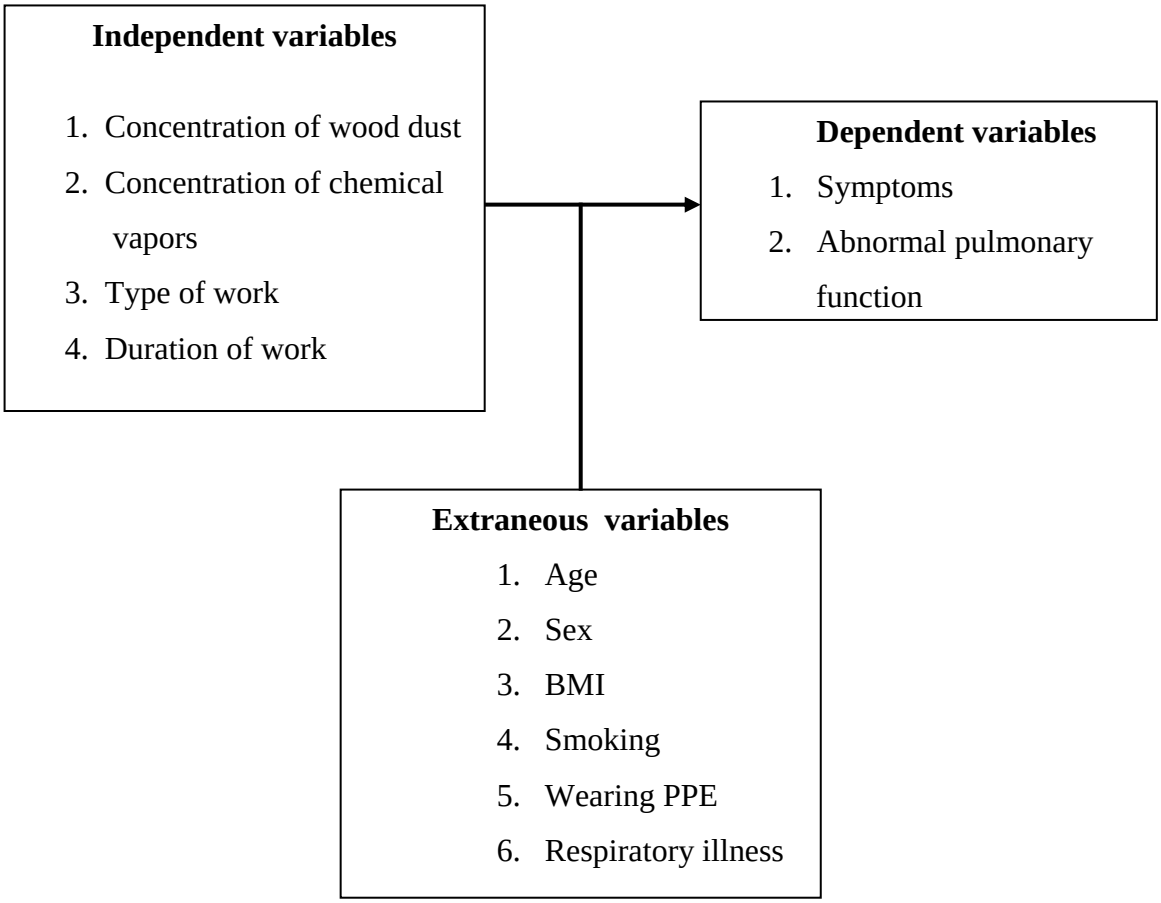
1.6 Agreements of this study

1.6.1 Population were workers in furniture factory that worked only in production line and divided workers.

1.6.2 The interpretation of the result from pulmonary function test will be using the reference spirometric values for healthy lifetime nonsmokers in Thailand (Siriraj Hospital).

1.6.3 Exclustion criteria of population were the workers who have past illness history such as tuberculosis and asthma.

1.7 Conceptual framework



1.8 Definition of keywords

1.8.1 Prevalence rate is computed as the number of cases divided by the number of workers in the study.

1.8.2 Symptoms are indicating disorder of bodily. Symptoms are the health effect that occurred from exposure to wood dust and solvent in furniture workers. Symptoms include respiratory symptoms such as cough, sputum, dyspnea, wheezing and breathlessness, irritation of the eyes, nose and skin.

1.8.3 Dusts are solid aerosols caused by mechanical fragment of rocks, minerals and other materials from blasting, crushing, grinding, milling, polishing and sawing. In this study divided 2 categories i.e. :

1. Inhalable dust are particulates through the upper respiratory tract and diameter less than 100 micron.

2. Respirable dust are particulates through the alveolar sac and diameter less than 10 micron. These particulates will be chronic effects when collected in respiratory tract.

1.8.4 Vapors are gaseous, molecularly dispersed form of substances which normally exist in the solid or liquid state. In this study had 3 categories as benzene , toluene and xylene.

1.8.5 Solvents are chemicals in liquid state that can to dissolve or dilute other chemicals such as grease , oil , ink , paint , plastic and resin. Generally, solvents have easily to evaporate , specific fragrance and highly flammable.

1.8.6 Pulmonary function test are measure the rate at which gas flow out of the lungs by Vitalograph Spirometer. Each measurements provided data on the patency of the airways , severity of the airways impairment and include the following.

1. Forced Vital Capacity (FVC) : the volume of gas that can be exhaled as forcefully and rapidly as possible after a maximal inspiration.

2. Forced Expiratory Volume , Timed (FEV_T) : The maximum volume of gas that can be exhaled over a specific period. This measurement is obtained from an FVC measurement. Commonly, used time period are 0.5 , 1.0 , 2.0 and 3.0 seconds but $FEV_{1.0}$ is the most commonly measurement thus in this study used FEV_1.

3. Forced Expiratory Volume in 1 Second/Forced Vital Capacity Ratio (FEV_1/FVC) : The compare volume of FEV_1 and FVC in percentage that can be calculated from (FEV_1 / FVC) * 100. The FEV_1/FVC ratio is used as a broad indicator of airway obstruction.

4. Forced Expiratory Flow $_{25-75\%}$: The $FEF_{25-75\%}$ is the average flow Rate over the middle half of expiration. Formerly called the maximal mid-expiratory flow rate (MMEF). This expiratory maneuver is commonly used to assess the status of medium sized airways in obstructive lung disease.

1.8.7 Type of abnormal pulmonary function : Spirometry can be interpreted from vitalogram that have 3 type of abnormal pulmonary function as :

1. Obstruction type : The primary abnormality detected by spirometry is airways obstruction. Obstructive lung diseases such as emphysema or chronic bronchitis. Included this group of disorders are chronic obstructive disease of the airways and the hallmark of this pattern is a reduction in FEV_1/FVC (FEV_1/FVC <

70% in large airway obstructive disease) and in Forced Expiratory Flow $_{25\text{-}75\%}$ ($FEF_{25\text{-}75\%}$ < 57% in small airway obstructive case).

2. Restrictive type : Resulting from pathogenesis in lungs which effect to reduced total lung capacities such as fibrosis, inflammation or pneumoconiosis. The degree of restriction is quantified by the reduction in FVC compared with the predicted value.

3. Combined type : Resulting from pathogenesis that reduce lung volume, lung capacities and that also include airway narrowing. This combined type is characterize by low FEV_1% (obstructive type) and small lung volume(restrictive type).

1.8.8 Cramer test : Perform Cramer-test for two-sample-problem. Both univariate and multivariate data is possible. The function phi (ϕ) is the kernel function mentioned in the Parameters section. Character-string giving the name of kernel function, default is “phi Cramer” The functions needs to be able to deal with matrix arguments. Kernel function need to be defined on the positive real line with value 0 at 0 and have a nonconstant completely monotone first derivative.

CHAPTER II
LITERATURE REVIEW

2.1 Furniture Manufacturing (1,5,6,7)

Furniture manufacturing is as old as civilization it self. Much of what is known about early furniture revealed in the artwork preserved from the ancient cultures of Asia, Africa and the Middle east. Presently, modern furniture is manufactured from many of materials, including metals, polymers and a variety of woods. Two types of wood are harvested for furniture manufacturing, softwoods and hardwoods. Softwoods are derived from evergreen such as pine and birch. Hardwoods are derived from deciduous trees such as beech, maple, oak and rosewood.

2.1.1 Kind of furniture that divide from materials

In Thailand, furniture manufactures can be divided through the material. Figure 2-1 showed the king of furnitures in market place.

1. Wooden furniture : Wooden furniture have a good qualities which usually used teak wood in manufactured due to teak wood have beautiful grains and durable. Presently, teak wood more expensive and difficultly find than other wood. The plywood is used in wooden furniture instead of teak wood.

2. Fabric furniture : The fabric furniture are upholstering application such as an armchair or sofa that have beautiful colors and designs.

3. Leather furniture : The leather furniture have gentle and durable, out of these furniture must used leather coating the sponge for gentle and add spring for the flexibility of furniture.

4. Metal furniture : Metal furniture must have strongly and durable for often using such as cupboard or sideboard.

5. Ratten furniture : Ratten furniture have the ratten in major composition which using the ratten to bind or weave into the beautiful designs and delicate shape products.

2.1.2 Kind of wooden furniture in Thailand

In Thailand, wooden furniture manufactured have 2 categories as

1. Stable or Finish Furniture : These furniture are ready made that can using promptly. Most of products are responding for demand of the customers in domestic.

2. Knock-Down Furniture : These furniture can remove parts and carry out into the shape of products. The most of these furniture will be produced for export because to save area and cost in shipping. But, nowadays the customers in domestic increase using knock-down furniture due to easily to move or save area for impose.

Figure 2-1 The kind of furnitures

2.1.3 Furniture processes

The manufacture of wooden furniture involves three steps : milling, assembly, and finishing. The woodworking industry produces furniture and a variety of building materials, ranging from plywood floors to shingles. Figure 2-2 showed diagram for wood furniture manufacturing, which covers nearly the whole processes.

Drying : Some furniture manufacturing may purchase dried lumber, but others perform drying onsite using a kiln-dry or oven, fired by boiler.

Machining : Once the lumber is dried, it is sawed and other machined into the shape of the final furniture part such as table leg. In normal plant the wood stock moved from rough planer, to cutoff saw, to rip saw, to finish planer, to table saw, to band saw, to shaper, to drill and mortiser, to carver and then to sanders. Wood can be hand carved with a variety of hand tools, including chisels, rasps, files, hand saw, sandpaper and the like.

Assembly : Wood furniture can either be finished and then assembled. Furniture made of irregularly shaped components is usually assembled and then finished. The assembly process usually involves the use of adhesives (either synthetic and natural) in conjunction with other joining method followed by the application of veneers. After assembly, the furniture part is checked to ensure a smooth surface for finishing.

Surface finishing : Surface finishing may involve the use of variety coating. These coatings are applied after the product is assembled or in a flat line operation before assembly. Coatings could normally include fillers, strains, glazes, sealers, lacquers, paints, varnishes and other finishes. The coatings may be applied by spray, brush, pad, dip, roller or flow coating machine. Coating can be either solvent based or water based, Paints may contain a wide variety of pigment, depending on a desired color.

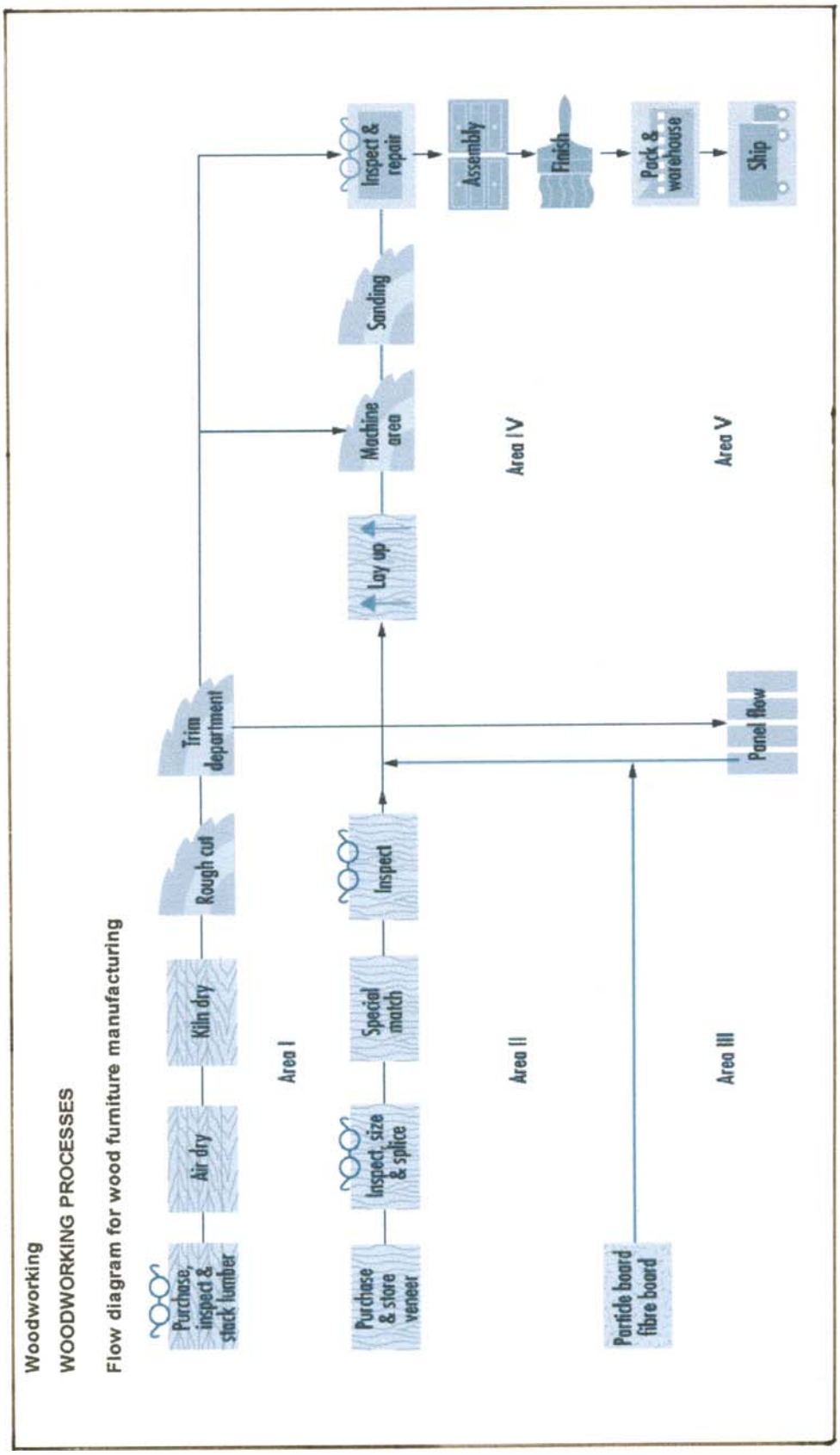


Figure 2-2 Flow diagram for wood furniture manufacturing (ILO ; Encyclopaedia of Occupational Health and Safety,1998)

2.2 Potentially hazardous exposure in furniture manufacturing (8,9)

The hazards of furniture manufacturing include physical hazards, related to the use of machinery or tools, and toxic hazards related to the base materials, additives or treatment. Furniture workers may be exposed to a wide range of potentially hazardous materials at each step in the manufacturing processes. Prior milling, chemicals may be added to serve as pesticides and to strengthen the wood. During the milling process, the wood is shaped, planed and sanded. These may lead to the generation of particulates of wood dust, some of which may be small enough to be inhaled deeply into the lung. Next, various chemicals may be used to finish the furniture during or after assembly. If wood was previously finished or painted, it may necessary to strip or sand the old materials in preparation for retreatment. In these processes may lead to various chemicals exposures. Table 2-1 showed the potential exposures for furniture manufacturers.

Table 2-1 Potential exposures for furniture manufacturers

Toxic exposure	Source	Route of exposure	Potential effects
Pentachlorophenol	Preservative/pesticide	Dermal/inhalation	Irritation, uncoupling of oxidative phosphorylation
Wood dust	Milling/sanding	Dermal/inhalation	Irritation, contact allergy, asthma, hypersensitivity pneumonitis, nasal adenocarcinoma
Epoxy resins	Glues and adhesives	Dermal/inhalation	Irritation, allergy
Solvents	Finishing products	Dermal/inhalation	Irritation, CNS depresstion
Glycol and glycol ethers	Finishing products	Dermal/inhalation (if heated)	Irritation, adverse reproductive effects

2.3 Wood dust (10)

Wood dust is derived from trees and is composed of many substances including cellulose, polyoses, lignins, fatty acids, terpenes, tannins, carbohydrates, alkaloids, proteins and various inorganics. Trees, botanically, are divided into gymnosperms and angiosperms. Gymnosperms or conifers are described as softwoods and comprise two-thirds of all wood products and wood dusts. Angiosperms or the deciduous hardwoods such as beech and oaks, account for the balance of wood products that are produced. Wood dust varies in particle size from less than a micron to very large particles in the 30 – 40 micron range. Most wood dust particulates have a mean diameter of greater than 5 microns, but a sizable percentage of wood dust particulates are less than 5 microns and extend down to less than 1 micron in size. Any particles less than 2.5 microns is classifield as an RSP (respirable suspended particle) and the health hazards with these small particles is great. RSP's are particles that are small enough to evade mucosal capture by the protective cilia and mucosa of the human upper respiratory system and invade the deeper reaches of the lungs with serious health consequences. In fact, any particles of 5-10 microns or less is considered a definite inhalation hazard because of the inability of the human body to filter effectively these particles from the lungs. The other significant problem associated with wood dusts in general is the presence of additive chemicals during manufacture and production of wood and wood products. These additives exacerbate the exposure potentials of wood dusts by adding their own potentials to the wood dust particulates. These chemicals include preservatives, solvents and glues used in wood manufacture.

2.4 Health effects from exposure to wood dust (2,11,12,13,14,15,16,17,18,19,20)

The health effects of exposure to wood dust are due to chemicals in the wood or chemical substances in the wood created by bacteria, fungi, or moulds. Coughing or sneezing are caused by the dust itself. Dermatitis and asthma may be due to sensitivities to chemicals found in the wood. Toxic woods contain chemicals that may be absorbed into the body through the skin, lungs, or digestive system and cause effects in other parts of the body. Health effects can include headaches, giddiness, weight loss, breathlessness, cramps and irregular heart beat. Toxic woods are typically

hardwoods such as yew, teak, oleander, laburnum and mansonia. Table 2-2 summarizes the health effects from exposures to various type of wood.

