THE INFLUENCE OF INDOOR AIR POLLUTION SOURCES ON RESPIRATORY HEALTH OF OCCUPANTS IN OFFICES: A CROSS-SECTIONAL STUDY AT SUAN SUNANDHA RAJABHAT UNIVERSITY, BANGKOK, THAILAND

Mr. Thammarak Srimarut

จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY

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อิทธิพลของแหล่งกำเนิดมลพิษอากาศภายในอาคารต่อสุขภาพระบบทางเดินหายใจของผู้ปฏิบัติงานในสำนักงาน: ศึกษาแบบภาคตัดขวางที่มหาวิทยาลัยราชภัฏสวนสุนันทา กรุงเทพมหานคร ประเทศไทย

นายธรรมรักษ์ ศรีมารุต

จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรดุษฎีบัณฑิต
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ลิขสิทธิ์ของจุฬาลงกรณ์มหาวิทยาลัย

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By	Mr. Thammarak Srimarut
Field of Study	Public Health
Thesis Advisor	Professor SURASAK TANEEPANICHSKUL, M.D.

Accepted by the COLLEGE OF PUBLIC HEALTH SCIENCES, Chulalongkorn University in Partial Fulfillment of the Requirement for the Doctor of Philosophy

.... Dean of the COLLEGE OF PUBLIC HEALTH SCIENCES
(Professor SATHIRAKORN PONGPANICH, Ph.D.)

DISSERTATION COMMITTEE

.... Chairman
(Associate Professor RATANA SOMRONGTHONG, Ph.D.)

.... Advisor
(Professor SURASAK TANEEPANICHSKUL, M.D.)

.... Examiner
(Professor SATHIRAKORN PONGPANICH, Ph.D.)

.... Examiner
(Associate Professor WATTASIT SIRIWONG, Ph.D.)

จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY

.... External Examiner
(Associate Professor Witaya Yoosook, D.Eng.)

ธรรมรักษ์ ศรีมารุต : อิทธิพลของแหล่งกำเนิดมลพิษอากาศภายในอาคารต่อสุขภาพระบบทางเดินหายใจของผู้ปฏิบัติงานในสำนักงาน: ศึกษาแบบภาคตัดขวางที่มหาวิทยาลัยราชภัฏสวนสุนันทา กรุงเทพมหานคร ประเทศไทย. (THE INFLUENCE OF INDOOR AIR POLLUTION SOURCES ON RESPIRATORY HEALTH OF OCCUPANTS IN OFFICES: A CROSS-SECTIONAL STUDY AT SUAN SUNANDHA RAJABHAT UNIVERSITY, BANGKOK, THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก : ศ. นพ.สุรศักดิ์ ฐานีพานิชสกุล

มลพิษอากาศภายในอาคารประกอบด้วยสารหลากหลายชนิดซึ่งสามารถเกิดขึ้นจากแหล่งต่างๆ โดยเฉพาะสารอินทรีย์ระเหยง่ายและฝุ่นละอองขนาดเล็ก การสัมผัสกับมลพิษเหล่านี้สามารถก่อให้เกิดผลต่อสุขภาพทางเดินหายใจทั้งแบบเฉียบพลันและเรื้อรัง การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาผลของมลพิษอากาศต่อสุขภาพทางเดินหายใจของผู้ปฏิบัติงานในห้องสำนักงานและปัจจัยที่ส่งผลต่อสุขภาพทางเดินหายใจ

การศึกษานี้ทำการศึกษาห้องสำนักงานจำนวน 14 สำนักงาน โดยตรวจวัดปริมาณความเข้มข้นในอากาศของฝุ่นละอองขนาดเล็ก ($PM_{2.5}$) และสารอินทรีย์ระเหยง่าย (TVOC) ในห้องสำนักงาน ทำการตรวจวัดที่ความสูง 1.20 เมตร เป็นเวลา 8 ชั่วโมง พร้อมสำรวจข้อมูลอายุตึก วัสดุพื้น วัสดุตกแต่ง ปริมาตรของแต่ละสำนักงาน จำนวนเครื่องคอมพิวเตอร์ เครื่องพิมพ์ และเครื่องถ่ายเอกสารในห้องสำนักงาน กลุ่มตัวอย่างคือผู้ปฏิบัติงานในห้องสำนักงานจำนวน 212 คน ทำการตรวจวัดสมรรถภาพปอด และเก็บข้อมูลแบบสอบถามอาการเกี่ยวกับทางเดินหายใจ อาทิ ไอ มีเสมหะ หายใจมีเสียงดัง และหายใจลำบาก

ผลการศึกษาพบว่า ผู้ปฏิบัติงานส่วนใหญ่เป็นเพศหญิง ไม่สูบบุหรี่ อายุเฉลี่ย 34.61 ปี ส่วนใหญ่ไม่มีประวัติการเจ็บป่วยและประวัติการทำงานในที่มีฝุ่น ฟูม ก๊าซและสารระเหยง่าย จำนวนหนึ่งในสี่ของผู้ปฏิบัติงานมีประสบการณ์ทำงานมากกว่า 10 ปี จำนวนหนึ่งในสามของผู้ปฏิบัติงานทำงานเกินวันละ 8 ชั่วโมง ตึกสำนักงานมีอายุระหว่าง 8-26 ปี พื้นเป็นกระเบื้อง กระเบื้องยาง และพรม ผนังฝ้าเป็นซีเมนต์ ยิปซั่มและกระจก เฟอร์นิเจอร์ทำจากไม้อัดเอ็มดีเอฟและเหล็ก จำนวนเครื่องคอมพิวเตอร์ เครื่องพิมพ์ และเครื่องถ่ายเอกสารในห้องสำนักงานมากที่สุด คือ 50, 28 และ 3 เครื่อง ตามลำดับ ปริมาณความเข้มข้นในอากาศของฝุ่นละอองขนาดเล็ก ($PM_{2.5}$) ในห้องสำนักงานอยู่ระหว่าง 0.015-0.039 มิลลิกรัมต่อลูกบาศก์เมตร และมีค่าเฉลี่ย 0.026 ± 0.006 มิลลิกรัมต่อลูกบาศก์เมตร ปริมาณความเข้มข้นในอากาศของสารอินทรีย์ระเหยง่าย (TVOC) ในห้องสำนักงานอยู่ระหว่าง 45.33-260.67 ส่วนในพันล้านส่วน และมีค่าเฉลี่ย 156.38 ± 59.34 ส่วนในพันล้านส่วน พบความชุกของสมรรถภาพปอดผิดปกติแบบจำกัดการขยายตัว แบบอุดกั้น และแบบผสมเป็น 236, 28 และ 28 ต่อพันราย ความชุกของอาการไอ มีเสมหะ หายใจมีเสียงดัง และอาการหายใจลำบากเป็น 255, 160,184 และ 156 ต่อพันราย จากการวิเคราะห์การถดถอยพบว่า ความเข้มข้นของสารอินทรีย์ระเหยง่ายสัมพันธ์กับ FVC และอาการหายใจมีเสียงดังอย่างมีนัยสำคัญทางสถิติ ($p < 0.05$), ความเข้มข้นของฝุ่นละอองขนาดเล็กกับ FEV1/FVC มีความสัมพันธ์กันอย่างมีนัยสำคัญทางสถิติ ($p < 0.05$), การสูบบุหรี่สัมพันธ์กับอาการไออย่างมีนัยสำคัญทางสถิติ ($p < 0.05$) และยังพบความสัมพันธ์อย่างมีนัยสำคัญทางสถิติ ($p < 0.05$) ระหว่างประสบการณ์ทำงานในที่มีก๊าซหรือสารอินทรีย์ระเหยง่ายกับอาการมีเสมหะ และระหว่างประสบการณ์ทำงานในห้องสำนักงานกับ FEV1/FVC และพบว่า กลุ่มที่สัมผัสกับสารอินทรีย์ระเหยง่ายในระดับสูงมีโอกาสพบสมรรถภาพปอดผิดปกติแบบจำกัดการขยายตัวมากกว่ากลุ่มที่สัมผัสในระดับต่ำ 9.289 เท่า และมีโอกาสเกิดอาการหายใจมีเสียงดัง 3.196 เท่า กลุ่มที่สัมผัสกับฝุ่นละอองขนาดเล็กในระดับสูงมีโอกาสพบสมรรถภาพปอดผิดปกติแบบอุดกั้นมากกว่ากลุ่มที่สัมผัสในระดับต่ำ 3.588 เท่า การสูบบุหรี่เสี่ยงเกิดอาการไอมากขึ้น 2.438 เท่า ผู้ที่เคยทำงานสัมผัสกับก๊าซอินทรีย์ระเหยง่ายมีโอกาสเกิดเสมหะมากขึ้น 4.184 เท่า เพศหญิงมีโอกาสเกิดอาการหายใจลำบากมากกว่าเพศชาย 2.791 เท่า

ผลการศึกษานี้แสดงว่าการสัมผัสกับมลพิษอากาศภายในอาคารอาจมีความเสี่ยงต่อสุขภาพทางเดินหายใจ อีกทั้งการสูบบุหรี่และประสบการณ์ทำงานก็อาจส่งผลต่อสุขภาพทางเดินหายใจ ดังนั้นถ้ามลพิษอากาศภายในอาคารน้อยลงอาจทำให้ความเสี่ยงต่อสุขภาพทางเดินหายใจลดลงได้

ภาควิชา	ไม่สังกัดภาควิชา/เทียบเท่า	ลายมือชื่อนิสิต	
สาขาวิชา	สาธารณสุขศาสตร์	ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก	
ปีการศึกษา	2561		

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Chulalongkorn University

5479160653 : DOCTOR OF PHILOSOPHY

Thammarak Srimarut : THE INFLUENCE OF INDOOR AIR POLLUTION SOURCES ON RESPIRATORY HEALTH OF OCCUPANTS IN OFFICES: A CROSS-SECTIONAL STUDY AT SUAN SUNANDHA RAJABHAT UNIVERSITY, BANGKOK, THAILAND. ADVISOR: Prof. SURASAK TANEEPANICHSKUL, M.D.

Background: Indoor air pollution contains several substances and can emanate from a range of sources. In particular importance might be substances known as volatile organic compounds and respirable particulates. The exposure to indoor air pollution can induce a wide range of acute and chronic respiratory health effects. The study's aims were to identify the effect of indoor air pollution sources and concentrations in offices on respiratory health of occupants and identify potential factors that may be related to respiratory health problems.

Methods: Fourteen offices were measured the concentration of $PM_{2.5}$ and TVOC at 1.20 meters high for 8 hours and office characteristics such as building age, floor and furnishing materials, room volume were observed together with number of computers, printers and photocopiers. The 212 occupants in these offices were questioned and tested the lung function. The subjective respiratory symptoms were cough, phlegm, wheezing and short breathing. Focus group discussions was conducted with twelve occupants with abnormal lung function and symptoms

Results: Two hundred and twelve occupants mostly are female, nonsmoker and age average 34.61 ± 7.501 years old. They mostly report no history in medical records and history in dusty job, gas or volatile job and fume job. Quarter of them have over ten year experience in current job and two third work more than eight hour a day. The age of office buildings are 8-26 years. Floor materials are tile, rubber, carpet and furnishing materials are MDF, cement, gypsum, glass and metal. The most number of computers, printer and photocopiers is 50, 28 and 3 sets respectively. The mean concentration of $PM_{2.5}$ in these offices is 0.026 ± 0.006 mg/m^3 and in range of 0.015 - 0.039 mg/m^3. The mean concentration of TVOC in these offices is 156.38 ± 59.34 ppb and in range of 45.33 – 260.67 ppb. The prevalence of restrictive lung function, obstructive lung function and combined are 236, 28 and 28 cases per thousand persons respectively and the prevalence of cough, phlegm, wheezing and short breathing are 255, 160, 184 and 156 cases per thousand persons respectively. The logistic regression analysis shows that concentration of TVOC was significantly associated with FVC and wheeze symptoms (p-value < 0.05), concentration of $PM_{2.5}$ was significantly associated with FEV1/FVC (p-value < 0.05) and smoking was significantly associated with cough (p-value < 0.05). The significantly association between history in gas/volatile job and phlegm, current work experience and FEV1/FVC were found. The odds of restrictive abnormal lung function were 9.289 times higher in high TVOC exposure and 0.110 times lower in the large office. The odds of obstructive abnormal lung function were 3.588 times higher in the high $PM_{2.5}$ exposure and 3.407 times higher in longer experience in current job. The odds of cough were 2.438 times higher in smoker. The odds of phlegm were 4.184 times higher in former exposure in gas or volatile. The odds of wheezing were 3.196 times higher in the high TVOC exposure. The odds of short breathing were 2.791 times higher in female.

Conclusion: Indoor air pollution exposure can risk the respiratory health effects. Smoking and work experience also affect to the respiratory health. The risk of occupational respiratory health may decrease if indoor air pollution become lower.

Department:	Common Course	Student's Signature ....
Field of Study:	Public Health	Advisor's Signature ....
Academic Year:	2018	

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Thammarak Srimarut

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Chapter I

Introduction

1.1 Background

An air pollution exposure is major public health concern, air pollutants have been linked to a range of adverse health effects include respiratory infections, heart disease, and lung cancer. The decreased levels of air pollution concentration will reduce the global health burden related to these illness and also greenhouse gas emissions and global warming effects (WHO, 2008, 2010). An important issue about occupational health and safety is indoor air quality (IAQ) problem. People may spend an average of 87% of their time in enclosed buildings (Klepeis et al., 2001). As people spend most of their time indoor, the IAQ is important for their breath. Indoor pollutants can emanate from a range of sources. Of particular importance might be substances known as volatile organic compounds and respirable particulates. The number and amount of organic compounds have increased with the greater use chemical and synthetic building materials. The emissions of volatile organic compounds from building products including building materials and furnishings influence the indoor air quality. The concentrations of volatile organic compounds are higher in indoor air than in outdoor air so the IAQ influences public health more than outdoor air quality. In addition to during the decades, personal computers, printers, and photocopiers have become common in office environments. These also have changed indoor air quality by several pollutant emissions.

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Organic chemicals are widely used as ingredients in household products such as paints, vanishes, wax, cleansers, aerosol sprays, disinfectants etc. volatile organic compounds are emitted as gases from certain solids or liquids and include a various chemicals which have adverse health effects. The volatile organic compounds and particulates can be also emitted from personal computers, printers, photocopiers and people activities. The exposure to volatile organic compounds and particulates can induce a wide range of acute and chronic respiratory health effects such as sensory irritation, nervous system impairment, lung function, asthma and cancer. Sign and symptoms associated with exposure to volatile organic compounds are eye, nose and throat irritation, allergic skin reaction, headaches, dizziness, emesis and fatigue. Many organic compounds are known to cause cancer in animals, some are suspected of causing, or are known to cause, cancer in humans. The perceived IAQ is odor perception, sensory irritation in eye and airways, symptoms related to the central nervous system (M. Hodgson, 2002; Jaakkola, Yang, Ieromnimon, & Jaakkola, 2007). The poor IAQ results in allergic and asthma symptoms, chronic obstructive and pulmonary diseases, airborne respiratory infections, cardiovascular mortality and morbidity, lung cancer, odor and sensory irritation in eyes and airways (Fernandes, 2009).

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In previous time, most buildings used natural ventilation by air movement from indoor-outdoor air pressure difference (non-sealed buildings). But at the present time, most office buildings use mechanical ventilation systems to exchange indoor-outdoor air and circulate air within the buildings (sealed buildings). Tightly sealed buildings are concerned for the health of people who live and work inside. A population living in the tight buildings catch upper respiratory diseases at rates 46 to

50% higher than the population living in better ventilated buildings (Skolnick, 1989). Some symptoms such as eye dryness, runny nose, dry throat and lethargy were more prevalence in sealed building than non-sealed building.

A concentration of indoor air pollution depend on a large number of factor such as indoor sources and rate of emission, removal rate of pollutants from indoor surfaces, exchange rate of air, and pollutant contaminated from outdoor (Beak, 1997; Kamen, 1999; Thatcher, 1995). Up to date offices are built with materials, equipment and usage of various cleaning agents which emit chemicals and particles reflect IAQ along with the incoming outdoors. In addition, pollutants that are emitted from office equipment such as laser printer emit ozone, volatile organic compounds and particles (H. Salonen et al., 2009; Wells et al., 2017; Weschler & Carslaw, 2018; P. Wolkoff, 2013). The best way to reduce indoor air expose is by reducing products that contain volatile organic compounds. Try to find safer substances and to be sure to have adequate ventilation. The possible or practical strategy for control indoor air contaminants is using ventilation filtration, and source control.

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The concentration of $PM_{2.5}$ in air conditioned university classroom with wooden floor is 26 $\mu g/m^3$ on weekdays and the concentration of $PM_{2.5}$ in air conditioned university classroom with carpeted floor is 37 $\mu g/m^3$ on weekdays (Klinmalee, Srimongkol, & Kim Oanh, 2009). The study on concentration of volatile organic compounds in classroom indicated total volatile organic compounds was 58 $\mu g/m^3$ (Godwin, 2007), the maximum mean TVOC value was reported as 180 $\mu g/m^3$ (D. Norback, Torgen, M., Edling, C., 1990).

Although many studies have reported IAQ and associate exposure related symptoms in office workers (Azuma, Ikeda, Kagi, Yanagi, & Osawa, 2015; Bluyssen et al., 2016; Brightman, Milton, Wypij, Burge, & Spengler, 2008; Magnavita, 2015; Reijula & Sundman-Digert, 2004b). Few studies have been done on lung function of office workers. There are many sources of indoor air pollution in office such as computer, printer, copier, furniture, cleaning agent, building material and personal activity perhaps including outdoor air quality. In university office is a kind of sealed office that has many indoor air pollution sources and mass documents.

1.2 Research Questions

1) Do the indoor air pollution sources and concentrations in offices influence on respiratory health of occupants as measured by lung function and respiratory symptoms prevalence?

2) What are potential factors which related to respiratory health problems in risk group (have abnormal lung function and respiratory symptoms)?

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1.3 Hypothesis

1) The indoor air pollution sources and concentrations in offices influence on respiratory health of occupants as measured by lung function and respiratory symptoms prevalence.

2) Some potential factors may be related to respiratory health problems in risk group (have abnormal lung function and respiratory symptoms).

1.4 General Objective

To identify the effect of indoor air pollution sources and concentrations in offices on respiratory health of occupants as measured by lung function and respiratory symptoms prevalence and identify potential factors that may be related to respiratory health problems in risk group (have abnormal lung function and respiratory symptoms).

1.5 Specific Objectives

- To characterize sources and concentrations of indoor air contaminants in offices
- To characterize the prevalence of lung function and respiratory symptoms.
- To examine the parameters that affect on lung function.
- To examine the parameters that affect on respiratory symptoms.
- To describe potential factors which may be related to respiratory health problems in risk group (have abnormal lung function and respiratory symptoms).

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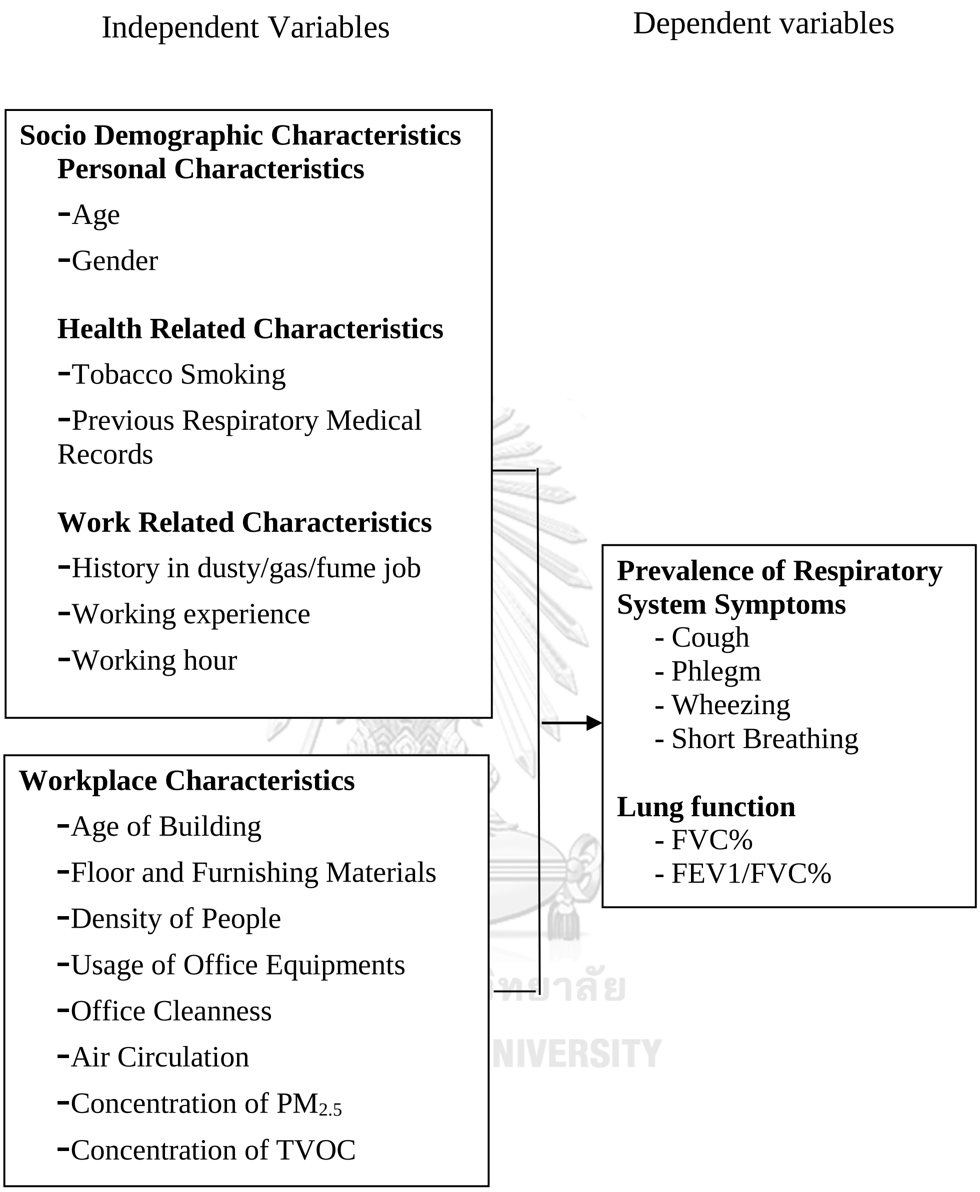
1.6 Conceptual Framework



1.7 Operational Definitions

Indoor Air Quality (IAQ) is the air quality within buildings and structures, especially as it relates to the health and comfort of building occupants.

Indoor air pollution is when pollutants from things such as gases and particles contaminate the air indoors include the physical, chemical, and biological characteristics of air in the indoor environment. Indoor air pollution is the presence of one or more contaminants indoors that carry a certain degree of human health risk.

Volatile Organic Compounds (VOCs) are organic chemicals that have a high vapor pressure at ordinary, room-temperature conditions. Their high vapor pressure results from a low boiling point, which causes large numbers of molecules to evaporate from the liquid or solid form of the compound and enter the surrounding air such as benzene, toluene, xylene etc.

Total Volatile Organic Compounds (TVOC) is a grouping of a wide range of organic chemical compounds to simplify reporting when these are present in ambient air or emissions such as group of aliphatic and aromatic hydrocarbon etc.

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Particulate Matter 2.5 ($PM_{2.5}$) are fine particles that suspend in the air (particle size less than 2.5 micrometers)

Medium density fiberboard (MDF) is an engineered wood product made by breaking down hardwood or softwood residuals into wood fibers, combining it with wax and a resin binder, and forming panels by applying high temperature and pressure.

Lung Function Test or Spirometry is a complete evaluation of the respiratory system to identify the severity of lung impairment.

Forced Vital Capacity (FVC) is the volume of air that can forcibly be blown out after full inspiration, measured in liters. The normal value of FVC is eighty percent.

Forced Expiratory Volume (in 1 second) (FEV1) is the volume of air that can forcibly be blown out in one second, after full inspiration.

Forced Expiratory Volume (in 1 second) per Forced Vital Capacity (FEV1/FVC) is the ratio of the volume of air that can forcibly be blown out in one second after full inspiration and the volume of air that can forcibly be blown out after full inspiration. The normal value of FVC is seventy percent.

Obstructive lung disease is the diseases that reduce flow from the lungs. Measured by lung function test, FEV1/FVC less than seventy percent.

Restrictive lung disease is the diseases that reduce the ability of lungs to expand fully. Measured by lung function test, FVC less than eighty percent.

Combined is the disease that combine obstructive and restrictive lung function.

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Chapter II

Review of Literature

This chapter contains relating concepts and researches of the study, as follows: Indoor air pollution, Volatile organic compounds, Volatile organic compounds in office building, Factors and health effects, Particulates, Respiratory System, Spirometry, Indoor exposure and health effects and Qualitative research.

2.1 Indoor air pollution

Indoor air pollution is caused by an accumulation of contaminants that mostly come from inside the building, and some from outdoors. Common sources of indoor air pollution include tobacco smoke, biological organisms, building materials and furnishings, cleaning agents, copy machines, and pesticides (U.S.EPA, 1990). There are many indoor air contaminants shown in table 2.1 with their main sources.

