Full paper

International Journal of Real Estate Studies

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Indoor Air Quality (IAQ) in Malaysian Kindergarten: A Thematic Review

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Article history: Received: *7 October 2021* Received in revised form: *13 November 2021*
Accepted: *18 November 2021* Published online: *25 November 2022*

Abstract

Indoor air quality (IAQ) is an essential component of a healthy indoor environment , which is necessary for occupants' comfort and well-being. The poor IAQ in kindergartens has a negative effect on children's learning performance and increases their chance of developing asthma and other respiratory diseases which cause absenteeism. Since children spend a significant amount of time in kindergartens, it is important to acknowledge studies have been conducted and have identified the needs for IAQ improvement. This paper explores the IAQ research patterns in Malaysia from 2010 to 2021 using thematic review. The themed review was conducted by examining articles from four electronic databases: Web of Science, Science Direct, SCOPUS, and Google Scholar. Information on IAQ in kindergarten were extracted from 22 studies, which identified four main themes: indoor air contaminants, indoor air exposure, physical environment, and intervention. The findings will be useful in future studies on IAQ in the kindergarten environment besides determining areas that required further investigation.

Keywords: Indoor air quality, indoor environment, kindergarten, thematic review

1.0 INTRODUCTION

IAQ refers to the air quality inside the building and surrounding area that can affect the health and well-being of building occupants. The air within buildings can be more contaminated than outdoor air (United States Environmental Protection Agency, 2009) and is one of the top five health risks posed by the environment (United States Environmental Protection Agency, 2013). IAQ in buildings is characterised by various pollutants, such as particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen oxide (NO_2), ozone (O_3), carbon dioxide (CO_2), carbon monoxide (CO), sulphur dioxide (SO_2), volatile organic compounds (VOCs), bacteria, and fungi. Indoor air concentrations are associated with humidity, temperature, and air velocity. Different sources may directly or indirectly emit pollutants, and they can be categorised according to their context, occupant, and building (Korsavi et al., 2018). Due to the number of sources and confined air volume in buildings, the indoor air concentration in spaces fluctuates every hour, depending on space usage and indoor physical settings such as ventilation systems and indoor activities (Vasile et al., 2020). This situation highlights the importance of IAQ in any indoor space where humans, especially children, spend most of their time.

Children's growth and development are influenced by the air quality that they breathe. IAQ is critical in kindergartens to keep children and teachers safe, healthy, and productive. However, previous research indicated that various air contaminants are present in classrooms, and they are sometimes at increased levels. A large body of evidence revealed that poor air quality could negatively affect children's health, particularly respiratory health, attendance, and academic achievement (Branco et al., 2020; Deng et al., 2016b; Sá et al., 2019). Children are at greater risk of getting severe health consequences from indoor air since their bodies are still developing, and processing toxins is physically more difficult for children. Furthermore, children are more susceptible to the effects of air contaminants because they play closer to the ground, engage in more hand-to-mouth activities, and have a decreased ability to identify and protect themselves from potential threats (Bridger, n.d.).

In Malaysia, the majority of parents send their children to kindergartens as a learning preparation before starting primary school (Dahari & Ya, 2011). Early education has become an important component of children's social development. Referring to the Sustainable Development Goal (SDG) 4 and UNESCO's approach to education in 2030, children will be equipped with basic early education before entering primary education (UNESCO, 2015). In line with this agenda, the Ministry of Education Malaysia is determined to enrol all children in kindergartens as early as four years old (MOE, 2013), increasing the demand for kindergartens every year. Based on Malaysia Education Statistics 2019, there are currently a total of 6,152 government preschools and 613,247 kindergartens by other government

agencies and private institutions (MOE, 2019). The establishment of kindergartens has two objectives: to care and to educate. Therefore, it is important to provide a good indoor environment (Rahman et al., 2019; Salleh et al., 2015). The indoor environment includes the comfort of IAQ, space, lighting, and aesthetics (Stankovic et al., 2015). IAQ is important in the kindergarten setting, especially in the current COVID-19 pandemic where several studies have demonstrated that improved IAQ reduces the likelihood of coronavirus transmission in indoor environments (Lovec et al., 2021; Morawska et al., 2020). Thus, this paper investigates past trends and current discussions on IAQ in Malaysian kindergartens published between 2010 and 2021.

2.0 MATERIALS AND METHODS

The primary data sources were extracted from Web of Sciences, SCOPUS, Science Direct, and Google Scholar for additional sources. The approach for thematic review used in this paper is based on Zairul (2021a, 2021b) and utilises ATLAS.ti 8 as the analysing tool. Thematic analysis is used in this approach of inquiry. Thematic analysis is described as the process of detecting patterns and developing themes after conducting substantial research on a subject (Clarke & Braun, 2013). As part of this investigation, the findings will be analysed and interpreted to provide recommendations for future research on IAQ. The works of literature were chosen based on several selection criteria: 1) publications from 2010 to 2021, 2) the use of the keyword “indoor air quality” in the content, and 3) papers that focus on kindergartens, preschools, or nursery schools in Malaysia. The study was focused to Malaysia to aid in the identification of future improvements to IAQ in Malaysian kindergartens. Table 1 shows the search strings that were used to find relevant literature.