Table 2-2 Health Effects Reported with Various Types of Woods

Wood Type	Use	Health Effects
Alder (common,black,red)	Toys, general turnery, broom and brush backs	Dermatitis associated with black alder, decrease in lung function
Aspen	Furniture, strandboard, pulp and paper	No health effects reported
Beech	Furniture, bobbins, brush backs, handles, domestic woodware, flooring, plywood manufacture	Dermatitis (wood cutters' disease), rhinitis, asthma, nasal cancer
Cedar, Western Red	Furniture, decorative objects, pulp and paper	Asthma, allergic contact dermatitis, sensitizer, decrease in lung function, eye irritation and conjunctivitis, rhinitis
Douglas Fir	Interior and exterior construction, flooring, boats, veneer, furniture	Contact eczema , decrease in the lung capacity
Mahogany	Furniture, cabinetry, boats	Dermatitis, sensitizer
Maple	Furniture, interior construction, cabinets	Rhinitis, asthma, Maple bark Strippers' Disease
Oak	Furniture, decorative veneer	Nasal cancer
Pine	Interior and exterior construction, pulp and paper	Skin irritation, contact dermatitis, rhinitis, asthma
Rosewood	Decorative veneer, furniture, cabinets instrument	Eczema , allergic contact dermatitis
Spruce	Interior and exterior construction, furniture, pulp and paper	Skin irritation, Wood pulp Workers' Disease , decrease in lung function
Teak	Ship building, interior fittings and moulding, furniture,flooring	Toxic, dermatitis , sensitizer

2.4.1 Irritation of the eyes, nose and throat

Many hardwoods and softwoods contain chemicals that can irritate the eyes, nose and throat, causing shortness of breath, dryness and soreness of the throat, sneezing, tearing and conjunctivitis (inflammation of the mucous membranes of the eye). Wood dust usually collects in the nose, causing sneezing and runny nose (rhinitis). Numerous mucosal and non-allergic respiratory effects have been reported in worker exposed to wood dust. These symptoms are observed even when exposures are relatively low such as 2-4 mg/m^3. Other observed effects include nosebleeds, an impaired sense of smell, and complete nasal blockage **(Ahman et al., (11)).**

2.4.2 Skin

The main effect is irritation. This can be caused by skin contact with wood, dust, bark, sap, or even lichens growing on the bark. Irritation can in some species of wood, lead to nettle rashes or irritant dermatitis. These effects tend to appear on forearm, backs of the hands, the face (particularly eyelids), neck, scalp and the genitals. On average they take 15 days to develop. Symptoms usually only persist as long as the affected skin site remains in contact with the source of irritation. Symptoms subside when contact with the irritant is removed.

However, to get an allergic-type rash, first must be allergy-prone to one of more of the chemicals found in certain woods called sensitizers. And, it may take repeated contact for the body to develop a great enough allergy for it to react (the so-called “latency period” of as little as five days and up 6-8 months). If do eventually get reaction, the rash will look like poison ivy red with small, individual, itchy bumps.

Sensitization dermatitis is more problem and is usually caused by skin exposure to fine wood dust of certain species. This is also referred to as allergic contact dermatitis and results in similar skin effects to those produced by skin irritants Once sensitized the body sets up an allergic reaction, and the skin may react severely if subsequently exposed to very small amounts of the wood dust. Sensitizer woods include cypress, balsam fir, beech, birch, elm, greenheart, mahogany, maple, western red cedar and teak.

2.4.3 Respiratory system effects

Respiratory system effects due to wood dust exposure include decreased lung capacity and allergic reaction. Two types of allergic reactions can take place in the

lung : hypersensitivity pneumonitis (inflammation of the walls of the air sacs and small airways) and occupational asthma.

Decreased lung capacity is caused by mechanical or chemical irritation of lung tissue by the dust. This irritation causes the airways to narrow, reducing the volume of air taken into the lungs and producing breathlessness. It usually takes a long time to see a reduction in lung capacity. Exposure in a furniture factory were shown to be accompanied by decreases in both forced expiratory volume in 1 second (FEV_1) and forced vital capacity (FVC), adjusted for age, height and smoking. There were accompanied by significant increases in shortness of breath and wheeze with chest tightness and the occurrence of bronchitis and asthma. Hessel looked at a group of sawmill workers in Alberta who were processing pine and spruce for a least three years **(Hessel et al.,(14)).** This study found that workers who smoked and were exposed to wood dust were more greatly affected than workers who did not smoke. This condition can worsen during the work week and improve during a worker's days off. Over the long term, some workers may develop a permanent decrease in lung function (chronic obstructive lung disease).

Asthma is of particular concern. Most wood dusts can irritate the respiratory tract provoking asthma attacks in workers. Some wood dust can cause asthma as a specific allergic reaction. Once sensitized, the body will quickly react if subsequently exposed, even to tiny traces of dust. Unlike irritation, where workers can continue to work with dust once it is controlled to below the level at which irritation occurs, workers who become sensitized will not normally be able to continue working with the dust, no matter how low the exposure. One of the most studied woods with respect to wood dust related asthma is western red cedar. It has been estimated that at least five percent of forest industry workers in British Columbia exposed to cedar dust are allergic **(BC Research, (15)).** The first symptoms of asthma due to exposure to western red cedar usually begin late at night and resemble a cold (eye and nose irritation, stuffiness, runny nose, dry cough and tightness in the chest). Eye and nose irritation can slowly improve, leaving wheezing and coughing as the only symptoms. With prolonged exposure, wheezing and coughing happen during the day as well. Plicatic acid, for example, found naturally in western red cedar, is responsible for asthma reactions and allergic effects associated with the wood **(Chan-Young, (16)).** In

some cases, asthma attacks can start after only a few weeks of contact with cedar dust. Research indicates that occupational exposure to wood dust should kept below 2 mg/m^3 to prevent allergic effects and respiratory disease **(Demers et al., (17)).**

Hypersensitivity pneumonitis appears to be triggered when small particles penetrate deeply into the lungs where they trigger and allergic response. Particles that are known or suspected to cause this condition include moulds, bacteria and the fine dust from some tropical hardwood **(BC Research, (15)).** The initial effects can develop within hours or after several days following exposure and are often confused with flu and cold symptoms (headache, chills, sweating, nausea, breathlessness and other fever symptoms). Tightness of the chest and breathlessness often occur and can be severe. With exposure over a long period of time, this condition can worsen, causing permanent damage to the lungs. The walls of the air sacs thicken and stiffen, making breathing difficult. Some diseases that have been classified as hypersensitivity pneumonitis include maple bark stripper's disease, seqooiosis (from breathing redwood dust containing mould particles), wood trimmer's disease and wood-pulp worker's disease. These diseases are caused by mould growing on the wood rather than wood dust itself. The mould spores become airborne when wood chips are moved, lumber is trimmed and bark is stripped.

2.4.4 Cancer

The International Agency for Research on Cancer (IARC) has classified wood dusts as carcinogenic to humans. A study completed in 1965 observed that a large number of furniture workers and other workers exposed to wood dust in England developed a rare of nasal cancer (adenocarcinoma). An usually high incidence of nasal cancer has been described among woodworkers in Australia, Canada, Denmark, Finland, France, Italy, Natherland, United Kingdom and United States. Many addition studies have shown that workers employed in logging, sawmills, furniture and cabinet making, and carpentry are at an increased risk of developing nasal cancer **(Demers et al., (19)).** The highest risks appear to be to those workers exposed to hardwood dusts, most commonly beech and oak. Many of studies looked at workers exposed in the 1940s and 1950s (the cancer can take more than 20 years to develop), and most of the exposure levels were much higher than those seen in today's industry. Most of the studies looked at workers who were exposed to unspecified types or mixtures of wood

dust. Some research have suggested that limiting exposure to wood dust to below 5 mg/m^3 (8 hour exposure) may lower the risk of cancer to workers **(Blot et al., (20)).** Cancer from wood dust usually begins with bleeding from the nose, sinusitis-type pain, or swelling of the face. It is a very serious cancer and needs fast, specialist treatment to be cured. Delay in treatment can be fatal. Any working with wood who gets any symptoms from the nose or in the face must see a doctor immediately and tell the doctor about they work with wood.

2.5 Evaluate wood dust concentration (21,22)

Several organizations have set standards or given recommendation for wood dust exposure. In Table 2-3 included OSHA, NIOSH, ACGIH and the International Agency for Research on Cancer (IARC) recommendation.

Table 2-3 Standard or recommendation for wood dust exposure

Agency/Substance	Standard Level
OSHA PEL	15 mg/m^3 as total dust
NIOSH REL	1 mg/m^3 as total dust
ACGIH TLVs (Current-2000) : A1	
Certain hardwoods such as beech and oak	TWA 5 mg/m^3
Softwood	TWA 5 mg/m^3 , STEL 10 mg/m^3
ACGIH TLVs (Proposed-2000)	
Hardwoods and Softwoods (nonallergenic) : A4	TWA 5 mg/m^3
Beech and Oak : SEN ; A1	TWA 5 mg/m^3
Birch,Mahogany, Teak, Walnut : SEN ; A2	TWA 5 mg/m^3
Softwoods and other Hardwoods (allergenic) : SEN ; A4	TWA 5 mg/m^3
Western red cedar : SEN ; A4	TWA 0.5 mg/m^3
Ministry of Interior, Thailand	
Respirable dust ; sized less than 10 microns	TWA 5 mg/m^3
Total dust	TWA 15 mg/m^3

2.6 Chemicals exposure (7,23,24,25)

Wood often contains exogenous chemicals applied in the course of its processing. These include adhesives, solvents, resin binders, insecticides and fungicides, waterproofing compound, paint and pigments, lacquers and varnishes. Many of these are volatile and may be emitted when wood treated, heat or incinerated ; they are also conveyed as elements in wood dust. The most important of these include toluene, methanol, xylene, methyl ethyl ketone, *n*-butyl alcohol, 1,1,1-trichlorethane and dichloromethane **(EPA**, **(25)).**

Under certain conditions, systemic absorption of solvents can be expected to take place via the lungs because of the high vapor pressure of most organic solvents and the vast capillary networks in the lungs. Dermal absorption is the other potential route for solvent absorption. Both acute and chronic toxicity may be associated with solvent exposures. In these study, furniture factory used solvent in production line which contained major chemicals are benzene, toluene and xylene. Thus, the following are presented characteristics of benzene, toluene and xylene.

2.6.1 Benzene (26,27)

Benzene is a colorless liquid with a sweet odor. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable and is form both natural processes and human activities. Benzene is widely used in the United States ; it ranks in the top 20 chemicals for production volume. Some industries use benzene to make other chemicals which are used to make plastics, resin, and nylon and synthetic fibers. Benzene is also used to make some type of rubbers, lubricants, dyes, detergents, drugs and pesticides. Natural sources of benzene include volcanoes and forest fires. Benzene is also a natural part of crude oil, gasoline and cigarette smoke. Benzene is well absorbed in human and experimental animals after oral and inhalation exposure, but in humans dermal absorption is poor. Approximately 50% absorption occurs in human during continuous exposures to 163-326 mg/m^3 for several hours. After a 4 hours exposure to 170-202 mg/m^3 , retention in the human body was approximately 30%, with 16% of the retained does having been excreted as unchanged benzene in expired air.

Effects on humans : Acute inhalation and oral exposures of humans to high concentrations of benzene have resulted in central nervous system depression and

death. The most noted effects resulting from long term exposure to lower levels of benzene are hemato-toxicity, immunotoxicity and neoplasia. Breathing very high levels of benzene can result in death, while high levels can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion and unconsciousness. Eating or drinking foods containing high levels of benzene can cause vomiting, irritation of stomach, dizziness, sleepiness, convulsion, rapid heart rate and death.

The major effect of benzene from long-term (365 days or longer) exposure is on the hematologic system. Benzene causes harmful effects on the bone marrow and can cause a decrease in red blood cells leading anemia. It can also cause excessive bleeding and can affect the immune system, increasing the chance of infection. Women may retain a greater percentage of inhaled benzene than men. Some women who breathed high levels of benzene for many months had irregular menstrual periods and a decrease in the size of their ovaries. It is not known whether benzene exposure affects the developing fetus in pregnant women or fertility in men.

Carcinogenic effects : The Department of Health and Human Services (DHHS) has determined that benzene is a known human carcinogen. Long-term exposure to high levels of benzene in the air can cause leukemia, cancer of the blood-forming organs.

2.6.2 Toluene (7,28,29,30)

Toluene is a clear, colorless liquid with a distinctive smell. Toluene occurs naturally in crude oil and in the tolu tree. It is also produced in the process of making gasoline and other fuels from crude oil and making coke from coal. Toluene is use in making paints, paint thinners, fingernail polish, lacquers, adhesives, rubber and leather tanning processes. Toluene is absorbed into the body mainly through the respiratory tract , to a lesser extent, through the skin. It penetrates the alveolar barrier, the blood per air mixture being in the proportion of 11.2 to 15.6 at 37 degree of Celsius and then spreads through the different tissues in amounts depending on their perfusion and solubility characteristics respectively.

Effects on humans : Toluene has an acute toxicity somewhat more intense than benzene. At a concentration of about 200 or 240 ppm and it gives rise after 3 to 7 hours. Acute exposure from breathing high concentration may be harmful. Mist or vapor can irritate the throat and lungs. Breathing this material may cause central

nervous system depression with symptoms including nausea, headache, dizziness, fatigue, drowsiness or unconsciousness. Eye contact with toluene can cause eye irritation with tearing, redness or stinging or burning feeling, Further, it can cause swelling of the eyes with blurred vision. Effects may become more severe with repeated or prolong contact. If skin contact with toluene may cause mild skin irritation with redness and/or an itching or burning feeling. Effects may become more severe with repeated or prolonged contact. It is likely that this material is able to pass into the body through the skin and may cause similar effects as from breathing or swallowing. Swallowing this material may cause stomach or intestinal upset with pain, nausea or diarrhea. This material can get into the lungs during swallowing or vomiting. Small amounts in the lungs can cause lung damage, possibly leading to chronic lung dysfunction or death.

Chronic health effects : The chronic health effects can occur at some time after exposure to toluene and can last for months or years. The symptoms of chronic toxicity are those habitually encountered with exposure to the commonly used solvents include irritation of the mucous membrane, euphoria, headaches, vertigo, nausea, loss of appetite and alcohol intolerance. These symptoms generally appear at the end of the day, are more severe at the end of week and become less or disappear during the weekend or on holiday. Aspiration into the lungs may cause pneumatocele (lung cavity) formation and chronic lung dysfunction. Prolonged or repeated overexposure to toluene has been associated with reproductive effects in experimental animals and in long-term chemical abuse situation and toluene may damage the developing fetus. Long-term overexposure to toluene has been associated with impaired color vision. Prolonged contact can cause drying, cracking, itching and a skin rash, repeated toluene exposure may cause liver, kidney and brain damage.

Carcinogenic effects : Studies in human and animals generally indicate that toluene does not cause cancer. This product is not know to contain any components at concentrations above 0.1% which are considered carcinogenic by OSHA, IARC or NTP and the EPA has determined that the carcinogenicity of toluene can not be classified too.

2.6.3 Xylene (7,31,32,33,34)

Xylene is a colorless, sweet-smelling liquid that catches on fire easily. It occurs naturally in petroleum and coal tar and is formed during forest fires. Human can smell xylene in air at 0.08-3.7 parts of xylene per million parts of air (ppm) and begin to taste it in water at 0.53-1.8 ppm. Chemical industries produce xylene from petroleum. It's one of the top 30 chemicals produced in the United States in term of volume. Xylene is used as a solvent in the printing, rubber and leather industries. It is also used as a cleaning agent. A thinner for paint, and in paints and vanishes. It is found in small amounts in airplane fuel and gasoline. Acute exposure to high concentrations of xylene can result in central nervous system effects and irritation in human. However, there have been no long-term controlled human studies or epidemiological studies. The chronic toxicity appears to be relatively low in laboratory animals. There is suggestive evidence, however, that chronic in central nervous system effects may occur in animals at moderate concentrations of xylene.

Acute effects on humans : The main effect of inhaling xylene vapor is depression of the central nervous system (CNS), with symptoms such as headache, dizziness, nausea and vomiting. Irritation of the nose and throat can occur at approximately 200 ppm after 3 to 5 minutes. Exposures estimated at 700 ppm have caused nausea and vomiting. Extremely high concentration (approximately 10000 ppm) could cause incoordination, loss of consciousness, respiratory failure and death. Symptoms of pulmonary edema, such as shortness of breath and difficulty breathing, may be delayed several hours after exposure. However, these effects are rarely seen since xylene is irritating and identifiable by odor at much lower concentrations. When xylene contact with skin have shown irritation, redness and a burning sensation. These effects are reversible shortly (usually within 1 hour) after the contact stops. Xylene contact with the eyes is probably a mild irritant, based on animal information. Eye irritation has been reported at vapor levels as low as 200 pm. Corneal vacuoles (pockets of fluid or air in the cornea) have also been reported following exposure to underfined vapor concentrations. This effect was reversible within 8 to 11 days for 7 of 8 workers.

Chronic effects on human : Chronic exposure in complaints about general weakness, excessive fatigue, dizziness, headache, irritability, sleeplessness, loss of

memory and ringing in the ear. Typical symptoms are cardiovascular disorders, sweetish taste in the mouth, nausea , sometimes vomiting, loss of appetite, thirsty, burning in the eyes and bleeding from the nose. Functional disorders of central nervous system associated with pronounced neurological effects, impairment of protein-forming function and reduced immunobiological reactivity may be observed in certain cases. Women are liable to suffer from menstrual disorders (menorrhagia, metrorrhagia). It has been reported that female workers exposed to toluene and xylene in concentrations which periodically exceeded the exposure limits were also affected by pathological pregnancy condition and infertility. Xylene can damage the liver and kidney.

Carcinogenic effects : The International Agency for Research on Cancer (IARC) has determined that xylene is not classifiable as to its carcinogenicity in humans. Humans and animal studies have not shown xylene to be carcinogenic, but these studies are not conclusive and do not provide enough information to conclude that xylene does not cause cancer. In Table 2-4 showed summary health hazards of benzene, toluene and xylene.

Table 2-4 Health hazards of benzene, toluene and xylene

Chemical name	Short-Term Exposure	Long-Term Exposure	Routes of Exposure and Symptoms
Benzene	Skin, respiratory tract, lungs and CNS	Skin, blood, liver and immune system	Inhalation : dizziness, drowsiness, headache, nausea, shortness of breath, convulsions, unconsciousness Skin : may be absorbed, dry skin Ingestion : abdominal pain, sore throat, vomiting
Toluene	Eyes, respiratory tract, lungs and CNS	Skin, CNS and heart	Inhalation : dizziness, drowsiness, headache, nausea, unconsciousness Skin : dry skin, redness Eyes : redness, pain Indestion : abdominal pain, burning sensation

Table 2-4 Health hazards of benzene, toluene and xylene (continued)

Chemical name	Short-Term Exposure	Long-Term Exposure	Routes of Exposure and Symptoms
Xylene	Throat, eyes, lungs and CNS	Skin, lungs and CNS	Inhalation : dizziness, drowsiness, headache, unconsciousness Skin : dry skin, redness Eyes : redness, pain Ingestion : abdominal pain, burning sensation

2.7 Evaluate chemicals exposure (22,35)

Exposure to hazardous substances should be routinely evaluated. This may include collecting air samples. In Table 2-5 showed exposure limits for benzene, toluene and xylene.