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Table 2.1 Common indoor air contaminants and their main sources

Contaminants	Sources
Carbon dioxide (CO_2), tobacco smoke, perfume	building occupants
Dust, fiberglass, asbestos, gases, including formaldehyde	building materials
Toxic vapors, volatile organic compounds	workplace cleansers, solvents, pesticides, disinfectants, glues
Gases, vapors, odors	furniture, carpets, and paints
Dusts	carpets, fabric
VOC/TVOC (total volatile organic compounds), Particles, Ozone	Printers, photocopiers, personal computer
Microbial contaminants, fungi, moulds, bacteria	damp areas
Ozone	photocopiers, electric motors, electrostatic air cleaners

Indoor pollution can affect occupants. The dirtiness of the air inside offices occurs when toxic substances attach to various objects in building. Contaminant agents, whether volatile or in suspension, enter into direct contact with the occupants through their skin, eyes, nose and throat and damage them. Occupants of new buildings rarely open the windows to allow air circulation so that the air ventilation system in new buildings works by using the air inside the building drawing in only 25% fresh air from outside. Pollution in the office buildings consists of toxic gas or invisible molecules. These things harm our health. The pollution which we cannot see occurs more rapidly inside buildings than it does outside them so there are higher indoor pollutants concentration than outdoors (Godish, 1989; Li, Lee, & Chan, 2001; U.S.EPA, 1991).

The characteristics of the buildings which are prone to have indoor air quality problem as follows;

1) A tight building that prevents fresh outdoor air from entering. It has a controlling mechanism that forces the heating, ventilating and air-conditioning system to circulate and condition the inside air only.

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2) A building that is designed to select the heating, ventilating and air-conditioning system and which does not allow individual control. Occupants of a certain room may not feel comfortable but they cannot adjust the conditions for themselves. This may make some occupants in the building feel uncomfortable, stressed and sick. Furthermore, the indoor circulation rate may not be sufficient for the occupants, with an unsuitable setup of temperature range and relative humidity.

When the thermostat detects that the level of temperature and relative humidity are equal to the determined values, it sends a signal to the fan controlling device to reduce the distributed air volume. In the meantime, the fans which circulate and ventilate indoor air and those which bring the outdoor air into the building would also be slowed down. Therefore, there is not enough air volume to meet the demand of the occupants or to de-pollute the indoor air.

3) The location of indoor ventilation inlets. As they are normally placed on the ceiling, air flow is often blocked or diverted by some objects, decreasing indoor air distribution and circulation rates (while the air condition and ventilation work on part load) and area coverage. As a result, the indoor air ventilation process is not effective.

4) A building whose air flow circuit in the heating, ventilating and air-conditioning, distributing and circulating is not continuous and covers an insufficient area. Therefore, there is a lack of indoor air for the occupants and an accumulation of indoor pollution.

5) A building in which the location of outdoor ventilation and exhaust inlets are inappropriate. The purpose of installing ventilation inlets is to bring in outdoor air to mix with a part of the remaining indoor air at the Air Handing Unit (AHU). Bringing outdoor air into the building may also bring in contaminants which accumulate inside the building, especially when the air inlets are located near heavy traffic roads, parking lots or highways. An insufficient number of air inlets and outlets can slow down elimination of indoor contamination.

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6) A building in which there are construction materials, decoration materials, furniture, synthetic materials, modern office equipment, cleaning products and floor wax which can cause irritation to its occupants. Dust and toxic fumes from formaldehyde, hydrocarbon, and amines compounds, which have nitrogen and other particles in them, can affect the human body and produce dispersion of toxic

contaminants within the building. Also, these contaminants may be the source of germs, bacteria and viruses, provoking infections or sicknesses (Sensod, 2010).

Some of chemicals may have short- and long-term adverse health effects, especially organic chemicals are widely used as ingredients in household products. Paints, varnishes, and wax all contain organic solvents. Concentration of many volatile organic compounds are consistently higher indoors (up to ten times higher) than outdoors. The volatile organic compounds are emitted by a wide variety of products such as paint, lacquers, cleaning supplies, pesticides, building materials and furnishings, office equipment such as copiers and printers.

An increasing number of health effects related to time spent in buildings due to physical and chemical exposures in the office environment. There is higher prevalence of work-related upper respiratory symptoms and tiredness was observed in the air conditioned building than in the building with natural ventilation (J. L. Rios et al., 2009). The chemical reactions can occur indoors, and there is indirect evidence that they are associated with eye and airway irritation (Peder Wolkoff & Nielsen, 2001). According to (Sensod., 2010) the frequency of using the office equipment, the frequency of office cleaning, the smoker and eyesight condition problem affect to health symptoms such as respiratory system, nose and throat.

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2.2 Volatile Organic Compounds

Volatile Organic Compounds are organic chemicals that have a high vapor pressure at ordinary, room-temperature conditions. Their high vapor pressure results from a low boiling point, which causes large numbers of molecules to evaporate or sublimate from the liquid or solid form of the compound and enter the surrounding air. The volatile Organic Compounds include various substances and are everywhere in the indoor environment (Phillips, 2006). Several of the commonly known volatile Organic Compounds are benzene, chloroform, methylene chloride, octane, toluene, terpenes, and polycyclic aromatic hydrocarbon (Maroni., Seifert., & Lindvall., 1995). An example is formaldehyde, with a boiling point of –19 °C (–2 °F), slowly exiting paint and getting into the air. Health Canada classes VOCs as organic compounds that have boiling points roughly in the range of 50 to 250 °C (122 to 482 °F). The emphasis is placed on commonly encountered VOCs that would have an effect on air quality. European Union defined VOCs as any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa and can damage to visual or audible senses. In US VOCs (or specific subsets of the VOCs) are legally defined in the various laws and codes under which they are regulated. The United States Department of Labor and its Occupational Safety and Health Administration (OSHA) regulate VOC exposure in the workplace. Volatile organic compounds that are hazardous material would be regulated by the Pipeline and Hazardous Materials Safety Administration while being transported.

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In many scientific publications indicates the total concentration of volatile organic compounds rather than reports the concentration of volatile organic compounds individually, the total concentration of VOCs usually called TVOC (total volatile organic compounds) (Molhave L. & et., 1997). TVOC generally refers to sum of the concentration of individual VOCs, specific of very volatile and highly reactive compounds (Alfred T. Hodgson, 1995; A. T. Hodgson, Rudd, Beal, & Chandra, 2000). As of 1989, over 900 various volatile organic compounds had been found in the indoor environment (Maroni. et al., 1995). In addition, (Spengler, 2001) reported that there were more than 1000 different volatile organic compounds in indoor environment. The number of volatile organic compounds detected in indoor environment is normally higher than outdoor environment since they are released by almost building materials, furnishings, consumer products, pesticides and fuels. The common indoor items such as cleaners, waxes, paints, furnishings and combustion appliances can emit VOCs (Maroni. et al., 1995). (Black & Worthan., 1999) have described The VOCs/ TVOC emissions of laser printers, dry process photocopiers and personal computers moreover (Lee, Lam, & Kin Fai, 2001) characterized volatile organic compounds from office equipment. The amount of total volatile organic compounds (TVOC) in indoor air, has been measured using different techniques. The TVOC values obtained from a PID instrument was compared with tenax sampling and gas chromatographic analysis did not find a distinct correlation. The TVOC assessment procedure may start with a simple integrating detector reporting the concentration in toluene equivalents. The use of simple integrating instruments such as FID or PID for assessing TVOC should be restrict to situation. If the value obtained with a simple integrating detector is above 0.3 mg/m3, detailed analysis should be made. The TVOC refer to a specified range of volatile organic compounds which measured concentrations of identified volatile organic compounds including minimum 64 target compounds in following groups: aromatic and aliphatic hydrocarbons, cycloalkanes, terpenes, alcohols, glycols or glycol ethers, aldehydes, ketones, halocarbons, acids, and esters (ECA-IAQ, 1997).

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There are different ways to measure TVOC concentration, the instrument namely MiniRAE2000/ ppbRAE portable volatile organic compounds monitor is compact monitor designed as a broadband volatile organic compounds gas monitor and data logger for work in hazardous environments. It monitor volatile organic compounds vapor using a Photo-Ionization Detector (PID) at part per million (ppm) and part per billion (ppb) levels. The calibration of newly instruments should be tested by exposing the sensor to known concentration calibration gas for the first time and the accuracy should be checked by exposing the sensor to known concentration calibration gas before use by the two-point field calibration of zero and standard reference gas. The two-point calibrating process using fresh air and the standard reference gas; first a fresh air calibration, which contains no detectable volatile organic compounds (0.0 ppm, ppb), is used to set a zero point for the sensor then a standard reference gas that contains a known concentration of a given gas is use to set the second point of reference. The miniRAE2000 and ppbRAE monitor used a newly developed electrodeless discharge UV lamp as the high-energy photon source for the PID. As organic vapors pass by the lamp, they are photo-ionized and the ejected electrons are detected as a current. The PID sensor with a lamp detects a broad range of organic vapors.

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2.3 Volatile organic compounds in office building

There is an increasing concern about indoor air quality (IAQ) and its impact on health, comfort, and work performance in office environments (Carrer & Wolkoff, 2018). Chemical pollutants and bio-effluents have been suggested to cause mental stress (Zhang et al., 2017). Changes in building design devised to improve energy efficiency have meant that modern homes and offices are frequently more airtight than older structures and built with materials, equipment and usage of various cleaning agents which emit chemicals such as volatile organic compounds. The pollutants are emitted from office equipment such as laser printer (H. Salonen et al., 2009; Wells et al., 2017; Weschler & Carslaw, 2018; P. Wolkoff, 2013) and they also provide indoor environments in which contaminants are readily produced and may build up to much higher concentrations than are found outside. Indoor pollutants can emanate from a range of sources. Of particular importance might be substances known as volatile organic compounds, which arise from sources including paints, varnishes, solvents, and preservatives (Jones, 1999). (Li et al., 2001) measured volatile organic compounds concentration in ten office buildings in Hong Kong and found indoor concentration of aromatic and chlorinated hydrocarbons higher than outdoors similar to (Ongwandee, Moonrinta, Panyametheekul, Tangbanluekal, & Morrison, 2009) investigated concentration and strengths of formaldehyde in twelve office buildings in Bangkok and found indoor concentration of formaldehyde and acetaldehyde higher than outdoors. The indoor concentration of volatile organic compounds and Formaldehyde were higher than the outdoor concentration (Aslan. GÜler., 2008). There are many studies reported that higher volatile organic compounds concentrations were measured indoors than outdoors (Aslan. GÜler., 2008; Ilgen. & al., 2001; Khoder, 2006; Pośniak, Makhniashvili, & Koziel, 2005; Sofuoglu, Aslan, Inal, & Sofuoglu, 2011). The indoor volatile organic compounds concentrations in fifty six US office buildings ranged from below the limit of detection to 450 $\mu g/m^3$ (Girman., Hadwen., Burto., Womble., & McCarthy., 1999). (Missia, Demetriou, Michael, Tolis, & Bartzis, 2010) found indoor concentration of volatile organic compounds were higher in during winter period than summer which

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was also observed by (Rehwagen, Schlink, & Herbarth, 2003), (Aslan. GÜler., 2008) and (Mentese, Rad, Arisoy, & Gullu, 2012).

An important parameter that influence on indoor volatile organic compounds exposure is sources and emission rates within the building (A. T. Hodgson et al., 2000; Sparks, Guo, Chang, & Tichenor, 1999; Tichenor. & Sparks., 1996). (Wargocki, Bakó-Biró, Clausen, & Fanger, 2002) found the concentration of TVOC was higher in the office when indoor pollution sources were present. The indoor air concentrations of volatile organic compounds are varied depending on the building age and type. The percentage of approximately 40% of the indoor air quality levels originated from building materials (Missia et al., 2010). The building materials can be significantly emission sources of volatile organic compounds which may affect to level of concentration in indoor environments (Knudsen, Kjaer, Nielsen, & Wolkoff, 1999). (Ongwandee, Moonrinta, Panyametheekul, Tangbanluekal, & Morrison, 2011) studied the indoor source emission factors of each VOC in sixteen offices, the findings were that toluene and limonene were contributing to highest emission factors. The indoor emission sources of toluene were found in various indoor materials and associated with occupants whereas limonene was possibly from air fresheners and cleaning products. In addition (Zuraimi, Tham, & Sekhar, 2004) identified limonene was coming from building materials such as wood furniture. The volatile organic compounds are mainly used as a solvent for manufacturing office products, furniture and interior decoration materials. They vaporize into indoor air from various indoor sources including cleaning products, furniture, fax machines and printers (Chun, Sung, Kim, & Park, 2010). Major sources of the volatile organic compounds in indoor air are construction materials, furnishings, paints, carpets, insulation, adhesives,

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textiles and paper, varnishes and solvents, and cleaning compounds (Hai Guo & Murray, 2001; H. Guo, Murray, & Wilkinson, 2000; Kelly, Smith, & Satola, 1999; Kwok, Lee, Guo, & Hung, 2003; Samfield., 1982). Combustion, tobacco smoking, photocopying and laser printing influences on indoor volatile organic compounds concentration (Baek & Jenkins, 2001; Etkin., 1996). In addition, high concentration of volatile organic compounds attribute to occupant-related printing activities in a new building (Alfred T. Hodgson, Daisey, & Grot, 1991; A. T. Hodgson et al., 2000).

Office buildings with air-conditioning systems in Thailand are operated with a tight thermal envelope. This leads to low fresh-air ventilation rates and is thought to be partly responsible for the sick building syndrome symptoms reported by occupants. The study in sources of 13 volatile organic compounds in office buildings with air-conditioning systems in the business area of Bangkok have documented that the volatile organic compounds concentrations varied significantly among the studied buildings. The two most dominant volatile organic compounds were toluene and limonene with average concentrations of 110 and 60.5 mg m^{-3}, respectively. A Wilcoxon sum rank test indicated that the indoor concentrations of aromatic compounds and limonene were statistically higher than outdoor concentrations at the 0.05 level. Indoor emission factors of toluene and limonene were found to be highest with the average values of 80.9 and 18.9 mg m^{-2} h^{-1}, respectively. Principal component analysis was applied to the emission factors of 13 volatile organic compounds, producing three components based on source similarities. Furthermore, a questionnaire survey investigation and field measurements of building air exchange pointed to indoor air complaints related to inadequate ventilation (Ongwandee et al., 2011).

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Another study in sources of volatile organic compounds were identified and quantified in five tropical air-conditioned office buildings in Singapore. A mass balanced model is applied to determine area-specific emission rates and to apportion the sources of volatile organic compounds into 3 broad categories of sources i.e. building materials, ventilation systems and occupants and their activities. The highest contributor of TVOC comes from the ventilation systems at 39.0%. This was followed by occupants and their activities at 37.3% and finally building materials at 23.7%. Ducted supply and return ventilation design has the lowest volatile organic compounds area-specific emission rates as compared to buildings employing the open space above the false ceiling as return plenum. The TVOC area-specific emission rates from building materials and ventilation systems decreased from 6 to12 months (Zuraimi et al., 2004).

(An, Kim, Kim, & Seo, 2010) found ventilation and temperature affected on the rate of formaldehyde and TVOC emission. Seasonal and spatial variations of the most abundant species were not significant, pointing at dominant indoor sources, whereas the effect of outdoor sources cannot be disregard. The influence of climate parameters on the emission rates and the possible impact of volatile organic compounds on health and comfort in the indoor environment are necessary to know. Parameters such as air velocity, temperature, relative humidity and oxygen may have an impact that depends on the mechanisms and processes of emission. The temperature and relative humidity may affect the emission rate depending on the type of building product and type of volatile organic compounds emitted (P. Wolkoff, 1999). (H. J. Salonen et al., 2009) showed the geometric mean concentration of total

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volatile organic compound (TVOC) in office rooms was higher than the open plan offices.

2.4 Factors and health effects

Air quality inside of buildings is related to a various range of chemical, physical, and biological factors. Many influences depend on the emission rates of diverse chemicals, the frequency which inside air is exchanged with ambient air, the efficiency of atmospheric circulation within the building, and numerous other factors. Factors affecting indoor air quality are sources of contaminant, heating ventilation and air conditioning system, pollutant pathways, and occupants (U.S.EPA, 2015).

The indoor air contaminants can originate within building or penetrate from outdoors. The indoor elements are building components and furnishings which produce or collect dust or fibers include textured surfaces such as carpeting, curtains and other textiles, old or deteriorated furnishings, material containing damaged asbestos, maintenance activities include remodeling, new furniture/carpet, or pest control, emissions from office equipment such as photocopier machines and video display terminals, office supplies such as toners and carbonless paper products, housekeeping include deodorizers, cleaning materials, or dust, personal activities such as smoking and personal hygiene. The indoor air quality may also be affected from heating ventilation and air conditioning system is not able to control existing air contaminants and ensure thermal comfort condition. The air movement in building can produce many patterns of contaminant distribution (U.S.EPA, 2015).

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The effects of indoor air quality problems are frequently non-specific symptoms rather than clearly defined illnesses. Symptoms normally reasoned to indoor air quality problems include headache, fatigue, sinus congestion, shortness of breath, cough, sneezing, dizziness, nausea, skin irritation, eye, nose, and throat irritation. Many different symptoms have been associated with sick building syndrome, which is occasionally used to describe cases in which building occupants experience acute health and comfort effects, including respiratory complaints, irritation, and fatigue. Odor are often associated with a perception of poor air quality. Environmental stress such as lighting, noise, vibration, overcrowding, ergonomics and psychosocial problems (U.S.EPA, 2015).

2.5 Particulates

Particulates or particulate matter (PM) are small particles of which the size is directly linked to their potential for causing health problems. The air we breathe contains airborne particles in many forms such as dusts, fumes, fibers and mists. Only very small particles are respirable (capable of being breathed into the lung). Particles greater than 2.5 or 3 µm equivalent size are deposited in the upper respiratory system (the nasal cavity, the trachea and the bronchial tubes) whereas particles 2µm in equivalent size are deposited about equally in upper respiratory system and in the alveolar. Particles about 1 µm in equivalent size are deposited more in the alveolar than elsewhere.

The nature and magnitude of indoor particle exposures can change rapidly because of rapid changes in activities and sources. In university campus, $PM_{2.5}$ levels on weekdays were higher than on weekends showing the dependence on the presence of people (Klinmalee et al., 2009) similar in the school (Braniš, Šafránek, & Hytychová, 2009).

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The indoor concentration of $PM_{2.5}$ ranged from 3.0 to 35.4 $\mu g/m^3$ in a hundred US office buildings (Burton., J.G.Girman., & S.E.Womble., 2000) and range from 4.9 to 5.3 $\mu g/m^3$ in office building in Taiwan. (Klinmalee et al., 2009) reported the indoor $PM_{2.5}$ concentration in university campus in Thailand were 37±6 $\mu g/m^3$ (floor with carpet) and 26±6 $\mu g/m^3$ (wooden floor). The indoor $PM_{2.5}$ levels were sometimes higher than outdoor levels (Chunram., Vinitketkumnuen., Deming., & Chantara., 2007) and higher in winter than summer (Braniš et al., 2009; Mentese et al., 2012) whereas (Burton. et al., 2000) found low correlation between indoor and outdoor $PM_{2.5}$ concentration (r=0.44).

Factors which contributing to indoor air pollution were include building location, air intake, building design, building material, furnishing and indoor activities. Some of common causes of indoor air problem are the present of indoor sources of pollution (Chunram. et al., 2007). Other studies found particle emission of laser printers, photocopiers, personal computers and office equipment (Black & Worthan., 1999; Lee et al., 2001; P. Wolkoff, 1999).

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According to (Mahmoud., Mike., & Bijan., 2010), mean PM2.5 concentration in the big office were more than small quiet office. In home, cooking increased PM2.5 concentration. Mean PM2.5 concentrations measured in smoking area were much higher than in non-smoking area. Outdoor air pollution can affect the indoor particulate concentration when the indoor source not exists.

There are several means to measure the concentration of particulate matter (PM). Dusttrak aerosol monitor can simultaneously measure both mass and size fraction of particulates. Its laser photometers measure five size-segregated mass fraction concentrations corresponding to PM, $PM_{2.5}$, Respirable, PM_{10} and Total PM.

The MiniVol portable air sampler is an ambient air sampler for particulate matter. It is a popular choice for use in air quality assessments because it is portable and inexpensive relative to fixed site monitors. The characterization of spatial distributions of PM_{10} and $PM_{2.5}$ mass concentrations with the MiniVol can be accomplished with a high level of confidence (Baldauf, Lane, Marotz, & Wiener, 2001). It use the patented low flow technology that was developed jointly by the U.S. Environment protection Agency (EPA) and the Lane Regional Air pollution Authority in an effort to address the need for portable air pollution sampling technology. In the particulate matter (PM) sampling mode, air is drawn through a particle size separator and then through a filter medium. Particle size separation is achieved by impaction. Critical to the collection of the correct particle size is the correct flow rate through the impactor. For the MiniVol, the actual volumetric flow rate must be 5 liters per minute (5 lpm) at ambient condition. Impactors are available with a 10 micron cut-point (PM_{10}) and a 2.5 micron cut-point ($PM_{2.5}$). Operating the sampler without an impactor allow for collection of total suspended particulate matter (TSP).

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2.6 Air pollution and respiratory symptoms

Air pollution risk is a hazard of the pollutant and the exposure to that pollutant. The health impacts from polluted air including respiratory irritation or breathing difficulties. The risk of adverse effects depends on type and concentration of pollutant, and the length of exposure to the polluted air. The high level of air pollution can cause immediate health problems including damaged cells in the respiratory system, aggravated cardiovascular and respiratory illness. The long-term exposure to polluted air can loss lung capacity and decrease lung function. Small particles, $PM_{2.5}$ or fine particulate matter, cause the greatest health problems because they bypass the body's natural defenses and can get deep into your lungs and potentially your bloodstream. The exposure to particulate pollution can result in health problems including increased respiratory symptoms such as the airways irritation, coughing or difficulty breathing, decreased lung function, aggravated asthma, chronic respiratory disease, chronic bronchitis or chronic obstructive lung disease, eyes, nose and throat irritation, coughing, chest tightness and shortness of breath. The levels of exposure to airborne particulate matter (PM) in North American and Western European cities are associated with a range of health outcomes (Dockery. & Pope., 1994; Katsouyanni et al., 1997; U.S.EPA, 1996).

(Finnegan, Pickering, & Burge, 1984) studied sick building syndrome symptoms among workers in nine natural ventilation offices and found the prevalence of wheeze and shortness of breath are 3.1 % and 1.6 % respectively while the prevalence of cough, wheezing and shortness of breath among workers in office building are 9.9-11.7 %, 1.8-2.7 % and 4.5 % respectively (Dai-Hua Tsai, Jai-Shiang Lin, & and Chang-Chaun Chan, 2012) and another showed 1.6% cough, 0.2% wheezing and 0.3% shortness of breath (Azuma et al., 2015). (Hummelgaard et al., 2007) reported the prevalence of symptoms among occupants in office building are 17.5% in cough and 3.75% in difficult to breath. Two studies in symptoms prevalence among office workers in office buildings indicated 5% cough (Mendell, Lei-Gomez, Mirer, Seppanen, & Brunner, 2008), 8.3% wheezing and 20% breathlessness (Boechat. et al., 2005).

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The study in Silesia Vovideship reveal majority of respondents pointed to respiratory disorders including allergies and asthma, headache, irritation of mucous membranes and eyes, and cancer (Karolina., Agata., & Renata., 2012).

(Reijula & Sundman-Digert, 2004a) studied indoor air problems and symptoms and found the most common indoor air problems were dry air, stuffy air, dust or dirt in the indoor environment and draught. The most common work relate symptoms were irritated, stuffy, or runny nose (20%), itching, burning or irritation of the eyes (17%), and fatigue (16%).

The study in Oke Oyi, Kawara State, Nigeria among 384 inhabitants revealed that the most of respondents indicate the treat from indoor air pollutants and health effects. They indicated cough, rhinitis, eye irritation, headache and asthma (Osagbemi., Adebayo., & Aderibigbe., 2010).

Cough was observed in 8.46% of the school teachers of Shimla city in western Himalayas, production of sputum was also seen in 8.46%, wheeze was reported by 1442% and the prevalence of shortness of breath was 16.4% (Vaidya, Kashyap, Sharma, Gupta, & Mohapatra, 2007).

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2.7 Respiratory System

The respiratory system by which oxygen is delivered to the body and carbon dioxide is removed from important part of the body. The respiratory system consists of all the organs of the body that contribute to normal respiration or breathing including the nose, pharynx, larynx, trachea, bronchi and the lungs. Respiration is the act of breathing including inhaling or inspiration that is the act of breathing in oxygen, and exhaling or expiration that is the act of breathing out carbon dioxide. The respiratory system is divided into upper and lower respiratory tract. The upper respiratory tract is made up of nose, nasal cavity, sinuses, larynx and trachea. The lower respiratory tract is made up of the lungs, bronchi, bronchioles and alveoli or air sacs.