Table 1 Search strings from Web of Science, SCOPUS and Science Direct

Search strings from Web of Science	(ALL=(indoor air quality) AND (kindergarten OR preschool OR nursery school) AND (Malaysia) Result = 12 articles
Search strings from SCOPUS	TITLE-ABS-KEY ((("indoor air quality") AND ("kindergarten" OR "preschool" OR "nursery school"))) AND Malaysia AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010)) Result = 6 articles
Search strings from Science Direct	(("indoor air quality") AND ("kindergarten" OR "preschool" OR "nursery school") AND “Malaysia”) Year: 2010-2021 Result = 72 articles

From the Web of Science search, (ALL=(indoor air quality) AND (kindergarten OR preschool OR nursery school) AND (Malaysia) generated 12 articles. From the SCOPUS search, the TITLE-ABS-KEY ((("indoor air quality") AND ("kindergarten" OR "preschool" OR "nursery school"))) AND Malaysia AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010)) generated 6 articles on IAQ in Malaysia from 2010–2021. From the Science Direct search, the term (("indoor air quality") AND ("kindergarten" OR "preschool" OR "nursery school") AND “Malaysia”) yielded 72 articles. The next strings of searches used the Google Scholar database and yielded over 1,470 results. Therefore, we only reviewed the first 10 result pages in Google Scholar. After removing duplicates and scanning all abstracts to remove irrelevant articles, 22 articles were identified for review as shown in Figure 1. All 22 articles were grouped into several themes. The review’s findings were classified into two categories: quantitative and qualitative findings.

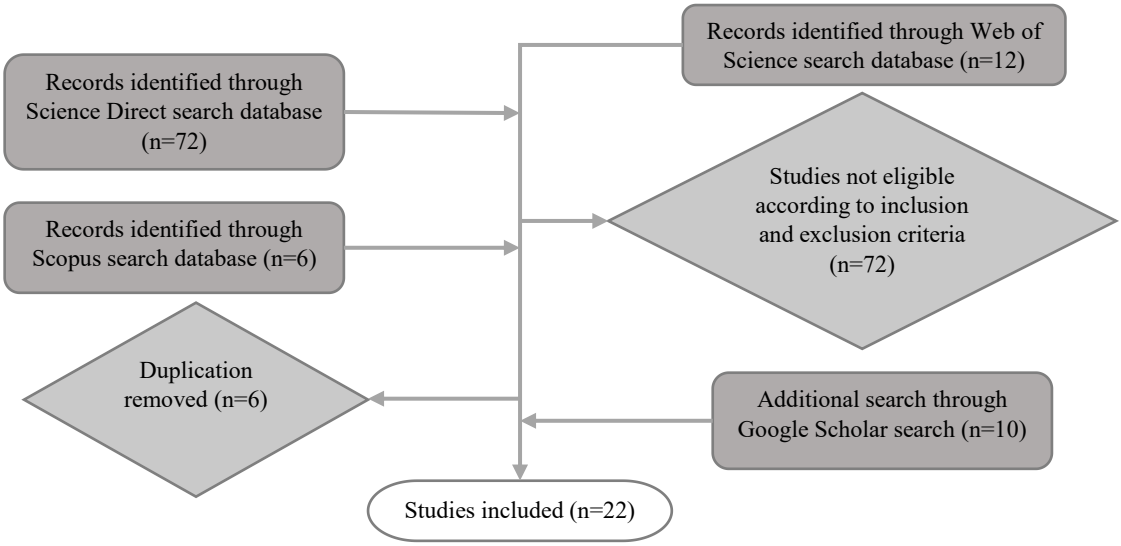

Figure 1 Screening profile for thematic review

The articles were first entered into ATLAS.ti 8 software (textual analysis software) and then categorised into the following: 1) author, 2) issue number, 3) periodical, 4) publisher, 5) volume, and 6) year of publication. As a result, the articles were grouped, allowing them to be evaluated based on their publication year and the pattern of discussion. Twenty-two articles were finalised using ATLAS.ti 8 after several rounds of screening (Table 2). Over the last decade, numerous studies have examined IAQ. Publications on the subject are increasing from year to year. This field of study became popular in 2015 and has continued to progress over time. However, there is no publication on IAQ in 2020 due to the coronavirus (COVID-19) pandemic, which has forced the temporary closure of all kindergartens' operations. At the time of this article was written, the year 2021 only has 1 publication.

Table 2 Reviewed articles according to year

Year	Articles
2011	1
2013	1
2014	3
2015	5
2016	3
2017	2
2018	1
2019	5
2021	1
Total	22

According to Figure 2, a word cloud summary from the 22 articles captured the term "health" that was mentioned 468 times, while "respiratory" was mentioned 329 times and "PM10" was mentioned 297 times. IAQ is presumed to be directly related to children's health.

Figure 2 Word cloud summary of 22 articles

3.0 RESULTS AND DISCUSSIONS

Table 3 contains a list of publications and their classification into several subcategories. The trends and patterns generated 22 initial codings after the recall of the 22 articles. After numerous iterations of code merging and re-coding in ATLAS.ti 8, the final patterns and trends revealed four main themes on IAQ in kindergartens up to date. The four main themes are indoor air contaminants, indoor air exposure, physical environment, and intervention.

Table 3 Documents to a theme table

	Indoor air contaminants	Indoor air exposure	Physical environment	Intervention
Rahman et al. (2019)	√			
Rawi et al. (2015)		√		
Salleh et al. (2016)	√	√		
Abas et al. (2021)				√
Darus et al. (2019)				√
Kamaruzzaman and Razak (2011)	√			
Zainudin et al. (2019)		√		
Sarijuddin et al. (2017)		√		
Salleh et al. (2015)			√	
Salleh et al. (2013)	√	√	√	
Nazri et al. (2017)	√			
Chua et al. (2015b)		√		
Nahar and Salleh (2019)	√		√	
Abdullah et al. (2019)	√			
Kamaruddin et al. (2015)		√		
Chua et al. (2015a)		√		
Asrul and Juliana (2017)		√		
Salleh et al. (2016)			√	
Wesley and Jalaludin (2015)		√		
Hisyam and Juliana (2014)		√		
Salleh et al. (2016)	√		√	
Aziz et al. (2014)	√	√		
Total	**9**	**12**	**5**	**2**

3.1 Indoor Air Contaminants

Most studies on the IAQ in Malaysian kindergarten environments focused on multipollutant monitoring studies. A study was conducted on urban, suburban, and rural kindergartens in Selangor, which has the highest number of registered kindergartens (MOE, 2019). Multipollutant monitoring includes particulate matter, gas contaminants, and biological contaminants (Figure 3). The most frequently studied parameters are temperature, humidity, CO_2, VOCs, CO, $PM_{2.5}$, PM_{10}, bacteria, and fungi. The IAQ parameters measured were compared with the Industry Code of Practice (ICOP) on IAQ 2010 (DOSH, 2010) established by the Department of Safety and Health of the Ministry of Human Resources. Despite this ICOP was not intended for the kindergarten context, it is now utilised as an indicator for evaluating the permitted concentration levels in an indoor setting.

