INTERNATIONAL JOURNAL OF INTEGRATED ENGINEERING
ISSN: 2229-838X e-ISSN: 2600-7916

IJIE

Vol. 17 No. 7 (2025) 247-262
https://publisher.uthm.edu.my/ojs/index.php/ijie

Perceived Indoor Air Quality and Sick Building Syndrome among Work-From-Home Workers Using Geospatial Approach

Norsaffarina Aziz[1], Mohammad Adam Adman[1]*, Nurud Suria Suhaimi[2], Syarifuddin Misbari[1], Lim Fang Lee[3], Md Mobarak Hossain Khan[4], Azrina Abd Aziz[1]

[1] *Faculty of Civil Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26300 Kuantan, Pahang, MALAYSIA*
[2] *Faculty of Industrial, Science & Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26300 Kuantan, Pahang, MALAYSIA*
[3] *Faculty of Engineering and Green Technology, Universiti Tunku Abdul Rahman, 31900 Kampar, Perak, MALAYSIA*
[4] *Faculty of Liberal Arts and Social Sciences, East-West University, Dhaka 1212, BANGLADESH*

*Corresponding Author: adamadman@umpsa.edu.my
DOI: https://doi.org/10.30880/ijie.2025.17.07.024

Article Info

Received: 19 February 2025
Accepted: 22 August 2025
Available online: 31 December 2025

Keywords

Perceived indoor air quality (PIAQ), sick building syndrome (SBS), climate, remote workers, geospatial

Abstract

This study aims to assess the associations between perceived indoor air quality (PIAQ) and several risk factors for sick building syndrome (SBS) among work-from-home (WFH) workers through appropriate statistical analyses. Using a geospatial approach, it also aims to identify the spatial correlation between PIAQ and SBS. The study was conducted among 131 WFH workers in Kuantan through a questionnaire survey. Multiple logistic regression was used to analyse the associations between the risk factors of PIAQ and SBS symptoms. The significant factors associated with the SBS symptoms were further analysed using a geospatial approach. The study found the prevalence of SBS by WFH workers in Kuantan was 75.6%. The most prevalent symptom reported was difficulty concentrating (42.7%), while nausea (9.2%) was the least prevalent symptom. There was no significant difference in SBS symptoms between genders. Findings showed associations between SBS symptoms and PIAQ climate factors, such as drought (3.28, 1.01-10.59) and dust (2.82, 1.01-7.87). The geospatial approach of this study illustrates a visual mapping of the hotspot of SBS symptoms and the correlation between the risk factors and SBS. These findings underscore the importance of addressing IAQ issues among WFH workers to mitigate the occurrence of SBS symptoms.

1. Introduction

Air pollution is one of the most severe environmental issues, particularly concerning respiratory health [1]. Indoor air pollution is often more severe than outdoor pollution. Believing that an individual is safe from dangerous pollutants at home is a misconception. Most people are unintentionally exposed to air pollutants as they spend 90% of their time indoors [2]. The term "perceived indoor air quality" (PIAQ) refers to how people feel about the

quality of the air they breathe indoors [3]. Environmental factors, such as temperature, relative humidity, and air movement, influence it. PIAQ may affect the occupants' productivity, comfort, and health. New furniture, painting activities, the use of electrical appliances, daily cleaning, and culinary activities are some things within a building that may produce indoor pollutants. Indoor health issues have gained global focus as remote work arrangements surged with the onset of the COVID-19 pandemic, driven by safety measures [4]. Improper ventilation and poor IAQ can make occupants of the buildings feel uncomfortable and raise common health concerns like SBS [5].

1.1 Sick Building Syndrome (SBS)

The term "SBS" describes situations in which occupants encounter health issues that appear to be related to the building's environment, but no specific illness or cause is identified [6]. One of the IAQ-related health problems that usually affects workers is SBS. According to the Department of Occupational Safety and Health Malaysia (DOSH), no specific medical tests or known causes can determine or confirm whether a person has SBS. It is a situation where a person has a variety of symptoms or overall discomfort but no identifiable diagnosis that describes these symptoms [7]. SBS symptoms are often divided into general, mucosal, and dermal symptoms. The most frequently reported symptoms are the general symptoms, including headaches and fatigue [8], [9]. The least reported were skin-related symptoms, including skin irritation and dryness, which are dermal symptoms. Meanwhile, mucosal symptoms include irritation or dryness of the eyes, nose and throat. Typically, SBS symptoms are transient and subside shortly after leaving the building. Based on the previous research, the studies of SBS and IAQ in home settings are limited compared to office settings [10]. More studies are needed to understand the factors that impact employee well-being and productivity in the home workplace.

SBS is progressively becoming a significant occupational hazard all over the globe. However, the prevalence of SBS in Malaysia still needs to be discovered. The prevalence of SBS in Malaysia is estimated to range from 18% to 80% among office workers [11]-[13]. However, the prevalence of SBS among remote workers in home settings has not been documented in Malaysia. There are limited studies of SBS in home settings, especially among WFH workers, compared to office settings. This may be due to the privacy of the workers and bureaucracy, which complicate the process. Although numerous studies have been conducted on SBS in home settings globally, they have not included WFH workers. Most of these studies focused on the occupants in their homes and those working in office settings.