Table 2-5 Standard or recommendation for chemicals exposure

Chemical name	Agency	Standard Levels
Benzene	OSHA : TWA NIOSH REL : TWA ACGIH : TWA Thailand : TWA	1 ppm 0.1 ppm (Potential carcinogen) 0.5 ppm (Suspect carcinogen) 10 ppm
Toluene	OSHA : TWA NIOSH : TWA ACGIH : TLV Thailand : TWA	200 ppm 100 ppm 50 (skin) 200 ppm
Xylene	OSHA : TWA NIOSH : TWA ACHIH : TLV Thailand : TWA	100 ppm 100 ppm 100 ppm 100 ppm

2.8 Respiratory system (36,37,38)

The term of respiration refers to three separate but related functions : (1) ventilation (breathing) ; (2) gas exchange, which occurs between the air and blood in the lung and between the blood and other tissues of the body ; and (3) oxygen utilization by the tissue in the energy-liberating reaction of cell respiration.

The respiratory system is often divided into upper and lower tracts. The organs of the upper respiratory tract are located outside of the thorax or chest cavity, whereas those in the lower tract or division are located almost entirely within it. The upper respiratory tracts is composed of the nose, pharynx and larynx. The lower respiratory tracts consists of the trachea, all segments of the bronchial tree and the lungs. Figure 2-3 showed a schematic of the respiratory tract, a highly branching system of tubes.

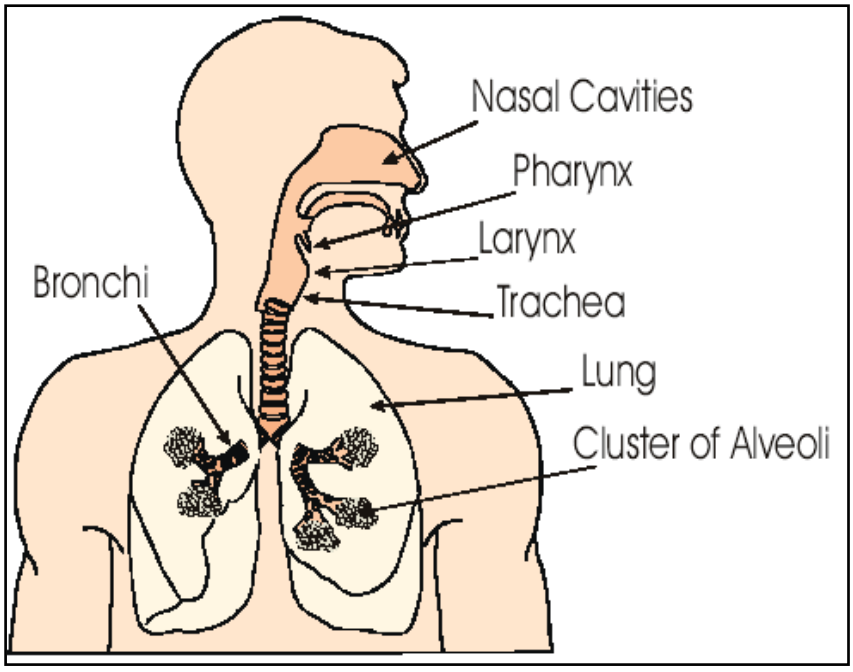


Figure 2-3 The anatomy of the respiratory tract

Air that enter either the nose or the mouth next enters the pharynx, the tube located at the convergence of the nasal and oral cavities. The pharynx is essentially an extension of the esophagus or the food tube, which leads to the stomach. However, air does not normally enter the stomach. Instead, air taken in upon inhalation must enter

into a second tube, called the trachea or the windpipe. During breathing, both the trachea and the esophagus are in an open position. However, the flow of air is through the trachea, as a negative pressure is being developed in the lungs on inhalation, and the flow is out of trachea, as a positive pressure is developed upon exhalation.

Just below the epiglottis and in the uppermost region of the trachea is the larynx or the voice box. This organ is composed of two folds of skin or membranes, called the vocal cords. As air ruches past them, and they are stretched or tightened, sounds are produced that are further modified by the tongue, the sinuses, the oral cavity in general, and the lips, This relatively simple organ is the basis for speech. Although it seems inconsequential in its location, with respect to environmental contaminants, one should keep in mind that it is located in the respiratory tract and therefore is exposed to the contaminants that enter the body this route. Loss of speech through a disease such as cancer of the larynx is particularly debilitating.

Below the larynx, the trachea or windpipe continues foe approximately 11 to 12 centimeters, at which point it splits into right and left main trunks. These two main trunks are called the bronchi, one going to the right lung and the other to the left lung. The two bronchi are not symmetrical, as indeed the two lungs are not symmetrical. The right lung is considerably larger than the left lung, mainly because of the position of the heart, which is located on the left side of the body. Hence, the right bronchus is shorter and because it must supply a larger lung, it is also wider than the left bronchus. More important, the right bronchus continues in approximately the same direction as the trachea, most aspirated material that enters the respiratory tract ends up in the right lung. Once the bronchi enter the lungs, then many thousands of branches, or bifurcations. The smallest branches of this bronchial tree are termed bronchioles.

At the terminal ending of each bronchiole are located very small sacs that further divide into spherical bulbs, called the alveoli. These sacs are functional part of the respiratory system in that the exchange of gases across their membranes take place and allows the process of biochemical respiration to take place. The walls of the alveoli are only two cells thick that are approximately 300 million of these tiny bulbs, and 8 million sacs exist, having a total cross-sectional area of approximately 1.2 square meters.

Ventilation is the mechanical process that moves air into and out of the lungs. Since air in the lungs has higher oxygen concentration than the blood, oxygen diffuses from air to blood. Carbon dioxide, conversely, moves from the blood to the air within the lungs by diffusion down its concentration gradient. As a result of this gas exchange, the inspired air contains more oxygen and less carbon dioxide than the expired air. More importantly, blood leaving the lungs has higher oxygen concentration and a lower carbon dioxide concentration than the blood delivered to the lungs in the pulmonary arteries. This results from the fact that the lungs function to bring the blood into gaseous equilibrium with the air.

2.9 Pulmonary function test (39,40,41,42,43)

Pulmonary function test is the basic tools for evaluating a patient's respiratory status. In patients with suspected pulmonary disease, it is often the first diagnostic test employed in the work up. Pulmonary function tests (PFTs) are used for pre-operative evaluation, managing patients with know pulmonary disease and quantify pulmonary disability. Figure 2-4 showed instrument for pulmonary function test.

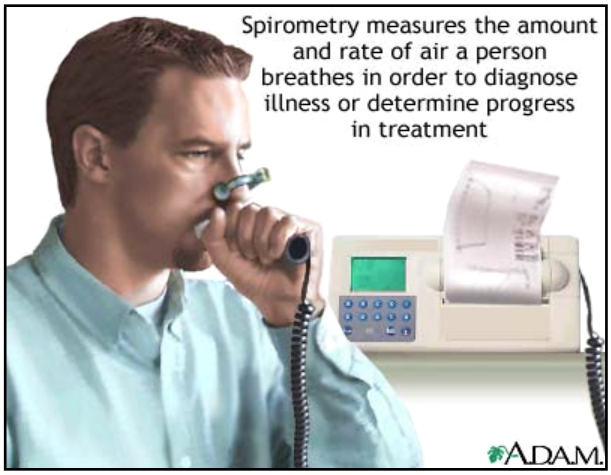


Figure 2-4 Instrument and method for pulmonary function test

Spirometry with flow volume loops assesses the mechanical properties of the respiratory system by measuring expiratory volumes and flow rates. This test requires the patient to make a maximal inspiratory and expiratory effort. The patient in a sitting or standing position breathes into a mouthpieces and nose clips are placed a

prevent air leak. To obtain interpretable results from spirometry, it is essential that the patient give full effort during testing. At least three tests of acceptable effort are performed to ensure reproducibility of results.

2.9.1 Measurement

Such measurements provide data on the patency of the airways, the severity of the airway impairment and whether the patient has a large-airway or small airway problem, and include the following.

1. Forced Vital Capacity (FVC) : The volume of gas that can be exhaled as forcefully and rapidly as possible after a maximal inspiration. In obstructive lung disease, FVC is reduced when compared to the slow vital capacity, indicating air trapping with forced exhalation.

2. Forced Expiratoty Volume in one second (FEV_1) : The volume expired in the first second of maximal expiration after a maximal inspiration and is a useful measure of how quickly full lungs can be emptied.

3. Forced Expiratory Volume in 1 second/Forced Vital Capacity Ratio (FEV_1/FVC Ratio) : The FEV_1 expressed as a percentage of the FVC and give a clinically useful index of airflow limitation. The FEV_1/FVC ratio is used as a broad indicator of airway obstruction.

4. Forced Expiratory Flow $_{25\text{-}75\%}$ ($FEF_{25\text{-}75\%}$) : The average expired flow over the middle half of FVC manouver and is regarded as a move sensitive measure of small airways narrowing than FEV_1.The normal $FEF_{25\text{-}75\%}$ in the average healthy male between 20 and 30 years of age is about 4.5 L/sec. The normal $FEF_{25\text{-}75\%}$ in the average healthy female between 20 and 30 years of age is about 3.5 L/sec. The $FEF_{25\text{-}75\%}$ progressively decrease in obstructive diseases and with age.

2.9.2 Predicted normal values

To interpret pulmonary function tests in any individual, compare the results with reference values obtained from a well-defined population of normal subjects matched for gender, age, height and ethic origin and using similar test protocols and carefully calibrated and validated instruments. Normal predicted values for pulmonary function generally vary as following.

1. Gender : For a given height and age, males have a larger FEV_1,FVC, $FEF_{25-75\%}$ and PEF, but a slightly lower FEV_1/FVC%.

2. Age : FEV_1, FVC, $FEF_{25-75\%}$ and PEF increase, while FEV_1/FVC% decreases, with age until about 20 years old in females and 25 years in males.

3. Height : All indices other than FEV_1/FVC% increase with standing height.

4. Ethic Origin : Caucasians have a largest FEV_1 and FVC and, of the various ethic groups, Polynesians are among the lowest. The values for black African are 10-15% lower than for Caucasians of similar age, sex and height because for a given standing height their thorax is shorter. Chinese have been found to have an FVC about 20% lower than matched Caucasians. There is little difference in PEF between ethic groups.

There is a vast literature of normal population studies, in Thailand has a research of the " Reference Spirometric Values for Healthy Lifetime Nonsmokers in Thailand " by Siriraj Hospital. This resulting of these research is know the standard values of pulmonary function in nonsmoker, the standard values are FVC, FEV_1 , FEV_1/FVC% , $FEF_{25-75\%}$ and PEFR. Total population in these study are 3654 ; 1655 males and 2299 females, aging are ten years upward, nonsmoker or smoking less than 0.5 packs/year and stop smoking not less than 6 months. Subjects not have heart trouble and respiratory disorders before and females did not pregnant in studying. Study method are using questionnaire of the American Thoracic Society (ATS-DLD-78), physical examination and chest x-ray. Instrument for pulmonary function test is electroric turbine pneumotachometer that have standardize from ATS. Siriraj Equation for predicted normal values of Thailand population are following.

Table 2-6 Siriraj Equation

Parameters	Sex	Equations
FVC(L)	Male	$-2.601+0.122A-0.00046A^2+0.00023H^2-0.00061AH$
	Female	$-5.194+0.088A-0.0003A^2+0.056H-0.0005AH$
FEV_1(L)	Male	$-7.697+0.123A+0.067H-0.00034A^2-0.0007AH$
	Female	$-10.6+0.085A-0.00019A^2+0.12H-0.00022H^2-0.00056AH$
FEV_1/FVC%	Male	$19.632+0.49A+0.829H-0.0023H^2-0.0041AH$
	Female	$83.126+0.243A+0.002A^2+0.084H-0.0036AH$
$FEF_{25-75\%}$	Male	$-19.049+0.201A+0.207H-0.00042A^2-0.00039H^2-0.0012AH$
	Female	$-21.528+0.11A-0.00017A^2+0.272H-0.0007H^2-0.00082AH$
PEFR(L/S)	Male	$-16.859+0.037A+0.141H-0.0018A^2-0.001AH$
	Female	$31.355+0.162A-0.00084A^2+0.391H-0.00099H^2-0.00072AH$
A = age (years) , H = height (cm.)		

Values of FVC and FEV_1 in Siriraj equation are 84% of American values and 90% of Europe values but closely with Hongkong values. The researchers believed the standard values of these study should be convincible. Thus, in these thesis will be used Siriraj equation in calculating the predicted normal values, for interpret pulmonary function test of sample size.

2.9.3 Interpretation of Pulmonary Function Test (42)

Measurements of pulmonary function may be useful in a diagnostic sense but they are also useful in following the natural history of disease over a period of time, assessing preoperative risk and in quantifying the effects of treatment. The presence of pulmonary abnormality can be inferred if any of FEV_1 , FVC, or FEV_1/FVC% are outside the normal range. Normal value of pulmonary function are the following.

- FVC ≥ 80% of predicted value
- FEV_1/FVC ≥70% of predicted value
- $FEF_{25-75\%}$ ≥57% of predicted value

Classifying abnormal pulmonary function can be divided into 3 groups i.e.;

1. Obstructive pulmonary disorders : A number of different conditions may cause obstruction of the airways. For example, exposure to cigarette smoke and other common air pollutants can trigger a reflexive constriction of bronchial airways. Obstructive disorders may obstruct inspiration and expiration, whereas restrictive disorders mainly restrict inspiration. In obstructive disorders, the total lung capacity may be normal, or even high, but the time it takes to inhale or exhale maximally is significantly increased. This pattern is reduction in Forced Expiratory Volume in 1 second value and Forced Vital Capacity value, FEV_1/FVC is less than 80% of predicted value that can be classified into the severity i.e.;

- Mild % Pred. FEV_1/FVC = 60-79%
- Moderate % Pred. FEV_1/FVC = 40-59%
- Severe % Pred. FEV_1/FVC < 40%

2. Restrictive pulmonary disorders : Restrictive pulmonary disorders involved restriction (reduced stretch) of the alveoli. Because they inhibit inspiration, restrictive disorders reduce pulmonary volumes and capacities such as inspiratory reserve volume and vital capacity. Some restrictive disorders arise in connective tissue of the lung itself. For example, inflammation or fibrosis (scarring) of the lung tissue caused by exposure to asbestos, coal or silicon dust can restrict alveoli. Restriction of breathing can also be caused by the pain that accompanies pleurisy or mechanical injury. The hallmark of the restrictive pattern is a reduction in Forced Vital Capacity (FVC < 80%) and that can be divided to the class of severity i.e.;

- Mild % Pred. FVC = 60-79%
- Moderate % Pred. FVC = 40-59%
- Severe % Pred. FVC < 40%

3. Mixed or combined pulmonary disorders : The pattern that both Forced Expiratory Ratio value (FEV_1/FVC) is less than 80% and $FEF_{25-75\%}$ value is less than 57% of the predicted value. Mixed pulmonary disease is combination of both obstruction and restriction , or alternatively may occur in airflow obstruction as a consequence of airway closure resulting in gas trapping, rather than as a result of small lungs. It is necessary to measure the patient's total lung capacity to distinguish between these two possibilities. Figure 2-5 showed shapes of flow volume curves and spirograms for obstructive, restrictive and combined.

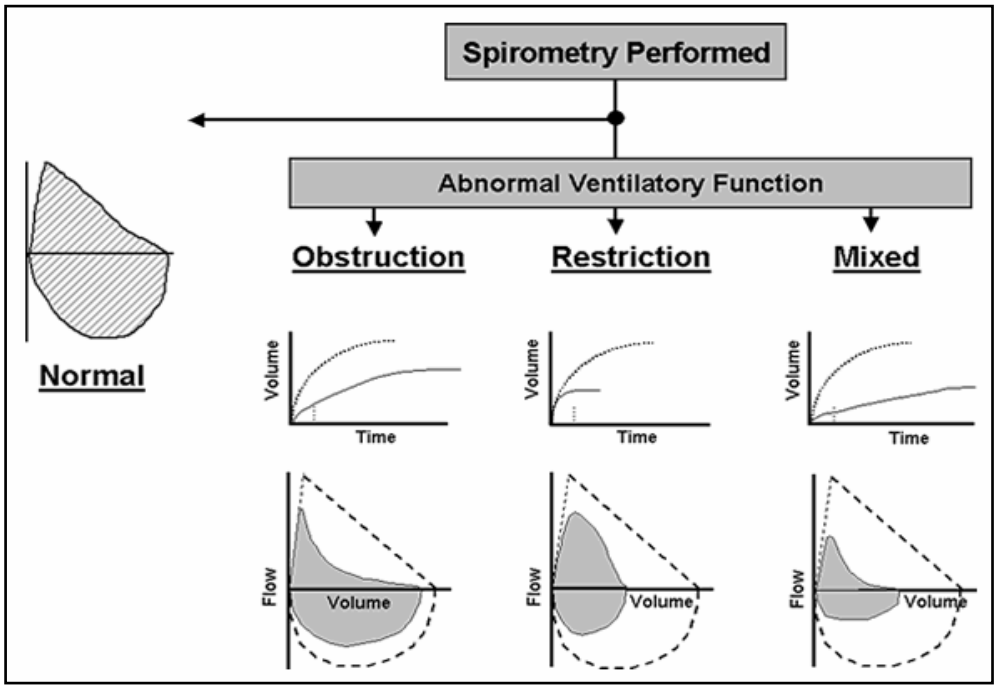


Figure 2-5 Schematic diagram idealized shapes of flow volume curves and spirograms for obstructive, restrictive and combined.

2.9.4 Sources of variation in Pulmonary function test

Variation of the test result from a predicted value may be due to the presence of disease, however, it may also be due to another unwelcome source of variation. Instrument performance can be ensured with sound initial system design, careful individual instrument evaluation, regular calibration, careful maintenance and continued monitoring of equipment performance. Individual sources of variability include comprehension, motivation and effort, body position and temporal timing of testing. The most important interindividual sources of variability and the factors used as predictors of normal values for spirometry include height, age, sex and race.

1. Heigh. Height is a powerful of spirometric measurement. Most equation for predicting spirometric variables vary in direct proportion to height. Seated height or arm span are sometimes used as a surrogate for standing height. Weight is a relatively poor predictor of lung function, producing rather small effect at height and low extremes.

2. Age. Spirometry variables increase during childhood and adolescence. Maximal spirometric values, as a function of lung growth, are reached in the late teens or early 20s. Pulmonary function is thought to be relatively stable until the mid to late 30s, at which point there is a gradual but accelerating decline in pulmonary function. FEV_1 and FVC both decline by approximately 25 to 30 ml/years after age 35 to 40 and more rapidly in older person.

3. Sex. Men of a given height and age have a slightly greater pulmonary volumes and maximal flows than women. Most equation for predicted values separate equation for men and women.

4. Race. Most published equation for calculating predicted values have been derived from groups of white North American or European subjects. Far fewer studies have been done with African, Asian or Native American subjects. The current practice in most laboratories is to use predicted equation derived from white population. In the absence of better recommendation, most laboratories use race as stated or as reported on income tax forms or on the government census.

