EFFECTIVENESS OF URBAN CHILDCARE CENTER INDOOR AIR QUALITY MANAGEMENT PROGRAM (UCC-IAQ) ON BUILDING RELATED SYMPTOMS AMONG CARETAKES:A QUASI EXPERIMENTAL STUDY

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A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy in Public Health
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ประสิทธิผลของโปรแกรมการจัดการคุณภาพอากาศในอาคารศูนย์ดูแลเด็กเล็ก (ยูซีซี-ไอเอคิว) ต่อกลุ่มอาการป่วยเหตุอาการในกลุ่มผู้ดูแลเด็ก:การศึกษาวิจัยกึ่งทดลอง

นายสุดเขต เดชพิทักษ์ยนต์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรดุษฎีบัณฑิต
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มลพิษทางอากาศภายในอาคารเป็นสาเหตุการเสียชีวิตของคน จำนวน 7 ล้านคนต่อปี ส่วนในประเทศไทยมีผู้เสียชีวิต 50,000 ราย ดังนั้น การศึกษานี้จึงมีวัตถุประสงค์เพื่อทดสอบประสิทธิภาพของโปรแกรมการจัดการคุณภาพอากาศในอาคารศูนย์ดูแลเด็กเล็ก (UCC-IAQ) โดยใช้ quasi-experimental โดยรวบรวมจากผู้ดูแลเด็กในจังหวัดนนทบุรีและสระบุรีของประเทศไทยจากศูนย์เด็กเล็กทั้ง 10 แห่ง เป็นเวลา 8 ชั่วโมงและข้อมูลเกี่ยวกับ BRS จากผู้ดูแลเด็กจำนวน 81 ราย และสำรวจอาคารศูนย์เด็กเล็ก

UCC-IAQ มีผลต่อความถี่ของ BRS ในกลุ่มผู้ดูแลเด็ก มีการลดลงอย่างมีนัยสำคัญทางสถิติ โดยพบว่า อาการทั่วไปของกลุ่มแทรกแซงลดลง 5.38 เท่า อาการโดยรวมลดลง 13.60 เท่า อาการทางเดินหายใจส่วนบน ลดลง10.95 เท่า และอาการทางเดินหายใจส่วนล่างลดลง 10.95 เท่าอย่างมีนัยสำคัญทางสถิติ เมื่อเปรียบเทียบกับกลุ่มเปรียบเทียบ จาก Multivariate linear regression พบว่า ผู้ดูแลเด็กที่ทำงานอยู่ในห้องที่มีอุณหภูมิเปลี่ยนแปลงอย่างรวดเร็วมีโอกาสที่จะเกิด BRS (Adjusted OR Ratio = 10.72) นอกจากนี้ยังพบว่าผู้ดูแลเด็กที่มีการใช้สเปรย์ปรับอากาศในห้อง มีโอกาสที่จะเกิด BRS (Adjusted OR Ratio = 5.54)

UCC-IAQ ในศูนย์เด็กเล็กนั้นมีผลต่ออาการเจ็บป่วยที่เกี่ยวเนื่องกับอาคาร ของผู้ดูแลโดยเฉพาะในกลุ่มที่ได้รับการแทรกแซง และยังพบว่าการเปลี่ยนแปลงอุณหภูมิอย่างรวดเร็วในอาคารและการใช้สเปรย์ปรับอากาศในห้องมีผลกระทบต่อ BRS ของผู้ดูแลเด็กในศูนย์เด็กเล็ก

สาขาวิชา	สาธารณสุขศาสตร์	ลายมือชื่อนิสิต ....
ปีการศึกษา	2565	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
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Sudkhed Detpetukyon : EFFECTIVENESS OF URBAN CHILDCARE CENTER INDOOR AIR QUALITYMANAGEMENT PROGRAM (UCC-IAQ) ON BUILDING RELATED SYMPTOMSAMONG CARETAKES:A QUASI EXPERIMENTAL STUDY. Advisor: Assoc. Prof. NUTTA TANEEPANICHSKUL, Ph.D. Co-advisor: Asst.Prof. Dr. WANDEE SIRICHOKCHATCHAWAN, Ph.D.

This study investigates the effectiveness of the UCC-IAQ program in Thai childcare centers, focusing on BRS and indoor air pollution. It involves 81 childcare workers in Nonthaburi and Saraburi provinces, Over eight hours, air quality measurements were taken at ten settings. Data on BRS and building-related factors were collected via surveys.

Statistically significant differences in pollution levels were not observed between the UCC-IAQ program's intervention and comparison groups. However, the intervention group experienced a significant decrease in BRS compared to the comparison group. Caretakers in rooms with rapid temperature variations had a 10.72 times higher likelihood of experiencing BRS (Adjusted odds ratio = 10.72, 95% CI = 2.65 - 43.41, p-value = 0.001). Furthermore, the use of aerosol air fresheners increased caretakers' symptom incidence by 5.54 times (Adjusted odds ratio = 5.54, 95% CI = 1.74 - 17.62, p-value = 0.004). This study indicates that the implementation of the UCC-IAQ program in childcare centers has an effect on BRS among caretakers, particularly in the intervention group. In addition, the researchers found that sudden changes in temperature in buildings and the use of room air fresheners had a significant impact on the BRS of childcare center caregivers.

Field of Study: Public Health	Student's Signature ....
Academic Year: 2022	Advisor's Signature ....
	Co-advisor's Signature ....

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CHAPTER I

INTRODUCTION

1.1 Background and Rationale

Air pollution has the greatest impact on human health and affects everyone in every region of the world. 41% of the world's population is exposed to indoor air pollution(1), both in urban and rural areas, because all humans breathe air during their whole lives. According to the World Health Organization, indoor air pollution kills 7 million people each year (2). 97% of populations in developing countries do not meet WHO air quality requirements, according to the World Health Organization's (WHO) report on developing countries (3). Indoor air pollution is equally harmful to health. According to the World Health Organization, 3.8 million people die each year from indoor air pollution (4). air pollution was responsible for the deaths of 200,000 people annually in the United States (5) and 2.2 million in South-East Asia (6). 50,000 deaths in Thailand have been attributed to air pollution(7). However, indoor air pollution affects everyone, especially those who spend most of their time indoors for work and daily activities.

Based on past data, workers may be more exposed to indoor air pollution; this is an essential concern for indoor workers because it affects the health of indoor workers worldwide. When the worker spends more time indoors, they may be more likely to be affected by indoor air pollution. As more people work outside, indoor air pollution causes diseases such as chronic obstructive pulmonary disease (COPD), asthma, cancer, and cardiovascular disease (4). In 1983, indoor air pollution was one cause of discomfort and illness for those who worked or lived in this building. "Sick Building Syndrome" (SBS) (8) is a term coined by the World Health Organization (WHO) to describe symptoms experienced by building occupants for which the underlying cause cannot be determined, although the United States uses the term "building-related symptoms" (BRS) (9). It refers to a building-related illness (BRI) if clearly identified causes are attributable to an indoor air pollutant and a set of symptoms with an uncertain cause is associated with a job or occupation in a building (10).

In accordance with numerous findings, sick building occupants are caused by indoor air pollution 88% of the time (11) and Mohammad reported a prevalence of 62.9% in male offices and 54.5% in female offices (12) In addition, Asian research indicates that 54.4% of Malaysian academic office workers are allergic to indoor air pollutants. accordance with many reports showed indoor air pollution cause of sick from building some studies mention about 88% (11) and Mohammad was found prevalence of 62.9 % among men office and 54.5% in woman office (12) Also studies from Asia, Malaysian among academic office workers found prevalence allergic from indoor air pollutant 54.4%. 84% of hospital workers in Taiwan are the subject of studies focusing on the present prevalence rate (13). Studies from China focusing on children in Shanghai reported a prevalence of 76.9% (14), and studies from Malaysia working on 447 employees found a prevalence of 62.3% (15) in the workplace. However, relatively few studies have been conducted on building-related illnesses in Thailand.

Numerous studies have shown that indoor pollution affects the health of indoor occupants. For example, in a study investigating indoor air quality, ventilation, and sick building syndrome in China, sick building syndrome was found to significantly impact indoor air quality, particularly dry air ultrafine particles and 2-ethyl-1-hexanol (16). This corresponds to the information in the textbook describing volatile organic compounds in indoor environments. Indoors, large quantities of volatile organic compounds can irritate the eye, nose, and throat, resulting in a sick building (17). The most commonly reported SBS symptom in Greece, according to research, is fatigue (34.1%). General, mucosal, and dermal symptoms each had a prevalence of 40.8%, 19.8%, and 8.1%, respectively. Discomfort Scale, atopy, difficulty sleeping, female, exposure to biological and chemical agents, PC usage, Psychosocial Work Scale, and work satisfaction were all found to be associated with SBS(18). And Taiwan studies, the purpose of this one was to evaluate the effect of personal characteristics, work-related psychosocial stress, and the work environment on the development of SBS in Taiwanese office employees in high-rise buildings(19). Similarly, a study in Thailand on respiratory symptoms and sick-building syndrome among hospital office workers found that air temperature, allergic rhinitis, regular working hours per week, carbon dioxide, and a total viable bacterial count were associated with respiratory symptoms and sick building syndrome. In addition, this study found that nasal symptoms had the highest prevalence of SBS (25.3%) (20). And while a number of studies have implicated indoor surroundings as a probable source of SBS symptoms, it is also plausible that outdoor environments have a significant influence on the development of these symptoms(21). It is necessary to protect people from indoor air pollution and maintain high indoor air quality, as every study has found a relationship between indoor air pollution and illness and disease.

Air quality can link to Indoor air pollution within area around the buildings it effects with people health sources of indoor air pollution come from air or particles primary cause of indoor air quality issue, including ventilation temperature and humidity can increase indoor pollutants (22) from US EPA present 3 major way how to improve indoor air quality 1). Source Control 2). Improved Ventilation 3). Air cleaners (23) similar to bureau of Occupational and Environmental Diseases of Thailand recommend to control indoor air pollution by engineering control and management control, The suggestion in buildings should clean the air conditioning system and maintain ventilated airflow greater than 10 liters per second per person, and should not deliver outdoor air directly into the building. When using outdoor air, the purification process system should be in place until the indoor air quality is checked annually (24). However, some buildings cannot use engineering control because of limitations such as budget or building structure. Despite the fact that many studies show the effectiveness of engineering control for reducing indoor air pollution, some buildings still involve management control because it is more costly than engineering control and can be used in both old and new buildings. For example studies from Portugal have used management control by increase natural ventilation and control relative humidity among hospitals and primary healthcare center results show when keeping low indoor air relative humidity in hospitals and primary healthcare center has an effect to reducing fungi concentration in indoor air (25) and studies from Manuel,.B use management control by change behavior fuel from kerosene to electricity use after 2 years has shown average PM2.5 level decrease 66% when compared with households non electricity fuel use (26) and studies of indoor air quality when during sleep among group close door and window and group change management by open door and window for the results showed group close door and window highest levels of carbon dioxide, carbon monoxide, and volatile organic compounds (27).

When air pollution levels are high in Thailand and reports show that air pollution affects the health of children, the Queen Sirikit National Institute of Child Health announces on its website symptoms such as coughing and an increase in phlegm, difficulty breathing, and angina. Increase the hospitalization rate (28). according to the Thailand State of Pollution Report 2018, the air quality in 33 provinces in Thailand is still higher than Thailand's standard, especially during the dry season. Many provinces in Thailand have a problem with air pollution due to high pressure on the country's central region, which causes air stagnation when there is no wind. All air pollution is still present in this region, affecting the residents, especially the most sensitive groups. The presence of volatile organic compounds (VOCs) is a problem in Thailand(29). Attributed to the prevalence of agricultural land, factories, a large number of construction sites, automobile traffic, and an airport, the metropolitan region of Thailand has a high level of air pollution. During the dry season, the sources of air pollution in this region are automobiles, farms, herbicides, pesticides, and construction. And metropolitan children have a high incidence of upper respiratory tract infections (URTI). It is crucially significant since outdoor air pollution has a significant impact on indoor air pollution Many studies have reported the relationship between indoor air pollution and building-related symptoms as well as the effectiveness of engineering controls and air filters for reducing indoor air pollution. For example, a study by Min Jeong Kim et al. showed that ventilation systems can improve indoor air quality(30), and a study by Wei Dong encompassing 44 children in Beijing revealed that ionization air purifiers can improve children's health(31).

Similar to a Swedish study, the installation of new ventilation systems can improve classroom indoor air quality by increasing individual airflow and air exchange rates (32). In addition, many epidemiological studies had conclusively established the association between indoor air pollution and inflammation of the respiratory passageways in children. However, limited studies of program for reduce indoor air pollution in childcare center by management control. Because some place has limitations when change by engineering control and focus on Caretakers in childcare center. Therefore, this current study aims to access efficacy of program for reduce indoor air pollution by change management control in childcare center and focus on building related symptoms to evaluate from indoor air pollution among caretakers in childcare center at Thailand.

1.2 Knowledge gaps

The many studied reported effect indoor air pollution and building related symptoms and a lot of studied reported the effectiveness for reduce indoor air pollution by engineering control or use air filter and focus on office workers. In addition, the relationship between indoor air pollution and sign and sick from building among office workers had been well established through several epidemiological studies. However, few studies of programs for decreasing indoor air pollution in urban childcare centers have focused on the management control of building-related health symptoms among caretakers. Because some areas cannot be improved by engineering. Therefore, few studies of programs for decreasing indoor air pollution in urban childcare centers have focused on the management control of building-related health symptoms among caretakers.

1.3 Research Question

- Does UCC_IAQ management program effect on BRS among caretaker in childcare center?

- Does UCC_IAQ management program effect on indoor air quality among caretaker in childcare center?

1.4 Objective

General objective

- To access an effect of UCC_IAQ management program on building – related health symptom (BRS) of caretakers.

Specific objectives

- To compare building – related health symptom (BRS) of caretakers in caretakers before and after using UCC_IAQ management program within intervention and comparison group.

- To compare building – related health symptom (BRS) of caretakers in caretakers before and after using UCC_IAQ management program between intervention and comparison group.

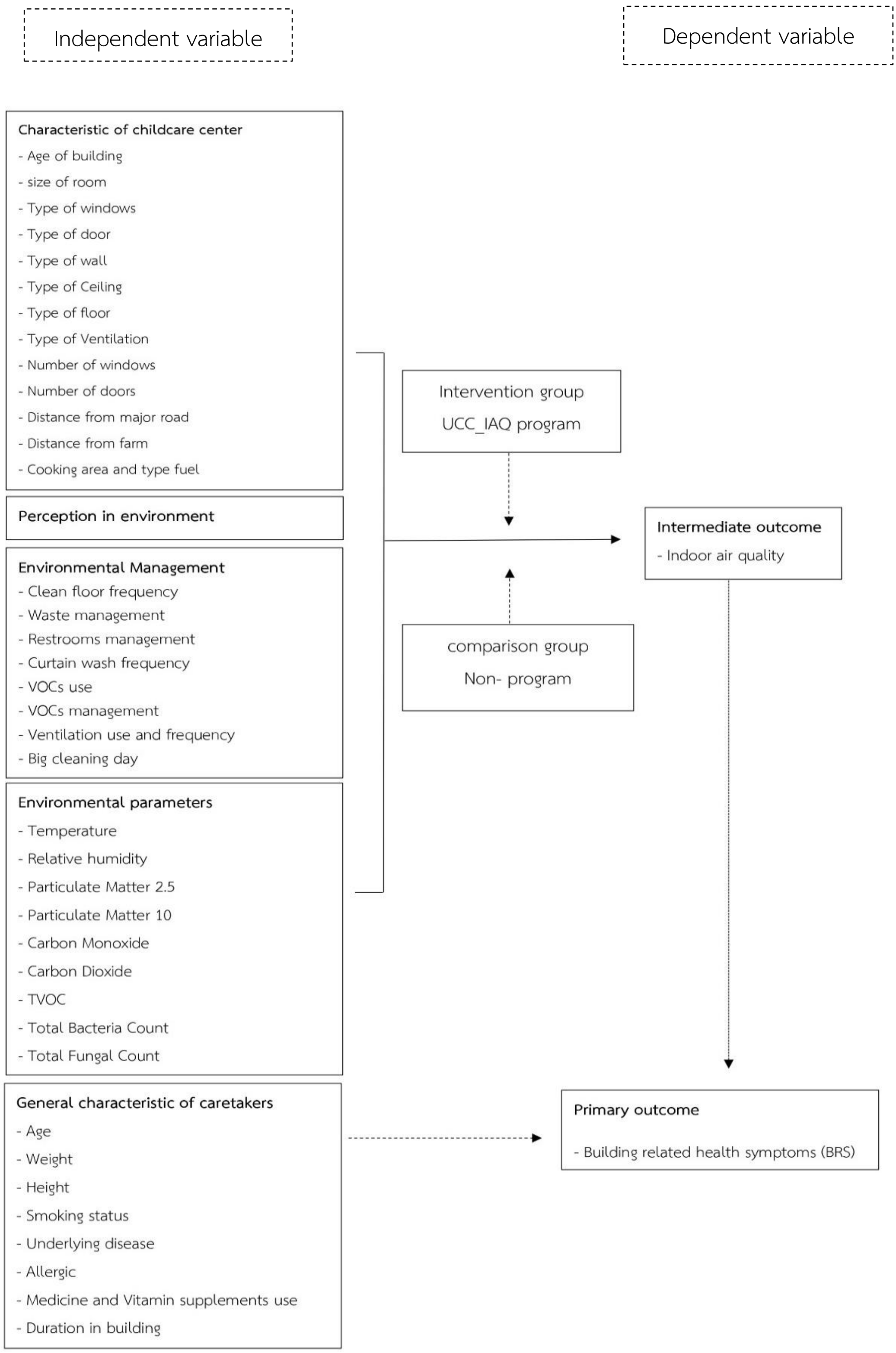
- To compare indoor air quality before and after using UCC_IAQ management program within intervention and comparison group.

1.5. Research Hypotheses

- The UCC_IAQ management program effect on indoor air quality in childcare centers.

- The UCC_IAQ management program effect on BRS among caretakers in childcare center.

1.6 Conceptual framework



1.7 Term of Definition

1.7.1 Operational Definition

Caretakers: In this study, caretaker refer to a person who take care of children in a center more than 1 months.

Childcare center: In this study, childcare center includes a center which located in urban area of central region of Thailand with number of children less than 100.

Urban childcare center indoor air quality management (UCC-IAQ): This intervention program focuses on indoor air quality management of childcare center in urban area of Thailand. This management program includes multi-stakeholders in the center and concentrates on behavioral changes of stakeholders related to indoor air quality. A handbook together with management protocol is engaged in the program.

Intermediate outcome

Indoor air quality: In this study, indoor air quality refers to particulate matter 2.5 micrometers (PM2.5), particulate matter 10 micrometers (PM10), Carbon Dioxide (CO2), Carbon monoxide (CO), Total Volatile organic compounds (VOCs), Total Fungal Count, Total Bacteria Count.

Primary outcome

Building related health symptoms (BRS): BRS focus on 4 major symptoms including General symptoms, Upper respiratory symptoms, Lower respiratory symptoms, and Dermal symptoms. The symptoms are collected as “present” / “absent” and severity during last 1 month and cut point who have only single symptoms form BRS according to BRS criterion (9)

General characteristic of caretaker

Age; In this study focus on caretakers who have age 18 – 59 years old.

Weight; In this study focus body weight among caretaker's unit is kilograms (Kg).

Height; In this study focus body height among caretaker's unit is centimeter (Cm).

Smoking status; In this study focus caretakers had smoking or non-smoking including smoking in the past and dose per day.

Underlying disease; In this study collection all underlying disease and diagnosed by physician before collecting data.

Allergic; For this study including all allergic among caretakers.

Medicine and vitamin supplements; Including all drug and vitamin supplements use regularly more than 1 month

Duration in building; Collection all-time when caretakers live or working in the building and count unit is hours/weeks (approximately), day/month and weeks/month.

Characteristic of childcare center

Age of building; Counting from the building was completed.

Size of room; Calculate size from width multiply by the length multiply by the height unit is cubic meter (m^3).

Type of windows; Classified by materials used the windows such as wood, aluminum plastic.

Type of door; Classified by materials used the door such as wood, aluminum plastic.

Type of wall; Classified by materials used the wall such as concrete, wood.

Type of Ceiling; Classified by materials used the ceiling such as Gypsum sheet, wood.

Type of floor; Classified by materials used the floor such as tile, wood, rubber.

Type of Ventilation; Collection Ventilation use in room and frequency use air conditioner, a/c fan ventilators and windows(nature).

Number of windows; Count from the number of windows in-room use.

Number of doors; Count from the door number in-room use.

Distance from major road; Count from childcare center until the major road. (33), (34)

Cooking area and type fuel; Focus room distance from the kitchen including type fuel use such as LPG gas, firewood. (33), (35)

Environmental Management

Clean floor frequency; For this study interested frequency of floor clean floor per day.

Waste management; In this study collection how to management garbage or waste, focus on storage characteristics, place.

Restrooms management; In this study collection how to management such as clean frequency, cleanser type used VOCs or non VOCs and moisture from restrooms.

Curtain wash frequency; Focus on frequency wash curtain per week or per month.

Volatile Organic Compounds use; In this study interested product childcare center VOCs use.

Volatile Organic Compounds management; In this study interested how to childcare center use VOCs and how to keep VOCs product.

Ventilation use and frequency; Collection Ventilation use in room and frequency use air conditioner, a/c fan ventilators, Air filter system and windows(nature), and frequency of this Ventilation use Hr/day and day/week

Big cleaning day; Focus on frequency childcare center have big cleaning day

Environmental parameters

Temperature; Investigation room temperature the result is average in 8 hours Similar to working hours and report in degrees Celsius (°C).

Relative humidity; Investigation room relative humidity the result is average in 8 hours Similar to working hours and report in percent (%).

CHAPTER II

LITERATURE REVIEW

2.1 Indoor air pollution and standard of indoor air pollution

In 1987 World Health Organization begin published indoor air quality guidelines for Europe inside showed health risk assessments of 28 chemical in air and contaminants indoor air then in 2000 World Health Organization has published second published and update indoor air quality guidelines for global indoor air quality guidelines, third generation in 2005 update again in 2006 in year 2006 guidelines were recommended how to use in microenvironments (table 2.1). However, all of old edition not focus on occupational exposure standards. lead to update in 2009 develop for importance two categories of risk factor of particular it effects with health from indoor air environments in year add biological agents and indoor combustion and the last edition in 2010. From third generation and last edition focus indoor air pollution in developing countries because World Health Organization estimate world population dead from indoor air pollution approximately 3% or about 1.6 million people and showed indoor air pollution its effect health more than outdoor air pollution.

Table 2.1 Pollutants from the WHO indoor air quality guidelines (Year 2006)

Guidelines recommended	**Recommended but evidence not sufficient for guidelines**
1. Benzene	1. Acetaldehyde
2. Carbon monoxide	2. Asbestos
3. Formaldehyde	3. Biocides, pesticides
4. Naphthalene	4. Flame retardants
5. Nitrogen dioxide	5. Glycol ethers
6. Particulate matter ($PM_{2.5}$, PM_{10})	6. Hexane
7. Polycyclic aromatic hydrocarbons,	7. Nitric oxide
especially benzo-(a)-pyrene	8. Ozone
8. Radon	9. Phthalates
9. Trichloroethylene	10. Styrene
10. Tetrachloroethylene	11. Toluene
	12. Xylenes

From table 2.1 World Health Organization recommended used on nine out of the ten compounds listed in guidelines recommended for evaluate indoor air pollution (36), (37)

U.S. Environmental Protection Agency (EPA) was mention to indoor air pollution it effects to health may be two to five times. from scientific evidence has indicated that the air under buildings or home can be more seriously polluted than the outdoor air and other report that people spend time approximately 90 percent time indoors. young people, elderly people and the chronically illness, especially those from respiratory or cardiovascular disease this group is sensitive with pollution it very important protection people from indoor air pollution (38).

The US EPA focus on indoor sources it primary cause pollution indoor air some study was showed building materials, furnishings, products smoking, cleaning, Unvented or malfunctioning appliances or improperly used products it can release pollutants to room and focus on ventilation high temperature and humidity levels in building also effects indoor air pollution. Not only indoor sources outdoor sources still association with indoor air pollution from US EPA focus on outdoor particulate matter, radon and pesticides. The relative importance of any single source depends on with how much pollutant in the air it emits and how hazardous those emissions of pollutant.

US EPA was focus on Indoor pollutants and sources some pollutants different with World Health Organization was showed in table 2.2 (22)

From Thailand in indoor air pollution standard start from 1993 for studies radon indoor in 20 provinces on North of Thailand was found Hight level in this location, in 1999 focus on department store in Bangkok was found 3 of 9 department store Hight level of carbon dioxide, in car park also Hight level of carbon monoxide, particulate matter (PM_{10}) in year 2001 bureau of Occupational and Environmental Diseases (BOED) in Thailand focus on hospital in Thailand showed Nitrous oxide and Halothane Hight level in operation room and Nitrous oxide contaminated around operation room area in present time Thailand focus on 12 pollution according to

1. Temperature
2. Relative humidity
3. Air movement
4. Particulate matter 10 micrometers (PM10)
5. Carbon Dioxide (CO_2)
6. Carbon monoxide (CO)
7. Ozone (O_3)
8. Nitrogen Dioxide (NO2)
9. Formaldehyde (HCHO)
10. Total Volatile organic compounds (VOCs)
11. Total Fungal Count
12. Total Bacteria Count. (39)

Table 2.2 Compare indoor air pollution concern from US EPA, WHO and Thailand.

Pollutants	EPA	WHO	Thailand
Asbestos	✓	X	✓*
Biological Pollutants	✓	✓	✓
Carbon Monoxide (CO)	✓	✓	✓
Formaldehyde/Pressed Wood	✓	✓	✓
Products Lead (Pb)	✓	X	X
Nitrogen Dioxide (NO2)	✓	✓	✓
Pesticides	✓	X	X
Radon (Rn)	✓	✓	✓*
Indoor Particulate Matter	✓	✓	✓
Stoves, Heaters, Fireplaces and Chimneys	✓	✓	X
Volatile Organic Compounds (VOCs)	✓	X**	✓
Secondhand Smoke/ Environmental Tobacco Smoke	✓	X	X

* Only observe but not use for indoor air parameter.

** US EPA separate investigation one by one of VOCs

Table 2.3 Compare Standard indoor air pollution Thailand and US EAP and WHO (39),(40),(41)

Pollutants	Thailand[42]	US EPA[5]	WHO[5]
Temperature	24-26°C	20.2-26.9°C [6]	-
Relative humidity	50-65 %	30–60% [7]	-
Air movement	0.1-0.3 m/s	>0.2 m/s [6]	-
Particulate Matter 10*	50 µg/m^3	150 µg/m^3	-
Particulate Matter 2.5 *	25 µg/m^3	35 µg/m^3	35 µg/m^3
Carbon Monoxide (CO)	9 ppm	9 ppm	10 ppb
Carbon Dioxide (CO_2)	1000 ppm	1000 ppm	-
Ozone (O_3)	0.1 ppm	0.08 ppm	0.064 ppm
Formaldehyde (HCHO)	120 µg/m^3	-	0.081 ppm
Total Volatile Organic Compounds (TVOC)	3 ppm	- **	-
Total Bacteria Count	500 CFU/m^3	-	100 CFU/m^3
Total Fungal Count	500 CFU/m^3	-	500 CFU/m^3

* average of 24 hr., ** US EPA separate investigation one by one of VOCs

Table 2.4 Standard indoor air pollution of Thailand (42)

Pollutants	Thailand
Temperature	24-26°C
Relative humidity	50-65 %
Air movement	0.1-0.3 m/s
Particulate Matter 10*	50 µg/m^3
Particulate Matter 2.5 *	25 µg/m^3
Carbon Monoxide (CO)	9 ppm
Carbon Dioxide (CO_2)	1000 ppm
Ozone (O_3)	0.1 ppm
Formaldehyde (HCHO)	120 µg/m^3
Total Volatile Organic Compounds (TVOC)	3 ppm
Total Bacteria Count	500 CFU/m^3
Total Fungal Count	500 CFU/m^3

2.2 Indoor air pollution and Sources

2.2.1.Particulate matter

In the study focus on 2 type of particulate matter is $PM_{2.5}$ and PM_{10} are particles of all solid or liquid in air, PM_{10} are particles of all solid or liquid in air are generally 10 micrometer, $PM_{2.5}$ are particles of all solid or liquid in air are generally 2.5 micrometer.

Sources of particulate matter It come from outdoor and indoor sources, from outdoor can spread from outdoor to indoor when open door or windows even leak of door, windows, wall or building design all effect to outdoor particulate matter can move to indoor. indoor sources also effect can be generated from smoking, cooking or some hobbies can be generated particulate matter such as small woodcutting .(43, 44)

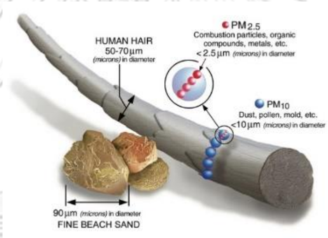


Figure 2.1 Size of $PM_{2.5}$, PM_{10} compare with human hair and sand (43)

2.2.2 Carbon Monoxide

Carbon monoxide it gasses odorless, no color but toxic for human in general human can’t see or smell some time can see by see fumes.

