THE IMPACT OF INDOOR POLLUTION ON HEALTH OF POPULATION IN BANGKOK METROPOLIS

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ABSTRACT

Title of Dissertation	The Impact of Indoor Pollution on Health of Population in Bangkok Metropolis
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This is a quantitative study of the impact of pollution found within office buildings upon the occupants of those buildings. Data were gathered by means of questionnaires completed by a case of 396 office workers.

The purposes on this research were: 1) To identify the characteristics which contribute towards the probability of an individual contracting each of six symptoms. 2) To ascertain means by which the effects of those contributory characteristics may be mitigated. 3) To establish the extent of these symptoms and the probability that an office worker will suffer each of them. 4) To establish the general characteristics of the sampled population and specifically gender, age, education level, income, status, working hours per day and working days per week.

Logistic regression analysis was used to establish relationships between four relating characteristics (personal characteristics, workplace characteristics, health characteristics and work environment characteristics) and the six types of symptoms (eye symptoms, nose symptoms, throat symptoms, respiratory system symptoms, nervous system symptoms and skin symptom). In order to analyze the characteristics that influenced to the six types of symptoms of Bangkok Metropolis' populations by consider on the adjusted R square, significance and odds ratio.

The researcher used the Logistic Regression Analysis via enter method and found that the irrelevant characteristics that caused to the six types of symptoms were as follow: the frequency of using the office equipments, the frequency of office cleaning, the smoker and eyesight condition problem. Later the researcher used the

Logistic Regression Analysis via stepwise method and found that the causes of the six types of symptoms were as follow: the people who had the health background on asthma, migraine and dermatitis, the frequency of office cleaning, eyesight condition problems and the smoking background of population.

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CHAPTER 1

INTRODUCTION

1.1 Background and the Importance of the Problem

Today Bangkok Metropolis is ranked as the most populated province in comparison with the other provinces in Thailand. Table 1.1 shows the ranking of the most highly populated provinces.

Table 1.1 Population of 5 Highly Populated Provinces in Thailand

		Population		
Rank	**Province**	**Male**	**Female**	**Total**
1	Bangkok Metropolis	2,722,313	2,988,570	5,710,833
2	Nakhon Ratchasima	1,269,885	1,295,232	2,565,117
3	Ubon Ratchathani	899,951	895,502	1,795,453
4	Khon Kaen	871,047	885,054	1,756,101
5	Chiang Mai	819,750	850,567	1,670,317

Source: The National Statistical Office, 2009.

Since Bangkok Metropolis is the national business center, there is constant economic expansion. Economic Growth or rate of economic growth creates a genuine expansion in the quantity of products and services in the economy. According to statistics of gross domestic product from 1999-2009 in Table 1.2, the GDP that we can see since 2002 and afterwards (http://www.moc.moe.go.th/GDP), Thailand has had positive GDP all times. Even though there were economic problems due to various crises which caused reductions in economic expansion from the year before such as

1998 when economic expansion was equal to 3.3%, lower than year 2002 where economic expansion was equal to 7.8%.

Because of this growth, there has been economic migration from other provinces to Bangkok Metropolis in order gain employment. Population believed that Bangkok Metropolis was a place which supported labor more than other provinces. Information from the National Statistical Office indicates that Bangkok Metropolis was the province with the largest labor force in the country in 2009, as shown on Table 1.3.

Table 1.2 GDP in Year 1999 – 2009

Fiscal Year	**Gross Domestic Product**	**(GDP)**
	Amount	**%(+,-)**
1999	5,583,000	-2.6
2000	5,420,000	-2.9
2001	5,208,600	-3.9
2002	5,614,900	7.8
2003	5,799,700	3.3
2004	6,263,700	8.0
2005	7,123,710	13.7
2006	7,878,500	9.5
2007	8,399,000	7.5
2008	9,418,600	11.0
2009	10,266,000	9.0

Source: The National Statistical Office, 2009.

Table 1.3 Provinces with the Largest Labor Force in Year 2009

Rank	Province	Labor Force
1	Bangkok Metropolis	561,465
2	Samut Prakan	499,280
3	Samut Sakhon	313811
4	Chon Buri	240,709
5	Pathum Thani	222,271
6	Phra Nakhon Si Ayutthaya	184,565
7	Nakhon Pathom	149,474
8	Chachoengsao	127,801
9	Rayong	127,463
10	Nakhon Ratchasima	121,361

Source: The National Statistical Office, 2009.

Labor force migration constantly creates a lot of constructions such as residential buildings, commercial and office buildings. According to the statistics from the National Statistical Office in December 2009, Bangkok Metropolis had the highest number of commercial and office buildings in the country and in July of 2009, residential buildings peaked at 6,071 buildings, as shown on Table 1.4.

Table 1.4 The Number of the Buildings That were Permitted to be Constructed, Categorized by Types of Constructions in Year 2009

Month	Residential Buildings	Commercial and Office Buildings	Industries and Factories
Jan.	3,313	162	44
Feb.	3,444	141	56
Mar.	5,237	293	103
Apr.	3,314	153	61

Table 1.4 (Continued)

Month	Residential Buildings	Commercial and Office Buildings	Industries and Factories
May	4,040	148	85
Jun.	4,698	185	68
Jul.	6,071	144	99
Aug.	4,558	208	70
Sep.	5,134	277	100
Oct.	5,107	214	84
Nov.	5,697	269	84
Dec.	5,829	318	85

Source: The National Statistical Office, 2009.

As Bangkok Metropolis was modernized, the number of office buildings and residential buildings increased and population's life styles changed. Most of population now spend 90% of their time in each day in buildings or spend more than 8 hours per day working in buildings. The Environmental Protection Agency in the U.S.A. reported that in our daily lives we have to encounter health risks, especially from activities relating to work, relaxation, enjoyment, trips, living at home, and environmental outings with a level of risk or having factors that can cause disease in population when they are weak. Finally there will be occurrences of illnesses, such as respiratory diseases, which commonly occur in population who live or work in air polluted environments such as mines and quarries.

There are various risks which we cannot avoid or which can only be avoided at the expense of a limited life style. We can avoid some risks if we are aware of them. Pollution in buildings is one of the risks which can be managed. Over a period of many years, there has been some evidence from the scientific research showing that the level of pollution inside houses and buildings which are in extremely poor condition can be worse than that outside in civic and the large industrial areas. For

example the study of Kulaporn Nokchan, 1999: 35; Wantanee Phanprasit, 2001: 14; Krisada Indharasatit, 2002: 5 -6 mentioned that illness will happen when working or living in improper buildings. Patients suffering from Sick Building Syndrome will normally have headache or eye pain, coughing and itchiness or they can sometimes have dizziness, nausea and weakness without reason and be unable to specify the cause. Individual patients have different levels of symptoms which will disappear when a patient leaves the residential or office building. In these cases, most the population will exhibit dramatic health problems due to the pollution in the buildings. Other than this, some population who have to endure the pollution in the buildings for a long time will feel sensitive and weak, particularly children, the elderly and patients who suffer chronic respiratory system illnesses.

Differences in the tasks undertaken by employees play an important role in determining the level of pollution which population are exposed to, depending on who comes into contact with dirtiness more directly than others. For example, it is necessary to have rules and regulations to protect the workers working in the industrial activities who must come into contact with the dirtiness and pollution during their work.

Pollution in buildings can be critical to the health of the workers. The dirtiness of the air inside offices occurs when toxic substances attach to various objects in building and there is insufficient air ventilation resulting in problems for eyes, nose, and throat, or causing skin irritation. 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. However, at the present time, the new buildings are built in a closed structure then those buildings are able to prevent the air pollution from outside. A study by the U.S. Environmental Protection Agency (U.S.EPA), found that the pollution in buildings was the 4th most significant cause of cancer out of 13 factors which were studied. Certain factors are particularly significant in determining an individuals' risk from the pollution in buildings. Most important is that most population spend most of their time in buildings. The study found that Californians spend about 87% of their time each day in buildings. Inhalation is the

most common means by which pollution causes symptoms in population. The toxic substances which were found by examination of the areas where pollution occurred in the buildings found formaldehyde, chloroform (odorless substance) and substance used in the manufacture of synthetic rubber at a level more than 2.5 times the level of the pollution outside the building (Hal, 1995).

The decline in health of individuals which occurs as a result of pollution in buildings may be due to various characteristics such as:

1) The workplace characteristics, particularly room characteristics, numbers of people, floor characteristics, improvement in workplace, surroundings of workplace, conveniences in workplace, and cleaning methods.

2) The work characteristics, particularly positions, working period, and using of office equipments such as copiers, printers, computers, and appliances.

3) The work environment characteristics, particularly cleanness of workplace and organization of office equipment.

4) The personal characteristics, particularly gender, age, education level, tobacco smoking, medical history and individual disease.

Population cannot avoid many of polluting activities from modern life, not only using of cars and other kinds of automobiles, but many of activities performed on a daily basis are polluting the environment and this trend appears to have been increasing constantly. However, there are several choices of methods which can be used to resolve these problems. Those population who have a high risk of suffering the effects of sick building syndrome are teenagers, elders, and population who have chronic diseases, especially those who have the respiratory system problems or arterial disease. Their risks are not improved by using of biomass such as charcoal, animal dung, plant fiber and cooking fuel. Burning biomass obviously impacts the quality of air. It is necessary to ensure that the air which we breathe is clean especially for those who are weak such as infants, children, pregnant women, fetuses, and elders. These population are particularly susceptible to respiratory system illnesses or allergies such as asthma. Even though there may be control over the design of the structure of buildings, if the air ventilation system is not good or the equipment used in buildings malfunctions, pollution is able to build up to a level which may represent a risk to health.

In the present the majority of the population of Bangkok Metropolis work in office buildings, therefore the main reason most population encounter health problems is pollution inside buildings. A population which resides in the commercial, education, technology, and business areas will have high risk of contracting diseases related to pollution in buildings more than population who reside elsewhere. It is important to further research the impact of the pollution in the buildings on the health of the population in Bangkok Metropolis in order to raise awareness of the problem and its causes. There are six types of symptoms arising from the problem:

1) group of eye symptoms,
2) group of nose symptoms,
3) group of throat symptoms,
4) group of respiratory system symptoms,
5) group of nervous system symptoms,
6) group of skin symptoms

By choosing the sample group from the population of Bangkok Metropolis office workers the research should show the relationship of the symptoms to causes and be useful for the prevention and reduction of the risk factors related to disease in the six types of symptoms identified above.

1.2 The Purpose of the Research

1) To study the personal characteristics of the population such as gender, age, education level, marital status, income, number of working days per week and number of working hours per day.

2) To study the frequency and the ratio of the occurrence of the symptoms.

3) To identify those characteristics which influence the occurrence of the six types of symptoms and whether there is any common characteristics which relates to each group of symptoms.

4) To present methods by which it may be possible to mitigate the occurrence of the six types of symptoms.

1.3 The Boundary of the Research

In this study, we have indicated the boundary of the research as following;

1) This study was performed on the sample group, which was selected by Quota sampling from the population of persons aged 20-60 years old who reside in high office buildings within six districts of Bangkok Metropolis, Sathon District, Pathum Wan District, Huai Khwang District, Din Daeng District, Bang Kapi District, and Chatuchak District. Then the most crowded office building was selected from each district. Buildings higher than 23 meters were excluded. From those selected buildings, by quota sampling, we selected workers aged 20-60 years old, both men and women in a balance proportion, from each floor of the target building. The total sample group was equal to 396 cases.

2) Data were collected from questionnaires and data analysis used basic statistics and Logistic Regression Analysis.

1.4 Benefits Which may be Expected

1) The researcher knew the level of the relationship between independent variables and dependent variables.

2) The outcome of the research may assist the regulatory enforcement of existing regulations for the control of office buildings and form a basis for requesting the co-operation of both building managers and employers to improve office buildings and the work environment characteristics in order to reduce the incidence of the six types of symptoms. Public sector also can be the agent for the distribution of information to increase awareness of the population regarding the relationship between the workplace characteristics, the work environment characteristics and the health characteristics of individuals. By these means the risk incidence of the six types of the symptoms may be reduced.

3) The results of the research may indicate to employers how they can effectively change the work environment characteristics in order to reduce absence from work and inefficiency which may be the consequence of the six types of symptoms.

4) Identification of which independent variables have impact on dependent variables will assist investigation of the problem in order to prevent and reduce the risk of the occurrence of the six types of symptoms.

5) This research may provide a framework and basis for future research in the same field by developing methods of analysis to be applied in monitoring of conditions.

CHAPTER 2

LITERATURE REVIEW

This chapter contains relating concepts and researches, including conceptual framework of the study, as follows:

2.1 Concepts and Theories on Indoor Pollution.

2.2 Impacts of Indoor Air Quality Problem

2.3 Building- related Illnesses

2.4 Building-related Syndromes

2.5 Diagnostics of Building-relating Symptoms

2.6 Relating Researches

2.7 Terms and Definitions Used in This Study

2.8 Research Concept

2.1 Concepts and Theories on Indoor Pollution

2.1.1 Definition of Indoor Pollution

Indoor Pollution is the condition where there is a level of impurities in the air long enough to endanger human health and the surrounding environment.

The pollution may be triggered by different factors; e.g. decorating materials, carpets, curtains, copying machines, decorative plants, cleaning products, cigarettes, insecticides, food, dust, pets and moisture that may harm human health, provoking building–related syndromes such as headache, respiratory problems, asthma, lung cancer, anxiety, depression, and allergy (Sasithorn Narongsak, 1993:23-27).

2.1.2 Characteristics of Buildings Which Cause Indoor Air Quality Problems

Energy-saving office buildings located in the hot and humid climate of Thailand have experienced improper air quality. They require heating, ventilating, air-

conditioning and purifying measures, which comply with and suit the energy-saving purpose of the building, in order to promote occupants' comfort, work efficiency and good health. This concept leads to the design of energy-saving buildings which utilizes a cover which effectively shields the inner space and eliminates the air flow in and out of the building. For this purpose, heating, ventilating and air-conditioning systems which allow control over Variable Air Volume (VAV) are employed in these buildings. As a result, there is a decrease in the volume of fresh air circulating inside the building because the systems avoid bringing in fresh outdoor air, which has not gone through the air-conditioning process, in order to reduce the burden of indoor air cooling. However, such a designed building is at risk of having indoor air quality problems. Occupants tend to experience thirst, eye irritation, headache, dizziness, fatigue, asthma, cough and nausea. These symptoms are usually aggravated by poor indoor air quality (Kulaporn Nokchan, 1999:31-51). According to Sterling's study research can classify the characteristics of the buildings that 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.

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.

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.

The characteristics and types of materials which are the source of indoor contaminant emission, shedding some light on the type of construction materials which can result in indoor air problems (Wantanee Panprasit, 2001:12-17).

(1) Wet or damp materials which emit contaminants into the air during the construction period. These materials include solvents, paint, glue and sealants used in the construction or renovation period. Reducing contact with these materials may be achieved by moving staff into another building or area for a while after these materials are applied.

(2) Wet or damp materials which emit contaminants into the air during use of the building include cleaning products, wax, sterilizers and insecticides.

(3) Dry materials which emit contaminants into the air such as rubber mat under carpets and formaldehyde from plywood. They pollute the air by, at first, attracting surrounding contaminants which sink in on their surfaces and releasing the contaminants back into the air. The sinking and emitting rates depend on the material's surface, temperature, chemical characteristics and the chemical intensity of the air. Sinking occurs when the chemical intensity of the air is higher than that of the material, and emission would take place vice versa.

7) A building whose heating, ventilation and air-conditioning system maintenance is inadequate. Dust, oil, dirt and germs accumulate on the grille, diffuser sand ducts are not removed and cleansed (Sterling, 2003:63-72).

2.1.3 Variables Which Affect Indoor Air Quality

As for the solutions to indoor air quality problem introduced variables or conditions to indicate whether a certain area has good indoor air quality by taking into consideration the occupants' awareness of indoor toxic level as follows;

1) Rate the occupant's comfort level towards the temperature, relative humidity and air flow speed of in an area to see if it is acceptable.

2) Check whether occupants can breathe with ease which depends on the concentration of oxygen and carbon dioxide in that area.

3) Measure the concentration of contaminating gas, impure particles and radioactive substances to determine if they exceed the safe levels suggested by the Environment Protection Agency under IAQ Publications.(Environmental Protection Agency, 2004) An Office Building Occupant's Guide to Indoor Air Quality. However, Krisada Indarasathit promotes a different approach and suggests that environmental and personal factors affect the air quality awareness of occupants and this modifies responses to the level of toxins which directly impact the occupants by affecting their thermal comfort, health and the effectiveness of their performance (Krisada Indarasathit, 2002:17-23).

2.1.4 Environmental Factors

Environmental Factors include odor, temperature (too hot or too cold), wind speed (too windy or too stuffy), heat or glare from the sun, glare from the ceiling

light, glare from the computer, crowdedness of furniture and ergonomic design of the working area, e.g. chair height, table height and layout of the working area, and etc.

2.1.5 Personal factors

This includes stress whilst working at home or in the office, feelings towards the physical aspects of the working area such as location, work environment, natural light, and aesthetics including color or design of the building.

A case study on a commercial building in Singapore regarded the factors which affected indoor air quality problem and was a comparative study of bio-aerosol contamination of indoor air quality with reference to age of building, condition of heating, ventilation and air-conditioning systems, the maintenance of those systems, office layout, concentration of occupants, and purification of air before entering the building. It was found that those factors contributing to bio-aerosol contamination problems are environmental factors and personal factors e.g. design of occupants' activity building, operation system and maintenance of heating, ventilating and air-conditioning system. Furthermore, the study showed that the main source of bio-aerosol contamination was from the occupants in that office. The researcher has suggested that cleaning is crucial to the reduction of bio-aerosol contamination (Tan, F. et al., 2010).

According to the case study, only one factor causing the indoor air quality problems may be induced by various elements of the building.

2.1.6 Sources of Indoor Pollution

Indoor air quality which can affect health has been of interest for more than 20 years. The National Institute of Occupational Safety and Health in the United States of America conducted an inspection following complaints in 529 buildings and found that indoor pollutions were triggered by the following:

1) Indoor air ventilation problems such as an inadequate volume of outdoor air being drawn into the building, poor air distribution and unfit temperature or humidity. This accounted for 53% of all indoor pollutions.

2) Indoor pollutions; including cigarette smoke, ozone, organic compound fumes, formaldehyde and dust account for 15%.

3) Outdoor pollutions; such as car exhaust from the traffic, smoke from various sources, construction dust and pollen account for 10%.

4) Indoor bio-aerosol contamination is 5%.

5) Building structure and interior decoration materials account for 4%

6) Unidentified causes account for 13%

The American College of Occupation and Environmental Medicine has classified indoor pollution sources into 4 categories:

1) External environment: A building without an air ventilating system is often in an unfavorable condition. Indoor pressure is low. Air density is less than that of the outdoor air as air would move from high density side to the low density side. When a door is opened, outdoor air tends to rush into a room, preventing pollutants in indoor air from flowing outside. This difference in air pressure leads to temperature differences. Wind brings contaminants into the building including various kinds of smoke. Tight buildings are built to avoid this problem. New, big and modern buildings employ air ventilation which creates positive air pressure. Theoretically, a positively pressured atmosphere can prevent air diffusion. However, an increase in air pressure can induce air to diffuse to other parts of the building. Moreover, mechanical systems bring air into the building. Buildings in which problems were found usually had outdoor sources of pollution such as outdoor contaminated air which contained pollen, dust, fungus spores, industrial contaminants and car exhaust. Contaminants emitted from nearby sources include car exhaust from nearby streets, parking lots or auto shops, exhaust from building ventilating outlets flowing back into the building, bad odor from trash or waste collection, earthly gas such as Radon, insecticides, other chemical contaminants in the soil and from water puddles in drainage pipe and condensate pans.

2) Building fabric and interior furnishing: When buildings are used for purposes other than that for which they were originally designed more problems arise. Inappropriate design of the building, building construction and renovation are the major sources of bad indoor air quality, impacting the air-conditioning system. Sometimes open hallways connecting buildings can affect the air flow direction. In some cases, contaminants, instead the fresh air, enter the building. In addition, some furniture or fixtures can be a source of indoor pollution, for example, those not in a

sanitary condition such as wet ceilings. Some pollutants come from building renovation, e.g. fumes of new furniture, dust from demolition, and organic compounds which evaporate from construction materials. Chemical substance emitted from the building, furniture, physical degradation of the material, such as urea and formaldehyde, which is used for making insulation, partition, carpet, paint release organic compounds. These also include scratches on the surface of the products which use asbestos and other organic substances and dust collecting on areas like upholstery, curtains, carpets, furniture, old walls and other surfaces.

3) Indoor mechanical systems: Nowadays, most buildings are tight, requiring air circulating systems in order to bring in fresh air for breathing and to vent the exhaust out of the building. Air should be circulated and should have acceptable quality according to the usage of each area. Unsuitable air-conditioning can also be the reason for indoor air quality problems during usage. For example, when thermostat and air blowing controls are not synchronized, the circulating rate decreases and less fresh air is brought into the building. Hence, the volume of carbon dioxide and chemical substances emitted from tools and equipments used in the office rises. Air quality is determined by the building system, temperature, relative humidity and the dust level. They vary directly with the effectiveness the of air-conditioning system such as air ducts, air filters, grilles, and fans. Examples of indoor pollution set off by indoor mechanical systems would be a heating, ventilating and air-conditioning system (HVAC) in which dust collects in the air duct, microbes grow in the condensate pan, improper use of fungicides and bacteriacides, leakage of freon, and ineffective ventilation of smoke from cooking or burning activities.

4) Occupant generated pollution: Activities of occupants can also be the source of indoor pollution, especially in heavily populated buildings or buildings in which smoking is allowed. The use of office equipment such as printers, copying machine, carbonless copying paper, adhesives, cleaning products and insecticides can also contribute to the problem. Examples of occupant generated pollution are personal activities such as smoking, cooking, applying perfume, coughs and sneezes, fume from office supplies such as ammonia, solvents, and fumes from laboratories. Furthermore, storing and cleaning process can induce pollution, starting from the products which are used for cleaning, cleaning methods, contaminants dispersal from garbage or dumpsters, using air freshener, dispersal of dust from sweeping, cleaning

organic waste from humans and animals, and maintenance activities such as dispersing dust from organic compounds, evaporating substances from paint, adhesives and sealants, and usage of insecticides.