The most investigated kindergarten is the landed kindergarten building located at a residential unit (Nahar & Salleh, 2019; Nazri et al., 2017; Salleh et al., 2016), whereas another researcher did not mention the kindergarten's building typology. Studies conducted in other education buildings such as schools found three main factors influencing IAQ, namely outdoor traffic/surrounding areas, ventilation condition, and occupancy (Hazrin et al., 2017; Rim et al., 2017). In the kindergarten environment, most researchers studied the IAQ from the standpoint of occupancy as one of the crucial factors determining pollutant concentrations. Most of the pollutants detected in the learning classroom are due to ventilation problems where the CO_2 levels are high, with some kindergartens exceeding the acceptable limit of 1000ppm set by ICOP 2010. This issue occurred in two scenarios:1) when the learning room uses air conditioning (Salleh et al., 2016); and 2) when there is a high occupancy rate of children in a learning room (Nazri et al., 2017). To examine the occurrence in further detail, a recent research by Nahar and Salleh (2019) revealed that space per child contributed to the increment of CO_2. The investigated kindergartens were located at different locations; hence, the magnitude of PM concentration was substantially different due to the impact

of the surrounding area (Abdullah et al., 2019). High concentrations of VOCs were found in the learning classroom and probability they are linked to the properties of the furniture (Kamaruzzaman & Razak, 2011; Rahman et al., 2019).

Overall, studies in Malaysia focused on indoor air contaminants without measuring the outdoor air. There were not enough outdoor data available to determine the indoor/outdoor (I/O) ratio. Outdoor sources are considered an important factor that can influence indoor air contaminants. This condition is alarming for kindergartens that are situated in commercial or industrial areas where the outside air is more polluted than inside residential areas (Abdullah et al., 2019). Furthermore, there is a need to continuously evaluate the concentration of indoor air contaminants that considers the comparison of occupation and non-occupied periods. To determine the IAQ status, there is a need to investigate all parameters stated in the ICOP 2010, including physical parameters, especially air-conditioned classrooms.