Carbon monoxide come from incomplete oxidation by fuel, wood, gasoline, automobile exhaust or from tobacco smoke. WHO was shows people all word exposed with household air pollution resulting from cooking 41% Sometime Carbon monoxide come from outdoor but can lead to house or building by gap of windows, door or house ventilator. (1), (45)

2.2.3 Carbon Dioxide

Carbon Dioxide (CO_2) consists from one carbon atom and two oxygen atoms a colorless gas it come from nature such as volcanoes, hot springs or from human and animal respiration, burn, the vehicle, burning fossil fuels, solid waste, some human activity and Industry. Source of Carbon Dioxide similar to Carbon monoxide it come from incomplete oxidation by fuel some studies show classroom close to main road level of Carbon Dioxide it high when compare with classroom far from main road (34)

2.2.4 Ozone (O_3)

Ozone (O_3) composed of oxygen three atoms come from nature by solar ultraviolet radiation reaction with oxygen molecular and come from man-made some product can increase ozone to air it formed photochemical ozone. However, ozone in troposphere or lower than stratosphere (Ground level) ozone it toxic with human. In troposphere main reason from nitrogen oxides and group of volatile organic compounds (VOC) with UV and hot temperature, UV and hot temperature from sunlight reaction with nitrogen oxides and moisture in air (H_2O) it generate ozone in troposphere level followed Figure 2.2. (46), (47)

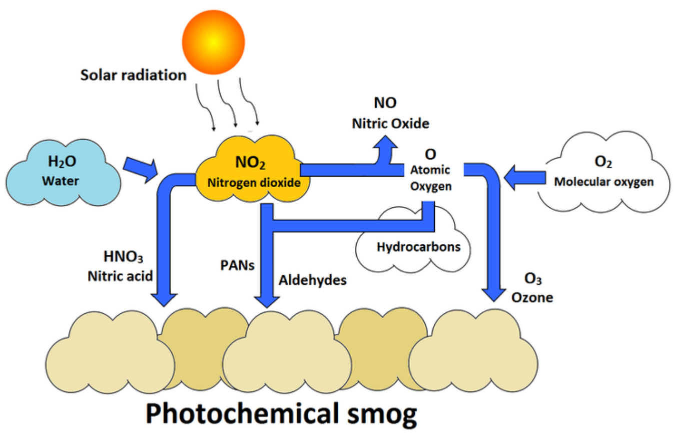


Figure 2.2 Ozone formation from nitrogen oxides in stratosphere (47)

2.2.5 Formaldehyde (HCHO)

Formaldehyde or Formalin is chemical compound from hydrogen, oxygen and carbon and showed in gas state, colorless in the room temperature but strong smell gas. Formaldehyde can come from organism and human make. From organism Including human, animals, bacteria or plants. Formaldehyde is product of metabolism system. From human use formaldehyde in household products such as pressed-wood products, glues products, wood furniture coating, plastic products, rubber products, fabric products, resin, fiberglass paper, house paint or electrical products. (48), (49), (50)

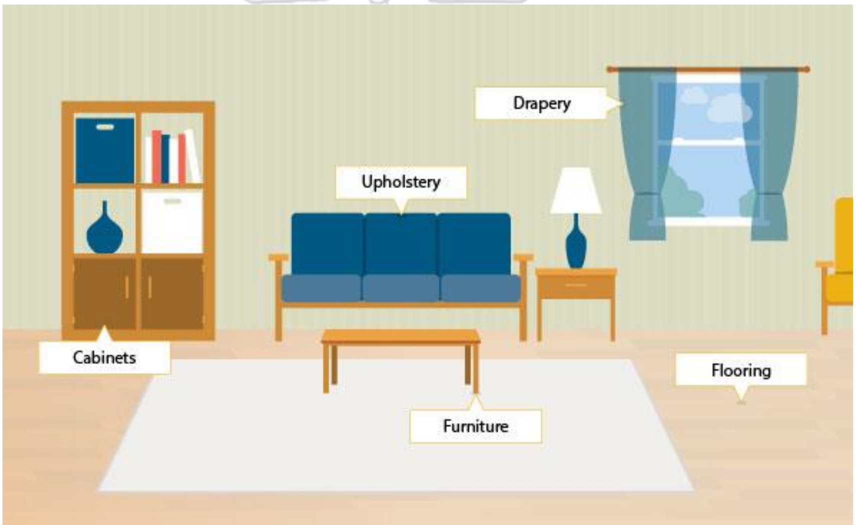


Figure 2.3 Indoor formaldehyde source (50)

2.2.6 Volatile Organic Compounds (VOCs)

Volatile Organic Compounds means many carbon compounds whereas excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate it action with atmospheric photochemical reactions and VOCs it evaporate under room temperature and normal environment (51). And source of VOCs had two major sources one from outdoor and indoor sources from many studies was a show VOCs from outdoor can lead to the indoor environment moreover some studies found the VOCs concentration indoor higher than outdoor for the example studies from Aynul Bari et al. from Canada, show indoor have VOCs more than out door and 70% among indoor VOCs come from indoor sources and showed 44% of indoor VOCs come from household products, tobacco smoke 10.5%, deodorizers 8.4% and building materials 5.9%. Main outdoor VOC sources include fossil fuel vehicles, oil industry, gas industry. (52)

2.2.7 Indoor microorganisms (bacterial and fungal)

Microorganisms it general in environment in normal microorganisms it beneficial and detrimental to humans. microorganisms' aerosols and airborne have a chance penetrate to indoor environment or be generated within them by daily activities. these microorganisms can be controlled volume by eliminating or reducing their sources of microorganisms. In environment can specify sources of indoor microorganisms 7 major sources 1). Humans 2). Plants in room or close room 3). Pets 4.) Plumbing system 5). Ventilation system 6). Air conditioning system (heating and air-conditioning systems) and 7.) outdoor environment (53)

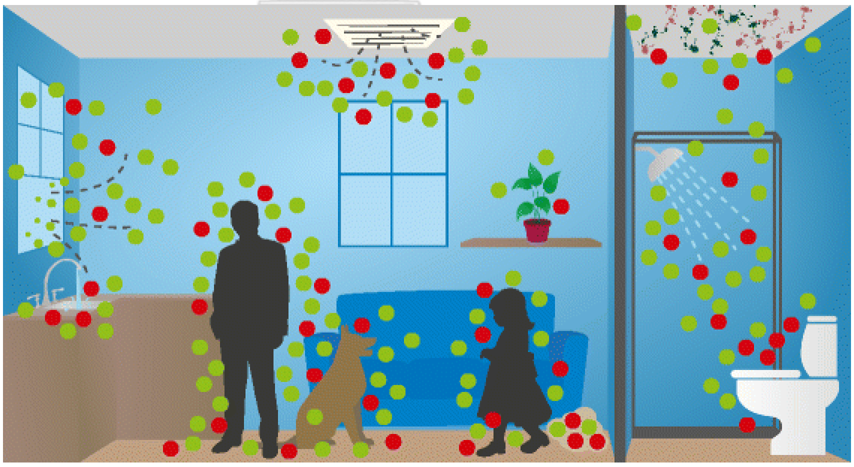


Figure 2.4 sources of indoor microorganisms (53)

2.3 Indoor air pollution and health

The health effects of air pollution many reports show air pollution with heart disease, cardiovascular disease, and lung cancer. Some reports use microscopic to seen effect from small pollutants that can slip past into the respiratory tract, circulatory system, brain, heart, and cell. In the World Health Organization show some time can see smog but air not clean. Many cities around the words have air pollution problems, an average of air quality annual values recommended from WHO's air quality guidelines(54). US EPA shows effects from indoor air pollution the same outdoor but indoor air pollution it Hight effect more than outdoor Some health effects may show in shortly after onetime exposure with pollutants or repeated exposures to indoor air pollutants. After exposure to pollution body shows some symptom two group 1. Short-Term effects or Immediate Effects 2. Long-Term Effects

For short effects or Immediate effects may represent in short time may minute, hour, day. Symptom such as, eyes symptom, nose symptom, respiratory symptom, headaches, dizziness or fatigue. However, body reflect from indoor air pollution depends on many effects including age gender body weight, underlying disease, medical conditions or individual sensitivity. it is very important for attention to the time and the place when symptoms show. If the symptoms lessen or recover when some one person is away from the location for example, someone stay in room after that feel dizziness don't know source and leave from room feel better its possible dizziness come from indoor air pollution.

For Long-Term Effects its cumulative effect, effects may represent in week, month or year after exposure indoor air pollutant has occurred or long-term effects was showed after long or repeated periods with exposure. The effect lead to respiratory diseases, heart disease cancer or severely debilitating in fatal.(22)

According data from World Health Organization and US EPA air pollution effect many people studies of human exposure with indoor air pollution show indoor air pollution levels of pollutants may high two to five times and sometime more than 100 times when compare with outdoor levels. It very important levels of indoor air pollutants because most people spend time about 90% time indoors or in budding(55). However, the building or house can't protect people from air pollution Monika scibor and others investigates 24 hour 179 locations in Krakow of concentrations PM_{10} and $PM_{2.5}$ compare outdoors and inside homes conducted data from questionnaire and air pollution data in report show relationship between concentrations of PM_{10} ($r = 0.78$, $p < 0.001$) and $PM_{2.5}$ ($r = 0.82$, $p < 0.001$) it increases indoor concentration follow by outdoors increase concentration ($p < 0.001$). and some paper show effect indoor air pollution increase when people spend time indoors more people spend time outdoor in this studies show type of window and open windows effect to indoor air pollution, windows double-glazed and draught sealed and not open windows when high outdoor pollution it can control indoor air pollution (56) study from Liqun Liu and others use a case-control study design for evaluate the relationship among indoor air pollution, tobacco use with lung cancer was showed indoor air pollution has associations with lung cancer who live in this building (57).

In this study scope on 5 types of indoor air pollution with human health and human health including particulate matter 2.5 and 10, Carbon Monoxide, Carbon Dioxide, Ozone (O_3), Formaldehyde (HCHO), Total Volatile Organic Compounds (VOCs) Indoor microorganisms. For human health effect focus on 2 types of signs first, sign building-related symptom and second upper respiratory tract inflammation will test inflammation of upper respiratory tract by saliva nitric oxide

2.3.1 Particulate matter 2.5 and 10 with health

Particulate matter its small size is direct to the human body and causing many health problems especially Particulate matter size lower than 10 micrometers in diameter because their very small size can get long or can lead to the blood circulation it effects to heart, lung and lung development in children, blood Vessel. Moreover, particulate can generate other human diseases such as a group of lung disease, group of heart disease, vascular disease, diabetes, obesity, birth weight, preterm deliveries, death fetus in utero and many reports that particulate matter is linked to an increased risk of hospital admissions heart attack and premature mortality (58) , (59). From study from Taiwan included 285,046 participants findings the associations long-term exposure $PM_{2.5}$ and reduced lung function when $PM_{2.5}$ increment 5 $\mu g/m^3$ was associated with forced vital capacity (FVC) a decrease 1·18%, a decrease 1·46% for forced expiratory volume in 1 s (FEV1), maximum mid-expiratory flow (MMEF) a decrease 1·65% , ratio of forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC) 0·21% from annual report the study findings more a decrease when compared to first quartile as follows FVC decrease 0·14%, FEV1 decrease 0·24%, MMEF decrease 0·44%, and FEV1:FVC ratio 0·09%. And hazard ratio who exposure with $PM_{2.5}$ for fourth quartiles = 1·23 (95% CI 1·09–1·39), third quartiles = 1·30 (1·16–1·46), and second quartiles = 1·39 (1·24–1·56) for COPD development. (60)

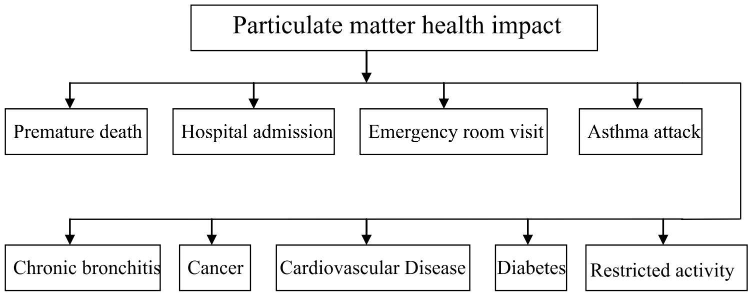


Figure 2.5 Health effect of Particulate matter (58)

2.3.2 Carbon Monoxide with health

Carbon monoxide poisoning all generations nevertheless infants, elderly, and people live with underlying disease chronic heart disease, anemia, and respiratory disease.(61), in accordance with a study in China studied from secondary data focus on all respiratory diseases and those for asthma, bronchiectasis , chronic obstructive pulmonary disease (COPD) and number daily hospital outpatient visit compare with level Carbon monoxide findings Carbon monoxide increase the risk for respiratory diseases, asthma, bronchiectasis and pneumonia among 89,484 hospitals when after 3 days exposure with Carbon monoxide increase the hospital outpatient all respiratory diseases increase 5.62%, asthma increase 8.86%, bronchiectasis increase 6.67% and pneumonia increase and 7.20% at 95% confidence interval.(62) and articles from Hiroshi Kinoshita showed carboxyhemoglobin (CO-Hb) level and toxicity in the respiratory system (acute effect) in table 2.5 (63)

Table 2.5 Levels of carboxyhemoglobin saturation and clinical symptoms.

CO-Hb (%)	clinical symptom
< 1	normal range (due to endogenous production)
< 10	smoker's blood (no symptom)
10–20	headache, fatigue, ear ringing
20–30	headache, weakness, nausea, vomitting
30–40	severe headache, dizziness, nausea, vomitting
40–50	syncope, confusion, increased respiration and heart rate
50k60	coma, convulsions, depressed respiration
60–70	coma, convulsions, cardiopulmonary depression, often fatal
70 <	respiratory failure, death

2.3.3 Carbon Dioxide with health

The health effects associated with exposure to carbon dioxide concentration when exposure high concentration via inhaled after carbon dioxide come to respiratory tract in alveolar membrane carbon dioxide can diffused same oxygen in alveolar when carbon dioxide leak to circulation system can lead to loss of controlled, loss of consciousness, convulsions, hypoxic or death(64). Studies from 600 elderly people from 50 nursing homes reported indoor carbon dioxide associated with breathlessness and cough among elderly people (65) and second studies present when 25 subjects exposures with carbon dioxide concentration 3000 ppm in 255 min the subjects show symptoms headache, fatigue, sleepiness and difficulty in thinking clearly(66).

2.3.4 Ozone with health

People breathing since taken up in the nose ozone in the troposphere can affect to health effects when the body get ozone by inhaled ozone can react with chemically in the respiratory tract 80% of Inhaled ozone is deposited on the airways it effects to health such as deduct lung function, airways Inflammation or neutrophilic inflammation, bronchoconstrictors, coughing, discomfort when taking a deep breath, wheezing, shortness of breath and airway injury. from observational studies show when daily ozone levels in troposphere increased are associated with increased asthma attacks are associated with increased the patient of asthma attacks among hospital admissions and increased mortality. The effect of ozone lessens after an elevated ozone exposure about 48 hr. And airways Inflammation from ozone increase in small airway obstruction, decrease in the integrity of the airway epithelium and airway reactivity (67), (68) as same as studies from University of North Carolina USA studies reported ozone cause of epithelial injury, inflammation and airway hyperreactivity and oxidative stress cause of inflammation, cytokines and proteases driving leading to alveolar epithelia with emphysema and respiratory failure.(69) like studies from 26 subjects found ozone exposure association with cardiovascular diseases and decrease in lung function, airway inflammation, and airway injury among 26 subjects had mild asthma.(70)

2.3.5 Formaldehyde with health

Formaldehyde increases indoor have health problems with people live in building most health problems show will show have breathing problems or irritation of the eye or the nose some time show skin irritation when exposure formaldehyde. Formaldehyde it can affects with all people nevertheless children or older people and people have respiratory diseases such as asthma or Chronic Obstructive Pulmonary Disease (COPD) and other breathing problems are more likely to have more of these symptoms from formaldehyde. (50)

Long-term Health Effects from formaldehyde has been linked to rare nose cancers and throat cancers(50) same as the study from Ying Zhou et al mention formaldehyde can cause of nose cancers and throat cancers and take the people disability-adjusted life year (5.5 years) (71) and study from Korean found risks of leukemia and Hodgkin lymphoma from reviewed reports occupational exposure to formaldehyde in largest industrial the study concluded high exposure formaldehyde among worker significant with leukemia and Hodgkin lymphoma (72).

2.3.6 Total Volatile Organic Compounds with health

Volatile Organic Compounds a chemical to cause health effects as same as other chemical the level of exposure and duration of exposure it effects to toxic from volatile organic compounds from shot time effects include conjunctival irritation, burning nose or throat discomfort, skin allergic, headache, nausea, emesis, fatigue or dizziness(73). According with systematic review from 852 papers from evidence VOCs exposure can develop to asthma, allergy (74) and studies among the worker plastic recycling factory found high level indoor TVOCs microenvironments. lifetime cancer risk assessment among worker plastic recycling factory suggested also suffered from definite cancer risk (75). As same as studies from Hua approved VOCs effect with human genes VOCs can motivate oxidative stress in human genes level Rheumatoid Disease, immune diseases, cancer.(76)

2.3.7 Indoor microorganisms with health

Microorganisms in buildings or houses are at increased risk of respiratory infections, inflammatory or increase of asthma symptoms, risks of allergic rhinitis, asthma. Many studies showed exposure with exposure to mold or microbial agents increase risks of hypersensitivity pneumonitis, allergic chronic rhinosinusitis among nonatopic populations. Especially allergic people are easy sensitive to biological and chemical agents. The symptoms increasing prevalence's asthma or allergies in many countries people susceptible to the effects from microorganisms in dampness area. (77) from systematic review found microorganisms from carpets can generate microorganisms the most likely cause unhealthy and associated with irritative symptoms or asthma.(78) similarly to other studies mention microorganisms particularly with cough symptoms among urban areas of China (79) and studies use Meta-Analyses focus on specific health outcomes from exposure to dampness and mold 15% of allergic, 16% of asthma cases and 14% of bronchitis cases in the USA relative with indoor mold exposure and people go to hospital from exposure to dampness and mold. (80)

2.4 Health effect from indoor air pollution

2.4.1 Building – related symptom

Sick from building it focus on eyes symptom, nose symptom, respiratory symptom, headaches, dizziness or fatigue in working people in building but can't find main cause some time many people in building same symptom this concept develop from WHO as a medical condition in 1983 it focus on from indoor environment and health explain by pathophysiologic mechanism and inside mention to Sick Building Syndrome (SBS)(8) In United States use building related symptoms all it mention to a group of symptoms of unclear cause and is relation with work in or occupation in building, it not only office building it including house, schools, hospitals and definition of Sick Building Syndrome "a collection of nonspecific symptoms including eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritations, which seem to be linked with occupancy of certain workplaces" when combined with Syndrome The meaning is A group of symptoms who live in building or Indoor it may have one symptoms or some symptoms or all symptoms of the ill-health subclinical symptoms (9). However, Sick Building Syndrome can develop to a building-related illness if clearly identifiable causes come from indoor air pollutant. building-related illness is focus on cause of an illness is known cause and related with the person who spending time in the building (10). In book name "Sick Building Syndrome in Public Buildings and Workplaces" by Sabah A. Abdul-Wahab had definition of Sick Building Syndrome is syndrome of signs or symptoms of unhealthy or sick from building (Including; walls, roof, doors, windows etc.) and indoor environment it causes of unhealthy or sick who live, work, spend time in building (10).

However, this study will use building related symptoms (BRS) for cover all signs and symptoms and use building related symptoms is signs or symptoms was showed start from one signs or symptoms of unhealthy or sick from indoor environment and use 4 criteria for cut building related symptoms out of other causes as follows.

1. Who complain or show signs and symptoms associated with acute non-comfortable e.g., sneezing, running nose, rash, Itching eyes

2. The cause of the signs and symptoms is not known.

3. Who complain or show signs and symptoms when live in childcare center and relief soon after leaving from childcare center.

4. Have same signs and symptoms again when come to budding.

Janis Jansz summarizes in article topic about SBS have included common symptoms and likely causes or sources related with building related symptoms in figure 2.6 and model of causes of sick building syndrome

Table e groups of health problems related to building occupancy (Property Council of Australia, 2009, p. 37)

Common symptoms	*Likely causes or sources*
Group A	Outdoor air rates and distribution
Headaches	Possible air pollution
Lethargy	Carbon monoxide may be entering from outdoor air intakes
Nausea	Other obvious pollutant generators from neighboring or industrial sources may be present
Drowsiness	
Dizziness	
Group B	Pollutants entering air stream from local pollutant generators; the outdoor air quality; HVAC-related problems; building materials
Congestion	
Swelling	Be aware of hypersensitivities and other preexisting medical conditions in individuals
Itching or irritation of eyes, nose, or throat	Lighting problems, e.g., flicker caused by magnetic ballasts and computer glare, which contribute to eye irritation
Subclinical symptoms (e.g., headache, fatigue, nausea)	
	Ergonomic problems, e.g., muscle strain, eye strain, and fatigue
Group C	Stimulated by thermal discomfort factors including temperature and humidity settings, outdoor air rates, and distribution
Cough	
Shortness of breath	Particulate pollutants such as dust are often irritants
Fever, chills, and/or fatigue after return to the building	More serious fever/chill problems can point to microbial contamination in the building
Diagnosed infection	Microbial problems – acute case scenarios relate to Legionnaires' disease and acute asthma. Chronic cases of asthma, infection, and irritation are more wide spread
Discomfort and/or health complaints that cannot be readily ascribed to air contaminants or climatic conditions	Examine cooling towers, HVAC system, (including ducting) or outdoor air
	May be related to problems with environmental, ergonomic, or other job-related psychosocial factors

HVAC, heating, ventilation, and air conditioning system.

Figure 2.6 summary common symptoms and likely causes or sources related with building related symptoms. (9)

From figure 2.6 Janis Jansz divided common symptoms 4 group all group had reported, and studies showed the symptoms from indoor air pollutant from this article mention the most common was found from respiratory tract it most common, respiratory tract including running nose, wheezing, dry sore throat, cough, shortness of breath, allergic at nose, sinus congestion, blocked nose, hoarseness of voice, inflammation etc. The second group was showed related with eye irritation included eyes watering or dry, itchiness at eye, eye Irritate, light sensitivity or blurred vision. followed by skin symptoms; skin irritation, dry skin, itchy skin, rash skin and other symptoms headaches or dizziness etc.

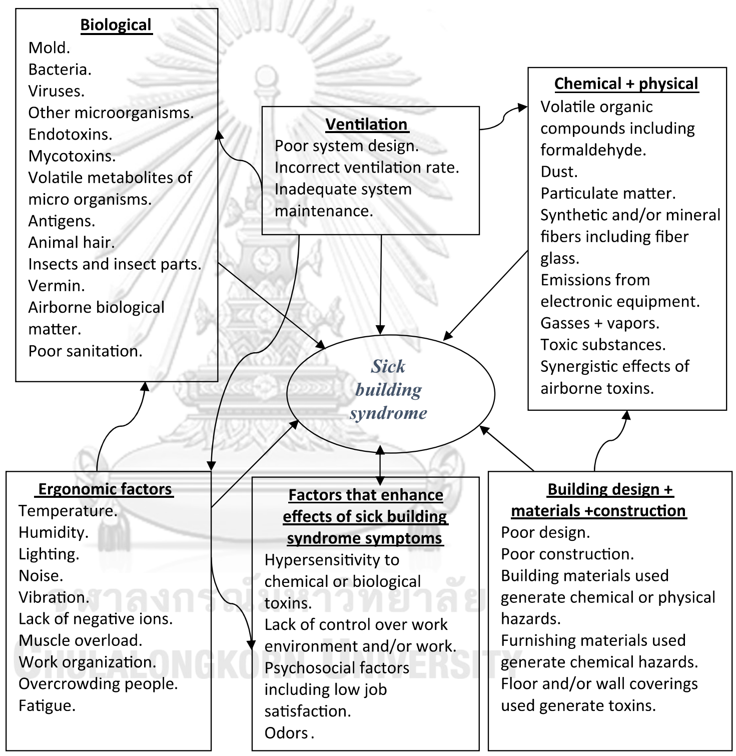


Figure 2.7 Model of causes of sick building syndrome (9)

From figure 2.7showed the main causes of sick building syndrome ware spending time in the building design, building materials and the materials used inside the building because some materials some of these materials spread chemical and health hazards that were causes of SBS. From the figure not only materials design for good ventilation also effects with indoor air pollution because slowly indoor ventilation concentration of pollutant maybe builds up and some biological indoor environmental can contaminants and grown from room or building high humidity. Some biological it effects to health and also effects to symptoms of SBS. In new building, room renovation, new furniture it effects to symptoms of SBS by VOCs it Important to control risk indoor it can reduce symptoms of SBS (9).

Sick Building Syndrome and building related symptoms it interested from The researcher from developed countries or developing countries for example, Kenichi Azuma studies topic building-related symptoms and Physicochemical risk factors from offices divided 2 winter season, summer season total 312 participants from Tokyo, Osaka, and Fukuoka Japan and send self-reported questionnaires to all participants found Winter season high prevalence of SBS than Summer. The highest prevalence were Tired or strained eyes symptoms (18.3%) followed Tension, irritability, or nervousness (prevalence=14.1%) and Dry, itching, or irritated eyes (prevalence=13.9%), upper respiratory symptoms had correlation with indoor temperature increased (OR=1.55). Upper respiratory symptoms were correlated with particles ($PM_{0.3}$) from air-conditioning systems use in winter (OR=1.31) (81). Other cross-sectional study from Japan among 3024 office worker showed prevalence of BRS in summer season higher than that in winter 27.8% VS 24.9% and symptoms the most weekly prevalence was general symptoms 18.3%, Second eye irritation 14.1% and upper respiratory symptoms 6.7% when use risk factors examined analyses with SBS showed air dryness had associated with SBS, humidity was significant with general symptoms in summer season (OR=1.20) and other showed carpeting use, recently painted walls, unpleasant chemical, dust were significant risk factors of BRS(82). Similar to studies from Sweden and focus no VOCs among room in hospital and collecting building related symptoms (BRS) data from included 51 people working in hospital. BRS show in room petrochemicals and chemicals emitted from plastics (83) as same as studies among urban buildings in India in the study was conducted data from non-residential in July – September temperature is 13-44 °C, relative humidity 14-70%. conducted indoor air 8 hour every working day from each building the studies focus on $PM_{2.5}$, VOCs and CO_2. Results was showed the average of CO_2 higher than the ASHRAE standard some buildings $PM_{2.5}$ level higher than the ASHRAE standard in studies found the buildings use air-filtration $PM_{2.5}$ level lower ASHRAE standard and occupant density in buildings effect to indoor air pollution (84) and study from indoor air pollution and health risk factors in households, China. measurements level $PM_{2.5}$, Formaldehyde, acetaldehyde, VOCs, SVOCs, airborne fungi and fungi in autumn and winter season and use questionnaire conducted data from with schoolchildren 10-12 years old from the affiliated primary school of Hunan University, the questionnaire accordance with American Thoracic Society-Division of Lung Disease (ATS-DLD) and focus on indoor air pollution with health risk factors among schoolchildren was showed concentrations of CO_2 most schoolchildren households lower 1000 ppm, concentrations of $PM_{2.5}$ all for schoolchildren households higher than the Chinese national standard (75mg/m^3), Total VOCs level higher than the Chinese national standard(85).

In the study focus on indoor air pollution including particulate matter 2.5 micrometers ($PM_{2.5}$), particulate matter 10 micrometers (PM_{10}), Carbon Dioxide (CO_2), Carbon monoxide (CO)
Ozone (O_3), Formaldehyde (HCHO), Total Volatile organic compounds (VOCs), Total Fungal Count, Total Bacteria Count and group of comfort including Temperature, Relative humidity and can divide group of indoor air pollution is 3 type from structure and components

1. Particles and Aerosols including particulate matter 2.5 micrometers ($PM_{2.5}$), particulate matter 10 micrometers (PM_{10}).

2. Biological including Bacterial and Fungal.

3. Gas including Carbon Dioxide (CO_2), Carbon monoxide (CO) Ozone (O_3), and Formaldehyde (HCHO).

2.5 Standard Construction of Childcare Center

From national standard for early childhood care development and education of Thailand have explained standard construction of childcare center as follows

1. The structure of the building is sturdy and have clearly of entrance and exit, building it make from standard material not close to dangerous zone.
2. The childcare center not close to source of outdoor air pollution, water pollution, soil pollution such as factory, Gas transportation area.
3. Have a check building and improve plan system every 3 months.
4. Problems are analyzed when find a problem by solving system. (86)

2.3 Instruments that are used to evaluate the quality of indoor air

In this investigation, the instruments utilized to evaluate indoor air quality corresponded to the requirements established by the Bureau of Environmental Health, Department of Health, Ministry of Public Health. The Met One Aerocet-531S was used to evaluate PM2.5 and PM10, which are respectively small and coarse particles that can cause respiratory problems and exacerbate preexisting diseases including asthma and allergies.

Carbon dioxide (CO2) and carbon monoxide (CO) are important pollutants that must regularly be monitored as an indicator of the quality of indoor air. High levels of CO2 and CO can cause headaches, dizziness, and even cognitive damage. and even death in extreme cases. Consequently, the Indoor Air Quality Monitor - AQ Expert was used to measure CO2 and CO levels in this study.

Using the Indoor Air Quality Monitor - AQ Expert, total volatile organic compounds (TVOCs) were also measured. TVOCs are a collection of volatile organic compounds generated by household items such as cleaning agents, paints, and air fresheners. They can cause respiratory problems, headaches, and eye irritation.

In addition to these harmful substances, the study included the IUL Spin Air Samplers 90005500 to measure the Total Fungal Count and Total Bacterial Count. These instruments are used to gather and assess air samples for fungal and bacterial growth. Excessive exposure to these microbes can cause a variety of health problems, including allergies, respiratory infections, and even pneumonia.

According to the criteria of the Bureau of Environmental Health, Department of Health, and Ministry of Public Health, this study measured indoor air quality using a variety of instruments. The acquired data provided useful insights into the level of pollutants and microorganisms present in the indoor environment and assisted in identifying solutions to improve indoor air quality for the health and well-being of the residents.

There was also a literature study related to the measuring of indoor air pollution as follows

PM2.5 and PM10

One tool commonly used to measure PM2.5 and PM10 dust is a particulate matter (PM) monitor. One popular brand of PM monitor is the Met One Particle Counter GT531S. Other brands and models are also available(87).

Particulate matter (PM) is a type of air pollution that consists of tiny particles suspended in the air, which can be harmful to human health and the environment.

The size of these particles is an important factor in determining their potential impact on health. PM2.5 refers to particulate matter that has a diameter of 2.5 micrometers or less. These particles are very small and can be inhaled deeply into the lungs, potentially causing respiratory problems and other health issues. Sources of PM2.5 include vehicle exhaust, power plants, and wildfires. (88) (89) (90) (91)

PM10 refers to particulate matter that has a diameter of 10 micrometers or less. These particles are still small enough to be inhaled, but they are larger than PM2.5 particles and are more likely to be trapped in the upper respiratory system. Sources of PM10 include road dust, construction sites, and industrial activities.

Overall, both PM2.5 and PM10 are important measures of air quality, and governments and organizations around the world monitor levels of these pollutants in order to protect public health and the environment.

There are different types of PM monitors that use various methods to measure PM2.5 and PM10 dust. These include:

1. Optical particle counters: These monitors use lasers to detect and count particles as they pass through the monitor. They can provide real-time measurements and are often used in indoor air quality monitoring.

2. Gravimetric samplers: These monitors collect particles on a filter, which is then weighed to determine the amount of particulate matter. This method is often used for long-term monitoring and can provide accurate measurements but requires laboratory analysis.

3. Beta attenuation monitors: These monitors use beta radiation to detect and count particles as they pass through the monitor. They are often used for outdoor air quality monitoring.

4.Condensation particle counters: These monitors use a condensation process to enlarge and detect particles. They can provide real-time measurements and are often used for indoor air quality monitoring.

In summary, there are various types of PM monitors that use different methods to measure PM2.5 and PM10 dust, including optical particle counters, gravimetric samplers, beta attenuation monitors, and condensation particle counters.(92) (93, 94) (95)

Nonetheless, in this study the standard equipment of Thailand's Department of Health's Bureau of Environmental Health was used to test pm2.5 and pm10 (Met One Particle Counter GT531S).

Temperature and the Relative Humidity

Temperature and the Relative Humidity of the Air Are Measured Here There are now three primary approaches to measuring, which can be broken down as follows:

1. Psychrometer is traditional instrument consists of two thermometers, one of which includes a wet wick. The relative humidity is calculated using the difference in temperature between two thermometers. While being less handy than digital equipment, analog devices can be accurate and cost-effective.

Figure: Traditional psychrometer

2.The digital thermo-hygrometer is a handheld instrument that simultaneously measures temperature and relative humidity. It is simple to operate and offers precise readings. Certain versions also include a data logging function that allows for the recording of measurements over time.

Figure: Digital thermo-hygrometer

3. Data Loggers: These are little electrical devices that can be left in a room for a period of time to measure temperature and humidity. They can be programmed to take measurements at predetermined intervals and store data for subsequent study.

In this investigation, precise and exact procedures were utilized to measure temperature and relative humidity data. Using data loggers and the Met One particle counter GT531S, these variables were measured and recorded.(96)

Figure: Met One Particle Counter GT531S

Carbon dioxide (CO_2)

Measuring CO2 concentrations in indoor air can aid in determining if a place has sufficient ventilation and air exchange. If CO2 levels are continuously high, it may be necessary to add more ventilation to the space. Proper ventilation is required for the removal of indoor air pollutants, such as volatile organic compounds (VOCs) and other contaminants that can severely impact indoor air quality, occupant health, and comfort.

Carbon dioxide (CO2) in indoor air can be detected with specialized CO2 sensors or meters. These instruments are designed to measure the CO2 concentration in the air, which can serve as an indicator of indoor air quality and ventilation. (96) Many of these sensors also monitor parameters such as air pressure, temperature, and humidity.

The TPI 1010A Indoor Air Quality meter, the Temperature Process Instruments portable AQ-110S Carbon Dioxide (CO2) and Ambient Temperature Meter, and the commercial CO2 sensors provided by IAQ by CO2 Monitoring or AQ EXPERT - Indoor Air Quality Monitor.

Carbon Monoxide (CO)

Carbon monoxide (CO) detectors are electrical instruments that monitor the concentration of carbon monoxide in the air. CO is a colorless, odorless, and tasteless gas that, in high amounts, can be fatal. It is created by the incomplete combustion of fossil fuels such as natural gas, oil, and coal, and is emitted by a variety of sources, including gas stoves, heaters, fireplaces, and automobiles.(97)

Total volatile organic compounds (TVOCs)

The two most commonly used methods for measuring the levels of volatile organic compounds (VOCs) in indoor air are Flame Ionisation Detection (FID) and Photo Ionisation Detection (PID). FID measures the number of combustible organic vapors in the air, while PID measures the number of chemicals in the air. Both methods are accurate and reliable for measuring VOC levels in indoor air. (98)

To ensure accurate and reliable measurements of indoor air quality, the equipment used in this study was calibrated to Bureau of Environmental Health standards. The Bureau of Environmental Health is a department of the Ministry of Public Health. The Department of Health establishes stringent guidelines for measuring and maintaining indoor air quality. These guidelines were adhered to produce accurate and meaningful results in this investigation.