The process of respiration is breathing (movement of chest/lung complex to ventilate the alveoli), external respiration (exchange of gas between lung and blood), internal expiration (exchange of gas between blood and cells) and intracellular respiration (utilization of oxygen by the cells with the coincident release of carbon dioxide. In relaxed state, you breathe in and out 10-14 times a minute. While such exertion, the need for air increases many times so that the breathing rate may be speed up to one breath per second. In an ordinary inhalation the first air to enter the lungs is the air that was in the bronchi, throat and nose because the air had left in the lungs from the previous expiration but had not been pushed out. Then some of fresh air which remains in the air passages is useless and expired again before it can get to the lungs. In each breath, fresh air actually entering the lungs may only 1/18 of the lungs' total capacity. The quantity of expelled air varies with body size and age.

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The respiratory system starts from nose (nasal), pharynx, trachea, bronchi (left and right), bronchiole and alveoli. (Shown in figure 2.1 with reachable particle size)

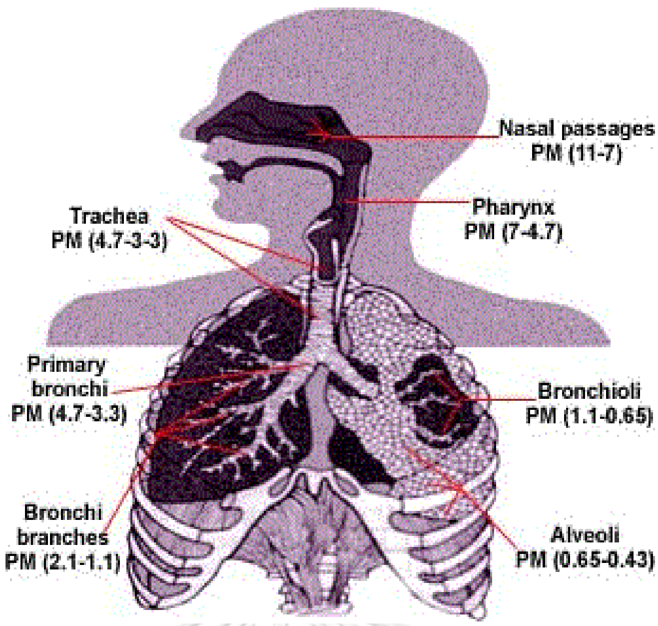

Figure 2.1 Anatomy of respiratory system and reachable particle size

From *http://hpe4.anamai.moph.go.th/hia/pm2health.php*

The total capacity of the lung at full inspiration is divided into several function subdivisions as shown in figure 2.2.

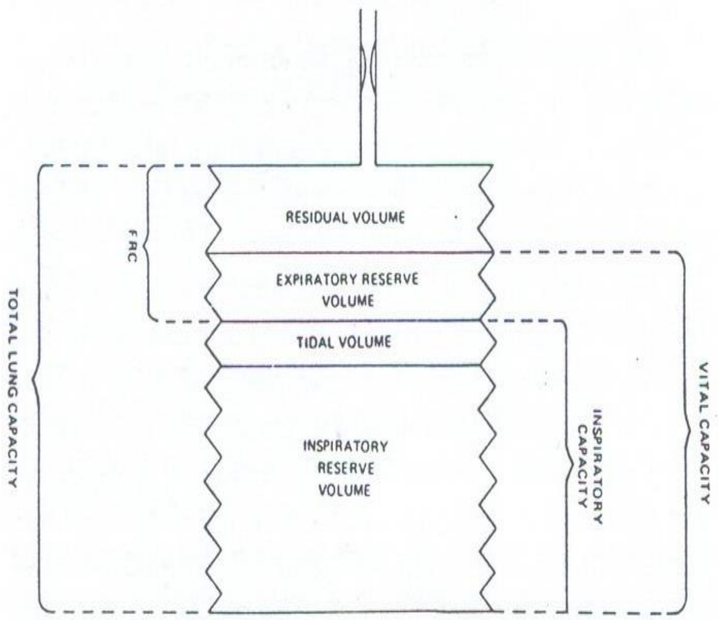

Figure 2.2 Inspiratory capacity and tidal capacity

From: The Lungs in Fundamentals of Industrial Hygiene, 4th ed.

The four primary lung volumes are as follows:

- Tidal volume (TV) is the volume of gas inspired during each respiratory cycle
- Inspiratory reserve volume (IRV) is the maximal volume that can be forcibly inspired following a normal inspiration.
- Expiratory reserve volume (ERV) is the maximum amount of air that can be forcibly expired following a normal expiration.
- Residual volume (RV) is the amount of air remaining in the lungs following a maximum expiratory effort.

The four following capacities includes two or more of primary volume

- Total lung capacity (TLC) is the sum of all four of the primary lung volumes
- Inspiratory capacity (IC) is the maximum volume which the lung can be increased by a maximum inspiratory effort from mid position.
- Vital capacity (VC) is the maximum amount of air that can be exhaled from the lungs after a maximum inspiration.
- Functional residual capacity (FRC) is the normal volume at the end of passive exhalation (G.S.Benjamin, 1996).

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2.8 Spirometry

Spirometry is a measurement of air (the ventilatory capacity of the lungs). The spirometer achieves this by measuring volumes of air and relating them to time. Change in the ability to move air into and out of the lungs in a normal manner results in abnormality (obstructive or restrictive ventilator defect, or a combination of the two). The spirometer use pneumotacho flow sensor to sense airflow. The principal of pneumotacho is a differential pressure transducer measures the pressure different across a transparent film as the air stream passes through it. The resulting pressure change is converted to a signal propotional to the air flow rate. The calibration of spirometer using 3-L calibrated syringe which has an accuracy of ±0.5%. The syringe is connected to the spirometer for volume check and pumped air into it 3 times with different velocity (in 1, 3 and 6 seconds). The ±3% accuracy is available. The spirometry test should be to record about smoking, recent illness, medication use and measure weight and height. The test need to instruct and demonstrate including correct posture, completely inhale, mouthpiece position and maximal force exhale. The test should be repeated at least 3 times (not more than 8 times). The three acceptable spirograms are needed. The acceptability criteria, subjects have maximum inspiration and smooth continuous exhalation (Extrapolated volume <5% of FVC or 0.15 L, whichever is greater) and during the test, they are free from cough during the first second of exhalation also cough at any other time that the test technician thinks could affect the validity of the test result, early termination of expiration, hesitation, leak, obstructed mouthpiece, and taking the extra breath. The repeatability criteria, the two largest values of FVC must be within 0.15 L of each other and the two largest values of FEV1 must be within 0.15 L of each other (Miller & et., 2005).

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The test of ventilatory function is the evaluation of the respiratory system in terms of these following:

- Vital capacity (VC) is the largest volume of air measured on complete expiration after the deepest inspiration without forced or rapid effort.
- Forced vital capacity (FVC) is the vital capacity performed with expiration as forceful and rapid as possible.

- One-second forced expiratory volume (FEV1) is volume of air exhaled during the performance of a forced expiratory maneuver in the first second.
- Peak expiratory flow rate (PEFR) is the rate of maximal expiratory flow.

The American Medical Association (AMA) guides classify respiratory impairment into four classes: none, mild, moderate and severe (G.S.Benjamin, 1996).

The results of the test are compared to the predicted values that are calculated from his age, size, weight, sex and ethnic group. After the test, two graphs are shown: the volume-time curve (in figure 2.3) and the flow-volume loop (in figure 2.4).

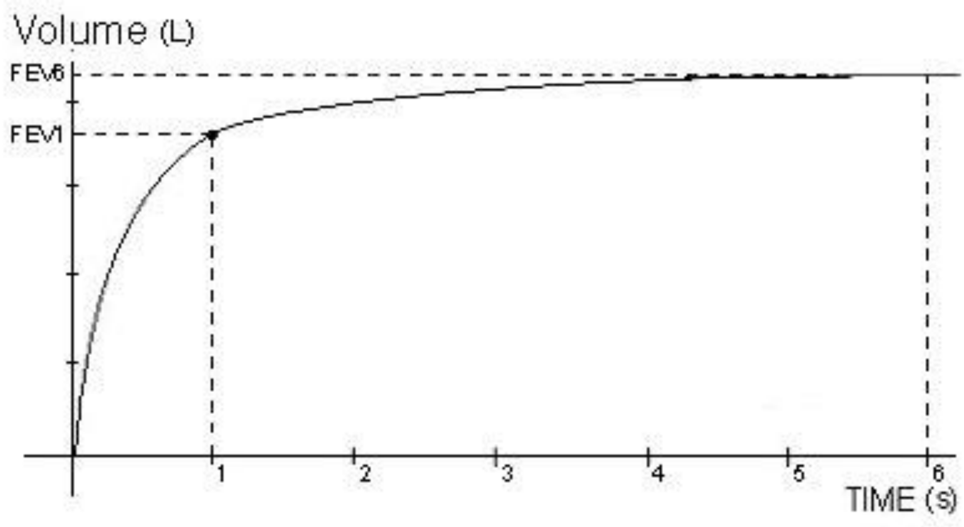

Figure 2.3 Volume-time curve

From: http://www.spirometry.guru/img/volume-time.jpg

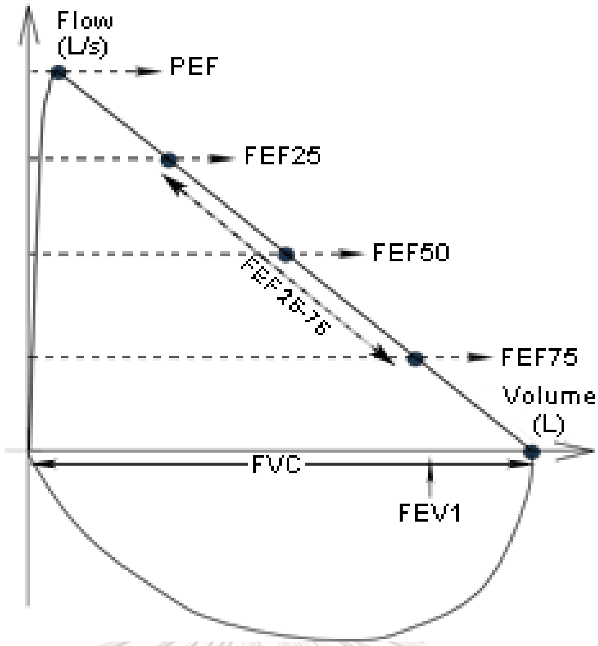

Figure 2.4 Flow-volume loop

From: http://www.spirometry.guru/img/curves/flowvolume.png

These figures show the ventilatory functions such as FVC, FEV1, PEF, and FEF 25%-75%.

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2.9 Indoor exposure and health effects

The relationship between high chemical compound exposure and human health has been an important worldwide issue. High exposure to chemical compounds can make harmful health effect. The study on volatile organic compounds exposure level and Multiple Chemical Sensitivity documented that self-reported symptom surveys and personal six Volatile Organic Compounds exposure measurements were conducted with three categories of construction employment, including exterior workers, interior workers, and office workers. The job category with the greatest exposure to volatile organic compounds was the interior workers, followed by office workers, and then exterior workers. However, based on the self-reported symptom surveys, office workers demonstrated a relatively high risk for Multiple Chemical Sensitivity (MCS) among the three job categories (Chun et al., 2010). Volatile Organic Compounds exposure can induce a range of adverse human health effects both acute and chronic. Many volatile organic compounds found indoors have been determined to be human carcinogen, affect to central nervous system, and also cause irritation in the eyes and respiratory system. At high concentration, many volatile organic compounds have caused kidney and liver damage (Maroni. et al., 1995).

The study on personal exposures for 12 participants as well as residential indoor/outdoor, workplace and in vehicle, volatile organic compounds concentrations were measured for 5 days and calculate the inhalation cancer health risk. The cancer risk analysis of personal exposure, benzene, chloroform, carbon tetrachloride and 1,3-butadiene had median upper-bound lifetime cancer risks that exceeded the U.S. EPA benchmark of 1 per one million, and benzene presented the highest median risks at about 22 per one million population. The median cumulative cancer risk of personal exposure to 5 volatile organic compounds was approximately 44 per million, followed by indoor exposure (37 per million) and in vehicle exposure (36 per million) (Zhou et al., 2011).

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Another study investigated personal exposures of 100 adult non-smokers living in the UK, as well as home and workplace microenvironment concentrations of 15 volatile organic compounds. The results showed the strength of the association between personal exposure and indoor home and workplace concentrations as well as with central site ambient air concentrations in medium to low pollution areas (Delgado-Saborit, Aquilina, Meddings, Baker, & Harrison, 2011). According to

(Elliott, Longnecker, Kissling, & London, 2006) found that exposure to 1,4-dichlorobenzene, a volatile organic compounds related to the use of air freshener, may result in reduced pulmonary function as same as the result from (Wan-Kuen Jo & Kung-Cho Moon, 1999) housewives' exposure to volatile organic compounds relative to proximity to roadside service stations Atmospheric Environment respectively.

According to (J. L. d. M. Rios et al., 2009) some symptoms such as eye dryness, runny nose, dry throat, and lethargy were more prevalent in sealed building than non-sealed building. Similar to (Hedge et al., 1989) symptoms of sleepiness, nasal irritation, concentration difficulties, cold/flu-like symptoms, and eye focusing problems were significantly more prevalent in the air conditioned office.

Airborne particulate matter (PM) has been associated with various adverse health effects (Brunekreef et al., 1997; Duhme, Weiland, & Keil, 1998; Schwartz, Dockery, & Neas, 1996) and linked to numerous adverse health effects including increased hospital admissions and emergency room visit, respiratory symptoms, exacerbation of chronic repiratory and cardiovascular disease, decreased lung function and premature mortality (EPA., 2003). The $PM_{2.5}$ can enter the respiratory tract, reach deeper parts of the lung and be deposited in the alveoli (Hinds, 1999). Inhaled contaminants adversely affect the lungs. Aerosols and dusts which deposited in the lungs may produce tissue damage, disease or physical obstruction. Toxic gases produce adverse reaction in the lungs' tissue. Potential health hazards from dust when the inhalation of sufficient quantities of dust can cause a person to choke or cough and can cause allergic or sensitization reaction in the respiratory tract, it can also accumulate in the lungs.

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(Benigno Linares & et al, 2010) studied air pollutants (O_3, SO_2, NO, NO_2, NO_x and PM_{10}), respiratory symptoms and lung function in children. They found frequency of respiratory symptoms and abnormalities in lung function were more frequent in the school closer to the most polluted area. Pollutant levels were more often associated with obstructive type than restrictive type changes in lung function. PM10 levels were the most consistent factor related to FVC, FEV_1, PEF and FEV_1/FVC coefficient in boys and girls.

(Ashton, 1981) studied lung function of office workers who exposed to humidifier fever antigen and found the symptoms were preceded by a 6% reduction in FEV, VC and $FEF_{75\%}$ whereas no change in PEF and $FEF_{50\%}$. The symptoms usually developed starting in the afternoon. The prevalence of abnormal lung function of office workers in northeastern Malaysia which is 13.5 percent include 10.3 percent of restrictive lung function and 3.1 percent of obstructive lung function (Junaidi Djoharnis. & al., 2012).

(Boskabady, Mahmoodinia, Boskabady, & Heydari, 2011) indicated that smoking leads to increased respiratory symptoms and reduction of PFTs values. (Siwarom et al., 2017) found PM_{10} and bacterial count is a significant problem in Bangkok metropolitan DCCs (Child Day Care Centers). The respiratory symptoms of children positively associated with PM_{10}, CO, benzene and dust mite level.

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2.10 Qualitative research

Qualitative research consists of an investigation that seek answer to the question collects evidence, producer findings. Qualitative research is especially effective in obtaining culturally specific information about the values, opinions, behavior, and social contents of particular populations (Bernard, 2006). The strength of qualitative research is its ability to provide complex descriptions of how people experience a given research issue and effective in identifying intangible factors. When used along with quantitative methods, qualitative research can help us to interpret and better understand the complex reality of given situation and implications of the quantitative data. There are three common qualitative methods are observation, in-depth interviews, and focus group discussions. A specific type of data is obtained from suitable method. The observation is suitable for naturally occurring behavior, in-depth interviews are appropriate for individuals' data particularly sensitive topic and focus group discussions are proper in generating broad overviews of issues of concern to the groups represented (Bernard, 2006), (Denzin & Lincoln, 2017).

Focus group discussions are small groups of individuals gathered to discuss a particular topic under the direction of a moderator. Focus group discussions are method to eliciting information from group of participants who should have a similar background in relation to the issue under investigation. Focus group discussions produce qualitative data that provide insight into the attitudes, perceptions, and opinions of participants. The information on the topic should be obtained from several different perspective. The participants should be invited at least one or two days in advance and the general purpose of the focus group discussion should be explained. A discussion guide preparation, list of the topics should be written in the open ended questions. One of the members of the research team should be a facilitator for the focus group, one should serve a recorder (McDowell, 2006). The facilitator should explain the purpose of the discussion, the kind of information needed, and how the information will be used, formulate questions and encourage as many participants as

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possible to express their views, remember there are no “right” or “wrong” answers. Let the discussion continued from topic to topic and then summarize, check for agreement and thank the participants at the end of the meeting (McDowell, 2006). The items to be recorded include characteristics of participants, opinions of participant especially key statements and vocabulary used (Moretti et al., 2011). The report of discussions should be prepared that reflects the discussions as completely as possible: using participant own words, list the key statements, ideas and attitudes expressed for each topic of discussion. Categorize the statements for each topic (if required), summarize and interpret the findings. Select the most useful quotations that emerged from the discussion to illustrate the main ideas (McDowell, 2006).

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Chapter III

Methodology

This chapter describes research methodological approaches to investigate the prevalence of symptoms and lung function of occupants in air-conditioned offices of Suan Sunandha Rajabhat University. The topic consist of research design, study area and study population, sample and sample size, measurement tools, data collection, data analysis and ethical consideration.

3.1 Research Design

This study is cross-sectional study with mixed-method. The quantitative research is used to examine the statistically association between Independent variables and dependent variables and the qualitative research is used to explain the results in-depth.

3.2 Study Area and Study Population

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In this study, the research area is the office building in Suan Sunandha Rajabhat University, Bangkok that consist of 14 studied offices include 6 faculties, 6 divisions and 2 institutes as shown in figure 3.1.

This university is near high density public road and some office building is developed from the old palace which designed as resident, not office. In this study area has many kinds of different characteristics such as building age range 8 to 26 years, floor materials are tile, rubber, and carpet, amount of personal computers in range of 11 to 50 and 5 – 28 printers. All offices contain split type air conditioners which operate all time during working hour and windows always close.

Whole population of this study refers to 245 occupants who aged 20-60 years old and work at 14 offices (in studied area) which located in 9 buildings on different storeys as follow:

1) Office in building no. 11 on the 1st floor consists of 10 people
2) Office in building no. 26 on the 1st floor consists of 16 people
3) Office in building no. 35 on the 1st floor consists of 17 people
4) Office in building no. 43 on the 2nd floor consists of 12 people
5) Office in building no. 56 on the 1st floor consists of 15 people
6) Office in building no. 58 on the 1st floor consists of 11 people
7) Office in building no. 32 on the 1st floor consists of 23 people
8) Office in building no. 32 on the 3rd floor consists of 28 people
9) Office in building no. 32 on the 3rd floor consists of 16 people
10) Office in building no. 32 on the 4th floor consists of 22 people
11) Office in building no. 32 on the 4th floor consists of 21 people
12) Office in building no. 38 on the 3rd floor consists of 17 people
13) Office in building no. 38 on the 2nd floor consists of 12 people
14) Office in building no. 34 on the 1st floor consists of 25 people

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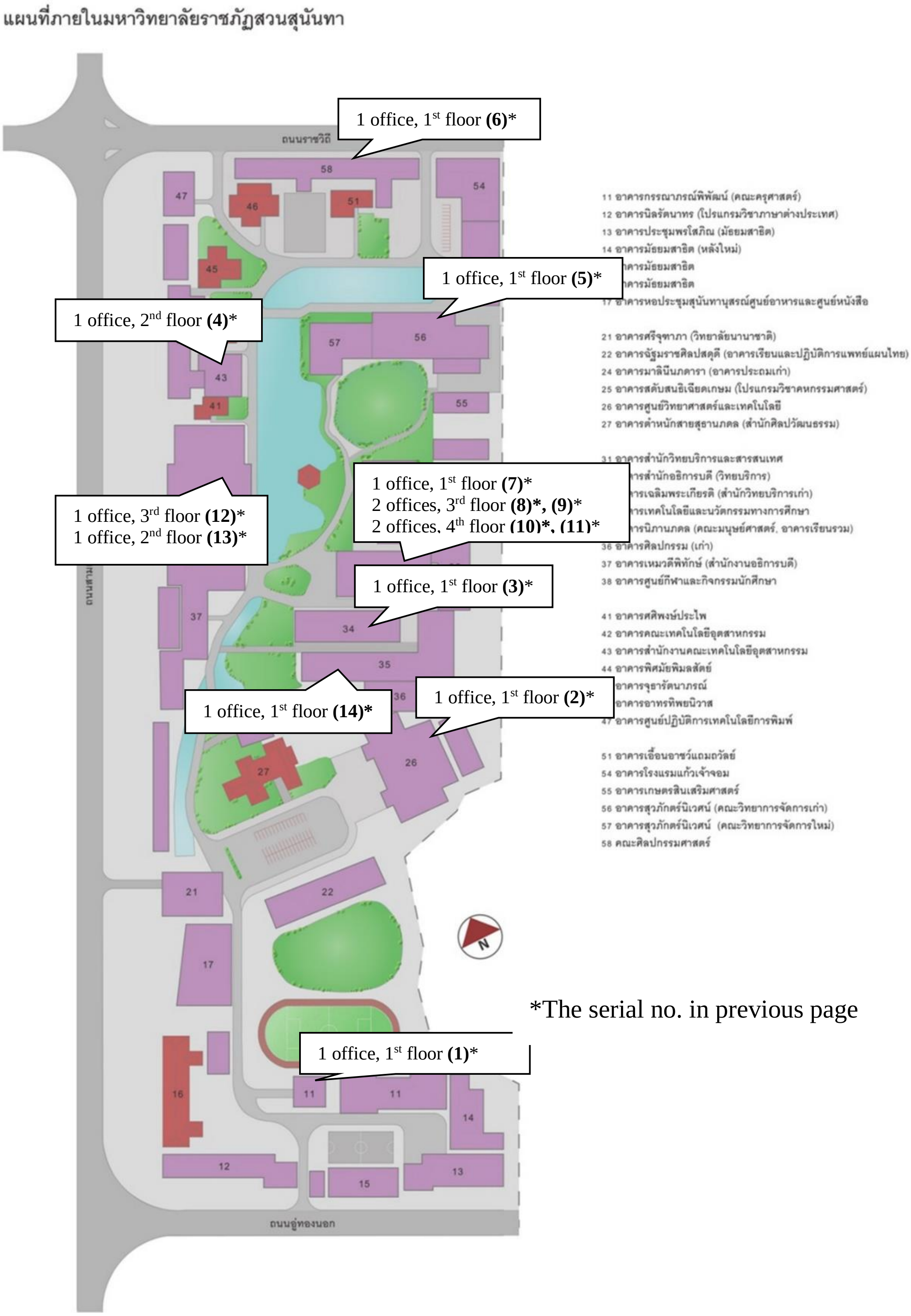

Figure 3.1 Lay out of Suan Sunandha Rajabhat University (all campus and show 14 studied offices in 9 buildings)

3.3 Sample and Sample size

In quantitative research

This sample size calculation is based on the FEV1, a continuous measurement of lung function. For a continuous variable, for 2 equal subgroups (in this case, subgroups of the study sample with higher and lower air pollutant levels), the formula for sample size requirement in each of the 2 subgroups is as follows:

$$n = 2\left(\frac{Z_{1-\alpha/2} + Z_{1-\beta}}{ES}\right)^2$$ [1,2]

[1] *Boston University School of Public Health Available from: http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704_Power/BS704_Power_print.html(Health.)*
[2] *(Elashoff & Lemeshow, 2007)*

Where

n is sample size required in each of the 2 subgroups mentioned above.

α is the selected level of significance (0.05).

$Z_{1-\alpha/2}$ is value from standard normal distribution holding 1-α/2 below it (confidence level of 95%).

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1-β is the selected power (80%).

$Z_{1-\beta}$ is value from standard normal distribution holding 1-β below it

ES is the effect size, defined as:

$$ES = \frac{|\mu_1 - \mu_2|}{\sigma}$$

$|\mu_1 - \mu_2|$ is the absolute value of the difference in mean between two groups

σ is the standard deviation of the outcome of interest

According to (Sriproed et al., 2013) the predicted mean of FEV1 is 2.56 liters in high dust exposure and 2.88 liters in low dust exposure. The standard deviation is assumed to be 0.8.liters. I use these as the basis of sample size calculation.

$$ES = \frac{|2.88 - 2.56|}{0.8} = 0.4$$

Assume	α	=0.05 (95% confidence)	$Z_{1-\alpha/2}$	=1.96
	β	=0.2 (80% power)	$Z_{1-\beta}$	=0.84

$$n = 2\left(\frac{1.96 + 0..84}{0.4}\right)^2 = 98$$

= 98 in each group x 2

= 196 people

Whole population (245 people) were enrolled then list of all occupants in the studied areas (14 offices) was printed from personnel division. There was no sub-sampling from this overall group. The group of 212 people was included with criteria below.