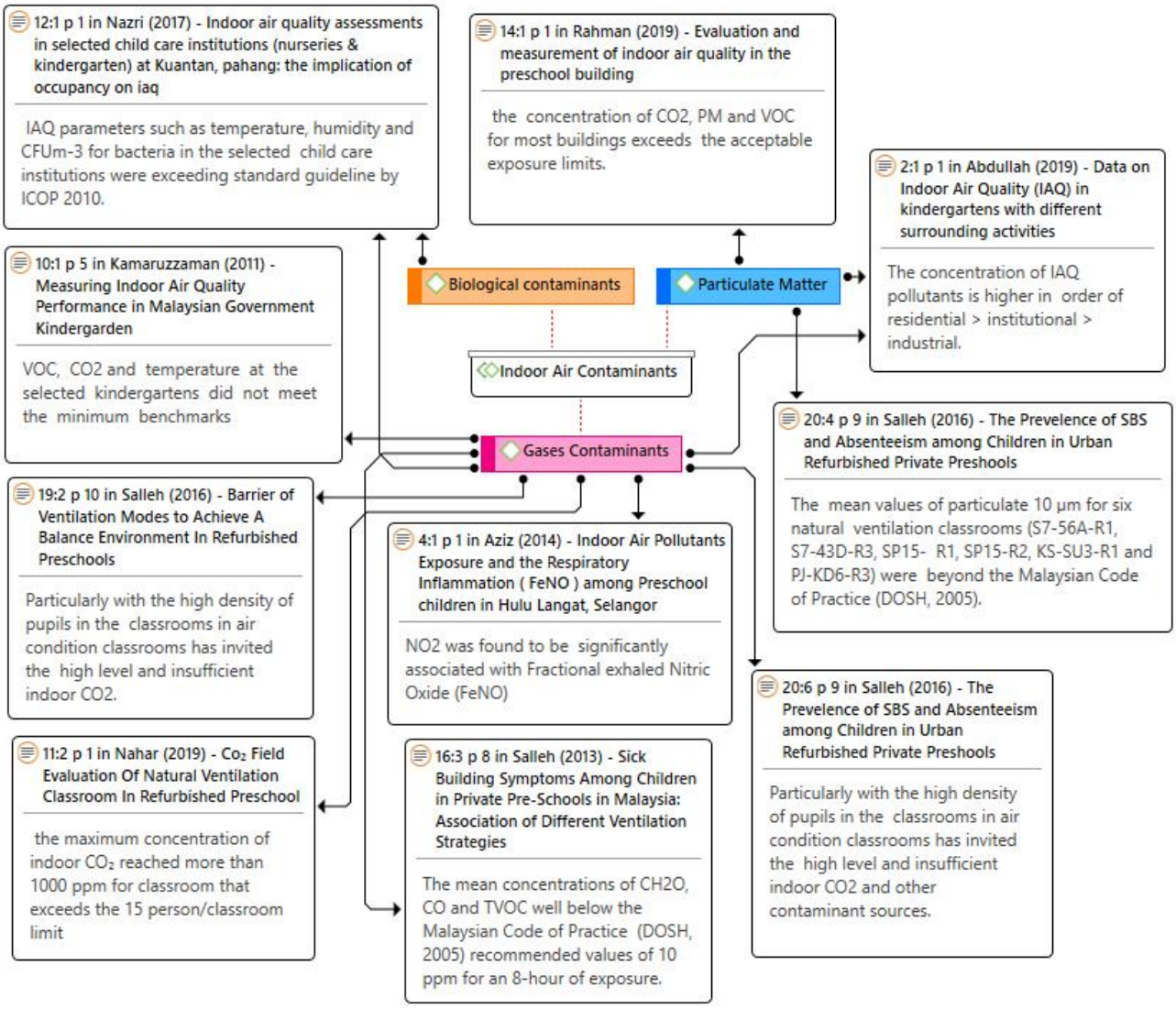

Figure 3 Network view of main publication on indoor air contaminants

3.2 Indoor Air Exposure

Indoor air exposure is one of the most popular publication studies in Malaysia. The intention of this research is to ascertain the effect of IAQ on children. A cross-sectional comparative study was conducted among preschoolers who attended kindergartens from urban areas, suburban areas, and rural areas in Selangor, Malaysia. A standardised set of questionnaires adapted from the American Thoracic Society entitled "Questionnaire ATS-DLD-78-C" was used to collect the data on respiratory symptoms and home exposures to pollutants (Chua et al., 2015a; Hisyam & Juliana, 2014; Zainudin et al., 2019). An additional questionnaire was adapted from the questionnaire on the International Study of Asthma and Allergies in Childhood (ISAAC) comprising questions on asthma and allergies (Hisyam & Juliana, 2014).

This theme discusses the effect of IAQ on children's health, including respiratory health symptoms (Asrul & Juliana, 2017; Chua et al., 2015b; Kamaruddin et al., 2015; Rawi et al., 2015), lung function (Chua et al., 2015a), respiratory inflammation (Aziz et al., 2014; Zainudin et al., 2019), upper way inflammation (Hisyam & Juliana, 2014), sick building syndrome (Salleh et al., 2013; Salleh et al., 2016),

and absenteeism (Salleh et al., 2016) (Figure 4). The most common health problem in an air-conditioned classroom is respiratory ailment such as runny nose, sore throat, coughing, difficulty breathing, and wheezing (Salleh et al., 2016). Rawi et al. (2015) discovered substantial associations between wheezing and indoor $PM_{2.5}$ concentrations. In addition, Kamaruddin et al. (2015) stated that there were strong link between PM_{10} with chest tightness, phlegm and cough among kindergarten children.

It can be concluded that PM contributes significantly to children's health problems, which depend on its chemical content. PM does not only settle deeper into lungs but also has a high concentration of organic compounds, which will have long-term consequences (Kamaruddin et al., 2015). Inadequate ventilation systems were discovered to be a factor contributing to the spread of infectious diseases (Salleh et al., 2013). The high concentration of CO_2 could lead to several symptoms like headache and fatigue (Jones, 1999). Similarly, rising CO_2 levels may lower children's productivity as this issue has been observed in office workers (Bakó-Biró et al., 2005). The prevalence of the majority of respiratory problems is higher in industrial areas than in suburban areas (Hisyam & Juliana, 2014). Hisyam and Juliana (2014) stated that outdoor pollutants from heavy traffic, industrial emissions, and constructions sites could contribute to the increased prevalence of respiratory health in kindergarten children living in industrial areas.

Based on the tested IAQ parameters, further investigation should be extended to biological contaminants. Biological contaminants such as bacteria and fungi can trigger allergic reactions, respiratory disorders, hyperactive diseases, and infectious diseases (DOSH, 2010). Bacteria are dangerous because they produce endotoxin, which is generally released by bacteria found in household dust (Asrul & Juliana, 2017). Inhaling airborne bacteria and bacterial endotoxins have been linked to various allergic reactions and respiratory symptoms (Deng et al., 2016a).