Met One Particle Counter GT531S.

Met One Particle Counter GT5 3 1 S is an instrument for measuring the concentration and size distribution of airborne particles. Using laser-based particle counting technology, particles are detected and counted in real-time.

The Met One is a portable and simple-to-use device that is suitable for a variety of applications, including environmental monitoring, indoor air quality testing, and cleanroom certification, among others. The equipment is designed to monitor particles between 0.3 and 10 microns in size, which encompasses the majority of typical airborne pollutants such as dust, pollen, mold spores, and other particulate matter.

The Met One has an integrated data logger capable of storing up to 8,000 data points. It also has a large LCD display that monitors particle counts in real-time. in addition to other vital information, including flow rate, battery status, and alert status.

Met One was used to collect PM2.5, PM10, temperature, and relative humidity every minute for eight hours in this investigation. Using a Laser diode, 90 mW, 780 nm with an accuracy of 10%, PM 10 and PM 2.5 data are collected.

The Met One Particle Counter GT531S detects and measures particles in the air using a laser diode as its light source. (99) (100)

Figure: Met One Particle Counter GT531S

A laser diode is a semiconductor device that converts electrical energy into light. When a voltage is applied across the diode, it causes a flow of electrons and holes within the semiconductor material, which emits light as photons.

Laser diodes were semiconductor devices that converted electrical energy into light. When a voltage across the diode is applied. It induces an electron and hole flow within the semiconductor material, which emits photons of light. The laser diode in the Met One Particle Counter GT5 3 1 S emits a light beam that passes through an air sample. As air particles pass across the laser beam, they are illuminated. A portion of the light is dispersed in various directions. This scattered light is subsequently detected by the particle counter's photodetector, which turns it into an electrical signal. The electronics of the particle counter subsequently process the electrical signal to determine the size and concentration of airborne particles. The intensity of light dispersed by a particle is exactly proportional to its dimension. So that the particle counter can calculate the particle size based on the amount of scattered light. The electronics of the particle counter subsequently process the electrical signal to determine the size and concentration of airborne particles. The intensity of light dispersed by a particle is precisely proportional to its dimension. So that the particle counter can calculate the particle size based on the amount of scattered light. (100) (101) (102) (103)

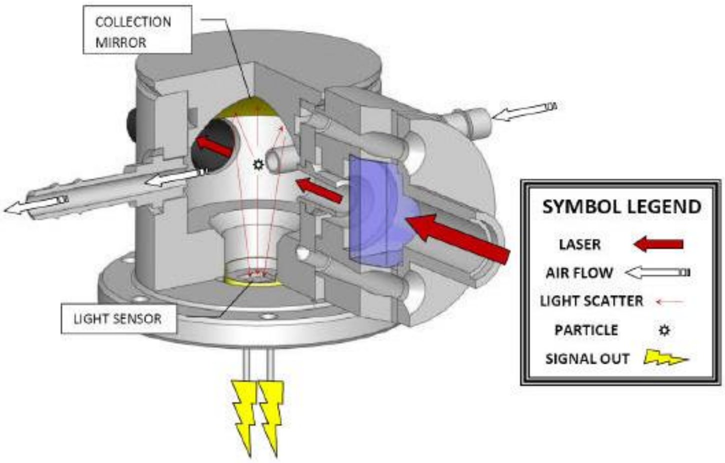


Figure: Laser diodes Anatomy(100)

An example of research using the Met One Particle Counter for data collection. The studies for the Met One Particle Counter are to collect data on exposure to coarse and fine particulate matter at and around major intra-urban traffic intersections, such as in the Nigerian metropolitan area of Ilorin. The paper uses data related to the concentration levels and composition of suspended particulate matter in different sizes emitted at major traffic intersections in Ilorin metropolis. In addition, the Met One GT531S was utilized to measure the area's particulate matter levels for this study. And The study also analyzes the seasonal variations and on-road respiratory deposition dose rates of particulate matter. The data is used to determine the contribution of different sources of particulate matter emissions using principal component analysis. The concentrations of PM (PM1.0, PM2.5, and PM10) measured at traffic intersections during rush hours were higher than those measured during non-rush hours, according to the study. In addition, the study discovered that the on-road respiratory deposition dose rates of PM1.0, PM2.5, and PM10 during the dry period at traffic intersections were higher than those obtained during the rainy period. Based on the calculated EF values, the paper determined that Pb and Zn were anthropogenic while Fe, Mn, Cr, Cu, and Mg were crustal. The principal component analysis (PCA) revealed that the most significant factors derived from particulate emission data were related to exhaust and non-exhaust emission sources, such as tire wear, oil, and fuel combustion (104). In Iran, there is also a study published AERMOD Modeling of Cement Factory Air Pollution

Dispersion. The study implements the AERMOD model, which is a dispersion steady-state model, to determine the concentration of various pollutants in various urban and rural, flat and rough, shallow diffusion in height, from perspective, and various shallow sources. The model posits that the concentration dispersion in the Stable Boundary Layer (SBL) in two horizontal and vertical directions is comparable to the horizontal concentration dispersion in the Gaussian convectional boundary layer. (CBL). Through environmental measurements and dispersion and diffusion modeling of pollution (AERMOD) by Met One GT-531, the quantity of particulate matter emitted by the cement factory and the nature of its dispersion in the adjacent areas will be determined. According to the results presented in the paper, the highest level of particulate matter concentration in all areas affected by the cement factory is 43.68 (g/m3), which occurred at a distance of 1500 meters in the east and 2100 meters in the north. The study emphasizes the significance of modeling air pollutants in order to evaluate air pollution standards, particularly in regions where measurement and installation of assessment and monitoring stations are impractical.(105). And study to investigated the singular and interaction effects of influencing parameters such as temperature, the volume of cooking oil, and time on cooking oil evaporation rate and pollutants emissions. The study also analyzed the density, viscosity, kinematic viscosity, smoke, flash and fire points of the cooking oils. The paper implemented data on the evaporative emissions of fifteen commonly used culinary oils, in addition to data on their density, viscosity, kinematic viscosity, smoke, flash, and fire points. The study investigated the effects of temperature, cooking oil volume, and time on the evaporation rate and pollutant emissions of cooking oil.(87)

Indoor Air Quality Monitor – AQ Expert

The AQ EXPERT - Indoor Air Quality Monitor is a device created exclusively to test the CO_2 concentration in indoor air. The Bureau of Environmental Health of Thailand's Department of Health recommends applying this instrument to monitor CO_2 since it is a dependable and precise method for measuring the concentration of this gas in the air. Therefore, this study used an instrument for measuring CO_2 in accordance with Thailand's Bureau of Environmental Health guidelines.

A typical Indoor Air Quality Monitor (IAQM), such as the AQ Expert, measures various parameters of the air quality in a room using sensors. These sensors detect and measure the concentrations of various airborne contaminants and compounds. The IAQM then analyzes the data collected by the sensors and displays it on a digital screen for the user.

Generally, the AQ Expert measures parameters such as:

1. Carbon monoxide (CO) and Carbon Dioxide (CO2) - The AQ Expert measures the concentration of CO and CO2 in the air, which is predictive of inadequate ventilation and high occupancy levels.

2. Volatile Organic Compounds (VOCs) - The AQ Expert measures the concentration of VOCs in the air using a metal oxide semiconductor sensor. VOCs can be detrimental to human health and can originate from a variety of sources, including cleaning products, building materials, and personal care products.

3. Temperature and Relative Humidity - The AQ Expert measures the air's temperature and relative humidity, which can influence human comfort and the development of mold and other pollutants.

4. Particulate Matter (PM) - The AQ Expert detects the concentration of small particulates in the air using a laser sensor. If present in excessive concentrations, these particles can be hazardous to human health.

The AQ Expert was used in this investigation to measure only carbon monoxide, carbon dioxide, and volatile organic compounds.(106) (107)

Figure: Indoor Air Quality Monitor – AQ Expert

The AQ Expert Indoor Air Quality Monitor measures carbon dioxide levels in the air using an NDIR (Non-Dispersive Infrared) sensor. This type of sensor generates an infrared light beam through an air sample and then measures the quantity of light absorbed by carbon dioxide molecules. The greater the concentration of carbon dioxide in the air, the more light can be absorbed, allowing the sensor to calculate the CO2 concentration in the air. The accuracy and dependability of NDIR sensors for measuring CO2 levels in indoor environments are exceptional. (108) (109)

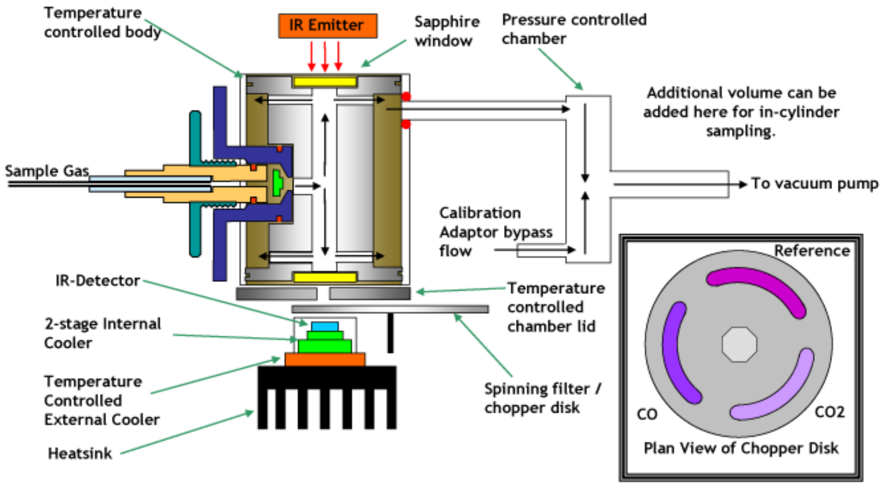


Figure: Non-Dispersive Infra-Red (NDIR) detectors (109)

The Indoor Air Quality Monitor – AQ Expert measures volatile organic compounds with a metal oxide semiconductor (MOS) sensor. (VOCs). The MOS sensor detects VOCs by reacting with them leading to a change in electrical resistance, which is then measured and converted to a concentration value for VOCs. However, they are impacted by temperature and humidity fluctuations, which can result in inaccurate measurements (108). (110)

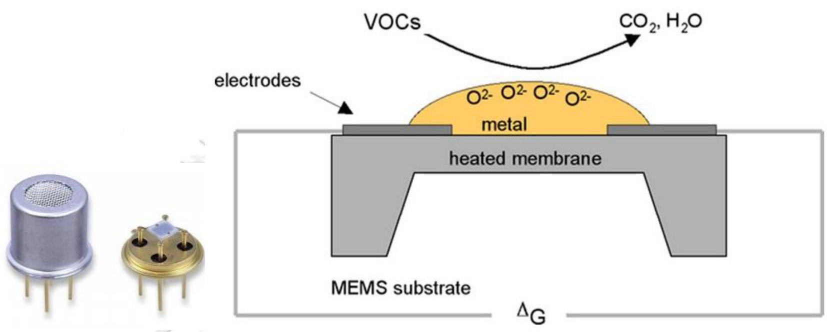


Figure: Non-Dispersive Infra-Red (NDIR) detectors (110)

These sensors serve the same function as electrochemical sensors nonetheless are constructed differently and can detect a wide variety of gases. They, too, have a gas-sensitive film made of a metal oxide, such as tungsten oxide or tin oxide. When gas penetrates the sensor, it reacts with the film, triggering the device if the detected concentration exceeds a predetermined threshold. In normal conditions, i.e., in the presence of Oxygen, electrons responsible for the flow of current react with Oxygen and are absorbed by the film (Oxygen absorbs and attracts unbound electrons), thereby preventing the flow of current. Therefore, the sensor is unpowered. In the presence of a reducing gas, however, oxygen molecules absorb oxygen. In the absence of Oxygen, electrons have nothing to attract them, thereby resuming their flow and triggering the sensor. (110)

There are also studies that collect data using an Indoor Air Quality Monitor – AQ Expert, such as the study Effects of particulate matter, volatile organic compounds, and comfort parameters on the indoor air quality of homes in Greece with young children. This paper's methods included a study of particulate matter

(PM), total volatile organic compounds (TVOCs), and comfort parameters in Athens, Greece, residences with young kids younger than three years of age. Over the course of 6-7 days, indoor PM and TVOC concentrations were measured in real-time. In addition, the study investigated the factors that influence indoor PM and TVOC concentrations, as well as how the socioeconomic status of residents and their daily activities influence diurnal variations in these indoor pollutants. Young children in Athens, Greece were found to be exposed to indoor air pollution, with mean concentrations of PM1, PM2.5, and PM10 of 8.1, 10.6, and 20.9 g/m3, respectively. The study also found that the mean concentrations of TVOCs ranged from 24 g/m3 to 890 g/m3, indicating a wide range of concentrations across the studied residences. Carbon dioxide (CO2) levels exceeded the reference value of 1000 ppm in a number of residences, particularly in children's rooms, whereas air exchange rates (AERs) were found to be less than 0.5 h1 in each of the homes studied. The results indicated that both PM and TVOC concentrations were primarily attributable to the indoor activities of the study participants.(111) There are also investigations that measure carbon dioxide and carbon monoxide using Non-Dispersive Infrared. The study involved the creation of a low-cost multi-gas detection system capable of simultaneously measuring the concentrations of up to three gases, namely CO2, CH4, and H2O. The paper also suggests a sine-like signal as a preferable parameter for gas detection, as it is stable and proportional only to the concentration of a specific gas, making it independent of the concentration of other gases and temperature. This paper presents experimental results for the detection of CO2 and CH4 gases, which are applicable to a variety of applications, including environmental monitoring, industrial safety, and medical diagnostics. This study's findings present a low-cost multi-gas detection instrument that can simultaneously measure up to three gases. The investigation examined the CO2 gas, CH4 gas, and H2O vapor concentrations. Due to their sensitivity to temperature and gas flow parameters, continuous heating of the IR source and absolute values of thermopile voltages were deemed unsuitable for gas detection by the researchers. A signal resembling a sine wave is preferable for the measurement system. The amplitude of the sine is constant and proportional to the concentration of a single gas, rendering it independent of the concentration of other gases and temperature. With the same apparatus, the CO2 gas concentration can be measured from 50 ppm to 400 000 ppm. The lowest detectable level of CH4 was approximately 500 ppm.(112)

Total Fungal Count and Total Bacteria Count

An air sampler is a device used to acquire the Total Fungal Count and Total Bacterial Count from the air. A device that captures air samples by drawing in a known volume of air over a specified time period is called an air sampler. There are numerous varieties of air samplers, which vary in sampling efficiency, portability, and price. Here are a few of the most prevalent air samplers used to capture Total Fungal Count and Total Bacterial Count in the air:

1. Impingers are glass or plastic devices that capture airborne microorganisms using liquid media. They capture microorganisms by drawing a known volume of air through a liquid, which captures them. The collected liquid is then analyzed in the laboratory to ascertain the Total Fungal Count and Total Bacterial Count.

Figure: Impingers sample

2. The Andersen sampler is a famous impactor air sampler that uses a series of plates with small holes to impact air onto nutrient agar. Following that, the plates are incubated. Counting and identifying the resulting colonies determines the Total Fungal Count and Total Bacterial Count.

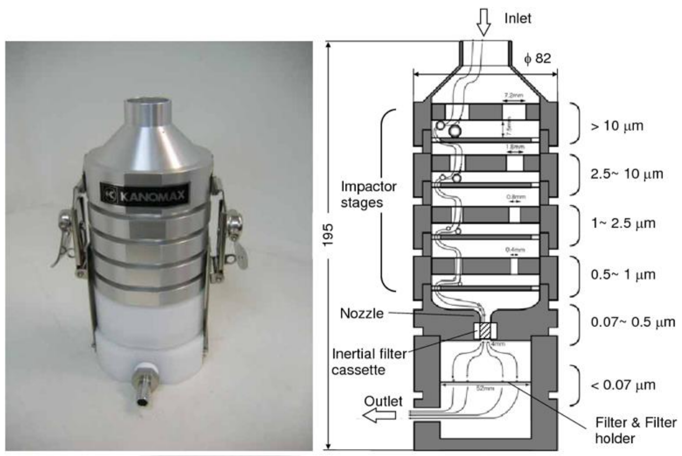


Figure: Andersen sampler

3. Surface sampling is an additional technique for determining the Total Fungus Count and Total Bacteria Count in the air. This procedure involves exposing agar plates to oxygen for a specified amount of time. The plates are then collected and examined in a laboratory.

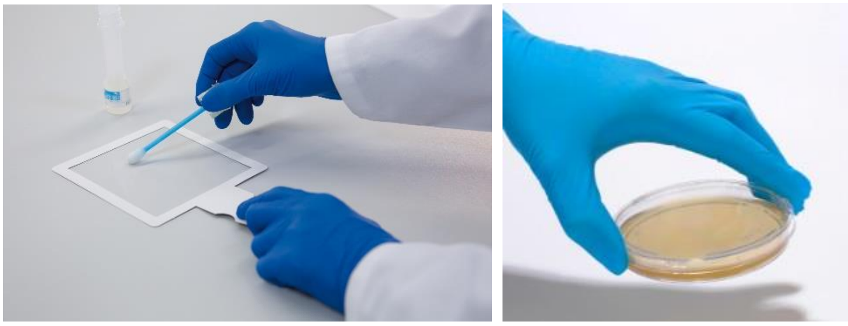


Figure: Surface sampling

4. Bioaerosol samplers: Bioaerosol samplers are portable devices that capture airborne microorganisms using various sampling mechanisms, such as impaction, filtration, or cyclonic separation. These samplers are beneficial for outdoor sampling and can monitor the Total Fungal Count and Total Bacterial Count in the air in real-time.

Figure: Bioaerosol samplers

To obtain accurate results, it is important to select the appropriate air sampler for the study and follow to standard sampling protocols. Bioaerosol samplers were used to collect the Total Fungal Count and Total Bacterial Count in this investigation, with a flow rate of 28.3 L/min (1 ft3/min) and a spend time of 5 minutes.

Sample study in which Bioaerosol samplers were used to collect air samples. The paper investigated the concentration, size distribution, and species composition of bacteria and fungi in the air of glasshouses in a botanical garden by collecting air samples. The same parameters were investigated as well in the garden and street air. Various laboratory techniques were applied to the collected samples in order to identify the various types of microorganisms prevalent in the air. And found that the concentration of environmental bacteria and fungi was higher in the botanical garden's glasshouses than in outside areas. The respirable fraction of microorganisms predominated, with bioaerosol particles smaller than 4.7 m contributing significantly to the inside air. In addition, the study identified various plant- or soil-derived bacteria and fungi, including potentially hazardous and allergenic agents, in the greenhouses' interior air. The results indicate that the presence of various plants in the confined area of the garden glasshouses has a significant impact on indoor air quality (113). This study examined sampling techniques for collecting bioaerosols (culturable fungi and bacteria, and fungal spores) from 14 Class I and one Class II laboratory in the Bangkok metropolitan area. The samples were collected with a single-stage impactor and a cassette containing a Versa Trap spore capture. After 72 hours and 48 hours of incubation, respectively, culturable fungi and bacteria colonies were counted. On the basis of their morphological characteristics, cultivable fungi and spores were determined. Evaluation of the associations between bioaerosols, indoor air parameters, and laboratory characteristics. In the laboratories analyzed, the concentrations of culturable bacteria, culturable fungi, and fungal spores were relatively low, according to the study. The average concentrations of culturable bacteria, culturable fungi, and fungal spores were 87 CFU/m^3, 294 CFU/m^3, and 771,8 spores/m^3, respectively. Aspergillus/Penicillium, ascospores, and Cladosporium were prevalent types of fungal spores in laboratories. The study also discovered that culturable fungi increased substantially with the number of employees and visible molds, while water leaks and culturable fungi increased fungal spore concentrations significantly. There was a correlation between the quantity of trash cans and freezers kept at 80 °C and the presence of bacteria that could be cultured. Proper indoor air management is still required, according to the paper, in order to reduce emissions and exposure, which can help employees avoid adverse health outcomes and reduce the likelihood of experimental contamination (114).

Table 2.6 A summary of the measuring instruments used to investigate indoor air pollution.

Indoor air pollution	Instrument's	Sensor	Accuracy
PM 10	Met One Aerocet -531S	Laser Diode	± 10%
PM 2.5	Met One Aerocet -531S	Laser Diode	± 10%
CO2	AQ expert	NDIR	±2% Rdg. ±10 ppm
CO	AQ expert	NDIR	±1 ppm Rdg. ±0.2 ppm
TVOCs	AQ expert	PID	10 % Rdg. ± 20 ppb
Total Fungal Count	IUL Spin Air Samplers 90005500	Flow 28.3 L/min (1ft^3/min) spend time 5 minute	
Total Bacteria Count	IUL Spin Air Samplers 90005500		

2.4.3 Summary studies related Indoor air quality with health effect and indoor air management program

Table 2.7 Summary studies related indoor Air Quality, and Sick building syndrome

Name ,Year	Methodology	Results
Sun Chanjuan et al., 2018 (14)	- used a cross-sectional survey (n= 13,335) to examine the incidence of SBS symptoms among residents of Shanghai during April 2011–April 2012.	- The incidence of SBS symptoms is 76.9% for fatigue and 65.2% for overall symptoms. - Pollutants expressed as their mixes were also substantially related to a portion of SBS symptoms.
Jeonghoon Kim et al., 2019 (115)	- Cross-sectional studies in 2017, 314 workers in Seoul, Korea. - To examine SBS symptoms and workers' IAQ perceptions, as well as IAQ perception and store type in underground shopping areas.	43.6% of SBS patients reported skin symptoms, 62.4% eye irritation, 65.6% respiratory symptoms, and 64.7% general symptoms in the previous month. IAQ perception increased SBS symptoms (odds ratio: 1.81–7.84). Several IAQ perceptions were related to the store type.

Table 2.7 Summary studies related indoor Air Quality, and Sick building syndrome. (continuous.)

Name ,Year	Methodology	Results
Xi Fu et al., 2021 (116)	- used a Cross-sectional study. In this study, 308 kids from 21 classrooms at 7 junior high schools in Johor Bahru, Malaysia.	- There were eight microbial genera associated with SBS. Higher indoor relative humidity and evident dampness or fungus in classrooms were associated with an increased concentration of potential risk bacteria and a decreased concentration of potential protection bacteria.
Ioannis Sakellaris et al., 2020 (117)	- used a cross-sectional survey (n= 1,299) in 37 office buildings among eight countries.	- VOCs were connected with headaches, fatigue, and skin complaints in general. Formaldehyde was associated with respiratory and general symptoms, acrolein with respiratory symptoms, propionaldehyde with respiratory, general, and cardiac symptoms, and hexanal with general SBS.

Table 2.8 Summary studies related with Indoor air quality in childcare center

Name ,Year	Methodology	Results
Sung HoHwang et al., 2017 (118)	- Use cross-sectional study design among 25 daycare centers and collected indoor pollutants and environmental factors.	- level of bacteria higher than the Korea's Indoor Air Quality (IAQ) and level of bacteria positive association with building age, location but negative association with ventilation time. - level of mold association with water-damaged. - The levels of the indoor VOCs nighttime higher indoors. - The ventilation management and humidity management can reduce indoor air pollutants.
Shahidah N. et al., 2017 (119)	- Use cross-sectional study and compare two type of daycare centers (urban location and sub urban location) in Malaysia and factors on level of bacteria and fungi contaminant in the nursery	- a high concentration of airborne bacteria contaminant in babe room - Occupancy, lower temperature and higher percentage of relative humidity effect to level of bacteria - a significant impact on level of bacteria associations with proximity to the major road, ventilation system and a number of occupants.

Table 2.9 Summary studies related with Indoor air quality and health effects in childcare center

Name ,Year	Methodology	Results
Raihan Khamal et al., 2019(120)	- Use cross-sectional study among urban 10 daycare centers arm access to children's health symptoms and indoor air pollutants in Malaysia	- All of 10 daycare centers had indoor air pollutants (least one indoor air quality parameter) - The prevalence of children's health symptoms show wheezing symptoms was 18.9% - Significant different in mean concentration of $PM_{2.5}$ and total bacteria associations with those without wheezing symptoms (P = 0.02, P = 0.006).
Edris Hoseinzadeh et al., 2016 (121)	- Use cross-sectional study among day care child centers in Delfan city, Lorestan province Iran. And collected indoor air pollutants.	- The mean temperature of indoors is 24.5 ± 1.5 °C. relative humidity of the air was 42.7 ± 7.1%, - The most type of fungal were Penicillium Spp - Maximum of total fungi were 372 CFU/and 1314 CFU/m^3 and minimum of total fungi were 91 CFU or 322 CFU/m^3 - A significant difference of relative humidity and temperature associations with Penicillium Spp.

Table 2.10 Summary studies related with Indoor air quality.

Name ,Year	Methodology	Results
Nkosana Jafta. et al., 2017 (33)	- Use case control study among children younger than 15 years in South Africa (n=246) focus on PM10 NO_2 and SO_2 monitoring in 24 hours in 114 household	- Positive correlations between pollutants with housing structure (p-value= < 0.0001), number of smokers in the household (p-value= 0.0150), primary fuel type (p-value= < 0.0001) and distance from the major roadway (p-value= 0.0066).
P.T.B.S.Branco et al., 2019 (34)	- Use cross-sectional study among 25 nursery and primary schools and measurement CO_2, CO, HCOH, NO_2, O_3, TVOCs, PM1, PM2.5, PM10, TSP, meteorological and comfort parameters in 101 room.	- Traffic in the near road have associated with CO_2 in occupancy and PM10 in non-occupancy ($p < 0.05$).
Ryan E et al., 2018 (35)	- Use cross-sectional study measurement in 9 building to observe the impact of the fine particulate matter (PM2.5) emissions when cooking.	- In cooking hours PM2.5 increased to 1,400,000 particles/cm^3 (non-cooking hours 1220 - 6200 particles/cm^3) - In cooking hours PM10 increased than indoor air quality standards of Taiwan.

Table 2.11 Summary studies related with indoor air management program

Name ,Year	Methodology	Results
Darius Ciuzas et al., 2015 (122)	- Use quasi experimental focus on concentrations were assessed for 20 indoor activities had ventilation system and use furniture polisher spraying, floor wet mopping with detergent and test air sensor.	- $PM_{0.01-0.3}$ slow decay rate since use ventilation or cleaning rates - The lowest concentrations of particles when use floor vacuuming
Wenjuan Wei et al., 2015 (123)	- Reviews from study and report topic green building	- Statistical analysis was showed building follow green building guideline no specific indoor air pollutant - Main of green building use emission source control, ventilation

CHAPTER III

METHODOLOGY

3.1 Study Design

The study was quasi-experimental. The primary objective was to evaluate the effectiveness of the urban childcare center indoor air quality management (UCC-IAQ) program in reducing building-related symptoms (BRS) among childcare workers in Nonthaburi province and Saraburi province, because Nonthaburi Thailand. From November 2020 to January 2021, the total duration of the study is 3 months.

In the study, a protocol for controlling or reducing indoor air pollution was applied to the childcare center as part of a program to reduce indoor air pollution. To develop a unique program for childcare centers in Nonthaburi and Saraburi provinces to reduce indoor air pollution, with a focus on building-related symptoms of indoor air pollution, for research into the impact of indoor air pollution.

Developed a guidebook and protocol for case group participants who work in childcare. The protocol included guidelines for cleaning the room, the floor, the walls, the curtain, the mosquito wire screen, and increasing ventilation. Include frequency of room cleaning, floor cleaning, wall cleaning, curtain washing, and mosquito wire screen cleaning. Evaluate the indoor air quality three times: at the beginning, in the middle, and at the end. Particulate matter 2.5 micrometers (PM2.5), particulate matter 10 micrometers (PM10), Carbon Dioxide (CO2), Carbon monoxide (CO), Total Volatile organic compounds (TVOCs), Total Fungal Count, and Total Bacterial Count were evaluated for indoor air quality. And including building-related symptoms among caregivers in childcare centers who work in childcare centers.

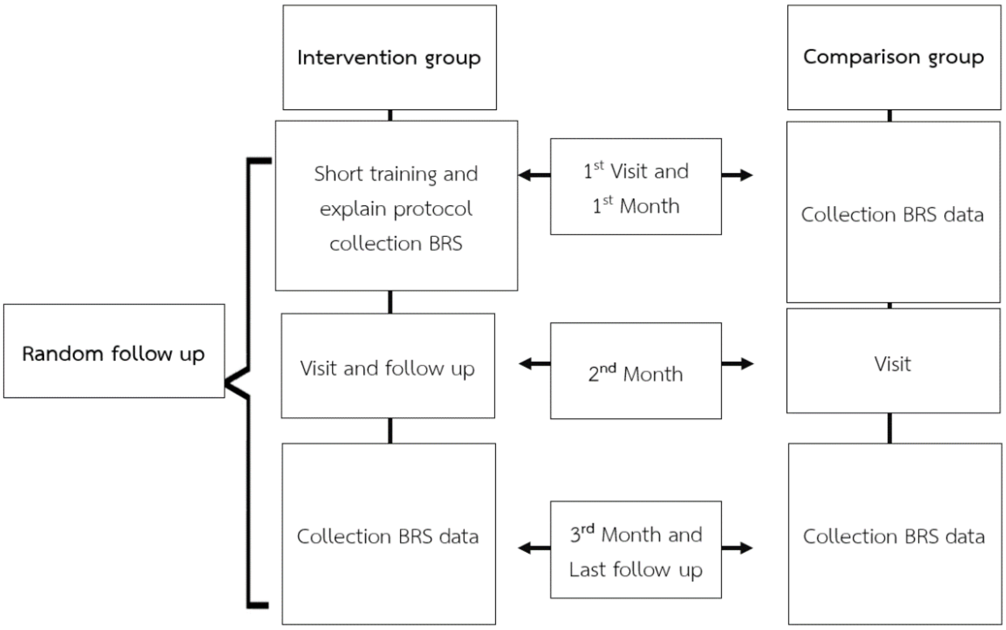
Before being used in intervention, the manual protocol had to be validated by an indoor air pollution expert and environmental engineers. The indoor air pollution expert provided suggestions regarding the type of indoor air pollution and a method to remove each indoor air pollution or some air pollution that is very concerning to health and mobility, and the environmental engineering expert made recommendations regarding the building's structure, materials, and ventilation type that affect indoor air pollution. However, before using in an intervention, the researcher consulted with caregivers in another region (the Ministry of Public Health's childcare center) to ensure that caregivers are capable of performing the tasks. And the appendix section has been included in the final version.

When starting an intervention, divide the 10 childcare centers in the provinces of Nonthaburi and Saraburi into two groups: intervention (5 childcare centers) and comparison (5 childcare centers).. Researchers from the intervention group provide a short training and protocol explanation to the childcare center director, caretakers, and housekeeper. In short training, 1-2 hours were employed, and instruction was conducted once before the intervention began. In the training section, the researcher explained the Plan of Management for Indoor Air Pollution in Child Care Centers, as shown in Table 3.1. If caretakers or housekeepers have any issues, they can always contact the researcher directly via phone or line application.

Table 3.1 Lesson Plan of management for indoor air pollution in childcare center

Section	**Duration/ minute**	**Detail**
Introduction	10 - 15	- Self introduction - Talk about why we must concern indoor air pollution
Content	45 - 90	- Explain type of indoor air pollution and source - Explain health and indoor air pollution - How to management indoor air pollution - How to clean room for indoor air pollution
Conclude	15 – 20	- Summarize all content - Question and answer

Before intervention, both groups collected data on building-related symptoms in the evening, before caretakers left for the day's activities. In addition, the researcher collected indoor air pollution data from both groups. Between the studies, the researcher conducted a checklist-based follow-up of childcare centers that followed protocol and a random follow-up to reconfirm whether childcare centers followed protocol or not. At the finish of three months, the researcher collected data on building-related symptoms, as well as indoor air pollution levels from both groups. And the study guidelines were shown in Flow chart 3.1.