2.1.7 Causes of Indoor Pollution

1) Characteristics of buildings and indoor mechanical systems: The Environmental Protection Agency has studied air quality inside large buildings. They noted that unsuitable air conditioning is a significant contributor to indoor air quality problems and pollution. The Energy Efficiency Institute (Thailand) Foundation, has classified the causes of indoor air pollution problems relating to inappropriate indoor air-conditioning as follows;

(1) Insufficient air ventilation systems drawing in an insufficient volume of fresh air is the main cause of indoor air pollution. This is a result of attempts to design energy-saving buildings. The volume of fresh air which is introduced from outside depends on the determined indoor room temperature. However, when that air volume is not related to the volume of fresh air needed by the occupants, there is an accumulation of odor, germs and different irritating particles suspended in the air. When the air flow and pressure varies in different parts of the building, odor and dirt in higher pressure areas moves to the lower pressure areas.

(2) Ineffective air filtration, allowing gas and other particles to enter the air circulation system and disperse inside the building.

(3) Inadequate air filtration standards which often happens when building designer and building operation controller do not use a standard in filtering the air (Kua-anan Techato, 2005).

The causes of indoor air quality problems which are relating to indoor air pollution include;

(1) Environmental Tobacco Smoke, a pollution created by occupants smoking cigarettes. Other occupants may not be able to breathe comfortably and are at risk of second-hand smoking or passive smoking. It has been proved that cigarette smoke is a major factor which damages the environment created by a well designed ventilating system.

(2) Synthetic construction materials and indoor decoration materials can be sources which produce different gases such as formaldehyde and organic

substances. Chemical substances can be emitted from various materials like paint, furniture adhesive, carpet, and vinyl wall paper. Formaldehyde has a strong odor and is often found in construction adhesives.

There is a case study concerning the affects on building occupants of chemical fumes emitted from organic construction material (Rukseans, 2004). Furthermore, research on Volatile Organic Compound Measurement in A Newly Refurbished Office Building conducted in Australia, which emphasized the relationship between indoor air quality problems and the occupants, showed that many occupants complained about poor indoor air quality and took more sick leave than usual specifying that they fell ill as a result of the refurbishment. In the construction and refurbishment, wood, adhesives, resin and paint were used. These factors caused the occupants to complain about poor and stuffy air quality which resulted in health problems including respiratory problems, asthma attacks, headaches, and fatigue caused because indoor air had a certain level of organic contaminants and the air ventilation was inadequate. This suggests that owners and managers of newly refurbished buildings should consider the following three categories in relation to air quality;

(1) Indoor ventilation system
(2) Suitable ventilation rate
(3) Organic compound released from building decoration materials.

The study suggests that poor selection of construction materials can trigger sicknesses in occupants when there is poor artificial ventilation without natural ventilation and there is sealed up building cladding. Moreover, The National Institute of Occupational Safety and Health launched a study in the United States of America into 1,000 complaints about indoor air quality problems (Wantanee Panprasit, 2001:12-17). In the study, it was found that that 50% of indoor air quality complaints arose from poor indoor ventilation e.g. insufficient volume of outdoor air injected into the building, incomplete indoor air circulation coverage resulting in unsuitable indoor temperature and humidity, and trapped indoor contaminants; 30% was due to indoor contaminants such as formaldehyde, fumes, microbial dust and various suspended particles; 10% came from outdoor pollution including traffic dust, car exhaust and construction dust; and the last 10% was unidentified.

2) Building management causes which can be classified as follows;

(1) Lack of indoor cigarette smoking policy

(2) Deficiency in heating, ventilating and air-conditioning system management, leading to failures in the system, resulting in the system becoming a source of air contamination or bringing in outdoor contaminants into the building.

(3) Absence of building renovation, maintenance or refurbishment control. For example, putting up walls to create many small rooms, even though the room is not designed for such a purpose, would block indoor air circulation.

(4) Absence of indoor insecticide or pesticide control

(5) Lack of chemical usage control such as the use of furniture, floor and equipment cleaning products

(6) Crowded room layout and decoration filling the room with people or too many things.

2.1.8 Factor Affecting Indoor Air Quality

It is widely known that the indoor environment is the result of building compositions which are related to the occupants' indoor activities, indoor temperature level, architectural design, building system works, construction materials, indoor equipment, sources of indoor contamination and pollution. These are all the sources of indoor air quality problems (EPA, 2004). These factors can be discussed as follows;

1) Source of pollution: Different kinds of pollutions can occur due to both indoor and outdoor sources. Therefore, if these sources are controlled so that they do not disperse contaminants or appropriate control and maintenance measures are implemented in respect of heating, ventilating and air-conditioning system, indoor air quality problems can be minimized.

As for the sources of pollution and types of contaminants has presented information in respect of both indoor and outdoor sources, and also regarding the impact of pollution on the occupants (Wantanee Panprasit, 2001:12–17).

Outdoor sources

(1) Outdoor air contaminated with pollen, dust and fungus spores.

(2) Contaminants released from nearby sources such as car exhaust created through fuel combustion which is full of gases harmful to human bodies including;

a. Carbon monoxide gas which prevents red blood cells from taking up oxygen to feed body tissues, causing dizziness, vomiting and fatigue. In case of high intake levels, it may result in unconsciousness or even death.

b. Nitrogen dioxide gas which irritates skin, eye tissues, nose and throat, triggers chest pain, coughing and interrupted breathing, and reduces immunity to respiratory diseases such as bronchitis, asthma and pulmonary emphysema.

c. Sulfur dioxide which irritates the respiratory system. Respirable particles may be trapped inside lungs, harming pleura.

(3) Exhaust air from ventilation ducts and foul odor from garbage dumpsters. Odor from sanitary system flowing back into the building may occur if the ventilation duct is too close to fresh air duct or by a change in wind direction during certain seasons, blowing the odor back into the building.

(4) Gas released from the ground, such as Radon, insecticide and chemical contamination in the soil. Radon gas can enter the building through the basement floor or building foundation. Radon is created by decomposition of such radioactive elements in the ground as Uranium and Thorium. It is an inert gas, inactive to other substance, which would flow upward or contaminate the soil or the water seeping into the building. Radon dispersion is achieved through mixing with dust suspended in the air. Therefore, when we breathe these particles into our lungs, they are usually trapped there, eventually triggering lung cancers. In the United States of America, there are 5,000 -15,000 patients/year whose lung cancers are aggravated by Radon.

(5) Water puddles e.g. water drainage, water trays, and water collected under the plant pots, water leakage into buildings through cracks, water which seeps through walls, indoor condensate on the ceiling and damp carpets can be sources which accumulate fungus, bacteria and microbes causing illnesses. Microbes, especially Legionnaire which favors damp places, can also grow in the condenser coil and cooling tower, dust in the air-conditioning system including in the air filter, cold air duct, condensate pan and cooling tower.

Indoor sources

(1) Heating, ventilating and air-conditioning equipment, tools and general equipment.

a. Dust trapped in the air ducts

b. Microbes growing in the condensate pan

c. Contamination in the indoor Heat Recovery Wheel for buildings which employ the Heat Recovery Wheel or Rotary Air to Air Heat Exchanger with the purpose of conserving energy. There is usually a leakage which brings contaminated air through the wheel into the fresh air. Contaminants can be carried over through heat absorbing materials, allowing some contaminants to flow back into the building.

d. Toxins from fungicides, antiseptics and insecticides, that are used on indoor plants or are used to kill termites and cockroaches in the building, can trigger irritation, cancer, and damage the central nervous system after a long period of exposure.

e. Fumes or gases released from office supplies and equipment. Ozone (O_3), which is released by high voltage electronic equipment such as copying machines, can cause irritation and damage to the nose, eye, throat and lung tissues. Also, hydro-carbons emitted by copying machine can trigger some symptoms.

(2) Human activities

a. Personal activities: Smoking, cooking, putting perfume on. Moreover, there are some other odors like body odor, cosmetic fragrance, cleaning product smells or building decoration material odor.

b. Storing and cleaning activities: Floor cleaning products, other cleaning products and air freshener.

c. Maintenance activities: Microbes in the water mist from cooling tower, Volatile Organic Compounds (VOC) from paint and adhesives.

(3) Building composition and decoration

a. Dust collecting areas like walls, curtains, upholstery, carpets, old furniture and rotten floors.

b. Insanitary environments like wet and moldy ceilings and gas leaks from sewage and drainage systems.

(4) Building renovation, refurbishment and fixing: Fume from new furniture, dust from demolition, Volatile Organic Compounds (VOC), chemical substances release from construction materials such as paint, adhesive, furniture, carpet, vinyl wall paper, and, above all formaldehyde.

2) Heating, Ventilation and Air-condition System

In relation to the design concept and utilization of heating, ventilating and air-conditioning system, there are 3 aspects to consider as follows;

(1) Heating, ventilating and air-conditioning systems must create a thermal comfort environment in the building. Among the variables which correlate with one another, the variable which most strongly affects thermal comfort is air temperature. Less significant variables are age, type of indoor activities and body type can also influence thermal comfort. Kitchai has mentioned six physical factors which affect thermal comfort as follows;

a. Air Temperature: If temperature is too high, blood vessels would be enlarged in order to vent heat through perspiration, prompting an uncomfortable feeling. However if temperature is too low, blood vessels would constrict to reduce loss of heat, giving a cold and shivering sensation.

b. Mean Radiant Temperature: Feeling abnormally cold or hot despite air temperature being at a suitable level can be explained by radiation of heat from or to surfaces that have either a higher or lower temperature than that of the indoor air. The human body radiates thermal radiation to cooler material. On the other hand, it receives thermal radiation from hotter material.

c. Relative Humidity: If relative humidity is too high, it is more difficult for the body to perspire, producing feelings of being hot and uncomfortable. But if relative humidity is too low, it irritates the skin and respiratory system. In some cases it creates a confusion if there are also aggravating chemical substance in that area. Anyway, humidity is a factor relating to thermal comfort. An increasing relative humidity would lower the body’s ability to lose heat (through evaporation of sweat). It produces the same result as when temperature rises. Therefore, when relative humidity is high, indoor air quality problems can occur. When relative humidity is too high or too low, there is a discomfort. Furthermore, when relative humidity is too high, mold and fungus thrive, but when it is low, mold

and fungus may release their spores into the air causing the onset of illness and allergic reactions.

d. Air Velocity: High air velocity makes the body feel cold because wind quickly takes heat away from body skin. On the other hand, when air velocity is too low, it feels hot, muggy and uncomfortable as body heat cannot be released properly (Kitchai Jitkajornvanich, 2001:175 - 181).

e. Personal Activity or Metabolic Rate

f. Personal Clothing Thermal Resistance

(2) Ventilation according to need of occupants

(3) Odor and Contaminant Control

In order for a ventilation system to achieve a higher effectiveness, the system must effectively distribute wind, together with the ability to effectively filter the odor and contaminants. Odor and contaminant controls which employ the air pressure principle must seriously consider usage or special demands in each area of the building. For example, the welcome hall or public areas of the building should be designed to be at a high pressure relative to the rest of the building, by adjusting the volume of air, in order to prevent or reduce the inflow of unconditioned air from outside. Outdoor air has the possibility of carrying into the building dust, contaminants and air which makes occupants feel uncomfortable. Regarding effective ways to eliminate and control odor and contaminants, Environmental Protection Agency has suggested the following techniques;

a. Diluting indoor odor and contaminants by introducing outdoor air and applying an effective mixture of suitable wind distribution and air circulation.

b. Making sure that heating, ventilation and air-conditioning system works properly by adjusting the indoor air volume and the pressure in each room so as to achieve appropriate positively and negatively pressurized rooms.

c. Ventilating each indoor area in such a way as to always keep the air pressure of the area surrounding sources of contamination low or installing mechanical ventilating equipment in each area that needs supplementary ventilation. Adding an air cleaner to the ventilating system is effective in helping to eliminate or controlling indoor odor and contaminants. Selecting and installing an air cleaner

would yield effective results when suitable equipment is used, installed and maintained (EPA, 2004).

3) Building Occupant: Normally, 'indoor occupant' means people who work all day and the term includes customers and guests as well as employees and residents. However, individual occupants may not have the same tolerance level, expectation, or sensitivity to chemical and irritating stimulants. Those who are more sensitive may react more strongly to air quality problems while others in the same room may not exhibit any discomfort or sickness at all. However, they may have the same awareness of odor or, in some cases, may make the same complaint throughout the building as a result of one person's reaction spreading to others. When air temperature in the room is too high for human activity, people feel discomfort. As the temperature increases the discomfort level also increases, followed by fatigue which could be triggered more by air pollution than by the high temperature. Indoor air quality problems tend to produce generalized symptoms rather than specific illnesses (the symptoms may appear in only one person or a whole group of people). When occupants complain about an uncomfortable environment they may complain about foul odor nearby and assume that it is an indoor air quality problem. However, indoor air quality problems can be initiated by other stimulants such as noise, light, unsuitable vibration, utilization of poorly designed equipment or stress from work which leads to headache, fatigue, shortness of breath, blood-filled sinuses, coughing, sneezing, irritation of eyes, nose, throat and skin, dizziness, nausea and vomiting.

We can use the symptoms of occupants as a tool to look for solutions to indoor air quality problems. Information about the symptoms may be used to identify the time of the onset of sicknesses and the condition and characteristics of problems which are the causes of illnesses in especially sensitive groups of people. Those who suffer from air contaminants can be categorized as follows;

a. People who have allergy or asthma

b. People who have respiratory illnesses

c. People with reduced immunity due to treatments; including chemotherapy, radiotherapy; and some illnesses. Some people who appear to be especially vulnerable may be affected easily when they are exposed to pollution.

d. People with heart disease: If they are exposed to even a small volume of carbon monoxide, they may get more serious symptoms than healthy people.

e. Children in the Environment Tobacco Smoke (ETS) are at risk of having respiratory sicknesses. If they are exposed to nitrogen dioxide, they are at risk of getting respiratory infection more easily.

2.2 Impacts of Indoor Air Quality Problem

Indoor air quality problems have both direct and indirect affects upon the health and effectiveness of occupants. The impacts may be classified by the type of the illness caused. Seriousness of the sickness varies with exposure time.

2.2.1 Symptoms of Impacted Occupants

Environmental Protection Agency has summarized the types of effects which are exhibited by occupants as follows;

1) Acute Effects: These are effects which happen within 24 hours of being exposed to the impacting factors. If an occupant receives chemical contamination from building construction material, he will have headache, itchy eyes caused by fungus spores and a runny nose. Typically, these effects would appear to be short term symptoms and would then disappear. However, occasionally, if he is exposed to microbes (fungus, bacteria and virus), which are aggravated by dampness, inadequate ventilation and poor building system management, he may contract respiratory illnesses more easily and may suffer chronic effects in the future.

2) Chronic Effects: These are effects which happen slowly, taking a long time to develop depending on the frequency of exposure. Most indoor contaminants can cause cancer. For example, being exposed to cigarette smoke, Radon and asbestos over a long period of time would increase the risk of cancer.

3) Discomfort Effects

4) Performance Effects: Environmental changes such as ambient temperature and relative humidity produce a measurable effect on an individual's ability to focus, his mental condition and efficiency of physical work. The study

shows that air pollution caused by insufficient ventilation or by indoor air pollution can reduce work effectiveness.

2.2.2 Syndromes Triggered by Indoor Air Quality Problems

As occupants perform various indoor activities, they have some chance of exposure to indoor contaminants, germs or chemical substances with many causes and factors. This may trigger an individual occupant, group of occupants, or all occupants to experience different syndromes, depending of the causes. The syndromes caused by indoor air quality problems may be classified as follows;

Group 1 Sick Building Syndrome (SBS)

Patients with Sick Building Syndrome report headache, eye pain, irritated throat, dry cough, skin itchiness or they may faint, feel dizzy, nauseas and fatigued without apparent reason or identified cause Kulaporn Nokchang (1999:31-51). The severity of the syndromes of each patient varies and the syndromes may be eased or disappear when an occupant leaves the building or stops working in that building. However, at least 20% of the syndromes occur to people who work in the same environment, with time of sickness of more than 2 weeks (Sasithorn Narongsak, 1993: 40 - 51). These syndromes do not have specific or certain symptoms but they are more general symptoms which are similar to having a cold or respiratory infection. These syndromes are aggravated when working in the building for a long period of time, especially before the working day is over or towards the end of the working week. The syndromes would disappear or be reduced during the weekend or holidays but will be aggravated again when they return to work(Krisada Indarasathit, 2002: 17-23).

The causes of Sick Building Syndrome (SBS) become of those buildings with poor indoor ventilation, air contaminants including dust, fungus, germs, cigarette smoke and Legionella bacteria in air-conditioning systems (cooling tower) (Tawee Vejapruet, 2001: 148 - 150). This syndrome would disappear when the indoor activities cease. A case study has displayed the relation between indoor air circulation rate and the number of people who have the Sick Building Syndrome. Indoor air circulation rate affects the risk of having the syndrome (Jaakkola and Miettinen, 1995: 29 – 41). In the study, interview questionnaires were used as data collecting tools, together with samples collected from inside 14 commercial buildings which had no

indoor ventilating system and with little temperature and humidity ventilation. The questionnaires were used with 399 indoor staff working in those buildings. The result stated that those ventilation systems which brought in outdoor air at a rate of less than 15-25 liters/minute/person had an indoor source of pollution and there was a risk of having the syndromes.

United States Environmental Protection Agency (U.S.EPA) has explained the meaning of Sick Building Syndrome (SBS) as a situation in which building occupants experience acute health and comfort effects which appear to be linked to the length of time spent in a building, but where no specific illness or cause can be identified. The complaints may be localized in a particular room or zone, or may be widespread throughout a building. The symptoms found were nasal congestion, runny noses, irritated eyes, coughs, chest pain, fatigue, and headache. These symptoms have no specific illness and usually disappear when occupant leaves the building.

It has been observed that individuals who work or live in insanitary buildings complain of Sick Building Syndrome. Patients with Sick Building Syndrome report headache, eye pain, irritated throat, dry cough, skin itchiness or may faint, feel dizzy, nauseas and fatigued without apparent reason or identified causes. The severity of the syndromes of each patient varies. The syndromes may be eased or disappear when occupant leaves the building or stop working in that building.

World Health Organization (WHO) has estimated that 30% of new office buildings or newly refurbished buildings have occupants with Sick Building Syndrome but 20-35%of the people who work in office buildings which have no indoor air quality problem also have Sick Building Syndrome. Research conducted in Thailand found that 20% of people who work in tall, tight office buildings with central heating, ventilating and air-conditioning systems suffer from this syndrome every week. People who work in old office buildings would have more symptoms than those in the new buildings.

Sick Building Syndrome (SBS) appearing in office buildings may be divided by type of symptoms. Sasithorn has suggested different symptom groups according to affected body parts as follows;

1) Eye Irritation: Eyes would become dry, red, irritated and feel burned without an eye infection.

2) Nasal Manifestation: Nasal congestion would begin as soon as an occupant enters the office building and would persist throughout the whole working period. Nasal congestion, coughing and sneezing would increase as room temperature rises. Sometimes, the nose feels irritated and loses the sense of smell, similar to allergy.

3) Headache, Fatigue and General Malaise: Occupant would have a headache in the forehead area. When pain becomes severe, it would feel similar to migraine and accompany body soreness.

4) Throat and Lower Respiratory Tract Symptoms: Similar to having an asthma attack. These symptoms include dry and irritated throat, which would get better after drinking a lot of water, chest congestion and the symptoms which affect the lower respiratory system like difficulty breathing and shortness of breathe as if there is not enough oxygen. These symptoms would go away when inhaling fresh air deeply and slowly many times.

5) Skin Problems: Skin would feel dry and stretched accompanied by a rash similar to a skin infection. These symptoms are aggravated in dry air.

6) Upper Respiratory Tract Infection: These symptoms include Pharyngitis and Tonsillitis.

Although these symptoms may not cause severe illnesses or be life-threatening, they reduce ability to focus on work, interpersonal interaction, work efficiency and motivation to work. They are displayed in various ways such as taking more leave, lack of attention to work, less overtime and higher staff turnover. Three quarters of people who have Sick Building Syndrome in Bangkok report an impact on work efficiency. In other countries like the United States of America, it is found that Sick Building Syndrome has cost 0.5-1.0 % of Gross Domestic Product (Sasithorn Narongsak, 1993: 40 - 51).

Group 2 Building Related Illness (BRI)

They are illnesses which are related to buildings and are caused by working or living in insanitary buildings. The cause of these illnesses can be identified as being related to indoor pollution. These illnesses can be diagnosed, identified and treated. Building Related Illness (BRI) is clearly different from Sick Building Syndrome (SBS) as BRI would not disappear or be eased by walking out of the building like SBS. However BRI takes time to cure. The symptoms of BRI are cough, chest congestion, fever, shivering and muscle pain (Wantanee Panprasit, 2001: 12-17).

When discussing Indoor Air Quality in Large Building, BRI is an illness which is contracted by being exposed to indoor air contamination by microbes from humidification systems, cooling towers, or materials with damp surfaces and by chemical substances like formaldehyde. Toxin from microbes found in wet and damp areas can cause Humidifier Fever, which will result in fever, shivering, cough and pneumonia. Illnesses in the group of Hypersensivity Pneumonitis and Legionnaires' Disease are normally contracted by inhalation of organic and fungus dust (Krisada Indarasathit, 2002:17-23).

Group 3 Multiple Chemical Sensitivity (MCS)

They are the syndrome in which the immune system reacts quickly and more strongly than usual to chemical substances. Patients may feel nauseas, dizzy, light-headed, irritation in the eyes, nose, and throat, chest pain, nose congestion and vomit. As soon as he is exposed to a substance such as light fragrance when walking by crowd, symptoms would immediately appear. This is even more serious when tissues on the face, lungs or other parts of the body are damaged after the chemical contact with even a very small quantity (Krisada Indarasathit, 2002:17-23).

Regarding detail of types and impact of indoor pollution on occupant's health, has explained that the detail of gas, chemical substance, fume and suspended particles in the air which can be used as guidance for consideration, diagnosis and problem identifying in order to identify the causes of air quality problems and to clearly and precisely determine the problem boundary.

1) Aerosols and Environmental Tobacco Smoke (ETS) such as cigarette smoke, general dust, asbestos, fungus spores, pollen, bacteria and virus. Cigarette smoke triggers inflammation of nose tissues, laryngitis, nose congestion, cough, eye tissue irritation, headache, bronchostenosis and chronic respiratory system problems in adults and asthma, infection of the upper respiratory system, pneumonia, bronchitis and snoring in children. In addition, asbestos particles cause lung cancer.

2) Volatile Organic Compounds (VOC) are substances which have at least 1 atom of carbon and hydrogen. They can be classified as Volatile Organic Compounds, Semi-Volatile Organic Compounds and Nonvolatile Organic Compounds. VOC usually have low vapor pressure. Formaldehyde comes from construction and interior decoration materials like plywood, carpet, furniture, cloth, paint, adhesive,

wood stain, insecticide, cleaning products and cigarette smoke. If Total Volatile Organic Compounds found in a building exceed a determined value they cause irritation in the respiratory system, headache and damage nerves. However the danger from exposure to many VOCs at the same time is still unknown. In order to evaluate this issue it will be necessary to consider the Additive Effects of VOC rather than measure each separately.