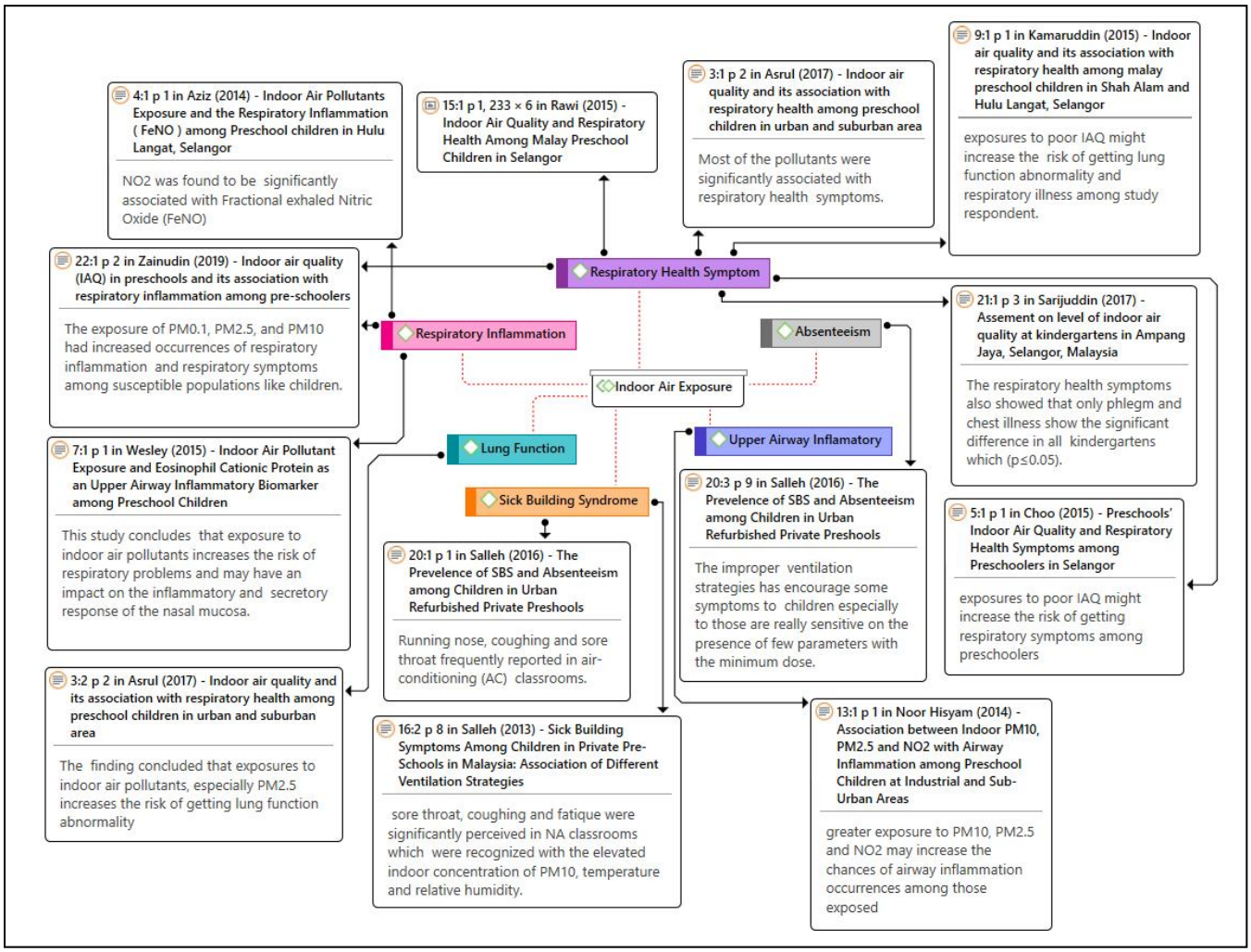

Figure 4 Network view of main publication on indoor air exposure

3.3 Physical Environment

The physical environment can also affect the IAQ in kindergartens. Among the factors discussed are indoor environmental quality (IEQ) and ventilation strategies (Figure 5). IEQ is regarded as one of the essential aspects influencing children's physical development. Hence, it is important to evaluate the internal environment of kindergartens in renovated houses that have changed their original function. IAQ, temperature, visual aspects, acoustics, natural and artificial lighting, ergonomics, and space are all building factors that affect children's health and performance (Salleh et al., 2015). However, some private kindergarten operators were not concerned about IEQ. Most

kindergarten buildings do not comply with the minimum allowable space per child, classroom location, and random selection of kindergarten premises. Buildings that are modified against the guidelines will attract pollutants and organic effluences such as polluted gases, mould, and fungi into the building (Salleh et al., 2016).

The type of ventilation also significantly affects the IAQ in kindergartens. It has been discovered that mechanical ventilation has both positive and negative effects on health. Mechanical ventilation is beneficial in lowering respiratory problems such as asthma; but if they are not properly maintained, it can result in improper air exchange rates and elevated CO_2 concentrations (Nahar & Salleh, 2019; Salleh et al., 2013; Salleh et al., 2016). Although commercial buildings can be used as kindergartens, natural ventilation is not an option due to the building's placement in a busy surrounding environment. The reliance on air conditioning will increase the CO_2 level without any fresh air intake. To obtain a good ventilation system, the selection of building position and location should also be considered. Hence, comprehensive guidelines on the physical setting of kindergartens are needed to enhance the indoor environment of kindergartens.