5. Other sources. Other between subject variations that are predictive of pulmonary function, but for which predicted values are not adjusted, include personal exposure history, including cigarette smoking and occupational exposure, personal health history, socioeconomic factors and presence of airway hyperresponsiveness and atopy. All of these have significant effects but are related to disease processes, not normal variations.

2.10 Literature cited

In 1983, **Goldsmith (44)** had a pilot study in North Carolina hardwood furniture plant was related to the prevalence of respiratory disease and impairment of pulmonary function. The study sample included 99 workers, of whom 55 were exposed to wood dust and measured atmospheric particulate. Symptoms prevalence generally showed no significant differences between wood dust jobs and other exposure categories. The peak flow correlation significantly ($p = 0.0345$) with cumulative person-months of exposure wood dust.

In 1986, **Paggiaro et. al.(45)** surveyed epidemiological on symptoms and disease and lung function in workers of furniture plant in Arezzo. Significantly higher

prevalence rates of cough in smokers than in non-smokers, and of cough, phlegm, wheeze in non-smoker workers than in control group from a general population. Lung function indices were in the normal range : smokers had significantly lower values than non-smokers. A lower FEV_1% after adjusting for age and smoking was shown by subjects with more working years.

In 1992, **Pisaniello, Tkaczuk and Owen (46)** examined the association of pulmonary and nasal symptoms, wood dust exposure and lifestyle variables (cigarette smoking, alcohol use, overweight, physical in activity and stress) in sample 168 woodworkers. Level of wood dust exposure were not systematically associated with symptoms. Statistically significant associations were found for cigarette smoking, heavy drinking was significantly associated with pulmonary symptoms and preserved stress was associated with both pulmonary and nasal symptoms.

In 1992, **Shamssain (47)** studied problem of exposure to wood dust which used spirometry (FVC, FEV_1, FEV_1/FVC, FEF, FMF, PEF) and questionnaire to find respiratory symptoms (cough, phlegm, breathlessness, wheezing and nasal symptoms) in 145 non-smoking workers that exposed to wood dust in furniture factory, and 152 non-smoking control subjects from bottling factory. After adjustment for age and standing height the forced expiratory indices were significantly lower in the exposed male workers than the control subjects. FEF and PEF in the exposed men were 81.3% and 89.4% of predicted values and were lower than other indices. FVC in exposed men showed a significant inverse correlation with exposure. The exposed workers had more respiratory symptoms than the control subjects, the prevalence, especially of cough and nasal symptoms, increasing with the increase in the number of years of employment.

In 1995, **Yousef (48)** studied pulmonary function and symptoms in workers exposed to wood dust. A group studied were 120 male wood workers with control group of male worker from food and dairy production. The questionnaire used to collect data include demographic variables, occupational history and respiratory symptoms. Spirometry used to pulmonary function test and wood dust concentration measurement. The results of respiratory system were more prevalent among the wood workers, compared with control and PFT showed a high significant decrease in FVC, FEV_1 and PEF. Long term exposure to wood dust is likely to increase the risk of

respiratory symptoms and reduce FVC, FEV_1 and PEF, where as acute exposure to wood dust may reduce FVC and FEV_1.

In 1996, **OSH (49)** had a research to study the association between exposure to wood dust and respiratory symptoms in mill workers. Dust concentration were measured by six stage cascade impactors. Among exposed and control smokers, the prevalence of respiratory symptoms was elevated but independent of exposure. High exposure workers had significantly more symptoms than non-smoking controls. All parameters of pulmonary function were significantly lower in the exposed workers than in controls for both smokers and non-smokers. Most pulmonary function deficits also showed a significant decreasing trend with increasing levels of wood dust exposure classified by job titles.

In 1996, **Milanowski et.al.(50)** have been performed in 48 furniture factory workers by medical-environmental questionnaire, physical examination and pre-shift and post-shift spirometry. The workers showed the work-related symptoms : cough, shortness of breath, chest pain, headache ,general malaise, skin symptoms, eyes symptoms and rhinitis. No relationship was found between the spirometry values and frequency of the symptoms. The exposed workers showed a significant post-shift reduction of the FVC, FEV_1, FEV_1/FVC% and PEF ($p < 0.001$). The presented data show that processing of wood may be associated with work-related respiratory symptoms and diseases in exposed workers.

In 2001, **Douwes et.al.(51)** studied respiratory symptoms in pine mill workers, used respiratory health questionnaire in 722 pine sawmill workers and job-title based exposure. The resultant about asthma in exposed workers was more common than in the general population. Asthma was also more common in the low and high exposure group than in the non-exposed workers. Eye and nose irritations were significantly more prevalent in the low and high exposure group. Thus, working in pine sawmill is associated with an increased prevalence of asthma and cough symptoms and eyes and nose irritation.

In 2001, **Laraqui et.al.(52)** have carried out a retrospective survey which concerned exposed workers and control in twenty small handicraft workshops in joiners' souk of Marrakesh, it evaluated the prevalence of the clinical symptoms and disorders of respiratory function in 242 exposed subjects to wood dust and 121

controls. The resultant from questionnaire, clinical examination and spirometry discovered rhinitis, asthma, conjunctivitis, chronic bronchitis and dermatitis were significantly in exposed workers than non-exposed. Smoking exhibited a potential effect on airborne contaminants because among exposed workers disorders were 1.8 times more frequent in smokers than non-smokers.

In 2002, **Rongo et.al.(53)** studied respiratory symptoms and dust exposure level in small-scale wood industry workers in Africa. Method in studied had questionnaire for interviewed 546 workers that exposed to wood dust and 565 control subjects, inhalable dust measurement were collected for 106 workers. Prevalence of respiratory symptoms in the previous 12 months was significantly higher in the exposed group compared with non-exposed office workers. Allergy and sensitivity symptoms were reported regularly in the exposed group with odds ratios and 95% confidence intervals varying from 2.4 for low and 2.7 for high exposure groups compared with controls.

In 2002, **Milanowski et.al.(54)** were examined 48 woodworkers that employed in furniture factory and 41 office workers in control group. The examination included interview on work-related symptoms, physical examination and pulmonary function test performed before and after the working-day. 38 out of 48 woodworkers reported work-related symptoms : dry cough, general malaise, conjunctivitis, rhinitis and skin symptoms. The increased pulmonary function parameters (FVC, FEV_1) were observed in woodworkers who smoked compared to non-smokers. There were significant over-shift decrease of all measured spirometric values : FVC, FEV_1, FEV_1/FVC, PEF among woodworkers ($p<0.001$). There was a significant pre-shift, post-shift decline in FVC, FEV_1, FEV_1/FVC and PEF among workers under 30 years of age ($p<0.001$).

In 2003, **Fransman et.al.(55)** studied work exposure and respiratory symptoms in New Zealand plywood mill workers. The resultant were founded asthma symptoms more common in plywood mill workers than in the general population (20.5% and 12.8%, respectively). Asthma symptoms were associated with duration of employment and were reported to lessen or disappear during holidays.

In 1996, **Regional Health Promotion Center 4, Rajburi Province, Thailand (56)** studied hazard in workplace and evaluated health risk about respiratory

system in workers that exposed to wood dust. From random sampling 265 workers in 13 factory, workers have malaise 32.8%, sneezing 23.8%, cough and chest tightness 15.1%, irritant eyes and conjunctivitis 17.0%, most of workers have more than one symptoms. The symptoms in workers occurred not more than one year and severed until to treatment with medicine 49% and when stop working or resting, the symptoms get well 53.8%. For spirometry, workers have abnormal 33.2%, type of abnormal were mild and moderate restrictive.

In 2000, **National Institute for the Improvement of Working Condition and Environment, Ministry of Labors, Thailand (57)** had project to study work environment and occupational disease surveillance in saw mill, wood transformation, wood manufacture and wood products. This project studied to health condition of workers in five furniture factories which used the questionnaire and pulmonary function test with workers who exposed to wood dust. The result showed prevalence rate of work related symptoms as 79.58%, most of symptoms were headache (66.93%) and cough (50.26%). Workers had abnormal pulmonary function test 12.45%, restrictive type 61.67%, obstructive type 33.33% and combined type (5%), respectively.

In 2002, **Suwit Numpa (58)** studied of 200 plywood processing workers in Samutprakarn Province. The results of study showed that mean concentrations of respirable dust in the three studied groups were significant different at p-value < 0.05. Workers have obstructive type 35.86%, restrictive type 47.82% and combined type 16.31%. For comparison factors among normal and abnormal pulmonary function groups, it was found age, duration of work, weight and height were statistically different at p-value <0.05 related with FEV_1 and $FEF_{25-75\%}$.

CHAPTER III
MATERIALS AND METHODS

3.1 Study Design

This study was a cross sectional study. The prevalence rate and factors associated with symptoms and abnormal pulmonary function test among furniture workers were obtained from study.

3.2 Sample size and groups (59)

Population was workers in furniture factory who worked in only production line. Workers divided into 5 groups through the type of work such as part, sanding, assembly, coating and finishing sections, and packing sections. Workers size was calculated by the following.

3.2.1 Sample size

The number of workers in production line of furniture factory will be calculated from formula :

$$n_0 = \frac{Z^2_{\alpha/2}\, pq}{d^2}$$

Where n_0 = the desired workers size

$Z^2_{\alpha/2}$ = the standard normal deviate, set at 1.96 with 95% confidence level

p = the proportion of work related symptoms as 0.79

q = 1.0- p

d^2 = degree of accuracy desired, set at 0.05

$\therefore \quad n_0 = (1.96^2)(0.79)(0.21) / (0.05^2)$

$= 254.98 \approx 255$

Due to the value of n_0 more than the number of workers in production line. Thus, value of n_0 must be calculated for adjust the number of sample size when known the number of population from formula :

$$n = \frac{n_0}{1 + n_0 / N}$$

Where n = the number of workers after adjusted

N = the number of population in production line as 223

$$\therefore \quad n = \frac{255}{1 + (255/223)}$$

$$= 119.15 \approx 120$$

120 workers in production line of furniture factory were needed. Workers size in each section were calculated and random sampling was used for collection of the data.

3.3 Instruments

The following instruments were used :

3.3.1 Questionnaire : These questionnaire should be applied from Occupational and Environmental Disease Unit , University of British Columbia and divided into 6 parts i.e.

Part I General informations

Part II Work history

Part III Health behavior included smoking and wearing PPE

Part IV The symptoms of the eyes, nose, skin and respiratory systems

Part V Past respiratory illness history

Part VI Acute symptoms questionnaire

3.3.2 Pulmonary Function Test : Minato spirometer model PAL will be used for standardized tests of FVC, FEV_1 , FEV_1/FVC% and $FEF_{25-75\%}$

3.3.3 Dust sampler : Inhalable dust and respirable dust will be collected by personal pumps and analyzed following NIOSH Method 0500 and 0600, respectively.

3.3.4 Chemicals vapors sampler : Vapors of benzene, toluene and xylene will be collected by charcoal tube and analyzed following NIOSH Method 1501.

3.4 Study and sampling method

3.4.1 Collected data by questionnaire : The production line workers (120 workers) were random sampling and interviewed.

3.4.2 Pulmonary Function Test : PFT was tested after the workers worked at least 2 hours. The parameters collected are FVC , FEV_1 , FEV_1/FVC% and $FEF_{25-75\%}$. The results will be interpreted the predicted normal values from the reference spirometric values for healthy lifetime nonsmokers in Thailand from Siriraj Hospital. The procedures are following :

1. To ensured an acceptable result, the FVC manoeuver must be performed with maximum effort immediately following a maximum inspiration, it should be rapid start.
2. To explained procedures with workers, ensuring that the workers were standing with feet firmly on the floor and told the workers to breath in forcefully.
3. Seal their lips around the mouthpiece and blow air out as fast as and long enough that they can do until the lungs were completely empty (at least 6 second expiration).
4. Test repeated at least three acceptable maneuvers should be obtain and recorded the best values.
5. Interpreted the results.

3.4.3 Dust sampler : In this study, inhalable and respirable dusts used partial period consecutive workers measurement method. Inhalable dust will be collected by filter holder in workplace or area sampling. Respirable dust will be collected by cyclone attach with worker (personal sampling method).

1. Inhalable dust will be colleted in workplace. Equipments and methods in dust collected are the following.

- Equilibrate 37-mm PVC, 2 to 5 μm pore size membrane filter in an environmentally control weighing area or chamber for at least 24 hours.
- Handle the filter with forceps and weigh the filters in an environmentally controlled area or chamber. Record the filter tare weight, W_1 (mg).
- Assembly the filters in the filter cassettes that have support pad and close firmly so that leakage around the filter will not occur. Place a plug in each opening of the filter cassettes and run numbers.
- Calibrate each personal sampling pump at 2 L/min with a representative in line.
- Attach a series of collected dust with tripods and bring to set up in workplace, adjusted height of tripods for attach cassette in breathing zone. Turn on the personal sampling pump and record time to start.
- After collected dust finished, wipe dust from the external surface of the filter cassette. Remove the top and bottom plugs from the filter cassette. Equilibrate for at least 24 hours in chamber.
- Remove the cassette band, pry open the cassette and remove the filter gently with forceps and to avoid loss of dust.
- Weigh each filter, record the post-sampling weight,W_2 (mg)
- Calculate the concentration of total particulates, C(mg/m^3), in the air volume workersd, V(L) :

$$C = \frac{(W_2 - W_1) - (B_2 - B_1) * 10^3}{V}, \text{ mg/m}^3$$

Where : W_1 = tare weight of filter before sampling (mg)

W_2 = post-sampling weight of workers (mg)

B_1 = mean tare weight of blank filter (mg)

B_2 = mean post-sampling weight of blank filter (mg)

2. Respirable dust used the same equipments as inhalable dust collected but add cyclone attach with cassette for collected dust sized less than 10 micron. Method to collected respirable dust are the following.

- Contained the 37-mm PVC, 2 to 5 μm pore size membrane filters after equilibrated and support pad into cassettes with cyclone.
- Connected cyclone with personal sampling pump that part to calibrated at 2 L/min.
- Bring the series attach with workers who had more risks exposed to respirable dust through type of work. Set up the series in breathing zone of workers, turn the hold of cyclone out of the workers.
- Turn on the personal sampling pump and record time to started.
- After collected dust finished, same perform when collected inhalable dust and calculated to find concentration of respirable dust too.

3. Vapors chemicals ; This study collected vapors of benzene, toluene and xylene in workplace and workers. Collecting vapors of workers will be performed with the workers who worked only in coating and finishing section. Equipments and methods collected vapors are the following.

- Charcoal tube, 7 cm long, 6-mm OD, 4-mm ID, flame-sealed ends, containing two sections of activated coconut shell charcoal (front = 100 mg, back = 50 mg) separated by a 2-mm uretane foam plug and personal sampling pump, with flexible connecting tubing.
- Sampling method : Calibrate each personal sampling pump with a representative sampler in line.
- Break the ends of the charcoal tube immediately before sampling. Attach charcoal tube to personal sampling pump with flexible tubing.

- Calibrate personal sampling at flow rate 0.2 L/min. Attach the series with worker that charcoal tube in breathing zone.
- Turn on the personal sampling pump and record time to start.
- Cap the charcoal tube with plastic caps after collected finished and pack securely in cool place for shipment.
- Analyzed vapors by using Gas chromatography which set condition through the recommendation in NIOSH Method 1501 and adjusted in suitable.
- Determine the mass, μg of analyze found in the workers front (W_f) and back (W_b) sorbent section, and in the average media blank front (B_f) and back (B_b) sorbent sections.
- Calculate concentration, C , of analyze in the air volume workersd, V (L) :

$$C = \frac{(W_f + W_b - B_f - B_b)}{V} \text{ , mg/m}^3$$

3.5 Data analysis (59,60)

3.5.1 Descriptive analysis

Prevalence rate of symptoms and abnormal pulmonary function test, demographic and other characteristics of study subjects were showed by percentage, mean and standard deviation.

3.5.2 Analytical analysis

1. Chi-square used to test association between qualitative variables and symptoms and abnormal pulmonary function test. Qualitative variables in this study were sex, type of work, smoking habit, wearing PPE and past respiratory illness.

2. Simple linear regression used to test association between dependent variables and independent variables. This method used to study association of quantitative variables such as concentration of wood dust, concentration of vapor chemicals, age, BMI and duration of work.

3. Program for analyze was SPSS for Window Version 9.0

CHAPTER IV
RESULTS

The collected data, from 120 furniture workers, summarized into 4 parts as the following :

1. General characteristics
2. The results of wood dust and vapor chemicals concentration
3. The prevalence rate of symptoms and abnormal pulmonary function test
4. Relation between studied factors with symptoms and abnormal pulmonary function test

4.1 General characteristics

The general characteristics of workers were collected among 120 workers showed in Table 4-1.

Sex

The majority of the workers were females (64.2%) while the males consisted of only 35.8%.

Status

The status of workers were classified into 4 groups such as single, married, divorce and widow. The majority of the workers were married (66.7%), minority were single (28.3%) and widow (3.3%). The least number of the workers were divorce (1.7%).

Residence

The majority of the workers lived in private house (61.7%), minority were factory's room which located in the furniture factory area (20.0%) and the least number of workers were room or house for rent which located outside the furniture factory area (18.3%).

Type of work

Type of work was divided into 5 groups as the following : part (29.2%), sanding (15.8%), assembly (18.3%), coating and finishing (12.5%) and packing section (24.2%). The majority of the workers were part section.

Smoking habit

75.8 % of the workers were not smoking while only 24.2 % were smoke.

Member in family smoking

The majority of workers had members in family smoking (51.7%) while had not members in family smoking 48.3%

Wearing PPE

The majority of the workers wear personal protective equipment 85.8% while 14.2 % did not wear personal protective equipment.

Table 4-1 General characteristic of furniture workers (Qualitative variables)

Variables	Number (120)	Percentage (100%)
1. Sex		
- Male	43	35.8
- Female	77	64.2
2. Status		
- Single	34	28.3
- Married	80	66.7
- Divorce	2	1.7
- Widow	4	3.3
3. Residence		
- Factory’s room	24	20.0
- Room/house for rent	22	18.3
- Private house	74	61.7
4. Type of work		
- Part	35	29.2
- Sanding	19	15.8
- Assembly	22	18.3
- Coating and Finishing	15	12.5
- Packing	29	24.2

Table 4-1 General characteristic of furniture workers (Qualitative variables) (Cont.)

Variables	Number (120)	Percentage (100%)
5. Smoking habit		
- Smoking	29	24.2
- Not-smoking	91	75.8
6. Member in family smoking		
- Have	62	51.7
- Not have	58	48.3
7. Wearing PPE		
- Wearing	103	85.8
- Not wearing	17	14.2
Total	**120**	**100.0**

For the general characteristics of workers can be concluded as the following ; (see Table 4-2)

Age

Majority of the workers were in the age group of 20-29 years (53.3%). Minority of the workers were in the age group of 30-39 years (36.7%) and 40-49 years (8.3%). The least number (1.7%) were less than 20 years old. The average ages of the workers were 29.74 years old (29.74 ± 6.72), the minimum of ages were 18 years old and the maximum were 48 years old.