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Inclusion criteria

- People who aged 20-60 years old
- Working in air-conditioned office (in the study area) for entire working hours
- Willing to participate

Exclusion criteria

- History of pulmonary disease
- Pregnant

In qualitative research

The planning for focus group discussions including first decision concerns who participate in the group, next determines how the group was structured, then decisions about the size of the group. According to the rule of thumb, focus group discussions most often use homogeneous participants and rely on structured interview with high moderator involvement. Focus group discussions are conducted with purposively selected samples in which the participants are recruited with inclusion and exclusion criteria. The common rule of thumb size that specific the range of 6-10 participants however the lower and the upper boundary may not be restricted. The smaller size would be conducted that would have been unmanageable at size 6, the larger size would be naturally conducted in which the process was quite orderly. Eventually, both the purposes of the research and the constraints of the field situation must be taken into account. The estimated sample size for focus group discussions would be a group of 10-12 participants with both have something to say about the topic and feel comfortable saying it to each other.

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When the spirometry test and questionnaire were finished, the participants with normal and abnormal lung function were got and the participants with respiratory symptoms were also got. The qualitative study part was continued by using focus group discussion for getting in-depth qualitative information in group of 12 participants with inclusion criteria below.

<u>Inclusion criteria</u>

- People who work in studied offices

- Having both abnormal lung function and respiratory symptoms

The abnormal lung function include:

- Obstructive (FEV1/FVC <70%)
- Restrictive (FVC<80%)
- Combined (Obstructive and Restrictive)

The respiratory symptoms include:

- Cough, Phlegm, Wheezing and Short breathing

<u>Exclusion criteria</u>

- Not available to participate

(The participants will be informed and transferred to the doctor if they want.)

3.4 Measurement Tools

In quantitative research

- Survey questionnaire (Interviewer administered) asked about socio demographic characteristics, health related characteristics, workplace characteristics, occupational history characteristics and respiratory symptoms.
  - Content validity was verified by four experts as follows:
    - Robert S. Chapman, M.D.
    - Assoc. Dr. Wattasit Siriwong
    - Assoc. Dr. Ratana Somrongthong
    - Assist. Dr. Arroon Ketsakorn

    The result of IOC ≥ 0.5 for all each item
  - Reliability was obtained from pre-test in pilot study (30 office workers at Suan Dusit University, Bangkok), cronbrac alpha (α)

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was 0.712 for five items in second part and KR-20 was 0.790 for twenty five items in third to fifth part of questionnaire.

- DustTrak DRX Desktop Aerosol Monitor Model 8533 used to measure area $PM_{2.5}$ concentration in mg/m^3 (in range 0.001-150 mg/m^3). It is an aerosol monitor and can measure both mass and size fraction (PM1, PM2.5, Respirable, PM10, and TPM) with 90˚ light scattering and resolution of 0.1% of reading or 0.001 mg/m^3 whichever is greater.

Figure 3.2 DustTrak DRX Desktop Aerosol Monitor Model 8533

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- ppb RAE 3000 VOC monitor used to measure area TVOC concentration. It was designed to continuously monitor TVOC vapor at ppb level (1 ppb resolution in range 1 ppb-10,000 ppm) by using Photo-Ionization Detector (PID). A pump continuously pulls the air under test through the PID to detect airborne gases and vapors, indicating the concentration of TVOC. Two points or three points calibration for zero and span with fresh air and isobutene.

Figure 3.3 ppbRAE3000 VOC monitor

- FUTUREMED Discovery-2 Diagnostic Spirometer as shown in figure3.2, is used to measure lung function (Specific measure: body height and weight, FVC, FEV1, flow-volume curve and volume-time curve).
    - According to American Thoracic Society (ATS) and European Respiratory Society (ERS)
    - Calibration with 3-L calibrated syringe before use

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Figure 3.4 FUTUREMED Discovery-2 Diagnostic Spirometer

In qualitative research

- Focus group discussion was use for getting in-depth qualitative information and beliefs of the occupants about indoor air pollution hazards. The series of questions relate to indoor air pollution hazards base on guideline in 3 main issues include 1) Risk behavior and air pollution exposure, 2) Awareness to level of hazard from air pollution, and 3) Protection from air pollution hazards.

  To explore the participant’s risk behavior that may affect to respiratory health and to explore the participant’s exposure to air pollution (dust, smoke and airborne chemicals especially volatile organic compounds)

  - Let’s participants clarify their risk behavior that may affect to respiratory health.
  - Let’s participants discuss on air pollution in their offices.
  - Let’s participants reveal their symptoms when expose to air pollution

  To explore the participant’s awareness in hazard of air pollution (dust, smoke and airborne chemicals)

  - Let’s participants mention about the level of hazard from air pollution in their offices.

  To explore participant’s protection from hazard of air pollution (dust, smoke and airborne chemicals)

  - Let’s participants explain about their protection themselves from those hazard.

- Content validity was verified by expert in qualitative research

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3.5 Data Collection

Researcher ask for permission letter to access in all university offices and ask the head of each office to announce my plan to other participants. Then the data was collected in each parameters as follow:

In quantitative research

<u>Independent variables</u>

- **Socio-demographic characteristics, health related characteristics, workplace characteristics and occupational history characteristics,** using research survey and research questionnaire. Four interviewers were recruited from 4th year student in bachelor degree of safety technology and occupational health program. They were intensively trained about the questionnaire in each question practiced question by question for understanding in same direction. Researcher survey in each office and the questionnaires were administered to participants at the end of the work shift in each office.
- **Concentration of $PM_{2.5}$,** using DustTrak DRX Desktop Aerosol Monitor Model 8533). The aerosol monitor was placed at 1.20 meter high (breathing zone when sitting) in 3 positions (among occupants, near printers or photocopiers) in each office to measure concentration of $PM_{2.5}$. Each position was conducted for 8 hour on any weekday. (Normally, the activities in offices are not different on Monday to Friday)
- **Concentration of TVOC,** using ppbRAE3000 VOC monitor. The VOC monitor was used to measured concentration of TVOCs at 1.20 meter high (breathing zone when sitting) in 3 positions (among occupants, near printers or photocopiers) in each office. Each position was conducted for 8 hour on any

weekday. (Normally, the activities in offices are not different on Monday to Friday)

<u>Dependent variables</u>

- **Respiratory Symptoms**, using survey questionnaire. Recruit and train several interviewers and administer the questionnaire to participants at the end of the work shift in each office.
- **Lung function,** using spirometry test. The spirometer was used to measure the participants' lung function in each office. *The spirometry test was conducted in the office by certified body.* The spirometer (FUTUREMED Discovery-2) was used in this study. It was calibrated by certified body every year and calibration checked before use by 3-L calibrated syringe. First, the syringe which had an accuracy of ±0.5% was connected to the spirometer for volume check and pumped air into it 3 times with different velocity (in 1, 3 and 6 seconds). The ±3% accuracy is available. Second, the subjects were asked about smoking, recent illness, medication use and measured weight and height. Next, the staff instructed and demonstrated the test to the subjects including correct posture, completely inhale, mouthpiece position and maximal force exhale. Finally, the subjects were set in the correct posture, inhale completely, place mouthpiece in mouth, close lips around the mouthpiece and exhale forcibly if possible until no more air can be expelled. The subjects repeated maneuver at least 3 times (not more than 8 times) and staff checked test acceptability and repeatability. The three acceptable spirograms are needed.

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- The acceptability criteria, the subjects have maximum inspiration and smooth continuous exhalation. (Extrapolated volume <5% of FVC or 0.15 L, whichever is greater.) During the test, they are free from cough during the first second of exhalation also cough at any other time that the test technician thinks could affect the validity of the test result, early termination of expiration, hesitation, leak, obstructed mouthpiece, and taking the extra breath.
- The repeatability criteria, the two largest values of FVC must be within 0.15 L of each other and the two largest values of FEV1 must be within 0.15 L of each other.

In qualitative research

More structured approaches to focus group discussions are useful when there a preexisting agenda and a higher level of moderator involvement that will be keep the discussion concentrated on the topics rather than extraneous issues. Low structured approaches to focus group discussions are useful for exploratory research when existing knowledge is based on researcher-imposed agendas. The goal is to learn something new from the participants then it is best to let them speak for themselves.

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- Using focus group discussion in risk group (Having both abnormal lung function and respiratory symptoms) to get information about risk behavior and air pollution exposure, awareness to level of hazard from air pollution and protection from air pollution hazards which may affect to respiratory health. Focus group discussion was carried out for about one to two hours with group of ten to twelve participants wherever possible within the working space of the participants. The moderator controlled the discussion to be sure that every participants had an equal chance to tell his or her opinion. The interview guide simply asked to hear as much as possible about each participant's risk behavior and air pollution exposure along with his or her awareness and protection himself or herself. Digital recordings were made of the discussions (with permission).

- Using observation to get information about working behavior and environment that expose to air pollution such as location of their office (near the door, the air-conditioner, the printer, the photocopier etc.), desk clearness (amount of paper, dust etc.) and smoking.

3.6 Data Analysis

In quantitative research

For analysis, the data was divided into two groups by median of concentration of air pollution that each occupant expose in his or her office. The group of low concentration exposure and the group of high concentration exposure was analyzed in each factor include TVOC and $PM_{2.5}$ and also analyze as follows:

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- Descriptive statistics was used to describe socio demographic characteristics, health-related characteristics, workplace characteristics, occupational history characteristics and respiratory symptoms.
- To evaluate dependent variables in relation to independent variables: concentration of indoor air contaminants (TVOC and $PM_{2.5}$), socio demographic, health-relate characteristics and occupational history characteristics to lung function and respiratory symptoms, using logistic regression.

- Use the bivariate analysis to choose variable for multivariate analysis. The bivariate is a kind of screening procedure. Independent variables for which $p<0.2$ in bivariate analysis will be include in multivariate analysis.
- Multivariable analysis: use logistic regression

In qualitative research *(use to explain the results in quantitative research)*

- The result of focus group discussion was transcribed, crosschecked with the respondents and translated into English. Then categorized into sub-topics namely risk behavior, air pollution exposure (amount, duration, frequency and symptoms), awareness to level of hazard from air pollution and protection from air pollution hazards.
- All measures for hazard prevention from participants were collected and summarized to establish the recommendations.
- The recommendation was established for further research and for reduction of indoor air pollution exposure and improvement of respiratory health. *(For the university to improve working environment, for the occupants to adjust their behavior and consult the doctor if they want)*

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3.7 Ethical Consideration

The participants were cleared about the objective of the study, possible risk and benefit. Their names were not included in the questionnaire and their answers were confident. This research obtained for ethical approval from The Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University (COA No. 710/2559).

Chapter IV

Results

This study was conducted in air-conditioned offices of Suan Sunandha Rajabhat University. The results of study comprised 6 parts, namely 1) characterization of socio demographic of occupants in offices 2) characterization of sources and concentrations of indoor air contaminants, 3) characterization of prevalence of abnormal lung function and respiratory symptoms, 4) examination of parameters affecting on lung function, 5) examination of parameters affecting on respiratory symptoms, and 6) qualitative study part.

4.1 Characterization of socio demographics of occupants in offices

The questionnaires were distributed to 212 occupants in 14 offices then the socio demographic characteristics of occupants in each office such as age, gender, smoking, history medical records in asthma, chronic lung disease, emphysema, chronic bronchitis, pneumonia, hay fever (allergic rhinitis), heart disease, high blood pressure and diabetes, history in dusty job, history in gas/volatile job, history in fume job, current working experience and working duration (hour per day) were collected and shown in table 4.1.

Table 4.1 Characteristics of occupants in air conditioned offices (N = 212)

characteristic	N	%
Personal characteristic		
Age (years)		
≤ 30	59	27.8
31 - 40	122	57.6
41 - 50	20	9.4
> 50	11	5.2
Mean 34.61 ± 7.501		
Gender		
Male	65	30.7
Female	147	69.3
Health related characteristic		
Smoking		
Non smoking	179	84.4
Smoking	33	15.6
Previous medical records[1]		
Never have illness	170	80.2
illness	42	19.8
Work related characteristic		
History in dusty job		
Never	178	84.0
ever	34	16.0
History in gas/volatile job		
Never	191	90.1
ever	21	9.9
History in fume job		
Never	204	96.2
ever	8	3.8
Current working experience (years)		
≤10	157	74.1
>10	55	25.9
Working hour per day (hours)		
≤ 8	70	33.0
> 8	142	67.0

[1]illness records about asthma, chronic lung disease, emphysema, chronic bronchitis, pneumonia, hay fever (allergic rhinitis), heart disease, high blood pressure and diabetes

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The characteristics of occupants in table above result that more than half of them are 31-40 years old, nearly seventy percent of them are female and the most of them are not smoking. More than eighty percent of them never had asthma, chronic lung disease, emphysema, chronic bronchitis, pneumonia, hay fever (allergic rhinitis), heart disease, high blood pressure and diabetes. Sixteen percent of them has experience in dusty job, less than ten percent of them has experience in gas/volatile job and nearly four percent of them has experience in fume job. Nearly twenty six percent of them has been working in current job more than ten years and sixty seven percent of them work more than eight hour per day.

4.2 Characterization of sources and concentrations of indoor air contaminants

Characteristics of the 14 offices (in list below) such as building age, furnishing materials, density of people, cleaning frequency, air circulation and number of computer, printer and photocopier were collected. The results are shown in table 4.2.

Office 1. Faculty of Education

Office 2. Faculty of Science and Technology

Office 3. Faculty of Humanities and Social Sciences

Office 4. Faculty of Industrial Technology

Office 5. Faculty of Management Science

Office 6. Faculty of Fine and Applied Arts

Office 7. General Affairs Division

Office 8. Academic Services Division

Office 9. Financial Division

Office 10. Policy and Planning Division

Office 11. Personnel Division

Office 12. Student Affairs Division

Office 13. Institute for Research and Development

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Office 14. The Office of General Education and Innovative Electronic Learning

Table 4.2 Characteristics of each office

Office	Building Age (years)	Floor and furnishing materials	Density of people (Person/m2)	Number of Computer	Number of Printer	Number of Photocopier	Frequency of Cleaning /day	Air Circulation (ACH)
1	8	Tile, Cement, Gypsum, MDF	0.10	11	5	0	1	12.4
2	15	Tile, Gypsum, MDF	0.14	19	11	0	1	10.4
3	18	Tile, Cement, Gypsum, MDF	0.18	17	8	0	1	8.4
4	13	Tile, Cement, Gypsum, MDF	0.26	12	12	0	1	12.8
5	24	Tile, Cement, Gypsum, MDF	0.13	16	16	1	1	9.9
6	13	Rubber, Cement, Gypsum, MDF	0.07	11	9	1	1	12.5
7	26	Rubber, Glass, Gypsum, MDF	0.08	25	15	2	1	8.7
8	26	Rubber, Glass, Gypsum, MDF	0.08	50	28	3	1	8.3
9	26	Rubber, Glass, Gypsum, MDF	0.07	16	16	0	1	10.4
10	26	Rubber, Glass, Gypsum, MDF	0.19	22	10	0	1	15.2
11	26	Rubber, Glass, Gypsum, MDF	0.08	23	13	1	1	9.5
12	10	Tile, Cement, Gypsum, MDF, Steel	0.07	18	16	2	1	10.1
13	10	Carpet, Cement, MDF, Metal	0.10	13	10	2	1	9.4
14	19	Tile, Cement, Gypsum, MDF	0.16	25	12	0	1	16.1

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Each office had different building age from 8 to 26 years and various furnishing materials such as tile, cement, gypsum, MDF, rubber, glass, metal and carpet but every offices were furnished by MDF. The number of computer, printer and photocopier is different in each office which the number of printer is in range of 5 – 28 printers per office, the computer maximum is 50 computers per office, minimum is 11 computers per office, no more than three photocopiers in each office and half of offices does not contain photocopier. All offices were cleaned once a day, the density of people in each office is in a range of 0.07-0.26 person/m^2 and air circulation in each office is in a range of 8.3-16.1 air change/hour.

The aerosol monitor and TVOC monitor were placed in each office in three positions. The concentration of $PM_{2.5}$ was measured in mg/m^3 and the concentration of TVOC was measured in ppb. The average concentrations are presented in table 4.3.

Table 4.3 Average concentration of $PM_{2.5}$ and TVOC

Office	**No. of Occupants**	**Concentration of PM2.5 (mg/m3)**	**Concentration of TVOC (ppb)**
1	6	0.031 ± 0.002	45.33 ± 12.74
2	16	0.028 ± 0.002	78.00 ± 7.00
3	12	0.024 ± 0.000	135.67 ± 6.80
4	10	0.036 ± 0.001	123.33 ± 4.72
5	10	0.027 ± 0.001	243.67 ± 25.71
6	11	0.032 ± 0.003	150.67 ± 9.01
7	20	0.023 ± 0.001	162.33 ± 10.96
8	25	0.028 ± 0.001	260.67 ± 4.16
9	15	0.024 ± 0.001	247.00 ± 9.64
10	22	0.028 ± 0.002	122.00 ± 10.81
11	16	0.030 ± 0.005	127.67 ± 6.11
12	15	0.015 ± 0.004	156.00 ± 3.00
13	10	0.039 ± 0.002	135.00 ± 6.55
14	24	0.015 ± 0.002	116.33 ± 5.50
	N= 212	Mean 0.026 ± 0.006 Median 0.028	Mean 156.38 ± 59.34 Median 135.67
Standard/ Suggestion		15 μg/m^3 * 28 μg/m^3 (24hr) **	N/A * 3 ppm (8-hr TWA) ***

* American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) US, 2007

** Canadian Council of Minister of the Environment (CCME) Canada, 2015

*** Department of Occupational Safety and Health (DOSH) Malaysia, 2010

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The concentration of $PM_{2.5}$ ranged 0.015 - 0.039 mg/m^3 over the ASHRAE standard that is 15 μg/m^3 and mean concentration of $PM_{2.5}$ is 0.026 ± 0.006 mg/m^3, median is 0.028 mg/m^3. The concentration of TVOC ranged 45.33 – 260.67 ppb compliance the DOSH standard that is 3 ppm and mean concentration of TVOC is 156.38 ± 59.34 ppb, median is 135.67 ppb. The highest concentration of $PM_{2.5}$ is 0.039 mg/m^3 measured in office no.13 (Institute for Research and Development) which is only one furnished by carpet. The highest concentration of TVOC is 260.67 ppb measured in office no.8 (Academic Services Division) in which the most computer, printer and photocopier.

4.3 Characterization of Prevalence of abnormal lung function and respiratory symptoms

The spirometry test was done for 212 occupants in 14 air-conditioned offices and the questionnaire about respiratory symptoms were also distributed to them. The lung function of occupants was measured and interpreted in normal and abnormal (restrictive, obstructive and combined) by %FVC and FEV1/FVC%. The occupants also inform their respiratory symptoms such as cough, phlegm, wheezing and short breathing. The prevalence of lung function and respiratory symptoms are presented in table 4.4.

Prevalence rate was calculated as formula:

$$\text{Prevalence rate} = \frac{No.\,of\ Cases}{No.\,of\ Total\ Occupants}\ X\ 1000$$

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Table 4.4 Prevalence of abnormal lung function and respiratory symptoms

Respiratory Health	N	Prevalence Rate
Lung function		
Normal	150	
Restrictive (FVC <80%)	50	236 /1000
Obstructive (FEV1/FVC < 70%)	6	28 /1000
Combined (Restrictive and Obstructive)	6	28 /1000
Respiratory symptoms		
cough		
No symptoms	158	
Have symptoms	54	255 /1000
Phlegm		
No symptoms	178	
Have symptoms	34	160 /1000
Wheezing		
No symptoms	173	
Have symptoms	39	184 /1000
Short breathing		
No symptoms	179	
Have symptoms	33	156 /1000

The results of spirometry test are shown 50 persons have restrictive results (FVC less than 80 percent), 6 persons have obstructive results (FEV1/FVC less than 70 percent) and 6 persons have combined results (both FVC less than 80 percent and FEV1/FVC less than 70 percent) so there are 62 persons have an abnormal lung function. The prevalence of abnormal lung function is 292 cases per thousand persons which the major prevalence is restrictive lung function (236 cases per thousand persons), the minor prevalence is obstructive lung function (28 cases per thousand persons) and combined (28 cases per thousand persons). There are 91occupants report that they have at least one symptoms as follow cough, phlegm, wheezing and short breathing then the prevalence of respiratory symptoms is 429 cases per thousand persons. Providing 54 occupants report that they have cough then the prevalence of cough is 255 cases per thousand persons, 34 occupants report that they have phlegm

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then the prevalence of phlegm is 160 cases per thousand persons, 39 occupants report that they have wheezing then the prevalence of wheezing is 184 cases per thousand persons and 33 occupants report that they have short breathing then the prevalence of short breathing is 156 cases per thousand persons.

4.4 Examination of parameters affecting on lung function

The results of the examination of parameters affecting on lung function comprised in two parts: the examination of parameters affecting on FVC and the examination of parameters affecting on FEV1/FVC.

4.4.1 The examination of parameters affecting on FVC

The parameters which conducted to examine an effect on FVC are age, gender, smoking, previous medical records, history in dusty job, history in gas/volatile job, history in fume job, current working experience, working hour per day, concentration of $PM_{2.5}$, concentration of TVOC and room volume. The age of occupants is divided into four group (≤ 30, 31-40, 41-50 and more than 50 years old), the current working experience is divided into within ten years and more than ten years and the working hour per day is divided into within eight hours per day and more than eight hours per day. The concentration of $PM_{2.5}$ are divided into two groups by median so the low exposure and the high exposure are similar in group size. The median of $PM_{2.5}$ concentration is 0.028 mg/m^3. The concentration of TVOC are also divided into two groups by median then the low exposure and the high exposure are similar in group size. The median of TVOC concentration is 135.67 ppb. The results of univariate analysis of factors and FVC of occupants is presented in table 4.5 and

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the results of multivariate analysis of factors and FVC of occupants is presented in table 4.6.

.**Table 4.5** Univariate analysis of factors and FVC of occupants

Factors	Univariate OR (95% C.I.)	p-value
FVC (normal value ≥ 80%)		
Age (years old)		
≤ 30	1	
31 – 40	1.827(0.853-3.914)	0.121
41 – 50	2.350(0.760-7.263)	0.138
> 50	0.970(0.183-5.133)	0.971
Gender		
Male	1	
Female	1.289(0.653-2.546)	0.464
Smoking		
No	1	
Yes	0.714(0.291-1.751)	0.462
Previous medical records[1]		
No	1	
Yes	1.145(0.540-2.431)	0.723
History in dusty job		
No	1	
Yes	0.833(0.353-1.967)	0.677
History in gas/volatile job		
No	1	
Yes	0.629(0.202-1.956)	0.423
History in fume job		
No	1	
Yes	0.926(0.181-4.727)	0.926
Current working experience (years)		
≤ 10	1	
> 10	1.712(0.879-3.335)	0.114
Working hour per day (hours)		
≤ 8	1	
> 8	1.342(0.679-2.579)	0.410
Concentration of $PM_{2.5}$ (mg/m^3)		
Low (≤ 0.028)	1	
High (> 0.028)	0.663(0.314-1.402)	0.283
Concentration of TVOC (ppb)		
Low (≤ 135.67)	1	
High (> 135.67)	1.573(0.852-2.907)	0.148

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Table 4.5 Univariate analysis of factors and FVC of occupants (continued)

Factors	Univariate	
	OR (95% C.I.)	**p-value**
FVC (normal value ≥ 80%)		
Room volume (m^3)		
Small (≤ 400)	1	
Large (> 400)	0.662(0.357-1.228)	0.191

[1]illness records about asthma, chronic lung disease, emphysema, chronic bronchitis, pneumonia, hay fever (allergic rhinitis), heart disease, high blood pressure and diabetes

The results of logistic regression univariate analysis show that age, current working experience, concentration of TVOC and room volume seem to be marginally associated with FVC. The older occupants trend to have more restrictive lung function than younger ones. The occupants with more than ten year current working experience may risk to have restrictive lung function 1.712 times higher than the ones who have current working experience within ten years. The occupants exposed to high TVOC concentration may risk to have restrictive lung function 1.573 times higher than the ones exposed to low TVOC concentration. The occupants in the large offices may lower risk to have restrictive lung function than the ones in the small ones 0.662 times.

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Table 4.6 Multivariate analysis of factors and FVC of occupants

Factors	Multivariate[1]	
	OR (95% C.I.)	**p-value**
FVC (normal value ≥ 80%)		
Concentration of TVOC (ppb)		
Low (≤ 135.67)	1	
High (> 135.67)	9.289 (2.501-34.499)	0.001*
Room volume (m^3)		
Small (≤ 400)	1	
Large (> 400)	0.110 (0.029-0.410)	0.001*

[1] backward stepwise method

The results of logistic regression multivariate analysis with backward stepwise method showed that the concentration of TVOC was significantly associated with FVC (p-value = 0.001) and the office room volume was also significantly associated with FVC (p-value = 0.001). The odds of restrictive abnormal lung function were 9.289 times higher in the high TVOC concentration exposure than the low one; whereas, the odds of restrictive abnormal lung function were 0.110 times lower in the large office than the small one.