3) Inorganic Gaseous: Mostly created by combustion of organic compounds with Inorganic Gaseous particles, Inorganic Gaseous includes carbon dioxide which causes headache, fatigue, sleepiness, unconsciousness and problems with upper respiratory system. Carbon monoxide induces bleariness, headache and exhaustion. Being exposed to it in high concentration for more than 1 hour causes nausea, brain incomprehension and even death. Nitrogen Dioxide is a gas highly sensitive to chemical reaction. It can bond with other indoor contaminants creating toxic substances which can trigger bronchostenosis, reduced capacity of lungs, pneumonia, bronchitis and irritation of the respiratory system. If received in a big enough amount, it could cause death. Ozone can aggravate chest pain, cough, asthma, irritated throat, chronic respiratory sickness and reduce immunity of the respiratory system.

4) Bio-aerosols are microbes like fungus, bacteria, Rickettsia, protozoa, dust mites and small particles released from small life forms like pollen, fungus spores and dander. These bio-aerosols can cause infection, allergy and intoxication. Mostly witnessed are allergic reactions to small particles from animals, triggering severe asthma, tears and runny nose, nose congestion, itchiness, cough, headache and fatigue. As for intoxication, there are still not many studies about its impact and results are still unclear. However, microbial toxin can damage body tissues and internal organs like the liver, central nervous system, digestive system and the immune system.

5) Gas emitted from decomposition of Radium - 226 which comes from Uranium. This occurs naturally in the ground and rock. It is a colorless, odorless and tasteless. It moves through water and seeps through cracks or openings in buildings. Radon is the second most frequent cause of lung cancer in the United States of America.

2.2.3 Factors Relating to Sick Building Syndrome

Risk factors of encountering Sick Building Syndrome consist of personal factors, employment factors, the working environment and building characteristics. As shown in table 2.1, the frequency and symptoms in Sick Building Syndrome vary with the building characteristics because;

1) Many personal factors have increasing susceptibility

2) Contacting indoor pollution depends on the employment characteristics of each person. No specific factor yields a clear symptom even though they are the same kind of pollution. Each person may have a different level of reaction and expression.

3) Changes in outdoor temperature or pollution affects the indoor environment. Occupant's activities, office equipment and tools can also make a difference in microenvironments of different areas within the same building.

Table 2.1 Risk Factors of having Sick Building Syndrome in an Office Building

Factors	Description
Personal	Young female (<40 yrs) with allergy and smoking history.
Work	Filing and secretarial job, work on computer for long period, use carbonless copy paper, use or sit by office equipment like copying machine and printer, long hours of work, social psychological problem, stressful job hours, unsatisfied with work
Work Environment	Many people work in limited space, carpeted floor, water leak, poor cleaning and ergonomic problems
Building	Old, air-conditioned, has humidity control system, poor ventilation (ventilation<10 liter/second/person)

Source: Journal of Occupational and Environmental Medicine, 2004**.**

At present the identification of the causes of Sick Building Syndrome is being widely researched and investigated. Many causes have been identified including:

(A) Indoor chemical intoxication such as ozone, volatile organic compounds, low levels of which are released from furniture, interior decoration material, cleaning products, paint, and office equipment and supplies such as copying machine, together with sensitivity to chemical reaction.

(B) Contamination of microbes in carpeted areas, water leakage areas and in the central heating, ventilation and air-conditioning systems, cooling towers, filters and humidity adjustment.

(C) Dust particles and other environmental factors such as temperature, humidity, light and noise.

(D) Inadequate ventilation in the office can cause these symptoms. Furthermore, social psychological factors and personal factors induce change in Sick Building Syndrome.

However, the real cause still has not been determined because there is no individual or environmental group cause which can explain the syndrome. It is often found that the levels of different indoor pollutants have lower concentration than those levels which are thought to trigger the syndrome.

2.2.4 Prevention and Solution to Indoor Air Quality Problem

In addition to designing buildings, architects should guide, support and educate building owners, property managers, building superintendants, construction material dealers, construction material suppliers and other personnel in the construction industry so that knowledge and understanding of the causes and consequences of indoor air quality problems is spread. It is necessary that mechanical heating, ventilating and air-conditioning systems which determine the quality of indoor air work efficiently. Failures and inefficiencies result in the volume of fresh air brought into a tight building being too small. Circulation rates lower than 5 ft^3/minute/person have been recorded. Therefore air cannot be thoroughly distributed to all areas of the building and occupants' needs cannot be met. An air-conditioning system was designed for high rise buildings. Traditionally air-conditioning systems in Thailand have been mainly designed as Thermal Comfort Air-Conditioning with

Ambient Air Temperature and Relative Humidity, Air Motion or Air Circulation and Air Purifying (Thawee Vejapruet, 2001: 148 - 150). However more recent high rise building design has developed heating, ventilation and air-conditioning systems which provide more thermal comfort and promote good health for occupants. New building design principles provide thermal comfort levels suitable for occupants together with improved indoor air quality, energy saving, and the use of acoustic devices reduces noise and vibration problems.

However, the principles stated above are still in the conceptual stage of developing a process for the design of new buildings. The office buildings which have been designed, and constructed using design principle from the past which achieve thermal comfort and energy saving, may achieve the objectives of control or prevention of indoor air quality problem in 2 ways;

1) Operating and Maintenance (O&M): Setting up policies which promote good indoor air quality including;

(1) General policy: An air quality management structure, training for employees who take care of different systems, preparing a working schedule timetable for inspection and monitoring the performance of heating, ventilation and air-conditioning systems.

(2) Policies to control sources of contamination which are prone to cause indoor air quality problems, arranging non-smokers to work in areas where smoking is not allowed, encouraging smokers to quit smoking, allowing smoking only in designated areas, and providing separate heating, ventilating and air-conditioning system for smokers.

(3) Policy to control sources of contamination which are prone to cause indoor air quality problems through use of appropriate construction materials. It covers new construction, remodeling, renovation, refurbishment and fixing. It is suggested that a list is prepared of all materials with full description and history, studying and researching all the detail of each material to see how they release contaminants. This information can be found on Material Safety Data Sheet (MSDS) or different related articles, which specify emission characteristics. A materials shopping list should aid efforts to decrease contaminant release by allowing the material to age (allowing the chemical substances to evaporate) before installing

materials or using heat to bake out the chemical substances. Bake-out may be applied after installing the material by increasing indoor temperature thereby accelerating the evaporation of chemical substances. This kind of Bake-Out, called Building Bake-Out, can be applied only for a short time. Furthermore, the design and material specification should specify 1) types of tile which do not absorb organic compounds or at least do not emit the contaminants into the air after absorption, 2) covering or separating materials which absorb organic compounds such as carpets and curtains during remodeling, renovation and repair (RRR), 3) completely separating the heating, ventilation and air-conditioning system from other areas, 4) operating RRR when there is no occupant in the building and education of those who are undertaking RRR.

2) Indoor Air Quality Control: A concept of controlling indoor air quality so that the contamination is at an acceptable level. It consists of 4 methods. Controlling the sources:

There are 2 methods which can be used for control over sources of the problem; 1) selecting the materials which have low organic compound emission and 2) controlling chemical emission from the materials. These methods are both solutions at the management level. If use of products with chemical substances is unavoidable, these materials should be left outdoors to allow the chemical substances to fume into the air. This helps to minimize the concentration of chemical fumes in the air. However when the air inflow rate drops the chemical concentration in the air would rise if the source of contaminants is still in the building. Diluting the contamination with outside air can be done in 2 ways;

(1) Ventilation Rate Procedure: Ventilation is used to adjust indoor air so that it to meet the acceptable standards. ASHRAE (American Society of health, Refrigerating and Air Conditioning Engineers) has suggested a minimum air inflow rate of $15ft^3$/person according to ASHRAE 1989 standard. Using this method no calculation or consideration of evaporating rates of different materials is required.

(2) IAQ (Indoor air quality): Indoor air quality procedure requires calculation of the air inflow rate into the building. It should be sufficient to dilute contaminants to an acceptable concentration. This procedure requires the evaporating rate of the substance to be known in order to calculate air inflow rate from outside

into the building. However, to opt to dilute the contamination with outside air according to IAQ Procedure, the following factors should be considered;

a. Most air contaminants have a low concentration.
b. Concentration of air contamination is at a dangerous level.
c. Contaminant emitted into the air at a stable rate.
d. Evaporation is not at breathing level.
e. General weather has a mild temperature which is not too hot.
f. Outdoor air has less contamination than indoor
g. HVAC system can treat the air brought into the building
h. Source of contamination is difficult to remove or would incur high expenses to do so
i. Sources of contamination are scattered in many locations over a wide area

3) Indoor treatment and circulation: This method is highly suitable for buildings located in hot and damp climates. It saves energy and expenses because it lowers the volume of air brought into the building by relying on indoor circulation through a filtering process using different kinds of filter which can trap both suspended particles and gas. If this method is applied, there should be strict maintenance schedules to change filters according to predetermined timing. Otherwise, the filters would become a source of air contamination.

4) Identifying and improving deviant factors: Indoor air quality problems may be related to various environmental factors including temperature, relative humidity, air movement, noise and light. If these overall factors are appropriately improved, it would ease the intensity of indoor air quality problems.

2.2.5 Technical Method to Solve Indoor Air Quality Problem

Although the principle and concept are geared toward operating, managing, preventing and controlling indoor air quality problem as previously mentioned, the technical content of the problem can lead to using technical methods to solve indoor

air quality problems. There is the technical method about heating, ventilating and air-conditioning system which can be utilized for operating and managing the air quality. It is a technical treatment to prevent and control indoor air quality problem which can be applied to both new building design or remodeling or renovating the existing buildings (Krisada Indarasathit, 2002: 17-23).

The volume of fresh air brought into the building from outside must not be less than ASHRAE Standard 62-1999, regulation, standard recommendation of The Engineering Institute of Thailand or other government agencies.

Fresh Air Grille should be far from outdoor contaminated spots including

1) Streets with heavy traffic, parking lots or product delivery areas
2) Exhaust pipes of Boiler and Diesel Generator Set
3) Hot and damp air blown out of Cooling Towers
4) Ventilation ducts of toilets or kitchens in the building

Typically, the lower rim of fresh air grille should be at least 2 meters above the ground or 1 meter above the roof.

Exhaust Air Grille should be at least 9 meters away from the fresh air grille or located on different sides of a wall, with consideration of wind direction in each season and the impact of blowing wind against nearby buildings.

Air Change per Hour: The volume of indoor circulated air should be at least 6-10 times the volume of the room per hour so that the entering fresh air can be quickly distributed to other parts of the building.

Control of the air-conditioning system to be energy-saving must not lower indoor air quality.

1) Optimum Start Control and Optimum Stop Control must not be too slow in the morning or too fast in the evening so that an adequate volume of fresh air is brought in while there are still occupants in the building and that remaining contaminants can be ventilated. It may be done by letting the blower work even though the chiller stops working.

2) Duty Cycling Control of ventilating system must not be so long that contaminants accumulate and harm the occupants.

The ventilating fan for exhaust air should be installed in an area of the building in which air is highly contaminated such as toilet, printing house, copying

room, laboratory or kitchen. In some cases, effective hoods should be utilized together with the ventilating fan in order for the ventilation to work properly. For example, fume hoods can be used in the laboratory while kitchen range hoods can be placed in the kitchen.

Maintaining lower air pressure in the contaminated room than adjacent rooms prevents contamination from dispersing to other parts of the building.

Any humidifier used to increase humidity in air-conditioning systems, such as those used in computer centers of semi-conductor factories, should be a boiling water type which spray vapor into the air. However, water should be treated and cleaned first so that it would not disperse contaminants into the indoor air.

Air-conditioning systems must be easy and convenient to use and maintain, especially in the damp areas or areas which usually have water puddles e.g. humidifier water trays, cooling coils, air filters and cooling towers. This is to prevent microbes and fungus from growing.

Installing a filtering system suitable for fresh air and indoor circulated air requires selection of the proper type of filter for the expected contaminants and a type which is easy to use such as Panel Filter, Intermediate Efficiency for big and medium particles of dust, HEPA Filter for taking out microbes and small particles, Absorption Filter for dirty and smelly fumes, Washer or Scrubber for certain fumes which smell and for water or oil soluble substances, Electronic Air Cleaner to eliminate odor or medium particles found in office buildings, general factory and cigarette smoke.

Indoor temperature should be controlled to be at appropriate level of 24 degrees Celsius or in the range of 23-26 degrees Celsius which is desired by 80% of the occupants. The relative humidity should be at 20 - 60%.

2.3 Building Related Illness

Building related illness refers to health problems caused by air quality problems inside a building which is not used for manufacturing. An overseas magazine has classified them into 2 categories;

1) Building related illness or specific building related illness: This is the situation in which illness occurs in a building and its cause can clearly be identified. It

often happens to a group of people in the same environment. Examples of illness which are related to building are displayed in table 2.2.

2) Sick Building syndrome or non specific building related illness: This is a situation in which building occupants experience acute health and comfort effects which appear to be linked to the length of time spent in a building, but no specific illness or cause can be identified. The problem may happen in a specific part of, or the whole of, a building. These symptoms are specific but often disappear when occupants leave the building.

Table 2.2 Example of Different Kinds of Study of Buildings Which have Sources of Pollution and the Exposure Which Caused Building Related Illness.

Illness	Type of Study	Type of Building	Pollution Source	Exposure
-Infection				
Veteran Hospital	Case –report	Large building	Cooling Tower	L.pneunophilia
and Pantiac fever	Cross sectional study	Office building	Air-conditioner	Virus
Cold tuberculosis	Longiludinal study	Army camp	Human	M.tuberculosis
	Index case->cross	Office building	Human	
	Sectional study		Human	
-Immunity system				
Pneumonia from too	Case report	Office building	Humidifier	Bacteria fungus
active immune	Index case->cross	Office building	Air-conditioner	Asperguillus,
Fever from cold air	Sectional study	Factory	Humidifier	Penicillium
			Ventilator	Various microbes
-Allergy				Dust mite allergen
Infected skin	Case report	Office building	Dust Carpet	from plants and
Infected sinus and	Index case->cross	Office building	Clothes Humidifier	animal
Asthma Hives from	Sectional case	Factory	Carbonless copy	Unidentified
contacting	report	Office building	paper	Alkylphenol
Swollen nodule				novolac, resin
-Irritation				
Infected skin	case report	Office building	Ceiling Smoking	Fiber glass
Irritated respiratory			Vehicle	Combustion
tract both upper and			Combustion	byproduct e.g.
lower				Carbon dioxide

Source: www.acsedu.co.uk., 2005.

2.4 Building-Related Syndrome

2.4.1 Definition

"Sick building syndrome" (SBS) is a situation in which building occupants experience acute health and comfort effects which appear to be linked to the length of time spent in a building, but no specific illness or cause can be identified. The problem may happen in a specific part of, or the whole of, a building. These symptoms are specific but often disappear when occupants leave the building. It is also known by other names including Tight Building syndrome, Building illness syndrome and Non Specific Building related illness.

In 1984 the World Health Organization (WHO) ranked the frequency of symptoms of sick building syndrome in order from more to less as follows;

1) Sensory irritation in mucus membrane of eye, nose and throat such as painful eyes, dry nose and throat, sore irritated throat, loss of voice.

2) Neurotoxic or general health problems including headache, amnesia, loss of focus, dizziness, fatigue, nausea and vomiting.

3) Skin irritation, e.g. itchy and painful skin, skin rash and dry skin.

4) Nonspecific hypersensitivity reaction such as cough, asthma-like symptoms.

5) Distorted odor and taste sensations.

The Commission of European Communities (CEC) mentioned that symptoms of sick building syndrome depend of personal sensitivity which is triggered by many factors. Diagnosis can be performed by eliminating other causes which induce illnesses which are clearly related to buildings. Most symptoms occur to eyes, nose, throat, skin and general symptoms like headache, exhaustion and fatigue. The symptoms appear only temporarily during work and disappear after leaving the office or specific environment.

The American Thoracic Society (ATS) stated that the syndrome appears among a group of people in a building or part of the building. The symptoms gradually start and continue. They would become clearly apparent after there are problems in the building and would disappear after those problems are gone. The symptoms include eye irritation, headache, fatigue, sleepiness, irritated throat without

infection, cough, phlegm in the throat of those who are not smokers but are exposed to cigarette smoke, stuffy voice, chest pain, discomfort which is related to loss of focus and amnesia, infected sinus or itchy nose without any record of allergy. These symptoms are relieved after leaving the environment.

The Lancet mentioned that there is no international definition of this syndrome and no theory to back the actual causes of it. Most symptoms have no specific illness and happen to different groups of people and in some parts of an office building. There is no clear cause like pneumonia, too active an immune system or infection. The most frequent symptoms are shown in table 2.3. The frequency of the symptom varies with various factors in each office building. Frequent symptoms are irritated upper respiratory tract, headache and sleepiness. The type and intensity of symptoms in the same office building differ, depending on each person, microenvironment and personal factors.

Table 2.3 Comparison of Symptoms Appearing in the Syndrome as Reported by Different Organization.

Reported Symptom	WHO	CEC	ATS
Irritation	/	/	/
Nerve	/	/	/
Skin	/	/	×
Respiratory System	/	×	/
Abnormal chemical awareness	/	×	×

Source: The American Journal of Drug, 1988

Note: The symbol / ; The symptoms are appearing in the Syndrome
The symbol × ; The symptoms are not appearing in the Syndrome

When comparing basic information from overseas, there is some difference in symptoms as shown in table 2.3 above. Recent research gives a better understanding of the abnormal chemical awareness not being a part of Sick Building Syndrome. Therefore, this symptom is no longer mentioned.

From the study, most of the causes which were mentioned as being due to the occurrence of office syndrome are

1) Inadequate Ventilation. The ventilation system determines the density of indoor pollution. The polluted area, starting from the contamination by bacteria, toxin from fungus, antibiotics liquid and insecticide or volatile organic compounds from the air filtration system or the maintenance of pipes will create a problem if there is not enough outside air in the building or not enough distribution and blending of air. High or unstable temperature, high humidity and malfunction of filtering systems are also the factors.

2) The most recent American standard for ventilation systems issued by the American Society of Heating , Refrigerating and Air-conditioning Engineers is 20 Square Ft per minute for office buildings or 60 Square Ft per minute per person in high tobacco smoking areas. From the literature review, we found that ventilation rates of lower than 10 square ft per minute per person in any building produce significant health problems. The literature review found that 20 out of 27 publications the statistics suggest that low levels of ventilation are associated with the occurrence of health symptoms. Results from the nine studies suggest that more than 80% of the risk of having a symptom will be reduced once the ventilation rate is more than 40 sq ft per minute per person.

The study by Mendell and his team found that the frequency of the symptoms is related to the increase of outside air ventilation (Mendell, 1990:40-59) while Bourbeau and team who concentrated on the study of ventilation systems and the occurrence of building syndrome still have not reached any conclusion as to whether or not ventilation systems are a cause or help to reduce the occurrence of building syndromes (Bourbeau, 1998: 42-56). Whilst investigating building syndrome they found that tested subjects were frequently mentioned hot and steamy conditions. Moreover, a double blind experimental study by Jaakkolaa found no important evidence of building syndrome in those inside buildings with a ventilation level of between 13-42 sq ft per minute per person (Jaakkolaa, 1995:29 – 41).

Mendell performed Meta-Analysis in order to study the symptoms of people who work inside buildings (Mendell, 1990:40-59). By comparing buildings with different ventilation systems, he found relationships between those who work inside

buildings with air conditioning and the nervous system class of building syndrome symptoms i.e. headache (Odd ratio = 1.3-3.1), sleepiness (OR = 1.4-5.1) and respiratory system symptoms (OR = 1.3-4.8). It is interesting to learn that there was no high frequency of symptoms found for ventilation systems without air-condition. Fisk found that air conditioning systems within buildings, with or without humidity control can cause the building syndromes 30-200 times more often than normal (Fisk, 2008:35-41).

2.4.2 Multiple Chemicals

One out of five of the investigations of indoor pollution problems found the causes of the indoor pollution shown in table 2.4 i.e. Ozone from copier, Trinitrofluorenone from laser printer, Ammonia Gas and Acetic Acid from blueprint machine, Formaldehyde from Carbonless copy paper as well as other volatile organic compounds which may be from glue and chemicals used in offices, furniture and wood products, insecticide and liquid cleaners. Tobacco smoking and use of cooking gas within office buildings are also counted as they cause carbon monoxide gas, nitrogen and tiny dust particles in the buildings.

Table 2.4 Sources of Toxins Occurring Within Office Buildings in the Order in Which They are Most Found

• Fume
• Ozone from copiers and printers
• Volatile Organic Compounds (VOC) from carpets, furnitures, Contrution materials, Paiting colors and liquid cleaners
• Dust from external air, skin, papers, Ignition ie. cooking and fume
• Isocyanate – toluene, diphenylmethane, hexamethylence, naphthalene from glue, fume, wallpapers, painting colors and foul ball
• Formaldehyde from insulation materials, buildings structure, carpets, wall and ceiling, lacquer Antibiotics

Source: www.detoxsafely.org/toxic-environments.html, 2009.

Moreover, outdoor air pollution can be one of the sources of chemicals which cause building syndrome. Outdoor air pollution can enter buildings in many ways such as through the doors, windows, ventilators, and through any area which is not closed properly. Examples of outside polluted areas are buildings at slum areas, polluted air which flows out of buildings, smoke and smells from kitchens and smoke from automobile exhausts inside garages.

Examples of chemicals which cause building syndrome.

1) Chemical Vapour

Formaldehyde is a substance which is frequently found in construction equipment and decorating items. Items which contain Formaldehyde are plywood and items which are made of plywood, foam, papers, fiberglass, curtains and carpets. Formaldehyde is also used as an admixture in coating furniture and cupboards including wooden walls and ceilings. Formaldehyde causes irritation to eyes and tissue of the upper respiratory track such as nose, throat and skin and causes allergies, asthma and more importantly, cancer. Formaldehyde has also an impact on menstruation and the reproductive system.

2) Volatile organic compounds

Apart from Formaldehyde, there are many volatile organic compounds which are source of problems for indoor air quality including aliphatic substance, aromatic substance, Benzyl, Ketone, Polycyclic Aromatic and hydrocarbon which has chlorine as an admixture. Important sources of these volatile organic compounds are ignition, cooking, construction equipment, furniture, paint, solvents, glue and sealing products, automotive exhausts, office equipment, personal items and insecticide. It is of concern is when even small quantities of these substances combine as they promote the occurrence of the symptom and cause cancer. Cancer causing substances which are found include Benzyl, Dichlorobenzene, Chloroform, Tetrachloroethylene, Toluene, Xylene and Styrene.