BMI

Majority of the workers were in normal group (66.7%). Minority of the workers were in under weight group (20.0%), over group (11.7%) and obesity group (1.7%), respectively. The average BMI values of the workers were 21.24 (21.24 ± 3.16), the minimum of BMI were 13.39 and the maximum were 33.06.

Members in family

Majority of the workers were 1-3 peoples (49.2%). Minority of the workers were 4-6 peoples (40.8%) and ≥ 7 peoples (10.0%), respectively. The average members in family were 3.98 (3.98 ± 1.95), the minimum of members were 1 people and the maximum were 10 peoples.

Duration of work

Majority of the workers were ≤ 2 years (51.7%) while the duration of work more than 2 years were 48.3%. The average duration of work was 3.98 years (3.98 ± 1.95), the minimum duration of work was 2 months and the maximum was 10 years.

Table 4-2 General characteristics of furniture workers (Quantitative variables)

Variables	Number (n=120)	Percentage (100%)
1. Age		
- < 20 years	2	1.7
- 20-29 years	64	53.3
- 30-39 years	44	36.7
- 40-49 years	10	8.3
Mean ± SD = 29.74 ± 6.72 Min = 18 Max = 48		
2. BMI		
- Under weight (<18.5)	24	20.0
- Normal (18.5-24.9)	80	66.7
- Over (25-29.9)	14	11.7
- Obesity (>30)	2	1.7
Mean ± SD = 21.24 ± 3.16 Min = 13.96 Max = 33.06		
3. Member in family		
- 1-3 peoples	59	49.2
- 4-6 peoples	49	40.8
- ≥ 7 peoples	12	10.0
Mean ± SD = 3.98 ± 1.95 Min = 1 Max = 10		
4. Duration of work		
- ≤ 2 years	62	51.7
- > 2 years	58	48.3
Mean ± SD = 1.95 ± 1.95 Min = 0.02 Max = 10		

The general characteristics about the symptoms of respiratory systems, the eyes, nose, skin and past respiratory illness of workers can be concluded as the following; (see Table 4-3)

The workers who ever usually cough in the morning were found only 6 workers (5.0%) and never had symptoms 114 workers (95.0%) while the workers had sputum in the morning were found 23 workers (19.2%) and never had symptom 97 workers (80.8%). The workers who had symptoms about dyspnea, breathlessness and wheezing were found 27 workers (22.5%), 30 workers (25.0%) and 14 workers (11.7%), respectively. For the symptoms about the eyes, nose and skin irritation were found these symptoms in 50 workers (41.7%), 31 workers (25.8%) and 51 workers (42.5%), respectively.

For the general characteristics about past respiratory illness found workers had problems 42 workers (35.0%), majority of the workers had allergy 30 workers (0.71%), minority of the workers had bronchitis 9 workers (0.21%) and pneumonia 3 workers (0.07%), respectively. The workers did not have any past respiratory illness 78 workers (65.0%).

Table 4-3 General characteristics about the symptoms of respiratory systems, the eyes, nose, skin and past respiratory illness of workers

Variables	Number (n = 120)	Percentage (100%)
1. Cough in morning	6	5.0
2. Sputum in morning	23	19.2
3. Dyspnea	27	22.5
4. Breathlessness	30	25.0
5. Wheeze	14	11.7
6. Nose Irritation	50	41.7
7. Eyes Irritation	31	25.8
8. Skin Irritation	51	42.5
9. Past respiratory illness		
• **Have problem**	**42**	**35.0**
- Bronchitis	9	21.4
- Pneumonia	3	7.1
- Allergy	30	71.4

4.2 The results of wood dust and vapor chemicals concentration

The sampling of wood dust and vapor chemical were done both of personal sampling and area sampling. The total of wood dust sampling were 37 workers and vapor chemicals were 23 workers. The results showed in Table 4-4.

4.2.1 Inhalable dust : Workers who work in sanding section have a lot of wood dust spread working area and more than other processes. The average concentration of inhalable dust in sanding area were 3.02 mg/m^3 (3.02 ± 0.36). The least concentration of wood dust in working area were coating and finishing section that have only 0.67 mg/m^3 (0.67 ± 0.49).

4.2.2 Respirable dust : A lot of concentration of respirable wood dust were 0.59 mg/m^3 (0.59 ± 0.31) which found in sanding section. The least concentration of respirable wood dust were in packing area that have only 0.08 mg/m^3 (0.08 ± 0.06). The results concentration of wood dust, both of inhalable dust and respirable dust were not more than TLV-TWA in Thailand at 15 mg/m^3 and 5 mg/m^3, respectively.

Table 4-4 The Inhalable dust and Respirable dust concentration (mg/m^3)

Processes	Inhalable dust (n=15)			Respirable dust (n=22)			%
	Mean(SD)	Min	Max	Mean(SD)	Min	Max	RSP/Inhalable
Part	1.97(0.34)	1.64	2.96	0.29(0.19)	0.18	0.64	14.72
Sanding	3.02(0.36)	2.78	3.44	0.59(0.31)	0.26	0.98	19.54
Assembly	0.85(0.48)	0.33	1.29	0.21(0.11)	0.08	0.29	24.71
Coating	0.57(0.39)	0.26	1.21	0.12(0.08)	0.07	0.18	21.05
Packing	0.86(0.31)	0.58	1.17	0.08(0.06)	0.02	0.09	9.30

4.2.3 Vapor chemicals : Sampling of vapor chemicals collected only coating and finishing section. The results of area sampling were found a lot of toluene, the average vapor concentration of toluene was 9.02 ppm (9.02 ± 11.37). The average vapor concentration of benzene and xylene in coating and finishing section area were 1.94 ppm (1.94 ± 0.27) and 0.71 ppm (0.71 ± 0.26), respectively. (see Table 4-5)

The results of personal sampling similar area sampling that found a lot of toluene more than benzene and xylene. The average vapor concentration of toluene in personal sampling was 10.07 ppm (10.07 ± 10.75), benzene and xylene were 1.96 ppm (1.96 ± 0.18) and 1.25 ppm (1.25 ± 0.87), respectively. The results of vapors can not compared with TLV-TWA, due to it did not collect through 8 hours.

Table 4-5 The vapor chemicals concentration in coating and finishing section (ppm)

Vapor chemicals	Area sampling (n=8)			Personal sampling (n=15)			% Personal / Area
	Mean(SD)	Min	Max	Mean(SD)	Min	Max	
Benzene	1.94 (0.27)	1.62	2.29	1.96 (0.18)	0.61	2.35	101.03
Toluene	9.02 (11.37)	0.27	26.45	10.07 (10.75)	0.51	26.55	111.64
Xylene	0.71 (0.26)	0.09	1.84	1.25 (0.87)	0.11	2.91	175.06

4.3 Prevalence rate of symptoms and abnormal pulmonary function

4.3.1 Prevalence rate of symptoms : From interviewed 120 workers by questionnaire about symptoms in one week (see Table 4-6). Finding the workers had symptoms 96 workers (80%), maximum symptom was headache (62%), next symptom was itchy (47.92%) and most of workers had more than one symptoms. In each processes, part section had maximum symptoms, next was sanding section. The number of workers who have symptoms in part and sanding section were 33 workers with PR 94.29% and 16 workers with PR 84.21%, respectively. Prevalence rate of acute symptoms in each processes are the following.

- Part section : majority was itchy with PR 60% and minority was headache with PR 54.29%.
- Sanding section : majority was headache with PR 47.37% and minority were nose irritantation, blocknose, malaise, skin irritation and itchy with PR 31.58%.
- Assembly section : majority was headache with PR 45.45% and minority was blocknose with PR 31.82%.
- Coating and Finishing section: majority was dyspnea with PR 40% and minority was nose irritation with PR 33.33%.
- Packing section : majority was headache with PR 55.17% and minority was malaise with PR 51.72%.

Table 4-6 Number and prevalence rate of symptoms in each processes

Processes	Symptoms												Total have symptom
	Cough	Cough & Sputum	Wheeze	Dyspnea	Breath-lessness	Nose irritant	Block nose	Eyes irritant	Malaise	Head-ache	Skin irritant	Itchy	
Part (n=35)	10 (28.57)	7 (20.0)	4 (11.43)	5 (14.29)	4 (11.43)	11 (31.43)	15 (42.86)	9 (25.71)	11 (31.43)	19 (54.29)	18 (51.43)	21 (60.0)	33 (94.29)
Sanding (n=19)	5 (26.32)	4 (21.05)	1 (5.26)	2 (10.53)	3 (15.79)	6 (31.58)	6 (31.58)	4 (21.05)	6 (31.58)	9 (47.57)	6 (31.58)	6 (31.58)	16 (84.21)
Assembly (n=22)	1 (4.55)	6 (27.27)	1 (4.55)	4 (18.18)	2 (9.09)	6 (27.27)	7 (31.82)	6 (27.27)	5 (22.73	10 (45.45)	7 (31.82)	5 (22.73)	16 (72.73)
Coating (n=15)	1 (6.67)	4 (26.67)	2 (13.33)	6 (40.0)	2 (13.33)	5 (33.33)	3 (20.0)	3 (20.0)	3 (20.0)	6 (40.0)	3 (20.0)	4 (26.67)	10 (66.67)
Packing (n=29)	3 (10.34)	7 (24.14)	3 (17.24)	6 (20.69)	6 (20.69)	11 (37.93)	9 (31.03)	5 (17.24)	15 (51.72)	16 (55.17)	11 (37.93)	10 (34.48)	21 (72.41)
Total (n=120)	23 (23.96)	28 (29.17)	13 (13.54)	23 (23.96)	17 (17.71)	39 (40.63)	40 (41.67)	27 (28.13)	40 (41.67)	60 (62.5)	45 (46.88)	46 (47.92)	96 (80.0)

Remark : - The most of workers had more than one symptoms

- In parenthesis was prevalence rate / 100 (%)

4.3.2 Prevalence rate of symptoms and other variables

Prevalence rate of symptoms and other variables such as sex, age, BMI, duration of work, smoking habit, wearing PPE and past respiratory illness are the following : (see Table 4-7)

Sex

From 43 workers in male group, 35 had symptoms with PR 81.39% and 77 workers in female group, 61 had symptoms with PR 79.22%.

Age

From 64 workers in age group of 20-29 years, 49 had symptoms with PR 76.56%. In the age group of 30-39 years had symptoms 39 workers (from total 44 peoples) with PR 88.64%, and in the age group of 40-49 years had 8 workers with PR 80.0% but do not had any symptoms in the age less than 20 years.

BMI

From 80 workers who had BMI in normal group, 66 had symptoms with PR 82.5%. In under weight group and over group had symptoms 19 workers (PR 79.17%) and 11 workers (PR 78.57%), respectively. In obesity group had not symptoms.

Duration of work

From 62 workers who have duration of work ≤ 2 years, 48 had symptoms with PR 77.42% and 58 workers who have duration of work more than 2 years, 48 workers had symptoms with PR 82.76%.

Smoking habit

From 29 workers in smoking habit, 23 had symptoms with PR 79.31% and 91 workers in non-smoking habit, 73 had symptoms with PR 80.22%.

Wearing PPE

From 103 workers in wearing PPE group, 82 had symptoms with PR 79.61% and 17 workers in not wearing PPE group, 14 had symptoms with PR 82.35%.

Past respiratory illness

From 42 workers who had past respiratory illness, 39 had symptoms with PR 92.86% and 78 workers who had not past respiratory illness, 57 had symptoms with PR 73.08%.

Table 4-7 Prevalence rate of symptoms and other variables

Variables	Number of workers	Work related symptoms		Prevalence rate / 100
		Have symptoms	Not have symptoms	
1. Sex				
- Male	43	35	8	81.39
- Female	77	61	16	79.22
Total	**120**	**96**	**24**	**80.0**
2. Age				
- < 20 years	2	0	2	0
- 20-29 years	64	49	15	76.56
- 30-39 years	44	39	5	88.64
- 40-49 years	10	8	2	80.0
Total	**120**	**96**	**24**	**80.0**
3. BMI				
- Under weight	24	19	5	79.17
- Normal	80	66	14	82.50
- Over	14	11	3	78.57
- Obesity	2	0	2	0
Total	**120**	**96**	**24**	**80.0**
4. Duration of work				
- ≤ 2 years	62	48	14	77.42
- > 2 years	58	48	10	82.76
Total	**120**	**96**	**24**	**80.0**
5. Smoking habit				
- Smoking	29	23	6	79.31
- No-smoking	91	73	18	80.22
Total	**120**	**96**	**24**	**80.0**

Table 4-7 Prevalence rate of symptoms and other variables (Continued)

Variables	Number of workers	Work related symptoms		Prevalence rate / 100
		Have symptoms	Not have symptoms	
6. Wearing PPE				
- Wearing	103	82	21	79.61
- Not wearing	17	14	3	82.35
Total	**120**	**96**	**24**	**80.0**
7. Past respiratory illness				
- Have symptoms	42	39	3	92.86
- Not have symptoms	78	57	21	73.08
Total	**120**	**96**	**24**	**80.0**

4.3.3 Prevalence rate of abnormal pulmonary function test

From 120 workers who had spirometry test, 40 workers had abnormal pulmonary function test with PR 33.33% (see Table 4-8). Six workers worked in coating and finishing section with PR 40%, 13 workers with PR 37.14% worked in part section, 7 workers with PR 31.82% worked in assembly section, 9 workers with PR 31.03% worked in packing section and 5 workers with PR 26.32% worked in sanding section.

The abnormal pulmonary function test classified to 31 mild restrictive pattern (PR 77.5%), 5 moderate restrictive pattern (PR 12.5%), 1 mild obstructive and 1 moderate obstructive pattern (PR 5%). (see Table 4-9).

Table 4-8 Number and prevalence rate of abnormal pulmonary function test in each processes.

Processes	Number of workers	Pulmonary function test		Prevalence rate / 100
		Abnormal	Normal	
Part	35	13	22	37.14
Sanding	19	5	14	26.32
Assembly	22	7	15	31.82
Coating & Finishing	15	6	9	40.0
Packing	29	9	20	31.03
Total	**120**	**40**	**80**	**33.33**

Table 4-9 The characteristics of abnormal pulmonary function in each processes

Characteristics of abnormal pulmonary function	Processes					%
	Part (n=35)	Sanding (n=19)	Assembly (n=22)	Coating & Finishing (n=15)	Packing (n=29)	
Obstructive						
- Mild	1	-	-	1	-	5.0
- Moderate	1	-	-	1	-	5.0
Restrictive						
- Mild	10	3	7	4	7	77.5
- Moderate	1	2	-	-	2	12.5
Total	**13**	**5**	**7**	**6**	**9**	**33.33**

4.3.4 Prevalence rate of abnormal pulmonary function test and other variables

Prevalence rate of abnormal pulmonary function test and other variables such as sex, age, BMI, duration of work, smoking habit, wearing PPE and past respiratory illness are the following : (see Table 4-10)

Table 4-10 Prevalence rate of abnormal pulmonary function test and other variables

Variables	Number of workers	Pulmonary function test		Prevalence rate / 100
		Abnormal	Normal	
1. Sex				
- Male	43	11	32	25.58
- Female	77	29	38	34.66
Total	**120**	**40**	**80**	**33.33**
2. Age				
- < 20 years	2	-	2	-
- 20-29 years	64	21	43	32.81
- 30-39 years	44	18	26	40.91
- 40-49 years	10	1	9	10.0
Total	**120**	**40**	**80**	**33.33**
3. BMI				
- Under weight	24	7	17	29.17
- Normal	80	27	53	33.75
- Over	14	5	9	35.71
- Obesity	2	1	1	50.0
Total	**120**	**40**	**80**	**33.33**
4. Duration of work				
- ≤ 2 years	62	18	44	29.03
- > 2 years	58	22	36	37.93
Total	**120**	**40**	**80**	**33.33**
5. Smoking habit				
- Smoking	29	7	22	24.14
- No-smoking	91	33	58	36.26
Total	**120**	**40**	**80**	**33.33**

Table 4-10 Prevalence rate of abnormal pulmonary function test and other variables (Continued).

Variables	Number of workers	Pulmonary function test		Prevalence rate / 100
		Abnormal	Normal	
6. Wearing PPE				
- Wearing	103	33	70	32.04
- Not wearing	17	7	10	41.18
Total	**120**	**96**	**24**	**80.0**
7. Past respiratory illness				
- Have symptoms	42	19	23	45.24
- Not have symptoms	78	21	57	26.92
Total	**120**	**96**	**24**	**80.0**

Sex

From 43 workers in male group, 11 had abnormal pulmonary function test with PR 25.58% and 77 workers in female group, 29 had abnormal pulmonary function test with PR 37.66%.

Age

From 64 workers in the age group of 20-29 years, 21 had abnormal pulmonary function test with PR 32.81%. In the age group of 30-39 years had abnormal pulmonary function test 18 workers (from total 44 peoples) with PR 40.91% and in the age group of 40-49 years had 1 workers with PR 10.0% but did not have any abnormal pulmonary function test in the age group less than 20 years.

BMI

From 2 workers who had BMI in obesity group, 1 had abnormal pulmonary function test with PR 50%. In over group, normal group and under weight group had abnormal pulmonary function test 5 workers (PR 35.71%), 27 workers (PR 33.75%) and 7 workers (PR 29.17%), respectively.

Duration of work

From 62 workers who had duration of work ≤ 2 years, 44 had abnormal pulmonary function test with PR 29.03% and 58 workers who had duration of work more than 2 years, 36 had abnormal pulmonary function test with PR 37.93%.

Smoking habit

From 29 workers in smoking group, 7 had abnormal pulmonary function test with PR 24.14% and 91 workers in non-smoking group, 33 had abnormal pulmonary function test with PR 36.26%.

Wearing PPE

From 103 workers wearing PPE, 33 had abnormal pulmonary function test with PR 32.04% and 17 workers did not wear PPE, 7 had abnormal pulmonary function test with PR 41.18%.

Past respiratory illness

From 42 workers who had past respiratory illness, 19 had abnormal pulmonary function test with PR 45.24% and 78 workers who had not past respiratory illness, 21 had abnormal pulmonary function test with PR 26.92%.

4.4 Association between studied factors with symptoms and abnormal pulmonary function test.

4.4.1 Association between qualitative variables and symptoms

The associated between qualitative variables and symptoms that was analyzed by chi-square test. The results of association are the following : (see table 4-11)

Sex

The results showed association between sex and symptoms with χ^2 of 0.082, p-value of 0.775. There were not associated significantly at p-value > 0.05.

Type of work

The results showed association between type of work and symptoms with χ^2 of 1.028, phi = 0.260 and p-value of 0.011. There were associated significant statistically at p-value = 0.011.

Smoking habit

The results showed association between smoking habit and symptoms with χ^2 of 0.011 and p-value of 0.915. There were not associated significantly at p-value > 0.05.

Wearing PPE

The results showed association between wearing PPE and symptoms with χ^2 of 0.069 and p-value of 0.793. There were not associated significantly at p-value > 0.05.