4.4.2 The examination of parameters affecting on FEV1/FVC

The parameters which conducted to examine an effect on FEV1/FVC are age, gender, smoking, previous medical records, history in dusty job, current working experience, working hour per day, concentration of $PM_{2.5}$, concentration of TVOC and room volume. The age of occupants is divided into four group (≤ 30, 31-40, 41-50 and more than 50 years old), the current working experience is divided into within ten years and more than ten years and the working hour per day is divided into within eight hours per day and more than eight hours per day. The concentration of $PM_{2.5}$ are divided into two groups by median so the low exposure and the high exposure are similar in group size. The median of $PM_{2.5}$ concentration is 0.028 mg/m^3. The concentration of TVOC are also divided into two groups by median then the low exposure and the high exposure are similar in group size. The median of TVOC concentration is 135.67 ppb. The results of univariate analysis of factors and FEV1/FVC of occupants is presented in table 4.7 and the results of multivariate analysis of factors and FEV1/FVC of occupants is presented in table 4.8.

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Table 4.7 Univariate analysis of factors and FEV1/FVC of occupants

Factors	Univariate OR (95% C.I.)	p-value
FEV1/FVC (normal value ≥ 70%)		
Age (years old)		
≤ 30	1	
31 – 40	1.735(0.349-8.620)	0.501
41 – 50	3.167(0.416-24.119)	0.266
> 50	2.850(0.236-34.469)	0.410
Gender		
Male	1	
Female	0.600(0.183-1.966)	0.399
Smoking		
No	1	
Yes	1.090(0.228-5.218)	0.914
Previous medical records[1]		
No	1	
Yes	2.132(0.610-7.448)	0.236
History in dusty job		
No	1	
Yes	1.050(0.220-5.020)	0.951
Current working experience (years)		
≤ 10	1	
> 10	3.082(0.950-9.994)	0.061
Working hour per day (hours)		
≤ 8	1	
> 8	0.985(0.286-3.390)	0.981
Concentration of $PM_{2.5}$ (mg/m^3)		
Low (≤ 0.028)	1	
High (> 0.028)	3.255(1.002-10.571)	0.050
Concentration of TVOC (ppb)		
Low (≤ 135.67)	1	
High (> 135.67)	0.587(0.171-2.012)	0.397
Room volume (m^3)		
Small (≤ 400)	1	
Large (> 400)	0.510(0.149-1.748)	0.284

[1]illness records about asthma, chronic lung disease, emphysema, chronic bronchitis, pneumonia, hay fever (allergic rhinitis), heart disease, high blood pressure and diabetes

The results of logistic regression univariate analysis show that current working experience and concentration of $PM_{2.5}$ are marginally associated with FEV1/FVC.

The occupants with more than ten year current working experience may risk to have obstructive lung function 3.082 times higher than the ones who have current working experience within ten years. The occupants exposed to high $PM_{2.5}$ concentration may risk to have obstructive lung function 3.255 times higher than the ones exposed to low $PM_{2.5}$ concentration.

Table 4.8 Multivariate analysis of factors and FEV1/FVC of occupants

Factors	Multivariate[1] OR (95% C.I.)	p-value
FEV1/FVC (normal value ≥ 70%)		
Current working experience (years)		
≤ 10	1	
> 10	3.407 (1.024-11.340)	0.046*
Concentration of $PM_{2.5}$ (mg/m^3)		
Low (≤ 0.028)	1	
High (> 0.028)	3.588 (1.078-11.943)	0.037*

[1] backward stepwise method

The results of logistic regression multivariate analysis with backward stepwise method showed that the concentration of $PM_{2.5}$ was significantly associated with FEV1/FVC (p-value = 0.037) and current working experience was also significantly associated with FEV1/FVC (p-value = 0.046). The odds of obstructive abnormal lung function were 3.588 times higher in the high $PM_{2.5}$ concentration exposure than the low one and the odds of obstructive abnormal lung function were 3.407 times higher in the group of more than ten year experience in current job than the group of within ten year experience.

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4.5 Examination of parameters affecting on respiratory symptoms

The results of the examination of parameters affecting on respiratory symptoms comprised in four parts: the examination of parameters affecting on cough, the examination of parameters affecting on phlegm, the examination of parameters affecting on wheezing and the examination of parameters affecting on short breathing.

4.5.1 The examination of parameters affecting on cough

The parameters which conducted to examine an effect on cough are age, gender, smoking, previous medical records, history in dusty job, history in gas/volatile job, history in fume job, current working experience, working hour per day, concentration of $PM_{2.5}$, concentration of TVOC and room volume. The age of occupants is divided into four group (≤ 30, 31-40, 41-50 and more than 50 years old), the current working experience is divided into within ten years and more than ten years and the working hour per day is divided into within eight hours per day and more than eight hours per day. The concentration of $PM_{2.5}$ are divided into two groups by median so the low exposure and the high exposure are similar in group size. The median of $PM_{2.5}$ concentration is 0.028 mg/m^3. The concentration of TVOC are also divided into two groups by median then the low exposure and the high exposure are similar in group size. The median of TVOC concentration is 135.67 ppb. The results of univariate analysis of factors and cough of occupants is presented in table 4.9 and the results of multivariate analysis of factors and cough of occupants is presented in table 4.10.

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Table 4.9 Univariate analysis of factors and cough of occupants

Factors	Univariate OR (95% C.I.)	p-value
Cough		
Age (years old)		
≤ 30	1	
31 – 40	0.678(0.338-1.362)	0.275
41 – 50	0.569(0.167-1.944)	0.369
> 50	1.302(0.338-5.009)	0.701
Gender		
Male	1	
Female	0.757(0.393-1.457)	0.404
Smoking		
No	1	
Yes	2.188(1.002-4.775)	0.049*
Previous medical records[1]		
No	1	
Yes	0.758(0.336-1.706)	0.503
History in dusty job		
No	1	
Yes	1.502(0.677-3.329)	0.317
History in gas/volatile job		
No	1	
Yes	2.433(0.963-6.147)	0.060
History in fume job		
No	1	
Yes	0.974(0.191-4.978)	0.975
Current working experience (years)		
≤ 10	1	
> 10	0.764(0.368-1.587)	0.471
Working hour per day (hours)		
≤ 8	1	
> 8	1.780(0.881-3.596)	0.108
Concentration of $PM_{2.5}$ (mg/m^3)		
Low (≤ 0.028)	1	
High (> 0.028)	0.935(0.455-1.921)	0.856
Concentration of TVOC (ppb)		
Low (≤ 135.67)	1	
High (> 135.67)	0.864(0.463-1.612)	0.646
Room volume (m^3)		
Small (≤ 400)	1	
Large (> 400)	0.654(0.349-1.222)	0.183

[1]illness records about asthma, chronic lung disease, emphysema, chronic bronchitis, pneumonia, hay fever (allergic rhinitis), heart disease, high blood pressure and diabetes

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The results of logistic regression univariate analysis show that smoking is significantly associated with cough (p-value = 0.049). History in gas/volatile job, working hour per day and room volume seem to be marginally associated with cough. Smokers may risk to cough 2.188 times higher than nonsmokers. History in gas/volatile job may higher risk to cough than unexposed job 2.433 times. The occupants who work in offices more than eight hours per day may risk to cough higher than the ones who work within eight hours per day 1.780 times. The occupants in the large offices may lower risk to cough than the ones in the small ones 0.654 times.

Table 4.10 Multivariate analysis of factors and cough of occupants

Factors	Multivariate[1] OR (95% C.I.)	p-value
Cough		
Smoking		
No	1	
Yes	2.438(1.091-5.447)	0.030*
Working hour per day (hours)		
≤ 8	1	
> 8	2.015(0.979-4.148)	0.057
Room volume (m^3)		
Small (≤ 400)	1	
Large (> 400)	0.580(0.305-1.106)	0.098

[1] backward stepwise method

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The results of logistic regression multivariate analysis with backward stepwise method showed that smoking was significantly associated with cough (p-value = 0.030); whereas, the working hour per day and office room volume were marginally associated. The odds of cough were 2.438 times higher in smoker than non-smoker.

4.5.2 The examination of parameters affecting on phlegm

The parameters which conducted to examine an effect on phlegm are age, gender, smoking, previous medical records, history in dusty job, history in gas/volatile job, history in fume job, current working experience, working hour per day, concentration of $PM_{2.5}$, concentration of TVOC and room volume. The age of occupants is divided into four group (≤ 30, 31-40, 41-50 and more than 50 years old), the current working experience is divided into within ten years and more than ten years and the working hour per day is divided into within eight hours per day and more than eight hours per day. The concentration of $PM_{2.5}$ are divided into two groups by median so the low exposure and the high exposure are similar in group size. The median of $PM_{2.5}$ concentration is 0.028 mg/m^3. The concentration of TVOC are also divided into two groups by median then the low exposure and the high exposure are similar in group size. The median of TVOC concentration is 135.67 ppb. The results of univariate analysis of factors and phlegm of occupants is presented in table 4.11 and the results of multivariate analysis of factors and phlegm of occupants is presented in table 4.12.

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Table 4.11 Univariate analysis of factors and phlegm of occupants

Factors	Univariate OR (95% C.I.)	p-value
Phlegm		
Age (years old)		
≤ 30	1	
31 – 40	0.755(0.331-1.722)	0.505
41 – 50	0.770(0.192-3.096)	0.713
> 50	0.970(0.183-5.133)	0.971
Gender		
Male	1	
Female	0.777(0.359-1.684)	0.523

Table 4.11 Univariate analysis of factors and phlegm of occupants (continued)

Factors	Univariate OR (95% C.I.)	p-value
Phlegm		
Smoking		
No	1	
Yes	1.516(0.598-3.840)	0.381
Previous medical records[1]		
No	1	
Yes	1.059(0.426-2.631)	0.901
History in dusty job		
No	1	
Yes	3.223(1.389-7.477)	0.006*
History in gas/volatile job		
No	1	
Yes	4.980(1.905-13.021)	0.001*
History in fume job		
No	1	
Yes	1.792(0.346-9.275)	0.487
Current working experience (years)		
≤ 10	1	
> 10	0.702(0.287-1.718)	0.439
Working hour per day (hours)		
≤ 8	1	
> 8	1.448(0.636-3.296)	0.377
Concentration of $PM_{2.5}$ (mg/m^3)		
Low (≤ 0.028)	1	
High (> 0.028)	1.308(0.580-2.951)	0.518
Concentration of TVOC (ppb)		
Low (≤ 135.67)	1	
High (> 135.67)	0.446(0.201-0.986)	0.046*
Room volume (m^3)		
Small (≤ 400)	1	
Large (> 400)	0.381(0.172-0.843)	0.017*

[1]illness records about asthma, chronic lung disease, emphysema, chronic bronchitis, pneumonia, hay fever (allergic rhinitis), heart disease, high blood pressure and diabetes

The results of logistic regression univariate analysis show that history in dusty job is significantly associated with phlegm (p-value = 0.006) and the odds of phlegm were 3.223 times higher in the group of history in dusty job than the group of never history in dusty job. History in gas/volatile job is significantly associated with phlegm

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(p-value = 0.001) and the odds of phlegm were 4.980 times higher in the group of history in gas/volatile job than the group of never history in gas/volatile job. The concentration of TVOC is significantly associated with phlegm (p-value = 0.046) and the odds of phlegm were 0.446 times lower in the group of high concentration of TVOC exposure than the group of low concentration of TVOC exposure. The room volume is significantly associated with phlegm (p-value = 0.017). The odds of phlegm were 0.381 times lower in the group in large office than the group in small one.

Table 4.12 Multivariate analysis of factors and phlegm of occupants

Factors	Multivariate[1] OR (95% C.I.)	p-value
Phlegm		
History in gas/volatile job		
No	1	
Yes	4.184(1.567-11.170)	0.004*
Room volume (m^3)		
Small (≤ 400)	1	
Large (> 400)	0.447(0.197-1.010)	0.053

[1] backward stepwise method

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The results of logistic regression multivariate analysis with backward stepwise method showed that history in gas/volatile job was significantly associated with phlegm (p-value = 0.004) while office room volume was marginally associated. The odds of phlegm were 4.184 times higher in the group of ever experience in gas/volatile job than the group of never.

4.5.3 The examination of parameters affecting on wheezing

The parameters which conducted to examine an effect on wheezing are age, gender, smoking, previous medical records, history in dusty job, history in gas/volatile job, history in fume job, current working experience, working hour per day, concentration of $PM_{2.5}$, concentration of TVOC and room volume. The age of occupants is divided into four group (≤ 30, 31-40, 41-50 and more than 50 years old), the current working experience is divided into within ten years and more than ten years and the working hour per day is divided into within eight hours per day and more than eight hours per day. The concentration of $PM_{2.5}$ are divided into two groups by median so the low exposure and the high exposure are similar in group size. The median of $PM_{2.5}$ concentration is 0.028 mg/m^3. The concentration of TVOC are also divided into two groups by median then the low exposure and the high exposure are similar in group size. The median of TVOC concentration is 135.67 ppb. The results of univariate analysis of factors and wheezing of occupants is presented in table 4.13 and the results of multivariate analysis of factors and wheezing of occupants is presented in table 4.14.

Table 4.13 Univariate analysis of factors and wheezing of occupants

Factors	Univariate OR (95% C.I.)	p-value
Wheezing		
Age (years old)		
≤ 30	1	
31 – 40	0.722(0.324-1.609)	0.426
41 – 50	1.679(0.533-5.287)	0.376
> 50	0.870(0.166-4.569)	0.870
Gender		
Male	1	
Female	1.352(0.615-2.969)	0.453
Smoking		
No	1	
Yes	0.397(0.115-1.375)	0.145
Previous medical records[1]		
No	1	
Yes	1.055(0.445-2.501)	0.903

Table 4.13 Univariate analysis of factors and wheezing of occupants (continued)

Factors	Univariate OR (95% C.I.)	p-value
Wheezing		
History in dusty job		
No	1	
Yes	0.730(0.263-2.025)	0.546
History in gas/volatile job		
No	1	
Yes	0.718(0.201-2.568)	0.610
History in fume job		
No	1	
Yes	0.624(0.075-5.224)	0.664
Current working experience (years)		
≤ 10	1	
> 10	2.078(0.996-4.336)	0.051
Working hour per day (hours)		
≤ 8	1	
> 8	1.317(0.613-2.831)	0.480
Concentration of $PM_{2.5}$ (mg/m^3)		
Low (≤ 0.028)	1	
High (> 0.028)	0.734(0.314-1.714)	0.475
Concentration of TVOC (ppb)		
Low (≤ 135.67)	1	
High (> 135.67)	1.524(0.759-3.063)	0.236
Room volume (m^3)		
Small (≤ 400)	1	
Large (> 400)	0.887(0.442-1.781)	0.737

[1]illness records about asthma, chronic lung disease, emphysema, chronic bronchitis, pneumonia, hay fever (allergic rhinitis), heart disease, high blood pressure and diabetes

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The results of logistic regression univariate analysis show that smoking and current working experience are marginally associated with wheezing. Smoker may lower risk wheezing than nonsmoker 0.397 times. The occupants with more than ten year current working experience may risk to wheezing 2.078 times higher than the ones who have current working experience within ten years.

Table 4.14 Multivariate analysis of factors and wheezing of occupants

Factors	Multivariate[1] OR (95% C.I.)	p-value
Wheezing		
Current working experience (years)		
≤ 10	1	
> 10	2.019(0.954-4.272)	0.066
Concentration of TVOC (ppb)		
Low (≤ 135.67)	1	
High (> 135.67)	3.196(1.040-9.820)	0.043*
Room volume (m^3)		
Small (≤ 400)	1	
Large (> 400)	0.351(0.114-1.078)	0.067

[1] backward stepwise method

The results of logistic regression multivariate analysis with backward stepwise method showed that the concentration of TVOC was significantly associated with wheezing (p-value = 0.043); whereas, the current working experience and office room volume were marginally associated. The odds of wheezing were 3.196 times higher in the high TVOC concentration exposure than the low one.

4.5.4 The examination of parameters affecting on short breathing

The parameters which conducted to examine an effect on short breathing are age, gender, smoking, previous medical records, history in dusty job, history in gas/volatile job, current working experience, working hour per day, concentration of $PM_{2.5}$, concentration of TVOC and room volume. The age of occupants is divided into four group (≤ 30, 31-40, 41-50 and more than 50 years old), the current working experience is divided into within ten years and more than ten years and the working hour per day is divided into within eight hours per day and more than eight hours per day. The concentration of $PM_{2.5}$ are divided into two groups by median so the low exposure and the high exposure are similar in group size. The median of $PM_{2.5}$ concentration is 0.028 mg/m^3. The concentration of TVOC are also divided into two groups by median then the low exposure and the high exposure are similar in group size. The median of TVOC concentration is 135.67 ppb. The results of univariate analysis of factors and short breathing of occupants is presented in table 4.15 and the results of multivariate analysis of factors and short breathing of occupants is presented in table 4.16.

Table 4.15 Univariate analysis of factors and short breathing of occupants

Factors	Univariate OR (95% C.I.)	p-value
Short breathing		
Age (years old)		
≤ 30	1	
31 – 40	1.457(0.579-3.667)	0.425
41 – 50	1.857(0.481-7.165)	0.369
> 50	1.651(0.295-9.251)	0.569
Gender		
Male	1	
Female	2.212(0.866-5.652)	0.097
Smoking		
No	1	
Yes	0.713(0.233-2.183)	0.554
Previous medical records[1]		
No	1	
Yes	0.883(0.339-2.299)	0.798
History in dusty job		
No	1	
Yes	1.883(0.767-4.623)	0.167
History in gas/volatile job		
No	1	
Yes	1.314(0.413-4.187)	0.644
Current working experience (years)		
≤ 10	1	
> 10	1.534(0.689-3.413)	0.294
Working hour per day (hours)		
≤ 8	1	
> 8	0.983(0.447-2.162)	0.967

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Table 4.15 Univariate analysis of factors and short breathing of occupants (continued)

Factors	Univariate OR (95% C.I.)	p-value
Short breathing		
Concentration of $PM_{2.5}$ (mg/m^3)		
Low (≤ 0.028)	1	
High (> 0.028)	1.151(0.498-2.660)	0.743
Concentration of TVOC (ppb)		
Low (≤ 135.67)	1	
High (> 135.67)	0.553(0.253-1.207)	0.137
Room volume (m^3)		
Small (≤ 400)	1	
Large (> 400)	0.553(0.257-1.190)	0.130

[1]illness records about asthma, chronic lung disease, emphysema, chronic bronchitis, pneumonia, hay fever (allergic rhinitis), heart disease, high blood pressure and diabetes

The results of logistic regression univariate analysis show that gender, history in dusty job, concentration of TVOC and room volume trend to be marginally associated with short breathing. Female may higher risk to have short breathing than male 2.212 times. The occupants with history in dusty job may higher risk to have short breathing than the ones never history in dusty job. The occupants exposed to high concentration of TVOC may lower risk to short breathing than the ones exposed to low concentration of TVOC 0.553 times. The occupants in the large offices may lower risk to short breathing than the ones in the small ones 0.553 times.

Table 4.16 Multivariate analysis of factors and short breathing of occupants

Factors	Multivariate[1] OR (95% C.I.)	p-value
Short breathing		
Gender		
Male	1	
Female	2.791(1.035-7.530)	0.043*
History in dusty job		
No	1	
Yes	2.558(0.979-6.685)	0.055

[1] backward stepwise method

The results of logistic regression multivariate analysis with backward stepwise method showed that gender was significantly associated with short breathing (p-value = 0.043) while history in dusty job was marginally associated. The odds of short breathing were 2.791 times higher in female than male.

4.6 Qualitative Study Part

There are twenty four occupants who have both abnormal lung function and respiratory symptoms. The twelve occupants are purposively selected for focus group discussion. The topics of discussion are air pollution, risk behavior and health. The results are presented in two parts including the part of socio demographic information and the part of focus group discussion.

Socio demographic information

Demographic information of the twelve studied occupants including gender, age, smoking behavior and current working experience was gathered during the study. Sample demographic information of the occupants is presented in table 4.17

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Table 4.17 Sample demographic information of the occupants (N = 12)

variable	n	percentage	Range	Mean	S.D.
Gender					
Male	4	33.33			
Female	8	66.67			
Age			24-49	34.58	7.46
Smoking	3	25.00			
Year in current work			2-21	8.92	6.20

The demographic information of twelve occupants shows that one-third of the occupants are men (33.33%) and one-fourth of the occupants are smoker (25%). The average age and average current working age are 34.58 and 8.92 years respectively.

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Focus group discussion

The results of the focus group discussion are categorized in three parts including 1) Risk behavior and air pollution exposure, 2) Awareness to level of hazards from air pollution, and 3) Protection from air pollution hazards.

1) Risk behavior and air pollution exposure

Risk behavior

The findings show that one-fourth of the participants are smoker and perceive smoking is their risk behavior. Most of the participants catch the bus to the office and perceive that is risk behavior. Few of them often use motorbike and only one try to avoid the risk behavior and prevent from anything that may risk due to her allergies. For example:

Man, 42 years *"I think smoking is risk behavior because smoking is danger to respiratory health and lung"*

Woman, 28 years *"I catch the bus to office every day and inhale dust/smoke along the road"*

Man, 25 years *"I am also a smoker and I ride a motorbike"*

Man, 33 years *"I don't smoking but I often ride a motorbike, too"*

Man, 38 years *"I've been smoking and I'd ever been welding Technician for three years"*

Woman, 41 years *"I have allergies, I normally avoid the risk situations (I think) such as dust, pets, perfume"*

Air pollution exposure

The findings show that most of the participants perceive air pollution exposure in their office that they refer to dust from a lot of document paper and many things which store in their offices; however, the few of them mention that there are few in the office when compare with air pollution in the outdoors. Most of the participants perceive photocopier and printer are sources of air pollution in office and also perceive the air conditioners may be air pollution sources because of sometimes undesirable odors especially early stage of operation. In addition, they mostly reveal the symptoms when expose to dust are respiratory irritation, sneeze and cough. For example:

Woman, 30 years *"I think about dust in my office because there are a lot of document and other things kept for a long time"*

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Man, 25 years *"I think so but maybe few when compare with the outdoor"*

Woman, 34 years *"There may be low level of dust indoors because of an air-conditioned office"*

Woman, 28 years *"Maybe the air conditioner may be an indoor source also. When the air conditioner has just turned on, undesirable odors can be perceived"*

Man, 33 years *"I think so, sometimes I perceive that odor, too"*

Woman, 39 years *"Photocopier. Bulk of documents was copied during the semester. It's possible to be source of air pollution"*

Woman, 24 years *"Maybe printer too. During printing, printer toner possibly emanate into the air"*

Woman, 41 years *"Expose to dust result in respiratory irritation, sneeze and cough. Maybe allergies."*

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2) Awareness to level of hazards from air pollution

The findings show that most of the participants perceive the air pollution harm to health especially respiratory system because inhalation of anything that contaminate in the air naturally can be worse affect to health. Most of them perceive the respirable dust may enter to respiratory tract and accumulate in the lung. They mostly concern that long term effect of air pollution exposure and high concentration exposure may be the respiratory disease and lung disease. However, few of the participants hardly recognize the hazard from indoor air pollution because of low level of hazard. For example:

Man, 33 years	*"The air pollution usually affects to respiratory health"*
	"Because any hazardous thing often decline the health"
Woman, 24 years	*"The small dust can enter to the respiratory tract and cause the respiratory disease"*
Woman, 30 years	*"Maybe enter and remain in the lung that may hazard to the lung"*
Man, 42 years	*"Expose for a long time, there are more hazards"*
Woman, 39 years	*"High concentration exposure may also have more hazards"*
Woman, 49 years	*"It's possible to occur respiratory disease and lung disease"*
Woman, 42 years	*"The respiratory disease and lung disease will occur if we expose to high concentration of air pollution for a long time"*
Woman, 34 years	*"As the few pollutants in office might not be the serious hazard"*

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3) Protection from air pollution hazards

The findings show that most of the participants perceive the air pollution hazard but they hardly protect themselves from air pollutants hazard because of their duty in the office. They mostly use protective mask when they have a cold with cough, go to somewhere that may obviously perceive the hazards such as the hospital. Although they mostly do not protect themselves from air pollution in routine work, few of them sometime use mask to protect their respiratory health in the office when they use photocopiers for a long time and during big cleaning in the office. For example:

Man, 38 years *"The air pollution can harm to health but more task to do in the office"*

Woman, 39 years *"I concern that hazard but I still work"*

Woman, 41 years *"I always use the protective mask when I go to the hospital"*

Woman, 24 years *"I normally use the protective mask when I have cough"*

Woman, 49 years *"Sometimes I have to copy the bulk of document, I will use mask"*

Woman, 32 years *"I use mask when I have to do some activities particularly cleaning the office on a big cleaning day"*

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The observation reveal all participants have their own printer at working station. The most of them working in offices with photocopier (s) inside. There are a lot of paper documents around their work station and almost everywhere in their office. All of their desk which have the partition are not near by the door and air-conditioner.