In 1996, Molhave assumed that all volatile organic compounds are measurable and found that 0.16mg/m3 exhibited no impact while the range of 0.2-3 mg/m3 may demonstrate an impact on health. Sickness started when the range became higher than 3 mg/m3 and ranges of more than 25 mg/m3 were hazardous (Molhave, 1996:11-20).

A survey and investigation of 100 buildings in America by the EPA (Environmental Protection Agency) found that the sources of volatile organic

compounds had a direct relationship with problems affecting tissues of the lower respiratory track. The sources of these substances are shown in figure 2.1. They produce substances that cause irritation and have a relationship with the group of building syndrome symptoms.

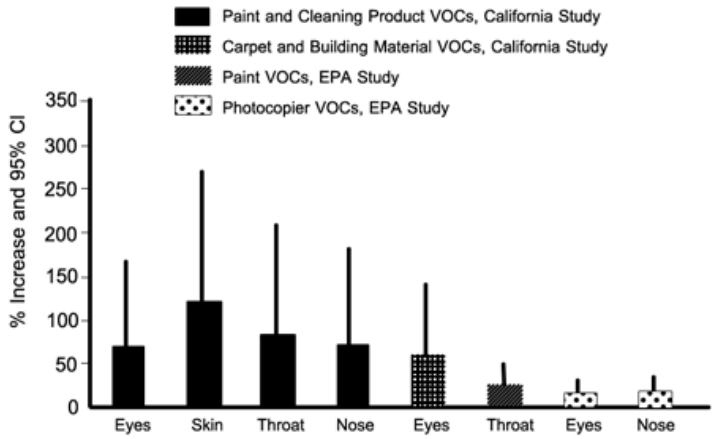


Figure 2.1 Findings of the Study in America Where Symptoms Due to Volatile Organic Compounds from Many Sources are Found

Source: www.epa.gov/iaq/pubs/hpguide.html, 2005**.**

Insecticides are semi-volatile compounds frequently found in buildings where they is used to prevent and eliminate insects, cockroaches, flies, mosquitoes, fleas, termites and ants. This has impact on health in both short and long term by causing cancer from Chlodane and Pentachlorophenal substances. Acute symptoms related to these substances are headache and nausea. Both Chlodane and Pentachlorophenal substances are suspected by EPA as a group of substance that cause cancer.

Liquid cleaners in general contain acid or Sodiumhypochloride which helps increase cleaning ability. These substances have affects on skin, eyes and respiratory system and cause coughing as well as irritating body issues.

Gas cooking stoves and ovens can be an important source of carbon monoxide, carbon dioxide, nitrogen oxide and nitrogen dioxide. It releases aldehyde, other organic substances and dust particles, depending on stove condition, method of use and the ventilation system. Carbon monoxide and nitrogen dioxide are of interest within this group of substance because they are hazardous gases frequently found in

high buildings. Carbon monoxide causes nausea, weakness, lack of oxygen and can cause death at high concentrations. These substances have impact on the nervous system, blood and heart. Nitrogen oxide can cause respiratory disease. Households that use cooking gas tend to be a source of more patients with respiratory system than those which use electric stoves.

3) Aerosol

Generally found in buildings in many forms such as fumes, dust and fibers. Smoking fumes are the most interesting form as they impact both active and passive smokers. Smoking fumes inside buildings frequently cause irritation to the respiratory tract, headache, breathlessness and can cause cancer. It is for these reasons that tobacco smoking is prohibited in most buildings.

Dust and pollens, both inside and outside buildings are also a cause of symptoms, specifically allergies. A case study by Danish Town Hall found that increases in tissue irritation are related to the proportion of dust. It is also found that lacking of cleaning and crowded workplaces are related to a group of building syndrome symptoms.

2.4.3 Microorganism

Bacteria, fungus and virus are microorganism which can cause building syndrome. These microorganisms are found in various places but are extensively found in areas which flood or areas with high humidity such as inside the pipes of ventilation systems, inside humidity machines and drainage tracks or on fittings and equipment inside buildings such as carpets, ceilings and damp walls. Dirty air filters, insects and bird faeces are also causes. Using a water boiler inside a building can cause infection such as Legionella.

Fungus is an important factor that causes Allergy and Asthma. From the experimental tests in Europe it was found that 5-10% of allergy patients were subjected to fungus, spore and fibers. Fungus spores have size between 3-200 microns while most that are found have size smaller than 10 microns. Fungus can stay in the air for a long period of time and can get into people’s respiratory system where it will release volatile substances which cause irritation and micro toxins. A study by Bholah found that fungus is related to occurrence of building symptoms (Bholah, 2002:93-98).

Burge and team, in several studies, said that there was relationship found between the increase of symptoms in patients who live in office buildings and an microorganisms, however, the symptoms are not yet obvious. Checking levels of Bacteria and fungus, there was no relationship found between building symptoms and the amount of contaminant seen in the air. This explains that those symptoms were caused by toxin from fungus, Myco toxin, and toxin from Bacteria, Endotoxin, produced by microorganisms. Apart from that, microbial pesticide such as Glutaraldehyde and Chlorhexidine can also cause building symptoms (Burge, 2004:185-190).

2.4.4 Physical Factors

Temperature, humidity as well as light and sound are factors which impact on air quality inside buildings and the occurrence of building syndrome. Good temperature and should be around 20-27 Celsius with relative humidity at around 40-60. A temperature higher than 20 degrees Celsius reduces awareness in people and increase the vapors of volatile substances which speed the growth of Bacteria, fungus and fleas. Temperature with too low humidity can cause irritation to skin and tissues of the respiratory track.

Ultraviolet light from light bulbs can be responsive to the vapors of volatile substances and cause other substances which irritate eyes. Inadequate light cause eye pain while too much light causes headache. Quality of light has a vision impact on the elderly. Noise, even at low levels, (50-60 decibels) can cause trouble, tension and disturb concentration. They can also affect the working process of body and mind if one is exposed for a long period of time. This is also a cause of high blood pressure leading to heart disease. Niven and team found that sound at low decibel is related to some symptoms like stuffed nose, itchy eyes and dry skin while sound at higher decibel (80-90) caused fatigue, more tension and if exposure continues for a long period of time, one can loose hearing ability (Niven, 2000:47-58).

2.4.5 Relevant Factors to Building Symptoms

Study of the impact on the health of the sample group found relationships between health and contaminated areas and suggests that there are many factors which have both direct and indirect impacts which are difficult to diagnose. Those factors can be categorized in Table 2.5 below.

Table 2.5 Personal Characteristics, Work Characteristics, Workplace Characteristics and Ventilation Systems of Relevant Buildings to Office Building Syndrome

Factors	The Study that Found Relevance to Office Building Syndrome (Significant)		The Study that do not Find Relevance to Office Building Syndrome(No Sig.)	
	Number of Study	Number of Population	Number of Study	Number of Population
▪ Personal Characteristics				
-Gender	7	23,764	1	3,948
-Age 21-40 years old	4	17,166	2	8,450
- Allergy, Asthma background	9	23,662	0	-
-Tobacco smoking	2	8,433	4	13,944
▪ Work characteristic				
-Social mental problem in work	7	21,762	0	-
-Admin and secretarial wok	3	9,301	2	6,489
-Work with computers	6	22,277	1	880
-Usage of carbonless papers	4	16,373	0	-
-Work near copiers	4	10,720	1	3,948
▪ Workplace characteristic				
-Open offices	2	6,489	1	3,948
-Group work	3	11,430	0	-
-Carpeted floor	3	8,335	1	4,943
-Dust	2	7,455	2	11,986
-Noisy	2	5,338	0	-
▪ Building characteristic				
-Air-con	5	26,838	0	-
-Humid	2	9,721	1	11,672
-Ventilation <10 liter/min/person	3	4,959	0	-

Source: www.hse.gov.uk/pubns/indg, 2002

Kukkonen and team had categorized the risk between work environment and the occurrence of office syndrome in table 2.6 below (Kukkonen, 2006:14-19).

Table 2.6 Work Environment Risk Level Which Influences the Occurrence of Office Syndrome

Risk Factor	**Level of Risk Factors**		
	Low	**Medium**	**High**
Temperature	21-23	21-22	<20
(Celsius)		23-24	>24
Changing of temperature	<2	2-3	>3
(Celsius)			
Wind speed (m/s)	<0.15	0.15-0.20	>0.20
Decibel (dBA)			
Average	<60	60-65	>65
Background	<35	35-40	>40
Light			
In general	Proper	Proper	Improper
At working desk	Yes	No	No
Reflection	No	Controllable	too bright
Brightness	Good	Controllable	Too much/not enough
Different in electricity	<1	1-2	>2
Voltage (kV)			
Ventilation system for	>14	8-14	<8
Individual (L/sec)			
Ventilation system	Natural system,	with heater system	with humidity
In general	Controllable	or cool system	system
No of people in a room	<3	3-7	>7
Office appliance	Separated room	-	Shared room
Cleaning frequency	Everyday	3-4 days per week	<2 days per week
Type of Floor	Quite hard	Carpet	Carpet used>10 years
Humidity	None	Short time	Long time

Source: International Labor Office Report, 2006.

2.4.6 Mechanism of Occurrence of Office Symptom

The responsiveness of people is in relation to;

1) Sensory perception of the indoor-environment

Sense includes smell, taste and perception of chemical substances. Perception of chemical substances leads to nerve membrane stimulation and the skin responds to this perception. Sense stimulation causes irritation and the body produces defense mechanisms such as sneezing.

2) Weak inflammatory reaction related to micro-organisms, metabolism or the immune system. Generally, this reaction protects damaged cells. The occurrence of this reaction is transitory, however it is sudden.

3) Environmental stress reaction

Attempts by the body to protect itself from environmental stress and contamination produce self defense and protective reactions which may cause the occurrence of secondary symptoms such as headache.

Irritation of non-specific areas occurs when a sense reaction stimulates the $5^{th,}$, trigeminal, nerve inside membrane causing irritation and pain. Otherwise it stimulates the first nerve, olfactory, nerve causing abnormal smell or chemical substance perception. Moreover, there can be other symptoms such as skin rash and headache (Molhave, 1996: 11-20).

The nature of building syndrome depends on changes in the work place or of air quality. Symptoms can develop when a person leaves a building or when there is some alteration to indoor air quality, however, some symptoms take a longer time to develop.

By synthesis of the relevant data relating to building syndrome patients it was found that;

1) Different Susceptibility

Each group in the population has a different susceptibility so they exhibit different reactions to environmental changes e.g. different perceptions when inhaling formaldehyde. Some perceive a strong smell and others do not. Some experience irritation, others not. Similar variability was found in to reactions to Volatile Organic Compounds or tobacco fumes. Differences in reaction time were also found when investigating temperature, ozone, sulfate and microorganism substances.

2) Response levels to the impacting substances

When there is a widespread incidence of building syndrome only a minority exhibit severe symptoms. In general, abnormality such as a high number of white blood cells or a change in lung capability can be found in some people however no symptoms may be found in the majority of people.

3) Difference contact level in broad rooms or in spacious buildings

Alteration of outdoor air temperature and pollution has an impact on the indoor environment and on the activities of those who live inside buildings. Office appliances also create differing micro-environments within buildings.

From above data, we can deduce that if there is independent transition of a substance's concentration and an individual's susceptibility toward those substances is variable, then a patient will be able to perceive only 1 or 2 substances. This deduction is difficult to prove, however it may be the reason why no relationship between the cause and the symptom in studies of building syndrome has been found.

2.5 Diagnosis from Building-Relating Symptoms (Clinical Assessment)

2.5.1 Checking Clinical History

Physicians should check details of patient occupation and the both workplace and home environments, as well as symptoms. When considering the work characteristics and indoor environment the physician should take into account the ventilation system, the amount of dust and other physical factors such as temperature, humidity and light. More importantly, if there have been any changes in the work environment such as new carpets, new office appliances or any changes that may have caused occurrence of the symptom. Clinical history should also include details of characteristics such as satisfaction with work, the level of tension and relationships with colleagues and superiors.

Building syndromes are non-specific and effect many body systems so we should consider other causes of symptoms. If patients have symptoms that are relevant to building symptoms (BRI) such as asthma or pneumonia, there should be laboratory examinations such as chest X ray, Spirometry or peak flow. If patients have symptoms of the lower respiratory track such as coughing or breathlessness there should be an investigation to find out if there is hyper-reactive airway. This is because

it is difficult to identify whether there may be a relationship between the patient's daily activities and irritation of the respiratory track and asthma by merely checking the clinical history.

Investigation of building syndrome depends on the symptoms of each patient. However other possible diseases should be considered before concluding that the problem is caused by building syndrome.

Presently, there is no international guideline in investigating building syndrome, however the study revealed similarities in the group of symptoms;

1) Symptom of each of body system like eye symptoms, nose symptoms, throat symptoms, symptoms of the middle respiratory track, nervous system symptoms and skin symptoms. Each system has different indicative symptoms as follows;

(1) Eye symptoms. Mostly irritation, weeping, itchy eyes, dry eyes, painful eyes and red eyes without infection. Some found difficulty in wearing contact lens.

(2) Nose symptom. Starting with irritaiton, stuffy nose and itchy nose. Synptoms which look similar to allergy.

(3) Throat symptoms. Similar symptoms to an infected respiratory system i.e. dry throat, sore throat, pain and difficulty swallowing.

(4) Symptom of the lower respiratory track. Similar symptoms to Asthma i.e tight chest, breathlessness and coughing.

(5) Nervous symptom. Symptoms are non-spicific to any disease of Nervous system. General symptom found are headache, sleepy, moody, nausea and lack of concentration

(6) Skin symptoms. Normally occur at exposed areas where the symptoms are like dry skin, irritation of the face, rash and skin infection.

2) Association with work i.e. symptoms happen only when working in the building and are relieved when leaving or stopping work.

3) Elimination of diseases or other factors which can cause such symptoms before commencing investigation for office syndrome.

4) No specific factors found to confirm the occurrence of any above mentioned symptoms i.e. Pneumonia and Asthma.

2.5.2 Evaluation of Indoor Air Quality

This helps to manage the problem. The evaluation team should be composed of physicians, industrial hygienists and civil engineers. The investigation process should include a field survey in order to identify and record facilities, appliances, tenants and their health records.

Interviewing tenants also help to identify problems. There should be follow up of problems arising after the investigation as patients will normally remain in buildings after evaluation. In order to minimize costs reliance should be placed on the experience of the industrial hygienists as an investigator.

2.5.3 Differential Diagnosis

Other medical conditions that have similar symptoms can confuse the diagnosis. Diseases that should have separate diagnosis are;

1) Building related illness.

Symptoms are similar to those of building syndrome, however the difference between the two is the ability to explain the causes of symptoms. Details of the differences are listed in table 2.7 below.

Table 2.7 Differences Between Building Related Illness and Sick Building Syndrome

Differences	Building Related Illness	Sick Building Syndrome
Symptom Period	both sudden and chronic	Mostly chronic
Clinical symptom	Similar	Different
Symptom	Infection, immune system disease Allergy, Asthma, toxin	Symptoms are not specific
Physical check up	symptoms follow its disease	No abnormality
Lab examination	abnormal	Not helpful in diagnosis
Cause of symptom	from single factor	Unknown from various factors
Frequency of the occurrence	rarely found	generally found
Symptom when leave buildings	takes time till the symptoms disappear	take shorter time

Source: www.home-air-purifier-expert.com/sick-building-syndrome.html, 2006.

2) Mass Psychogenic illness.

There are many symptoms of mass psychogenic but the significant ones are those of the nervous system. The most common symptom is similar to Hyperventilation i.e. tight chest, breathlessness, dizziness, weakness and others. This is more common in females than males and in teenagers and young adults. It frequently occurs in closed communities and is spread to many after first being exhibited by one individual. Stress appears to be an important influencing factor. This is different from patients of building symptoms because the symptoms of mass psychogenic illness remain even after patients have left the building.

3) Multiple chemical sensitivity

Multiple chemical sensitivity is a symptom that happens after one or several exposures to chemical substances which have made the individual susceptible to further chemical exposure. The symptoms appear suddenly when exposed to chemical substances such as products from petroleum oil, perfumes or other substances used inside buildings. Symptoms of multiple chemical sensitivity can be exhibited in many forms such as headache and weakness. Symptoms can also be found in the upper and lower respiratory track followed by skin symptoms and heart symptoms. These symptoms become chronic or appear together with hyperventilation.

2.6 Related Research

2.6.1 Domestic Study

A study of the relationship between indoor air pollution and symptoms which occur due to working inside buildings. The study produced figures for some symptoms as follows; headache 63.1%, stuffed nose 59.34%, cold 58.36%, eyes irritation 58.03%, throat irritation 48.83% and skin irritation 42.30%. From these figures, it was found that there was a relationship between eye and nose irritation and the density of dust found in the air. Headache was related to the concentration of carbon monoxide and carbon dioxide gas in the air while throat irritation is related to bacterial infection. From the study, it was observed that contaminant substances, disease, dust particles and gases inside building are factors which cause sickness in those patients (Sasithorn Narongsak, 1993:40–51).

Akarat Srion studied the mitigation of indoor air pollution by using fiber glass coated with titanium dioxide. The objective of his study was to reduce indoor air pollution by using the treatment process called Photocatalytic Oxidation. He mixed Titanium powder with Rasin. An air purifier was also used in this study. It was composed of fiber glass coated with a reactor which was UVC tube at wavelength 254 nanometer. There were a total of 4 tubes and an air fan blew air into the purifier. This study found that the Titanium powder can spread out steadily and throughout the fiber glass at the proportion of 5g:200 between Titanium and Rasin. Using an Energy Dispersive X-Ray Fluorescence Spectrometer, EDX at 2000 times magnification to see the results. It was found that the proportion of 5g:200ml between Titanium dioxide and Rasin, was the best for the treatment of carbon monoxide which was 7.95$\pm$0.7 % within 120 min., Brightness 0.89 mW/cm^2 at starting density 100 ppm. It is found that the proportions of titanium dioxide able to treat carbon monoxide gas at a concentration of 100 ppm was 25g/m^2 and 35 g/m^2, which is similar in terms of the treatment 82$\pm$1.4% and 84.5$\pm$0.7% accordingly, within 120 min at brightness equal to 0.89 mW/cm^2 (Akarat Srion, 2008:12-20).

Next experiment was chemical kinetics treatment of Carbon monoxide Gas in simulator by air-con. It is found that at low concentrations of carbon monoxide gas there was only a small reduction. Increasing the concentration of carbon monoxide to 50, 100 and 200ppm yielded results of 82$\pm$1.4%, 85$\pm$2.1% and 88$\pm$1.4% respectively within 120 min at a brightness level of 0.89 mW/cm$^{2.}$. Concentrated bright light has ability to treat Carbon Monoxide Gas at about 72-88% within 120 min at a concentration of 200 ppm.

The Chemical Kinetics study under various conditions for the carbon monoxide treatment of smoke fumes found that Chemical Kinetics for the treatment of Carbon monoxide Gas is the best treatment. In the study of the efficiency of Chemical Kinetics for the treatment of all Volatile Organic Compounds by the using an air purifier, it was found that there is a similar result at concentration of 80, 100 and 150 ppm, at treatment efficiency 89$\pm$0.5% , 86$\pm$1.0% and 82$\pm$0.2% accordingly within 150 min, brightness 0.89 mW/cm$^{2.}$ From this study also, it is found that the best reaction and pictures of microscopic structure by scanning electron microscopy, SEM revealed that after the treatments, there were some change in the condition of

Rasin used to coat the glass fiber. A possible cause may be the heat from UV. The work to increase efficiency of the treatment should continue.

Nuttapong Taphan studied whether the design of office buildings has any impact on indoor air quality and the incidence of cancer. The tool used in this study was Computational Fluid Dynamics: (CFD). The main objective of this study was to investigate specifically office buildings which use air conditioning with a central air supply system, in which cold air and reabsorbed the air are distributed through ceiling ducts. The success indicator in the study was sufficiency of air ventilation in relation to accumulation and position of concentrations of carbon dioxide gas (CO_2). The maximum acceptable concentration was 800 ppm. The study compared the positions where carbon monoxide concentrations of over 800 ppm accumulated within office buildings of different design. The study found that:

1) There is no difference in the ability of middle and side core air ventilation systems to reduce carbon dioxide.

2) Offices with open areas should select office desk sets with a zone partition of 1.5 meters. This separation best supports the ventilation system. Alternatively, a zone partition of 1.2 meters was the next best spacing. It was also found that physical office partitions obstruct the intended direction of the air flow.

3) A ventilation rate of 20 sq.ft./min/person as per the ASHRAE standard and as required by Bangkok city regulations may not be sufficient.

Therefore, the introduction of air from outside the building and increased air velocity should be considered in order to balance air supply with the requirements of occupants.

4) The air change rate of 7 times a room’s capacity/hour required by Bangkok city regulations may not adequately ventilate office buildings due to the stability of the combination of new and old air. It was also suggested that a rate of change of 10 times per hour may not be sufficient.

5) Increasing the number of air nozzles may help to improve ventilation as this increases the diffusion of air.

The study gave guidelines for the design of office walls, furniture and ventilation systems which could mitigate issues with ventilation systems. It also suggested that the integration of architectural design, engineering design and interior design may

improve the effectiveness overall design to mitigate interior air problems (Nuttapong Taphan, 2005:14-20).

Daranee Jareemit investigated ways in which design and management of office buildings could reduce air borne infection. The objectives of this study were to learn about the risk of infection from indoor air and to find ways to prevent infection. The study was divided into two parts. The first part of the study considered the collection of data relating to building design and management. The second part modeled air flow using Computational Fluid Dynamics (CFD), a method of calculating the flow of fluids (Daranee Jareemit, 2003:23-42).

Studies of relevant theory and literature suggest that characteristics of air such as temperature, humidity and movement may promote the accumulation of disease causing bacteria. Temperatures in the range 23-26 Celsius with relative humidity in the range 35-55 help to prevent disease by not promoting the growth of disease causing bacteria. However, experiments on the design of double ventilation systems used temperatures of 20-23 Celsius with relative humidity 50-70. The double ventilation system was comprised Mixing Ventilation Systems and Displacement Ventilation systems. The study investigated the effects of indoor airflow on 3 risk factors; the accumulation of the diseases, how people get disease and the spread of air borne diseases.

The study found that Displacement Ventilation systems are safer than Mixing Ventilation systems as they make available fewer accumulation areas for disease. It also found that good building management, such as regular cleaning, is an important factor mitigating the occurrence of disease.

This study investigated the concentrations of volatile organic compounds like Benzyl, Toluene, Ethylbenzene and Isomer of Xylene which are released from paint and gypsum boards and suggested methods for the reduction of these concentrations by use of Homalomena, Rubescens, Kunth and Thai Deli (Jiratha Boonprakob, 2008:31-42).