Flow chart 3.1 Study flow char

From flow chart 3.1, after dividing childcare centers (Intervention group and Comparison group), the Intervention group was managed to bring to the training program before the beginning of the intervention. During the training, the overall purpose of the intervention was explained, as well as the protocol for the director of the childcare center, caretakers, and housekeepers. However, the comparison group adheres to the Thai standard for indoor air pollution (42) in each childcare center until the study is finished.

3.2 Study Area

The focus of the study was on childcare centers in Nonthaburi and Saraburi provinces (Figure 3.1). Because the provinces of Nonthaburi and Saraburi involve factories, many buildings, many constructions, a high volume of car traffic, and agricultural areas. In the provinces of Nonthaburi and Saraburi, air pollution is caused by nearby traffic, building construction, farming, herbicides, pesticides, and open burning. Particularly in the province of Saraburi, limestone mountains are blasted for cement factories. This research focuses on the selection of childcare centers in the provinces of Nonthaburi and Saraburi. This study selects childcare centers that meet inclusion and exclusion criteria and have pollution in their centers. Using a pilot survey, 10 childcare centers from Nonthaburi and Saraburi provinces that meet inclusion and exclusion criteria and have pollution in childcare centers are included in this study. Previous to the randomization, each childcare center was matched following flow chart 3.2.

Consequently, the effectiveness of 10 childcare centers in Nonthaburi and Saraburi provinces was examined in this study. Flowchart 3.2 represents this study's evaluation of the effectiveness of indoor air quality management and the UCC-IAQ program, as well as its potential to enhance BRS among childcare center caretakers.

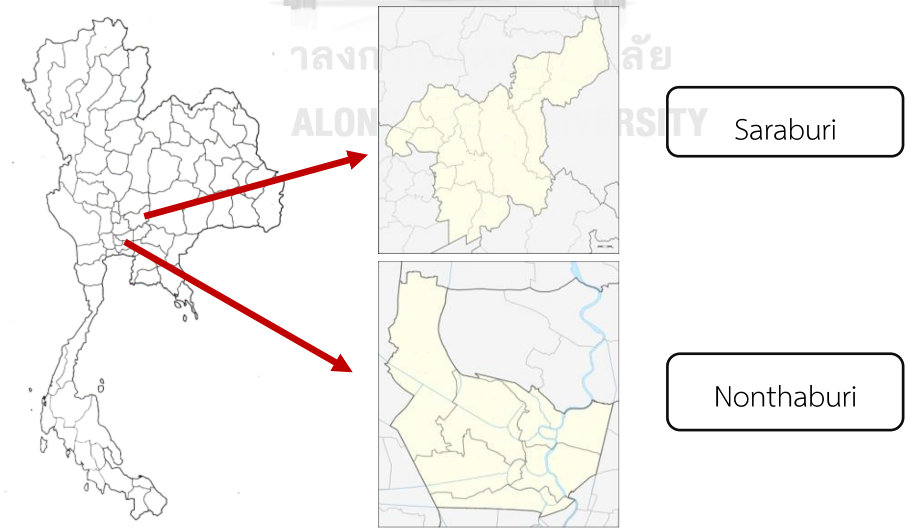


Figure 3.1 Study area (Nonthaburi province and Saraburi)

3.3 Study Population and Sample Group

All air samples were collected from childcare centers in the Thai provinces of Nonthaburi and Saraburi, and all study participants were caretakers from the same childcare centers where air samples were collected. As this study has two types of inclusion criteria and two types of exclusion criteria, all samples and all participants met the inclusion and exclusion criteria as follows:

3.3.1 Inclusion criteria

3.3.1.1 Inclusion criteria for childcare center

1. Childcare center in Nonthaburi and Saraburi province.

2. Childcare center where pass the standard of Childcare center standard. following Standards for child development center operations of Local Administrative Organizations include

1). Personnel and management

2). Building environment and safety

3). Academic and curriculum activities

4). Community involvement and support (42)

3. The building of the Childcare center passes the standard construction of the Childcare following Standards for child development center operations of Local Administrative Organizations include

1). Location

2). Number of floors of the building

3). Entrance, exit, door, and windows

4). Structure of door and window

5). Usable area. (42)

4. Children in Childcare center 10 – 100 persons.

5. Have indoor air pollution (Have one or some pollutant higher than Thailand standard) following Standards for Ministry of Public Health in Manual to measuring indoor air quality for entrance - exit country (42)

6. welcome to join intervention.

3.3.1.2 Inclusion criteria for caretakers in childcare center

1. Caretakers who have age 18 – 59 years old.

2. Who working in Childcare center more than 1 month.

3. Welling to participants in this study.

3.3.2 Exclusion criteria

3.3.2.1 Exclusion criteria for childcare center

1. Quality below the level B (C, D) following National Standard for Early Childhood Care, Development and Education Thailand Table 3.2

Table 3.2 Summary score of childcare centers from the principles of the National Early Childhood Development Center. (42)

Quality	Summary score	The number of items to improve
A	≥ 80	Not to improve
B	60 – 79.99	1-7
C	40 – 59.99	8-15
D	≤ 40	16

3.3.2.2 Exclusion criteria for caretakers

1. participants who have Cancer disease and diagnosed by physician before collecting data.

The questionnaire provided the general characteristics of the environment and participants. The survey checklist and data of indoor air quality from the indoor air pollution report, as well as the level of childcare center quality according to the Thai Department of Health (A= Very good, B= Good, C= Past in minimum, D= Need to improve) (124). Age of caretakers according to the Thai Ministry of Public Health and the World Health Organization (125),(126).

3.4 Sample Size and Sampling Technique

For the location selection in this study, Nonthaburi province and Saraburi province were selected because Nonthaburi province and Saraburi province had high pollution levels for a longer period of the year compared to other areas. Total participants are dependent on the number of providers of childcare who meet inclusion and exclusion criteria. All participants are caretakers from 10 childcare centers; therefore, each childcare center has between two and ten participants from the pilot survey. The overall sample size is 81 people. (In this study, all caretakers from 10 childcare facilities were used, and all caretakers met inclusion and exclusion criteria.)

Sampling techniques were first used in surveys in Thailand's Nonthaburi and Saraburi provinces. Nonthaburi province (121 centers) and Saraburi province (120 centers) are included when calculating the total number of childcare centers in Nonthaburi and Saraburi provinces, respectively (157 centers) (127). In the process of surveying the whole number of childcare centers in Nonthaburi province and Saraburi province (all 278 centers), the researcher screened for indoor air pollution in childcare centers that were willing to participate in an intervention.

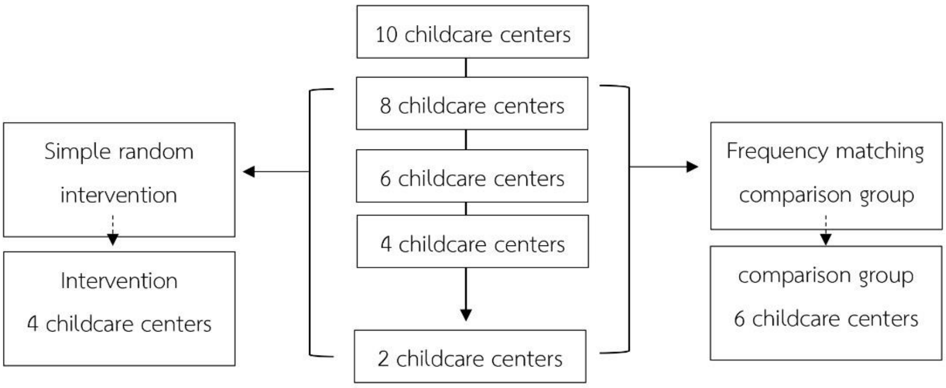
When childcare centers joined the study, a researcher visited them and screened for indoor air pollution according to Ministry of Public Health standards in the Manual for Measuring Indoor Air Quality for Entrance - Exit of the Country. After screening for indoor air pollution, PM2.5, PM10, TVOCs, and CO2 (42). were highlighted. In screening indoor air pollution, researchers measured every room using the same device (PM2.5 and PM10 were measured using real-time optical scattering or piezoelectric monitors, CO2 was measured using a real-time non-dispersive infrared sensor, and TVOCs were measured using a real-time photoionization detector) (42).

After getting the total number of childcare centers in the provinces of Nonthaburi and Saraburi, researchers assessed childcare centers dependent on inclusion and exclusion criteria. In this study, 10 daycare centers completed all inclusion and exclusion criteria. When child care centers were approached by a researcher, this study method was explained. Include study protocol, study population, study design, and ethical considerations for childcare workers.

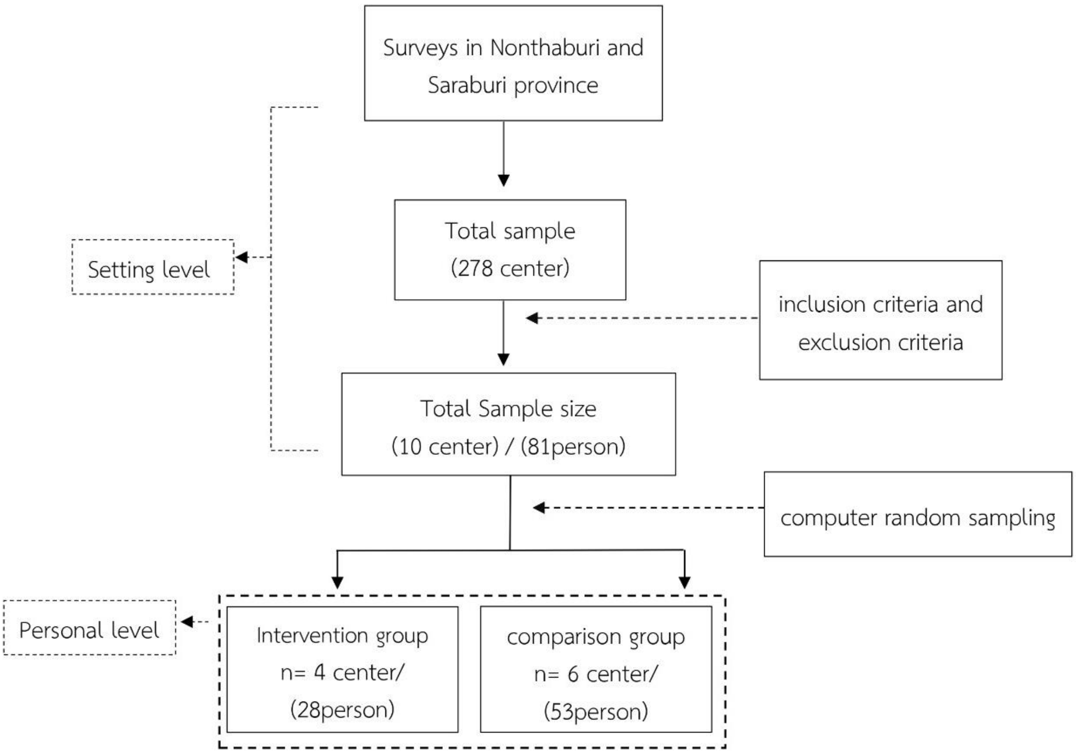
Child care centers that have passed the inclusion and exclusion criteria but have many classrooms The study has been selected. Two rooms with the highest air quality were picked to represent the daycare center's air pollution rooms. And used the criteria there is more than one person using the room each hour of the day.

when the total sample size was available. The study was divided into two groups by frequency matching for the intervention (5 centers) and control groups (5 centers). The study was divided into two groups, the intervention group, and the control group, using Microsoft Excel version 16.28 and frequency matching the following

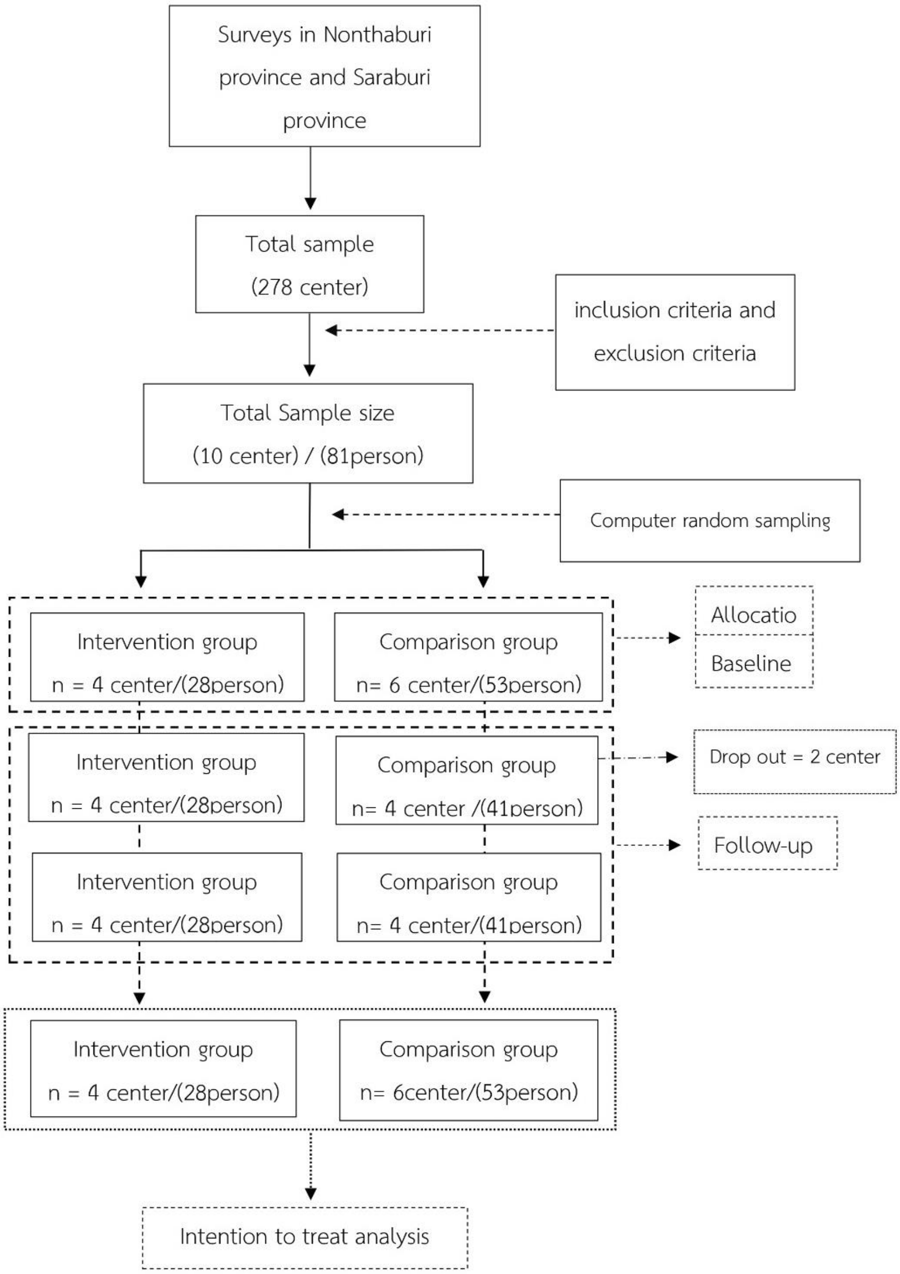
1. Room size
2. Occupancy
3. Room ventilation type



Flow chart 3.2 Divide and frequency matching flow chart



Flow chart 3.2 sampling technique flow chart



Flow chart 3.3 Consort flowchart

According to the Consort flowchart at the beginning of the procedure, there were a total of 10 childcare centers. After the first follow-up, there were 2 childcare centers in Nonthaburi, and the comparison group withdrew from the study. Therefore, after the intervention, there were 4 centers in the intervention group and 4 centers in the comparison group.

3.5 Measurement Tools

A researcher collects data on indoor air pollution and reports the research results. The data were collected using air quality sampling techniques in accordance with the Ministry of Public Health's Manual to Measuring Indoor Air Quality for Entrance-Exit Countries and the International Organization for Standardization's scope on investigations of air pollutants in buildings (ISO 16000- 32: 2014) (42) .

A questionnaire was gathered by the researcher and research assistant. The researcher's collected survey checklist. Standard machines were used to collect indoor air data in accordance with ISO 16000-32: 2014 and the Ministry of Public Health's guideline to measuring indoor air quality for entrance - exit country (42)

3.5.1 Questionnaire and survey checklist

In this study, the questionnaire has passed the validity and reliability tests. The validity test used an index of item objective congruence test (IOC) with an overall score of 0.93, while the reliability test used an alpha coefficient for the Likert rating scale, showing a result of 0.983%. Following is a questionnaire that corrects childcare center and participant general characteristics following.

3.5.1.1 Part 1: General information

Childcare center general characteristics were gathered using a questionnaire and survey that included a survey checklist and a questionnaire. Age of building, room size, Category of windows, Type of door, Type of wall, Type of bed, Type of flooring, and Number of windows. Number of doors, distance from a main road, Cooking area, Distance from the farm, and ventilation system. And indoor air quality data consists of Temperature, Relative humidity, particulate matter 2.5 micrometers (PM2.5), particulate matter 10 micrometers (PM10), Carbon Dioxide (CO_2), Carbon monoxide (CO), Total Volatile organic compounds (VOCs), Total Fungal Count, Total

Bacterial Count, Legionella test this data measurement and Inspection by standard tool following ISO 16000-32:2014.

Among caretakers, the questionnaire included three groups of general characteristics: Time period of working place data, underlying (diagnosed by a medical doctor), medicines and supplements used.

General characteristics including gender divided to meal and female, age unit is year, weight unit is kilogram, height unit is centimeter, medication and supplement or vitamin regularly consume, smoking status divided to never, used and stop using and current including volume used

All underlying diseases diagnosed by a physician as a result of exposure to indoor air pollution are compiled and classified into four severity levels.

1 = Mild (Have signs and symptoms, but they do not actually impact or inhibit daily life or work.)

2 = Modulate (Have symptoms that interfere with daily life or work.)

3 = Severity (Have symptoms or signs and quit working immediately.)

4 = Very severity (Have symptoms or signs. It has the effect of suspending work until the next day.)

The first level of meaning is having symptoms that do not affect daily life or work, the second is having symptoms that decrease the quality of daily life or work, and the third is not having any symptoms.

3.5.1.2 Part 2: Behavior information

For behavior data from questionnaire is clean floor frequency (time/month), clean wall frequency (time/month), bedding wash frequency (time/month), VOCs use (time/month), VOCs keep Ventilation use and frequency (hour/day/week), big cleaning day (time/month).

3.5.1.3 Part 3: Signs and symptoms information

And this questionnaire collects signs and symptoms of indoor air pollution, such as sneezing, fatigue, nasal congestion, and runny nose, in caretakers who stay in a childcare center. These symptoms include the following from building-related health symptom (BRS) and looking for severity, frequency of symptoms divided into 5 levels.

0 = No signs and symptoms

1 = Mild (Have signs and symptoms, but they do not actually impact or inhibit daily life or work)

2 = Modulate (Have symptoms that interfere with daily life or work.)

3 = Severity (Have symptoms or signs and quit working immediately.)

4 = Very severity (Have symptoms or signs. It has the effect of suspending work until the next day.)

For The frequency of symptoms divided into 3 level following

Almost every day = Severity

1-2 days/week = Modulate

Lest than 1 -2 days/week = Mild

Only the researcher has access to the key code and password-protected key code data for each and every questionnaire.

3.5.2 Indoor air data analysis

Indoor air parameter investigations utilize an average of 8 hours of time-continuous investigation time following 8 hours of indoor work time. Except for the total fungal count, the total bacterial count took 4 minutes or as long as the room size required. And the temperature and relative humidity were measured every 60 minutes for 8 hours.

- Temperature used globe in the center room of a childcare center, the thermometer measures Celsius. measurement is taken in the room's center according to figure 3.3

- Relative humidity was measured using a hygrometer as a percentage in the center living room of a daycare center. a measurement taken in the room's center according to figure 3.3

- Air movement parameter was used the hot-wire anemometer unit measures in kilometers per hour. Figure 3.3 depicts the measurement in the classroom's center and back for a childcare center.

- Particulate matter with a diameter of 2.5 micrometers (PM2.5) utilized Real-time piezoelectric or optical scattering. If a childcare data center with a high level of PM 2.5 uses the gravimetric method for a depth investigation, the unit is g/m^3. measurement is taken in the room's center according to figure 3.3

- particulate matter 10 micrometers (PM10) used Real-time piezoelectric or Optical scattering. If a childcare center has a high level, investigate its depth using the gravimetric method. unit is $\mu g/m^3$. a measurement taken in the room's center according to figure 3.3

- For carbon monoxide (CO), was detected using an electrochemical sensor in real-time. a measurement in the room's center according to figure 3.3.

- Carbon Dioxide (CO_2) was used a Real-time electrochemical sensor. in childcare center has high-level use of Real-time chemiluminescence for depth investigation, unit of measurement is ppm in the center of the room according to figure 3.3.

- The real-time photoionization detector was utilized for Total volatile organic compounds (VOCs). The Real-time photoionization permits the investigation of 12 distinct chemical reactions follows, Benzene, Carbon Tetrachloride, Chloroform, 1,2-Dichlorobenzine, 1,4-Dichlorobenzine, Dichloromethane, Ethylbenzene, Styrene, Tetrachloroethylene, Trichloroethylene, Toluene and Xylene (m-Xylene, o-Xylene, p-Xylene) or use EPA air Metod, Toxic Organics-15 (TO-15) measurement in the central of the room following figure 3.3.

- Total bacteria count was implemented. Adjust the air flow to 28.3 L/min (1 ft^3/min). spend 5 minutes or more with room dimensions. Two malt extract agar is used as a culture medium in an incubator at a temperature of 35 degrees Celsius for 48 hours. The unit is reported in CFU/m^3 at the room's center, as shown in Figure 3.3.

- Total fungus count was determined using an impactor with a flow rate of 28.3 L/min (1 ft3/min) and a dwell time of 5 minutes, or as determined by room size. The culture medium was tryptone soy agar at 35°C for 48 hours, and the measuring unit was CFU/m3 at the room's center (Figure 3.3)

The researcher measured all parameters of indoor air. Moreover, the researchers installed all necessary equipment and inputted imported data.

Figure 3.3 Central of the room measurement

3.6 Data Collection

The collected data was utilized for approximately three months. General characteristics of childcare centers and staff Include behavior information from the survey and questionnaire. From the time of admission through the completion of the intervention, indoor air quality measures were taken. In the Thai provinces of Nonthaburi and Saraburi, all data on childcare centers were collected. The researcher utilized the questionnaire and survey checklist throughout the first and final measurement visits. During the baseline visit and after the intervention, signs, and symptoms of indoor air pollution were collected using a questionnaire.

During the pre-intervention and post-intervention visits, data on indoor air quality were obtained. In this study, a total of monthly visits was completed (1 time for baseline, 3 times for Follow up)

Two research assistants were accountable for data collection. For this study, the following responsibilities were allocated to research assistants:

1. Equipment such as machinery and documents are transferred.

2. Transfer the machinery to a vehicle after use; however, researchers were responsible for setting up all equipment.

3. A research assistant distributed questionnaires. However, before beginning data collection, all research assistants must be trained by researchers and have all questions answered.

3.6.1 Room selection

Room selection in a daycare center with multiple rooms was used to screen all rooms, and all rooms were tested for screening before collecting indoor air pollution including particulate matter 2.5 micrometers (PM2.5), particulate matter 10 micrometers (PM10), Carbon Dioxide (CO_2) and Carbon monoxide (CO) and total Volatile organic compounds (VOCs) for screening about 5 minutes by screening machine and then select one room for test indoor air pollution for each childcare center for test indoor air pollution.

The mechanism for screening Standard equipment was used to collect indoor air data in accordance with ISO 16000-32: 2014 and the Ministry of Public Health's Manual for Measuring Indoor Air Quality for Entry - Exit Countries (42).

3.6.2 Questionnaire

During the first visit, the questionnaire was used to find out about the care worker's and daycare center focus on general characteristics and behavior. There was a collection of Age of building clean floor frequency (time/month), clean wall frequency (time/month), bedding wash frequency (time/month), VOCs use (time/month), VOCs keep Ventilation use and frequency (hour/day/week), big cleaning day (time/month). All data come from childcare center staff.

The data on signs and symptoms were used to determine the distribution of BRS. Signs and symptoms of BRS were reported within the past month. There are 4 answer options for reporting the frequency of each symptom: frequently (more than 2 days a week), sometimes (1-2 days a week), infrequently (less than 1 day per week), and never. This study outlines the meaning of BRS. To implement the BRS symptom system as follows.

- Who complain or show signs and symptoms of acute discomfort, such as sneezing, runny nose, rash, and itchy eyes

- The cause of the symptoms and signs is unknown.

- Who complain or exhibit signs and symptoms while living in a childcare center, but find relief shortly after leaving a childcare center.

- Have same signs and symptoms again when come to budding.

Building – related health symptom (BRS) focuses on 4 major symptoms

1). General symptoms

2). Upper respiratory symptoms

3). Lower respiratory symptoms

4). Dermal symptoms

In the questionnaire, check for signs and symptoms including fatigue, headache, nausea, sneezing, runny nose, cough, itchy eyes, and rash. including the frequency and severity of symptoms.

3.6.3 Survey checklist

Collect environment factor data and analyze this data using the following survey checklist.

- Size of room calculate from Weight(m) x Height(m) x Length(m)= Δ Cubic Meter
- Wood, steel, aluminum, and plastic are the materials from which windows are constructed.
- Observed types of doors and walls are wood, steel, aluminum, and plastic for the door and walls.
- Type of floor Cement, Tile, Wood, Laminate and others.
- In the room selected for the study, the researcher counted the number of windows.
- Number of doors, Distance from major road, Distance from farm.
- Cooking area looking the childcare center have kitchen in same area with living zone of children
- Ventilation system in childcare center use (Fan, Air conditioning, mix or Natural)

All surveying and measurements were conducted by the researcher and recorded on the survey checklist during the initial visit to each childcare center.

3.6.4 Indoor air quality

For analysis of indoor air quality, a standard machine and method are utilized for each form of pollution. The researcher evaluates indoor air quality. During the dry season, all measurement data on indoor air pollution. and the source of all air pollution is the same period. When researchers have data on indoor air pollution, they document it in a record format and calculate the mean for each set of data. This study collected indoor air pollution samples following:

- Temperature
- Relative humidity
- particulate matter 2.5 micrometers (PM2.5)
- particulate matter 10 micrometers (PM10)
- Carbon Dioxide (CO_2), Carbon monoxide (CO)
- Total Volatile organic compounds (TVOCs)
- Total Fungal Count, Total Bacteria Count

However, since collecting data from ten childcare centers, TVOCs levels have been within acceptable limits. Generally, there is no formaldehyde measurement according to Thai guidelines. Formaldehyde is therefore not reported in this study.

This study uses Indoor Air Quality (IAQ) data from every (inferential statistic). From data on indoor air quality, the researcher calculates the means of each group and compares them to the means of the intervention and comparison groups (Independent t-test). To compare the means of the intervention group before and after the intervention, the researchers utilized a dependent t-test.

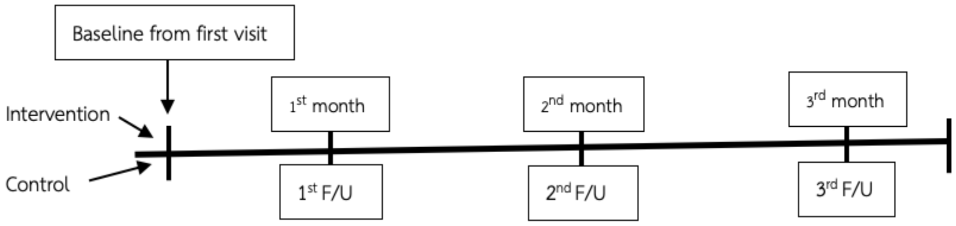


Figure 3.4 Flow of data collection

3.7 Statistical analysis

In this study, the statistical analysis was divided into two groups. Statistics uses both descriptive and analytical statistics. Statistical methods were utilized to describe and analyze the clauses in accordance with the objectives of the study.

3.7.1 Descriptive statistics:

- Nominal data such as gender and BMI were analyzed using frequency, percent, and mode.

- Ordinal data, including frequency of signs and symptoms, the severity of signs and symptoms, and environmental management, were analyzed using frequency, percent, and median.

- Interval and ratio data, such as age, weight, height, and group, were analyzed using frequency, percentage, maximum, minimum, median, and percentile.

In the part evaluating (CHAPTER IV) the indoor air parameter, two levels have been established: high and normal. In the evaluation, Thailand's outdoor air quality requirements were used to separate the two groups. According to Thai standards, Relative Humidity is divided into dry and humid situations.

In addition, Table 4.6 divides BRS into "Have" and "Have no" categories. Table 4.8 classified BRS as "Decrease" or "Does not decrease." used before - after is interpreted as "Decrease" for non-negative results (greater than zero), and "Does not decrease" for negative outcomes.

The Summary of BRS means the modification of BRS to a dichotomous form, wherein the term "Have" shows the presence of at least one symptom from each symptom group related to BRS. The term "Have no" indicates the absence of any symptom of BRS within each syndrome. And the terms "have" and "have not" have been used in the analysis of the association between the overall attributes of caretakers and BRS.

The average indoor air quality level within a building over an 8-hour period has been calculated by collecting and subsequently averaging the recorded values. In comparison to the standards established by the Department of Health in Thailand. In the study used, the term "Normal" refers to indoor air quality that gets within the established standard, while "above" indicates indoor air quality that outshines the standard.

When analyzing the modifications in This study, identified two separate patterns of change. The first pattern, defined as "Decrease," indicates a reduction in building-related health symptoms by the end of the study. The second pattern, labeled "Doesn't decrease," indicates that building-related health symptoms did not decrease or were the same from the beginning to the end of the study.

3.7.2 Analytic statistics:

For analytical analysis. Before analyzing the data, the normal distribution test was done. Non-parametric statistical analysis was done on skewed data. Statistical analysis served the following objectives:

Obj.- To compare IAQ before and after using UCC_IAQ management within intervention and comparison group.

Wilcoxon signed-rank test for non-parametric data was used to determine whether there was a significant difference in the concentration of each air pollutant (continuous data) before and after intervention within the same group.

Obj. - To compare indoor air quality change before and after using program between intervention and comparison group.

Multivariate linear regression was utilized to determine the effect of indoor air quality change on intervention. Intervention / Control was the main independent variable used. Other confounding variables were utilized to adjust the model.

**Indoor air pollutants change = Pollutant concentration after intervention – Pollutant concentration before intervention*

$$Y \text{ (Indoor air pollutants change)} = \beta_0 + \beta_1\text{(Intervention / Control)} + \beta_2 X_2 + \ldots\ldots\ldots\ldots\ \beta_n X_n$$

Obj. - To compare respiratory health status of caretaker in childcare center before and after using program within intervention and comparison group.

Building – related health symptom (BRS) (Modified from dichotomous data to continuous data)

The BRS was examined based on four categories of main symptoms: general symptoms, upper respiratory symptoms, lower respiratory symptoms, and Dermal symptoms. The total score for each major symptom was determined. For each symptom presented, a score of "1" was presented. When a symptom is absent, the score is displayed as "0". Following this, Wilcoxon signed-rank test for non-parametric data was conducted to see whether there was a difference in the sum score of each main symptom category before and after intervention within the same group.

Obj.- To compare change of health effect of caretaker in childcare center between intervention and comparison group.

Building – related health symptom (BRS) (Modified from dichotomous data to continuous data)

A multivariate linear regression was conducted to determine the effect of BRS change on intervention.

BRS change = *Sum score of each main symptoms after intervention – Sum score of each main symptoms before intervention*

$$Y \text{ (BRS change)} = \beta_0 + \beta_1\text{(Intervention / Control)} + \beta_2 X_2 + \ldots\ldots\ldots\ldots\ldots\ \beta_n X_n$$

In the will coxson singlang test comparison, the indoor air parameter was divided into high and normal categories. The high and normal categories are determined by Thai standards. For each item, the frequency and severity of symptoms were evaluated. The frequency of symptoms was measured between 0 and 72. The severity of the symptoms was graded between 0 and 96. to compare the pre-study and post-study scores (By will coxson singlang test).

3.8 Ethical

Participant was given all information by the researcher. Rights of study participants and participant impact information. The study approved Chulalongkorn University's Human Research Ethics Committee or COA No. 133/2564. Before participating in the study, written agreement was obtained from each participant.