Past respiratory illness

The results showed association between past respiratory illness and symptoms with χ^2 of 6.676, phi value = 0.236 and p-value of 0.010. There were associated significant statistically at p-value = 0.010. To consider direction of associated between past respiratory illness and symptoms, finding association were high level (phi=0.236, normal range 0-0.77). In addition, to consider prevalence rate of workers who had past respiratory illness (PR 92.86%) would be have symptoms higher than workers who had not past respiratory illness (PR 73.08%) that prevalence rate ratio was 1.27.

Table 4-11 Association between qualitative variables and symptoms

Variables	χ^2	df	ϕ	p-value
1. Sex	0.082	1	-	0.775
2. Type of work	1.028	4	0.260	0.011*
3. Smoking habit	0.011	1	-	0.915
4. Wearing PPE	0.069	1	-	0.793
5. Past respiratory illness	6.676	1	0.236	0.010*

The results of associated between past respiratory illness and symptoms that allergy associated with seven symptoms such as cough (p=0.021), cough and sputum (p=0.024), wheezing (p=0.001), nose irritation (p<0.001), blocknose (p=0.001), eyes irritation (p=0.035) and skin irritation (p=0.002), respectively. (see Table 4-12)

To consider direction of associated between allergy and seven symptoms, most of association were moderate level such as cough and sputum (phi=0.265), skin irritation (phi=0.277), blocknose (phi=0.301), wheeze (phi=0.316) and nose irritation (phi=0.353). Eyes irritation and cough had direction of association were high level (phi=0.193 and 0.211, respectively). In addition, to consider prevalence rate of workers who had allergy would be have symptoms higher than workers who had not allergy (PR in 44.44 - 62.93%) and prevalence rate ratio were 1.88 - 2.97 (see Appendix, Table C-1).

Table 4-12 The results of association between allergy and seven symptoms

Symptoms	χ^2	df	ϕ	p-value
1. Cough	5.324	1	0.211	0.021
2. Cough & sputum	8.443	1	0.265	0.004
3. Wheeze	12.009	1	0.316	0.001
4. Nose irritation	14.985	1	0.353	<0.001
5. Blocknose	10.855	1	0.301	0.001
6. Eyes irritation	4.453	1	0.193	0.035
7. Skin irritation	9.204	1	0.277	0.002

4.4.2 Association between quantitative variables and symptoms

The association between quantitative variables and symptoms that was analyzed simple linear regression. The results of association are the following : (see table 4-13).

Age

The results showed association between age and symptoms with r of 0.118, r^2 of 0.014 and p-value of 0.200. There were not associated significantly at p-value > 0.05.

BMI

The results showed association between BMI and symptoms with r of 0.104, r^2 of 0.011 and p-value of 0.257. There were not associated significantly at p-value > 0.05.

Duration of work

The results showed association between duration of work and symptoms with r of 0.041, r^2 of 0.002 and p-value of 0.693. There were not associated significantly at p-value > 0.05.

Concentration of respirable dust

The results showed association between concentration of respirable dust and symptoms with r of 0.231, r^2 of 0.053 and p-value of 0.301. There were not associated significantly at p-value > 0.05.

Concentration of vapor chemicals

The results showed association between concentration of benzene vapor and symptoms with r of 0.112, r^2 of 0.013 and p-value of 0.691, toluene vapor and symptoms with r of 0.239, r^2 of 0.057 and p-value of 0.390, xylene vapor and symptoms with r of 0.220, r^2 of 0.048 and p-value of 0.431. All of three vapors were not associated significantly at p-value > 0.05.

Table 4-13 Association between quantitative variables and symptoms

Variables	r	r^2	p-value
1. Age	0.118	0.014	0.200
2. BMI	0.104	0.011	0.257
3. Duration of work	0.041	0.002	0.653
4. Concentration of wood dust	0.231	0.053	0.301
5. Concentration of vapors			
- Benzene	0.112	0.013	0.691
- Toluene	0.239	0.057	0.390
- Xylene	0.220	0.048	0.431

4.4.3 Association between qualitative variables and abnormal pulmonary function test

To find associated between qualitative variables and abnormal pulmonary function test that was analyzed by chi-square test. The results of association are the following : (see Table 4-14).

Sex

The results showed association between sex and abnormal pulmonary function test with χ^2 of 1.812, p-value of 0.178. There were not associated significantly at p-value > 0.05.

Type of work

The results showed association between type of work and abnormal pulmonary function test with χ^2 of 1.041 and p-value of 0.903. There were not associated significant at p-value > 0.05.

Smoking habit

The results showed association between smoking habit and abnormal pulmonary function test with χ^2 of 1.455 and p-value of 0.228. There were not associated significantly at p-value > 0.05.

Wearing PPE

The results showed association between wearing PPE and abnormal pulmonary function test with χ^2 of 0.548 and p-value of 0.459. There were not associated significantly at p-value > 0.05.

Past respiratory illness

The results showed association between past respiratory illness and abnormal pulmonary function test with χ^2 of 4.121, phi=0.185 and p-value of 0.042. There were associated significant statistically at p-value = 0.042. Allergy associated with abnormal pulmonary function test with χ^2 of 5.930, phi=0.222 and p-value of 0.015.

To consider direction of association between past respiratory illness and abnormal pulmonary function test, finding association was high level (phi=0.185). Similar associated between allergy and abnormal pulmonary function test that had association in high level (phi=0.222). In addition, to consider prevalence rate of workers who had past respiratory illness (PR 45.24%) would be have abnormal pulmonary function test higher than workers who had not past respiratory illness (PR 26.92%) that prevalence rate ratio was 1.68.

Table 4-14 Association between qualitative variables and abnormal pulmonary function test

Variables	χ^2	df	ϕ	p-value
1. Sex	1.812	1	-	0.178
2. Type of work	1.041	4	-	0.970
3. Smoking habit	1.455	1	-	0.228
4. Wearing PPE	0.548	1	-	0.459
5. Past respiratory illness	4.121	1	0.185	0.042 *
• Allergy	5.930	1	0.222	0.015 *

4.4.4 Association between quantitative variables and abnormal pulmonary function test

To find associated between quantitative variables and abnormal pulmonary function test that was analyzed by simple linear regression. The results of association are the following (see Table 4-15).

Age

The results showed association between age and abnormal pulmonary function test with r of 0.004, r^2 of < 0.001 and p-value of 0.970. There were not associated significantly at p-value > 0.05.

BMI

The results showed association between BMI and abnormal pulmonary function test with r of 0.034, r^2 of 0.001 and p-value of 0.712. There were not associated significantly at p-value > 0.05.

Duration of work

The results showed association between duration of work and abnormal pulmonary function test with r of 0.182, r^2 of 0.033 and p-value of 0.047. There were associated significantly statistically at p-value = 0.047. ($p < 0.05$)

Concentration of respirable dust

The results showed association between concentration of respirable dust and abnormal pulmonary function test with r of 0.281, r^2 of 0.079 and p-value of 0.205. There were not associated significantly at p-value > 0.05.

Concentration of vapor chemicals

The results showed association between concentration of benzene vapor and abnormal pulmonary function test with r of 0.036, r^2 of 0.001 and p-value of 0.898, toluene vapor and abnormal pulmonary function test with r of 0.041, r^2 of 0.002 and p-value of 0.884, xylene vapor and abnormal pulmonary function test with r of 0.565, r^2 of 0.391 and p-value of 0.028. Benzene and toluene vapor were not associated significantly at p-value > 0.05 but xylene vapor associated significantly statistically at p-value = 0.028.

Table 4-15 Association between quantitative variables and abnormal pulmonary function test

Variables	r	r^2	p-value
1. Age	0.004	< 0.001	0.970
2. BMI	0.034	0.001	0.712
3. Duration of work	0.182	0.033	0.047 *
4. Concentration of wood dust	0.281	0.079	0.205
5. Concentration of vapors			
- Benzene	0.036	0.001	0.898
- Toluene	0.041	0.002	0.884
- Xylene	0.565	0.391	0.028 *

CHAPTER V
DISCUSSION

5.1 Discussion of Methodology

This study was a cross sectional study in furniture workers. The main objective was a study prevalence rate and factors associated with work related symptoms and abnormal pulmonary function test. Samples were 120 workers in furniture factory that divided into 5 groups through type of work such as part, sanding, assembly, coating and finishing, and packing section. Samples size were randomized assignment, the error of data collection and analyzing might be occurred due to random and systemic errors.

5.1.1 Systemic errors

1. Personal errors : Data collection procedure may be error from personal variations. Although, in procedure of air sampling collection, vapor chemicals collection, pulmonary function test and interviewed procedure performed in many persons but each collector would be received training and suggestion before collection the data. Thus, the collected data can be prevent error from inter-observer variations and minimize the errors.

2. Method errors : The method of air sampling may be error. In this study used partial period consecutive sample measurement method. Because this method could not showed the interval of maximum substances concentration but it can showed the mean concentration and other proper patterns will be costly. Therefore, this method was applied to use in this study. At the storage procedure, air sampling could not be analyzed immediately, after collected the cassette filters keep in dry and close the top and bottom of cassette with tightly plugs. About the analytical method, air sampling will be opened from the cassette and filter was removed gently to avoid losing of dust, then cleaned forcep was used to handle filter for weighting.

The samples of vapor chemicals were collected in equal time to protect breakthrough of charcoal tube in each samples. Although, samples could not analyze immediately, these samples were storage in 5°C for charcoal tube following NIOSH recommendation. This error occurred from analytical method and can be controlled by establishment of calibration curve and quality control together with the samples in all experiments.

3. Instrument errors : these errors may be occurred during procedures such as personal pump, pulmonary function test and GC analysis. However, this error could be controlled by calibrate the personal pump with bubble flow meter before and after measurement and calibrate spirometer for pulmonary function test. The questionnaire did not test reliability but almost of the topics in these questionnaires were applied from Occupational and Environmental Disease Unit which used this questionnaire in the former studied.

5.1.2 Random errors

These errors may be occurred from selection of subject and sample size. In this study the subjects were selected 120 workers by randomization method. Asthmatic and tuberculosis workers were recruit from this study. The workers who were selected for personal sampling, worked in highly hazardous who exposed with pollutant (wood dust and vapors) in each processes and follow the NIOSH recommendation.

5.2 Discussion on the study results

5.2.1 General characteristics results

These results as presented in Table 4-1 to Table 4-3 showed that most of them were female, most of status and residence were married and lived in private house, respectively. With regard to type of work, most of them worked in part section. Regard to smoking habit, only one-fourth were cigarette smoking and had members in family smoking 51.7% that could be effect to other persons in family (passive smoking). With regard to personal protective equipment, most of them wear personal protective equipment in working time but most of workers wear cotton dust. Unsuitable of PPE could be lead to health effects to workers. Most of age were 20-29

years that half of workers and 66.7% of workers had BMI within normal group (18.5-24.9). Most of the workers had duration of work less than 2 years.

With general characteristics about respiratory, eyes, nose and skin symptoms in the past, the results as presented in Table 4-3 showed most of workers had skin irritation. Next, the workers had nose irritation, eyes irritation, breathlessness, dyspnea, sputum in morning, wheezing and cough, respectively. With regard to respiratory illness in the past, the results showed most of them had allergy symptoms, bronchitis and pneumonia, respectively.

5.2.2 Air sampling analysis results

Two components for sampling and analysis include :

1. Inhalable dust and respirable dust
2. Vapor chemical of benzene, toluene and xylene

Air sampling for analysis were done in term of area and personal sampling. The total amount 37 samples for evaluation to associated with symptoms and abnormal pulmonary function test involvement. The results as presented in Table 4-4 and Table 4-5. The average concentration of inhalable and respirable wood dust were 3.02 mg/m^3 (3.02 ± 0.36) and 0.59 mg/m^3 (0.59 ± 0.31) which were in sanding section. Total groups' values were not over the TLV-TWA (Threshold limit values, time weight average in Thailand), 15 mg/m^3 and 5 mg/m^3, respectively.

The average concentration of vapor chemicals in coating and finishing section as presented in table 4-5. The most average concentration of vapor chemicals was toluene which collected in area and personal sampling was 9.02 ppm (9.02 ± 11.37) and 10.07 ppm (10.07 ± 10.75) which concentration of toluene more over than the average concentration of benzene and xylene. Total groups' value were not compared with TLV-TWA because air sampling of vapors did not collect through 8 hours but collected only 40 minutes per one sampling

5.2.3 Acute symptoms

These results as presented in Table 4-6 showed that most of symptoms were headache with PR 62.5%. This result similar with **National Institute for the Improvement of Working Condition and Environment, Ministry of Labors (57).**

About headache symptoms, it may be caused by the workers exposed with wood dust that some wood could effect with nervous system. Furthermore, noise and light also caused headache. High level of noise could have physiological effect with workers such as abnormal of blood circulation and nervous system. If exposed noise to 130 db(A) would be have dizzy, vomiting and hypertention. Low light would be effect with the eyes, headache, reduce work efficiency and accident. In coating and finishing section, most of symptoms were dyspnea and nose irritation with PR 40% and 33.33%, respectively.These symptoms caused by the workers exposure with high concentration of vapor chemicals that could be effect with respiratory system and wear unsuitable of PPE.

The study extraneous variables such as sex, age, BMI and past respiratory illness associated with symptoms. Only past respiratory illness associated with symptoms ($p=0.010$). Past respiratory illness that associated with symptoms was allergy symptom. Allergy associated with cough ($p=0.021$), cough and sputum ($p=0.004$), wheezing ($p=0.001$), nose irritation ($p<0.001$), blocknose ($p=0.001$), eyes irritation ($p=0.035$) and skin irritation ($p=0.002$), respectively. This result similar with **Rongo LM. (53) and Donatella T. (61)** that found workers, who had allergy symptom, have sensitivity with wood dust more than worker who had not exposure to wood dust.

Factors about smoking habit and wearing PPE were not associated with symptoms ($p>0.05$), this result different from the study of **Korn RJ. et al. (62)** that found smoking associated with symptoms statistically significant. But in this study, prevalence rate of symptoms and smoking habit, observed workers who not smoking had symptoms more than workers who smoking, caused effect members in family smoking (passive smoking).

Working factors such as type of work, duration of work, concentration of wood dust and concentration of vapor chemicals, only type of work associated with symptoms ($p=0.011$) and type of work that caused symptoms were assembly and coating. These results different from the studied of **Goldsmith (44)** that found the prevalence of symptoms did not statistically significant difference between exposed to wood dust and solvents.

5.2.4 Abnormal Pulmonary Function Test (PFT)

These results of abnormal pulmonary function test as presented in Table 4-8 and Table 4-9 showed that most of abnormal PFT found in part section with PR 37.14%. Type of abnormal pulmonary function were restrictive type (77.5%) that found in part section, too. This results similar with **National Institute for the Improvement of Working Condition and Environment, Ministry of Labors (57)**, that found most of workers have restrictive type in part section 17.35% and conformed with physical examination of factory on December, 2003. These study found workers in part assembly and packing section had restrictive more than other section especially new workers that had not examination before.

Wood dust exposure included decrease lungs capacity and allergic reaction. Two types of allergic reactions can take place in the lungs such as hypersensitivity pneumonitis and occupational asthma. Hypersensitivity pneumonitis appears to be triggered when small particles penetrate deeply into the lungs where the triggers and allergic response. Particles that are known or suspected to cause this condition include moulds, bacteria and fine dust from some tropical hardwood. **(BC Research, (15))**

Furthermore, restrictive dysfunction is marked by a reduction in lungs volumes. Spirometry is not a conclusive test for restrictive pulmonary disease, but based on the results of spirometry it can be determined if there should more specific test in order to identify and what is causing the pulmonary difficulty. Primary identifier is a low FVC value, since technically the FEV_1 may show up normal in a spirograph of an individual with restrictive pulmonary disease. This makes sense since the effect of restrictive disease is lungs inability to expand, so the FVC would suffer, where the FEV_1 for that individual may be normal because the lung can collapse, or expire, in one second as normal. In addition, the most common patient-related problems when performing the FVC manoeuver such as leaks between the lips and mouthpiece, incomplete inspiration or expiration, hesitation at the start of expiration, cough, obstruction of the mouthpiece by the tongue, vocation during the force manoeuver, poor posture and submaximal effort. Therefore, obtained true restrictive disease, it is necessary to measure lung volumes to accurately diagnose restrictive physiology and chest X-ray.

Other factors that found associated with abnormal pulmonary function test was past respiratory illness (p=0.042), that was allergy (p=0.015). the result of studied similar with **Yamaguchi (63)**. The workers who had allergy symptoms could be sensitive effected with wood dust or other sentitizer.

Duration of work associated with abnormal pulmonary function (p=0.047) that similar with **Carl Z. (64)**, workers who had duration of work since two years have difference statistically significant with workers who had duration of work less than two years (p=0.024)

About extraneous factors such as sex, age and BMI did not associate with abnormal pulmonary function test (p>0.05) that similar with **Goldsmith (44)**. Smoking habit did not associated with abnormal pulmonary function (p>0.05) similar with **Milanowski J. et al.(54)** but different from **Laraqui H. et al.(52)** that found the workers who exposed with wood dust and smoking had abnormal pulmonary function test more than workers who exposed but do not smoking. Wearing personal protective equipment did not associate with abnormal pulmonary function (p>0.05) similar with **National Institute for the Improvement of Working Condition and Environment, Ministry of Labors (57)**. But most of workers had a risk because they used cotton mask and a few of workers in coating used catridge respirator.

Type of work did not associate with abnormal pulmonary function test (p>0.05), this result different from the studied of **OSH (49)** that found the values of pulmonary function test have decreasing trend with increasing levels of wood dust exposure classified by type of work.

Concentration of wood dust and vapor chemicals (benzene, toluene and xylene) that showed in Table 4-12, concentration of wood dust did not associated with abnormal pulmonary function test (p>0.05) that similar with **Pisaniello (46)**

Concentration of vapor chemicals such as benzene, toluene and xylene that found benzene and toluene vapors did not associated with abnormal pulmonary function test (p>0.05), only xylene vapor associated with abnormal pulmonary function test (p=0.028) similar with **Ernstgard (65)** that found xylene had significantly effect of pulmonary function.

CHAPTER VI
CONCLUSION AND RECOMMENDATION

1. Conclusion

From the study, the results can be concluded as the following :

1. The prevalence rate of symptoms of furniture workers have 80.0% and prevalence rate in each precesses are following

- Part : majority was itchy with PR 60% and minority was headache with PR 54.29%.
- Sanding : majority was headache with PR 47.37% and minority were irritant nose, blocknose, malaise, irritant skin and itchy with PR 31.58%.
- Assembly : majority was headache with PR 45.45% and minority was blocknose with PR 31.82%.
- Coating and Finishing : majority was dyspnea with PR 40% and minority was irritant nose with PR 33.33%.
- Packing : majority was headache with PR 55.17% and minority was malaise with PR 51.72%.

2. Prevalence rate of abnormal pulmonary function test of furniture workers had 33.33% and prevalence rate in each processes are following.