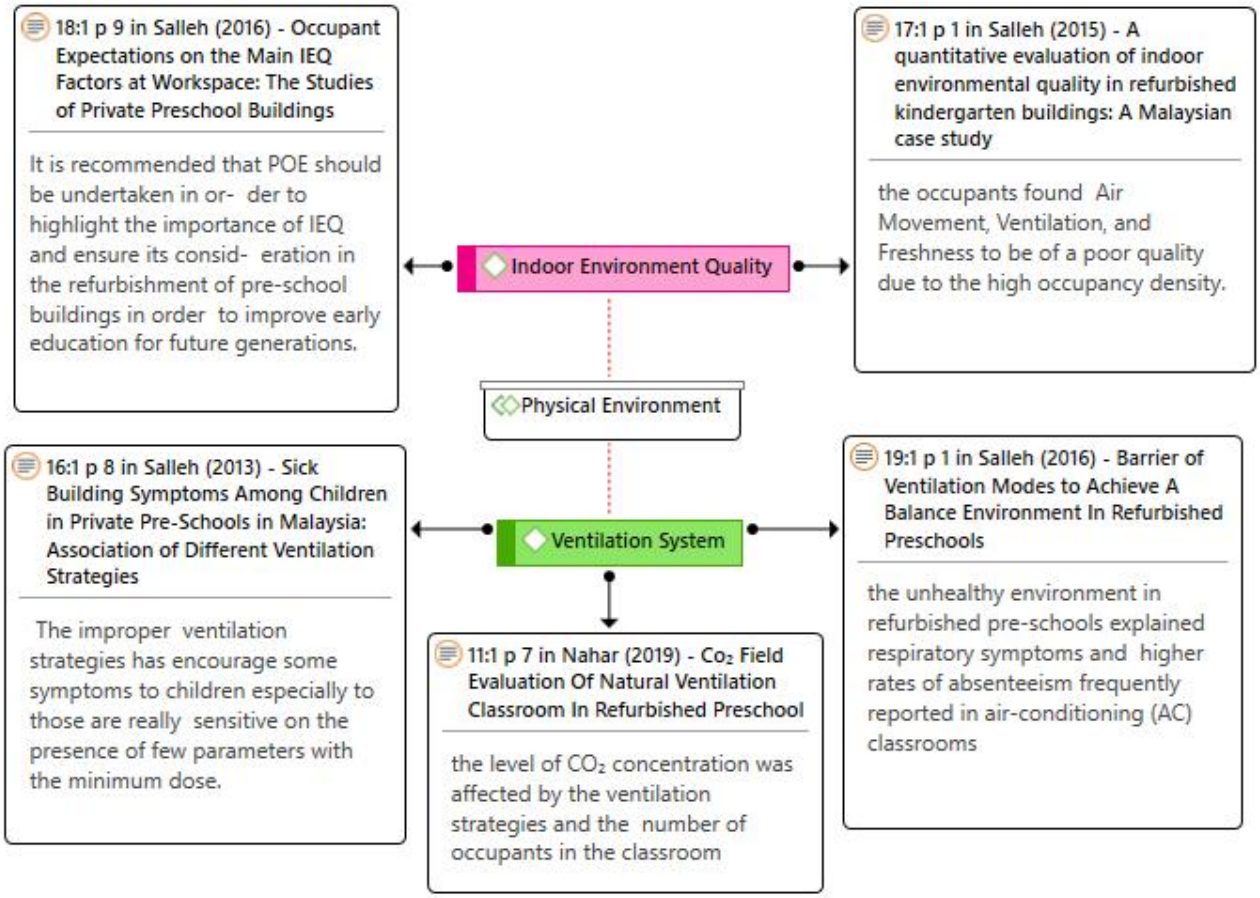

Figure 5 Network view of main publication on physical environment

3.4 Intervention

From the studies reviewed, the IAQ intervention includes antifungal agents and biological indicators (Figure 6). Biological contaminants such as fungi and bacteria, PM, and chemical gases polluted indoor air and have been linked to negative health effects (Asrul & Juliana, 2017). The main factors that promote fungi growth in indoor air are high moisture, temperature, and sufficient nutrients. Therefore, it is crucial to decontaminate indoor air from prolonged exposure to fungi. Darus et al. (2019) investigated five antifungal agents, namely lemongrass oil, tea tree oil, 70% ethanol, vinegar, and Febreze. Lemongrass oil was found to be the most effective antifungal agent, completely inhibiting both *Lichtheimia sp.* and *Curvularia sp.* spore growth and production, making it one of the best options for the remediation of fungal contamination (Darus et al., 2019).

In Malaysia, the use of bioindicator to check IAQ is still in its infancy stage. The monitoring of air pollution levels with a bioindicator has been done using lichen frequency count and lichen biodiversity index (Abas & Awang, 2015, 2017; Abas et al., 2018). Abas et al. (2021) introduced the use of lichen to assess IAQ. The study focused on trace metal content and assumed that the concentration of trace metal in the lichen's thalli offered an indication of environmental quality. The study revealed that aside from using instruments, indoor pollution levels can also be measured using a bioindicator.

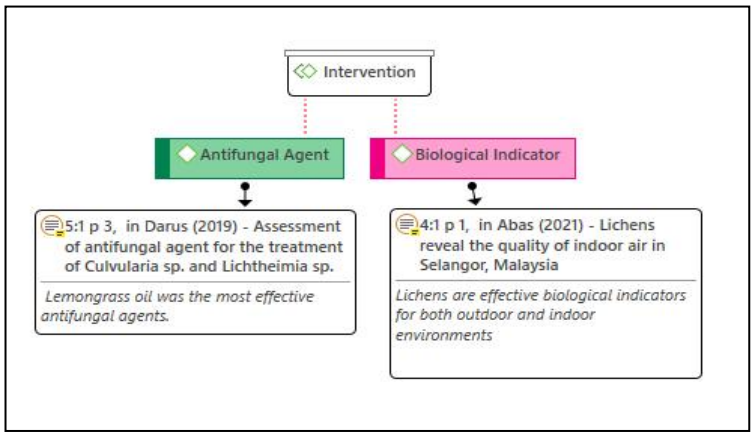

Figure 6 Network view of main publication on intervention

4.0 CONCLUSION AND FUTURE STUDIES

We conducted a comprehensive evaluation of the local scientific literature and gathered information from 22 articles published between 2010 and 2021. This review focused on the IAQ in the kindergarten environment with four research themes: indoor air contaminant, indoor air exposure, physical environment, and intervention. Research on indoor air pollutants and indoor air exposure make up the majority of the discussions. In the Malaysian tropical climate, the indoor kindergarten environment has been exposed to various contaminants. As children are susceptible to infections, kindergartens should strive to provide a pollution-free environment that will promote their overall well-being. Children that are exposed to high levels of contaminants are at risk of respiratory problems. In light of these findings, mitigation actions and preventative measures to minimise indoor pollution levels are required to protect children from dangerous exposure.

Overall, indoor contaminant concentrations are the result of a combination of both indoor and outdoor pollution that infiltrates the buildings. This study recommends further investigation of outdoor sources and the indoor/outdoor ratio. The investigation can provide a broad picture of the origin of pollutions and their sources. Another research area that can be explored further is the role of kindergarten's physical environment in IAQ, including space allocation, location, furniture, and finishes used in the building to have a comprehensive understanding of IAQ. The pandemic has spread around the globe; and currently, the Malaysian government is moving into the endemic phase, it is important to ensure the safety and health of kindergarten children. The risk of children contracting the virus is higher, especially for those below 12 years old as they are not vaccinated. A good IAQ can prevent the transmission of COVID-19 in kindergartens since children spend most of their time indoors.

Acknowledgement

The authors would like to convey their heartfelt appreciation to the Ministry of Higher Education (MOHE) Malaysia, Universiti Malaya (UM) and Universiti Teknologi MARA (UiTM). This work was supported by the Institute of Research Management and Services (IPPP), Impact-Oriented Interdisciplinary Research Grant Programme (IIRG), University of Malaya, Kuala Lumpur, Malaysia [Grant number: IIRG015A-2019].

References

Abas, A., & Awang, A. (2015). Penentuan tahap pencemaran udara di Malaysia menggunakan pendekatan penunjuk bio (Liken): Kajian kes Bandar Baru Bangi [Determination of Malaysia's air pollution levels using bio-indicators approach (Lichen): A case study of Bandar Baru Bangi]. *Geografia : Malaysian Journal of Society and Space, 11*(9), 67-74.

Abas, A., & Awang, A. (2017). Air pollution assessments using Lichen Biodiversity Index (LBI) in Kuala Lumpur, Malaysia. *Pollution Research, 36*(2), 242-249.