Chapter V

Discussion and conclusion

The present study was carried out to identify the effect of indoor air pollution sources and concentrations in offices on respiratory health of occupants. The findings composed of five parts including 1) Characteristics of occupants in air-conditioned offices, 2) Characteristics of offices and concentration of $PM_{2.5}$ and TVOC, 3) Prevalence of abnormal lung function and respiratory symptoms, 4) Factors influenced on lung function and 5) Factors influenced on respiratory symptoms.

5.1 Summary of findings

The findings of characteristics of occupants in air conditioned offices revealed that most of occupants are female, average age 34.61 ± 7.501 years old and mostly nonsmoker. They mostly have not history in at least one of medical records in asthma, chronic lung disease, emphysema, chronic bronchitis, pneumonia, hay fever (allergic rhinitis), heart disease, high blood pressure and diabetes. Most of them also hardly have history in dusty job, gas or volatile job and fume job. In addition, they mostly have experience in current job within ten year and work more than eight hour a day.

The findings of characteristics of offices and concentration of $PM_{2.5}$ and TVOC revealed that all offices furnished by MDF, their floor covered with tile, rubber and carpet in each. Other materials in offices such as cement, gypsum, glass and metal. The age of office buildings are 8-26 years. The most number of computers, printer and photocopiers in one office is 50, 28 and 3 sets respectively. The mean concentration of $PM_{2.5}$ in these offices is 0.026 ± 0.006 mg/m^3 and in range of 0.015 - 0.039 mg/m^3. The mean concentration of TVOC in these offices is 156.38 ± 59.34 ppb and in range of 45.33 – 260.67 ppb.

The findings of prevalence of abnormal lung function and respiratory symptoms revealed that the prevalence of restrictive lung function, obstructive lung function and combined are 236, 28 and 28 cases per thousand persons respectively and the prevalence of cough, phlegm, wheezing and short breathing are 255, 160, 184 and 156 cases per thousand persons respectively.

The finding factors influenced on lung function revealed that factors influenced on FVC are concentration of TVOC (p-value < 0.05) and room volume (p-value < 0.05), factors influenced on FEV1/FVC are current working experience (p-value < 0.05) and concentration of $PM_{2.5}$ (p-value < 0.05). The odds of restrictive abnormal lung function were 9.289 times higher in high TVOC exposure and 0.110 times lower in the large office. The odds of obstructive abnormal lung function were 3.588 times higher in the high $PM_{2.5}$ exposure and 3.407 times higher in longer experience in current job.

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The finding factors influenced on respiratory symptoms revealed that factor influenced on cough is smoking (p-value < 0.05), factor influenced on phlegm is history in gas or volatile job (p-value < 0.05), factor influenced on wheezing is concentration of TVOC (p-value < 0.05), and factor influenced on short breathing is gender (p-value < 0.05). The odds of cough were 2.438 times higher in smoker. The odds of phlegm were 4.184 times higher in former exposure in gas or volatile. The odds of wheezing were 3.196 times higher in the high TVOC exposure. The odds of short breathing were 2.791 times higher in female.

5.2 Discussion

1) Characteristics of occupants in air-conditioned offices

The studied occupants comprised 30.7% men and 69.3 % women. Most of them are 31-40 years old, nonsmokers, current job experience within 10 years, working more than 8 hours per day and no history medical record in asthma, chronic lung disease, emphysema, chronic bronchitis, pneumonia, hay fever (allergic rhinitis), heart disease, high blood pressure and diabetes resemble the office workers in Hsinchu, Taiwan who are generally nonsmokers, average age 31.9 years old, 11.3 average daily working hours and no history of sinusitis, asthma, eczema, hay fever and allergies (Dai-Hua Tsai et al., 2012) whereas the respondents in mechanically ventilated offices are more men than women and mean age is 41 years old (Hummelgaard et al., 2007) and the office workers in northeastern Malaysia are 54.2% smoker, mean age 41.1 years old, duration of work average 10.3 years and 53.1% working more than 8 hours per day (Junaidi Djoharnis. & al., 2012).

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2) Characteristics of offices and concentration of $PM_{2.5}$ and TVOC

The studied offices were furnished with various materials such as tile, cement, gypsum, MDF, rubber, glass, metal and carpet. The volatile organic compounds emission rate from carpet 134 μg /hr/ m^{-2} (T. Berrios, Zhang, Guo, Smith, & Zhang, 2005). All offices were furnished with MDF which can emit the indoor pollutants following (Kim et al., 2013) studied emission fluxes of aldehyde from the materials and found that the emission fluxes in the room with coated MDF and plywood panels was 46.8 μg m^{-2} h^{-1}. There are lots of computers and printers in every office and there are photocopiers in some offices. The office that contains the maximum number of computers, printers and photocopiers is the office of Academic Services Division (office no.8) which also found the highest concentration of TVOC. According to the findings of the study of volatile organic compound emissions from sources in a partitioned office environment reported that the emissions were 10 to 120 times higher when the computer were “ON” than “OFF” and emission rates were highest when the copier and printers were in operating mode (T. Berrios et al., 2005). Similar to the results of the study of chemical emission rates of personal computers and found that the formaldehyde emissions were 9 times higher when personal computer was on than when it was off (Funaki, Tanaka, Nakagawa, & Tanabe, 2003). The TVOC concentration in university offices is 45.33 to 260.67 ppb similar to volatile organic compounds concentration in Australian buildings and apartments (M.Rehwagen, U.Schlink, & O.Herbarth., 2003) nevertheless differ from the volatile organic compounds concentration in air conditioned offices adjacent to a busy road (Hedge et al., 1989) and also in roadside resident and non-industrial sector in building (Ismail, Md.Ceros, & Leman., 2010). The results indicate that the highest concentration of $PM_{2.5}$ is 0.039 mg/m^3 measured in the office of Institute for Research and Development (the office no.13) which is only one office furnished by carpet that can decent gather of the particulate matter. The range of $PM_{2.5}$ concentration in university offices is 0.015 - 0.039 mg/m^3 (15-39 μg/m^3) resemble the concentration of $PM_{2.5}$ in university classrooms is 26-37μg/m^3 (Klinmalee et al., 2009) whereas The $PM_{2.5}$ concentration in office in Hsinchu, Taiwan that is 4.9-5.3 μg/m^3 (Dai-Hua Tsai et al., 2012) and in office buildings in US.is in range 1.3-24.8 μg/m^3 (Burton. et al., 2000) which lower than in Bangkok.

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3) Prevalence of abnormal lung function and respiratory symptoms

The results of this study revealed that the prevalence of abnormal lung function of occupants in university offices is 292 cases per thousand persons (29.2 percent) comprises restrictive lung function, obstructive lung function and combined. The prevalence of restrictive lung function is 236 cases per thousand persons (23.6 percent), the prevalence of obstructive lung function is 28 cases per thousand persons (2.8 percent) and the prevalence of combined restrictive and obstructive lung function is 28 cases per thousand persons (2.8 percent). Whereas the prevalence of abnormal lung function of office workers in northeastern Malaysia which is 13.5 percent include 10.3 percent of restrictive lung function and 3.1 percent of obstructive lung function (Junaidi Djoharnis. & al., 2012).

The prevalence of respiratory symptoms of occupants in air-conditioned offices is 429 cases per thousand persons (42.9 percent) more than the prevalence of respiratory problems of workers in air conditioned offices adjacent to a busy road which is 10 percent (Hedge et al., 1989). The prevalence of cough of occupants in air-conditioned offices is 255 cases per thousand persons (25.5 percent) which more than the prevalence of cough at least sometimes of occupants in mechanically ventilated offices that is 17.5 percent (Hummelgaard et al., 2007), 5 percent in US (Mendell et al., 2008), 1.6 percent in Japan (Azuma et al., 2015), and the prevalence of cough of office workers in Hsinchu, Taiwan that is 11.7 percent in August and 9.9 percent in November (Dai-Hua Tsai et al., 2012). The prevalence of phlegm of occupants in air-conditioned offices are 160 cases per thousand persons (16 percent). The prevalence of wheezing of occupants in air-conditioned offices is 184 cases per thousand persons (18.4 percent) which is more than the prevalence of wheezing of office workers that is

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8.3 percent in Brazil (Boechat. et al., 2005), 0.2percent in Japan (Azuma et al., 2015), and in Hsinchu, Taiwan that is 2.7 percent in August and 1.8 percent in November (Tsai, Lin, & Chan, 2012). The prevalence of short breathing of occupants in air-conditioned offices is 156 cases per thousand persons (15.6 percent) similar the prevalence of shortness of breath of office workers in Brazil that is 20 percent (Boechat. et al., 2005; J. L. d. M. Rios et al., 2009), 0.3 percent in Japan (Azuma et al., 2015), but less than in France that is 32.3 percent (Teculescu et al., 1998) nevertheless more than in Singapore which are 2.3 percent (Ooi, Goh, Phoon, Foo, & Yap, 1998) and 2.82 percent (Chen & Chang, 2012), in US that is 2 percent (Brightman et al., 2008), in UK that is 2.9 percent (Finnegan et al., 1984), in Sweden which are 1.5 percent (Eriksson & Stenberg, 2006) and 8.7 percent (D. Norback & Nordstrom, 2008), and in Hsinchu, Taiwan that is 4.5 percent (Dai-Hua Tsai et al., 2012).

4) Factors influenced on lung function

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The results reveal that the concentration of $PM_{2.5}$ is significantly associated with FEV1/FVC. As $PM_{2.5}$ can be inhaled through the airways and may cause the obstruction so that the volume of air exhaled during the performance of a forced expiratory maneuver in the first second (FEV1) will decrease. Then exposure to $PM_{2.5}$ may result in reduced FEV1/FVC and low FEV1/FVC indicated the obstructive result of abnormal lung function owing to airway obstruction. The results also indicate that the concentration of TVOC is significantly associated with FVC. Low FVC indicated the restrictive result of abnormal lung function because of lung flexibility loss. The TVOC exposure may cause FVC reduction. Similar the findings of the study of volatile organic compound and lung function indicate that expose to volatile organic compounds (1, 4-dichlorobenzene) may result in reduced pulmonary function (Elliott et al., 2006).

5) Factors influenced on respiratory symptoms

The results indicate that smoking is significantly associated with cough resemble the study of respiratory symptoms in school teachers of Shimla city in the western Himalayas found the statistically significant relation of cough with smoking (Vaidya et al., 2007) and the study of pulmonary function tests and respiratory symptoms among smokers which result that more prevalence of cough in smokers than nonsmokers and smoking leads to increased respiratory symptoms and reduction of PFTs values (Boskabady et al., 2011; Brown., 2002). Whereas the study of office workers' sick building syndrome and indoor carbon dioxide concentrations found the significantly association between allergic history and cough (Tsai et al., 2012). The findings indicate that history in gas/volatile job was significantly associated with phlegm and exposure to TVOC appear to significantly associate with wheezing while (Tsai et al., 2012) found allergic history and smoking are marginally associated with wheezing and also found the significantly association between allergic history and shortness of breath. In addition, Gender was significantly associated with short breathing. Women reported more short breathing than men similar (J. L. d. M. Rios et al., 2009) studied symptoms prevalence among office worker in sealed building and found the prevalence of breathless were 22.4 % in women and 18.3 % in men and the study of (Reijula & Sundman-Digert, 2004a) indicated that women reported indoor air

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problems and work related symptoms more often than men. It is not clear about influence of gender may be the reflection of individual hypersensitivity to pollutants.

Focus group discussions

Focus group discussions was conducted among twelve occupants in air conditioned offices who had restrictive lung function result or obstructive lung function result or combined result and had at least one of respiratory symptoms include cough, phlegm, wheezing and shortness of breath. The main purpose is to get in-depth qualitative information and opinions of occupants about air pollution in their offices which focus on three parts namely 1) Risk behavior and air pollution exposure, 2) Awareness to level of hazards from air pollution, and 3) Protection from air pollution hazards.

According to the content analysis results, 1) the study showed that most of the participants perceive their risk behavior, air pollution exposure and the respiratory symptoms are respiratory irritation, sneeze and cough whereas the study in Silesia Vovideship reveal majority of respondents pointed to respiratory disorders including allergies and asthma, headache, irritation of mucous membranes and eyes, and cancer (Karolina. et al., 2012). 2) The study reveal awareness to level of hazards that most of the participants perceive the air pollution harm to health especially respiratory system resemble to the study in Silesia Vovideship about the level of awareness of exposure to indoor environmental factors found most of the respondents considered indoor air pollution as harmful to health (Karolina. et al., 2012). 3) The study found almost participants perceive the air pollution hazard whereas most of them hardly protect

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themselves from air pollutants hazard. However, better knowledge on health effects resulting from exposure to indoor air pollution and the methods of prevention.

5.3 Strength of the study

The present study use a mixed-method, the quantitative research and the qualitative research, which it is one of the strengths. The respiratory health measured both subjective symptoms and lung function which is scientific method.

5.4 Limitation of this study

The sampling group in this research was the occupants in the government university offices with the split type air conditioner. Hence, these research results cannot be generalized to other offices.

5.5 Conclusion

The risk of occupational respiratory health may decrease if indoor air pollution become lower. Several factors including concentration of TVOC, concentration of $PM_{2.5}$, working experience in current job and size of office room were associated with lung function of occupants. Smoking behavior, history in volatile job and concentration of TVOC were also associated with respiratory symptoms.

The occupants perceive the indoor air pollution exposure include dust, toner and odor and also perceive indoor sources such as document paper, printer, and photocopier. Their risk behaviors are smoking, welding, ride the motorbike and catch the bus may expose dust and smoke along the road, cleaning and copying. In addition, they perceive respiratory health hazards include respiratory and lung disease,

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allergies, and respiratory symptoms such as cough and sneeze. They hardly protect themselves while sometimes they use the mask to protect their respiratory health.

5.6 Recommendation

From the research findings, factors associated respiratory health effect are $PM_{2.5}$ and TVOC exposure, smoking behavior and working experience in current and previous job with volatile gas. Other factors may affect to respiratory health are dust and volatile gas from paper, toner, computer, printer, photocopier and roadside along with smoke from vehicle and welding. Therefore to reduce the risk of getting respiratory health effects, the population must more concern on health risk behavior and self-protection such as using mask and avoid air pollution exposure. To improve the working environment such as indoor source separation, more frequency of cleaning and air conditioner maintenance.

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APPENDIX

Appendix A

Research Tools

<u>Part I</u> Research Survey (for researcher)

Title: The Influence of Indoor Air Pollution Sources on Respiratory Health of Occupants in Offices: A Cross-sectional Study at Suan Sunandha Rajabhat University, Bangkok, Thailand.

Instructions

1. The objective of this questionnaire is to study the characteristics of offices and working environments.
2. The questionnaire is categorized into
    - Age of buildings
    - Floor and furnishing materials
    - Density of people
    - Usage of office equipments
    - Office cleanness
    - Air circulation

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<u>Workplace Characteristics</u> (Department of ……………….Building No…Floor…)

Age of Buildings

1. How old is this office building? ___________ Years
2. How long ago had this office been renovated (latest)? _____Years/Months ago

Floor and furnishing materials

3. What does the most of this office floor made from?

( ) Carpet ( ) Wood ( ) Cement/Stone

( ) Rubber, PVC ( ) Tile ( ) Other…………

4. What does the most of this office wall made from?

( ) Glass ( ) Wood ( ) Cement

( ) Wall paper ( ) Gypsum ( ) Other…………

5. What does the most of this office ceiling made from?

( ) Gypsum ( ) wood ( ) Cement

( ) Other…………

6. What does the most of desks in this office made from?

( ) Steel ( ) wood ( ) MDF ( ) Other…………

7. What does the most of Cabinets in this office made from?

( ) Steel ( ) wood ( ) MDF ( ) Other…………

Density of People

8. How much has this office area? (measure) ___________ Square meters
9. How much has this office height? (measure) ___________ Meters
10. How much has this office volume? (calculate)___________Cubic meters
11. How many people in this office? ___________ People

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Usage of Office Equipments (count)

12. How many personal computers in this office?___________ Computer(s)

13. How many printers in this office? ___________ Printer(s)

14. How many photocopiers in this office? ___________ Photocopier(s)

Office Cleanness

15. How often is this office cleaned? (only 1 choice maybe from record)

( ) less than 3 times/week ( ) 3-4 times/week

( ) 1 time/day ( ) several times/day

Air Circulation

16. How many air-conditioners in this office? (count) _____ Units

17. How much capacity of each air-conditioner? _____ BTU

If "Not same", please specify each of them ___________________________

18. How long has each air-conditioner been used? _____ Years

If "Not same", please specify each of them ___________________________

19. How often is/are the air-conditioner(s) cleaned?(from records)____ Time/year

20. In each day, When do/does the air-conditioner(s) turn on? _____ am/pm

When do/does the air-conditioner(s) turn off? _____am/pm

Do/does the air-conditioner(s) turn off during lunch time?

( ) yes ( ) no

21. Have/has the window(s) ever opened? (except electricity shutdown)

( ) yes ( ) no

22. Others (researcher measure air velocity /air flow rate)…………………………

……………………………………………………………………………………..

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<u>ตอนที่ 1</u> แบบสำรวจข้อมูลเพื่อการวิจัย (สำหรับผู้วิจัย)

เรื่อง อิทธิพลของแหล่งกำเนิดมลพิษอากาศภายในอาคารต่อสุขภาพระบบทางเดินหายใจของผู้ปฏิบัติงานในสำนักงาน:ศึกษาแบบภาคตัดขวางที่มหาวิทยาลัยราชภัฏสวนสุนันทา กรุงเทพมหานคร ประเทศไทย

คำชี้แจง

1. วัตถุประสงค์เพื่อศึกษาข้อมูลเกี่ยวกับที่ทำงานและสภาพแวดล้อมในการทำงาน
2. แบบสอบถามแบ่งออกเป็น
    - อายุของอาคาร
    - พื้นและวัสดุตกแต่ง
    - ความหนาแน่นในห้องทำงาน
    - การใช้อุปกรณ์สำนักงาน
    - ความสะอาดของห้องทำงาน
    - การหมุนเวียนอากาศในห้องทำงาน

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<u>ข้อมูลเกี่ยวกับที่ทำงาน</u> (สำนักงานหน่วยงาน...................................อาคาร...........ชั้น......)

อายุของอาคาร (ข้อมูลจากผู้ดูแลอาคาร)

1. ตึกสำนักงานนี้มีอายุกี่ปี? ___________ ปี
2. ห้องสำนักงานนี้มีการปรับปรุงล่าสุดเมื่อไร? ___________ ปี/เดือน ที่แล้ว

พื้นและวัสดุตกแต่ง

3. พื้นห้องสำนักงานนี้ทำด้วยวัสดุอะไร? (โปรดเลือกเพียง 1 ข้อ)

   ( ) 1.พรม ( ) 2.ไม้ ( ) 3.ปูน/หินขัด

   ( ) 4.กระเบื้องยาง ( ) 5.กระเบื้อง ( ) 6.อื่นๆ (โปรดระบุ)……….

4. ผนังห้องสำนักงานนี้ทำด้วยวัสดุอะไร? (โปรดเลือกเพียง 1 ข้อ)

   ( ) 1.กระจก ( ) 2.ไม้ ( ) 3.ปูน

   ( ) 4.วอลล์เปเปอร์ ( ) 5.ยิปซั่ม ( ) 6.อื่นๆ (โปรดระบุ)……….

5. ฝ้าเพดานห้องสำนักงานนี้ทำด้วยวัสดุอะไร? (โปรดเลือกเพียง 1 ข้อ)

   ( ) 1.ยิปซั่ม ( ) 2.ไม้ ( ) 3.ปูน

   ( ) 4.อื่นๆ (โปรดระบุ)……….

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6. โต๊ะในสำนักงานนี้ทำด้วยวัสดุอะไรมากที่สุด? (โปรดเลือกเพียง 1 ข้อ)

   ( ) 1.เหล็ก ( ) 2.ไม้ ( ) 3.ไม้อัด/MDF ( ) อื่นๆ (โปรดระบุ)……….

7. ตู้/ชั้น ในห้องสำนักงานนี้ทำด้วยวัสดุอะไรมากที่สุด? (โปรดเลือกเพียง 1 ข้อ)

   ( ) 1.เหล็ก ( ) 2.ไม้ ( ) 3.ไม้อัด/MDF ( ) อื่นๆ (โปรดระบุ)……….

ความหนาแน่นในห้องทำงาน

8. ห้องสำนักงานนี้มีพื้นที่เท่าไร? (จากการวัด) ___________ ตารางเมตร

9. ห้องสำนักงานนี้สูงเท่าไร? (จากการวัด) ___________ เมตร

10. ห้องสำนักงานนี้มีปริมาตรเท่าไร? (จากการคำนวณ) ___________ลูกบาศก์เมตร

11. ในห้องสำนักงานนี้มีจำนวนผู้ปฏิบัติงานทั้งหมดกี่คน? ___________ คน

การใช้อุปกรณ์สำนักงาน (จากการนับ)

12. ในห้องสำนักงานนี้มีคอมพิวเตอร์/โน้ตบุ๊ค/สแกนเนอร์ ทั้งหมดกี่เครื่อง?__________เครื่อง

13. ในห้องสำนักงานนี้มีเครื่องพิมพ์ทั้งหมดกี่เครื่อง? ___________เครื่อง

14. ในห้องสำนักงานนี้มีเครื่องถ่ายเอกสาร/โรเนียวทั้งหมดกี่เครื่อง? ___________เครื่อง

ความสะอาดของห้องทำงาน (ข้อมูลจากแม่บ้านหรือผู้เกี่ยวข้อง)

15. ห้องสำนักงานนี้มีการทำความสะอาดบ่อยแค่ไหน? (โปรดเลือกเพียง 1 ข้อ/ ข้อมูลจากบันทึกการทำความสะอาด)

( ) 1.น้อยกว่าสัปดาห์ละ 3 ครั้ง ( ) 2.สัปดาห์ละ 3-4 ครั้ง

( ) 3.วันละครั้ง ( ) 4.วันละหลายครั้ง

การหมุนเวียนอากาศในห้องทำงาน

16. ในห้องสำนักงานนี้มีเครื่องปรับอากาศทั้งหมดกี่เครื่อง? (จากการนับ)______ เครื่อง (ข้อมูลจากผู้ดูแลอาคาร/พัสดุ/ผู้เกี่ยวข้อง)

17. เครื่องปรับอากาศในห้องสำนักงานนี้มีขนาดเท่าไร? (ต่อเครื่อง)___________บีทียู

*ถ้าคนละขนาดกันให้ระบุแต่ละตัว*____

____

____

____

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18. เครื่องปรับอากาศในห้องสำนักงานนี้ใช้มานานเท่าไร? __________ ปี

*ถ้าไม่เท่ากันให้ระบุแต่ละตัว*____

____

____

____

____

19. มีการล้างทำความสะอาดเครื่องปรับอากาศบ่อยแค่ไหน? __________ ครั้ง/ปี

(ข้อมูลจากบันทึกการล้างทำความสะอาดหรือผู้เกี่ยวข้อง)

20. ในแต่ละวัน มีการเปิดเครื่องปรับอากาศกี่โมง? __________ นาฬิกา

มีการปิดเครื่องปรับอากาศกี่โมง? __________ นาฬิกา

มีการปิดช่วงพักเที่ยงหรือไม่? ( )1.ปิด ( )2. ไม่ปิด

21. หน้าต่างเคยเปิดหรือไม่ (ยกเว้นกรณีไฟดับ) ( )1. เคย ( )2. ไม่เคย

22. อื่นๆ (ผู้วิจัยทำการตรวจวัดค่าความเร็วลม/อัตราการไหลของอากาศ)

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Part II Research Questionnaire (for the office occupants)

Title: The Influence of Indoor Air Pollution Sources on Respiratory Health of Occupants in Offices: A Cross-sectional Study at Suan Sunandha Rajabhat University, Bangkok, Thailand.

Instructions

1. This questionnaire use for officers in university offices.
2. This questionnaire is research tool of thesis title in the Influence of Indoor Air Pollution Sources on Respiratory Health of Occupants in Offices:A Cross-sectional Study at Suan Sunandha Rajabhat University, Bangkok, Thailand. The objective is to study the characteristics of offices and working environments relate to officers' respiratory health.
3. Your answer will be confident and only use for study. The results of this study will not mention to you.
4. The questionnaire is categorized into
   - Socio Demographic Characteristics
   - Workplace Characteristics
   - Occupational History Characteristics
   - Health-related Characteristics
   - Respiratory Symptoms
5. Please answer all questions.

Researcher appreciates for your kindness to fill this questionnaire.

Thammarak srimarut (08-1880-8034)

researcher

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Instructions Please check √ in ( ) or fill in the blank.

Socio Demographic Characteristics

1. Gender ( ) Male ( ) Female
2. Age …………years old

Workplace Characteristics

Usage of Office Equipments (in last one year)

3. How many hours on average per day that you use computer

   ( ) Do not use ( ) average…hrs/day (please specify time period……...)