- Part section had prevalence rate of abnormal pulmonary function test 37.14%.
- Sanding section had prevalence rate of abnormal pulmonary function test 26.32%.
- Assembly section had prevalence rate of abnormal pulmonary function test 31.82%.
- Coating and finishing section had prevalence rate of abnormal pulmonary function test 40.0%.
- Packing section had prevalence rate of abnormal pulmonary function test 31.03%.

3. No association between symptoms and sex, age, height, smoking habit, wearing PPE, duration of work, concentration of wood dust and vapor chemicals (benzene, toluene and xylene) in this study.

4. Past respiratory illness associated with symptoms (p=0.010). Especially allergy that associated with cough (p=0.021), cough and sputum (p=0.004), wheezing (p=0.001), nose irritation (p<0.001), blocknose (p=0.001), eyes irritation (p=0.035) and skin irritation (p=0.002), respectively.

5. Type of work that associated with symptoms were assembly and coating and finishing section at p-value = 0.011

6. No association between abnormal pulmonary function test and sex, age, height, smoking habit, wearing PPE, type of work and concentration of wood dust in this study.

7. Past respiratory illness associated with abnormal pulmonary function test (p=0.042), especially allergy that associated with abnormal pulmonary function test at p-value = 0.015.

8. Duration of work associated with abnormal pulmonary function test at p-value = 0.047. The workers who had duration of work since 2 years had difference statistically significant with workers who had duration of work less than 2 years at p=0.024.

9. No association between abnormal pulmonary function test and vapor of benzene and toluene but vapor of xylene associated with abnormal pulmonary function test at p-value = 0.028.

10. Concentration of wood dust was not over the TLV-TWA (Threshold limit values, time weight average) of limited in Thailand.

2. Recommendation

Although, the concentration of wood dust (Inhalable dust and Respirable dust) and vapor chemicals (benzene, toluene and xylene) in furniture factory for this study were not more than standard values, but in some area had more concentration than the standard values. Thus, the control systems and improve work environment are necessary in workplace. The workers should have safety work and prevention from occupational disease.

1. To reduce spread out of pollutants, especially wood dust in work area, Due to in work area had more blow fans to reduced heat of workers and ventilate but most of fans located behind workers, wood dust could be spread into workers. Thus, the fans must be rank to wind direction inside of workers. (see Figure 6-1)

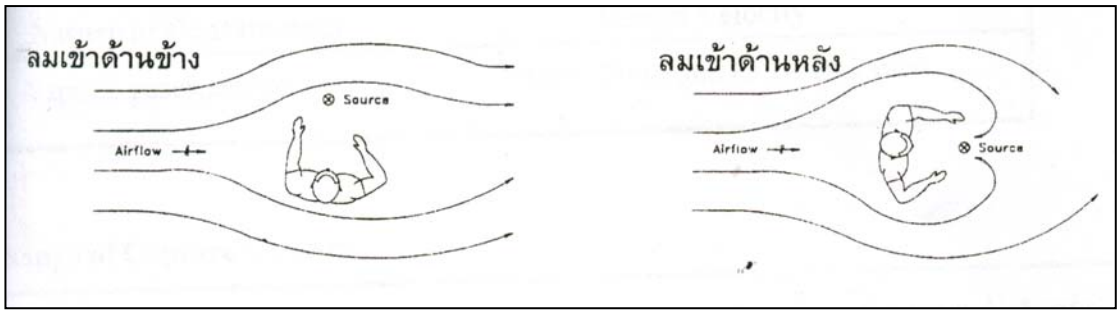


Figure 6-1 Direction of air flow

2. To install exhaust ventilation system (EVS) in painting area or make partition or room for painting that isolate between painting area and others area. Furthermore, EVS could be reduced spread of chemicals to workers who exposed with chemicals all time. Solvents or paint should be keep in tightly cloud containers, rags containing solvents should be discard quickly.

3. To provided suitable and sufficient personal protective equipment for workers. Respirator masks can give workers importantly protection against fine wood dust and vapor chemicals. Some respirators are designed primarily for nuisance dust, others for toxic dust particles and others for chemical gases and fumes. Lists indicating appropriate models and brands of respirators can be obtained from various agencies of industrial safety, such as the National Institute for Occupational Safety and Health (NIOSH). A respirator must be right for the kinds of solvent, the amount of vapor in the air and work situation. Furthermore, provided suitable protective clothing to protect susceptible skin areas. This clothing should be designed for prevent dust become trapped between clothing and skin such as coveralls, long sleeves and properly fitted industrial gloves.

4. Set up health surveillance system to monitoring dust concentration (Inhalable dust and Respirable dust) and vapor chemicals in working environment of furniture workers. The occupational health program proper by medical examination

should be serviced as routine such as respiratory system, chest X-rays, pulmonary function test, audiometry and skin allergy test. The workers who exposed chemicals should be done biological monitoring. The BEI determinant can be the chemical itself; one or more metabolites or characteristics, reversible biochemical change induced by the chemical. In most case, the specimen used for biological monitoring is urine, blood or exhaled air.

5. Health education about hazard of wood dust and chemicals or solvents for workers. The hazardous of wood dust and vapor chemicals are need of workers for protect themselves. In addition, the correct procedure, using personal protective equipment and first aid are necessary for workers.

For the further study we recommended that :

1. Further study should be research about biological hazard. Moulds, fungi, sap, latex or lichens which grew on the bark of trees that can cause health problems. The workers who have sawing task associate with these biological hazards, thus the research about these hazards are necessary. Study about other chemicals that associated with woodworking, these chemicals included preservatives, solvents and glues used in wood manufacture.

2. To find quantities of chemicals which can metabolite in body. The biological monitoring can assist the occupational health professional detect and determine absorption via the skin or gastrointestinal system, reconstruct past exposure in the absence of other exposure measurement, detect non-occupational exposure among workers, test the efficiency of personal protective equipment and engineering controls and monitor work practices.

3. Follow up pulmonary function test of furniture workers especially the workers with abnormal pulmonary function test should be monitored more carefully and frequency.

4. To study comparative among exposed group and control group which are other population to comparative in further study.

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APPENDIX

A. Questionnaire about nose, eyes, skin and respiratory symptoms

Part I General information

1. Name (Mr./Mrs./Miss) ……

2. Sex ❍ Male ❍ Female

3. Age …… years

4. Weight ……... kilograms Height ……. cm.

5. Status

❍ Single ❍ Marriage ❍ Divorce ❍ Widow

6. Residence in present

❍ Room in factory ❍ Room/house for rent

❍ Individual house ❍ Other …….

7. Member in family …… peoples

Part II Work history

8. In presently, you are working in …….. section

Duration of working in this section …… years ……. months

9. Have you ever worked in other section before working in this section ?

❍ Yes Section …….. Duration ……. Years

Section …….. Duration ……. Years

Section …….. Duration ……. Years

❍ No

10. Have you ever worked in other furniture factory before working in this factory?

❍ Yes Section …….. Duration ……. Years

Section …….. Duration ……. Years

❍ No

11. Have you ever worked in factory or place where exposed to dust before ?

❍ Yes Section …….. Duration ……. Years

Section …….. Duration ……. Years

❍ No

12. Have you ever worked in factory or place where exposed to gases or vapors chemical before ?

❍ Yes Section …….. Duration ……. Years
Section …….. Duration ……. Years

❍ No

Part III Health behavior

13. Have you ever been to smoking?

❍ Yes ❍ No (skip to 19.)

14. In the present, do you smoking?

❍ Yes

❍ No You stopped at the age …….. years

15. Duration of smoking …… years

16. You smoking about …… units/day

17. Have your member in family had smoking?

❍ Yes Number …… people

❍ No

18. Have you ever get education about personal protective equipments before?

❍ Yes ❍ No

19. Have you ever wear personal protective equipment in working time?

❍ Wear everyday

❍ Wear sometime

❍ Not wear (skip to Part IV)

20. In working time, what the personal protective equipment did you wear? (can choose more than 1 answer)

❍ Safety hat ❍ Glasses ❍ Ear muffs/ear plugs

❍ Mask ❍ Gloves ❍ Safety shoes

21. How long did you wear personal protective equipment?

❍ Less than 2 hours/day

❍ 2-4 hours/day

❍ 4-6 hours/day

❍ All day

Part IV Respiratory symptoms, nose, eyes and skin symptoms in the part

22. Do you usually cough at first time in the morning or on getting up?

❍ Yes ❍ No

23. Do you usually bring up phlegm, sputum or mucus from your chest first thing in the morning?

❍ Yes ❍ No

24. Do you have dyspnea or chest tightness in working time?

❍ Yes ❍ No

25. Do you have breathlessness or shortness of breath in working time?

❍ Yes ❍ No

26. Do you get short of breath while walking on level ground or walking upstairs?

❍ Yes ❍ No

27. Do you have chest ever sound wheezing or whisting?

❍ Yes ❍ No

28. Do you have sneezing, runny nose, blocknose, nasal stuffiness and nose irritation ?

❍ Yes ❍ No

29. Do you have irritant eyes, conjunctivitis or sore eye ?

❍ Yes ❍ No

30. Do you have skin dermatitis, skin itchy or irritation on face, hand and arm?

❍ Yes ❍ No

Part V History of Respiratory illness

31. Have you ever had these illness in the part?

❍ Bronchitis ❍ Pneumonia ❍ Allergy ❍ Chronic bronchitis
❍ Emphysema ❍ Asthma ❍ Not have illness

32. In presently, what illness do you have ?

❍ Bronchitis ❍ Pneumonia ❍ Allergy ❍ Chronic bronchitis
❍ Emphysema ❍ Asthma ❍ Not have illness

33. What illness that you get diagnosed from doctor ?

❍ Bronchitis ❍ Pneumonia ❍ Allergy ❍ Chronic bronchitis
❍ Emphysema ❍ Asthma ❍ Never diagnosed from doctor

Part VI Acute symptoms and frequency of work related symptom in once week

Symptoms	Yes	No	Frequency of symptoms in one week		
			Once a week	More than once but not everyday	Everyday
34. Cough					
35. Cough & sputum					
36. Wheezing					
37. Dyspnea					
38. Breathlessness					
39. Irritant nose					
40. Blocknose					
41. Irritant eyes					
42. Malaise					
43. Headache					
44. Irritant skin					
45. Skin itchy					

B. General characteristics in each section of furniture workers

Table B-1 Number and percentage of general characteristics in each section

Variables	Section					
	Part (n=35)	**Sanding (n=19)**	**Assembly (n=22)**	**Coating (n=15)**	**Packing (n=29)**	**Total (n=120)**
1. Sex						
- Male	14 (32.56%)	2 (4.65%)	10 (23.25%)	3 (6.98%)	14 (32.56%)	43 (35.83%)
- Female	21 (27.28%)	17 (22.08%)	12 (15.58%)	12 (15.58%)	15 (19.48%)	77 (64.17%)
2. Age						
- < 20 years	-	-	-	-	2 (100%)	2 (1.67%)
- 20-29 years	15 (23.44%)	8 (12.5%)	13 (20.31%)	10 (15.63%)	18 (28.12%)	64 (58.33%)
- 30-39 years	17 (38.64%)	9 (20.45%)	7 (15.91%)	4 (9.09%)	7 (15.91%)	44 (36.67%)
- 40-49 years	3 (30.0%)	2 (20.0%)	2 (20.0%)	1 (10.0%)	2 (20.0%)	10 (8.33%)
3. Status						
- Single	9 (26.47%)	3 (8.82%)	6 (17.65%)	4 (11.77%)	12 (35.29%)	34 (28.33%)
- Marriage	24 (30.0%)	15 (18.75%)	14 (17.5%)	10 (12.5%)	17 (21.25%)	80 (66.67%)
- Divorce	-	1 (50.0%)	1 (50.0%)	-	-	2 (1.67%)
- Widow	2 (50.0%)	-	1 (25.0%)	1 (25.0%)	-	4 (3.33%)

Table B-1 Number and percentage of general characteristics in each section (Cont.)

Variables	Section					
	Part (n=35)	**Sanding (n=19)**	**Assembly (n=22)**	**Coating (n=15)**	**Packing (n=29)**	**Total (n=120)**
4. Residence						
- In factory	7 (29.17%)	1 (4.17%)	5 (20.83%)	-	11 (45.83%)	24 (20.0%)
- Room for rent	6 (27.27%)	1 (4.55%)	3 (13.64%)	2 (9.09%)	10 (45.45%)	22 (18.33%)
- Private home	22 (29.73%)	17 (22.97%)	14 (18.92%)	13 (17.57%)	8 (10.81%)	74 (61.67%)
5. Members in family						
- 1-3 peoples	17 (28.81%)	6 (10.71%)	11 (18.64%)	4 (6.78%)	21 (35.59%)	59 (49.17%)
- 4-6 peoples	14 (28.57%)	10 (20.41%)	10 (20.41%)	9 (18.37%)	6 (12.24%)	49 (40.83%)
- 7-9 peoples	4 (36.36%)	2 (18.18%)	1 (9.09)	2 (18.18%)	2 (18.18%)	11 (9.17%)
- ≥ 10 peoples	-	1 (100%)	-	-	-	1 (0.83%)
6. BMI						
- Under weight	7 (29.17%)	7 (29.17%)	4 (16.67%)	3 (12.5%)	3 (12.5%)	24 (20.0%)
- Normal	23 (28.75%)	10 (12.5%)	14 (17.5%)	11 (13.75%)	22 (27.50%)	80 (66.67%)
- Over	5 (35.71%)	2 (14.29%)	3 (21.43%)	-	4 (28.57%)	14 (11.67%)
- Obesity	-	-	1 (50.0%)	1 (50.0%)	-	2 (1.67%)

Table B-1 Number and percentage of general characteristics in each section (Cont.)

Variables	Section					
	Part (n=35)	**Sanding (n=19)**	**Assembly (n=22)**	**Coating (n=15)**	**Packing (n=29)**	**Total (n=120)**
7. Duration of work						
- ≤ 2 years	15 (24.19%)	7 (11.29%)	10 (16.13%)	7 (11.29%)	23 (37.10%)	62 (51.67%)
- > 2 years	20 (34.48%)	12 (20.69%)	12 (20.69%)	8 (13.79%)	6 (10.34%)	58 (48.33%)
8. Smoking habit						
- Smoking	8 (21.58%)	1 (3.45%)	8 (27.59%)	2 (6.90%)	10 (34.48%)	29 (24.17%)
- No-smoking	27 (29.67%)	18 (19.78%)	14 (15.38%)	13 (14.29%)	19 (20.89%)	91 (75.83%)
9. Members in family smoking						
- Have	23 (37.10%)	10 (16.13%)	8 (12.90%)	8 (12.90%)	13 (20.97%)	62 (51.67%)
- Not have	12 (20.69%)	9 (15.52%)	14 (24.14%)	7 (12.07%)	16 (27.59%)	58 (48.33%)
10. Wearing PPE						
- Wear	31 (30.10%)	19 (18.45%)	17 (16.51%)	15 (14.56%)	21 (20.39%)	62 (51.67%)
- Not wear	4 (23.53%)	-	5 (29.41%)	-	8 (47.06%)	58 (48.33%)

Table B-2 Number and percentage of respiratory system, eyes, nose, skin and past respiratory illness

Variables	Section					
	Part (n=35)	**Sanding (n=19)**	**Assembly (n=22)**	**Coating (n=15)**	**Packing (n=29)**	**Total (n=120)**
1. Cough in morning	3 (50.0%)	2 (33.33%)	-	-	1 (16.67%)	6 (5.0%)
2. Sputum in morning	5 (21.74%)	2 (8.70%)	6 (26.08%)	2 (8.70%)	8 (34.78%)	23 (19.17%)
3. Dyspnea	7 (25.43%)	4 (14.81%)	2 (7.41%)	5 (18.52%)	9 (33.33%)	27 (22.5%)
4. Breathlessness	10 (33.33%)	5 (16.67%)	3 (10.0%)	3 (10.0%)	9 (30.0%)	30 (25.0%)
5. Wheezing	4 (28.57%)	1 (7.14%)	3 (21.43%)	3 (21.43%)	3 (21.43%)	14 (11.67%)
6. Nose irritation	13 (26.53%)	6 (12.24%)	9 (18.37%)	7 (14.28%)	14 (28.57%)	49 (40.83%)
7. Eyes irritation	9 (29.03%)	6 (19.35)	3 (9.68%)	5 (16.13%)	8 (25.81%)	31 (25.83%)
8. Skin irritation	17 (33.33%)	6 (11.76%)	7 (13.72%)	5 (9.80%)	16 (31.37%)	51 (42.5%)
9. Past respiratory illness						
• **Have problem**	13 (30.95%)	5 (11.9%)	10 (23.81%)	5 (11.9%)	9 (21.44%)	42 (35.0%)
- Bronchitis	2 (22.22%)	1 (11.11%)	4 (44.44%)	-	2 (22.22%)	9 (21.43%)
- Pneumonia	1 (33.33%)	-	2 (66.67%)	-	-	3 (7.14%)
- Allergy	11 (36.67%)	4 (13.33%)	4 (13.33%)	5 (16.67%)	6 (20.0%)	30 (71.43%)

C. Prevalence rate of allergy and symptoms of furniture workers

Table C-1 Prevalence rate of allergy and seven symptoms

Symptoms	Number of workers	Allergy		Prevalence rate / 100	Prevalence rate ratio (PRR)
		Have symptoms	Not have symptoms		
1. Cough					
- Have symptoms	23	11	12	47.83	2.02
- Not have symptoms	97	23	74	23.71	
2. Cough and sputum					2.3
- Have symptoms	28	14	14	50.0	
- Not have symptoms	92	20	72	21.74	
3. Wheeze					
- Have symptoms	13	9	4	69.23	2.96
- Not have symptoms	107	25	82	23.36	
4. Nose irritation					
- Have symptoms	39	20	19	51.28	2.97
- Not have symptoms	107	14	67	17.28	
5. Blocknose					
- Have symptoms	40	19	21	47.5	2.53
- Not have symptoms	80	15	65	18.75	
6. Eyes irritation					
- Have symptoms	27	12	15	44.44	1.88
- Not have symptoms	93	22	71	23.66	
7. Skin irritation					
- Have symptoms	45	20	25	44.44	2.38
- Not have symptoms	75	14	61	18.67	