Abas, A., Awang, A., & Aiyub, K. (2018). Lichen as bio-indicator for air pollution in Klang Selangor. *Pollution Research, 37*(4), 35-39.

Abas, A., Mazlan, S. M., Latif, M. T., Aiyub, K., Muhammad, N., Nadzir, M. S. M., Shahrul, M., & Nadzir, M. S. M. (2021). Lichens reveal the quality of indoor air in Selangor, Malaysia. *Ecological Processes, 10*, Article 3.

Abdullah, S., Hamid, F. F. A., Ismail, M., Ahmed, A. N., & Mansor, W. N. W. (2019). Data on Indoor Air Quality (IAQ) in kindergartens with different surrounding activities. *Data in Brief, 25*, Article 103969.

Asrul, S., & Juliana, J. (2017). Indoor air quality and its association with respiratory health among preschool children in urban and suburban area. *Malaysian Journal of Public Health Medicine, Special Volume*(1), 78-88.

Aziz, N. A., Jalaludin, J., & Bakar, S. A. (2014). Indoor air pollutants exposure and the respiratory inflammation (FeNO) among preschool children in Hulu Langat, Selangor. *Advances in Environmental Biology, 8*(15), 164-170.

Bakó-Biró, Z., Wargocki, P., Wyon, D. P., & Fanger, P. O. (2005, September 4-9). Poor indoor air quality slows down metabolic rate of office workers. In *Indoor Air 2005. Proceedings of the 10th International Conference on Indoor Air Quality and Climate* (vol. 1, pp. 76-80). Beijing: Tsinghua University Press.

Branco, P. T. B. S., Alvim-Ferraz, M. C. M., Martins, F. G., Ferraz, C., Vaz, L. G., & Sousa, S. I. V. (2020). Impact of indoor air pollution in nursery and primary schools on childhood asthma. *Science of the Total Environment, 745*, Article 140982.

Bridger, C. (n.d.). The health impacts of indoor air quality. Retrieved on 1 November 2021 from https://www.neefusa.org/health/asthma/health-impacts-indoor-air-quality

Chua, P. C., Jalaludin, J., Hamedon, T. R., & Adam, N. M. (2015a). Indoor air quality assessment and lung functions among children in preschool at Selangor, Malaysia. *Advances in Environmental Biology, 9*(9), 1-9.

Chua, P. C., Jalaludin, J., Hamedon, T. R., & Adam, N. M. (2015b). Preschools' indoor air quality and respiratory health symptoms among preschoolers in Selangor. *Procedia Environmental Sciences, 30*, 303-308.

Clarke, V., & Braun, V. (2013). Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning. *The Psychologist, 26*(2), 120-123.

Dahari, Z., & Ya, M. S. (2011). Factors that influence parents' choice of pre-schools education in Malaysia: An exploratory study. *International Journal of Business and Social Science, 2*(15), 115-128.

Darus, F. M., Misa, N. A. A., Ismail, Z. S., & Mahidin, H. (2019). Assessment of antifungal agent for the treatment of Culvularia sp. and Lichtheimia sp. *IOP Conference Series: Earth and Environmental Science, 373*, Article 012019.

Deng, W., Chai, Y., Lin, H., So, W. W. M., Ho, K. W. K., Tsui, A. K. Y., & Wong, R. K. S. (2016a). Distribution of bacteria in inhalable particles and its implications for health risks in kindergarten children in Hong Kong. *Atmospheric Environment, 128*, 268-275.

Deng, W.-J., Zheng, H.-L., Tsui, A. K. Y., & Chen, X.-W. (2016b). Measurement and health risk assessment of $PM_{2.5}$, flame retardants, carbonyls and black carbon in indoor and outdoor air in kindergartens in Hong Kong. *Environment International, 96*, 65-74.

Department of Occupational Safety and Health (DOSH). (2010). *Industry code of practice on indoor air quality 2010*. Putrajaya: DOSH.

Hazrin, A. H., Maryam, Z., Hizrri, A., Norhidayah, A., Samsuddin, N., & Mohd Shukri, M. A. (2017). Occupancy implications on indoor air quality (IAQ) in selected primary school classrooms around Kuantan, Pahang. *Malaysian Journal of Public Health Medicine, Special Volume*(1), 95-105.

Hisyam, N. H. N., & Juliana, J. (2014). Association between indoor PM_{10}, $PM_{2.5}$ and NO_2 with airway inflammation among preschool children at industrial and sub-urban areas. *Advances in Environmental Biology, 8*(15), 149-159.

Jones, A. P. (1999). Indoor air quality and health. *Atmospheric Environment, 33*(28), 4535-4564.

Kamaruddin, A. S., Jalaludin, J., & Chua, P. C. (2015). Indoor air quality and its association with respiratory health among Malay preschool children in Shah Alam and Hulu Langat, Selangor. *Advances in Environmental Biology, 9*(9), 17-26.

Kamaruzzaman, S. N., & Razak, R. A. (2011). Measuring indoor air quality performance in Malaysian government kindergarten. *Journal of Building Performance, 2*(1), 70-79.

Korsavi, S. S., Montazami, A., & Brusey, J. (2018). Developing a design framework to facilitate adaptive behaviours. *Energy and Buildings*, *179*, 360-373.

Lovec, V., Premrov, M., & Leskovar, V. Ž. (2021). Practical impact of the COVID-19 pandemic on indoor air quality and thermal comfort in kindergartens. A case study of Slovenia. *International Journal of Environmental Research and Public Health, 18*(18), Article 9712.