The experiment was divided into 2 steps. The first concentrated on the study of the releasing ratio of volatile organic compounds and the second step concentrated on the reduction of those volatile organic compounds by using ornamental plants like Homalomena Rubescens Kunth and Thai Deli. The study used a measurement tool called Gasmet DX-4015 FTIR.

It was found that only Benzyl with concentrations over 0.5 ppm amongst the other volatile organic compounds had an acceptable concentration while the concentrations of 1) Toluene, 2) Ethylbenzene, 3) Meta-Xylene and 4) Para-Xylene were not harmful to human health if found in proportions lower than 1) 50 ppm, 2) 100 ppm, 3) 100 ppm and 4) 100 ppm respectively.

The second experiment found that Homalomena, Rubescens, Kunth and Thai Deli help to reduce the amount of volatile organic compounds particularly the concentration of Toluene. Although these plants did not reduce the concentration of Benzyl it was suggested that increasing the number of plants may maintain the concentration of Benzyl at an acceptable level.

This research concluded that the use of Homalomena, Rubescens, Kunth and Thai Deli may be useful in the control of volatile organic compounds in buildings which have a limited level of ventilation.

Pairat Chukritanaset investigated the regulations related to the control and management of air inside office buildings. The objective of this study was to identify obstacles to effective regulation and problems encountered by agencies enforcing regulations (Pairat Chukritanaset, 2009:23-32).

The study found that Thailand had no effective regulation to control and manage air quality within office buildings and those regulations which have been adopted are not sufficient. In British Columbia, Canada there is specific regulation to control and manage indoor air quality within The Occupational Health and Safety Regulation (The OHS Regulation) which concentrates on safety and occupational health. This regulation is regulated by the authority of The Workers Compensation Act. In Singapore, where the climate is similar to Thailand, there was no specific regulation for the control of indoor air quality, however Guidelines for Good Indoor Air Quality in Office Premises were an attempt to manage the problem without legislation.

Pairat Chukritanaset suggested that there should be specific regulation used to control and manage indoor air quality under Ministry Law section 103 of Labor Protection Acts 1971 B.E together with Cabinet agreement. The regulations should embrace the aspects listed below:

1) Standard measurement of indoor air quality

2) Measures to resolve problems when air quality fails to meet regulated standards

3) Prohibition of smoking in all workplaces.

4) Standard measurement of air ventilation systems.

5) Regulation requiring the inspection and maintenance of ventilation systems and the cleaning of workplaces.

6) Standard measurement to protect office users and tenants.

Moreover, there should be one main agency responsible for coordination of these matters such as the Department of Labor protection and welfare which is an agency under Labor Protection Acts 1971 (Pairat Chukritanaset, 2009:23-32).

2.6.2 Studies from overseas

Bachmann and Meyer studied the experience of sick office syndrome in three buildings. They found relationships which are relevant to the symptoms in an environment of open offices containing 624 staff. The objective of the study was to compare office symptoms and office characteristics between the three office buildings, and their responses to the occurrence of office syndrome. The researcher used quantitative research with a Cross Section survey of a group of building users. Questionnaires were a tool used for data collection in this study which participants were asked to complete during working hours. Data was be collected after their work. The questionnaires asked questions regarding; work environment, Psychology details, question about work and symptoms. The questions, however, focused on Psychological symptoms which refer to the conditions of mind and emotions such as; concerns, aggressiveness, sadness, anger, fear of dark, claustrophobia, boredom and lack of concentration. Questions that were relevant to work were; whether there was enough time for work, resting time, working hours and skill of the individual including interest on their job, reward and satisfaction (Bachmann, M. and Meyers, J., 1995: 245–251).

The study found that most Swedes had a high tendency to occurrence of symptoms. Symptoms reported from the three buildings were similar, however, they

differed at the point that the workers thought that the building that they are working in was the cause of illness which is not correct. This suggests that the mind has an impact on the occurrence of an individual's illness.

Reverente studied indoor air quality in buildings in Manila. Questionnaires were used to gather data and the responders were Physicians in Manila, The Philippines. The study showed that air conditioning is used extensively in Manila, as is insect fumigation in office buildings. However, it is remarkable that the complaints focused on apparently poor ventilation systems rather than on smoking. This suggested that sufficient ventilation and increasing of air flow are important factors in the occurrence of office syndrome within air-conditioned offices. Further research should consider on amount of insecticide used in buildings as well as solutions used to clean carpets (Reverente, B., Jr., 1993: 117–120).

Chiang and Lai had studied indicators of indoor environment that are relevant to building users and the measurement of the indoor environment. To ensure that evaluation procedures were appropriate for each building, he had designed a standard indicator which could be used to assess results from review of the relevant literature. The researcher considered and divided the indicator into several groups such as noise, vibration, comfortable environment, indoor air quality, water quality, having green areas and the occurrence of the magnetic field (Chiang, C. M. and Lai, C. M., 2002: 87–92).

Lee and Chan studied data on the quality of both indoor and outdoor air in order to learn about and analyze levels of pollution in the air as well as the relationship between the occurrence of illnesses from different indoor activities and variables in the Jimsajui area where there is dense traffic and in the Satin area where there is low traffic density and small factories located at its outskirts (Lee, S. C. and Chan, L. Y., 1998: 29 – 37).

The researcher collected samples of pollution in the air form residential buildings, in living room and corridor areas and at different times which are morning and evening of each day of the week. They analyzed samples to find the concentration of each substance. Results indicated that the concentration of pollution in the air in Jimsajui and in Satin were not over the standard specified by ASHRAE (American Society of health, Refrigerating and Air Conditioning Engineers) and National

Ambient Air Quality Standard (NAAQS). The findings of polluted air in the 2 areas (P-Value <0.05) were as follows;

1) The concentration of pollution of all types in the air of the Jimsajui area is more than in the Satin area except for the concentration level of ozone whixh was higher in Satin than in Jimsajui. However, in both areas, it was found that concentrations of indoor Carbon dioxide were higher than outside.

2) The majority of people from both groups 1 & 2 who reside in Jimsajui tend to have illness more than those who live in the Satin area. Those illnesses found were specifically dry throat and sneezing. It was found that smokers from group 1 & 2 who lived in Jimsajui area were not different from those who lived in the Satin area. However, there was a high incidence of sinusitis and irritation of the respiratory system in people who lived in Satin. This was concentrated in smoking families rather than non-smoking families.

3) The frequency of cooking that is more than 1 time per day in group 1 of both Jimsajui and Satin areas. It was found that they have symptoms such as coughing, stuffed nose and runny nose. This is an important clue in the statistics as tenant who use air purifiers tend to be ill more than those who do not.

4) There is an important clue in the statistics which suggest that tenants in the Jimsajui area who uses incense, candles and mosquito-repellent have illness more than those at Satin. Results of the study also suggested that the incidence of illness increased when the frequency of lighting up incense, candles and mosquito-repellent, increased by more than 50% per day. The illness found were coughing, sneezing, stuffed nose, runny nose (P-Value < 0.05)

5) Tenants who used less of air purifier had less illness. This can be explained because people purchased air purifiers after their health problems started.

A study by Lagoudi suggested that building users are concerned about symptoms of any illness which has an impact on health. This research relied upon symptom experience as an indicator of building users opinions of their environment. This was used for an evaluation of indoor air quality following standards of European Concerted Action Indoor Air Quality and its Impact on Man in six office buildings. The researcher investigated environmental detail in each building in such as smell, measurement of ventilation, indoor pollution and data on energy consumption (Lagoudi, A. et al., 1996:237–243).

The study found that building users acknowledge that symptoms were caused by high buildings. Further investigation into energy use in those buildings, found that the total energy use was 553MJ/Sq.m comprising 309 MJ/Sq.m for the use of electricity, and 250/Sq.m in average use of petrol. This is low when compared to office buildings in Europe where total use of energy is 1,100MJ/Sq.m, 540/Sq.m used of electricity and 570MJ/Sq.m for the use of petrol. It was found that increased use of energy was related to increased incidence of symptoms. However, it is clear that modern office buildings have high energy consumption average about 570 MJ/Sq.m.

Haghighat and Donnini studied the impacts on Social Psychology of perceptions of indoor air quality within twelve buildings in order to find user's satisfaction with their environment and to study the relationship between satisfaction of the user with the environment and physical and social factors. The researchers studied buildings that were built in the period 1945-1992 and the use various systems on those buildings:- heat systems, air conditioning and ventilation (HVAC) type Fee Cooling, CAV – Double Duct VAV. They specified 40 survey locations classifying building types i.e. 50% of close offices where outsiders are not allowed to enter and 50% of open office where outsiders are allowed entry. Offices, survey locations, in the core of buildings were distinguished from survey locations on the periphery of buildings. Data on the physical environment was collected during the survey. The survey result of the moving environment measure the chemical composition of the air; concentration of total volatile organic compounds, TVOC, Formaldehyde, carbon dioxide and carbon monoxide, air temperature, dew point temperature, air pressure, average air temperature using globe temperature, wind speed and wind turbulence at air supply channel and suction channel, brightness, concentration of carbon monoxide gas, carbon dioxide gas and formaldehyde etc. Energy used by each building was also noted to compare with ASHRAE standard 62-89R. (Ventilation for Acceptable Indoor Air Quality Atlanta: American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. USA.)

The researchers also used questionnaires to obtain data from building users. The result reveals that levels of formaldyhide and total volatile organic compounds were outside the comfort zone (Haghighat, F. and Donnini, G., 1999:479-503).

The statistics of total acceptance of indoor air quality by building users, suggested that there was only 27% acceptance during winter and 63% acceptance

during the summer with 56% accepted in total. These figures are lower than standard ANSI and ASHRAE Standard 55-1992. They found that the opinions of some occupants regarding the condition of a building determined their opinions of air quality in that building regardless of measured air quality. Their perceptions could be sufficiently strong that they could cause symptoms of illnesses. However, the relationship between occupant satisfaction with their work and indoor air quality was positive. Building users prefer air movement within the building without being concerned with how much it should be.

A cross section study into ventilation systems, air quality and incidence of disease within newly built buildings in Paris investigated the impact which indoor air quality may have on health within buildings with different ventilation systems and the impact on health of air contamination and allergies during autumn. He randomly selected 139 offices. The first office used heating, ventilating, and air-conditioning systems. The second building used a Fan Coil Unit air conditioning system and the third building used a natural air ventilation system. From those three buildings there was never a complaint from building users about health (Vincent, D. et al., 1997: 100 – 112).

The study used observation methods to collect data regarding indoor air condition and health. At the same time it employed a method known as study by controlling whereby different types of ventilation system were compared over the same period of time. It used questionnaires to gather information about general symptoms and also used indoor environment measurements, IEMs, to measure the indoor environment.

In terms of analyzing problems, the researcher studied the sample group to find relationships between 1) health and ventilation systems, 2) ventilation systems and the measurement of indoor environment as well as 3) indoor environment and health. It found that HVAC and Fan Coil Unit ventilation systems raised the occurrence of illness when compare to natural ventilation systems. Symptom included irritation of throat, stuffed nose while waking up, migraine and coughing due to low temperature.

2.7 Terms and Definitions Used in This Study

1) Sick Building Syndrome: meaning an abnormal health condition which may exhibit eye symptoms, nose symptoms, throat symptoms, respiratory symptoms, nervous system symptoms and skin symptoms in those who work inside office buildings, specifically excluding factory buildings and residential buildings. The symptoms are exhibited during periods when patients were inside the office building, and specific causes of the symptoms cannot be specified. These symptom have no specific character. The symptoms normally disappear after finish working or when people leave the building.

2) Population who work inside office buildings: meaning those who permanently work inside the office buildings being studied.

3) High building: meaning buildings, or any construction or parts of buildings, with a shared area or shared floor area of over 10,000 sq.m. and which are higher than 23 m.

4) Total Volatile Organic Compound: TVOC meaning the total amount of volatile organic compounds that are measured.

5) Volatile Organic Compound: VOC meaning volatile organic compound that can evaporate at room temperature and at room air pressure. These substances are contained in areas of polluted air and in products used inside office buildings such as carpets, curtains, and constructing equipment like plywood.

6) Indoor Air Quality: meaning the quality of air inside office buildings which can be specified by the study and evaluated, as well as the amount of physical environment, chemical environment and biological environment.

2.8 Research Concept

From literature review above, the researcher proposes the research concept as shown in Conceptual Framework below, comprising variables affecting on the health occupants of buildings in Bangkok Metropolis as follows:

Independent Variables consist of;

1) Personal characteristics are gender, age, education level, marital status, income, working days per week and working hours per day.

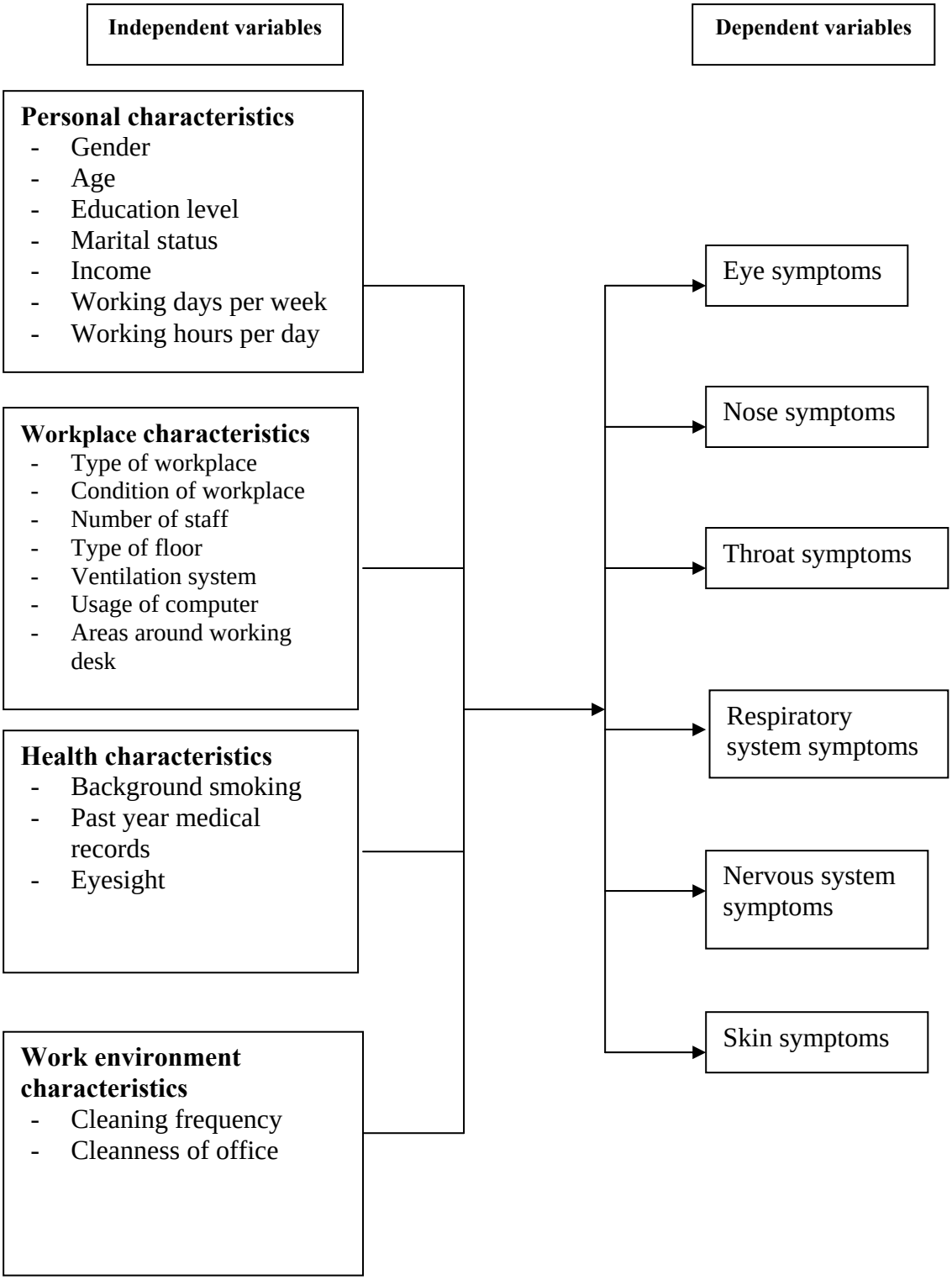
2) Workplace characteristics are type of workplace, condition of workplace, number of staff, type of floor, ventilation system, usage of computer and areas around working desk.

3) Health characteristics are background smoking, past year medical records and eyesight.

4) Work environment characteristics are cleaning frequency and cleanness of office.

Dependent Variables consist of Eye symptoms, Nose symptoms, Throat symptoms, Respiratory system symptoms, Nervous system symptoms and Skin symptoms.

Conceptual Framework



CHAPTER 3

METHODOLOGY

This chapter will explain in detail the methodology used in the study which consists of research design, sources and types of data, sampling methods, variables in the study, construction of questionnaires, level of measurement, field procedures, data processing and data analysis techniques.

3.1 Research Design

This is a quantitative study of the impact of indoor air pollution on Bangkok Metropolis' population, using questionnaires as a tool for collecting data from population aged 20-60 years old who work in six main areas of Bangkok Metropolis which are crowded with office buildings as follows:- Sathon District, Pathum Wan District, Huai Khwang District, Din Daeng District, Bang Kapi District, and Chatuchak District.

3.2 Sources and Types of Data

Both Primary and Secondary Data are used in this study. Primary data are collected from occupants of office building within the six crowded areas given above in 3.1. Secondary data are paperwork, published research and theses from both the state and private sectors.

3.3 Sampling Method

This study is a quantitative research. Using questionnaires to collect data as well as interviewing a sample of the Bangkok Metropolis population aged between 20-60 years old.

3.3.1 Target Population

The population living in Bangkok Metropolis who are between 20 – 60 years old, both male and female, total 5,710,883 (Department of Province Administration, 2008).

3.3.2 Sampling Techniques and the Sample Size

The samples are selected from the population by using Quota Sampling amongst a population with age between 20-60 years old who resides in Bangkok Metropolis which is detailed as follows:

Step 1 Consider each district in Bangkok Metropolis which has the highest number of office buildings. Six districts are selected:- Sathon District, Pathum Wan District, Huai Khwang District, Din Daeng District, Bang Kapi District, and Chatuchak District.

Step 2 From each district, the most crowded office building which is higher than 23 floors and is selected as follows:-

District	Selected Building
Sathon	Empire Tower
Pathum Wan	Sinthon Tower
Huai Khwang	Muang Thai Patara Complex Building
Din Daeng	RS Tower
Bang Kapi	The Mall, Bang Kapi
Chatuchak	Siam Cement Tower

Step 3 From each selected building, both male and female staff from each floor will be selected through quota sampling in a balanced proportion up to the target number. Selected staff should be in the age range of 20-60 years old.

The sample sizes are calculated by using Yamane' s formula (Yamane, 1967: 886) :

$$n = \frac{N}{1 + Ne^2}$$

when n = Sample Size

N = Population size =5,710,883

e = Error of random sampling = 5%

$$n = \frac{5{,}710{,}883}{1 + 5{,}710{,}883(0.05)^2}$$

= 400

The sample size for this research is 396 cases which can be distributed to these 6 representative buildings and comprises 66 cases from each building. Data are collected by using questionnaires from the target population which is both male and female. The probability of selection in each district is equal.

3.4 Data Collection

The primary data used in this study are collected from questionnaires completed by 396 cases during November 2009 – January 2010.

3.5 Variables Used in the Study

By reviewing literature, articles and annual reports as well as related research in order to establish the concept and outline used to analyze personal characteristics, workplace characteristics, health characteristics and work environment characteristics as independent variables and 6 symptoms caused by indoor air pollution as dependent variables.

Variables have been selected which have been researched in the past and which have a relationship with symptoms of polluted office environments. Independent variables that are used in this study are personal characteristics, workplace characteristics, health characteristics and work environment characteristics. Dependent variables which are used are 6 symptoms of office pollution. Details of the variables are given below;

3.5.1 Independent Variables

1) Personal characteristics
   (1) Gender

(2) Age
(3) Education level
(4) Marital status
(5) Income
(6) Working days per week
(7) Working hours per day

2) Workplace characteristics
(1) Type of workplace
(2) Condition of workplace
(3) Number of staff
(4) Type of floor
(5) Ventilation system
(6) Usage of computer
(7) Areas around working desk

3) Health characteristics
(1) Background smoking
(2) Past year medical records
(3) Eyesight

4) Work environment characteristics
(1) Cleaning frequency
(2) Cleanness of office

3.5.2 Dependent Variables

The occurrence of 6 types of symptoms

1) Eyes symptoms
2) Nose symptoms
3) Throat symptoms
4) Respiratory system symptoms
5) Nervous system symptoms
6) Skin symptoms

Variables used in the study consist of 6 dependent variables, and 19 independent variables as shown in table 3.1

Table 3.1 Variables and Measurement Criteria Used in the Study.