All data were protected; a code was used to protect the information, and none of the data could identify an individual respondent. Researchers needed a password to access the data, and only researchers have access to the data (10).

CHAPTER IV
RESULT

The study examined the effectiveness of the Urban Childcare Center Indoor Air Quality Management Program (UCC-IAQ) in reducing indoor air pollution. The results, analyzed using the Wilcoxon signed ranks test, showed no significant difference in pollution levels between the intervention and comparison groups after implementing the UCC-IAQ Program. Although there were potential reductions in indoor air pollution in the intervention group, including PM 2.5, PM 10, bacterial and fungal counts, and relative humidity, these reductions were not statistically significant. And the relationship between building-related health symptoms (by chi-square test) in the intervention and comparison groups. The results, with a p-value of 0.05, indicated that there were significant differences between the groups in terms of general symptoms and overall symptoms (p-value less than or equal to 0.001). Following the establishment of the UCC_IAQ management program, there was no discernible difference in indoor air quality between the groups.

The study examined the frequency and severity of building-related health symptoms (BRS) among caretakers before and after implementing the UCC-IAQ management program. In the intervention group, the usage of the program resulted in a noteworthy decrease in both the frequency and severity of general symptoms and overall symptoms. These reductions were statistically significant, the statistical analysis revealed that the frequency of general and overall symptoms was significant with a p-value of ≤0.001. Additionally, the severity of upper respiratory symptoms was found to be significant with a p-value of 0.021, and the overall symptoms were also significant with a p-value of 0.007. a clear improvement in the health of caretakers. However, in the comparison group, no significant differences in symptom frequency or severity were found after the study. This suggests that the UCC-IAQ management program was effective in reducing building-related health symptoms specifically within the intervention group, while the comparison group did not experience the same level of improvement.

The study examined the association between the frequency of building-related health symptoms (BRS) and different groups (intervention and comparison). The findings revealed significant improvements in the intervention group compared to the comparison group. Specifically, the intervention group experienced a 5.38 times (95%CI =1.90 – 15.24) decrease in the frequency of general symptoms and a 13.60 times (95%CI =3.39 – 54.60) reduction in the frequency of overall symptoms. In terms of severity, the intervention group showed a 13.60 times decrease (95%CI =3.39 – 54.60) in the severity of general symptoms, a 10.95 times decrease in the severity of upper respiratory symptoms (95%CI =2.13 – 56.22) , a 10.95 times decrease in the severity of lower respiratory symptoms (p-value of 0.004), and a 13.60 times (95%CI =3.39 – 54.60) drop in the severity of overall symptoms, all in comparison to the comparison group. These results highlight the effectiveness of the intervention in significantly improving both the frequency and severity of building-related health symptoms.

The results of multilevel logistic regression analysis revealed that caretakers who worked in rooms with rapid temperature fluctuations had a significantly higher risk of developing building-related symptoms (Adjusted odds ratio = 10.72, 95% CI = 2.65 - 43.41, p-value = 0.001). Additionally, caretakers who used aerosol air fresheners were also at a higher risk (Adjusted odds ratio = 5.54, 95% CI = 1.74 - 17.62, p-value = 0.004). These findings were statistically significant at a significance level of 0.05. In summary, the study identified that working in rooms with quick temperature changes and using aerosol air fresheners increased the risk of developing building-related symptoms among caretakers.

Table 4.1 shows 81 general caretaker characteristics, divide between the Intervention group (28 people) and Comparison group (53 people). Participants were divided by gender, with 97.53% female and 2.47% male. The sample size had 48 caretakers (59.26%) aged 36-51, with 13 in the Intervention group and 35 in the Comparison group (27.08% vs. 72.92%). Most caretakers had a normal BMI (45.68%), while 26 had first-level obesity (BMI 25.0-29.9), 13 had second-level obesity (BMI >30), and 5 were underweight. 77.78% of caretakers did not have underlying diseases, while the remaining 18 were split into 9-person Intervention and Comparison groups. Of the caretakers who responded, 66.67% did not use medication or supplements, and 33.33% did. Among those not taking medication or supplements, 64.81% were in the Intervention group, and 35.19% were in the Comparison group. Only one person reported smoking. Most caretakers had work experience ranging from 3 to 72 months (55.56%), with 74.07% working 8 to 10 hours per day. Two worked for fewer than 8 hours per day, and 19 worked for 11 hours per day.

The table of the diagnostic history of 81 caretakers. Out of the respondents, 12 reported allergy symptoms, with 91.67% experiencing low-severity symptoms. Asthma was diagnosed in 4.94% of caretakers, all with low severity. Chronic bronchitis had a prevalence of 1.23%, also with low severity. No ear infections were reported among the caretakers. The majority (87.65%) did not receive a diagnosis of allergic rhinitis. Two cases of sinusitis were identified (2.47%), one with low severity and one with mild severity. One caretaker had a low-severity respiratory infection, and no cases of skin infections were reported.

The caretaker's perception reveals that the majority (62.96%) of individuals in the childcare center room occupy the 2–15-person range. In the intervention group, a similar trend is observed, with 68.63% falling within this range, while the comparison group predominantly consists of 31 or more individuals (80.00%). Caretakers work in adequately illuminated environments, with a significant proportion (87.65%) utilizing suitable desks. However, a small subset of caretakers (6.17%) reported fair desk conditions. Among the caretakers, a minority (4.94%) do not use computers, whereas a small fraction of computer users (6.17%) employ them daily.

In the childcare center environment, the caretaker reported low ventilation in 5 participants from the intervention group and 6 participants from the comparison group. The majority of participants (66.67%) did not report low ventilation. Within the intervention group, 3 participants (21.43%) showed high ventilation at a seldom level, while in the comparison group, 11 participants (78.57%) exhibited the same. Additionally, 57 participants did not report high ventilation. Among 81 participants, the majority (54.32% or 44 participants) reported no instances of overheating in the building environment. However, a notable proportion (22.22% or 18 participants) experienced frequent or constant overheating in the childcare center. In the caretaker survey, it was found that most childcare centers (85.19%) did not experience sudden temperature changes. Three individuals reported frequent or constant temperature fluctuations. The majority of centers (85.19%) had air temperatures that were not very low, although a minority (3.70%) perceived the air as being very low. Regarding sensitivity to high relative humidity, 33.33% of the intervention group and 66.67% of the comparison group showed insensitivity. Both groups had similar perceptions of air dryness, with 34.48% in the intervention group and 65.52% in the comparison group. Nine participants (11.11%) reported dry air in childcare centers. The majority (71.60%) indicated that centers were not characterized by loudness. While inadequate ventilation from the air conditioner was not reported by the caretaker (76.54%), 20.00% of the intervention group perceived insufficient ventilation. The majority of respondents (88.89%) reported no olfactory perception from the air conditioning unit. Six individuals detected a seldom level of smell, while three reported frequent or constant odor. Most participants (90.12%) identified a fungus smell in childcare centers, while only 8 individuals in the comparison group reported the same (seldom: 7 individuals, frequent or constant: 1 individual). Regarding dust, 34.57% of participants never encountered it, while 54.32% claimed to have never found dust in the room. Ten cases (7.41% seldom, 4.94% frequent or constant) reported a smell of cigarettes in childcare centers. The majority (79 out of 81) did not detect any chemical smell in the centers.

According to the caretaker's questionnaire responses, the majority of workplaces not new carpeting (90.12%) and office rooms lack new paint (87.65%). Most participants (86.42%) do not have new furniture, although the intervention group has a higher percentage compared to the comparison group (54.55% and 45.45%). The majority of respondents (77 out of 81) reported no new wallpaper in childcare centers. Water stains were observed primarily in the intervention group (57.14%), while the comparison group had no identified water stains (70.15%). Fourteen caretakers reported mold spots in childcare centers, with the comparison group showing the highest prevalence (71.43%).

In the study involving 81 participants, only 8 individuals (9.88%) had carpets in their rooms, while the majority (90.12%) did not. Additionally, 59.26% of the participants reported having a printer in their room. When compared to another group, it was found that 75.00% of the respondents in the comparison group had printers. Regarding workspace conditions, over half (53.09%) of the participants reported having access to a photocopier, while 46.91% reported its absence. Furthermore, the majority of caretakers (90.12%) were situated at a distance greater than 2 meters from the door, with only 8 caretakers positioned closer than 2 meters. In terms of proximity to windows, the majority of caretakers (91.36%) worked at a distance greater than 2 meters, while 8.64% worked closer. Moving on to air fresheners, a majority of caretakers did not utilize room air fresheners, with only a minority reporting their use. Specifically, 37.04% of caretakers utilized ambient air fresheners, while 62.96% refrained from using such products. Expanding on air fresheners, it was found that 37.04% of caretakers used air fresheners, with 54.32% of caregivers employing spray air fresheners. Additionally, when investigating the use of mosquito repellent among caretakers in childcare centers, 56.79% reported not using it. However, in the intervention group compared to the comparison group, a higher percentage (40.00%) of the latter group reported using mosquito repellent.

The study found that 61.73% of participants did not report any symptoms of headache. Dizziness was observed in 23.46% of individuals in the seldom group, while the comparison group reported a higher frequency of 100%. The majority of participants (71.60%) did not experience symptoms of fatigue, except for fifteen individuals at the seldom level. Stress was frequently reported by caretakers, with a prevalence of 6.17%, primarily in the comparison group. Most caretakers (82.72%) did not exhibit symptoms of inattention, and 92.59% did not show signs of being squeamish. Among the caretakers, 69 out of 81 were asymptomatic and did not display dismal symptoms. Eye irritation was prevalent among caretakers, with a prevalence of 18.52% at the seldom level. The majority of participants (86.42%) did not experience symptoms of tears, but eight individuals reported tears symptoms at the seldom level. Dry eyes were less common, affecting 14 out of 81 caretakers, while 83.95% did not show any symptoms.

Non-throat discomfort was the most common symptom (75.31%), with most subjects reporting it seldom (22.22%). Only one individual in the Comparison group experienced frequent runny nose symptoms, and 69.14% of participants did not have these. 14.81% of caretakers experienced burning nose symptoms, while 83.95% did not. The comparison group had a higher frequency than caretakers (72.84%). Sneeze syndrome was 32.10% at seldom and higher in the comparison group among caretakers. 67.90% had no sneeze symptoms. 22.22% of caretakers experienced painful throat symptoms (Seldom level), whereas 76.54% did not.

Five caretakers (6.17%) had wheezing due to building-related symptoms (BRS). Caretakers had no chest pain (92.59%). 16.05% of caregivers had shortness of breath, while 83.95% did not. Twelve caretakers had sputum, with the comparison group having the most.

The study indicated that caregivers with building-related symptoms (BRS) mostly reported dry skin (90.12%), while those in the comparison group who reported dry skin were mostly caretakers (75.00%). One caretaker had frequent itchy skin, while 86.42% did not. 90.12% of caregivers completed the survey. No skin irritation was reported. 93.83% of caregivers completed the survey. had no rash. 5 caregivers reported rashes.

Building-related symptoms (BRS) for general symptoms showed that 29.63% of respondents had low-severity headaches, whereas only six (7.41%) had mild headaches. 23.46% of caretakers experienced low-severity dizziness, with 68.42% in the comparison group. Caretakers had 23.46% low-severity dizziness, with the comparison group having the most. 70.37% of caregivers are fatigue-free. The intervention group often has mild symptoms. 80.25% of caregivers reported no stress on the SBS Symptom Questionnaire. Stress symptoms were mild (17.28%). 14.81% of caretakers reported low-severity inattention, with the Comparison group reporting the most. 82.72% of caretakers reported no inattention. The Comparison group was most affected by Squeamish (93.83%). 11.11% of caretakers reported misery, which was mild and most common in the comparison group. 80.25% of caretakers had no eye irritation, and 2 to 2.47% had minor irritation. Caretakers reported no stress on the SBS symptom questionnaire (86.42%). 12.35% had mild tears.

The SBS upper respiratory symptom questionnaire found that 75.31% of caretakers who did not report throat irritation had symptoms. Runny nose symptoms were absent in 69.14% of caretakers. Those who reported such symptoms had mild symptoms. The comparison group had the highest runny nose rate, 38.89%. 13.58% of burning nose symptoms were low severity, while 2.47% were mild severe. The comparison group (57.14%) coughs mildly, while most caretakers (71.60%) do not. Sneezing was usually mild (30.86%) and most common in the Comparison group (68.00%). Two individuals mildly sneezed. 24.69% of sore throat symptoms were low severity, while 1.23% were mild severity.

Building-related symptoms (BRS) of the lower respiratory tract showed that most wheezing symptoms were mild (6.17%). 92.59 percent of caregivers reported no wheezing. Caretakers had no chest pain (92.59%). 13.58% of caretakers with shortness of breath had low-severity symptoms, with most in the comparison group. Caretakers (83.95%) reported no loss of breath. 13.58% of caretakers reported low-severity sputum, with the comparison group (72.73%) having the highest frequency.

The comparison group (75.00%) and 9.88% of caretakers reported low-severity dry skin. 90.12% of caregivers reported no dry skin complaints. 87.65% of caretakers did not report itchy skin on the SBS symptom questionnaire. Caretakers rarely have skin discomfort (90.12%). 5 participants had skin irritation, mostly in the Comparison group. The comparison group (40.00%) had the highest low-severity rash caretakers (6.17%).

This summarizes BRS. Caretakers had 59 general symptoms, divided into two groups: Intervention (38.98%) and Comparison (61.02%). General symptom score was 0–16. 45.68% of caregivers mentioned upper respiratory problems in the questionnaire. Upper respiratory symptoms were the most common in the Intervention group at 59.46%. The Intervention group scored a maximum of 6, while the Comparison group scored 15. 22.22% of caregivers reported lower respiratory problems. The intervention group reported 33.33% and the comparator group 66.67%. 23.46% of caregivers mentioned skin complaints in the questionnaire. The Intervention group had 68.42% upper respiratory symptoms. 63 people (77.78%) had symptoms, including 38.10% in the intervention group and 61.90% in the comparison group.

The bivariate analysis did not find any significant correlations between the general characteristics of caretakers (such as gender, age, BMI, underlying disease, medication use, smoking, and duration of employment) and their building-related symptoms. All factors were included in the analysis, but no associations were observed. Additionally, when examining the association between various health conditions (such as allergies, asthma, chronic bronchitis, ear infection, allergic rhinitis, sinusitis, skin infection, respiratory infection, and migraine) and building-related symptoms, no significant associations were found at the 0.05 level.

The bivariate analysis found a significant correlation between building-related symptoms and perception of the childcare center environment. Low ventilation was positively associated with building-related symptoms (OR = 8.59, 95%CI = 1.84 –

40.05). Rooms with high ventilation had a 6.91 times higher rate of building-related symptoms compared to rooms without high ventilation (95%CI = 1.48 – 32.34, p-value = 0.014). Occupying an overheated room significantly increased the probability of building-related symptoms compared to a non-overheated room, with an odds ratio of 6.91 (95%CI = 1.24 – 10.33, p-value = 0.019). Rooms with quick temperature changes were more likely to cause building-related symptoms (OR = 8.96, 95%CI = 2.40 – 33.47, p-value ≤ 0.001). Higher relative humidity increased the likelihood of building-related symptoms by 5.09 times (p-value = 0.016, 95%CI = 1.36 – 19.04). Occupying air-dry rooms significantly increased the likelihood of building-related symptoms (p-value = 0.018, OR = 6.42, 95%CI = 1.37 – 30.06). Exposure to dusty areas increased the likelihood of building-related symptoms (OR = 6.88, 95%CI = 2.08 – 22.72). Using spray air freshener in a room increased the rate of building-related symptoms by 4.49 times (p-value = 0.004, 95%CI = 1.60 – 12.64). Occupying rooms with mosquito repellent increased the chance of building-related symptoms compared to non-occupying such rooms.

The survey revealed that the majority of buildings in the intervention group were aged, while the control group consisted of newer buildings. The median distance of childcare centers from the main road was found to be 100.80 meters. Additionally, it was observed that 60.00% of the buildings in the comparison group were located at a distance of 501 meters or more from the main road. In terms of building structure, the majority of childcare centers (81.48%) were single-floor establishments, with the remaining 18.52% having two floors. The study also revealed that the median room size of childcare centers was 124.25 square meters, and 80.00% of the intervention group had rooms equal to or larger than 121 square meters.

Regarding windows, the survey indicated that 90.00% of childcare centers utilized aluminum windows, while only 10% used wooden windows. The median number of windows in a room was 5.50, and the majority of childcare centers (87.50%) had between 3 and 6 windows. In terms of doors, 50.00% of the centers used aluminum doors, while 30.00% opted for wooden doors. The median number of doors in a room was 1.50, and 80.00% of childcare centers had 1 to 2 doors.

The survey findings showed that a significant portion (70.00%) of childcare centers did not have kitchen rooms. Among the centers that did have kitchens, 66.67% belonged to the comparison group. Most childcare centers employed a kitchen hood system with a hood. Additionally, the study revealed that there was a distance of 17 meters or more between the kitchen and the classroom in the majority of childcare centers. As for fuel sources for cooking, it was found that almost all childcare centers with kitchens utilized liquefied petroleum gas (LPG).

The survey results indicated that the majority (90.00%) of childcare centers had air conditioning units installed, with only one center in the comparison group lacking this feature. Among centers with air conditioning, 50.00% had a maximum cooling capacity of 32,000 BTU or lower. In terms of additional air circulation measures, 90.00% of centers had fans, while only 10% used fans as a supplementary measure to air conditioning. None of the surveyed childcare centers employed building automation systems (BAS).

According to the survey, none of the childcare centers had a moist environment or an air circulation system in their office areas. The use of ventilation fans was also low, with 80.00% of centers not employing them. Only a minority (20.00%) of centers implemented the use of HEPA air filters, which were evenly distributed between the comparison and intervention groups. Mold spots were absent in the majority (70.00%) of centers, while the remaining 30.00% had detected mold spots. Water stains were found in only one out of the ten childcare centers surveyed. Interestingly, none of the centers were equipped with an air quality monitoring system. Translucent spaces were a common feature in all childcare centers.

In an 8 -hour test, the indoor air quality parameters were measured in childcare centers. The results showed that the median PM 2.5 level was 13.20 mg/m^3, with 90.00% of centers having acceptable levels and one center having elevated levels. For PM10, the median level was 81.21 mg/m^3, and 80.00% of centers exceeded the standard. Carbon dioxide levels were normal in 80.00% of centers, ranging from 35.01 ppm to 1179.01 ppm. Carbon monoxide levels were common and low, with a median of 0.01 PPM. Total VOC levels were within the normal range, ranging from 0.02 ppm to 1.54 ppm. Bacterial counts were higher than normal in 70.00% of centers, with a median count of 1,614 CFU/m³. Fungal counts were in the normal range for 60.00% of centers and higher for 40.00%. Temperature levels were acceptable, ranging from 24.56°C to 32.12°C, with a median of 15.00°C. The median relative humidity was 25.50, and low humidity was observed in five centers.

The post-study survey results were categorized into two groups: "decreases" and "does not decrease." The former group represents a decrease in the frequency of building-related symptoms (BRS) after the study, while the latter group indicates either no change or an increase in BRS frequency. The overall manifestation of symptoms was attributed to the presence of general symptoms, upper respiratory symptoms, lower respiratory symptoms, and skin symptoms.

In terms of general symptoms, the intervention group experienced a significant reduction of 51.85% in symptom frequency, whereas the comparison group exhibited a decrease of 16.67%. However, the study on the frequency of upper respiratory symptoms showed that the majority of symptoms in both groups (Intervention: 96.30%, Comparison: 98.15%) did not decrease. Similar results were observed for lower respiratory symptoms, with the intervention and comparison groups showing minimal reductions (Intervention: 96.30%, Comparison: 98.15%). When considering overall symptoms, the intervention group had a decrease of 44.44% in symptom frequency, while 55.56% did not experience a decrease. In contrast, the comparison group showed a decrease of 5.56%, with 94.44% not experiencing a decrease.

The severity of general symptoms showed similar patterns, with the intervention group experiencing a decrease of 44.44% and 55.56% not experiencing a decrease. The comparison group had a decrease of 5.56%, while 94.44% did not experience a decrease in severity Regarding respiratory symptoms, the intervention group had a substantial decrease of 44.44% in symptom severity, while the comparison group showed a relatively minor decrease of 5.56%. In terms of overall symptom severity, the intervention group had a decrease of 44.44%, while 55.56% did not experience a decrease. On the other hand, the comparison group had a decrease of 5.56%, with 94.44% not showing any decrease.

Table 4.1 General Characteristics of caretakers.

Characteristics	Intervention (n=28) Number (%)	Comparison (n=53) Number (%)	Total (n=81) Number (%)	P-value
Gender				
Male	2 (100)	0	2 (2.47)	0.049*
Female	26 (32.91)	53 (67.09)	79 (97.53)	
Age (Maximum= 59, Minimum=23, Median (IQR)=4 (30.50, 47.00), (Year)				
23 - 35	13 (50.00)	13 (50.00)	26 (32.10)	
36 - 51	13 (27.08)	35 (72.92)	48 (59.26)	0.133
≥ 52	2 (28.57)	5 (71.43)	7 (8.64)	
BMI (Maximum= 38.45, Minimum=17.07, Median (IQR)=4 (21.48, 28.61)				
> 18.5	3 (60.00)	2 (40.00)	5 (6.17)	
18.5 – 24.9	13 (35.14)	24 (64.86)	37 (45.68)	0.533
25.0 – 29.9	7 (26.92)	19 (73.08)	26 (32.10)	
≥ 30.0	5 (38.46)	8 (61.54)	13 (16.05)	
Underlying disease				
Yes	9 (50.00)	9 (50.00)	18 (22.22)	0.065
No	19 (30.16)	45 (69.84)	63 (77.78)	
Medicine or supplement				
Yes	18 (66.67)	9 (33.33)	27 (33.33)	0.536
No	35 (64.81)	19 (35.19)	54 (66.67)	
Smoking				
Yes	1 (100)	0	1 (1.23)	0.346[a]
No	27 (34.75)	53 (66.25)	80 (98.77)	
Working period in childcare centers per month(Maximum= 240, Minimum=3, Median (IQR)=4 (21.00, 120.00),(month)				
3 - 72	21 (46.67)	24 (53.33)	45 (55.56)	
73 - 144	2 (8.70)	21 (91.30)	23 (28.40)	0.007*
≥145	5 (38.46)	8 (61.54)	13 (16.05)	

* P-value ≤ 0.05, [a] Fisher exact test

Table 4.1 General Characteristics of caretakers. (Continuous)

Characteristics	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
Working period in childcare centers per hour (Maximum= 15, Minimum=7, Median (IQR)=60.0 (hour)				
<8	1 (50.00)	1 (50.00)	2 (2.47)	
8-10	22 (36.67)	38 (63.33)	60 (74.07)	0.638
≥11	5 (26.32)	14 (73.68)	19 (23.46)	

* P-value ≤ 0.05, [a] Fisher exact test

According to Table 4.1, there were 81 general caretaker characteristics divided between the Intervention group of 28 people and the Comparison group of 53 people. The participants of the study were divided into male (2.47%) and female (97.53%) groups according to the information provided in the table. Aged 36 - 51, the 48 caretakers (59.26%) who answered the questionnaire were divided into 13 intervention groups and 35 comparison groups (27.08% VS 72.92%), 7 caretakers greater than or equal to 52 years old (8.64%), respectively. Most caretakers had a BMI within the normal range (18.5 – 24.9 = 45.68%), although 26 had grade obesity first level (BMI 25.0-29.9), 13 had grade 2 obesity (BMI more than 30), and 5 were underweight. While the majority (77.78%) of caretakers who responded to the survey did not have an underlying disease, the 18 caretakers who did have an underlying disease were separated into 9-person intervention groups and 9-person comparison groups. where 66.67 % of caretakers did not use medication or supplements and 33.33 % did. The group that did not take any medication or dietary supplement was separated into the Intervention group (64.81%) and the Comparison group (35.19%). The study's sample size was comprised of one person who reported smoking behavior. Most of the caretakers had work experience ranging from 3 to 72 months per month (55.56%). In addition, the majority (74.07%) of childcare workers worked an average of 8 to 10 hours each day. Two of them worked in childcare centers for an average of fewer than 8 hours per day, while 19 worked an average of 11 hours per day.

Table 4.2 General information of caretakers and a diagnosis.

Characteristics	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
Allergy				
No	24 (34.78)	45 (65.55)	69 (85.16)	0.999
Yes	4 (33.33)	8 (66.67)	12 (14.81)	
Asthma				
No	27 (35.06)	50 (64.94)	77 (95.06)	0.999
Yes	1 (25.00)	3 (75.00)	4 (4.94)	
Chronic bronchitis				
No	28 (35.00)	52 (65.00)	80 (98.77)	0.999
Yes	0	1 (100)	1 (1.23)	
Ear infection				
No	28 (34.57)	53 (65.43)	81 (100)	N/A
Allergic Rhinitis				
No	23 (32.39)	48 (67.61)	71 (87.65)	0.999
Yes	5 (50.00)	5 (50.00)	10 (12.35)	
Sinusitis				
No	27 (34.18)	52 (65.82)	79 (97.53)	0.999
Yes	1 (50.00)	1 (50.00)	2 (2.47)	
Skin infection				
No	28 (34.57)	53 (65.43)	81 (100)	N/A
Respiratory infection				
No	28 (35.00)	52 (65.00)	80 (98.77)	0.999

* P-value ≤ 0.05, [a] Fisher exact test, N/A = Not Applicable

The diagnostic history of 81 caretakers is presented in a table. According to the Caretaker questionnaire, 12 individuals identified as having allergy symptoms, while 91.67% of respondents reported experiencing symptoms of low severity. Caretakers diagnosed with asthma comprised 4 . 9 4 % of the total number of caretakers, all of whom had low severity. The data showed conformity with the diagnosis of chronic bronchitis (1.23%), with a low level of severity. There are no reported cases of caregivers being diagnosed with an ear infection. The majority of caretakers (87.65%) responsible do not receive a diagnosis of allergic rhinitis. Two cases of sinusitis were diagnosed or 2.47%, with one case each of low and mild severity. A caretaker was diagnosed with a respiratory infection of low severity (1/81 case). There are no reported instances of the caretaker receiving a diagnosis of a skin infection occurring.

Table 4.3 Perception of childcare center environment.

Factor	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
Occupancy of the room (Maximum= 35, Minimum=3, Median (IQR)= 13.00 (8.00, 18.00),(person)				
2-15	16 (31.37)	35 (68.63)	51 (62.96)	0.430
≥15	12 (40.00)	18 (60.00)	30 (37.04)	
Room lighting				
Appropriate	28 (34.57)	53 (65.43)	81 (100)	N/A
Suitable table				
Have no	1 (50.00)	1 (50.00)	2 (2.47)	
Fair	3 (60.00)	2 (40.00)	5 (6.17)	0.409
Appropriate or more	24 (32.43)	50 (67.57)	74 (91.36)	
Computer use				
No	2 (50.00)	2 (50.00)	4 (4.94)	
Some time	24 (33.33)	48 (66.67)	72 (88.89)	0.765
Always	2 (40.00)	3 (60.00)	5 (6.17)	
Low ventilation				
Never	21 (38.89)	33 (61.11)	54 (66.67)	
Seldom	2 (12.50)	14 (87.50)	16 (19.75)	0.140
Frequently or always	5 (45.45)	6 (54.55)	11 (13.58)	
High ventilation				
Never	23 (40.35)	34 (59.65)	57 (70.37)	
Seldom	3 (21.43)	11 (78.57)	14 (17.28)	0.385
Frequently or always	2 (20.00)	8 (80.00)	10 (12.35)	
Overheat				
Never	18 (40.91)	26 (59.09)	44 (54.32)	
Seldom	5 (26.32)	14 (73.68)	19 (23.46)	0.107
Frequently or always	5 (27.78)	13 (72.22)	18 (22.22)	

* P-value ≤ 0.05, [a] Fisher exact test

Table 4.3 Perception of childcare center environment (Continuous).

Factor	Intervention (n=28) Number (%)	Comparison (n=53) Number (%)	Total (n=81) Number (%)	P-value
Sudden temperature change				
Never	17 (36.96)	29 (63.04)	46 (56.79)	0.485
Seldom	8 (35.00)	12 (60.00)	20 (24.69)	
Frequently or always	3 (20.00)	12 (80.00)	15 (18.52)	
Cold temperature				
Never	26 (37.68)	43 (62.32)	69 (85.19)	0.158
Seldom or more	2 (16.67)	7 (83.33)	9 (14.81)	
High relative humidity				
Never	18 (33.33)	36 (66.67)	54 (66.67)	0.474
Seldom	7 (46.67)	8 (53.33)	15 (18.52)	
Frequently or always	3 (25.00)	9 (75.00)	12 (14.81)	
Air dry				
Never	20 (34.48)	38 (65.52)	58 (71.60)	0.993
Seldom	5 (35.71)	9 (64.29)	14 (17.28)	
Frequently or always	3 (33.33)	6 (66.67)	9 (11.11)	
Loudness				
Never	21 (36.32)	37 (63.68)	58 (71.60)	0.580
Seldom	5 (26.32)	14 (73.68)	19 (23.46)	
Frequently or always	2 (50.00)	2 (50.00)	4 (4.94)	
Low ventilation from air conditioner				
Never	25 (40.32)	37 (59.68)	62 (76.54)	0.142
Seldom or more	15 (15.79)	16 (84.21)	19 (23.46)	

* P-value ≤ 0.05, [a] Fisher exact test

Table 4.3 Perception of childcare center environment (Continuous).

Factor	Intervention (n=28) Number (%)	Comparison (n=53) Number (%)	Total (n=81) Number (%)	P-value
Smell from air conditioner				
Never	27 (37.50)	45 (62.50)	72 (88.89)	0.117
Seldom or more	1 (11.11)	5 (88.89)	6 (11.11)	
Fungus smell				
Never	28 (38.36)	45 (61.64)	73 (90.12)	0.031[a]
Seldom or more	0	8 (100)	8 (9.88)	
Dusty				
Never	10 (22.73)	34 (77.27)	44 (54.32)	0.029*
Seldom	15 (53.75)	13 (46.43)	28 (34.57)	
Frequently or always	3 (3.33)	6 (66.67)	9 (11.11)	
Cigarette smell				
Never	26 (36.62)	45 (63.38)	71 (87.65)	0.301
Seldom or more	2 (20.00)	8 (80.00)	10 (12.35)	
Chemical smell				
Never	28 (35.44)	51 (64.56)	79 (97.53)	0.542
Seldom	0	2 (100)	2 (2.47)	
New carpet				
Yes	5 (62.50)	3 (37.50)	8 (9.88)	0.117
No	23 (31.51)	50 (68.49)	73 (90.12)	
New paint				
Yes	8 (80.00)	2 (20.00)	10 (12.35)	0.002*
No	20 (28.17)	51 (71.83)	71 (87.65)	

* P-value ≤ 0.05, [a] Fisher exact test

Table 4.3 Perception of childcare center environment (Continuous).

Factor	Intervention (n=28) Number (%)	Comparison (n=53) Number (%)	Total (n=81) Number (%)	P-value
New furniture				
Yes	6 (54.55)	5 (45.45)	11 (13.58)	0.176
No	22 (31.43)	48 (68.57)	70 (86.42)	
New wallpaper				
Yes	4 (100)	0	4 (4.94)	0.012 [a]*
No	24 (31.17)	53 (68.83)	77 (95.06)	
Water stain				
Yes	8 (57.14)	6 (42.86)	14 (17.28)	0.761
No	20 (29.85)	47 (70.15)	67 (82.72)	
Mold spot				
Yes	4 (28.57)	10 (71.43)	14 (17.28)	0.595
No	24 (35.82)	43 (64.18)	67 (82.72)	

* P-value ≤ 0.05, [a] Fisher exact test

According to the caretaker's perception of the childcare center environment. The majority of the occupants of the room are 2–15 persons It is 51 people, or 62.96 percent of the total number. Similar to the room occupied by the intervention (2-15 persons are 68.63%) group, however the comparison group most of more than or equal to 31 people (80.00%). All caretakers work within adequately illuminated rooms. The majority (87.65%) of the desks used by caretakers are deemed appropriate. According to the questionnaire responses, five people (6.17%) reported that the desks were deemed to be fair. caretaker, there are 4 people or 4.94% who do not use computers, among the people who use computers 5 people use them every day (6.17%).