4. How often do you use printer?

   ( ) do not use ( ) less than 3 times/week ( ) 3-4 times/week

   ( ) 1 time/day ( ) more than 1 time/day

5. How often do you use photocopier?

   ( ) do not use ( ) less than 3 times/week ( ) 3-4 times/week

   ( ) 1 time/day ( ) more than 1 time/day

6. How often do you use fax?

   ( ) do not use ( ) less than 3 times/week ( ) 3-4 times/week

   ( ) 1 time/day ( ) more than 1 time/day

7. How often do you use liquid corrector?

   ( ) do not use ( ) less than 3 times/week ( ) 3-4 times/week

   ( ) 1 time/day ( ) more than 1 time/day

8. How often do you use equipment of volatile chemical?

   ( ) do not use ( ) less than 3 times/week ( ) 3-4 times/week

   ( ) 1 time/day ( ) more than 1 time/day

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Occupational History Characteristics

Working Duration

9. How long have been working here? ______ Years___Months

10. What is your working period per day? ( ) within 8 hrs (working hour)

( ) More than 8 hrs (Over time)

Working History

11. Have you ever worked for a year or more in any dusty job? ( ) No ( ) Yes

*If "**Yes**" please specify: Job/Industry________________Total years worked___*

12. Have you ever been exposed to gas in your work? ( ) No ( ) Yes

*If "**Yes**" please specify: Job/Industry________________Total years worked___*

13. Have you ever been exposed to chemical fumes in your work? ( ) No ( ) Yes

*If "**Yes**" please specify: Job/Industry________________Total years worked___*

Health-related Characteristics

Tobacco Smoking

14. Have you ever smoke cigarette regularly? ( ) No ( ) Yes

*If "**Yes**" please answer:*

- Do you now smoke cigarette? ( ) No ( ) Yes

- How old were you when you first started smoking? ____ Years old

- How old were you when you completely stopped smoking? ____ Years old

- How many cigarettes do/did you smoke ***per day***? Average_____Cigarettes

15. Have you ever smoke pipe or cigars regularly? ( ) No ( ) Yes

*If "**Yes**" please answer:*

- Do you now smoke pipe or cigars? ( ) No ( ) Yes

- How old were you when you first started smoking? ____ Years old

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- How old were you when you completely stopped smoking? ____ Years old

Previous Medical Records

16. Has a doctor ever said that you had any of the illness listed?			*If "Yes", do you still have this illness now?	
- Asthma	( ) No	( ) Yes*	( ) No	( ) Yes
- Chronic lung disease	( ) No	( ) Yes*	( ) No	( ) Yes
- Emphysema	( ) No	( ) Yes*	( ) No	( ) Yes
- Chronic bronchitis	( ) No	( ) Yes*	( ) No	( ) Yes
- Pneumonia	( ) No	( ) Yes*	( ) No	( ) Yes
- Hay fever (allergic rhinitis)	( ) No	( ) Yes*	( ) No	( ) Yes
- Heart disease	( ) No	( ) Yes*	( ) No	( ) Yes
- High blood pressure	( ) No	( ) Yes*	( ) No	( ) Yes
- Diabetes	( ) No	( ) Yes*	( ) No	( ) Yes

Respiratory Symptoms (Adapted from American Thoracic Society Questionnaire) (considered in last one year)

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Cough

17. Do you have a cough? (Exclude clearing of throat and cough with colds)

( ) No ( ) Yes

*If **"Yes"** please answer:*

On the average, about how many days do you cough each week?

( ) 0-1 day ( ) 2-3 days ( ) 4-5 days ( ) 6-7 days

18. Do you usually cough at all on getting up or early in the morning? ( ) No ( ) Yes

19. Do you usually cough at all during the rest of the day or at night? ( ) No ( ) Yes

*If **"Yes"** to any of above, please answer:*

- Do you cough like this on most days for 3 consecutive months or more during the year? ( ) No ( ) Yes

- For how many years have you had this cough? _____ Years___months

Phlegm

20. Do you usually bring up the phlegm from your chest? (Exclude phlegm from the nose) ( ) No ( ) Yes

*If **"Yes"** please answer:*

On the average, about how many days do you do this each week?

( ) 0-1 day ( ) 2-3 days ( ) 4-5 days ( ) 6-7 days

21. Do you usually bring up phlegm from your chest on getting up or early in the morning? ( ) No ( ) Yes

22. Do you usually bring up phlegm from your chest during the rest of the day or at night? ( ) No ( ) Yes

*If **"Yes"** to any of above, please answer:*

- Do you bring up phlegm like this on most days for 3 consecutive months or more during the year? ( ) No ( ) Yes

- For how many years have you had trouble with phlegm? _Years__months

Wheezing

23. Does your chest ever sound wheezy or whistling when you have a cold?

( ) No ( ) Yes

24. Does your chest ever sound wheezy or whistling when you do not have a cold?

( ) No ( ) Yes

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25. Does your chest sound wheezy or whistling most days or nights?

( ) No ( ) Yes

*If "**Yes**" to any of above, please answer:*

- For how many years has this been present? ____ Years ___months

26. Have you ever had an attack of wheezing that has made you feel short of breath?

( ) No ( ) Yes

*If "**Yes**" please answer:*

How old were you when you had your first such attack? _____ Years old

Have you had 2 or more such attacks? ( ) No ( ) Yes

Have you ever required medicine or treatment for the attack(s)?

( ) No ( ) Yes

Breathlessness

27. Do you have shortness of breath when hurrying on the level or walking up a slight hill? ( ) No ( ) Yes

*If "**Yes**" please answer:*

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Do you have to walk slower than people of your age on the level because of breathlessness? ( ) No ( ) Yes

Do you ever have to stop for breath when walking at your own pace on the level? ( ) No ( ) Yes

Do you ever have to stop for breath after walking about 90 meters (or after a few minutes) on the level? ( ) No ( ) Yes

<u>ตอนที่ 2</u> แบบสอบถามเพื่อการวิจัย (สำหรับผู้ปฏิบัติงานในอาคาร)

เรื่อง อิทธิพลของแหล่งกำเนิดมลพิษอากาศภายในอาคารต่อสุขภาพระบบทางเดินหายใจของผู้ปฏิบัติงานในสำนักงาน

คำชี้แจง

1. แบบสอบถามนี้ใช้สำหรับผู้ปฏิบัติงานในอาคารสำนักงานของมหาวิทยาลัย
2. แบบสอบถามนี้เป็นส่วนหนึ่งของเครื่องมือวิจัยเรื่อง อิทธิพลของแหล่งกำเนิดมลพิษอากาศภายในอาคารต่อสุขภาพระบบทางเดินหายใจของผู้ปฏิบัติงานในสำนักงาน ซึ่งเป็นวิทยานิพนธ์ของนายธรรมรักษ์ ศรีมารุต นักศึกษาระดับดุษฎีบัณฑิต วิทยาลัยวิทยาศาสตร์สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย โดยมีวัตถุประสงค์เพื่อศึกษาข้อมูลเกี่ยวกับสภาพการทำงาน ปัจจัยเสี่ยงและผลกระทบต่อระบบทางเดินหายใจของผู้ปฏิบัติงานในอาคาร
3. ข้อมูลที่ท่านตอบแบบสอบถามจะถือเป็นความลับและใช้ในการศึกษาเท่านั้น ผลของการศึกษาจะไม่มีการกล่าวพาดพิงถึงตัวท่าน และนำเสนอข้อมูลในภาพรวม
4. แบบสอบถามแบ่งออกเป็น 5 ส่วน ดังนี้
    - ข้อมูลส่วนบุคคล
    - ข้อมูลเกี่ยวกับที่ทำงาน
    - ประวัติการประกอบอาชีพ
    - ข้อมูลเกี่ยวกับสุขภาพ
    - อาการระบบทางเดินหายใจ
5. ขอความกรุณาจากท่านโปรดตอบให้ครบทุกข้อคำถาม หากมีข้อสงสัยติดต่อสอบถามโดยตรง นายธรรมรักษ์ ศรีมารุต โทร. 08-1880-8034

ขอขอบพระคุณอย่างสูงที่ท่านกรุณาสละเวลาตอบแบบสอบถามฉบับนี้

นายธรรมรักษ์ ศรีมารุต

ผู้วิจัย

จุฬาลงกรณ์มหาวิทยาลัย
Chulalongkorn University

คำชี้แจง โปรดทำเครื่องหมาย √ ลงใน ( ) หน้าข้อความ หรือเติมข้อความลงในช่องว่าง

ส่วนที่1 ข้อมูลส่วนบุคคล

1. เพศ ( )1. ชาย ( ) 2.หญิง
2. อายุ ……………......

ส่วนที่ 2 ข้อมูลเกี่ยวกับที่ทำงาน

การใช้อุปกรณ์สำนักงาน (ในช่วง 1 ปีที่ผ่านมา)

3. คุณใช้คอมพิวเตอร์เฉลี่ยวันละกี่ชั่วโมง?

   ( ) 1.ไม่ได้ใช้ ( ) 2.เฉลี่ยวันละ………ชั่วโมง

   โปรดระบุช่วงเวลา...

4. คุณใช้ปริ้นเตอร์บ่อยแค่ไหน?

   ( ) 1.ไม่ได้ใช้ ( ) 2.น้อยกว่าสัปดาห์ละ 3 ครั้ง ( ) 3.สัปดาห์ละ 3-4 ครั้ง

   ( ) 4.วันละครั้ง ( ) 5.มากกว่าวันละ 1 ครั้ง

5. คุณใช้เครื่องถ่ายเอกสารบ่อยแค่ไหน?

   ( ) 1.ไม่ได้ใช้ ( ) 2.น้อยกว่าสัปดาห์ละ 3 ครั้ง ( ) 3.สัปดาห์ละ 3-4 ครั้ง

   ( ) 4.วันละครั้ง ( ) 5.มากกว่าวันละ 1 ครั้ง

6. คุณรับส่งเอกสารด้วยเครื่องโทรสารบ่อยแค่ไหน?

   ( ) 1.ไม่ได้ใช้ ( ) 2.น้อยกว่าสัปดาห์ละ 3 ครั้ง ( ) 3.สัปดาห์ละ 3-4 ครั้ง

   ( ) 4.วันละครั้ง ( ) 5.มากกว่าวันละ 1 ครั้ง

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Chulalongkorn University

7. คุณใช้น้ำยาลบคำผิดบ่อยแค่ไหน?

( ) 1.ไม่ได้ใช้ ( ) 2.น้อยกว่าสัปดาห์ละ 3 ครั้ง ( ) 3.สัปดาห์ละ 3-4 ครั้ง

( ) 4.วันละครั้ง ( ) 5.มากกว่าวันละ 1 ครั้ง

8. คุณใช้อุปกรณ์ที่มีส่วนประกอบของสารระเหย (เช่นกาว,ปากกาเคมี เป็นต้น) บ่อยแค่ไหน?

( ) 1.ไม่ได้ใช้ ( ) 2.น้อยกว่าสัปดาห์ละ 3 ครั้ง ( ) 3.สัปดาห์ละ 3-4 ครั้ง

( ) 4.วันละครั้ง ( ) 5.มากกว่าวันละ 1 ครั้ง

ส่วนที่ 3 ประวัติการประกอบอาชีพ

ช่วงเวลาการทำงาน

9. คุณทำงานที่นี่มานานเท่าไร? ____________ปี ____________ เดือน

10. โดยปกติคุณทำงานกี่ชั่วโมงต่อวัน? ( ) 1.ไม่เกิน 8 ชั่วโมง (ตามเวลาปฏิบัติงาน)

( ) 2.มากกว่า 8 ชั่วโมง (ปฏิบัติงานล่วงเวลา)

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ประวัติการทำงาน

11. คุณเคยทำงานที่มีฝุ่น เช่น ฝุ่นไม้ ฝุ่นหิน/ซีเมนต์ แป้ง โรงสี อาหารสัตว์ เป็นต้น (นาน 1 ปีขึ้นไป) มาก่อนหรือไม่? ( ) 1.ไม่เคย ( ) 2.เคย โปรดระบุ

งานอะไร? .... ทำมานานเท่าไร? ....

12. คุณเคยทำงานที่สัมผัสกับแก๊ส เช่น แก๊ส/ไอน้ำมัน ทินเนอร์ เป็นต้น มาก่อนหรือไม่?

( ) 1.ไม่เคย ( ) 2.เคย โปรดระบุ

งานอะไร? .... ทำมานานเท่าไร? ....

13. คุณเคยทำงานที่สัมผัสกับฟูม เช่น จากการหลอมโลหะ การเชื่อม มาก่อนหรือไม่?

( ) 1.ไม่เคย ( ) 2.เคย โปรดระบุ

งานอะไร? .... ทำมานานเท่าไร? ....

ส่วนที่ 4 ข้อมูลเกี่ยวกับสุขภาพ

การสูบบุหรี่ (นิโคติน)

14. คุณเคยสูบบุหรี่หรือไม่? ( ) ไม่เคย ( ) เคย โปรดระบุ

14.1 ตอนนี้คุณยังสูบอยู่หรือไม่? ( ) เลิกแล้ว ( ) ยังสูบอยู่

14.2 คุณเริ่มสูบตั้งแต่อายุเท่าไร? __________ *ปี*

14.3 คุณเลิกสูบตั้งแต่อายุเท่าไร? __________ *ปี*

14.4 คุณสูบบุหรี่วันละกี่มวน? เฉลี่ย __________ *มวน*

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15. คุณเคยสูบไปป์หรือซิการ์หรือไม่? ( ) ไม่เคย ( ) เคย โปรดระบุ

15.1 ตอนนี้คุณยังสูบอยู่หรือไม่? ( ) เลิกแล้ว ( ) ยังสูบอยู่

15.2 คุณเริ่มสูบตั้งแต่อายุเท่าไร? __________ *ปี*

15.3 คุณเลิกสูบตั้งแต่อายุเท่าไร? __________ *ปี*

ประวัติการเจ็บป่วย

16. แพทย์เคยระบุว่าคุณป่วยเป็นโรคต่อไปนี้หรือไม่?

					*ถ้า "เคย", ตอนนี้คุณยังป่วยอยู่หรือไม่
16.1 โรคหอบหืด	( ) ไม่	( ) เคย*		( ) หายแล้ว	( ) ยังป่วยอยู่
16.2 โรคปอดเรื้อรัง	( ) ไม่	( ) เคย*		( ) หายแล้ว	( ) ยังป่วยอยู่
16.3 โรคถุงลมโป่งพอง	( ) ไม่	( ) เคย*		( ) หายแล้ว	( ) ยังป่วยอยู่
16.4 โรคหลอดลมอักเสบเรื้อรัง	( ) ไม่	( ) เคย*		( ) หายแล้ว	( ) ยังป่วยอยู่
16.5 โรคปอดบวม	( ) ไม่	( ) เคย*		( ) หายแล้ว	( ) ยังป่วยอยู่
16.6 ไข้ละอองฟาง (ภูมิแพ้)	( ) ไม่	( ) เคย*		( ) หายแล้ว	( ) ยังป่วยอยู่
16.7 โรคหัวใจ	( ) ไม่	( ) เคย*		( ) หายแล้ว	( ) ยังป่วยอยู่
16.8 โรคความดันโลหิตสูง	( ) ไม่	( ) เคย*		( ) หายแล้ว	( ) ยังป่วยอยู่
16.9 โรคเบาหวาน	( ) ไม่	( ) เคย*		( ) หายแล้ว	( ) ยังป่วยอยู่

ส่วนที่ 5 อาการทางระบบทางเดินหายใจ (พิจารณาช่วง 1 ปีที่ผ่านมา)

ไอ

17. คุณมักจะมีอาการไอเป็นปกติ (ยกเว้นการไอจากการขากเสมหะและเป็นหวัด)

( ) ไม่ใช่ ( ) ใช่ โปรดระบุ

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โดยเฉลี่ยแล้วคุณมีอาการไอแบบนี้ประมาณกี่วัน / สัปดาห์

( ) 0-1 วัน ( ) 2-3 วัน ( ) 4-5 วัน ( ) 6-7 วัน

18. คุณมักจะไอตอนตื่นนอนหรือตอนเช้า ( ) ไม่ใช่ ( ) ใช่

19. คุณมักจะไอตอนพักผ่อนช่วงกลางวันหรือกลางคืน ( ) ไม่ใช่ ( ) ใช่

จากข้อ 20.-22. ถ้าคุณตอบ"ใช่" ข้อใดข้อหนึ่ง โปรดตอบ:

i. ในช่วงปี คุณมักจะไอแบบนี้เกือบทุกวันอย่างน้อย 3 เดือนติดต่อกัน

( ) ไม่ใช่ ( ) ใช่

ii. คุณมีอาการไอแบบนี้มานานเท่าไร? _______ปี _______เดือน

เสมหะ

20. คุณมักมีเสมหะบ่อย (เสมหะจากปอดไม่รวมจากจมูก) ( ) ไม่ใช่ ( ) ใช่ โปรดระบุ

โดยเฉลี่ยแล้วคุณมีเสมหะแบบนี้ประมาณกี่วัน / สัปดาห์

( ) 0-1 วัน ( ) 2-3 วัน ( ) 4-5 วัน ( ) 6-7 วัน

21. คุณมักจะมีเสมหะจากปอดตอนตื่นนอนหรือตอนเช้า ( ) ไม่ใช่ ( ) ใช่

22. คุณมักจะมีเสมหะจากปอดตอนพักผ่อนช่วงกลางวันหรือกลางคืน ( ) ไม่ใช่ ( ) ใช่

จากข้อ 23.-25. ถ้าคุณตอบ"ใช่" ข้อใดข้อหนึ่ง โปรดตอบ:

1) ในช่วงปี คุณมักจะมีเสมหะแบบนี้อย่างน้อย 3 เดือนติดต่อกัน

( ) ไม่ใช่ ( ) ใช่

2) คุณมีเสมหะแบบนี้มานานเท่าไร? __________ปี _______เดือน

หายใจมีเสียงดังฮืด ๆ

23. คุณมักหายใจมีเสียงดังฮืดๆ (จากปอด) เมื่อคุณเป็นหวัด ( ) ไม่ใช่ ( ) ใช่

24. คุณมักหายใจมีเสียงดังฮืดๆ (จากปอด) เมื่อคุณไม่เป็นหวัด ( ) ไม่ใช่ ( ) ใช่

25. คุณมักหายใจมีเสียงดังฮืดๆ (จากปอด) เกือบทุกวันหรือทุกคืน ( ) ไม่ใช่ ( ) ใช่

จากข้อ 26.-28. ถ้าคุณตอบ"ใช่" ข้อใดข้อหนึ่ง โปรดตอบ:

คุณมีอาการแบบนี้มานานเท่าไร? __________ปี _______เดือน

26. เมื่อคุณมีอาการแบบนี้ (อาการในข้อ 26.-28.) คุณจะรู้สึกหายใจไม่ออก

( ) ไม่ใช่ ( ) ใช่ โปรดระบุ

1) คุณมีอาการแบบนี้ครั้งแรกตั้งแต่อายุเท่าไร? __________ปี

2) คุณเคยมีอาการแบบนี้ตั้งแต่ 2 ครั้งขึ้นไป? ( ) ไม่ใช่ ( ) ใช่

3) คุณเคยรับยาหรือรับการรักษาอาการแบบนี้? ( ) ไม่ใช่ ( ) ใช่

หายใจไม่ออก

27. คุณมักหายใจไม่ทันเมื่อรีบเดินบนพื้นราบหรือเนินเตี้ยๆ? ( ) ไม่ใช่ ( ) ใช่ โปรดระบุ

1) คุณต้องเดินช้ากว่าคนในวัยเดียวกันเพราะหายใจไม่ทัน? ( ) ไม่ใช่ ( ) ใช่

2) คุณเคยต้องหยุดพักเพื่อหายใจขณะก้าวเดิน? ( ) ไม่ใช่ ( ) ใช่

3) คุณเคยต้องหยุดพักเพื่อหายใจหลังจากเดินบนพื้นราบระยะประมาณ 90 เมตร? ( ) ไม่ใช่ ( ) ใช่

ผู้วิจัยขอขอบคุณอย่างสูงที่ท่านกรุณาสละเวลาตอบแบบสอบถามฉบับนี้

นายธรรมรักษ์ ศรีมารุต

ผู้วิจัย

<u>Part III</u> Focus Group Interview Guide

This research is focusing on indoor air pollution sources and respiratory health. Today we will talk about air pollution, including dust, smoke and airborne chemicals as follow: dust, smoke, chemicals especially volatile organic compound.

We will start with this question.

Risk behavior and exposure

- What does your behavior related to air pollution (dust, smoke and airborne chemicals) and risk to your health?
- How do you think about the air pollutants in your offices and outside?
- What symptoms do you have when you expose to air pollution (dust, smoke and airborne chemicals)?

Awareness to level of hazards

- How do you think about the hazard from any air pollution that you mention?
- Why do you think so?
- How do you think about the hazard from air pollution in your office?
- Why do you think so?

Protection from hazards

- How do you do to protect yourself from that hazard?

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<u>ตอนที่ 3</u> แนวคำถามในการสนทนากลุ่ม

การวิจัยครั้งนี้ ศึกษาแหล่งกำเนิดต่างๆ ของมลพิษในอาคารและสุขภาพระบบทางเดินหายใจของผู้ปฏิบัติงานในอาคาร วันนี้เราจะพูดกันถึงเรื่องของมลพิษอากาศในรูปของฝุ่น ควัน และสารเคมีต่างๆ ที่แขวนลอยในอากาศ โดยเฉพาะกลุ่มของสารอินทรีย์ระเหยง่าย

(พฤติกรรมเสี่ยงและการสัมผัส)

- ท่านคิดว่าท่านมีพฤติกรรมใดที่เสี่ยงต่อการสัมผัสกับมลพิษ และส่งผลกับสุขภาพอย่างไร
- ท่านมีความคิดเห็นอย่างไรกับมลพิษอากาศต่างๆ เช่น ฝุ่น ควัน หรือสารเคมีอื่นใด
- ท่านมีอาการอย่างไร เมื่อสัมผัสกับมลพิษอากาศต่างๆ ข้างต้นเช่น ฝุ่น ควัน หรือสารเคมีใดๆ

(การตระหนักถึงอันตราย)

- ท่านมีความคิดเห็นอย่างไรเกี่ยวกับอันตรายจาก มลพิษอากาศที่กล่าวถึงข้างต้น
- ทำไมถึงคิดเช่นนั้น
- ท่านมีความคิดเห็นอย่างไรเกี่ยวกับอันตรายจาก มลพิษอากาศในห้องทำงานของท่าน
- ทำไมถึงคิดเช่นนั้น

CHULALONGKORN UNIVERSITY

(การป้องกันตนเอง)

- ท่านมีวิธีในการป้องกันตนเองจากมลพิษอากาศต่างๆ ข้างต้นหรือไม่ อย่างไร

Appendix B

Plan of university offices

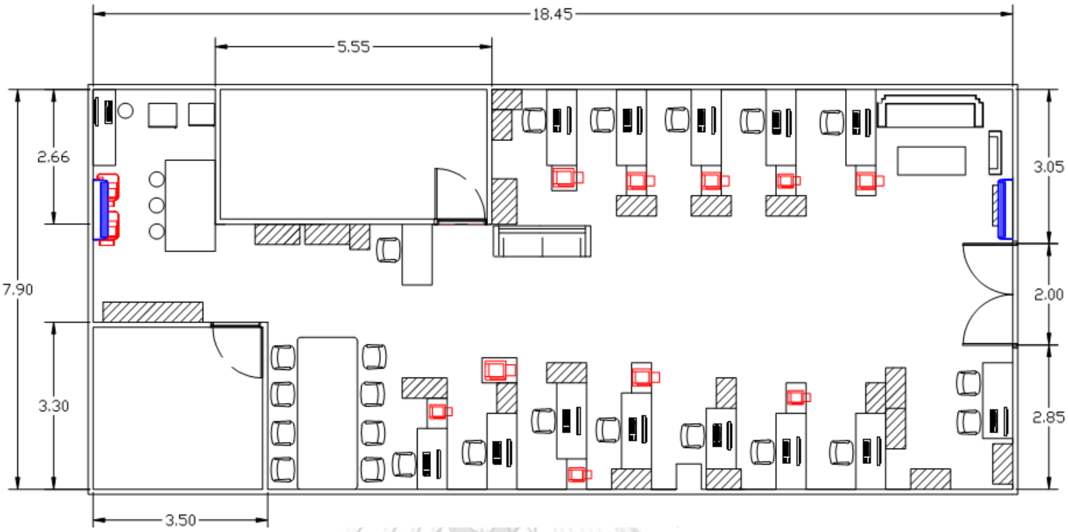

Figure 1 Plan of Institute for Research and Development

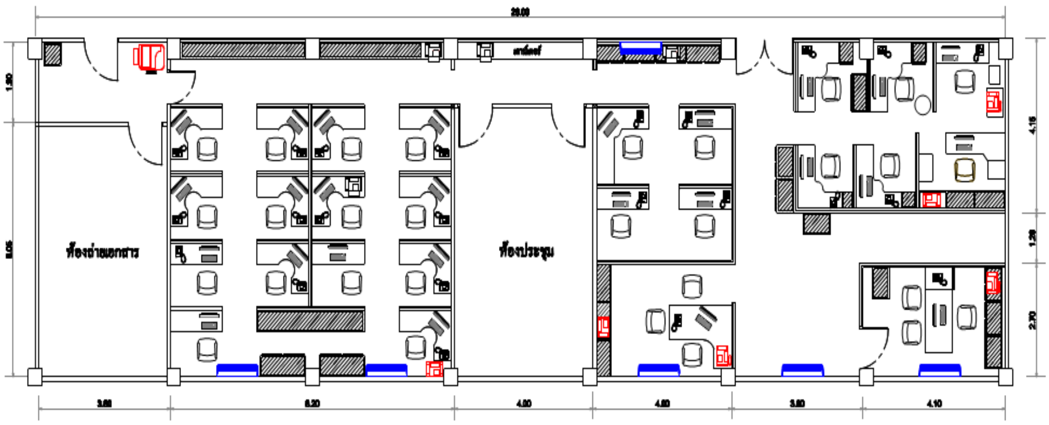

Figure 2 Plan of the Office of General Education and Innovative Electronic Learning