Variables	Measurement Criteria
Dependent Variables:	
Occurrence of 6 types of symptoms	1= Have symptoms (choose 1 or 2 or 3)
(0-3 = Frequency of occurrence)	0= Not have symptoms (choose 0)
Independent Variables:	
1. Gender	
	1= Male
	0= Female
2. Age	Use real records(years).
3. Education level	1= No education
	2= Lower than elementary education
	3= Elementary education
	4= Junior high school
	5= High school
	6= Diploma or certificate
	7= Bachelor's degree
	8= Higher than bachelor's degree
	0= Others
4. Marital status	1= Single
	2= Married
	0= Others
5 . Income	1= Lower than 10,000
	2= 10,001 – 20,000
	3= 20,001 – 30,000
	4= 30,001 – 40,000
	0= Above 40,000
6. Working days per week	Use real records(days)
7. Working hours per day	Use real records(hours)

Table 3.1 (Continue)

Variables	Measurement Criteria
8. Type of workplace	1= Office building
	2= Department store
	3= Educational institute
	4= Clinical building
	5= Factory building
	6= Residential building
	7= Government office
	0= Others
9. Condition of workplace	1= Private room
	2= Shared private room
	3= Shared room with partitions
	4= Shared room without partitions
	0= Others
10. Number of staff	1= 1 person
	2= 2 – 3 persons
	3= 4 – 7 persons
	0= 8 Persons and above
11. Type of floor	1= Carpet
	2= Wood
	3= Tile
	4= Rubber
	0= Others
12. Ventilation system	1= Separate air condition
	2= Central air condition
	3= Fan
	0= Others
13. Usage of computer	1= Use
	0= Not use

Table 3.1 (Continue)

Variables	Measurement Criteria
14. Areas around working desk	Use real records.
(0-4 = Frequency of usability	This variable use numbering in Likert scale
the office apparatus)	as follows;
-Usage of copy machine	1= Less than 3 times per week
	2= 3 - 4 times per week
	3= Once a day
	4= Many times per day
	0= Do not use
-Usage of mimeograph	1= Less than 3 times per week
	2= 3 - 4 times per week
	3= Once a day
	4= Many times per day
	0= Do not use
- Usage of printer	1= Less than 3 times per week
	2= 3 - 4 times per week
	3= Once a day
	4= Many times per day
	0= Do not use
-Usage of fax machine	1= Less than 3 times per week
	2= 3 - 4 times per week
	3= Once a day
	4= Many times per day
	0= Do not use
-Usage of carbon paper	1= Less than 3 times per week
	2= 3 - 4 times per week
	3= Once a day
	4= Many times per day
	0= Do not use

Table 3.1 (Continue)

Variables	Measurement Criteria
-Usage of correction liquid	1= Less than 3 times per week 2= 3 - 4 times per week 3= Once a day 4= Many times per day 0= Do not use
-Usage of glue	1= Less than 3 times per week 2= 3 - 4 times per week 3= Once a day 4= Many times per day 0= Do not use
- Usage of liquid cleaner	1= Less than 3 times per week 2= 3 - 4 times per week 3= Once a day 4= Many times per day 0= Do not use
- Equipment of chemical odor	1= Less than 3 times per week 2= 3 - 4 times per week 3= Once a day 4= Many times per day 0= Do not use
15. Background smoking	Use real records. This variable use numbering in Likert scale as follows; 1= Used to smoke but stopped 2= Still smoking 0= Never smoked
16. Past year medical records -Sickness in last year	1= Have 0= Not have

Table 3.1 (Continue)

Variables	Measurement Criteria
-Allergy history	1= Have
	0= Not have
-Sinusitis history	1= Have
	0= Not have
-Asthma history	1= Have
	0= Not have
-Migraine history	1= Have
	0= Not have
-Skin infected history	1= Have
	0= Not have
-Respiratory disease history	1= Have
	0= Not have
-Other Chronic illness history	1= Have
	0= Not have
17. Eyesight	1= Unknown
	2= Normal
	3= Short eye-sighted
	4= Long eye-sighted
	5= Astigmatism
	0= Other eye disease
18. Cleaning frequency	Use real records. This variable use numbering in Likert scale as follows;
	1= 1 time per month
	2= 1 time per week
	3= Almost everyday
	4= Everyday
	0= Never

Table 3.1 (Continue)

Variables	Measurement Criteria
19. Cleanness of office	Use real records. This variable use numbering in Likert scale as follows; 1= Quite dirty 2= Sometimes dirty, sometimes clean 3= Quite clean 4= Very clean 0= Very dirty

3.6 Level of Measurement

Table 3.2 Description and Levels of Variable Measurement Used in the Study

Variables	Measurement
1. Dependent Variables	
The occurrence of 6 types of symptoms	
1) Eyes symptoms	Nominal scale
2) Nose symptoms	Nominal scale
3) Throat symptoms	Nominal scale
4) Respiratory system symptoms	Nominal scale
5) Nervous system symptoms	Nominal scale
6) Skin symptoms	Nominal scale
2. Independent Variables	
1) Personal characteristics	
(1) Gender	Nominal scale
(2) Age	Ratio scale
(3) Education level	Ordinal scale
(4) Marital status	Nominal scale
(5) Income	Interval scale

Table 3.2 (Continue)

Variables	Measurement
(6) Working days per week	Ratio scale
(7) Working hours per day	Ratio scale
2) Workplace characteristics	
(1) Type of workplace	Nominal scale
(2) Condition of workplace	Nominal scale
(3) Number of staff	Interval scale
(4) Type of floor	Nominal scale
(5) Ventilation system	Nominal scale
(6) Usage of computer	Nominal scale
(7) Areas around working desk	Ordinal scale
3) Health characteristics	
(1) Background smoking	Ordinal scale
(2) Past year medical records	Nominal scale
(3) Eyesight	Nominal scale
4) Work environment characteristics	
(1) Cleaning frequency	Ordinal scale
(2) Cleanness of office	Ordinal scale

3.7 Research Instruments

Two types of tools were used in gathering data for this study. The tool was a questionnaire which collected both qualitative and quantitative data. The questionnaire was divided into 5 parts which are:

Part 1 Personal characteristics such as Gender, Age, Education level, Marital status, Income, Working days per week and Working hours per day.

Part 2 Workplace characteristics such as Type of workplace, Condition of workplace, Number of staff, Type of floor, Ventilation system, Usage of computer and Areas around working desk.

Part 3 Health characteristics such as Background smoking, Past year medical records and Eyesight.

Part 4 Work environment characteristics such as Cleaning frequency and . Cleanness of office.

Part 5 The occurrence of 6 types of symptoms such as Eyes symptoms, Nose symptoms, Throat symptoms, Respiratory system symptoms, Nervous system symptoms and Skin symptoms

Secondary data were gathered when the researcher was on site. Whilst using questionnaires to obtain data, pictures of each workplace were taken as supporting evidence in this research.

3.8 Data Analysis Techniques

The gathering of field data by using questionnaire with 396 cases that work in Bangkok Metropolis office buildings were undertaken over a period of four months.

Computers were used to process statistics and to check the accuracy of analysis and test hypotheses and other matters relating to this study. Procedures used to analyze data for this study were as follows;

3.8.1 Descriptive Analysis

Analysis of collected data provided values by frequency, percentage, average and standard deviation in order to explain the general condition of Personal characteristics, Workplace characteristics, Health characteristics and Work environment characteristics including the occurrence of 6 types of symptoms of people who work inside office buildings in Bangkok Metropolis.

3.8.2 Analysis of Relationships between Independent and Dependent Variables

Analysis of Relationships between Personal characteristics, Workplace characteristics, Health characteristics and Work environment characteristics including the occurrence of 6 types of symptoms which are eye symptoms, nose symptoms, throat symptoms, respiratory system symptoms, nervous system symptoms and skin

symptoms. Data collected by questionnaire were taken for analysis of characteristic of variables. Analysis of primary data used statistical analysis, of percentage and frequency values. Analysis of relationships between variables in this study employed Logistic Regression Analysis which analyzed the characteristics which influence the occurrence of the six groups of symptoms in the Bangkok Metropolis office population. Consideration of how independent variables related to dependent variable used the following measures: Nagelkerke R. Square and Odds Ratio.

Logistic regression Analysis was used as a statistical tool to analyze characteristics which produce symptoms in population who work inside office building in Bangkok Metropolis. This type of analysis was used to help find relationships of independent variables (Personal characteristics, Workplace characteristics, Health characteristics and Work environment characteristics) and dependent variables (data in respect of symptoms for those who work inside office buildings in Bangkok Metropolis). This method was also used to check the strength of relationships between independent and dependent variables and the result of the study revealed;

1) Size of influence an independent variable has on dependent variable and

2) Relationship model between independent and dependent variables.

CHAPTER 4

ANALYSIS OF RESULTS

This analysis of the effects of indoor air pollution on the health of Bangkok Metropolis' population has been based on data collected from cases of the population. The data are described and analyzed below;

4.1 Personal characteristics

4.2 Workplace characteristics

4.3 Health characteristics

4.4 Work Environment characteristics

4.5 Frequency of the occurrence of 6 types of symptoms

4.6 Correlation between variables

4.7 Relationship between 4 relating characteristics and 6 types of symptoms

4.1 Personal Characteristics

Data were collected from 396 individuals sampled within the following six Bangkok districts which had a large number of office buildings: Sathon District, Pathum Wan District, Huai Khwang District, Din Daeng District, Bang Kapi District, and Chatuchak District. The personal characteristics revealed are presented in Table 4.1

Table 4.1 Overall Personal Characteristics of 396 Cases

Characteristics	Number	Percentage
Gender (N=396)		
Female	248	**62.60**
Male	148	37.40

Table 4.1 (Continued)

Characteristics	Number	Percentage
Age (N=396)		
0 – 25	59	14.90
26 – 35	198	**50.00**
36 – 45	98	24.75
46 – 55	32	8.08
56 – 65	9	2.27
Education level (N=396)		
No education	7	1.70
Lower than elementary education	9	2.30
Elementary education	3	0.80
Junior high school	30	7.60
High school	7	1.80
Diploma or certificate	252	**63.60**
Bachelor's degree	84	21.20
Higher than bachelor's degree	4	1.00
Others	0	0.00
Marital status (N=396)		
Single	260	**65.70**
Married	133	33.60
Others	3	0.70
Income (N=396)		
Lower than 10,000	45	11.40
10,001 – 20,000	146	**36.90**
20,001 – 30,000	85	21.50
30,001 – 40,000	53	13.30
Above 40,000	67	16.90
Working days per week (N=396)		
1	1	0.30
2	2	0.50

Table 4.1 (Continued)

Characteristics	Number	Percentage
3	11	2.80
4	6	1.50
5	318	**80.30**
6	50	12.60
7	8	2.00
Working hours per day (N=396)		
1	1	0.30
2	2	0.50
3	5	1.30
4	1	0.30
5	22	5.50
6	12	3.00
7	22	5.50
8	215	**54.30**
9	53	13.40
10	52	13.10
11	3	0.80
12	8	2.00

Of the 396 cases 62.60% were female and 37.40% were male. Most, 65.70%, of the population was single and only 33.60% that were married. Half were aged between 26-35 years old and almost a quarter were 36-45 years old. Over a third of the cases had monthly income between 10,001-20,000 baht and more than a fifth had an income between 20,001-30,000 baht. Another fifth earned more than 40,000 baht per month and a little over ten percent earned less than 10,000 baht per month. The cases revealed a highly educated population. Nearly two thirds had attained diploma or certificate. Four fifths of the cases worked 5 working days per week and an eighth worked 6 days per week. The working day was 8 hours for a little over half of the population with more than an eighth working both 9 hours and 10 hours.

4.2 Workplace Characteristics

Table 4.2 Overall Workplace Characteristics of 396 cases

Characteristics	Number	Percentage
Type of workplace		
Office building	266	**67.20**
Department store	7	1.80
Educational Institute	73	18.40
Clinical building	2	0.50
Factory building	2	0.50
Residential building	38	9.60
Government office	8	2.00
Others	0	0.00
Condition of workplace		
Private room	23	5.80
Shared private room	89	22.50
Shared room with partitions	165	**41.70**
Shared room without partitions	115	29.00
Others	4	1.00
Number of staff		
1 person	26	6.60
2 – 3 persons	83	21.00
4 – 7 persons	134	33.80
8 Persons and above	153	**38.60**
Type of floor		
Carpet	139	**35.10**
Wood	12	3.00
Tile	126	31.80
Rubber	105	26.60
Others	14	3.50

Table 4.2 (Continued)

Characteristics	Number	Percentage
Ventilation system		
Separate air condition	83	21.00
Central air condition	302	**76.30**
Fan	7	1.70
Others	4	1.00
Usage of computer		
Use	340	**85.90**
Not use	56	14.10
Areas around working desk		
-Usage of copy machine		
Less than 3 times per week	37	9.30
3 - 4 times per week	7	1.80
Once a day	15	3.80
Many times per day	103	26.00
Do not use	234	**59.10**
-Usage of mimeograph		
Less than 3 times per week	34	8.50
3 – 4 times per week	7	1.80
Once a day	7	1.80
Many times per day	90	22.70
Do not use	258	**65.20**
-Usage of printer		
Less than 3 times per week	48	12.10
-Usage of fax machine		
Less than 3 times per week	90	22.70
3 - 4 times per week	15	3.80
Once a day	34	8.60
Many times per day	106	26.80
Do not use	151	**38.10**

Table 4.2 (Continued)

Characteristics	Number	Percentage
-Usage of carbon paper		
Less than 3 times per week	37	9.30
3 – 4 times per week	7	1.80
Once a day	15	3.80
Many times per day	103	26.00
Do not use	234	**59.10**
-Usage of correction liquid		
Less than 3 times per week	81	20.50
3 – 4 times per week	28	7.10
Once a day	37	9.30
Many times per day	124	31.30
Do not use	126	**31.80**
-Usage of glue		
Less than 3 times per week	77	19.40
3 – 4 times per week	22	5.60
Once a day	30	7.60
Many times per day	115	29.00
Do not use	152	**38.40**
-Usage of liquid cleaner		
Less than 3 times per week	39	9.80
3 – 4 times per week	25	6.40
Once a day	19	4.80
Many times per day	48	12.10
Do not use	265	**66.90**
-Equipment of chemical odor		
Less than 3 times per week	29	7.30
3 – 4 times per week	23	5.80
Once a day	16	4.00
Many times per day	43	10.90
Do not use	285	**72.00**

More than two thirds of 396 cases worked in office buildings. About 41.70% of overall worked in open plan offices with partitions. Under a third worked private rooms. More than a third, 38.00%, worked with more than 8 colleagues and another third, 33.80%, worked with 3-7 colleagues. Over a third, 35.10%, of the office floors were carpeted and another quarter, 26.50%, had rubber coverings. Three quarters, 76.30%, shared an air condition with only one fifth, 21.00%, having use of a separate air condition. It was found that a large majority, 85.90%, used a computer in the workplace. Half, 50.80%, used a printer more than 3-4 times per week, however a fifth, 19.90%, did not use a printer.

Large proportions of the cases reported that they did not use, and therefore had limited exposure to the effects on health of many items in their offices which may be expected to be associated with some risk to health. The proportions reporting that they did use items were following; copy machine 65.20%, mimeograph 59.10%, fax machine 38.10%, carbon paper 59.10%, correction liquid 31.80%, glue 38.40% and liquid cleaner 66.90%. However, significant proportions used these items intensively, a situation which should not be too surprising given the division of labors and the allocation of duties. These individuals reported that they used items ‘many times per day’ and they had significant exposure to any health risks associated with copy machine 26.00%, mimeograph 22.70%, fax 26.80%, carbon paper 26.00%, liquid corrector 31.30%, glue 29.00%, liquid cleaner 12.10% and equipment having chemical odor 10.90%.

4.3 Health Characteristics

Table 4.3 Overall Health Characteristics of 396 cases

Characteristics	Number	Percentage
Background smoking		
Used to smoke but stopped	19	4.80
Still smoking	14	3.50
Never smoked	363	**91.70**
Past year medical records		
-Sickness in last year		

Table 4.3 (Continued)

Characteristics	Number	Percentage
Not have	208	**52.50**
Have	188	47.50
-Allergy history		
Not have	264	**66.70**
Have	132	33.30
-Sinusitis history		
Not have	333	**84.10**
Have	63	15.90
-Asthma history		
Not have	316	**79.80**
Have	80	20.20
-Migraine history		
Not have	293	**74.00**
Have	103	26.00
-Skin infected history		
Not have	312	**78.80**
Have	84	21.20
-Respiratory disease history		
Not have	351	**88.60**
Have	45	11.40
-Other chronic illness history		
Not have	347	**87.60**
Have	49	12.40
Eyesight		
Unknown	25	6.30
Normal	112	28.30
Short eye-sighted	140	**35.40**
Long eye-sighted	73	18.40
Astigmatism	40	10.10
Other eye disease	6	1.50

The vast majority, 91.70%, of the sampled group were non-smokers. Almost half of the sample reported having been sick in the past year. One third reported having allergies and about half of that number had sinus problems, and one fifth reported having asthma. Only one quarter, 26.00% suffered migraines. Similarly, minorities reported having skin infections 21.00%, respiratory disease 11.00% and other chronic diseases 12.40%. These figures were reminiscent of the minorities reporting that they used potentially risky items many times per day in table 4.3 above. Short eye-sighted afflicted a third 35.40% , with over a quarter having normal eyesight, a fifth were long eye-sighted and 10.00% had astigmatism.

4.4 Work Environment Characteristics

Table 4.4 Overall Work Environment Characteristics of the 396 cases

Work Environment Characteristics	**Number**	**Percentage**
Cleaning frequency		
1 time per month	17	4.3
1 time per week	61	15.4
Almost everyday	73	18.4
Everyday	**175**	**44.2**
Never	70	17.7
Cleanness of office		
Quite dirty	46	11.6
Sometimes dirty, sometimes clean	97	24.5
Quite clean	**146**	**36.9**
Very clean	67	16.9
Very dirty	40	10.1

Almost half, 44.20%, worked in offices which had daily cleaning and almost a fifth, 18.40%, where there were cleaning almost every day cleaning. However, almost one fifth worked where there were no cleaning at all and 4.30% worked in a place with monthly cleaning.

One third 36.90% considered their workplaces to be quite clean. A quarter, 24.50%, thought that their workplaces were sometimes dirty and another 10.10% found that their workplaces were very dirty.

4.5 Frequency of the Occurrence of Disease in the 6 Types of Symptoms

Respondents were asked to report the number of occurrences within the past month of the 6 types of symptoms.

The following categorization was used to classify the levels of sickness;

0 No symptoms

1 Small symptoms (1-3 days per month)

2 Medium symptoms (1-3 days per week)

3 Heavy symptoms (almost every day)

The following categorization was used to explain the levels of sickness;

0 – 0.67	No symptoms
0.68 – 1.35	Small symptoms
1.36 – 2.03	Medium symptoms
>2.04	Heavy symptoms

4.5.1 Eye Symptoms

Table 4.5 Overall Occurrence of Eye Symptoms of 396 cases

Eye Symptoms	Score Range	Number	Percentage	Highest	Lowest	S.D.	Average	Level of Sickness
Irritating eyes	0	143	36.10	3	0	1.022	1.09	Small symptoms
	1	121	30.60					
	2	85	21.50					
	3	47	11.90					
Dry eyes	0	197	49.70	3	0	0.889	0.76	Small symptoms
	1	115	29.00					
	2	66	16.70					
	3	18	4.50					
Weeping eye	0	185	46.70	3	0	1.012	0.92	Small symptoms
	1	94	23.70					
	2	82	20.70					
	3	35	8.80					
Itchy eyes	0	154	38.90	3	0	0.962	0.97	Small symptoms
	1	135	34.10					
	2	72	18.20					
	3	35	8.80					
Red eyes	0	244	61.60	2	0	0.673	0.48	No symptoms
	1	112	28.30					
	2	40	10.10					
Painful eyes	0	193	48.70	3	0	0.887	0.76	Small symptoms
	1	128	32.30					
	2	53	13.40					
	3	22	5.60					

Analysis of data of eye symptoms collected from 396 cases found that a majority had some kind of eye problem. The average suggested that irritated eye symptoms occurred more than 3 days per month but less than 4 and were classified as being a small symptoms while other symptoms like dry eyes, weeping eye, itchy eyes and painful eyes occurred only 1-3 days per month. Based on average of the frequencies of occurrence, the significance of each eye related symptom could be ranked from great to small in the following order; irritating eyes, itchy eyes, weeping eye, dry eyes and painful eyes. Red eyes were ranked on no symptoms as the average is less than 0.67. It was clear from the data that the following environmental variables could be a cause of the occurrence of eye symptoms; frequency of cleaning, health factors including tobacco background smoking, sickness occurred within a year, allergy, Sinus, Asthma, Migraine, Skin infection, respiratory disease history, individual disease and differences in individual's eye conditions.

4.5.2 Nose Symptoms

Table 4.6 Overall Occurrence of Nose Symptoms of 396 cases

Nose Symptoms	Score Range	Number	Percentage	Highest	Lowest	S.D.	Average	Level of Sickness
Irritating nose	0	167	42.17	3	0	1	0.95	Small symptoms
	1	118	29.80					
	2	73	18.43					
	3	38	9.60					
Stuffy nose	0	171	43.2	3	0	0.931	0.85	Small symptoms
	1	147	37.1					
	2	44	11.1					
	3	34	8.6					
Runny nose	0	174	43.94	3	0	0.94	0.87	Small symptoms
	1	130	32.83					
	2	62	15.66					
	3	30	7.58					
Itchy nose	0	191	48.23	3	0	0.88	0.76	Small symptoms
	1	130	32.83					
	2	54	13.64					
	3	21	5.30					
Burning nose	0	226	57.07	3	0	0.81	0.60	No symptoms
	1	118	29.80					
	2	37	9.34					
	3	15	3.79					
Bleeding nose	0	226	69.70	3	0	0.66	0.40	No symptoms
	1	118	20.96					
	2	37	9.09					
	3	15	0.25					

Nose symptoms data collected from 396 cases revealed that about a third of respondents experienced stuffy nose, the most common symptom, 1-3 days per month. Runny nose and itchy nose were close behind with almost a third each 1-3 days per month. A majority experienced symptoms such as irritation, runny nose, and itchy nose of least 1-3 days per month. Based on their average occurrence, nose symptoms occurrence in following order; irritating nose, runny nose, stuffy nose, itchy nose, burning nose and bleeding nose. However, the standard measure of average levels of sickness suggested that the cases had small symptoms because the average level of sickness were between 0.68 and 1.35 except burning nose and bleeding nose that were ranked on no symptoms of the level of sickness.

4.5.3 Throat Symptoms

Table 4.7 Overall Occurrence of Throat Symptoms of the 396 cases

Throat Symptoms	Score Range	Number	Percentage	Highest	Lowest	S.D.	Average	Level of Sickness
Dry throat and thirsty	0	149	37.6	3	0	1.074	1.14	Small symptoms
	1	98	24.7					
	2	94	23.7					
	3	55	13.9					
Painful throat	0	212	53.5	3	0	0.829	0.68	Small symptoms
	1	103	26.0					
	2	75	18.9					
	3	6	1.5					
Irritating throat	0	186	47.00	3	0	0.814	0.74	Small symptoms
	1	135	34.10					
	2	66	16.70					
	3	9	2.30					
Sore throat	0	202	51.0	3	0	0.698	0.61	No symptoms
	1	149	37.60					
	2	43	10.90					
	3	2	0.50					
Swallow difficulty throat	0	233	58.80	3	0	0.755	0.57	No symptoms
	1	105	26.50					
	2	55	13.90					
	3	3	0.80					
Hoarse throat	0	222	56.10	3	0	0.794	0.60	No symptoms
	1	121	30.60					
	2	41	10.40					
	3	12	3.00					

Data collected from 396 cases about throat symptoms revealed that the majority experienced problems with their throat. More than a third experienced dry throat and thirsty more than 3 days per month which were much more often than other symptoms. Almost two thirds (62.00%) experienced dryness at some point each month. Some form of throat symptoms were experienced by over 40.00% at some time each month. The throat symptoms which occurred averagely often could be run in following order; dry throat and thirsty, irritating throat, painful throat, sore throat, hoarse throat, and swallow difficulty throat. However, the average level of sickness of its standard suggested that the symptoms of significance were dry throat and thirsty, painful throat and irritating throat. This was rated ‘small symptoms’ because the average level of sickness were equal to 1.14, 0.68 and 0.74 in order. Factors which cause of throat symptoms were workplaces characteristics, work environment characteristics and personal characteristics.