In the childcare center environment, the caretaker reported that 5 participants in the intervention group and 6 participants in the comparison group reported low ventilation. It was observed that 66.67% of the participants did not report low ventilation in the childcare center. The evaluation of the questionnaire revealed that within the intervention group, three participants showed high ventilation at the seldom level (21.43%), whereas within the comparison group, eleven participants (78.57%) exhibited the same. Additionally, it was observed that 57 participants did not report high ventilation within the childcare center. Out of a total of 81 participants, the caretaker of the majority, especially 44 participants (54.32%), reported no instances of overheating in the building environment. However, a notable proportion of 18 participants or 22.22% reported experiencing frequent or constant overheating in the childcare center. According to a survey conducted among caretakers, it was found that most (85.19%) childcare centers did not experience sudden changes in room temperatures. And the findings of the caretaker questionnaire, it was observed that there was a Frequent or always fluctuation in the room temperature has three people. The majority of childcare centers were found to have air temperatures that were not very low (85.19%).The results indicate that 33.33% of participants in the intervention group exhibited insensitivity to high relative humidity, while 66.67% of those in the comparison group demonstrated the same insensitivity. The findings are showing of a congruent sentiment regarding the absence of Air dry perception in both the intervention and comparison groups within childcare centers (34.48% VS 65.52%). And 9 people (11.11%) reported experiencing dry air in childcare centers. The majority of participants, especially 71.60%, indicated that childcare centers were not characterized by loudness. Although the caretaker did not report any sensation of inadequate ventilation from the air conditioner (76.54%), 20.00% of the participants in the Intervention group experienced a sense of insufficient ventilation from the air conditioner. The emission of smell from the air conditioning system. The majority (88.89%) of respondents reported a lack of olfactory perception from the air conditioning unit. Furthermore, six people reported detecting a smell that comes from the air conditioning unit at the Seldom level, while three people reported detecting the same odor at the frequently or always level. The results show that a majority of participants, specifically 90.12%, reported identifying a fungus smell in childcare centers. In contrast, a small number of individuals in the comparison group, specifically 8 participants, reported detecting a fungus smell in childcare centers (Seldom or more 9.88%). According to the questionnaire responses, 34.57% of the participants reported never encountering dust in the room, while 54.32% claimed to have never found dust in the room. Ten cases were reported where people detected a smell of cigarettes within childcare centers (7.41% is seldom or more). It was reported that the majority of respondents had not detected any chemical smell within childcare centers (79/81).

According to the caretaker's response to the questionnaire, the workplace is not equipped with new carpeting (90.12%). And to the caretaker's answers, the majority or 87.65% of office rooms don't have new paint. Furthermore, the majority (86.42%) of the participants did not have any new furniture; however, it was observed that the intervention group showed a greater percentage of new furniture compared to the comparison group (54.55% VS 45.45%). The survey results show that a majority of the participants, specifically 77 out of 81 respondents, reported having no new wallpaper in childcare centers. The majority of water stains appeared in the Intervention group (57.14%), whereas, in the comparison group, water stains were not identified (70.15%). fourteen caretakers reported the presence of mold spots in childcare centers. The comparison group had the highest prevalence of mold spots at 71.43%.

Table 4.4 Childcare center environment conditions among caretakers.

Factor	Intervention (n=28) Number (%)	Comparison (n=53) Number (%)	Total (n=81) Number (%)	P-value
Have carpet				
Yes	4 (50.00)	4 (50.00)	8 (9.88)	0.438
No	24 (32.88)	49 (67.12)	73 (90.12)	
Have printer				
Yes	12 (25.00)	36 (75.00)	48 (59.26)	0.035*
No	16 (48.48)	17 (51.52)	33 (40.74)	
Have photocopier				
Yes	9 (20.93)	34 (79.07)	43 (53.09)	0.010*
No	19 (50.00)	19 (50.00)	38 (46.91)	
Near door				
Yes	4 (50.00)	4 (50.00)	8 (9.88)	0.438
No	24 (32.88)	49 (67.12)	73 (90.12)	
Near window				
Yes	24 (32.43)	50 (67.57)	74 (91.36)	0.227
No	4 (57.14)	3 (42.86)	7 (8.64)	
Have air freshener				
Yes	12 (40.00)	18 (60.00)	30 (37.04)	0.474
No	16 (31.37)	35 (68.63)	51 (62.96)	
Use spray air freshener				
Yes	21 (47.73)	23 (52.27)	44 (54.32)	0.010*
No	7 (18.92)	3 (81.08)	37 (45.68)	
Mosquito repellent				
Yes	21 (60.00)	14 (40.00)	35 (43.21)	≤0.001*
No	7 (15.22)	39 (84.78)	46 (56.79)	

* P-value ≤ 0.05,

Out of the total of 81 participants, only 8 people (9.88%) reported having carpets in their rooms, while the majority (90.12%) of the respondents did not have carpets. it was found that 59.26% of them had a printer in their room. Upon comparing this group to another, it was found that 75.00% of the respondents in the Comparison group had printers. The findings indicate that over half (53.09%) of participants reported working in a workspace that was stocked with a photocopier, whereas a notable minority of 46.91% reported the absence of a photocopier in their work area. The study reveals that the majority of caretakers, especially 90.12%, were situated at a distance greater than 2 meters from the door. However, a small proportion of 8 caretakers were found to be positioned within a distance less than 2 meters from the door. The majority (91.36%) of caretakers work at a distance greater than 2 meters from a window, whereas a minority of 8.64% of caretakers work within a distance of less than 2 meters from a window. Out of a representative group of thirty caretakers, a majority did not utilize room air fresheners, while a minority reported their use. A minor percentage (37.04%) of caretaker showed the utilization of ambient air fresheners, whereas 62.96% refrained from using such products. A minor percentage (37.04%) of caretakers utilized air fresheners, whereas 62.96% refrained from using such products. About 54.32% of caregivers employed spray air fresheners. The utilization of mosquito repellent among caretakers in childcare centers was investigated, revealing that 56.79% of participants reported abstaining from its use. However, a higher percentage of mosquito repellent use was found in the intervention group compared to the comparison group, with 40.00% of the latter group reporting its use.

Table 4.5 The frequency of building-related symptoms (BRS) in general symptoms.

Symptoms	Intervention (n=28) Number (%)	Comparison (n=53) Number (%)	Total (n=81) Number (%)	P-value
Headache				
Never	14 (28.00)	36 (72.00)	50 (61.73)	0.151
Seldom or more	14 (48.28)	15 (51.72)	29 (35.80)	
Dizziness				
Never	20 (34.48)	38 (65.52)	58 (71.60)	0.980
Seldom or more	8 (42.11)	15 (65.22)	23 (28.40)	
Fatigue				
Never	16 (27.59)	42 (72.41)	58 (71.60)	0.066
Seldom	6 (42.86)	8 (57.14)	14 (17.28)	
Frequently	6 (66.67)	3 (33.33)	9 (11.11)	
Stressed				
Never	21 (32.81)	43 (67.16)	61 (79.01)	0.911
Seldom	5 (41.67)	7 (58.33)	12 (14.81)	
Frequently	2 (40.00)	3 (60.00)	5 (6.17)	
Inattention				
Never	22 (32.84)	45 (67.16)	67 (82.72)	0.542
Seldom	6 (42.86)	8 (57.14)	14 (17.28)	
Squeamish				
Never	26 (34.67)	49 (65.33)	75 (92.59)	0.999
Seldom	2 (33.33)	4 (66.67)	6 (7.41)	
Dismal				
Never	23 (33.33)	46 (66.67)	69 (85.19)	0.743
Seldom	5 (41.67)	7 (58.33)	12 (14.81)	
Eye irritation				
Never	20 (31.25)	44 (68.75)	64 (79.01)	0.125
Seldom or more	8 (53.33)	7 (46.67)	15 (18.52)	

* P-value ≤ 0.05, [a] Fisher exact test

Table 4.5 The frequency of building-related symptoms (BRS) in general symptoms (Continuous).

Symptoms	Intervention (n=28) Number (%)	Comparison (n=53) Number (%)	Total (n=81) Number (%)	P-value
Tears				
Never	24 (34.29)	46 (65.71)	70 (86.42)	0.893
Seldom or more	4 (36.36)	7 (63.64)	11 (13.58)	
Dry eyes				
Never	21 (30.88)	47 (69.12)	68 (83.95)	0.102
Seldom or more	7 (53.85)	6 (46.15)	13 (16.05)	

* P-value ≤ 0.05, [a] Fisher exact test

The number of symptoms related to buildings in relation to general symptoms. No symptoms of headache were detected (61.73%). The frequency of dizziness was found to be 28.40% in the seldom group, whereas the comparison group reported a higher frequency of 100% for dizziness. Most people, particularly 71.60%, had no symptoms of fatigue. Conversely, fifteen people showed symptoms of fatigue at "seldom" level. The caretakers have reported that the level of stress was frequently observed at a percentage of 6.17%, with the majority of cases being reported in the comparison group. The majority (82.72%) of caretakers have no symptoms of "inattention." And 92.59% of caretakers did not exhibit any "squeamish" symptoms. The majority of caretakers, mostly 69 out of 81, were asymptomatic and exhibited an absence of dismal symptoms. The study revealed that caretakers experienced eye irritation at a prevalence of 18.52% at the seldom or more level. The majority of people, especially 86.42%, have no symptoms of "Tears". However, it is noteworthy that "Tears" symptoms were observed in eight individuals at the seldom level. The frequency of dry eyes was found to be small among most caretakers 16.05%, compared to 83.95% of no symptomatic caretakers.

Table 4.6 The frequency of building-related symptoms (BRS) in upper respiratory symptoms.

Symptoms	Intervention (n=28) Number (%)	Comparison (n=53) Number (%)	Total (n=81) Number (%)	P-value
Throat irritation				
Never	17 (27.87)	44 (72.13)	61 (75.31)	0.033*
Seldom or more	11 (55.00)	9 (45.00)	20 (24.69)	
Runny nose				
Never	17 (30.36)	39 (69.64)	56 (69.14)	0.288
Seldom or more	11 (44.00)	14 (56.00)	25 (30.86)	
Burning nose				
Never	23 (33.82)	45 (66.18)	68 (83.95)	0.758
Seldom or more	5 (38.46)	7 (61.54)	13 (16.05)	
Cough				
Never	19 (32.20)	40 (67.80)	59 (72.84)	0.464
Seldom or more	9 (42.86)	12 (57.14)	21 (25.93)	
Sneeze				
Never	19 (34.55)	36 (65.45)	55 (67.90)	0.995
Seldom or more	9 (34.62)	17 (65.38)	26 (32.10)	
Sore throat				
Never	18 (29.03)	44 (70.97)	62 (76.54)	0.058
Seldom or more	10 (52.63)	9 (47.37)	19 (23.46)	

* P-value ≤ 0.05, [a] Fisher exact test

The most frequently reported symptom was non-throat irritation (75.31%), with the majority of participants indicating that it occurred seldom (24.69%). The majority or 69.14% of people were not showing symptoms of a runny nose, and only one person from the comparison group reported experiencing such symptoms with a frequency that could be described as frequently. Although burning nose symptoms were most reported as infrequent, a substantial percentage of caretakers (16.05%) did experience this symptom, while most of them (83.95%) did not. The comparison group exhibits an in comparison higher frequency, while the majority of caretakers do not exhibit this cough symptom (72.84%). The prevalence of sneeze syndrome among caretakers was found to be 32.10% at seldom and more frequent in the comparison group. About 67.90% of the participants reported an absence of symptoms related to sneezing. A total of 23.46% of caretakers showed experiencing sore throat symptoms (Seldom level), while the majority of caretakers, specifically 76.54%, reported not experiencing any sore throat symptoms.

Table 4.7 The frequency of building-related symptoms (BRS) in lower respiratory symptoms.

Symptoms	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
Wheezing				
Never	25 (32.89)	51 (67.11)	76 (93.83)	0.222
Seldom	3 (60.00)	2 (40.00)	5 (6.17)	
Chest Pain				
Never	25 (33.33)	50 (66.67)	75 (92.59)	
Seldom	3 (50.00)	3 (50.00)	6 (7.41)	0.659
Shortness of Breath				
Never	24 (35.29)	44 (64.71)	68 (83.95)	0.999
Seldom	4 (30.77)	9 (69.23)	13 (16.05)	
Sputum				
Never	25 (36.23)	44 (63.77)	69 (85.19)	0.343
Seldom	3 (25.00)	9 (75.00)	12 (14.81)	

* P-value ≤ 0.05, [a] Fisher exact test

Table 4.7 shows the prevalence of building-related symptoms (BRS) in lower respiratory symptoms, revealing that five caretakers (6.17%) exhibited wheezing. The majority of caretakers were found to exhibit an absence of chest pain symptoms (92.59%). The rate of shortness of breath was observed to be 16.05% among caretakers, while the majority of caretakers (83.95%) did not exhibit this symptom. The study reported that twelve caretakers exhibited sputum, with the comparison group showing the highest prevalence of this finding.

Table 4.8 The frequency of building-related symptoms (BRS) in skin symptoms.

Symptoms	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
Dry skin				
Never	26 (35.62)	47 (64.38)	73 (90.12)	0.432
Seldom	2 (25.00)	6 (75.00)	8 (9.88)	
Itchy skin				
Never	25 (35.71)	45 (64.29)	70 (86.42)	0.584
Seldom	3 (27.27)	8 (72.73)	11 (13.58)	
Skin irritation				
Never	25 (34.25)	48 (65.75)	73 (90.12)	0.568
Seldom	3 (37.50)	5 (62.50)	8 (9.88)	
Rash				
Never	25 (32.89)	51 (67.11)	76 (93.83)	0.222
Seldom	3 (60.00)	2 (40.00)	5 (6.17)	

* P-value ≤ 0.05, [a] Fisher exact test

The study found that caretakers who experienced building-related symptoms (BRS) mostly reported (90.12%) dry skin as their skin symptom, while those in the comparison group who reported dry skin were predominantly caretakers (75.00%). The majority of caretakers (86.42%) did not exhibit symptoms of Itchy skin, whereas one caretaker showed Itchy skin at a frequently level. The questionnaire was responded to by 90.12% of the caretakers. No instances of cutaneous irritation have been reported. The questionnaire was answered by 93.83% of the caretakers. was have never experienced a rash. And 5 caregivers have reported experiencing a rash.

Table 4.9 The severity of building-related symptoms (BRS) in general symptoms.

Symptoms	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
Headache				
No	14 (27.45)	37 (72.55)	51 (62.96)	
Low	12 (50.00)	12 (50.00)	24 (29.63)	0.181
Mild	2 (33.33)	4 (66.67)	6 (7.41)	
Dizziness				
No	20 (35.09)	37 (64.91)	57 (70.37)	
Low	6 (31.58)	13 (68.42)	19 (23.46)	0.929
Mild to moderate	2 (40.00)	3 (60.00)	5 (6.17)	
Fatigue				
No	15 (26.32)	42 (73.68)	57 (70.37)	
Low	12 (54.55)	10 (45.45)	22 (27.16)	0.520
Mild	1 (50.00)	1 (50.00)	2 (2.47)	
Stressed				
No	22 (33.85)	43 (66.15)	65 (80.25)	
Low	5 (35.71)	9 (64.29)	14 (17.28)	0.999
Mild	1 (50.00)	1 (50.00)	2 (2.47)	
Inattention				
No	22 (32.84)	45 (67.16)	67 (82.72)	
Low	5 (41.67)	7 (58.33)	12 (14.81)	0.882
Mild	1 (50.00)	1 (50.00)	2 (2.47)	
Squeamish				
No	27 (35.53)	49 (64.47)	76 (93.83)	0.432
Low	1 (20.00)	4 (80.00)	5 (6.17)	
Dismal				
No	24 (34.29)	46 (65.71)	70 (86.42)	
Low	3 (33.33)	6 (66.67)	9 (11.11)	0.999
Mild	1 (50.00)	1 (50.00)	2 (2.47)	

* P-value ≤ 0.05, [a] Fisher exact test

Table 4.9 The severity of building-related symptoms (BRS) in general symptoms (Continuous).

Symptoms	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
Eye irritation				
No	21 (32.31)	44 (67.69)	65 (80.25)	0.389
Low to mild	7 (43.75)	9 (56.25)	16 (19.75)	
Tears				
No	24 (34.29)	46 (65.71)	70 (86.42)	0.893
Low to mild	4 (36.36)	6 (63.64)	11 (13.58)	
Dry eyes				
No	21 (30.88)	47 (69.12)	68 (83.95)	0.111
Low to mild	7 (53.85)	6 (46.15)	13 (16.05)	

* P-value ≤ 0.05

The investigation of building-related symptoms (BRS) pertaining to general symptoms revealed that the majority of respondents experienced low-severity headache symptoms (29.63%), with only six subjects or 7.41% reporting mild severity headaches. The percentage of cases of low-severity dizziness among caretakers was found to be 23.46%, with the greatest number of cases observed in the comparison group (68.42%). The percentage of cases of low severity dizziness among caretakers was found to be 23.46%, with the greatest number of cases observed in the comparison group. The majority of the people who provide care do not exhibit symptoms of fatigue (70.37%). However, among those who do exhibit such symptoms, the intervention group frequently experiences low-level severity and intensity.

According to the SBS Symptom Questionnaire, a large percentage of caretakers 80.25%, reported not feeling stressed. Conversely, people who exhibited symptoms of stress were found to have a low severity of these symptoms (17.28%). The percentage of cases of low severity of inattention was reported by 14.81% of caretakers, with the greatest number of cases observed in the comparison group. On the other hand, the majority of caretakers (82.72%) reported no inattention. The majority of caretakers (93.83%) reported Squeamish as having a low severity level, with the comparison group being the most affected. The percentage of dismal, as reported by 11.11% of caretakers, was found to be of low severity and was observed to be most frequently occurring in the comparison group. The majority of caretakers showed no symptoms of eye irritation (80.25%), with only a low to mild severity of 19.75%. According to the SBS symptom questionnaire, the majority of caretakers (86.42%) did not report experiencing stress. However, those with tears of low to mild severity exhibited at 13.58%. Finally, the caretakers reported a frequency of 16.05% for the severity of dry eyes, ranging from low to mild.

Table 4.10 The severity of building-related symptoms (BRS) in upper respiratory symptoms.

Symptoms	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
Throat irritation				
No	17 (27.87)	44 (72.13)	61 (75.31)	0.027*
Low to mild	11 (55.00)	9 (45.00)	20 (24.69)	
Runny nose				
No	17 (30.36)	39 (69.64)	56 (69.14)	0.233
Low to mild	11 (44.00)	14 (56.00)	25 (30.86)	
Burning nose				
No	23 (33.82)	45 (66.18)	68 (83.95)	0.747
Low	5 (38.46)	6 (61.54)	13 (16.05)	
Cough				
No	19 (32.76)	39 (67.24)	58 (71.60)	0.587
Low to mild	9 (39.13)	14 (60.87)	23 (28.40)	
Sneeze				
No	19 (35.19)	35 (64.81)	54 (66.67)	
Low	8 (32.00)	17 (68.00)	25 (30.86)	0.911
Mild	1 (50.00)	1 (50.00)	2 (2.47)	
Sore throat				
No	18 (30.00)	42 (70.00)	60 (74.07)	0.144
Low to mild	10 (47.62)	11 (52.38)	21 (25.93)	

* P-value ≤ 0.05, [a] Fisher exact test

According to the upper respiratory symptom's questionnaire ingested by SBS, it was observed that 75.31% of caretakers who did not report any throat irritation actually exhibited symptoms of throat irritation. The study findings show a large proportion (69.14%) of caregivers did not exhibit symptoms of a runny nose. However, among those who did report such symptoms, the severity was generally low. Notably, the comparison group had the highest prevalence of runny nose symptoms, with 38.89% of individuals reporting this symptom. The study revealed that a minority of burning nose symptoms, specifically 13.58%, were classified as low severity, while a mere 2.47% of cases exhibited mild severe burning nose symptoms. Most of the caretakers do not exhibit symptoms of coughing (71.60%), whereas coughing is typically mild and prevalent among the comparison group (57.14%). The study on building-related symptoms (BRS) found that sneezing was mostly of low severity (30.86%) and was most frequently observed in the Comparison group (68.00%). Nevertheless, solely two of the participants exhibited a mild sneeze. The study found that a majority of sore throat symptoms at 24.69%, were categorized as low Severity, while a significantly smaller proportion, namely 1.23%, were classified as Sore throat mild Severity.

Table 4.11 The severity of building-related symptoms (BRS) in lower respiratory symptoms.

Symptoms	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
Wheezing				
No	25 (33.33)	50 (66.67)	75 (92.59)	0.409
Low to mild	3 (50.00)	3 (50.00)	6 (7.41)	
Chest Pain				
No	25 (33.33)	50 (66.67)	75 (92.59)	0.659
Low	3 (50.50)	3 (50.50)	6 (7.41)	
Shortness of Breath				
No	24 (35.29)	44 (64.71)	68 (83.95)	0.881
Low	3 (27.27)	8 (72.73)	11 (13.58)	
Mild	1 (50.00)	1 (50.00)	2 (2.47)	
Sputum				
No	25 (36.23)	44 (63.77)	69 (85.19)	0.450
Low to mild	3 (25.00)	9 (75.00)	12 (14.81)	

* P-value ≤ 0.05

The results of the study on building-related symptoms (BRS) related to the lower respiratory tract indicate that the majority of wheezing symptoms reported were of low severity (6.17%). Furthermore, 92.59 percent of caretakers did not report any wheezing symptoms. A large percentage of caretakers did not exhibit symptoms of chest pain (92.59%). Among the caretakers who reported experiencing shortness of breath, 13.58% exhibited low severity of symptoms, with the majority of such cases being observed in the comparison group. On the other hand, caretakers (83.95%) did not report any instances of shortness of breath. The frequency of sputum and low severity was reported by 13.58% of caretakers, with the highest frequency observed in the comparison group (72.73%).

Table 4.12 The severity of building-related symptoms (BRS) in skin symptoms.

Symptoms	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
Dry skin				
No	26 (35.62)	47 (64.38)	73 (90.12)	0.708
Low	2 (25.00)	6 (75.00)	8 (9.88)	
Itchy skin				
No	25 (35.21)	46 (64.79)	71 (87.65)	0.999
Low to mild	3 (30.00)	7 (70.00)	10 (12.35)	
Skin irritation				
No	25 (34.25)	48 (65.75)	73 (90.12)	0.999
Low	3 (37.50)	5 (62.50)	8 (9.88)	
Rash				
No	25 (32.89)	51 (67.11)	76 (93.83)	0.334
Low	3 (60.00)	2 (40.00)	5 (6.17)	

* P-value ≤ 0.05

Dry skin with low severity was reported by 9.88% of caretakers, and it was observed to be prevalent in the comparison group (75.00%). The majority of caretakers, at 90.12%, reported an absence of dry skin symptoms. According to the SBS symptom questionnaire, a majority of 87.65% of caretakers did not exhibit symptoms of Itchy skin. The majority of caretakers do not encounter any form of skin irritation (90.12%). Skin irritation was observed in a few people (5 people), with a higher incidence in the Comparison group and generally presenting as a low. 6.17% of caretakers reported low severity of rash which was most common in the comparison group (40.00%).

Table 4.13 Summary of BRS for general, upper respiratory system, lower respiratory system, and skin symptoms.

Symptoms	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
General symptoms				
Have	23 (38.98)	36 (61.02)	59 (72.84)	0.199
Have no	5 (22.73)	17 (77.27)	22 (27.16)	
Score	Maximum= 12, Minimum=0, Median (IQR)=4, (0.25,4.00)	Maximum= 16, Minimum=0, Median (IQR)=1, (1.00,3.00)	Maximum= 16, Minimum=0, Median (IQR)=4, (0,4.00)	
Upper respiratory symptoms				
Have	22 (59.46)	15 (40.54)	37 (45.68)	0.353
Have no	31 (70.45)	13 (29.55)	44 (54.32)	
Score	Maximum=6, Minimum=0, Median (IQR)=2, (2.00,3.75)	Maximum= 12, Minimum=0, Median (IQR)=4, (0,2.00)	Maximum= 12, Minimum=0, Median (IQR)=4, (0,3.00)	
lower respiratory symptoms				
Have	6 (33.33)	12 (66.67)	18 (22.22)	0.999
Have no	22 (34.92)	41 (65.08)	63 (77.78)	
Score	Maximum= 4, Minimum=0, Median (IQR)=0, (0,0)	Maximum= 4, Minimum=0, Median (IQR)=0 (0,0)	Maximum= 4, Minimum=0, Median (IQR)=0 (0,0)	
skin symptoms				
Have	6 (31.58)	13 (68.42)	19 (23.46)	0.791
Have no	22 (35.48)	40 (64.52)	62 (76.54)	
Score	Maximum= 4, Minimum=0, Median (IQR)=0 (0,0)	Maximum= 4, Minimum=0, Median (IQR)=0 (0,0)	Maximum= 4, Minimum=0, Median (IQR)=0 (0,0)	

* P-value ≤ 0.05

Table 4.13 Summary of BRS for general, upper respiratory system, lower respiratory system, and skin symptoms. (continuous)

Symptoms	Intervention (n=28)	Comparison (n=53)	Total (n=81)	P-value
	Number (%)	Number (%)	Number (%)	
Overall symptoms				
Have	24 (38.10)	39 (61.90)	63 (77.78)	0.269
Have no	4 (22.22)	14 (77.78)	18 (22.22)	
Score	Maximum= 26, Minimum=0, Median (IQR)=4, (30.50,9.25)	Maximum= 24, Minimum=0, Median (IQR)=1, (1.00,7.50)	Maximum= 26, Minimum=0, Median (IQR)=2, (0,7.00)	

* P-value ≤ 0.05

This is an overview of the symptoms caused by BRS. The study identified a total of 59 general symptoms among caretakers, which were categorized into two groups: Intervention (38.98%) and Comparison (61.02%). The general symptom score ranged from 0 to 16. According to the questionnaire responses, 45.68% of the caretakers reported experiencing upper respiratory symptoms. The Intervention group exhibited a frequency of 59.46% for upper respiratory symptoms, which was the most frequently reported type of symptom. And the maximum score for the Intervention group was 6, while the Comparison group had a maximum score of 15. Within the overall population of caretakers, a percentage of 22.22% reported experiencing symptoms related to the lower respiratory tract. This percentage was further stratified into two groups, including the intervention group, which reported a proportion of 33.33%, and the comparison group, which reported a proportion of 66.67%. 23.46% of the respondents to the questionnaire reported experiencing skin symptoms among the caretakers. The Intervention group exhibited a prevalence of 68.42% for upper respiratory symptoms. The study's caretakers discovered that the total number of individuals exhibiting symptoms was 63 (77.78%), with 38.10% belonging to the intervention group and 61.90% to the comparison group.

Table 4.14 Association between general characteristics of caretakers and BRS.

Characteristics	Intervention (n=28)	Comparison (n=53)	OR	95% CI	P-value
	Number (%)	Number (%)			
Gender					
Male	2	0		Reference	
Female	26	53	2.43	0.47 – 40.60	0.535
Age (Year)					
≤35	13	13	1.62	0.55 – 4.74	0.377
>35	15	40		Reference	
BMI					
Normal	13	24	1.26	0.48 – 3.30	0.638
Abnormal	15	29		Reference	
Underlying disease					
Yes	9	9	1.63	0.47 – 5.58	0.438
No	19	44		Reference	
Medicine or supplement					
Yes	9	18		Reference	
No	19	35	1.30	0.48 – 3.52	0.606
Smoking					
Yes	27	53		N/A	
No	1	0			
Working period in childcare centers per month,(month)					
≤ 120	23	41		Reference	
> 120	5	12	1.48	0.49 – 5.10	0.537
Working period in childcare centers per hour,(hour)					
≤ 8	7	17	1.38	0.47 – 4.80	0.555
> 8	21	36		Reference	

* P-value ≤ 0.05, N/A = Not Applicable

Through bivariate analysis, it was found that there were no significant correlations between the general characteristics of caretakers and their building related symptoms.

All factors were utilized to conduct the bivariate analysis. The variables that are investigated in this study are gender, age, body mass index (BMI), presence of underlying disease, and use of medication or supplements. Smoking and the duration of employment in childcare facilities per month and per hour were examined, with no association to the building related symptoms being observed.

Table 4.15 Association between diagnosis of caretakers and BRS.

Symptoms	Intervention (n=28)	Comparison (n=53)	OR	95% CI	P-value
	Number (%)	Number (%)			
Allergy					
No	24	45		Reference	
Yes	4	8	5.50	0.67 – 45.25	0.113
Asthma					
No	27	50	1.62	0.61 – 16.33	0.682
Yes	1	3		Reference	
Chronic bronchitis					
No	28	52		N/A	
Yes	0	1			
Ear infection					
No	28	53		N/A	
Yes	0	0			
Allergic Rhinitis					
No	23	48		Reference	
Yes	5	5	4.31	0.52 – 36.11	0.178
Sinusitis					
No	27	52	2.43	0.15 – 40.60	0.535
Yes	1	1		Reference	
Skin infection					
No	28	53		N/A	
Respiratory infection					
No	28	52		N/A	
Yes	0	1			
Migraine					
No	24	43	1.40	0.39 – 4.39	0.605
Yes	4	10		Reference	

* P-value ≤ 0.05, N/A = Not Applicable

The bivariate analysis of the association test was conducted using multiple variables, including Allergy, Asthma, Chronic bronchitis, Ear infection, Allergic Rhinitis, Sinusitis, Skin infection, Respiratory infection, and Migraine, to determine their correlation with building-related symptoms of Caretakers. However, the results of Table 4.15 indicate that no significant association was found at the 0.05 level.

Table 4.16 Association between perception of childcare center environment of caretakers and BRS.

Factor	Intervention (n=28)	Comparison (n=53)	OR	95% CI	P-value
	Number	Number			
Occupancy of the room (person)					
2-15	16	35		Reference	
> 15	12	18	2.97	0.97 – 9.06	0.056
Room lighting					
Appropriate	28	53		N/A	
Suitable table					
Have no	1	1	1.92	0.12 – 32.00	0.648
Have	27	52		Reference	
Computer use					
Yes	26	51		Reference	
No	2	2	1.28	0.13 – 12.94	0.836
Low ventilation					
Yes	7	20	8.59	1.84 – 40.05	0.006*
No	21	33		Reference	
High ventilation					
Yes	5	19	6.91	1.48 – 32.34	0.014*
No	23	34		Reference	
Overheat					
Yes	10	27	3.58	1.24 – 10.33	0.019*
No	18	26		Reference	
Sudden temperature change					
Yes	11	24	8.96	2.40 – 33.47	≤0.001*
No	17	29		Reference	

* P-value ≤ 0.05, N/A = Not Applicable

Table 4.16 Association between perception of childcare center environment of caretakers and BRS. (continuous)

Factor	Intervention (n=28)	Comparison (n=53)	OR	95% CI	P-value
	Number (%)	Number (%)			
Cold temperature					
Yes	26	43	2.34	0.47 – 11.60	0.298
No	2	10		Reference	
High relative humidity					
Yes	18	36	5.09	1.36 – 19.04	0.016*
No	10	17		Reference	
Air dry					
Yes	8	15	6.42	1.37 – 30.06	0.018*
No	20	38		Reference	
Loudness					
Yes	7	16	2.50	0.75 – 8.36	0.140
No	21	37		Reference	
Low ventilation from air conditioner					
Yes	3	16	10.62	1.33 – 84.85	0.026
No	25	37		Reference	
Smell from air conditioner					
Yes	27	45	3.76	0.44 – 31.82	0.225
No	1	8		Reference	
Fungus smell					
Yes	0	8	3.22	0.37 – 27.72	0.287
No	28	45		Reference	
Dusty					
Yes	18	19	6.88	2.08 – 22.72	0.002*
No	10	34		Reference	

* P-value ≤ 0.05, N/A = Not Applicable

Table 4.16 Association between perception of childcare center environment of caretakers and BRS. (continuous)

Factor	Intervention (n=28)	Comparison (n=53)	OR	95% CI	P-value
	Number (%)	Number (%)			
Have carpet					
Yes	4	4	1.29	0.24 – 6.92	0.763
No	24	49		Reference	
Have printer					
Yes	12	36	2.19	0.83 – 5.77	0.114
No	16	17		Reference	
Have photocopier					
Yes	9	34	1.92	0.73 – 5.06	0.184
No	19	19		Reference	
Near door					
Yes	24	50		Reference	
No	4	3	1.06	0.19 – 5.87	0.949
Near window					
Yes	24	49	1.29	0.24 – 6.92	0.463
No	4	4		Reference	
Have air freshener					
Yes	12	18	2.97	0.97 – 9.06	0.056
No	16	35		Reference	
Use spray air freshener					
Yes	21	23	4.49	1.60 – 12.64	0.004*
No	7	30		Reference	
Mosquito repellent					
Yes	21	14	3.11	1.08 – 8.97	0.036*
No	7	39		Reference	

* P-value ≤ 0.05, N/A = Not Applicabl

The findings of the bivariate analysis indicate a significant correlation between building-related symptoms and perception of the childcare center environment. Specifically, the results suggest that low ventilation is positively associated with building-related symptoms (OR = 8.59,95%CI = 1.84 – 40.05). The study revealed that people occupying rooms with high ventilation exhibited building-related symptoms at a rate of 6.91 times higher than those in rooms that had no high ventilation (95%CI = 1.48 – 32.34, p-value = 0.014). The study showed that the participants who were situated in the overheated room exhibited a significantly greater probability of building-related symptoms compared to those in the non-overheated room, with a statistical significance of 0.05 and an odds ratio of 6.91 (95%CI = 1.24 – 10.33, p-value = 0.019). The findings of the associated study that was conducted on the association between building-related symptoms and rapid temperature change indicate that people occupying rooms with quick temperature changes are more likely to develop building-related symptoms compared to those who do not occupy such rooms (OR = 8.96,95%CI = 2.40 – 33.47,p-value = ≤0.001). The study showed that people situated in places with higher relative humidity exhibited a 5.09-fold rise in building-related symptoms compared to those in areas without high relative humidity. The statistical analysis indicated a p-value of 0.016 or 95%CI = 1.36 – 19.04.