D. The results of pulmonary function test of furniture workers

Table D-1 The results of pulmonary function test

No	Predicted value from Siriraj equation				Values from spirometry test				% Predicted Values				Results		
	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	Normal	Obstruc	Restric
1	3.87	3.21	86.55	4.06	2.86	2.86	100.00	5.67	73.82	89.06	115.55	139.73			Mild
2	4.15	3.45	86.99	4.31	2.05	2.05	100.00	2.61	49.41	59.34	114.95	60.51			Moderate
3	3.86	3.24	87.38	4.13	2.62	2.50	95.40	4.25	67.80	77.27	109.18	102.91			Mild
4	3.30	2.75	87.07	3.63	3.40	2.82	82.90	2.93	103.03	102.62	95.21	80.72	✓		
5	4.50	3.76	87.40	4.62	2.49	2.46	91.10	4.84	55.36	65.49	104.23	104.81			Moderate
6	3.04	2.59	88.96	3.49	1.95	1.91	97.90	2.53	64.12	73.77	110.05	72.53			Mild
7	3.44	2.86	86.77	3.73	2.07	1.91	92.20	2.13	60.17	66.89	106.25	57.15			Mild
8	3.90	3.31	88.49	4.26	3.38	2.99	88.40	3.91	86.63	90.26	99.89	91.72	✓		
9	4.15	3.53	88.70	4.49	3.56	3.24	91.00	4.36	85.72	91.76	102.59	97.15	✓		
10	3.61	3.09	89.14	4.06	2.84	2.84	100.00	5.29	78.72	91.87	112.19	130.26			Mild
11	4.27	3.45	84.44	4.11	3.47	2.66	76.60	2.13	81.23	77.12	90.71	51.78	✓		
12	4.22	3.61	89.06	4.58	3.56	3.26	91.50	4.04	84.29	90.43	102.74	88.23	✓		
13	4.47	3.72	86.95	4.55	3.05	2.93	96.00	3.66	68.18	78.83	110.41	80.45			Mild
14	3.61	3.05	88.14	3.98	3.14	2.87	91.40	3.76	87.10	94.19	103.70	94.50	✓		
15	3.72	3.16	88.42	4.11	3.06	2.71	88.50	3.38	82.18	85.78	100.09	82.33	✓		

Table D-1 The results of pulmonary function test (Continued)

No	Predicted value from Siriraj equation				Values from spirometry test				% Predicted Values				Results		
	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	Nor-mal	Obstruc	Restric
16	4.03	3.43	88.79	4.40	3.72	3.52	94.60	5.40	92.33	102.56	106.54	122.84	✓		
17	3.61	3.09	89.14	4.06	3.00	2.93	97.60	4.68	83.16	94.79	109.49	115.24	✓		
18	3.91	3.33	88.87	4.30	3.24	3.04	93.80	4.26	82.93	91.21	105.55	99.05	✓		
19	3.90	3.30	88.31	4.24	2.19	1.82	83.10	1.71	56.18	55.13	94.10	40.30			Moderate
20	3.89	3.15	84.64	3.86	3.39	3.05	89.97	5.65	87.20	96.86	106.29	146.23	✓		
21	3.73	3.19	89.12	4.17	4.19	3.71	88.50	4.43	112.44	116.24	99.31	106.33	✓		
22	3.49	2.99	89.14	3.95	3.44	3.19	92.70	4.52	98.55	106.66	103.99	114.35	✓		
23	4.03	3.43	88.79	4.40	3.54	3.54	100.00	6.14	87.86	103.15	112.62	139.68	✓		
24	4.28	3.56	84.37	4.11	4.15	2.03	48.92	3.32	96.97	57.02	57.95	80.78		Moderate	
25	3.61	3.09	89.14	4.06	3.41	3.14	92.00	4.22	94.52	101.58	103.21	103.91	✓		
26	4.04	3.31	85.54	4.08	4.58	4.03	87.90	4.54	113.31	121.79	102.76	111.33	✓		
27	3.72	3.09	86.78	3.95	3.46	3.20	92.40	3.82	93.13	103.63	106.47	96.59	✓		
28	3.97	3.38	88.83	4.35	3.51	3.36	95.70	3.88	88.46	99.33	107.73	89.22	✓		
29	4.54	3.84	88.54	4.77	3.69	3.45	93.40	4.01	81.21	89.75	105.49	83.99	✓		
30	4.78	4.08	89.49	5.05	4.30	3.91	90.00	4.67	90.05	95.93	100.56	92.49	✓		
31	3.90	3.38	90.17	4.41	3.49	3.29	94.20	4.84	89.58	97.26	104.47	109.85	✓		

Table D-1 The results of pulmonary function test (Continued)

No	Predicted value from Siriraj equation				Values from spirometry test				% Predicted Values				Results		
	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	Nor-mal	Obstruc	Restric
32	4.01	3.33	86.76	4.18	3.54	3.07	86.70	3.25	88.27	92.15	99.93	77.67	✓		
33	4.22	3.61	89.06	4.58	3.47	3.47	100.00	6.88	82.16	96.25	112.28	150.26	✓		
34	4.56	3.90	89.45	4.88	3.89	3.75	96.40	4.26	85.24	96.10	107.77	87.22	✓		
35	4.18	3.51	87.61	4.40	3.91	3.86	98.70	5.88	93.52	110.07	112.66	133.58	✓		
36	3.39	2.77	85.58	3.58	3.45	2.90	84.00	2.69	101.75	104.51	98.15	75.04	✓		
37	3.58	3.11	89.97	4.11	3.09	3.04	98.30	3.67	86.20	97.77	109.26	89.37	✓		
38	4.22	3.58	88.65	4.53	3.61	3.11	86.10	3.36	85.63	86.86	97.13	74.13	✓		
39	4.57	3.91	89.68	4.91	3.61	3.03	83.90	2.94	79.06	77.40	93.56	59.88	✓		
40	3.71	3.21	89.81	4.21	3.80	2.56	67.30	3.12	102.30	79.68	74.93	74.04		Mild	
41	3.33	2.82	88.23	3.74	2.77	2.44	100.00	4.38	83.08	86.62	113.33	117.17	✓		
42	4.23	3.65	90.10	4.68	3.82	3.51	91.80	3.78	90.39	96.04	101.89	80.77	✓		
43	4.75	3.89	85.88	4.62	4.26	3.88	91.00	4.29	89.63	99.65	105.96	92.80	✓		
44	2.70	2.35	86.63	2.90	2.29	1.97	86.00	2.40	84.81	83.75	99.28	82.79	✓		
45	2.54	2.22	87.20	2.82	2.48	2.14	86.20	2.31	97.66	96.23	98.85	81.97	✓		
46	3.45	2.89	85.78	3.13	2.59	2.39	92.20	3.40	74.99	82.67	107.48	108.76			Mild
47	3.07	2.63	86.08	3.06	2.14	2.09	97.60	3.22	69.82	79.47	113.38	105.26			Mild

Table D-1 The results of pulmonary function test (Continued)

No	Predicted value from Siriraj equation				Values from spirometry test				% Predicted Values				Results		
	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	Nor-mal	Obstruc	Restric
48	2.58	2.28	88.04	2.94	2.61	2.44	93.40	3.32	101.05	106.81	106.09	112.85	✓		
49	2.68	2.39	88.55	3.09	1.93	1.74	90.10	1.74	71.89	72.78	101.75	56.39			Mild
50	2.73	2.38	86.97	2.96	2.30	1.96	85.20	2.21	84.35	82.19	97.97	74.69	✓		
51	3.12	2.77	88.85	3.43	2.30	2.26	98.20	3.42	73.69	81.58	110.52	99.58			Mild
52	2.78	2.46	87.90	3.10	2.47	2.18	88.20	2.66	88.76	88.64	100.35	85.72	✓		
53	2.80	2.49	88.30	3.16	1.92	1.92	100.00	3.28	68.55	77.22	113.26	103.85			Mild
54	3.01	2.56	85.49	2.94	2.43	2.06	84.70	2.06	80.84	80.42	99.08	70.02	✓		
55	2.48	2.15	86.47	2.69	2.07	1.85	89.30	2.03	83.44	85.89	103.28	75.57	✓		
56	2.81	2.50	88.50	3.19	1.95	1.95	100.00	2.93	69.41	78.02	112.99	91.98			Mild
57	2.77	2.45	87.70	3.08	2.43	2.12	87.20	2.20	87.64	86.70	99.43	71.54	✓		
58	2.67	2.32	86.30	2.84	2.15	2.06	95.80	3.16	80.49	88.86	111.01	111.36	✓		
59	2.58	2.28	88.04	2.94	1.96	1.93	98.40	2.55	75.89	84.48	111.77	86.68			Mild
60	3.30	2.95	90.14	3.67	2.68	2.68	100.00	3.80	81.22	90.76	110.94	103.67	✓		
61	2.54	2.22	87.20	2.82	2.37	2.16	91.10	3.40	93.33	97.13	104.47	120.64	✓		
62	2.78	2.46	87.90	3.10	2.49	2.34	93.90	3.31	89.48	95.15	106.83	106.66	✓		
63	3.01	2.61	86.84	3.13	2.49	2.25	90.30	3.17	82.86	86.17	103.98	101.19	✓		

Table D-1 The results of pulmonary function test (Continued)

No	Predicted value from Siriraj equation				Values from spirometry test				% Predicted Values				Results		
	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	Nor-mal	Obstruc	Restric
64	2.81	2.50	88.50	3.19	1.54	1.51	98.00	1.96	54.82	60.41	110.73	61.53			Moderate
65	3.19	2.85	89.60	3.55	2.80	2.65	94.60	3.12	87.69	92.93	105.58	87.79	✓		
66	2.81	2.50	88.50	3.19	2.23	2.05	91.90	2.96	79.38	82.02	103.84	92.92			Mild
67	3.21	2.81	88.09	3.39	2.25	2.25	100.00	3.23	70.07	79.94	113.53	95.21			Mild
68	3.05	2.66	87.28	2.96	2.64	1.81	68.56	2.53	86.56	68.05	78.55	85.47		Mild	
69	2.58	2.27	87.86	2.92	2.39	2.39	100.00	3.73	92.80	105.14	113.81	127.83	✓		
70	2.87	2.48	86.17	2.96	2.59	2.13	82.20	2.14	90.37	85.99	95.39	72.25	✓		
71	2.92	2.62	89.36	3.36	2.16	1.98	91.60	2.87	73.90	75.50	102.51	85.49			Mild
72	2.88	2.50	86.35	3.00	1.74	1.60	91.90	1.50	60.36	64.09	106.42	50.06			Mild
73	2.95	2.68	90.56	3.49	2.08	2.08	100.00	3.51	70.56	77.62	110.42	100.60			Mild
74	2.94	2.57	87.13	3.13	2.06	1.93	93.60	2.34	69.98	75.06	107.43	74.72			Mild
75	3.30	2.95	90.14	3.67	2.54	2.24	88.10	2.83	76.97	75.86	97.74	77.20			Mild
76	2.57	2.26	87.69	2.89	2.25	2.06	91.50	3.16	87.64	91.10	104.34	109.21	✓		
77	2.66	2.38	89.17	3.12	2.63	2.50	95.00	3.61	98.94	104.88	106.54	115.74	✓		
78	2.58	2.28	88.04	2.94	2.03	1.88	92.60	2.34	78.60	82.30	105.18	79.54			Mild
79	3.06	2.75	89.59	3.48	1.56	1.39	89.10	1.34	50.96	50.63	99.45	85.89			Moderate

Table D-1 The results of pulmonary function test (Continued)

No	Predicted value from Siriraj equation				Values from spirometry test				% Predicted Values				Results		
	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	Nor-mal	Obstruc	Restric
80	2.60	2.31	88.40	2.99	2.69	2.39	88.80	2.64	103.62	103.64	100.45	88.32	✓		
81	2.76	2.43	87.51	3.05	2.13	2.03	95.30	2.86	77.11	83.52	108.90	93.88			Mild
82	3.32	2.98	90.69	3.73	2.29	2.26	98.60	2.67	69.06	75.75	108.72	71.57			Mild
83	3.30	2.95	90.14	3.67	2.71	2.54	93.70	2.99	82.13	86.02	103.95	81.57	✓		
84	3.30	2.86	87.53	3.36	2.62	2.47	94.20	3.59	79.33	86.29	107.62	106.88			Mild
85	3.31	2.97	90.41	3.70	2.65	2.65	100.00	4.80	80.10	89.28	110.61	129.79	✓		
86	2.40	2.14	89.02	2.84	1.94	1.87	96.30	2.55	80.87	87.56	108.17	89.78	✓		
87	3.09	2.80	90.61	3.59	2.54	2.54	100.00	3.91	82.31	90.81	110.36	108.91	✓		
88	2.92	2.59	88.23	3.24	2.13	1.92	90.10	2.42	72.85	74.15	102.12	74.61			Mild
89	3.33	2.90	88.02	3.44	2.84	2.64	94.00	3.14	85.18	90.90	106.79	91.40	✓		
90	2.77	2.46	88.52	3.15	2.23	2.13	95.50	3.39	80.57	86.45	107.89	107.49	✓		
91	3.02	2.67	88.41	3.32	2.66	2.28	85.70	2.44	88.18	85.34	96.93	73.40	✓		
92	2.86	2.55	88.70	3.24	2.46	2.44	99.10	3.79	86.05	95.76	111.73	116.84	✓		
93	3.30	2.95	90.14	3.67	2.30	2.12	92.10	2.76	69.70	71.80	102.18	75.29			Mild
94	2.62	2.38	90.01	3.16	2.48	2.48	87.90	2.26	94.48	104.33	97.66	71.43	✓		
95	3.04	2.70	88.87	3.39	2.43	2.23	91.70	2.53	80.03	82.52	103.18	74.73	✓		

Table D-1 The results of pulmonary function test (Continued)

No	Predicted value from Siriraj equation				Values from spirometry test				% Predicted Values				Results		
	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	Nor-mal	Obstruc	Restric
96	2.72	2.48	90.72	3.31	3.13	2.65	84.60	2.77	115.13	106.71	93.26	83.59	✓		
97	3.38	2.93	88.00	3.45	2.81	2.54	90.30	3.34	83.26	86.59	102.61	96.90	✓		
98	2.99	2.64	87.97	3.26	2.15	2.15	100.00	2.42	71.79	81.45	113.68	74.20			Mild
99	3.09	2.72	88.15	3.34	2.49	2.37	95.10	3.99	80.63	87.11	107.89	119.57	✓		
100	2.40	2.15	89.39	2.88	2.06	2.06	100.00	3.21	85.80	95.91	111.87	111.62	✓		
101	2.79	2.47	88.09	3.13	2.44	2.29	93.80	3.31	87.39	92.60	106.48	105.72	✓		
102	3.39	3.02	90.15	3.71	3.05	2.80	91.80	3.09	89.98	92.65	101.83	83.32	✓		
103	2.81	2.50	88.50	3.19	2.87	2.59	90.20	3.20	102.16	103.62	101.92	100.45	✓		
104	2.58	2.28	88.04	2.94	1.73	1.73	100.00	4.24	66.98	75.73	113.59	144.12			Mild
105	3.25	2.90	89.86	3.61	2.40	2.36	98.30	3.52	73.93	81.32	109.39	97.51			Mild
106	2.87	2.48	86.17	2.96	1.90	1.69	88.90	1.88	66.29	68.23	103.17	63.47			Mild
107	2.62	2.36	89.58	3.12	2.51	2.33	92.80	3.04	95.76	98.66	103.59	97.37	✓		
108	3.05	2.72	89.11	3.42	2.42	2.42	100.00	4.80	79.47	89.07	112.22	140.52			Mild
109	3.24	2.96	88.45	3.26	2.79	2.63	94.26	3.11	86.11	88.85	106.57	95.40	✓		
110	2.40	2.15	89.39	2.88	2.26	1.17	51.78	2.75	94.13	54.48	57.93	95.63		Moderate	
111	2.60	2.32	88.59	3.01	2.42	2.01	83.06	3.42	93.08	86.63	93.75	113.54	✓		

Table D-1 The results of pulmonary function test (Continued)

No	Predicted value from Siriraj equation				Values from spirometry test				% Predicted Values				Results		
	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	FVC	FEV_1	FEV_1/ FVC(%)	FEF 25-75%	Nor-mal	Obstruc	Restric
112	3.38	2.96	88.79	3.55	3.13	2.75	87.85	3.31	92.60	92.91	98.94	93.30	✓		
113	2.35	2.05	87.44	2.64	2.19	1.88	88.85	1.89	93.19	106.83	101.61	71.52	✓		
114	2.90	2.58	88.68	3.27	2.75	2.23	81.09	3.20	94.83	86.43	91.44	97.86	✓		
115	3.17	2.82	89.09	3.49	2.72	2.61	95.96	3.79	85.80	92.55	107.71	108.60	✓		
116	3.07	2.76	89.84	3.50	2.83	2.58	91.17	4.79	92.18	93.48	101.48	136.86	✓		
117	3.39	2.95	88.26	3.49	3.04	2.54	83.55	3.46	89.68	86.10	94.67	99.14	✓		
118	2.73	2.43	88.54	3.12	2.50	2.19	87.60	3.80	91.58	90.12	98.94	121.79	✓		
119	2.61	2.28	86.58	2.82	2.41	2.03	84.23	2.62	92.34	89.04	97.29	92.91	✓		
120	3.28	2.92	89.60	3.60	2.87	2.64	91.99	3.10	87.50	90.41	102.66	86.11	✓		

E. Figure in this study

Figure E-1 Area sampling of wood dust

Figure E-2 Personal sampling of respirable wood dust

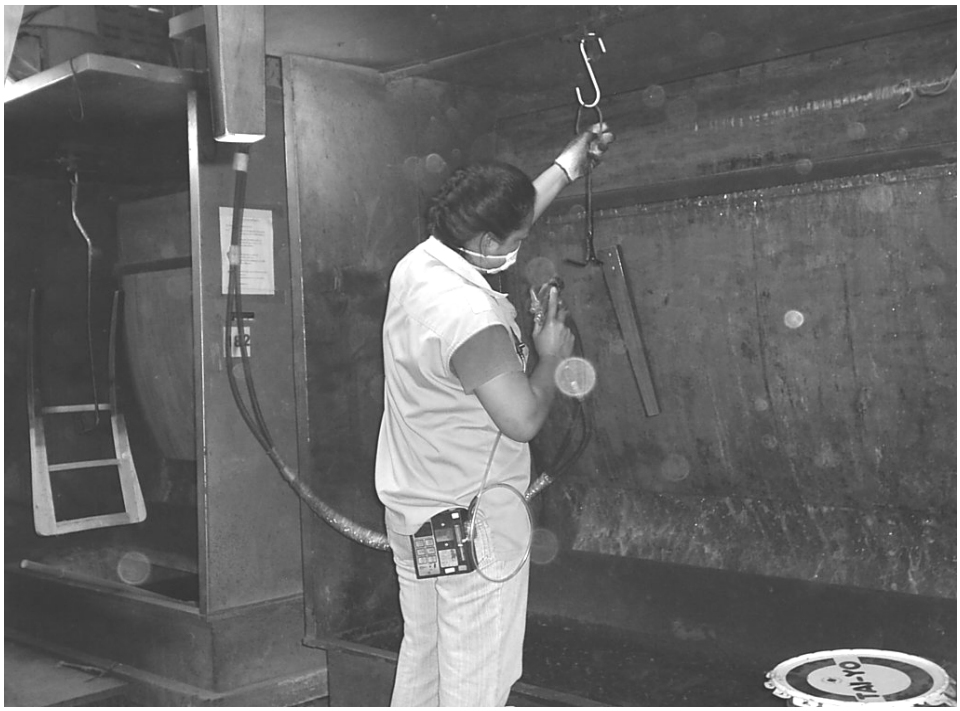

Figure E-3 Personal sampling of vapor chemicals

Figure E-4 Pulmonary function test of worker

BIOGRAPHY

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