4.5.4 Respiratory System Symptoms

Table 4.8 Overall Occurrence of Respiratory System Symptoms of 396 cases

Respiratory System Symptoms	Score Range	Number	Percentage	Highest	Lowest	S.D.	Average	Level of Sickness
Tight chest	0	227	57.3	3	0	0.906	0.69	Small symptoms
	1	77	19.4					
	2	78	19.7					
	3	14	3.5					
Breathing difficulty	0	233	58.8	3	0	0.831	0.60	No symptoms
	1	102	25.8					
	2	47	11.9					
	3	14	3.5					
Breathless	0	249	62.9	3	0	0.926	0.63	No symptoms
	1	66	16.7					
	2	35	15.2					
	3	8	5.3					
Cramp at chest	0	257	64.9	3	0	0.741	0.48	No symptoms
	1	96	24.2					
	2	35	8.8					
	3	8	2.0					
Cough	0	213	53.8	3	0	0.921	0.71	Small symptoms
	1	110	27.8					
	2	46	11.6					
	3	27	6.8					
pant	0	261	65.9	3	0	0.794	0.50	No symptoms
	1	86	21.7					
	2	36	9.1					
	3	13	3.3					

Data collected from 396 cases about respiratory system symptoms revealed that the majority experienced respiratory problems. Coughing was the symptoms which occurred most often. Almost half (46.00%) of the total cases had a cough at some point in the month. However most of them, 27.00% of the total cases, experienced the problem only 1-3 days per month. The respiratory system symptoms which occurred averagely often could be run in following in order; coughing, tight chest, breathless, breathing difficulty, panting and cramp at chest. The average level of sickness was less than 0.68. Therefore the most of total cases did not have a significant level of respiratory system symptoms. The causal characteristics of respiratory system symptoms were workplace characteristics, work environment characteristics and personal characteristics.

4.5.5 Nervous System Symptoms

Table 4.9 Overall Occurrence of Nervous System Symptoms of 396 cases

Nervous System Symptoms	Score Range	Number	Percentage	Highest	Lowest	S.D.	Average	Level of Sickness
Headache	0	105	26.5	3	0	1.007	1.24	Small symptoms
	1	149	37.6					
	2	83	21.0					
	3	59	14.9					
Dizziness	0	139	35.1	3	0	1.082	1.16	Small symptoms
	1	118	29.8					
	2	74	18.7					
	3	65	16.4					
Sleepy	0	79	19.9	3	0	1.075	1.58	Medium symptoms
	1	109	27.5					
	2	107	27.0					
	3	101	25.5					
Weak	0	106	26.8	3	0	1.087	1.42	Medium symptoms
	1	96	24.2					
	2	115	29.0					
	3	79	19.9					
Lack of concentration	0	167	42.2	3	0	0.991	0.98	Small symptoms
	1	98	24.7					
	2	101	25.5					
	3	30	7.6					
Nausea	0	227	57.3	3	0	0.950	0.71	Small symptoms
	1	79	19.9					
	2	66	16.7					
	3	24	6.1					

Data collected from 396 cases regarding nervous system symptoms revealed that the majority experienced nervous problems. Five of the six symptoms were experienced by over half of cases at some point in the past month suggested that most of these cases had suffered from more than one symptoms in the past month. Sleepiness was the most common with 80.00% of population reported that had been sleepy in the past month and almost three quarters reported that had been headache and dizziness. The nervous system symptoms which occurred averagely often could be run in following in order; sleepiness, headache, weak, dizziness, short of concentration, and nausea. After considered average level of sickness, we found that the most of these cases had ‘small symptoms’ level of nausea, headache, dizziness and lack of concentration because the average level of each case was between 0.68 and 1.35. The result of this research found that the causal characteristics of nervous system symptoms were workplace characteristics, work environment characteristics and personal characteristics.

4.5.6 Skin Symptoms

Table 4.10 Overall Occurrence of Skin Symptoms of 396 cases

Skin Symptoms	Score Range	Number	Percentage	Highest	Lowest	S.D.	Average	Level of Sickness
Dry skin	0	248	62.6	3	0	1.017	0.68	Small symptoms
	1	67	16.9					
	2	41	10.4					
	3	40	10.1					
Irritate at face	0	280	70.7	3	0	0.899	0.49	No symptoms
	1	66	16.7					
	2	20	5.1					
	3	30	7.6					
Rash at face	0	270	68.2	3	0	0.852	0.50	No symptoms
	1	76	19.2					
	2	28	7.1					
	3	22	5.6					
Blister	0	283	71.5	3	0	0.818	0.46	No Symptoms
	1	60	15.2					
	2	38	9.6					
	3	15	3.8					
Extraneous Itchy	0	261	65.9	3	0	0.869	0.54	No Symptoms
	1	75	18.9					
	2	40	10.1					
	3	20	5.1					
Eczema	0	275	69.4	3	0	0.876	0.51	No Symptoms
	1	59	14.9					
	2	42	10.6					
	3	20	5.1					

Data collected from 396 cases regarding skin symptoms revealed that over a third (37.00%) of population had dry skin in the past month and the other five symptoms were experience by at least 28.00% of population. The skin symptoms which occurred averagely often could be run in following in order; dry skin, extraneous itchy, eczema, rash at face, irritate at face, and blister. The most of total cases had never experienced a significant level of skin symptom because the average level of sickness was lower than 0.68. The result of this research found that causal characteristics of skin symptoms were workplace characteristics , work environment characteristics and personal characteristics.

4.6 The Statistical Analysis of the Relationship between the Four Relating Characteristics and the Six Types of Symptoms

To Analyze the relationship between personal characteristics, workplace characteristics, work environment characteristics and health characteristics that influenced to the occurrence of the six types of symptoms; eye symptoms, nose symptoms, throat symptoms, respiratory system symptoms, nervous system symptoms and skin symptoms of population in Bangkok Metropolis' districts with Logistic Regression Analysis and could categorize the result of the study by six types of the symptoms as follows;

1) The result from Logistic Regression Analysis of the effects of indoor pollution on health of Bangkok Metropolis' population, focusing on eyes symptoms.

The first analysis was on eye symptoms. It was found that most of the cases had eyes irritation that was the result of external characteristics such as dust or using computer for too long without resting eyes. It was regularly found that 70-80% of computer users used a computer for more than two hours per day.

Table 4.11 The Result of the Analysis of the 4 Characteristics Related to Eye Symptoms

	Coefficient	Standard Error	Wald	Df	Sig.	Odds Ratio
-Education level						
Bachelor's degree	-1.216	0.353	11.842	1	0.001**	0.296
-Type of workplace						
Government office	-1.010	0.438	5.331	1	0.021**	0.364
- Areas around working desk						
Usage of glue	0.458	0.115	15.981	1	0.000**	1.580
- Past year medical records						
Asthma history	2.155	0.566	14.511	1	0.000**	8.626
- Past year medical records						
Migraine history	1.165	0.429	7.375	1	0.007**	3.205
-Eyesight						
Normal	1.379	0.337	16.725	1	0.000**	3.971
-Eyesight						
Long eye-sighted	2.396	0.774	9.578	1	0.002**	10.981
Constant	0.723	0.326	4.923	1	0.027**	2.061

R = 0.219, R Square = 0.351, F = 126.922*, Sig F(2-tailed) = 0.000

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population stayed under these conditions as follow; the type of workplace was the government office building had the risk of the occurrence of eye symptoms less than the other type of workplace as 0.364 times, the area around working desk had the usage of glue made the population to risk more than the population that stayed away these conditions as 1.580 times. The population who had the bachelor's degree had the risk of the occurrence of eye symptoms less than the population that had the other education level as 0.296 times because the bachelor's degree was the most suitable education level for the office worker. Besides the population that had the medical records background of

asthma and migraine had risk percentage to have eye symptoms problems more than who did not have the medical records background of asthma and migraine as 8.626 and 3.205 times respectively. In the same way the population who had the normal eyesight and long eye-sighted had the risk of the occurrence of eye symptoms more than the others as 3.971 and 10.981 times respectively.

2) The result from Logistic Regression Analysis of the effects of indoor pollution on health of Bangkok Metropolis' population, focusing on nose symptoms.

From the survey, it was found that nose symptoms which occurred the most was irritating nose as 9.60%. The first cause of the problem was from internal factor such as personal disease or allergy which could stimulate nose symptoms whenever the health was weak and the second cause was from external environmental factor.

Table 4.12 The Result of the Analysis of the 4 Characteristics Related to Nose Symptoms

	Coefficient	**Standard Error**	**Wald**	**Df**	**Sig.**	**Odds Ratio**
-Type of workplace						
Office building	1.250	0.290	19.290	1	0.000*	3.490
- Number of staff						
2-3 persons	-0.960	0.310	9.320	1	0.000*	0.380
- Type of floor						
Tile	1.110	0.350	9.970	1	0.000*	3.030
- Past year medical records						
Allergy history	1.420	0.360	15.790	1	0.000*	4.150
- Past year medical records						
Asthma history	1.470	0.500	8.700	1	0.000*	4.370
Constant	-0.170	0.260	0.440	1	0.510	0.840

R = 0.203, R Square = 0.310, F = 105.78*, Sig F(2-tailed) = 0.000

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population under these

conditions as follow; the type of workplace was the office building had the risk of the occurrence of nose symptoms more than the other type of workplace as 3.490 times, the number of staff about 2-3 persons in each room made the population to risk less than the population that stayed away these conditions as 0.380 times, the type of floor was tile made the population to have risk percentage in nose symptoms problems more than the other type of floor as 3.030 times. Besides the population that had the medical records background of allergy and asthma had risk percentage to have nose symptoms problems more than who did not have the medical records background of allergy and asthma as 4.150 and 4.370 times respectively.

3) The result from Logistic Regression Analysis of the effects of indoor pollution on health of Bangkok Metropolis' population, focusing on throat symptoms.

From the survey, it was found that throat symptoms which occurred the most was dry throat or thirsty as 13.90%. Such the dry throat led to the diabetes problems that could happen more to Bangkok Metropolis' Population.

Table 4.13 The Result of the Analysis of the 4 Characteristics Related to Throat Symptoms

	Coefficient	**Standard Error**	**Wald**	**Df**	**Sig.**	**Odds Ratio**
- Gender						
Male	-0.681	0.343	3.951	1	0.047**	0.506
- Income						
30,001-40,000 baht	1.904	0.745	6.536	1	0.011**	6.715
- Condition of workplace						
Private room	-1.675	0.673	6.188	1	0.013**	0.187
- Condition of workplace						
Shared room with partitions	-1.097	0.351	9.747	1	0.002**	0.334
- Ventilation system						
Central air condition	0.978	0.388	6.361	1	0.012**	2.660
- Background smoking						
Still smoking	1.349	0.511	6.972	1	0.008**	3.854
- Past year medical records						

Table 4.13 (Continued)

	Coefficient	Standard Error	Wald	Df	Sig.	Odds Ratio
Sickness in last year	-0.856	0.319	7.214	1	0.007**	0.425
- Past year medical records						
Asthma history	1.703	0.476	12.824	1	0.000**	5.491
- Past year medical records						
Migraine history	1.306	0.391	11.134	1	0.001**	3.690
- Past year medical records						
Skin infected history	-1.010	0.361	7.834	1	0.005**	0.364
- Eyesight						
Normal	0.671	0.334	4.050	1	0.044**	1.957
- Cleaning frequency						
1 time per month	-0.333	0.123	7.351	1	0.007**	0.717
Constant	2.214	0.612	13.086	1	0.000**	9.155

R = 0.195, R Square = 0.311, F = 125.317*, Sig F(2-tailed) = 0.000

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population under these conditions as follow; the condition of workplace was private room and shared room with partitions made the population to risk less than the population that stayed away these conditions as 0.187 and 0.334 times respectively, the ventilation system was central air condition had the risk of the occurrence of throat symptoms more than the other ventilation system as 2.660 times and these population had the background of smoking made these population to have the risk in throat symptoms problems more than the other population as 3.854 times respectively. Male had the risk in throat symptoms problems less than female as 0.506 times and the population that had income about 30,001-40,000 baht had the risk in throat symptoms problems more than the other population 6.715 times. Besides the population that had the medical records background of asthma and migraine had risk percentage to have throat symptoms problems more than who did not have these medical records background as 5.491 and

3.690 times respectively. On the other hand the population that had the medical records background of sickness in last year and skin infected history had risk percentage to have throat symptoms problems less than who did not have these medical records background as 0.425 and 0.364 times respectively. In the same way the population who had the normal eyesight had the risk in throat symptoms problems more than the others as 1.957 times and then the office building that had the cleaning frequency less than one time per month had the risk in throat symptoms problems less than the others as 0.717 times.

4) The result from Logistic Regression Analysis of the effects of indoor pollution on health of Bangkok Metropolis' population, focusing on respiratory system symptoms.

Respiratory system symptoms occurred due to the increase of personal diseases and infection to the respiratory system symptoms which could be found throughout the year especially when changing from the rainy season to winter.

Table 4.14 The Result of the Analysis of the 4 Characteristics Related to Respiratory System Symptoms

	Coefficient	**Standard Error**	**Wald**	**Df**	**Sig.**	**Odds Ratio**
- Income						
20,001-30,000 baht	1.506	0.426	12.499	1	0.000**	4.511
- Working days per week						
Many days per week	0.724	0.246	8.643	1	0.003**	2.062
-Type of workplace						
Educational institute	-1.338	0.411	10.600	1	0.001**	0.262
- Condition of workplace						
Shared room without partitions	-0.670	0.329	4.147	1	0.042**	0.512
- Number of staff						
1 person	3.549	1.166	9.265	1	0.002**	34.769
- Type of floor						
Tile	0.962	0.371	6.711	1	0.010**	2.616

Table 4.14 (Continued)

	Coefficient	Standard Error	Wald	Df	Sig.	Odds Ratio
- Areas around working desk						
Usage of printer	-0.383	0.116	10.698	1	0.001**	0.682
- Areas around working desk						
Usage of carbon paper	0.322	0.124	6.775	1	0.009**	1.380
- Areas around working desk						
Usage of glue	0.383	0.128	8.901	1	0.003**	1.466
- Background smoking						
Still smoking	-0.955	0.360	7.032	1	0.008**	0.385
- Past year medical records						
Asthma history	2.222	0.476	21.785	1	0.000**	9.224
- Past year medical records						
Migraine history	1.756	0.395	19.790	1	0.000**	5.788
- Cleaning frequency						
1 time per month	-0.576	0.173	11.115	1	0.001**	0.562
Constant	-1.840	1.433	1.649	1	0.199	0.159

R = 0.404, R Square = 0.560, F = 41.061*, Sig F(2-tailed) = 0.000

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population under these conditions as follow; the condition of workplace was shared room without partitions and the type of workplace was educational institute made the population to risk less than the population that stayed away these conditions as 0.512 and 0.262 times respectively, the number of staff was only one person in each room and the type of floor was tile made the population to have the risk in respiratory system symptoms problems more than the population that stayed away these conditions as 34.769 and 2.616 times respectively. The population that worked in many days per week had the risk in respiratory system symptoms problems more than the other population 2.062 times and the population that had income about 20,001-30,000 baht had the risk in respiratory system symptoms problems more than the other population 4.511 times.

The population that had the background of smoking made these population to have the risk in respiratory system symptoms problems less than the other population as 0.385 times. Besides the population that had the medical records background of asthma and migraine had risk percentage to have respiratory system symptoms problems more than who did not have these medical records background as 9.224 and 5.788 times respectively. In the same way the area around working desk had the usage of carbon paper and glue made the population to have the risk in respiratory system symptoms problems more than the population that stayed away these conditions as 1.380 and 1.466 times respectively. In the other side the area around working desk had the usage of printer made the population to have the risk in respiratory system symptoms problems less than the population that stayed away these conditions as 0.682 times and then the office building that had the cleaning frequency less than one time per month had the risk in respiratory system symptoms problems less than the others as 0.562 times.

5) The result from Logistic Regression Analysis of the effects of indoor pollution on health of Bangkok Metropolis' population, focusing on nervous system symptoms.

Nervous system disorder could lead to many other diseases. It had been found that the following groups which had a tendency to nervous system diseases needed to be treated urgently; chronic headache and migraine and these symptoms rarely happened within a month but were serious.

Table 4.15 The Result of the Analysis of the 4 Characteristics Related to Nervous System Symptoms

	Coefficient	**Standard Error**	**Wald**	**Df**	**Sig.**	**Odds Ratio**
- Working house per day						
Many hours per day	-0.395	0.176	5.002	1	0.025**	0.674
-Type of workplace						
Factory building	-4.195	1.803	5.416	1	0.020**	0.015

Table 4.15 (Continued)

	Coefficient	Standard Error	Wald	Df	Sig.	Odds Ratio
- Condition of workplace						
Shared room with partitions	-1.586	0.460	11.902	1	0.001**	0.205
- Number of staff						
2-3 persons	-1.158	0.488	5.639	1	0.018**	0.314
- Number of staff						
4-7 persons	1.737	0.569	9.311	1	0.002**	5.682
- Areas around working desk						
Usage of copy machine	0.446	0.138	10.415	1	0.001**	1.562
- Past year medical records						
Sickness in last year	-1.004	0.439	5.215	1	0.022**	0.367
- Past year medical records						
Asthma history	2.842	0.898	10.011	1	0.002**	17.145
- Past year medical records						
Migraine history	3.164	1.084	8.514	1	0.004**	23.669
- Past year medical records						
Skin infected history	2.629	0.731	12.922	1	0.000**	13.862
- Eyesight						
Short eye-sighted	1.751	0.821	4.549	1	0.033**	5.761
- Cleaning frequency						
1 time per month	-0.535	0.163	10.747	1	0.001**	0.586
Constant	5.905	1.662	12.627	1	0.000**	366.804

R = 0.273, R Square = 0.509, F = 162.384*, Sig F(2-tailed) = 0.000

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population under these conditions as follow; the condition of workplace was shared room with partitions, the type of workplace was factory building and the number of staffs were 2-3 persons had risk percentage to have nervous system symptoms problems less than the population that stayed away these conditions as 0.205, 0.015 and 0.314 times respectively. The

area around working desk had the usage of copy machine and there were 4-7 persons in each room made the population to have the risk in nervous system symptoms problems more than the population that stayed away these conditions as 1.562 and 5.682 times respectively. The population that worked in many hours per day had the risk in nervous system symptoms problems less than the other population 0.674 times and the population that had the medical records background of asthma, migraine and skin infected had risk percentage to have nervous system symptoms problems more than who did not have these medical records background as 17.145, 23.669 and 13.862 times respectively. On the other side the population that had the medical records background of sickness in last year had risk percentage to have nervous system symptoms problems less than who did not have the medical records background as 0.367 times. Besides the population who had the short eye-sighted had the risk on nervous system symptoms problems more than the others as 5.761 times and then the office building that had the cleaning frequency less than one time per month had the risk on nervous system symptoms problems less than the others as 0.586 times.

6) The result from Logistic Regression Analysis of the effects of indoor pollution on health of Bangkok Metropolis' population, focusing on skin symptoms.

The survey suggested that there were no sever skin symptoms in these cases. The causes of skin symptoms were either personal factors such as personal cleanliness and hormone disorder or even external causes such as the general environment and the work environment.

Table 4.16 The Result of the Analysis of the 4 Characteristics Related to Skin Symptoms

	Coefficient	**Standard Error**	**Wald**	**Df**	**Sig.**	**Odds Ratio**
- Gender						
Male	-0.766	0.331	5.373	1	0.020**	0.465
- Marital status						
Single	1.071	0.356	9.026	1	0.003**	2.918

Table 4.16 (Continued)

	Coefficient	Standard Error	Wald	Df	Sig.	Odds Ratio
- Income						
< 10,000 bath	1.377	0.522	6.959	1	0.008**	6.259
- Type of workplace						
Department store	2.656	1.148	5.356	1	0.021**	14.235
- Type of floor						
Tile	1.834	0.368	24.872	1	0.000**	6.259
- Areas around working desk						
Usage of printer	0.475	0.119	15.805	1	0.000**	1.607
- Areas around working desk						
Usage of fax machine	0.356	0.153	5.385	1	0.020**	1.427
- Areas around working desk						
Usage of carbon paper	-0.453	0.145	9.740	1	0.002**	0.636
- Areas around working desk						
Usage of liquid cleaner	0.665	0.215	9.537	1	0.002**	1.945
- Areas around working desk						
Equipment of chemical odor	-0.424	0.219	3.757	1	0.053**	0.654
- Past year medical records						
Migraine history	-2.463	0.464	28.241	1	0.000**	0.085
- Past year medical records						
Skin infected history	2.006	0.411	25.240	1	0.000**	7.894
- Past year medical records						
Respiratory disease history	4.723	0.864	29.916	1	0.000**	112.543
- Eyesight						
Unknown	-0.842	0.367	5.263	1	0.022**	0.431
- Cleaning frequency						
1 time per month	-0.722	0.119	36.881	1	0.000**	0.486
Constant	-2.778	0.943	8.679	1	0.003**	0.062

R = 0.449, R Square = 0.599, F = 0.091*, Sig F(2-tailed) = 0.000

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population under these conditions as follow; the type of workplace was the department store, the type of floor was tile and the area around working desk had the usage of printer, fax machine and liquid cleaner made the population to have the risk on skin symptoms problems more than the population that stayed away these conditions as 14.235, 6.259, 1.607, 1.427 and 1.945 times respectively. On the other hand the area around working desk had the usage of carbon paper and equipment of chemical odor made the population to have the risk on skin symptoms problems less than the population that stayed away these conditions as 0.636 and 0.654 times respectively Male had the risk on skin symptoms problems less than female 0.465 times and the population that had income less than 10,000 baht had the risk on skin symptoms problems more than the other population 3.964 times. The population were single had the risk on skin symptoms problems more than the other population 2.918 times Besides the population that had the medical records background of skin infected and respiratory disease had risk percentage to have skin symptoms problems more than who did not have these medical records background as 7.894 and 112.543 times respectively. On the other hand the population that had the medical records background of migraine history had risk percentage to have skin symptoms problems less than who did not have these medical records background as 0.085 times In the same way the population who did not know their eyesight states had the risk on skin symptoms problems less than the others as 0.431 times and then the office building that had the cleaning frequency less than one time per month had the risk on skin symptoms problems less than the others as 0.486 times.

CHAPTER 5

SUMMARY AND SUGGESTIONS

5.1 Analysis and Result Discussion Summary

The total number of individuals who completed the questionnaire was 396 cases which was the sample size.

1) Personal Characteristics

Data of personal characteristics revealed that the gender ratio was 62.60% female and 37.40% male. Two thirds of the population, 65.70%, was single while only one third, 33.60%, were married. Half of the cases fell within the age range of 26-35 years old. A quarter, 24.75%, of the cases had the income of 10,001 – 20,000 Baht. The majority, 63.60%, had a bachelor's degree. The number in the cases who worked 5 days a week was considered 80.30% of the total and those who worked 8 hours per day accounted for a little over half, 54.30%.