The association between building-related symptoms and air-dry shows that people occupying air-dry rooms exhibit a significantly higher likelihood of developing building-related symptoms compared to those who do not occupy such rooms, with a p-value of 0.018 (OR = 6.42,95%CI = 1.37 – 30.06). The study revealed that individuals who were present in the area of Dusty exhibited an increased likelihood of symptoms related to the building as compared to those who were not exposed to dusty. The statistical analysis indicated a significant difference between the two groups, with a confidence interval of 95% ranging from 2.08 to 22.72 (OR=6.88). In the room where spray air freshener was used showed building-related symptoms at a rate that was 4.49 times higher than those who were situated in the room where spray air freshener was not used. The statistical analysis yielded a p-value of 0.004 and a 95% confidence interval ranging from 1.60 to 12.64. And the study revealed a correlation between the use of mosquito repellent and the rate of building-related symptoms. Specifically, people who occupied rooms where mosquito repellent was used exhibited an increased chance of experiencing building-related symptoms compared to those who did not occupy such rooms.

Table 4.17 General characteristics of building.

Characteristics	Intervention (n=4)	Comparison (n=6)	Total (n=10)	P-value
	Number (%)	Number (%)	Number (%)	
Age (year) (Maximum= 40, Minimum=1 , Median (IQR)=11.50 (6.5,13.88),(Year)				
1-10	1 (20.00)	4 (80.00)	5 (50.00)	0.197
≥ 11	3 (60.00)	2 (40.00)	5 (50.00)	
Distance from main road (Maximum= 2,500, Minimum=15, Median (IQR)= 100.80 (241.00, 1000.00),(meter)				
15 - 500	2 (40.00)	3 (60.00)	5 (50.00)	0.999
≥ 501	2 (40.00)	3 (60.00)	5 (50.00)	
Floor				
1	18 (27.27)	48 (72.73)	66 (81.48)	0.006*
2	10 (66.67)	5 (33.33)	15 (18.52)	
Room size (Maximum= 230, Minimum=30.60, Median (IQR)= 124.25 (54.02, 175.95),(m^2)				
≤ 120	0	5 (100)	5 (50.00)	0.048
≥ 121	4 (80.00)	1 (20.00)	5 (50.00)	
Type of windows				
Wood	0	1 (100)	1 (10.00)	0.999
Aluminum	4 (44.44)	5 (55.56)	9 (90.00)	
Average of number of windows/Room (Maximum= 8, Minimum=8, Median (IQR)= 5.50 (3.75, 6.00)				
3-6	4 (57.14)	3 (42.86)	7 (87.50)	0.216[a]
≥7	0	1 (100)	1 (12.50)	
Type of door				
Wood	2 (66.67)	1 (33.33)	3 (30.00)	0.714
Aluminum	1 (20.00)	4 (80.00)	5 (50.00)	
Wood and Aluminum	1 (50.00)	1 (50.00)	2 (20.00)	
Average of number of door/Room (Maximum=4.00, Minimum=1.00, Median (IQR)= 1.50 (1.00, 2.25)				
1-2	3 (37.50)	5 (62.50)	8 (80.00)	0.747
3-4	1 (50.00)	1 (50.00)	2 (20.00)	

* P-value ≤ 0.05, [a] Fisher exact test

Table 4.17 General Characteristics of building (continuous).

Characteristics	Intervention (n=4)	Comparison (n=6)	Total (n=10)	P-value
	Number (%)	Number (%)	Number (%)	
Kitchen room in area				
Have	1 (33.33)	2 (66.67)	3 (30.00)	0.778
Have no	3 (42.86)	4 (57.14)	7 (70.00)	
Kitchen hood				
Have	1 (33.33)	2 (66.67)	3 (30.00)	0.778
Have no	3 (42.86)	4 (57.14)	7 (70.00)	
Distance from kitchen to room Maximum= 21, Minimum=0,Median (IQR)= 16.00 (12.00, n/a), (meter)				
Have no	3 (42.86)	4 (57.14)	7 (70.00)	0.679[a]
10 -16	0	1 (100)	1 (10.00)	
≥ 17	1 (50.00)	1 (50.00)	2 (20.00)	
Fuel				
LPG	4 (40.00)	6 (60.00)	10 (100)	N/A
Air conditioning system (split type)				
Yes	4 (44.44)	5 (55.56)	9 (90.00)	0.999[a]
No	0	1 (100)	1 (10.00)	
Frequency use air conditioning system (split type)				
Have no	0	1(100)	1 (10.00)	N/A
Every day	4 (40.00)	6 (60.00)	9 (90.00)	
BTU of air conditioning (BTU)				
Have no	0	1(100)	1 (10.00)	0.659[a]
≤ 32,000	2 (40.00)	3 (60.00)	5 (50.00)	
> 32,000	2 (50.00)	2 (50.00)	4 (40.00)	
Fan use				
Yes	3 (33.33)	6 (66.67)	9 (90.00)	0.400
No	1 (100)	0	1 (10.00)	

* P-value ≤ 0.05, [a] Fisher exact test, N/A = Not Applicable

Table 4.17 General Characteristics of building (continuous).

Characteristics	Intervention (n=4)	Comparison (n=6)	Total (n=10)	P-value
	Number (%)	Number (%)	Number (%)	
Have building automation systems				
No	4 (40.00)	6 (60.00)	10 (100)	N/A
Temperature difference				
Yes	4 (40.00)	6 (60.00)	10 (100)	N/A
Air conditioning system (split type) work				
Yes	4 (40.00)	6 (60.00)	10 (100)	N/A
Dry area				
No	4 (40.00)	6 (60.00)	10 (100)	N/A
Air circulation system				
No	4 (40.00)	6 (60.00)	10 (100)	N/A
Ventilation fan				
Yes	1 (50.00)	1 (50.00)	2 (20.00)	0.999
No	3 (37.50)	5 (62.50)	8 (80.00)	
Air filter				
Yes and HEPA	1 (50.00)	1 (50.00)	2 (20.00)	0.999
No	3 (37.50)	5 (62.50)	8 (80.00)	
Maintenance air system				
No	4 (40.00)	6 (60.00)	10 (100)	N/A
Plan maintenance air system				
Yes	4 (40.00)	6 (60.00)	10 (100)	N/A
Mold spot				
Have	2 (66.67)	1 (33.33)	3 (30.00)	0.500
Have no	2 (28.57)	5 (71.43)	7 (70.00)	

* P-value ≤ 0.05, [a] Fisher exact test, N/A = Not Applicable

Table 4.17 General Characteristics of building (continuous).

Characteristics	Intervention (n=4)	Comparison (n=6)	Total (n=10)	P-value
	Number (%)	Number (%)	Number (%)	
Water stain				
Have	1 (100)	0	1 (10.00)	0.400
Have no	3 (33.33)	6 (66.67)	9 (90.00)	
Air quality monitor				
Have no	4 (40.00)	6 (60.00)	6 (100)	N/A
Have translucent area				
Have	4 (40.00)	6 (60.00)	6 (100)	N/A
Type of Ceiling				
Gypsum board	2 (28.57)	5 (71.43)	7 (70.00)	0.260
Cement and Fiber cement	2 (66.67)	1 (33.33)	3 (30.00)	
Type of floor				
Floor tiles	2 (40.00)	3 (60.00)	5 (50.00)	0.619[a]
Marble	1 (100)	0	1 (10.00)	
Laminate	1 (100)	0	1 (10.00)	
Rubber flooring tiles	0	2 (100)	2 (20.00)	
Fiber Cement Board	0	1 (100)	1 (10.00)	
Wall Type				
Cement	4 (44.44)	5 (5.56)	9 (90.00)	0.999 [a]
Steel	0	1 (100)	1 (10)	

* P-value ≤ 0.05, [a] Fisher exact test, N/A = Not Applicable

Table 4.17 General Characteristics of building (continuous).

Characteristics	Intervention (n=4)	Comparison (n=6)	Total (n=10)	P-value
	Number (%)	Number (%)	Number (%)	
Sweep the floor				
Yes	4 (40.00)	6 (60.00)	6 (100)	N/A
Mop the floor				
Yes	4 (40.00)	6 (60.00)	6 (100)	N/A
Clean curtains				
Have no	0	3 (100)	3 (30.00)	
≤ 1/week	2 (66.67)	1 (33.33)	3 (30.00)	0.400
> 1/week	2 (50.00)	2 (50.00)	4 (40.00)	
Vacuum cleaner				
Yes	1 (100)	0	1 (10.00)	0.400
No	3 (33.33)	6 (66.67)	9 (90.00)	
Frequency of using air fresheners				
Never used	1 (33.33)	2 (66.67)	3 (30.00)	
Some time	1 (50.00)	1 (50.00)	2 (20.00)	0.999
Every day	2 (40.00)	3 (60.00)	5 (50.00)	
Mosquito repellent sprays				
Never used	4 (57.14)	3 (42.86)	7 (70.00)	
Some time or Every day	0	2 (100)	2 (20.00)	0.467
Every day	0	1 (100)	1 (10.00)	
Big cleaning day				
1/week	3 (75.00)	1 (25.00)	4 (40.00)	0.371
≥ 1/month	1 (16.67)	5 (8.33)	6 (60.00)	

* P-value ≤ 0.05, [a] Fisher exact test, N/A = Not Applicable

According to the results of the indoor survey. The surveyor, who conducted research in a childcare center, found that the majority of the buildings in the intervention group were aged building that were no less than 11 years old, in comparison to the control group. The majority of the buildings are between one and ten years of age. The study found the median distance of the childcare center from the main road is 100.80 meters. Additionally, it was found that the Comparison group comprised buildings located at a distance greater than or equal to 501 meters from the main road, accounting for 60.00% of the group. The findings show that the majority of childcare centers, specifically 81.48%, are single floors, while a minority of 18.52% consists of two floors. The study revealed that the median room size of the childcare center was 124.25 square meters. Additionally, it was found that the intervention group had a room size greater than or equal to 121 square meters, accounting for 80.00% of the group.

According to the survey results, a majority of childcare centers (90.00%) use aluminum windows, while a mere 10% use wooden windows. This investigation showed that the median number of windows in a room was 5.50, with a majority (87.50%) of childcare centers having between 3 to 6 windows. According to the survey results, it was found that 50.00% of childcare centers utilize aluminum doors, while only 30.00% choose for wooden doors. The study found that the median value for the number of doors in the room was 1.50, with the majority or 80.00% of childcare centers having 1-2 doors. According to the survey results, it was found that childcare centers do not have kitchen rooms 70.00%. Additionally, it was found that childcare centers that have a kitchen room fall within the comparison group at a percentage of 66.67% in each childcare center employed a kitchen hood system. The majority of childcare centers have a distance of 17 meters or greater between the kitchen and the classroom. Nearly all of the childcare centers that have kitchens utilize liquefied petroleum gas (LPG) as their primary source of fuel for cooking purposes.

The majority of buildings. The system is outfitted with an air conditioning unit (90.00%). The Comparison Group possesses solely one edifice that lacks an installed air conditioning system. And every day, a total of nine childcare facilities that have air conditioning systems are utilized. The majority (50.00%) of childcare centers that had air conditioning systems had a maximum cooling capacity of 32,000 BTU or lower.

According to a survey, the majority of childcare centers (90.00%) were found to possess fans, while a mere 10% utilized fans as a supplementary measure for air conditioning. However, It has been observed that all of the childcare centers do not utilize building automation systems (BAS). According to the survey results, it was observed that none of those surveyed exhibited substantial differences in high temperature. Based on the results of the survey, it can be concluded that all types of Air split systems perform effectively. The investigation revealed that the childcare center workspace lacked a moist environment (Dry area). The research revealed that all childcare center facilities lacked an air circulation system within their office areas. The utilization of ventilation fans in childcare centers was investigated, showing that 80.00% of the centers did not employ such fans.

The study discovered that two childcare centers (20.00%) implemented the use of HEPA air filters. The buildings that utilized HEPA air filters were evenly distributed between the Comparison group and the Intervention group. Furthermore, it was discovered that the utilization of air HEPA filters was observed at varying frequencies, including daily (1 childcare center) and occasional (1 childcare center) use. Childcare center none of the center have air conditioning maintenance systems. And all of the childcare centers Each has a plan for air conditioning maintenance.

According to the findings of the survey conducted on childcare centers, it was observed that mold spots were absent in 7 out of the total (70.00%) number of centers surveyed, while in the remaining 3 childcare centers (30.00%), the presence of mold spots was detected. It was found that out of the 10 childcare centers examined, water stain was not detected in nine of them, while in one childcare center, water stain was identified.

Zero percent of daycare facilities are equipped with an air quality monitoring system. It is a common feature for childcare centers to possess a translucent space (100%).The majority of structures (71.43%) belonging to the intervention group utilize gypsum board as a material for constructing their ceilings. The predominant flooring options utilized in the majority of childcare centers are floor tiles (50.00%) and rubber flooring tiles (20.00%). The common material utilized for constructing walls in childcare centers is cement, accounting for about 90.00% of the total.

Our findings show the management of cleanliness in childcare centers involves daily sweeping and mopping of the floors. According to the survey results, the period between the cleaning of curtains at the childcare center exceeded one week (40.00%). Based on the results of a survey, one childcare center (10.00%) had been used to cleaning through the utilization of a vacuum cleaner, whereas nine other facilities did not employ such a cleaning method.

As per the findings of a survey, air fresheners are utilized on a daily basis in childcare centers, with an amount of 50.00% being reported in the Comparison group. The application of mosquito repellent sprays is a common practice, however, an important percentage of childcare centers, approximately 70.00%, do not utilize this method. And discovered that a comparison group utilized mosquito-repellent sprays. sometimes 2 childcare centers and mosquito repellent sprays each day one daycare center. The childcare center makes a weekly big cleaning day at a frequency of 40.00%.

Table 4.18 Level of indoor air quality in a building average in 8 hours in childcare center.

Parameter	Intervention (n=4)	Comparison (n=6)	Total (n=10)	P-value
	Number (%)	Number (%)	Number (%)	
PM 2.5 (mg/m³)				
Maximum = 27.92, Minimum = 6.80, Median (IQR) = 13.20 (7.66,15.18)				
Normal	4 (44.4)	5 (55.56)	9 (90.00)	0.999[a]
High	0	1 (100)	1 (10.00)	
PM 10 (mg/m³)				
Maximum = 187.36, Minimum = 35.01, Median (IQR) = 81.21 (56.61,135.50)				
Normal	0	2 (100)	2 (20.00)	0.467[a]
High	4 (50.00)	4 (50.00)	8 (80.00)	
Carbon dioxide (PPM)				
Maximum = 1179.01, Minimum = 207.01, Median (IQR) =604.99 (460.95,831.66)				
Normal	4 (50.00)	4 (50.00)	8 (80.00)	0.467[a]
High	0	2 (100)	2 (20.00)	
Carbon monoxide (PPM)				
Maximum = 0.01, Minimum = 0, Median (IQR) =0.01 (0.01,0.63)				
Normal	4 (40.00)	6 (60.00)	10 (100)	N/A
Total VOC (PPM)				
Maximum = 1.54, Minimum = 0.02, Median (IQR) =0.20 (0.12,0.54)				
Normal	4 (40.00)	6 (60.00)	10 (100)	N/A
Total bacterial count (CFU/m³)				
Maximum = 1,614.00, Minimum = 0.02, Median (IQR) =0.20 (0.12,0.54)				
Normal	0	3 (100)	3 (30.00)	0.200 [a]
High	4 (57.14)	3 (42.86)	7 (70.00)	

* P-value ≤ 0.05, N/A = Not Applicable

Table 4.18 Level of indoor air quality in a building average in 8 hours in childcare center (continuous).

Parameter	Intervention (n=4)	Comparison (n=6)	Total (n=10)	P-value
	Number (%)	Number (%)	Number (%)	
Total fungal count (CFU/m^3)				
Maximum = 221.00, Minimum = 8.00,				
Median (IQR) =15.00 (8.37,74.00)				
Normal	2 (33.33)	4 (66.67)	6 (60.00)	0.999
Spreader	2 (50.00)	2 (50.00)	4 (40.00)	
Temperature (°C)				
Maximum = 32.12, Minimum = 24.56,				
Median (IQR) =25.71 (25.50,27.50)				
Normal	2 (40.00)	3 (60.00)	5 (50.00)	0.999
High	2 (40.00)	3 (60.00)	5 (50.00)	
Relative Humidity (%)				
Maximum = 32, Minimum = 25,				
Median (IQR) =25.50 (25.50,27.50)				
Dry	1 (20.00)	4 (80.00)	5 (50.00)	0.524
Normal	3 (60.00)	2 (40.00)	5 (50.00)	

* P-value ≤ 0.05, N/A = Not Applicable, ** Exclude spreader (n=6)

The results of the indoor air quality parameter test conducted in an 8-hour period revealed that PM 2.5 had a median value of 13.20 mg/m^3. The majority (90.00%) of childcare centers were found to have PM 2.5 levels within the acceptable range, while one childcare center was a concentration of PM 2.5 elevated. The results of the study indicate that the median PM10 levels in childcare centers were 81.21 mg/m^3, with the majority (80.00%) of these centers exceeding the established standard. Furthermore, it was discovered that the carbon dioxide concentrations in childcare centers were within normal ranges at 80.00%, with the most elevated levels of carbon dioxide detected at 1179.01 ppm and the least at 35.01 ppm. The investigation's results indicate that the childcare center had a median carbon monoxide level of 0.01 PPM. All of the childcare centers showed common levels of carbon monoxide. The total VOC levels in childcare centers were within the normal range. The highest recorded level was 1.54 ppm, while the lowest was 0.02 ppm. The study has shown a median total bacterial count of 1,614 CFU/m3, with 70.00% of childcare centers exhibiting a higher than normal total bacterial count. The median total fungal count was determined to be 221 CFU/m3. It was observed that 60.00% of childcare centers exhibited a total bacterial count in the normal range, while 40% were identified as spreaders.

The results of the measurements indicated that the temperature levels in the daycare center were within an acceptable range. The data reveals that the maximum recorded temperature was 32.12 degrees Celsius, while the minimum was 24.56 degrees Celsius. The median temperature was 15.00 degrees Celsius. The median relative humidity level in the childcare center was 25.50. Additionally, it was observed that the relative humidity level in five of the childcare centers was low.

Table 4.19 Comparison of differences in indoor air pollution among 10 childcare centers within the intervention group and a comparison group. (n=10)

Parameter	Intervention (n=4)			Comparison (n=6)		
	$\bar{x}$	Z	P-value	$\bar{x}$	Z	P-value
PM 2.5 (mg/m³)						
Before intervention	12.52	-1.826	0.068	13.32	-0.365	0.715
After intervention	11.92			15.97		
PM 10 (mg/m³)						
Before intervention	102.99	-1.826	0.068	92.49	0.730	0.465
After intervention	78.29			113.27		
Carbon dioxide (PPM)						
Before intervention	601.07	-0.365	0.715	2.33	-0.730	0.465
After intervention	607.57			3.00		
Carbon monoxide (PPM)						
Before intervention	1.06	-1.604	0.109	0.00	N/A	
After intervention	0.00			0.00		
Total VOC (PPM)						
Before intervention	289.83	N/A		292.40	-1.826	0.068
After intervention	351.28			339.16		
Total bacterial count (CFU/m³)						
Before intervention	715.75	-1.826	0.068	1027.03	-0.730	0.465
After intervention	570.00			748.75		
Total fungal count (CFU/m³)						
Before intervention	6.33	N/A		12.80	-0.365	0.715
After intervention	5.25			305.50		
Temperature (°C)						
Before intervention	26.10	-1.826	0.068	26.89	-0.730	0.465
After intervention	25.34			27.68		
Relative Humidity						
Before intervention	53.30	-1.095	0.273	48.46	N/A	
After intervention	52.34			47.15		

* P-value ≤ 0.05, N/A = not applicable

The effectiveness of the Urban Childcare Center Indoor Air Quality Management Program (UCC-IAQ) in reducing indoor air pollution. The research used the Wilcoxon signed ranks test to compare the intervention and comparison groups. The findings revealed that there was no significant difference in the amount of indoor air pollution between the groups after implementing the UCC-IAQ Program, with a significance level of 0.05. Although the study suggested likely decreases in indoor air pollution within the intervention group, including PM 2.5, PM 10, total bacterial count, total fungal count, and relative humidity, However, these reductions were not deemed statistically significant.

Table 4.20 The indoor air quality change after using UCC_IAQ management program between group

Parameter	Group	OR	95% CI	P-value
PM 2.5	Intervention	3.00	0.15 – 59.89	0.472
	comparison		Ref	
PM 10	Intervention		N/A	
	Comparison			
Carbon dioxide	Intervention	9.00	0.37 – 220.93	0.180
	comparison		Ref	
Carbon monoxide	Intervention		N/A	
	comparison			
Total VOC	Intervention		N/A	
	comparison			
Total bacterial count	Intervention		N/A	
	comparison			
Total fungal count	Intervention	3.00	0.15 – 59.89	0.470
	comparison		Ref	
Temperature	Intervention	1.00	0.06 – 15.99	0.999
	comparison		Ref	
Relative Humidity	Intervention	1.00	0.06 – 15.99	0.999
	comparison		Ref	

* P-value ≤ 0.05

The UCC_IAQ management program was used in the Intervention group for a duration of three months with the aim of improving indoor air quality in four childcare centers. However, the Comparison group included six childcare centers that were not using the UCC_IAQ management program to improve air quality. There was no significant alteration found in the indoor air quality following the start of the UCC_IAQ management program across the groups.

Table 4.21 The relationship between building-related health symptoms and indoor air pollution after usage of the UCC IAQ management program.

Parameter	BRS Decrease Number	BRS Doesn't decrease Number	χ^2	P-value
PM 2.5 (mg/m³)				
Decrease	0	15 (100)	0.57	0.643[a]
Doesn't decrease	1 (3.70)	26 (96.30)		
PM 10 (mg/m³)				
Decrease	12 (23.53)	39 (76.47)	2.36	0.142[a]
Doesn't decrease	0	8 (100)		
Carbon dioxide (PPM)				
Decrease	6 (13.95)	37 (86.05)	1.78	0.214
Doesn't decrease	7 (26.92)	19 (73.08)		
Carbon monoxide (PPM)				
Decrease	6 (54.55)	5 (45.45)	16.89	≤0.001*
Doesn't decrease	3 (6.00)	47 (94.00)		
Total VOC (PPM)				
Decrease	6 (12.50)	42 (87.50)	9.76	0.002*
Doesn't decrease	6 (54.55)	5 (45.45)		
Total bacterial count (CFU/m³)				
Decrease	13 (24.07)	41 (75.93)	4.44	0.056
Doesn't decrease	0	15 (100)		
Total fungal count (CFU/m³)				
Decrease	13 (24.07)	41 (75.93)	0.01	0.068
Doesn't decrease	0	15 (100)		
Temperature (°C)				
Decrease	5 (27.78)	13 (72.22)	9.89	0.004*
Doesn't decrease	0	32 (100)		
Relative Humidity (%)				
Decrease	6 (31.58)	13 (68.42)	1.05	0.484
Doesn't decrease	5 (18.52)	22 (81.48)		

* P-value ≤ 0.05, [a] Fisher exact test

The table presented data showing a relationship between building-related health symptoms and indoor air pollution. particular the factors that showed a significant relationship between building-related health symptoms and indoor air pollution were carbon monoxide, Total VOC, and Temperature. Additionally, it was determined that there is no relationship among PM 2.5, PM 10, carbon dioxide levels, total bacterial count, total fungal count, and relative humidity. The study observed changes in health symptoms' relationships with building-related factors at the end of the study's period.

Table 4.22 The relationship between group and building-related health symptoms.

Symptoms	Intervention (n=28) n (%)	Comparison (n=53) n (%)	Total (n=81) n (%)	χ^2	P-value
General					
Decrease	14 (60.87)	9 (39.13)	23 (28.40)	9.82	0.002
Doesn't decrease	14 (24.14)	44 (75.86)	58 (71.60)		
Upper respiratory					
Decrease	1 (50.00)	1 (50.00)	2 (2.47)	0.22	0.642
Doesn't decrease	27 (34.18)	52 (65.82)	79 (97.53)		
Lower respiratory					
Decrease	1 (50.00)	1 (50.00)	2 (2.47)	0.22	0.642
Doesn't decrease	27 (34.18)	52 (65.82)	79 (97.53)		
Skin					
Decrease	0	1 (100)	1 (1.23)	0.54	0.654 [a]
Doesn't decrease	28 (35.00)	52 (65.00)	80 (98.77)		
Overall					
Decrease	3 (20.00)	12 (80.00)	15 (18.52)	16.80	≤0.001*
Doesn't decrease	50 (75.76)	16 (24.24)	66 (81.48)		

* P-value ≤ 0.05, [a] Fisher exact test

After applying the UCC - IAQ management program, the relationship test between building-related health symptoms in the intervention and comparison groups was conducted. A p-value of 0.05 showed that general symptoms and overall symptoms (p-value less than or equal to 0.001) differed between the intervention and comparison groups.

The study observed a significant change in symptoms among the general population, and the intervention group exhibited a more substantial decrease in the percentage of incidents compared to the comparison group (60.87% and 39.13%). And the results show a significant change in symptoms within the overall symptom group. Specifically, the intervention group exhibited an 80% reduction in overall symptoms, while the comparison group experienced a 20% decrease.

Table 4.23.1 The frequency of BRS among caretakers between the intervention and comparison groups after implementing the UCC-IAQ management program. (n=81)

Frequency of symptoms	Decrease	Doesn't decrease	Total	P-value
	n (%)	n (%)	n (%)	
General				
Intervention	14 (50.00)	14 (50.00)	28 (34.57)	0.002
Comparison	9 (16.98)	44 (83.02)	53 (65.43)	
Upper respiratory				
Intervention	1 (3.57)	27 (96.43)	28 (34.57)	0.642
Comparison	1 (1.89)	52 (98.11)	53 (65.43)	
Lower respiratory				
Intervention	1 (3.57)	27 (96.43)	28 (34.57)	0.642
Comparison	1 (1.89)	52 (98.11)	53 (65.43)	
Skin				
Intervention	0	28 (100)	28 (34.57)	0.999
Comparison	1 (1.89)	52 (98.11)	53 (65.43)	
Overall				
Intervention	12 (42.86)	15 (57.14)	28 (34.57)	≤0.001*
Comparison	3 (5.66)	50 (94.34)	53 (65.43)	

* P-value ≤ 0.05, [a] Fisher exact test

The post-study survey results have been divided into two groups: "decreases" and "does not decrease." The former refers to a decrease in the frequency of building-related symptoms (BRS) after the study, while the second refers to no change or an increase in the frequency of BRS at the end of the study. The number of general symptoms. The study revealed that a significant proportion of the intervention group experienced a reduction of 51.85% in the frequency of symptoms, whereas the comparison group exhibited a decrease of 16.67% in symptom frequency. The study on the frequency of upper respiratory symptoms showed that a majority of the symptoms observed in both the Intervention (96.30%) and comparison (98.15%) groups did not exhibit decreases. Similar to the findings regarding the frequency of lower respiratory symptoms, the intervention and comparison groups exhibited a minimal reduction in symptoms, with percentages of

96.30% and 98.15%, respectively. The intervention group showed a decrease of 44.44% in the frequency of overall symptoms, whereas 55.56% of the group were not shown a decrease. In contrast, the comparison group showed a decrease of 5.56% in symptom frequency, with 94.44% of the group not experiencing a decrease.

Table 4.23.2 The frequency of BRS within the intervention group and a comparison group among caretakers before and after the study. (n=81)

Frequency of symptoms	Intervention (n=27)			Comparison (n=54)		
	$\bar{x}$	Z	P-value	$\bar{x}$	Z	P-value
General						
Before intervention	3.00	-3.209	≤0.001*	2.68	-1.054	0.292
After intervention	2.018			2.88		
Upper respiratory						
Before intervention	0.48	-0.999	0.317	0.43	-0.447	0.655
After intervention	0.44			0.37		
Lower respiratory						
Before intervention	0.48	-0.999	0.317	0.43	-0.447	0.655
After intervention	0.44			0.37		
Skin						
Before intervention	0.41	N/A	N/A	0.43	-1.342	0.180
After intervention	0.41			0.33		
Overall						
Before intervention	4.37	-3.209	≤0.001*	3.56	-0.845	0.398
After intervention	3.22			2.98		

*p-value ≤0.05

Table 4.20.1shows before and after usage of the UCC-IAQ management program among the intervention and comparison groups. Statistically significant at less than or equal to 0.001, the usage of the UCC IAQ management program resulted in a decrease in the frequency of general symptoms and the overall frequency of symptoms in the intervention group. While the comparison group found no statistically significant difference in any symptom group after the end of the study.