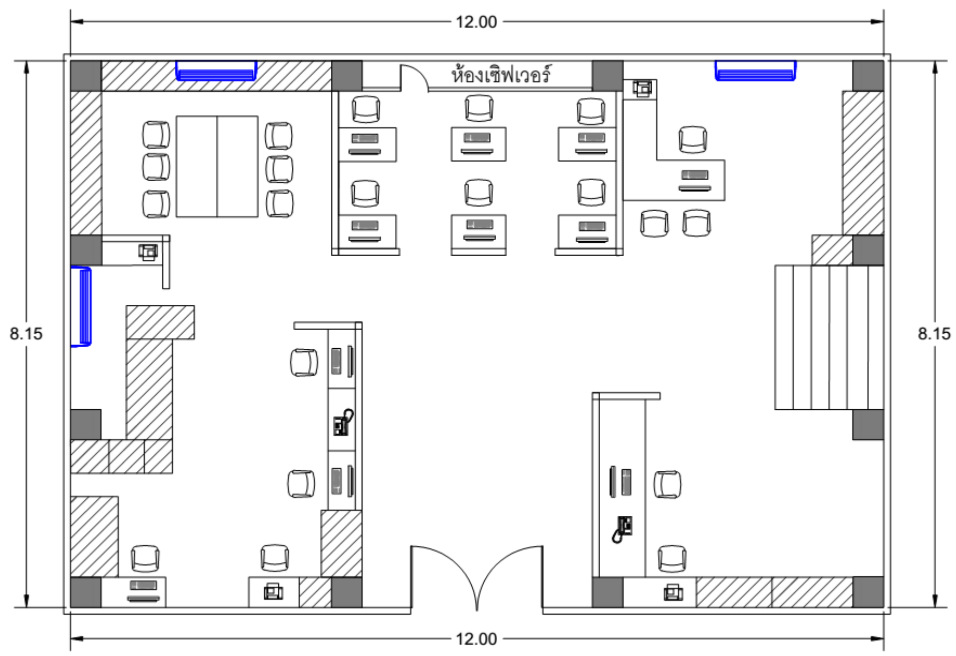

Figure 3 Plan of the Faculty of Education

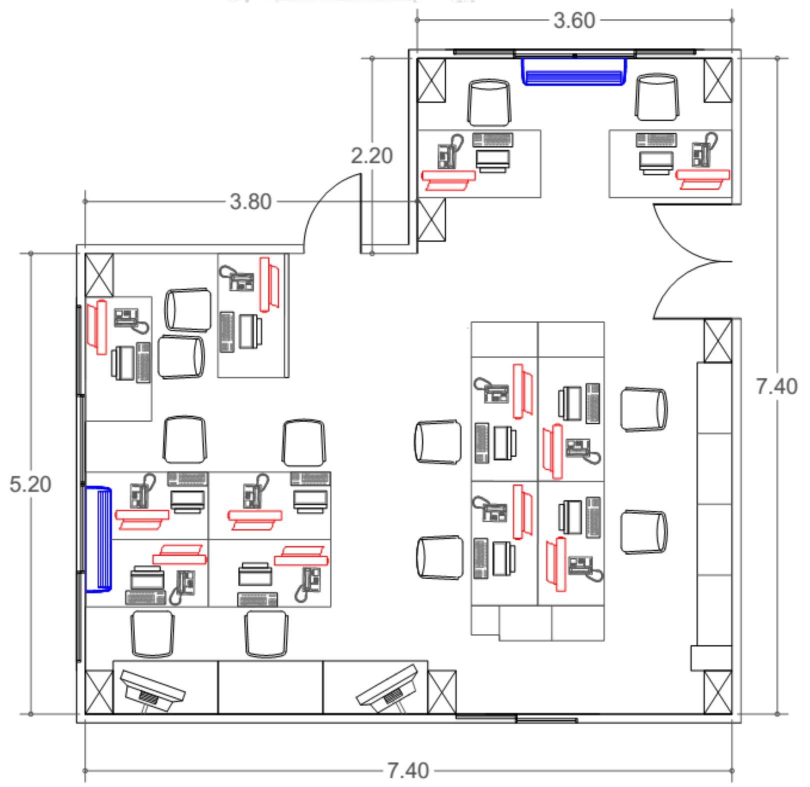

Figure 4 Plan of the Faculty of Industrial Technology

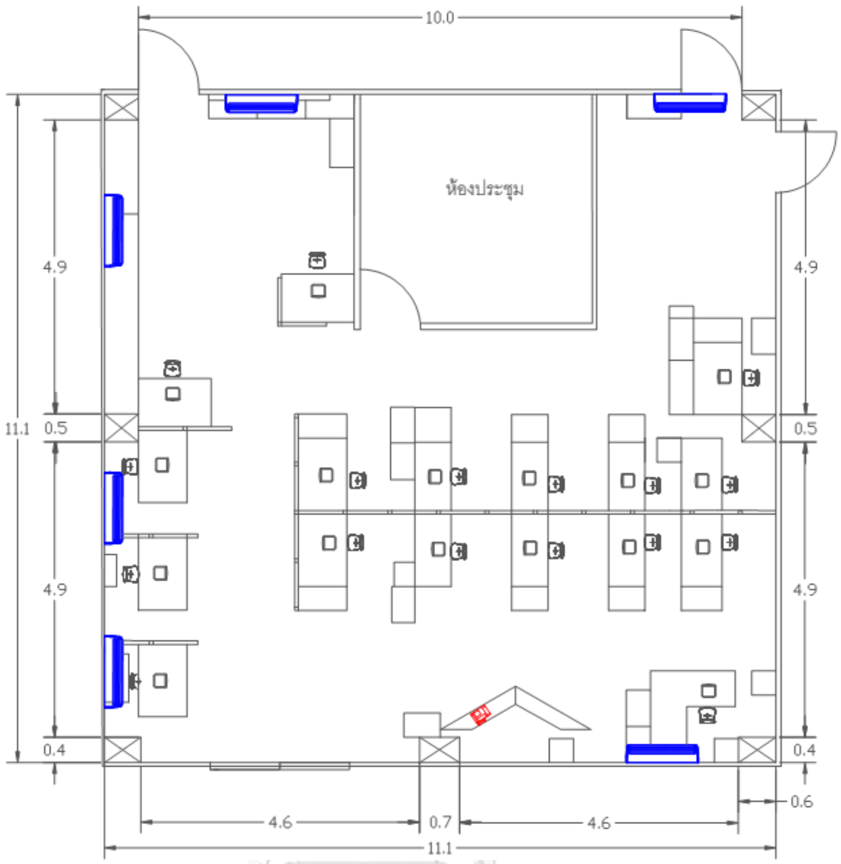

Figure 5 Plan of the Faculty of Humanities and Social Sciences

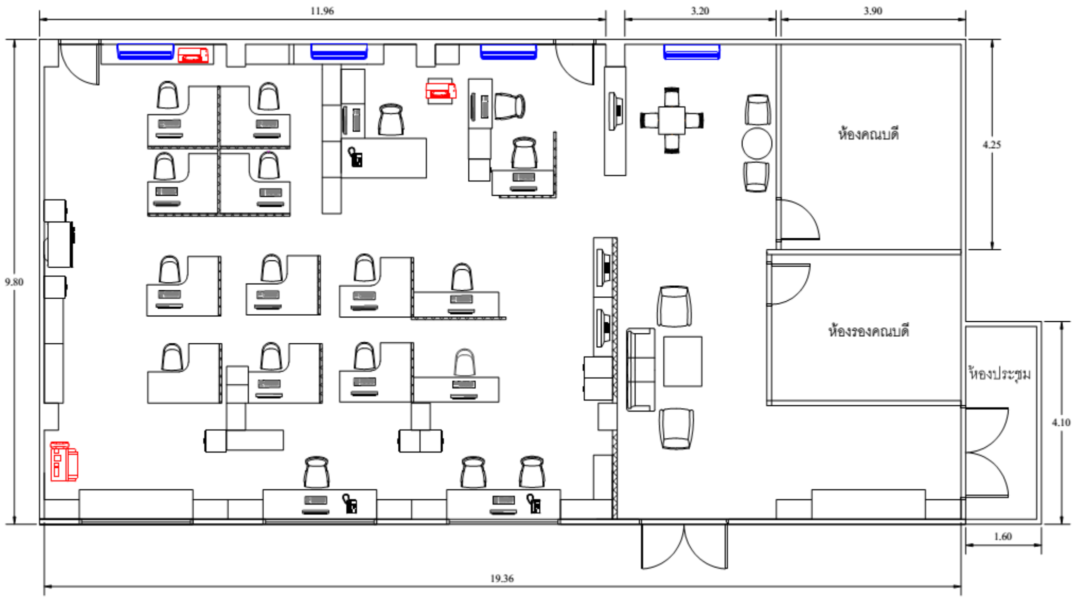

Figure 6 Plan of the Faculty of Management Science

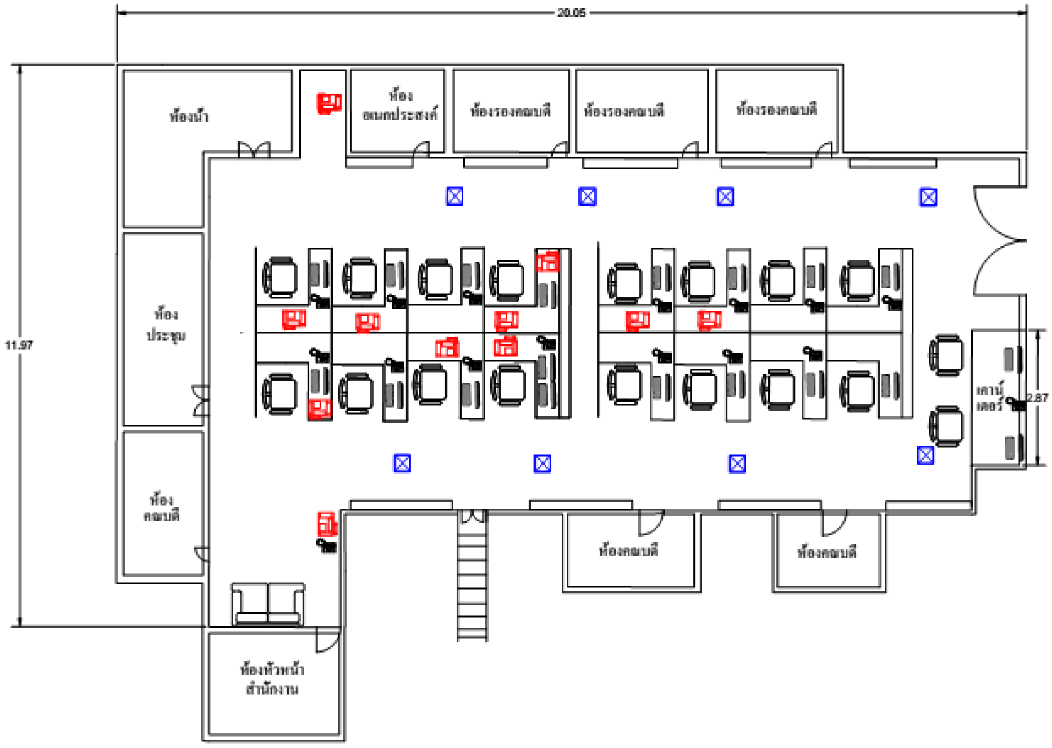

Figure 7 Plan of the Faculty of Science and Technology

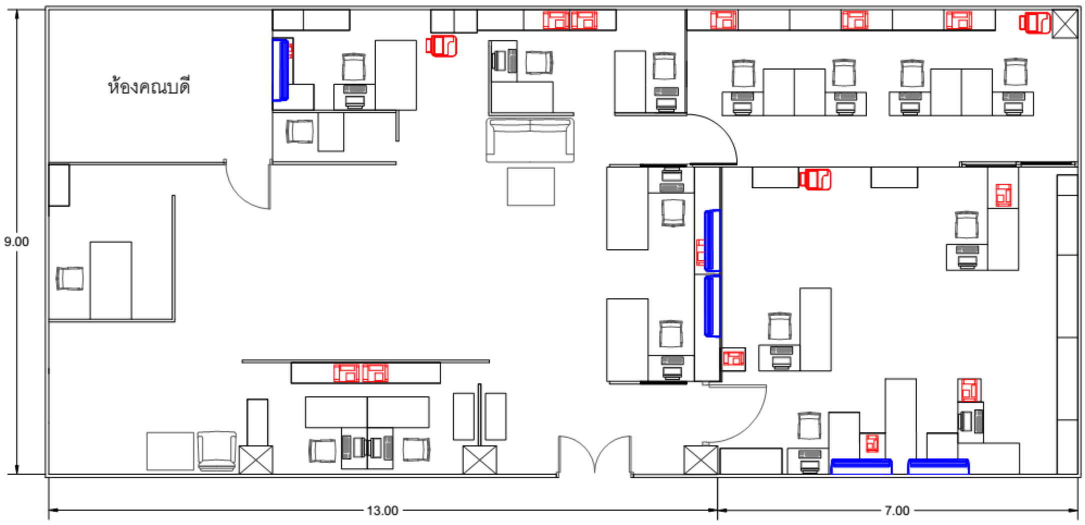

Figure 8 Plan of the Faculty of Fine and Applied Arts

Figure 9 Plan of the General Affairs Division

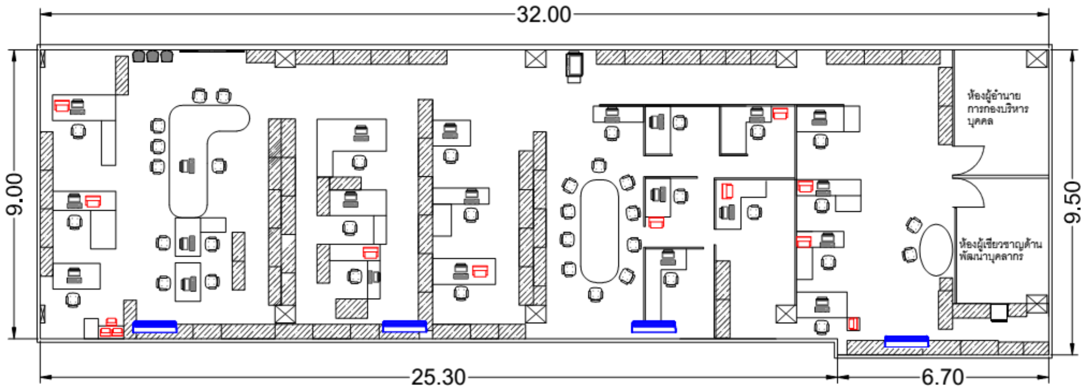

Figure 10 Plan of the Personnel Division

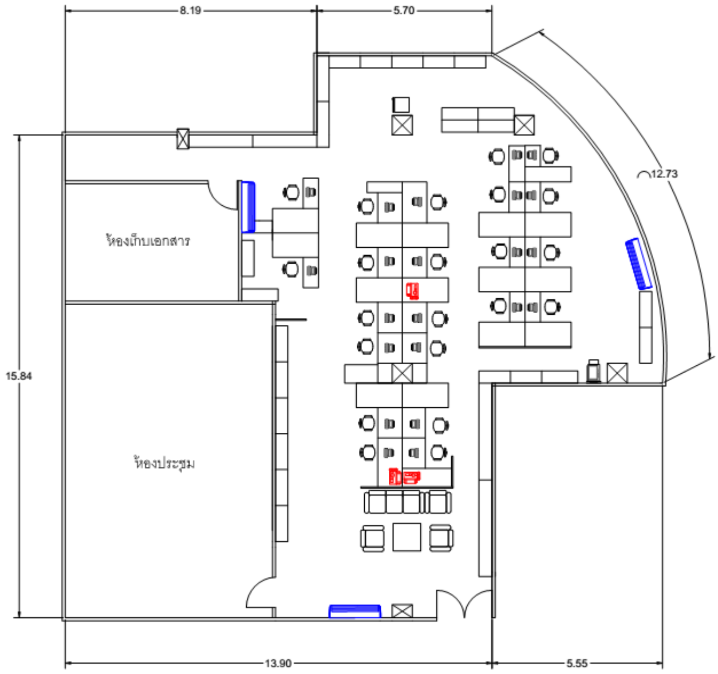

Figure 11 Plan of the Policy and Planning Division

Figure 12 Plan of the Academic Services Division

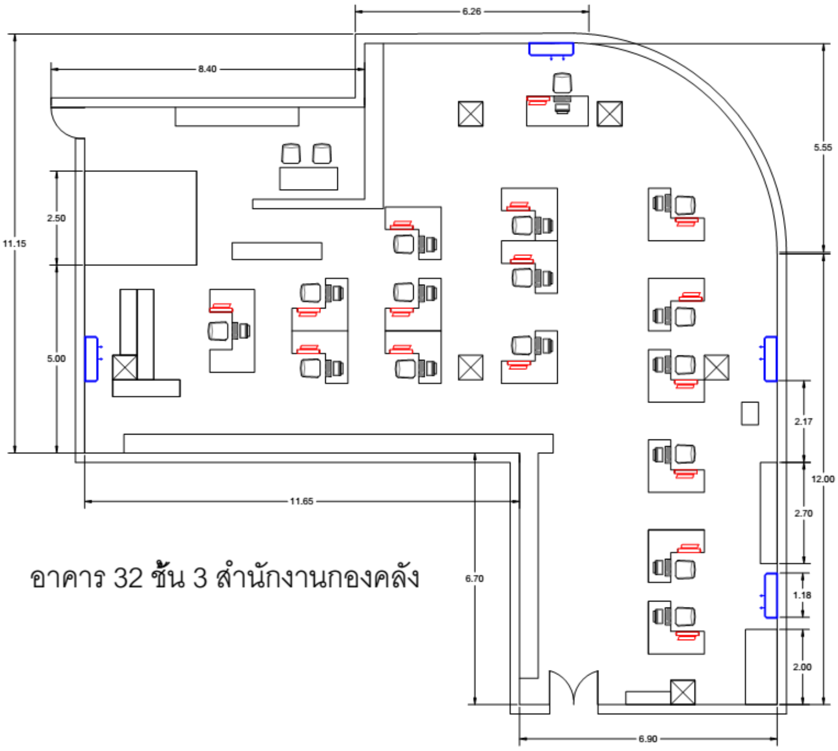

Figure 13 Plan of the Financial Division

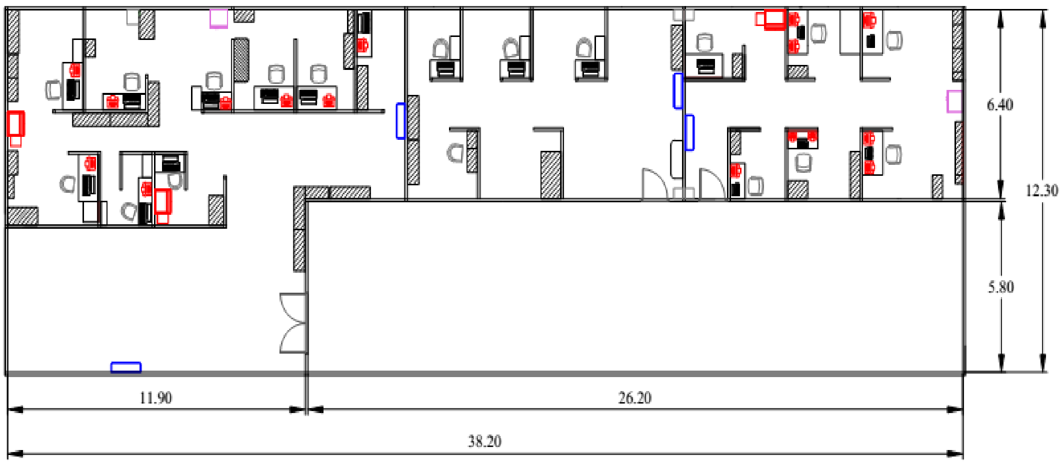

Figure 14 Plan of the Student Affairs Division

Appendix C

Ethical Approve

AF 01-12

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

COA No. 152/2559

ใบรับรองโครงการวิจัย

โครงการวิจัยที่ 089.1/59 : อิทธิพลของแหล่งกำเนิดมลพิษอากาศภายในอาคารต่อสุขภาพระบบทางเดินหายใจของผู้ที่ปฏิบัติงานในสำนักงาน: ศึกษาแบบภาคตัดขวางที่มหาวิทยาลัยราชภัฏสวนสุนันทา กรุงเทพมหานคร ประเทศไทย

ผู้วิจัยหลัก : นายธรรมรักษ์ ศรีมารุต

หน่วยงาน : วิทยาลัยวิทยาศาสตร์สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย

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

ลงนาม....................................	**ลงนาม**....................................
(รองศาสตราจารย์ นายแพทย์ปรีดา ทัศนประดิษฐ)	(ผู้ช่วยศาสตราจารย์ ดร.นันทรี ชัยชนะวงศาโรจน์)
ประธาน	กรรมการและเลขานุการ

วันที่รับรอง : 31 สิงหาคม 2559 **วันหมดอายุ** : 30 สิงหาคม 2560

เอกสารที่คณะกรรมการรับรอง

1) โครงการวิจัย
2) ข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัยและใบยินยอมของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย
3) ผู้วิจัย
4) แบบสอบถาม

เลขที่โครงการวิจัย 089.1/59
วันที่รับรอง 31 ส.ค. 2559
วันหมดอายุ 30 ส.ค. 2560

<u>**เงื่อนไข**</u>

1. ข้าพเจ้ารับทราบว่าเป็นการผิดจริยธรรม หากดำเนินการเก็บข้อมูลการวิจัยก่อนได้รับการอนุมัติจากคณะกรรมการพิจารณาจริยธรรมการวิจัยฯ
2. หากใบรับรองโครงการวิจัยหมดอายุ การดำเนินการวิจัยต้องยุติ เมื่อต้องการต่ออายุต้องขออนุมัติใหม่ล่วงหน้าไม่ต่ำกว่า 1 เดือน พร้อมส่งรายงานความก้าวหน้าการวิจัย
3. ต้องดำเนินการวิจัยตามที่ระบุไว้ในโครงการวิจัยอย่างเคร่งครัด
4. ใช้เอกสารข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย ใบยินยอมของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย และเอกสารเชิญเข้าร่วมวิจัย (ถ้ามี) ***เฉพาะที่ประทับตราคณะกรรมการเท่านั้น***
5. หากเกิดเหตุการณ์ไม่พึงประสงค์ร้ายแรงในสถานที่เก็บข้อมูลที่ขออนุมัติจากคณะกรรมการ ต้องรายงานคณะกรรมการภายใน 5 วันทำการ
6. หากมีการเปลี่ยนแปลงการดำเนินการวิจัย ให้ส่งคณะกรรมการพิจารณารับรองก่อนดำเนินการ
7. โครงการวิจัยไม่เกิน 1 ปี ส่งแบบรายงานสิ้นสุดโครงการวิจัย (AF 03-12) และบทคัดย่อผลการวิจัยภายใน 30 วัน เมื่อโครงการวิจัยเสร็จสิ้น สำหรับโครงการวิจัยที่เป็นวิทยานิพนธ์ให้ส่งบทคัดย่อผลการวิจัย ภายใน 30 วัน เมื่อโครงการวิจัยเสร็จสิ้น

VITA

NAME	Mr.Thammarak Srimarut
DATE OF BIRTH	14 September 1977
PLACE OF BIRTH	Nakhonpathom
INSTITUTIONS ATTENDED	1995 – 1999 Bachelor of Engineering (Food Engineering) Faculty of Engineering, Kasetsart University, Thailand. 2002 – 2006 Master of Science (Industrial Hygiene and safety) Faculty of Public Health, Mahidol University, Thailand.
HOME ADDRESS	195 Moo 1 Nakhonchaisri Nakhonchaisri Nakhonpathom

จุฬาลงกรณ์มหาวิทยาลัย
Chulalongkorn University