Ministry of Education Malaysia (MOE). (2013). *Malaysia Education Blueprint 2013-2025 (preschool to post-secondary education)*. Putrajaya: MOE. Retrieved from https://www.moe.gov.my/menumedia/media-cetak/penerbitan/dasar/1207-malaysia-education-blueprint-2013-2025/file

Ministry of Education Malaysia (MOE). (2019). *Quick facts 2019: Malaysia educational statistics*. Putrajaya: Ministry of Education Malaysia. Retrieved from https://www.moe.gov.my/muat-turun/penerbitan-dan-jurnal/terbitan/buku-informasi/2722-quick-facts-2019/file

Morawska, L., Tang, J. W., Bahnfleth, W., Bluyssen, P. M., Boerstra, A., Buonanno, G., … Yao, M. (2020). How can airborne transmission of COVID-19 indoors be minimised? *Environment International, 142*, Article 105832.

Nahar, A. A., & Salleh, N. M. (2019, November 6-7). CO_2 field evaluation of natural ventilation classroom in refurbished preschool. In J. Wahid, A. A. A. Samad, S. S. Ahmad, & P. Pujinda (Eds.), *ICRP 2019. Proceedings of the 4th International Conference on Rebuilding Place* (pp. 527-535). Penang: Future Academy.

Nazri, N. S. M., Aris, M. S. M., & Din, S. A. M. (2017). Indoor air quality assessment in selected child care institutions (nurseries & kindergarten) at Kuantan, Pahang: The implication of occupancy on IAQ. *Journal of Built Environment, Technology and Engineering, 2*, 175-181.

Rahman, M. A. A., Awang, M., Mustafa, M. S. S., Yusop, F., Sari, K. A. M., Musa, M. K., … Hamidon, N. (2019). Evaluation and measurement of indoor air quality in the preschool building. *IOP Conference Series: Earth and Environmental Science, 373*, Article 012018.

Rawi, N. A. M. N., Jalaludin, J., & Chua, P. C. (2015). Indoor air quality and respiratory health among Malay preschool children in Selangor. *BioMed Research International, 2015*, Article 248178.

Rim, D., Gall, E. T., Kim, J. B., & Bae, G.-N. (2017). Particulate matter in urban nursery schools: A case study of Seoul, Korea during winter months. *Building and Environment, 119*, 1-10.

Sá, J. P., Branco, P. T. B. S., Alvim-Ferraz, M. C. M., Martins, F. G., & Sousa, S. I. V. (2019). Children's exposure to indoor air in schools: Impact on wheezing. *WIT Transactions on Ecology and the Environment, 236*, 205-212.

Salleh, N. M., Kamaruzzaman, S. N., & Mahyuddin, N. (2013). Sick building symptoms among children in private preschools in Malaysia: Association of different ventilation strategies. *Journal of Building Performance, 4*(1), 73-81.

Salleh, N. M., Kamaruzzaman, S. N., Riley, M., Zawawi, E. M. A., & Sulaiman, R. (2015). A quantitative evaluation of indoor environmental quality in refurbished kindergarten buildings: A Malaysian case study. *Building and Environment, 94*-2, 723-733.

Salleh, N. M., Salim, N. A. A., & Kamaruzzaman, S. N. (2016a). Occupant expectations on the main IEQ factors at workspace: The studies of private preschool buildings. *MATEC Web of Conferences*, *66*, Article 00120.

Salleh, N. M., Esa, M., Kamaruzzaman, S. N., Mahyuddin, N., & Darus, F. M. (2016b). Barrier of ventilation modes to achieve a balance environment in refurbished preschools. *Jurnal Teknologi, 78*(5), 261-270.

Salleh, N. M., Salim, N. A. A., Kamaruzzaman, S. N., Mahyuddin, N., & Darus, F. M. (2016c). The prevelence of SBS and absenteeism among children in urban refurbished private preshools. *MATEC Web of Conferences*, *66*, Article 00119.

Sarijuddin, F. A., Saudi, A. S. M., Kamarudin, M. K. A., Isa, K. N. M., Mahmud, M., Azid, A., … Rizman, Z. I. (2017). Assement on level of indoor air quality at kindergartens in Ampang Jaya, Selangor, Malaysia. *Journal of Fundamental and Applied Sciences, 9*(4S), 801-811.

Stankovic, D., Tanic, M., Kostic, A., Vrecic, S., Kekovic, A., Cekic, N., … Vrecic, S. (2015). Resurgence of indoor environment of preschool building. *Procedia Engineering, 117*, 737-750.

UNESCO. (2015). Education 2030: Incheon Declaration and framework for action for the implementation of Sustainable Development Goal 4. Retrieved from https://iite.unesco.org/publications/education-2030-incheon-declaration-framework-action-towards-inclusive-equitable-quality-education-lifelong-learning/

United States Environmental Protection Agency. (2009). *Indoor air quality tools in schools: Reference guide.* Washington, DC: EPA. Retrieved from https://www.epa.gov/sites/default/files/2014-08/documents/reference_guide.pdf

United States Environmental Protection Agency. (2013). *America's children and the environment* (3rd ed.). Washington, DC: EPA. Retrieved from https://www.epa.gov/sites/default/files/2015-06/documents/ace3_2013.pdf

Vasile, V., Ion, M., & Dima, A. (2020). Indoor air pollutants, comfort parameters and their interactions in the context of sustainable development of the built environment. *IOP Conference Series: Earth and Environmental Science*, *588*, Article 032075.

Wesley, A. D., & Jalaludin, J. (2015). Indoor air pollutant exposure and eosinophil cationic protein as an upper airway inflammatory biomarker among preschool children. *Procedia Environmental Sciences, 30*, 297-302.

Zainudin, M. A., Jalaludin, J., & Sopian, N. A. (2019). Indoor air quality (IAQ) in preschools and its association with respiratory inflammation among pre-schoolers. *Malaysian Journal of Medicine and Health Sciences, 15*(SP4), 12-18.

Zairul, M. (2021a). A thematic review on Industrialised Building System (IBS) publications from 2015-2019: Analysis of patterns and trends for future studies of IBS in Malaysia. *Pertanika Journal of Social Sciences and Humanities, 29*(1), 635-652.

Zairul, M. (2021b). The recent trends on prefabricated buildings with circular economy (CE) approach. *Cleaner Engineering and Technology, 4*, Article 100239.