2) Workplace Characteristics

Just over two thirds, 67.20%, worked in office buildings and almost half worked in buildings of 10 floors or fewer. Almost all of the rest worked in buildings with up to 20 floors. Fewer than half, 41.70%, worked in a shared room divided by partitions. Those who had at least 8 colleagues accounted for 38.60%. The number in the cases who worked in a carpeted room was just over third, 35.1%, while a little more than three quarters, 76.3%, worked in a room that had central air conditioning system. The vast majority, 85.9% used computers in their workplace. Two thirds, 67.9%, used a printer more than 3-4 times a week. However, those who did not use a copying machine, a facsimile, carbon paper, correction fluid, adhesive, cleaning products, aromatic chemical substances, or a mimeograph account for 59.10%, 38.10%, 59.10%, 31.80%, 38.40%, 66.90% 72%, 65.20%, respectively.

3) Health Characteristics

The vast majority, 91.70%, were non-smokers. Over half, 52.5%, had been sick in a year. Two thirds, 66.7%, had allergy, 84.10% had no sinus infection, 79.80% had no record of asthma, 74.00% had no record of migraine, 78.8% had no record of infectious skin rash, 88.60% had no record of respiratory disease and 87.60% did not have a chronic illness. On the other hand, over a quarter, 26%, suffered from migraines and over a third were near-sighted. Only a quarter of the cases had normal vision.

4) Work Environment Characteristics

Almost half, 44.2%, worked in a place which was cleaned daily while only 4.3% worked in a place which was cleaned only once a month.

The effects of indoor pollution on the population in Bangkok were analyzed with the aid of Logistic Regression Analysis using the stepwise method. The analysis of each symptoms was as follows;

1) Analysis and consideration of the impact of indoor pollution which caused eye symptoms in the population of Bangkok Metropolis.

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population stayed under these conditions as follow; the type of workplace was the government office building had the risk of the occurrence of eye symptoms less than the other type of workplace as 0.364 times, the area around working desk had the usage of glue made the population to risk more than the population that stayed away these conditions as 1.580 times. The population who had the bachelor's degree had the risk of the occurrence of eye symptoms less than the population that had the other education level as 0.296 times because the bachelor's degree was the most suitable education level for the office worker. Besides the population that had the medical records background of asthma and migraine had risk percentage to have eye symptoms problems more than who did not have the medical records background of asthma and migraine as 8.626 and 3.205 times respectively. In the same way the population who had the normal eyesight and long eye-sighted had the risk of the occurrence of eye symptoms more than the others as 3.971 and 10.981 times respectively.

2) Analysis and consideration of the impact of indoor pollution which caused nose symptoms in the population of Bangkok Metropolis.

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population under these conditions as follow; the type of workplace was the office building had the risk of the occurrence of nose symptoms more than the other type of workplace as 3.490 times, the number of staff about 2-3 persons in each room made the population to risk less than the population that stayed away these conditions as 0.380 times, the type of floor was tile made the population to have risk percentage in nose symptoms problems more than the other type of floor as 3.030 times. Besides the population that had the medical records background of allergy and asthma had risk percentage to have nose symptoms problems more than who did not have the medical records background of allergy and asthma as 4.150 and 4.370 times respectively.

3) Analysis and consideration of the impact of indoor pollution which caused throat symptoms in the population of Bangkok Metropolis.

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population under these conditions as follow; the condition of workplace was private room and shared room with partitions made the population to risk less than the population that stayed away these conditions as 0.187 and 0.334 times respectively, the ventilation system was central air condition had the risk of the occurrence of throat symptoms more than the other ventilation system as 2.660 times and these population had the background of smoking made these population to have the risk in throat symptoms problems more than the other population as 3.854 times respectively. Male had the risk in throat symptoms problems less than female as 0.506 times and the population that had income about 30,001-40,000 baht had the risk in throat symptoms problems more than the other population 6.715 times. Besides the population that had the medical records background of asthma and migraine had risk percentage to have throat symptoms problems more than who did not have these medical records background as 5.491 and 3.690 times respectively. On the other hand the population that had the medical records background of sickness in last year and skin infected history had risk percentage to have throat symptoms problems less than who did not have these

medical records background as 0.425 and 0.364 times respectively. In the same way the population who had the normal eyesight had the risk in throat symptoms problems more than the others as 1.957 times and then the office building that had the cleaning frequency less than one time per month had the risk in throat symptoms problems less than the others as 0.717 times.

4) Analysis and consideration of the impact of indoor pollution which caused respiratory system symptoms in the population of Bangkok Metropolis.

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population under these conditions as follow; the condition of workplace was shared room without partitions and the type of workplace was educational institute made the population to risk less than the population that stayed away these conditions as 0.512 and 0.262 times respectively, the number of staff was only one person in each room and the type of floor was tile made the population to have the risk in respiratory system symptoms problems more than the population that stayed away these conditions as 34.769 and 2.616 times respectively. The population that worked in many days per week had the risk in respiratory system symptoms problems more than the other population 2.062 times and the population that had income about 20,001-30,000 baht had the risk in respiratory system symptoms problems more than the other population 4.511 times. The population that had the background of smoking made these population to have the risk in respiratory system symptoms problems less than the other population as 0.385 times. Besides the population that had the medical records background of asthma and migraine had risk percentage to have respiratory system symptoms problems more than who did not have these medical records background as 9.224 and 5.788 times respectively. In the same way the area around working desk had the usage of carbon paper and glue made the population to have the risk in respiratory system symptoms problems more than the population that stayed away these conditions as 1.380 and 1.466 times respectively. In the other side the area around working desk had the usage of printer made the population to have the risk in respiratory system symptoms problems less than the population that stayed away these conditions as 0.682 times and then the office building that had the cleaning frequency less than one time per month had the risk in respiratory system symptoms problems less than the others as 0.562 times.

5) Analysis and consideration of the impact of indoor pollution which caused nervous system symptoms in the population of Bangkok Metropolis.

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population under these conditions as follow; the condition of workplace was shared room with partitions, the type of workplace was factory building and the number of staffs were 2-3 persons had risk percentage to have nervous system symptoms problems less than the population that stayed away these conditions as 0.205, 0.015 and 0.314 times respectively. The area around working desk had the usage of copy machine and there were 4-7 persons in each room made the population to have the risk in nervous system symptoms problems more than the population that stayed away these conditions as 1.562 and 5.682 times respectively. The population that worked in many hours per day had the risk in nervous system symptoms problems less than the other population 0.674 times and the population that had the medical records background of asthma, migraine and skin infected had risk percentage to have nervous system symptoms problems more than who did not have these medical records background as 17.145, 23.669 and 13.862 times respectively. On the other side the population that had the medical records background of sickness in last year had risk percentage to have nervous system symptoms problems less than who did not have the medical records background as 0.367 times. Besides the population who had the short eye-sighted had the risk on nervous system symptoms problems more than the others as 5.761 times and then the office building that had the cleaning frequency less than one time per month had the risk on nervous system symptoms problems less than the others as 0.586 times.

6) Analysis and consideration of the impact of indoor pollution which caused skin symptoms in the population of Bangkok Metropolis.

The result from Logistic Regression Analysis that chose variables into the system using the Forward Stepwise Method found that the population under these conditions as follow; the type of workplace was the department store, the type of floor was tile and the area around working desk had the usage of printer, fax machine and liquid cleaner made the population to have the risk on skin symptoms problems more than the population that stayed away these conditions as 14.235, 6.259, 1.607, 1.427

and 1.945 times respectively. On the other hand the area around working desk had the usage of carbon paper and equipment of chemical odor made the population to have the risk on skin symptoms problems less than the population that stayed away these conditions as 0.636 and 0.654 times respectively Male had the risk on skin symptoms problems less than female 0.465 times and the population that had income less than 10,000 baht had the risk on skin symptoms problems more than the other population 3.964 times. The population were single had the risk on skin symptoms problems more than the other population 2.918 times Besides the population that had the medical records background of skin infected and respiratory disease had risk percentage to have skin symptoms problems more than who did not have these medical records background as 7.894 and 112.543 times respectively. On the other hand the population that had the medical records background of migraine history had risk percentage to have skin symptoms problems less than who did not have these medical records background as 0.085 times In the same way the population who did not know their eyesight states had the risk on skin symptoms problems less than the others as 0.431 times and then the office building that had the cleaning frequency less than one time per month had the risk on skin symptoms problems less than the others as 0.486 times.

5.2 In Depth Analysis

The research revealed that there was a relationship between the occurrence of nervous system symptoms and workplace characteristics and work environment characteristics. However, consideration of personal characteristics should take priority because of the severe nature of the symptoms in comparison with other groups of symptoms. Nervous system symptoms were headache, dizziness, sleepy and weakness. These symptoms mostly occurred to people who worked inside office buildings at least 5 days per week and 8 hours per day. These individuals might be working in sub-standard work environment characteristics. The most common symptoms in this group was migraine, which was a severe debilitating pained on one side of the head. Ninety percent suffered nausea and 1 out of 3 patients were sensitive to stimulators such as bright light. These symptoms could be found more in females

than in males and had particularly significant because of the nature of the pain and sickness caused. Some population suffered with such severe pain that they were incapable of work or study. Migraine was a disease which occasionally prevented even the most busy and important individuals from working. It caused a measurable loss of GDP for the economy and could cause psychological damage to the individual. The nervous systems of migraine sufferers could be sensitive to any environmental change. The blood vessels and the nerves surrounding the brain could become inflamed. Characteristics which trigger migraine were environment; changes in temperature, some smells including perfume, exhaust fumes, viewing computer screens for too long, stresses, or stress. Hence, in order to reduce their risk of nervous system symptoms, sufferers must to take good care of themselves, remain in a good mood, learn how to deal with stresses and avoid to poor environments.

It had been demonstrated that eye symptoms were related to work environment characteristics and health characteristics. Throat symptoms were related to work environment characteristics, the general environment and personal characteristics. These two groups of symptoms should be taken into consideration next. There was the possibility that these two groups of symptoms might be more common than the questionnaires suggested because many characteristics appeared to have a statistical relationship with them, although statistical correlation needed not imply causality. Relationships existed with the work environment characteristics, general environment and personal characteristics. Since characteristics that impacted these two groups of symptoms were external characteristics, improvement of the environment appeared to be the main mechanism for reduction of the risk of symptoms occurrence. For example offices should ensure that lighting was adequate without being excessive.

Symptoms on nose, respiratory system and skin rarely occurred within the cases, apparently only work environment characteristics influenced the occurrence of nose symptoms. Amongst the survey group it was found that respiratory system symptoms occurred most commonly in people who worked in a Siam Cement building where there were serious problems with air-conditioning system which had become a source of disease. These provided an example of the damage which could be caused by failure to undertake adequate regular maintenance and cleaning of

fixtures such as air-conditioning. The risks were more obvious in factories where hazardous activities were undertaken. Although those employees undertaking hazardous work might be protected, the same protection should be extended to those who visited or passed by. The evidence also supported the idea of placing a limit on the working hours.

Respiratory system symptoms had a relationship with work environment characteristics, workplace characteristics and health characteristics. The analysis found that those who worked in Empire Tower experienced the problems of dust from near by construction sites which was blown in when the door was opened causing symptoms of tight chest and breathlessness. The result strongly suggested that people in the area should wear masks in order to prevent dust and other diseases. In other countries construction sites were required to spray water in order to ‘damp down’ dust thereby limiting the problem.

Skin symptoms had a relationship with environmental and personal characteristics. A majority, 71.5%, of the cases reported having a rash due to skin exposure to stimulating characteristics.

We could conclude that the risks for the occurrence of nose symptoms, respiratory system symptoms and skin symptoms were lower than those for the occurrence of nervous system symptoms, eye symptoms and throat symptoms. However, with care there was always a possibility that the occurrence of any symptoms could become higher in the future.

5.3 Suggestions

5.3.1 General Suggestions

From the research could conclude that irrelevant characteristics caused the 6 symptoms as follow: the sickness background which could classify into asthma, migraine, dermatitis, eye sight problems, frequency of office cleaning and background smoking and these causes mostly came from internal characteristics on the cases. Therefore to reduce the risk of getting closed to the 6 symptoms, the population must more concern on health characteristics with health campaigns from the government. The only external characteristics was the frequency of office cleaning which should be more often and have correct standardization.

5.3.2 Suggestions from the Questionnaire

1) There should be anti bacteria devices for the visitors to use before entering the buildings and perhaps there should be automatic sanitization.

2) All buildings should include cleaning plan each day, twice per day as required for both office areas and parking lots. Furthermore the carpet should be cleaned at least twice a year and all the cleaning process must be under specialist vision.

3) Waste disposal should be at maximum standard and should dispose within a day and the area must be cleaned often to prevent germs. Furthermore rubbish should be separated before disposed.

4) The employers should play the key roles and encourage employees to keep the workplace clean and tidy that will increase the efficiency of employees.

5) It will be more nature atmosphere by putting small trees in the area and also can increase level of oxygen.

6) All the office machines and equipments should be cleaned regularly for the health purpose.

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APPENDIX A

QUESTIONNAIRE

Questionnaire: The Impact of Indoor Pollution on Health of Population in Bangkok Metropolis

Please answer all questions below by using ✓ inside ☐ or table, fill all the blanks and give comments as need

Part 1 : Personal characteristics

1) Gender

☐[1] Male ☐[2] Female

2) Age

Age ..... Year ..... Month

3) Education level

☐[1] No education ☐[2] Lower than Secondary School

☐[3] Secondary School ☐[4] Junior High School

☐[5] High School / Certificate ☐[6] Diploma / Certificate

☐[7] Bachelor ☐[8] Higher than Bachelor

☐[9] Others .....

4) Marital Status

☐[1] Single ☐[2] Married

☐[3] Others .....

5) Income

☐[1] Below Baht 10,000 ☐[2] Baht 10,001 - 20,000

☐[3] Baht 20,001- 30,000 ☐[4] Baht 30,001 –40,000

☐[5] More than Baht 40,000

6) How many days per week on average that you work inside an office building?

…… days

7) How many hours per day on average do you work inside an office building?

…… hours

Part 2 : Workplace characteristics

1) Type of workplace

☐[1] Office building ☐[2] Department Store

☐[3] Educational institute ☐[4] Clinical building

☐[5] Factory building ☐[6] Residential building

☐[7] Government office ☐[8] Others .....

2) Condition of workplace

☐[1] Private room ☐[2] Shared private room

☐[3] Shared room with partitions ☐[4] Shared room without partitions

☐[5] Others .....

3) How many colleague (including yourself) work with you in the room or in the same area

☐[1] 1 person ☐[2] 2 – 3 persons

☐[3] 4 – 7 persons ☐[4] More than 8 persons

4) Most common of floor covering in your office is

☐[1] Carpet ☐[2] Wood

☐[3] Tile ☐[4] Rubber, Plastic, PVC

☐[5] Others .....

5) Characteristics of the ventilation system at your workplace

☐[1] Separate air ☐[2] Central air

☐[3] Fan (No air-con) ☐[4] Others .....

6) How many hours on average per day that you use computer

☐[0] Do not use

☐[1] Averagely …… hrs/day

7) How often do you use the following office appliances while working

Office appliances	Do not use	Less than 3 times per week	3 – 4 Times per week	1 time per day	Several times per day
Copier	0	1	2	3	4
เครื่องโรเนียว	0	1	2	3	4
Printer type……..	0	1	2	3	4
FAX	0	1	2	3	4
Carbonless copy paper	0	1	2	3	4
Liquid corrector	0	1	2	3	4
Glue	0	1	2	3	4
Liquid cleaners	0	1	2	3	4
Equipment of chemical odor	0	1	2	3	4

Part 3 : Health characteristics

1) Smoking history, cigar, tobacco, pipe

☐[0] Never smoked

☐[1] Used to smoke but stopped

☐[2] Still smoking.

And - do you smoking inside the office?

☐[1] No ☐[2] Yes

2) Have you ever been sick because of cold i.e. having fever, runny nose, cough ≥ 2 times per year or not.

☐[0] No ☐[1] Yes

3) Have you ever had any of the following symptom or diseases?

	Yes	No
Allergy	☐[0]	☐[1]
Sinusitis	☐[0]	☐[1]
Asthma	☐[0]	☐[1]
Migraine	☐[0]	☐[1]
Skin inflammation	☐[0]	☐[1]
Respiratory disease	☐[0]	☐[1] ระบุ ……
Other chronic individual diseases	☐[0]	☐[1] ระบุ ……

4) How is your eyesight?

☐[0] Unknown ☐[1] Normal

☐[2] Short eye-sighted ☐[3] Long sighted

☐[4] Astigmatism ☐[5] Other eye disease please specify ……

Part 4 : Work environment characteristics

1) How often is your office cleaned each month

☐[0] Never / Almost never ☐[1] 1 time per month

☐[2] 1 time per week ☐[3] Almost every day

☐[4] Every day

2) In general, how clean do you think about your workplace is?

☐[1] Very dirty ☐[2] Quite dirty

☐[3] Sometime dirty, sometimes clean ☐[4] Quite clean ☐[5] Very clean

Opinion or suggestion toward your workplace

Part 5 : The occurrence of 6 types of symptoms

Within 1 past month, how often do you have these symptoms? And where were you when you the symptom started?

Eye Symptoms	**Frequency of the occurrence**			
	Never	**1 – 3 days /month**	**1 – 3 days/week**	**Almost every day**
Irritated eyes	0	1	2	3
Dry eyes	0	1	2	3
Weeping eyes	0	1	2	3
Itchy eyes	0	1	2	3
Red eyes	0	1	2	3
Stinging eyes	0	1	2	3

Nose Symptoms	**Frequency of the occurrence**			
	Never	**1 – 3 days /month**	**1 – 3 days/week**	**Almost every day**
Irritated nose	0	1	2	3
Stuffy nose	0	1	2	3
Runny nose	0	1	2	3
Itchy nose	0	1	2	3
Painful nose	0	1	2	3
Nosebleed	0	1	2	3

Throat Symptoms	**Frequency of the occurrence**			
	Never	**1 – 3 days /month**	**1 – 3 days/week**	**Almost every day**
Dry throat / frequently thirsty	0	1	2	3
Burning throat	0	1	2	3
Irritated at throat	0	1	2	3
Sore throat	0	1	2	3
Difficulty swallowing	0	1	2	3
Voiceless	0	1	2	3

Respiratory System Symptoms	**Frequency of the occurrence**			
	Never	**1 – 3 days /month**	**1 – 3 days/week**	**Almost every day**
Tight chest	0	1	2	3
Difficulty breathing	0	1	2	3
Breathless	0	1	2	3
Tight chest	0	1	2	3
Cough	0	1	2	3
Asthma	0	1	2	3

Nervous System Symptoms	**Frequency of the occurrence**			
	Never	**1 – 3 days /month**	**1 – 3 days/week**	**Almost every day**
Headache	0	1	2	3
Dizziness	0	1	2	3
Sleepiness	0	1	2	3
Weakness	0	1	2	3
Lack of concentration	0	1	2	3
Nausea	0	1	2	3

Skin Symptoms	Frequency of the occurrence			
	Never	1 – 3 days /month	1 – 3 days/week	Almost every day
Dry skin	0	1	2	3
Irritated at face	0	1	2	3
Rash on face	0	1	2	3
Raised red rash	0	1	2	3
Itchy externally	0	1	2	3
Dermatitis	0	1	2	3

Thank you very much for your time dedicated to this questionnaire researcher.

APPENDIX B

The Information on District Which has High Frequency of Population and Office Building

1) Satorn it located on the east side of Jawpraya river, it combine of 3 sub district which are Tung wat don sub district, Yannava sub district, Tongmahamake sub district. The total area 9.326 square meters with number of population equal to 89,294 and density equal to 9,574.73 per square meters.

Empire Tower

The researcher has collecting the data from people who working at Empire Tower, Bangkok city Building and finally Satorn city Building in Satorn area which congest by the office building.

2) Phatumwan District

Sintorn Building

Sintorn building was located on the south of Bangkok and it become one of the business center, commercial, service, education, diplomacy area, Also this area is located just in the heart of Bangkok and can reach by many ways. Phatumwan has divide up in to 4 sub district which are Rongmung sub district, Vangmai sub district, Phatumwan sub district and Lumpinee sub district. On this areas are fill up by many office building such as Sintorn Building, The office at central world, Aummarin Tower, Mneya Tower, Tonson Building etc.,

3) Huihwang District

The huihwang district was put in the middle Bangkok can represent the commercial, service and also the high dense residential area which divide into 3 sub district as follow Huihwang sub district, Bangkapi sub district, Samsennok sub district

Mung Thai Put complex Building

On the Huihwang district the researcher has collected the data from people who working or visit in Mung Thai Put complex Building whom mostly working on this area or have resident in this area because Huihwang district itself has high number of condominiums due to the convenient transportation in the area.

4) Bangkapi District

The Bangkapi district was located on the east side of Bangkok in the residential areas and divide into 2 sub district as follow , Khlong Chan sub district and Hua Mak sub district. Therefore the researcher has collecting the data from people who work in The Mall department store to represent the office worker in Bangkapi district area.

Inside the food court

Inside The Mall **B**angkapi department store food court has not even contain the worker in this area itself but also include visitors who come to use the service. Normally the peak time is set to be in the evening around 16.00-21.00 because the theater is located on the same floor and sometime it might has some event on this area.

5) Dindang District

Dingdang district is used to be sub district of Huihwang district but due to the increasing of population and the huge area of Dindang the government has concern about the convenient of people in the area therefore according to government proclamation on 8 October 2536 has promote Dindang sub district to be district which take total areas of 8.354 square meters and total population equal 157,896 (male 157,896 female 82,583).

RS Tower

Dindang district is connect to Huihwang district and has the tube located in the area, regarding to this convenient transportation it make the area full with residential and office building. The researcher has collecting the data on this area at RS Tower because this building has the most companies in the area and have 4 department store nearby as follow Carefour, Robinson, Jusco and Esplanade also the True Corporation Building.

6) Jatujak District is located on the north of Bangkok with the heart of commercial, service and residential area.

SCG Building

According to the research inside the building has shown that the building is use the air condition units which encourage the failure on respiratory system because the unsmooth fresh air flow. Also the air condition units were producing the CFC which causes the green house effect.

BIOGRAPHY

NAME	Miss Areerat Sensod
BACKGROUND ACADEMY	Bachelor of Science (Statistics) Prince of Songkla University, 1997 Master of Science (Actuaral Science) National Institute of Development Administration 2001
POSITION & OFFICE	Ground School Instructor (Administrative Affairs) Civil Aviation Training Center (CATC) , Thailand State Enterprise under Ministry of Transport (2005 – Present)
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