Table 4.23.3 The severity of BRS among caretakers between the intervention and comparison groups after implementing the UCC-IAQ management program. (n=81)

Severity of symptoms	Decrease	Doesn't decrease	Total	P-value
	n (%)	n (%)	n (%)	
General				
Intervention	12 (42.86)	16 (57.14)	28 (34.57)	≤0.001*
Comparison	3 (5.66)	50 (94.34)	53 (65.43)	
Upper respiratory				
Intervention	8 (28.57)	20 (71.43)	28 (34.57)	≤0.001*
Comparison	2 (3.77)	51 (96.23)	53 (65.43)	
Lower respiratory				
Intervention	8 (28.57)	20 (71.43)	28 (34.57)	≤0.001*
Comparison	2 (3.77)	51 (96.23)	53 (65.43)	
Skin				
Intervention	8 (28.57)	20 (71.43)	28 (34.57)	≤0.001*
Comparison	2 (3.77)	51 (96.23)	53 (65.43)	
Overall				
Intervention	12 (42.86)	16 (57.14)	28 (34.57)	≤0.001*
Comparison	3 (5.66)	50 (94.34)	53 (65.43)	

* P-value ≤ 0.05

Post-study survey results were divided into "decreases" and "does not decrease." The former number a decrease in building-related symptoms (BRS) after the study, while the latter number no change or an increase. Regarding the severity of general and overall symptoms, the intervention group expressed decreases of 44.44% and not a decrease of 55.56%, respectively. In contrast, the comparison group showed a decrease of 5.56% and no decrease of 94.44% in these same symptom categories. Amount of severity related to respiratory symptoms in the upper and lower parts of the respiratory tract. The research revealed that the Intervention group showed a substantial decrease of 44.44% in symptom severity, while the Comparison group showed a relatively minor decrease of 5.56% in symptom severity. The intervention group showed a decrease of 44.44% in the severity of overall symptoms, with the remaining 55.56% showing no decrease. In contrast, the comparison group experienced a decrease of 5.56% in symptom severity, while the remaining 94.44% did not show any decrease. The manifestation of overall symptoms is attributed to the presence of any of the following symptoms: general symptoms, upper respiratory symptoms, lower respiratory symptoms, and skin symptoms

Table 4.23.4 Compare Severity of building-related health symptoms (BRS) within the intervention group and a comparison group among caretakers before and after the study. (n=81)

Severity of symptoms	Intervention (n=27)			Comparison (n=54)		
	$\bar{x}$	Z	P-value	$\bar{x}$	Z	P-value
General						
Before intervention	2.93	-1.725	0.084	2.04	-0.530	0.596
After intervention	2.63			1.87		
Upper respiratory						
Before intervention	2.11	2.309	0.021*	1.56	-1.277	0.201
After intervention	1.81			1.67		
Lower respiratory						
Before intervention	0.56	0.999	0.317	0.48	-0.999	0.317
After intervention	0.52			0.41		
Skin						
Before intervention	0.41	N/A	N/A	0.39	-0.447	0.655
After intervention	0.41			0.33		
Overall						
Before intervention	6.00	-2.721	0.007*	6.203	-1.828	0.068
After intervention	5.37			5.510		

*p-value ≤0.05

To compare BRS before and after the implementation of the UCC-IAQ management program by the intervention group. The comparison group's pre- and post-study comparisons were as follows: Statistically significant at 0.021, the intervention group's use of the UCC IAQ management program decreased the severity of upper respiratory symptoms. After completing their studies, the comparison group found no statistically significant differences in any severity-symptom group.

Table 4.24.1 Compare the frequency change of BRS syndrome among caretakers between the intervention and comparison groups following the use of the UCC-IAQ management program.

Frequency of symptoms	Group	OR	95% CI	P-value
General	Intervention	5.38	1.90 – 15.24	0.002*
	comparison		Ref	
Upper respiratory	Intervention	2.04	0.12 – 33.90	0.620
	Comparison		Ref	
Lower respiratory	Intervention	2.04	0.12 – 33.90	0.620
	comparison		Ref	
Skin	Intervention		N/A	
	comparison			
Overall	Intervention	13.60	3.39 – 54.60	≤0.001*
	comparison		Ref	

* P-value ≤ 0.05, N/A = not applicable

By investigating the association between the frequency of BRS and groups (Intervention, comparison), the following frequency of BRS was identified to associate with groups were found as follows: The frequency of general symptoms decreased by 5.38 times in the intervention group compared to the comparison group (P-value 0.002) and compared to the comparison group, the frequency of overall symptoms was reduced by 13.60 times (95% CI 3.39 to 54.60) among the intervention group.

Table 4.24.2 Compare the severity change of BRS syndrome among caretakers in the intervention and comparison groups following the use of the UCC-IAQ management program.

Severity of symptoms	Group	OR	95% CI	P-value
General	Intervention	13.60	3.39 – 54.60	≤0.001*
	comparison		Ref	
Upper respiratory	Intervention	10.95	2.13 – 56.22	0.004*
	comparison		Ref	
Lower respiratory	Intervention	10.95	2.13 – 56.22	0.004*
	comparison		Ref	
Skin	Intervention		N/A	
	comparison			
Overall	Intervention	13.60	3.39 – 54.60	≤0.001*
	comparison		Ref	

* P-value ≤ 0.05, N/A = not applicable

In comparison to the comparison group, the severity of general symptoms was reduced by 13.60 times among the intervention group. And the severity of upper respiratory symptoms decreased by a ratio of 10.95 in the intervention group compared to the control group. Comparing the intervention group to the comparison group, the severity of lower respiratory symptoms was reduced by 10.95 times. Compared to the comparison group, the severity of overall symptoms dropped 13.60 times among the intervention group.

Table 4.25 Multilevel logistic regression analysis between perception of childcare center environment and BRS.

Characteristics	Intervention (n=28)	Comparison (n=53)	Crude OR.	Adj. OR.	95% CI	P-value
	Number	Number				
Sudden temperature change						
Yes	11	24	8.96	10.72	2.65 – 43.41	0.001*
No	17	29			Reference	
Use spray air freshener						
Yes	21	23	4.49	5.54	1.74 – 17.62	0.004*
No	7	30			Reference	

*The model incorporated nine factors, namely low ventilation, high ventilation, overheating, Sudden temperature change, high relative humidity, air dryness, dustiness, Utilized spray air freshener, and mosquito repellent spray.

A multilevel logistic regression analysis was conducted to investigate the association between multiple environmental variables and the likelihood of Building-Related Symptoms (BRS) of caretakers. The factors considered in the analysis included low ventilation, high ventilation, overheating, Sudden temperature change, high relative humidity, air dryness, dustiness, utilization of spray air freshener, and mosquito repellent spray. The results of the analysis revealed that two factors, including Sudden temperature change and use of spray air freshener, were significantly associated with BRS of caretakers.

The results of multilevel logistic regression analysis indicated that caretakers who worked in rooms with quick temperature fluctuations (Adj OR = 10.72,95%CI = 2.65 – 43.41, P-value = 0.001) and those that utilized aerosol air fresheners (Adj OR = 5.54,95%CI = 1.74 – 17.62, P-value =0.004) were at a higher risk for developing Building-Related Symptoms compared to those who worked in rooms without such conditions. The statistical significance of this finding was established at a level of 0.05.

CHAPTER V
DISCUSSION AND CONCLUSION

Discussion

A study investigating the effects of the UCC IAQ management program on building-related health symptoms (BRS) in the central area of Thailand among caretakers. The study was done from November 2020 to January 2021, for a total study duration of three months.

The UCC_IAQ management program reduces the prevalence of building-related health symptoms (BRS) in building workers. However, the program is not improving the indoor air quality of childcare centers. When comparing building-related health symptoms (BRS) of caretakers before and after implementing the UCC IAQ management program, there was a decrease in the intervention group, while there was no difference in the control group. In the intervention group, the UCC IAQ management program reduced the frequency of BRS general symptoms (P-value ≤0.001), the frequency of BRS overall symptoms (P-value ≤0.001), and the severity of BRS upper respiratory symptoms. This is also consistent with the comparison between the intervention and comparison groups, which found that the general (OR 5.38, 95%CI 1.90 – 15.24) and overall (OR 13.60, 95%CI 3.39 – 54.60) frequencies of BRS were significantly reduced in the intervention group compared to the comparison group.

In accordance with the comparison between the intervention and comparison groups, it was reported that the general severity of BRS (OR 13.60, 95%CI 3.39 – 54.60), the upper respiratory severity of BRS (OR 10.95, 95%CI 2.13 – 56.22), the lower respiratory severity of BRS (OR 10.95, 95%CI 2.13 – 56.22), and the overall severity of BRS (OR 13.60, 95%CI 23.39 – 54.60) were significantly reduced in the intervention group when compared to the comparison group.

This is related to the Korean study, which found that using the intervention to reduce SBS in the intervention group is effective (128). relatable to the present study A meta-analysis of randomized controlled trials showed that interventions aimed at improving air quality reduced the incidence of BRS in the intervention group.(129)In addition, it is consistent with research that reviews the published research on studies that implemented environmental interventions in office settings and evaluated their effectiveness at reducing the prevalence of health, well-being, comfort, and productivity-related complaints among office workers. The findings of this study showed that interventions that aim to improve the indoor environmental quality (IEQ) in offices can be beneficial in improving the health, well-being, and productivity of office workers(130) Similarly, a study on ventilation and sick building syndrome revealed that the comparison group (Low ventilation) had increased formaldehyde and volatile organic compound contents, as well as an increased prevalence of SBS.(16)This is consistent with the findings of a systematic review conducted by Sotiris, which indicated that some types of indoor air pollution can cause building-related symptoms in children.(131) There are publications that support indoor air pollution and the health effects of indoor air, such as Maryam's articles on the relationship between air quality and sick building syndrome(132). According to studies, BRS can be caused by exposure to particular airborne pollutants in an indoor environment(133). Another study of BRS in urban environments indicated that residents' BRS was influenced by indoor air quality and living space.(134) Another study of BRS in urban in addition, studies on petrochemicals and chemicals emitted from plastics have shown an effect on indoor air quality and BRS(135), however, this study found that the VOC levels of all childcare centers were below the recommended limits. The study found all childcare centers have open doors and windows during the morning and lunch hours, resulting in sufficient ventilation. Daily cleaning, a mechanical ventilation system in the kitchen or bathroom, residing in older buildings, and living in less urbanized areas were protective factors, according to a study conducted in China. Urban development, traffic exhaust, indoor emissions from redecorating and new furniture, gas cooking, and air pollution from burning incense and biomass can cause dermal and mucosal symptoms, headaches, and fatigue in Chinese adults. Daily cleaning, mechanical ventilation, and residing in older structures are protective factors.(136) According to this study found that childcare centers the majority are located away from the main road. All room is cleaned daily. However, we found only a small percentage of those who clean their rooms with a vacuum. There are no kitchens in the majority of childcare centers (all kitchens have smoke exhaust systems). Always be. Furthermore, indoor air pollution was associated with a higher prevalence of symptoms in children (20.6%) than in adults (15.0%). The health impacts are caused by allergens, building age, dampness, ventilation systems, formaldehyde, etc.,(137)However, in this study, it was reported that 77.78% of caretakers had any symptoms, while most caretakers were in rooms with low moisture content and low TVOC levels.

Before and after utilizing the UCC IAQ management program, there were no differences within the intervention and comparison groups of indoor air quality (used the Wilcoxon signed-rank test). According to a meta-analysis of research conducted by Leslie et al., air filters have no significant impact on respiratory symptoms.(138) Although the overall change was not significantly reduced, a number of indoor air pollution reductions were found in the intervention group; nonetheless, there was a minor decrease or increase in the intervention group for PM2.5, PM10, total bacterial count, etc. whereas the comparison group had no change at the end of the study (table 5.1). This is consistent with the findings of the Wei study conducted in China, in which the intervention group had better indoor air quality than the control group. In addition, the study discovered that the comparison group had a higher health impact than the intervention group.(31) In addition, air filtering experiments revealed that changes in indoor PM concentrations in response to air filtration interventions were evaluated using standardized mean differences. Indoor PM2 reductions range from 11 to 82 percent. 5 concentrations showed standardized mean differences of 1.19 (95% confidence interval: 1.50, 0.88) (139). Also, when comparing childcare centers with air purifiers (childcare center 2) to those without, the intervention group had a higher reduction in PM2.5 and PM10 than the other childcare centers. In the study, it was recommended that air purifiers be utilized whenever occupants are available. and recommended not opening windows and doors during lunch, as neither childcare center had air purifiers running continuously before intervention. along with furthermore to the study of high-efficiency and low-efficiency filtration systems in testing the differences between the two types of air filtration, it was discovered that their ability to filter PM2.5 was not different.(140) High-efficiency air filtration is used in childcare centers number 2 and 5, respectively.

The UCC IAQ management program used in the present study's intervention groups did not result in a significant reduction in indoor air pollution levels within childcare centers. This is in contrast to previous study results, which showed that the implementation of similar interventions can effectively mitigate indoor air pollution in various building types. The paper presents the first injera biomass gasification baking stove that can drastically reduce fuel consumption, emissions, and indoor air pollution. The stove achieved a thermal efficiency of 16%, reduced specific fuel consumption by 12.8%, and reduced baking time by 19% compared to the traditional three-stone fire. CO and PM emissions were reduced by 99% and 87%, respectively. The results show that it is possible to increase efficiency and reduce fuel consumption if the insulation is improved, and the heating up time between consecutive baked injeras is reduced (141). The study of testing with vegetative and spore-forming bacteria to quantify how indoor air decontamination reduces environmental surface contamination The objective of the study was to evaluate the potential of air decontamination for reducing environmental surface contamination within the same environment. The researchers conducted an experiment to assess the viability of three bacterial strains, namely Staphylococcus aureus and Acinetobacter baumannii, both of which are vegetative bacteria, and Geobacillus stearothermophilus, a bacterial spore-former. These strains were selected because they are representative of airborne bacteria. The air that was contaminated during the experiment was subjected to a decontamination process for a duration of 45 minutes, utilizing a device that operates on the principles of HEPA filtration and UV light. The device designed for air decontamination exhibited the capability to eliminate or render inactive the three types of bacteria that were subjected to testing, with a level of efficacy greater than 99.9%, as indicated by a reduction of more than 3.0 log10 units. This outcome was achieved within a time frame of 45 minutes during which the device was in operation. The aforementioned apparatus exhibited a significant decrease in the viability levels of all bacteria that were subjected to testing in the ambient atmosphere, with a reduction of greater than three logarithmic units (99.9% or more) observed within a duration of 45 minutes. The CFU levels observed on the Petri plates subjected to testing in the chamber were significantly reduced in comparison to the control group. Specifically, the first and second series of tested plates exhibited a reduction of 87% and 97% for A. baumannii, S. aureus, and G. stearothermophilus, respectively. The research findings indicate that air decontamination has the potential to significantly decrease surface contamination levels in a given environment, regardless of the specific type of pathogen present (142). Although this study used place in a room that had an air purifier and was lived in by caretakers, the average indoor air pollution levels did not differ significantly within the intervention group. While the study focused on experimental results regarding the effectiveness of air purifiers in reducing aerosol PM and VOCs. The findings indicate that the air purifier that underwent testing resulted in a significant reduction of PM10 and PM2.5 levels by a factor of 16.8 and 7.25, respectively. This translates to a reduction of approximately 90% and 80%. A significant decline in the concentrations of volatile organic compounds (VOCs) was noted, with a reduction of more than 50% of these gaseous substances being attained. Consequently, the efficacy of the air purifier in decreasing the levels of particulate matter (PM) and volatile organic compounds (VOCs) in the atmosphere was established (143). from a study for the investigation of controlling air pollution in hospital settings. The modeling has concluded that adequate ventilation is imperative to upholding healthy indoor air quality within hospitals and reducing the spread of airborne contaminants. This research employs computational fluid dynamics (CFD) software to conduct a numerical simulation of airflow within a hospital room. The simulation provides predictions regarding the distribution of velocities, temperatures, and contaminants within the room. The outcomes of the simulation can be employed for the purposes of managing infections and exploring the design of buildings. The article highlights the significance of ensuring an adequate proportion and flow rate of fresh air in the supply air to effectively eliminate contaminants from all areas of the hospital or isolation rooms (144). The research was conducted to evaluate the efficacy of a living wall module in eliminating total volatile organic compounds (TVOCs) with the aim of enhancing indoor air quality (IAQ). According to the research, the implementation of a living wall module containing Nephrolepis exaltata L. proved to be efficacious in decreasing the concentration of total volatile organic compounds (TVOCs) to a level that is deemed acceptable within a short span of time. Nonetheless, the research suggests conducting additional experiments involving diverse plant species and various factors associated with indoor air quality (IAQ). Thus, the paper's findings suggest that implementing a living wall module made of felt material can serve as a viable biofilter solution for enhancing indoor air quality through the elimination of total volatile organic compounds (TVOCs)(145). however, the study The UCC IAQ management program prescribed the cleaning and control of VOC contaminants as opposed to wall replacement. This finding is in accordance with the results of the study. The study found that an important number of childcare center rooms lacked proper ventilation. One childcare center was ventilated through the use of exhaust fans. According to our survey, childcare centers that lacked proper ventilation were found to be inadequate. According to our survey, childcare centers that had ventilation systems were mostly inactive during periods of occupancy due to the air-conditioning effect within the room. The majority of these entities lack proper ventilation infrastructure. In accordance with the advice provided to the caretakers belonging to the Intervention group, it was observed that the installation of an exhaust fan poses difficulties due to the mandatory one-year procurement plan that needs to be adhered to, based on the procurement regulations applicable to the government agencies. Several intervention groups have been unable to install exhaust fans upon entering the UCC IAQ management program. if they are installed air filters and exhaust fans. It is possible that certain varieties of indoor air pollution, such as PM10, PM2.5, and carbon dioxide, may be mitigated.

According to the results of this study, participation in intervention groups at childcare centers considerably reduced the frequency of general and overall symptoms. The findings of this study show that childcare centers implementing intervention groups had a significant reduction in the severity of general symptoms, upper respiratory symptoms, lower respiratory symptoms, and overall symptoms.

The findings of this study indicate that the implementation of the UCC IAQ management program reduces the effects of indoor air pollution. A notable disparity in the mean was observed, whereas the comparison to the control group exhibited no reduction. This study. This result is in accordance with previous research that has demonstrated a notable correlation between the frequency of outpatient consultations for allergic conjunctivitis (General symptom) and the concentration of fine particulate matter measuring less than 2.5 µm in diameter (PM2.5) in the atmosphere during the non-pollen season (May to July) in Tokyo, Japan. The results of the multivariate analysis indicated that PM2.5 had a statistically significant association with the number of outpatient visits observed during the specified time frame. Nonetheless, there was no observed association between the number of outpatient visits and any evaluated variable throughout the fall pollen season, which spans from August to October. The results of this study indicate a potential association between PM2.5 and the onset of allergic conjunctivitis outside of the pollen season (146).

The implementation of the UCC IAQ management program resulted in a significant decrease in the severity of upper respiratory tract symptoms (in the intervention group). This outcome aligns with existing research on the identification of risk factors linked to acute lower respiratory tract infection (ALRI) in children, particularly in relation to indoor air pollution. The research has identified various environmental risk factors associated with acute lower respiratory infection (ALRI). These factors include the utilization of wood as a cooking fuel, the presence of domestic animals, the absence of a separate kitchen, a family history of smoking, the lack of windows, and the use of kerosene lamps as a source of light.

The UCC IAQ management program has been found to have reduced the effects of lower respiratory tract after to its use. However, the results were not statistically significant. This finding is consistent with existing literature on the identification of risk factors linked to acute lower respiratory tract infection (ALRI) in children, particularly in relation to indoor environments. The topic of interest is air pollution. The research has identified various environmental factors that pose a risk for Acute Lower Respiratory Infection (ALRI). These factors include the utilization of wood as a cooking fuel, the presence of domestic animals, the absence of a separate kitchen, a family history of smoking, the lack of windows, and the use of kerosene lamps as a source of light(147). Nevertheless, the study on the UCC IAQ management program was unsuccessful in significantly reducing its effect on the lower respiratory system. The research found a significant correlation between indoor air pollution and the incidence of acute respiratory infections (ARI) among children residing in developing nations. The study conducted by the authors revealed that the heightened levels of smoke emanating from the incineration of biofuels, including wood, crop residues, and feces from animals, for the purposes of cooking or heating, in conjunction with tobacco smoke, are significant contributors to the risk of acute respiratory infections (ARI). Respirable particulates, which are comparable to tar found in cigarette emissions, are likely the most suitable metric for evaluating and contrasting toxic noncarcinogenic impacts. The findings of a semi-quantitative epidemiological investigation carried out in Nepal demonstrated a positive correlation between the reported number of hours per day spent in proximity to the stove by infants and children under the age of two, and the incidence of acute respiratory infections that pose a threat to life. According to the researchers, the optimal approach to preventing acute respiratory infections may involve prioritizing the mitigation of other risk factors before addressing smoke exposure, or alternatively, incorporating smoke exposure reduction into comprehensive programs targeting multiple risk factors(148). This finding is in alignment with the results of the study conducted on the UCC Indoor Air Quality (IAQ) management program. According to current research, the respiratory system is impacted by indoor air pollution. However, these results were the same as the expected outcome. The utilization of liquefied petroleum gas (LPG) observed in cooking fuel across all childcare centers was investigated in the present research (all from have kitchens). The study revealed that most childcare centers were equipped with fume extraction systems. Additionally, it was noteworthy that no instances of indoor smoking were observed in any of the childcare centers surveyed.

Similar findings were found in this study, which suggested solutions to reduce the effects of indoor air pollution. The study on air pollution in impoverished countries and its relationship with respiratory ailments in children have shown that reducing acute respiratory infections may be most effectively achieved by prioritizing other risk factors or by including smoke reduction measures within comprehensive programs focusing on multiple risk factors. Several potential approaches to mitigate household pollution can involve the following:

- The utilization of cleaner cooking fuels, such as liquefied petroleum gas (LPG) or biogas, in lieu of solid fuels, such as wood, crop residues, and animal dung, is recommended.

- Increasing the amount of ventilation in buildings to cut down on the amount of exposure to polluted indoor air.

- Promoting the adoption of stoves that show higher efficiency in combustion and emit lower levels of pollutants.

- Promoting the amount of ventilation in buildings to cut down on the amount of exposure to polluted indoor air.

- The implementation of educational and awareness initiatives aimed at disseminating information regarding the potential health hazards associated with indoor air pollution, as well as strategies for mitigating exposure (148).

In accordance with the recommendations contributed forth by the aforementioned research studies. The guidance provided in the UCC IAQ management program has a similarity to the aforementioned, but the UCC IAQ management program set of guidelines. The measures for reducing indoor air pollution include different approaches, such as controlling the sources of pollution, applying methods to reduce indoor air pollution, and disseminating knowledge about the effects of indoor air pollution. Furthermore, the UCC IAQ management program guidelines recommend the utilization of equipment that does not have an impact on indoor air quality.

Simultaneously, the UCC IAQ management program used for this study proved not effective in reducing indoor air pollution levels. It is feasible that management may not be sufficient. A few childcare centers show important building problems, such as compromised window structures that keep the closure of doors and windows within classrooms. Additionally, these centers have openings in the building structure that connect to the outside and are incapable of becoming closed. The UCC Indoor Air Quality (IAQ) Management Program It is recommended to decrease the entry of outdoor air into the building; however, this measure on its own shows inadequate effectiveness in reducing the level of indoor air pollution, as proven by the study. Furthermore, it is shown that some of the intervention buildings showed minimal levels of indoor air pollution at the commencement of the study. The starting point of the UCC IAQ management program resulted in restricted reductions in indoor air pollution due to the relatively low initial levels of indoor air pollution in the building. When considering the table that compares the levels of indoor air pollution before and after the implementation of the intervention, it becomes evident that there is an apparent decrease in the average indoor air pollution levels within the intervention group. There was a reduction in volume, however, the decrease was determined not to be significant.

Table 5.1 Comparing the interior air pollution levels before and after the intervention

Indoor air pollution	Intervention		Comparison	
	Before	After	Before	After
PM 2.5	12.65	12.27	13.32	12.77
PM 10	83.71	73.82	92.49	90.61
Carbon dioxide	670.05	685.60	680.93	353.25
Carbon monoxide	0.81	0	0	0
Total VOC	316.43	305.34	292.40	271.32
Total bacterial count	416.00	373.75	1027.03	599.00
Total fungal count	7.50	7.75	10.67	244.40
Temperature	26.52	25.52	26.89	22.15
Relative Humidity	47.98	47.64	48.46	37.72

Furthermore, it is interesting that the intervention group has shown a greater decrease in PM10 levels within each childcare center, as compared to the Comparison group. When exploring every childcare center by isolation, there was a discovered change in PM 10 levels. However, upon considering the intervention group as a whole, together with the comparison group, no significant change or difference was detected. The table presents a comparison of the levels of PM10 in centers.

Table 5.2 The table presents the PM 10 concentration in each childcare center.

PM 10	Intervention		Comparison	
	Before	After	Before	After
1			59.01	58.66
2	67.61	46.88		
3			95.51	125.15
4	109.41	98.90		
5			35.01	Drop out
6	78.90	74.74		
7	156.04	92.36		
8			187.36	178.76
9			49.40	Drop out
10			128.65	90.49

The UCC IAQ management program focuses on its two goals of reducing indoor air pollution and reducing the negative effects of indoor air pollution or building-related symptoms (BRS). The program has not significantly decreased indoor air pollution, especially by solving the problem of mobile machinery. The UCC IAQ management program has carried out strategies to reduce indoor air pollution, such as the move of photocopiers from densely populated areas. For the purpose of reducing the dispersion of dust particles, a transition from the act of sweeping to that of vacuuming is recommended. Minimizing activities that generate airborne particles within an enclosed space. And recommended setting up an air filter. Furthermore, the UCC IAQ management program provides caretakers with education on effectively controlling and reducing indoor air pollution, as well as increasing awareness about the possible adverse health effects associated with indoor pollution. Knowing the health implications associated with indoor air pollution may be important for helping to increase caretakers' awareness regarding the significance of reducing the effects of indoor air pollution on building-related symptoms (BRS). after the end of the study.

Therefore, this study also highlights the significance of knowledge, particularly regarding the health implications of indoor air pollution for people living indoors. This study highlights the necessity of educating the public regarding indoor air pollution and its associated effects on health, with a particular focus on vulnerable populations, such as children, who are more vulnerable to negative health effects. People with underlying diseases and the elderly population are more vulnerable to harmful health outcomes.

This study provides additional evidence demonstrating the critical significance of addressing indoor air pollution in Thailand. The findings indicate the importance of reducing the effects of indoor air pollution in child childcare center, as it affects not only the caretakers but also the children.

Indoor air pollution encompasses various pollutants that can originate from different sources, such as cooking, tobacco smoke, cleaning products, building materials, and outdoor air contaminants. These pollutants can have adverse effects on human health, especially when individuals are exposed to them for prolonged periods.

Childcare centers serve as environments where children spend a significant portion of their time. Thus, it becomes essential to prioritize measures that improve indoor air quality within these facilities. The potential health impacts of indoor air pollution on both caretakers and children in childcare centers are significant and must not be overlooked.

Caretakers, who spend extended hours in these environments, are at higher risk of developing respiratory issues, allergies, and other health problems due to continuous exposure to indoor air pollutants. Additionally, the children within these centers are particularly vulnerable to the adverse effects of poor air quality. Their developing respiratory systems and immune systems make them more susceptible to respiratory infections, asthma, allergies, and other respiratory conditions associated with indoor air pollution.

To address this issue effectively, it is crucial to implement comprehensive strategies aimed at reducing indoor air pollution in childcare centers. These strategies may include:

1. Source control: Identifying and minimizing or eliminating indoor pollution sources can significantly improve air quality. This involves using less toxic cleaning products, and ensuring proper maintenance of cooling systems. Materials that contain dust and volatile organic compounds (VOCs) must be kept in enclosed spaces, such as closed containers. Move the photocopier to a site with adequate ventilation.

2. Air filtration: Utilizing high-efficiency air filters can help remove particulate matter and other pollutants from the indoor air. Regular maintenance and replacement of filters are essential to ensure their effectiveness.

3. Adequate ventilation: Ensuring proper ventilation systems in childcare centers can help remove indoor air pollutants and improve air circulation. This can be achieved through the installation of mechanical ventilation systems or the use of natural ventilation methods, such as opening windows and doors when the ambient air quality in the immediate area of the building is within a limit that does not have a negative effect on human health.

4. Education and awareness: Providing caretakers and staff with education and training on indoor air pollution, its sources, and its health effects can help raise awareness and promote proactive measures. This can include educating them on proper ventilation practices, recognizing signs of poor indoor air quality, and encouraging them to report any concerns promptly.

5. Regular monitoring: Implementing a system for regular monitoring of indoor air quality can help identify potential issues and ensure that corrective actions are taken promptly. This can involve periodic testing for pollutants and maintaining records to track air quality trends over time.

By prioritizing the reduction of indoor air pollution in childcare centers, Thailand can significantly improve the health and well-being of both caretakers and the children in their care. Implementing these measures requires collaboration between relevant authorities, childcare center administrators, and staff to create a safer and healthier environment for everyone involved.

And finally for the last part of the discussion, a conclusion regarding the findings of the study. The UCC IAQ Management Program aims to mitigate indoor air pollution and improve the air quality within these centers. However, this study found that the program's effectiveness in reducing indoor air pollution was minimal due to various challenges faced by the childcare centers. This discussion will delve into the specific issues encountered during the implementation of the program and explore the limited impact observed.

1. Limitations in Building Restructuring: Childcare centers encountered a significant obstacle in their inability to carry out building restructuring. A few childcare centers experienced major leaks or lacked separate restroom facilities, posing challenges to effectively addressing these structural concerns. The program's potential impact was hindered due to the inability to modify crucial aspects such as proper ventilation and sealing, which are essential for reducing indoor air pollution.

2. Despite some childcare centers reporting initial improvements in indoor air quality after implementing the UCC IAQ Management Program, the overall reduction in indoor air pollution was found to be minimal. While the program may have contributed to slight improvements throughout the day, the end-of-Intervention measurements indicated that indoor air pollution levels remained largely unchanged.

3. Another significant factor affecting the program's impact was the limited budgets of many childcare centers. These centers often rely on government funding and must adhere to strict procurement regulations. As a result, implementing comprehensive measures to address indoor air pollution, such as upgrading ventilation systems or procuring air purifiers, becomes challenging. The lack of financial resources and delays in procurement processes significantly hindered the centers' ability to make substantial improvements to indoor air quality.

Although the reduction in indoor air pollution was minimal, this study uncovered an association between the presence of air pollution and building-related health symptoms. Even with limited improvements in air quality, the study found a significant reduction in health symptoms associated with indoor air pollution, indicating that the program's interventions may have had some positive impact on occupant health. It is essential to consider the overall health benefits of the program, even if the reduction in air pollution was not as substantial as anticipated.

Conclusion

The UCC_IAQ management program has an impact on the prevalence of building-related health symptoms (BRS) among caretakers. However, the program does not have a significant impact on indoor air quality among caretakers in childcare centers. Notwithstanding the lack of interesting changes in indoor air quality among both the intervention and control groups upon the study's conclusion, the research outcomes provide insight into the effect of the UCC IAQ management program on other important factors within childcare centers. The study findings indicate that the program implementation had an evident effect on the rate of building-related symptoms (BRS) and the overall frequency of BRS among the caregivers in the childcare centers of the intervention group.

Although the UCC IAQ management program did not directly lead to measurable improvements in indoor air quality, it showed success in addressing and reducing the incidence of BRS among caregivers. Even though the program did not directly affect the overall air quality, this finding demonstrates the program's effectiveness in promoting the well-being and health of childcare center workers.

By decreasing the frequency of general BRS and overall BRS, the UCC IAQ management program indirectly contributes to a healthier and more comfortable environment in childcare centers for both caregivers and children. As caregivers are essential to providing quality care and supervision to children, reducing the prevalence of BRS can improve their performance, job satisfaction, and overall work experience.

Although the UCC IAQ management program did not directly lead to measurable improvements in indoor air quality, it showed success in addressing and reducing the incidence of BRS among caregivers Even though the program did not directly affect the overall air quality, this finding demonstrates the program's effectiveness in promoting the well-being and health of childcare center workers.

Recommendations for future research

1. Future research should focus on conducting comparative studies between different seasons for the purpose to investigate potential variations in indoor air pollution and building-related symptoms (BRS) that may be influenced by seasonal changes.

2. Future research activities should aim to assess both indoor and outdoor air quality for the purpose to determine and compare possible differences between the two environments.

3. Future research projects should incorporate the use of a biomarker to confirm the observed effects caused by indoor air pollution.

Recommendations for organizations

1. It is necessary to disseminate knowledge regarding indoor air pollution and its related health effects among employees, for the purpose to increase their awareness and understanding of the harmful effects of indoor air pollution.

2. The organization is aware of the effects of indoor air pollution and avoids activities that contribute to it, such as using continuous fragrance diffusers and floor cleansers containing volatile organic compounds.

3. It is recommended to choose office equipment that does not contribute to the incidence of indoor air pollution, such as purchasing pieces of furniture that do not release volatile organic compounds (VOCs).

4. It is imperative to focus consideration on the investigation of building structures and ventilation systems within buildings, as they possess the potential to efficiently reduce the effects of indoor air pollution.

Recommendations for policy level

1. It is necessary to establish standardized guidelines for the construction of Childcare centers. Architectural and engineering methods can be used to effectively level or reduce the negative effects of indoor air pollution.

2. There is a developing campaign aimed at increasing public awareness regarding the impacts of indoor air pollution, especially for public health.

3. It is imperative to allocate financial resources towards childcare centers with the aim of solving the problem of indoor air pollution, with a special focus on its management within workplace environments. The problem of indoor air pollution

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