The prevalence of SBS among house occupants varied from 26% to 80% globally [14]-[16]. A study in Indonesia reported that 60.2% respondents have SBS while WFH [17]. Given the evolving nature of remote work, it is essential to consider the implications of SBS symptoms on workers' productivity. Two studies compared SBS between WFH and work from the office. SBS symptoms were more frequent among home-based and office-based workers [18]. However, a study found that SBS occurrences were fewer among workers who worked from home than among those who worked in the office [19]. The differences underscore the need for further research to elucidate the environmental and occupational factors associated with SBS among WFH workers. There are challenges associated with remote work, including the need for clear boundaries between work and personal life, potential negative impacts on mental and physical health, and a preference for office-based work [20], [21]. Understanding these rights and benefits can help individuals make informed decisions about remote work arrangements. Therefore, this study addresses the possible implications of WFH on work-life balance concerning SBS.

1.2 Risk factors of SBS

The risk factors related to SBS are classified into three categories: sociodemographic characteristics (e.g., gender), working circumstances (e.g., cleanliness, psychological, appliances, prior symptoms), and indoor air environment (e.g., temperature, RH, air pollutants, ventilation). The possible risk factors contributing to SBS symptoms in home settings in Malaysia were unclear. Poor IAQ is a significant health concern, especially in developing countries. The COVID-19 outbreak has brought indoor health issues and symptoms to global attention as people spend their daily lives indoors [4]. People often unintentionally expose themselves to indoor pollutants, which can lead to health issues. Moreover, their work-life balance and productivity while working might be affected. IAQ is essential in safeguarding health. Therefore, it is crucial to understand that the quality of the air we breathe indoors has a direct impact on our well-being. Ensuring clean and healthy indoor air is essential to mitigate these health risks and promote a safe, comfortable living and working environment. SBS at home is just as critical as that in the workplace to ensure the productivity of the WFH workers. Conducive indoor air in the house is essential to ensure a productive work environment.

1.3 Geographic Information System (GIS)

The geographical information system (GIS) approach was used to identify the spatial correlation between PIAQ and SBS among WFH workers. GIS can gather, store, analyse, and show data and information based on an exact

location. This tool is helpful for disease surveillance, which involves collecting and observing information on disease occurrence, prevalence, and spread [22], [23]. The integration of GIS enables the investigation of spatial correlations between PIAQ and SBS among WFH workers. GIS is a valuable tool for supporting spatial decision-making in public health via utilising the most recent analytical techniques to address problems with healthcare planning [24]. The application and analysis of GIS for air quality assessment are highly beneficial for mapping and examining air contaminants, as well as for disease surveillance [25]-[27]. GIS technology can enhance the quality and efficiency of health research, as significant correlations between a community's health and its geographic location can be identified. However, there are a few related applications of using GIS in SBS and IAQ association, as noted in previous studies. GIS enables spatial representation of data to support better risk management planning and decision-making for public health.

Concerning these health issues, many companies have transitioned to working remotely from home and implementing flexible working arrangements to ensure business continuity and reduce costs since the beginning of the COVID-19 pandemic [28]. WFH has evolved into a solution that businesses can utilise to ensure flexibility and job stability, reduce expenses, and continue operations while maintaining social distancing and environmental initiatives [28]. Houses might not be an excellent workplace compared to office environments with better ventilation systems [29]. The IAQ of a house significantly impacts the occupants' health [30]. The assessment of the PIAQ and SBS at home is just as critical as that of the workplace to ensure the productivity of the WFH workers. However, with the shift to remote work, there is a significant gap in knowing the prevalence of SBS and risk factors among WFH workers through spatial analysis.

Therefore, this preliminary study aims to determine the relationship between SBS symptoms and PIAQ, as well as other factors, in home settings.

2. Methodology

A cross-sectional study was undertaken at Kuantan-based enterprises utilising WFH from November 2022 to February 2023. Kuantan is the state capital of Pahang, Malaysia. It is situated between latitude 3.8168° in the north and longitude 103.3317° in the east on the east coast of Peninsular Malaysia, facing the South China Sea. Kuantan was chosen as the study area because few studies have focused on SBS and PIAQ on the East Coast of Malaysia [11], [31].

The sampling frame included workers who worked from home, performed office duties, and used information and communication technologies at home. The respondents must fulfil the inclusion criteria, including being at least 18 years old, not pregnant, having been WFH during the past twelve months, having a WFH location located in Kuantan, utilising information and communication technologies while working and having the ability to understand Malay or English. The respondents need to cover the area for geospatial purposes to minimise bias in terms of location. About 700 employees in Kuantan were approached through company emails and face-to-face meetings. One hundred thirty-one WFH workers in Kuantan voluntarily participated in the study, resulting in a 19.1% response rate. A record from the Department of Statistics Malaysia in 2022 shows that there is 234,200 people work in Kuantan. The calculated sample size for the study was 384, based on a 95% confidence level and a 5% margin of error. The sample size was established using Raosoft software. The study achieved only 34% of the calculated sample size due to challenges in participant recruitment, budgetary constraints, and time limitations, which impacted the ability to reach the originally planned sample. However, efforts were made to ensure the analysis remained robust by using appropriate statistical methods to account for the smaller sample.

A set of self-administered questionnaires was adapted from the Swedish MM 040 NA Office and the Industrial Code of Practice-Indoor Air Quality (ICOP-IAQ) 2010 questionnaire to assess the symptoms of SBS and PIAQ problems while WFH. The self-administered MM 040 NA Office questionnaire is designed for an epidemiological assessment of SBS, indoor air and building-related issues globally [32]. Meanwhile, the ICOP-IAQ 2010 questionnaire has been used to identify potential sources of IAQ pollutants and health-related effects in Malaysia [7]. Many previous studies have used these validated standardised questionnaires to assess the relationship between SBS and PIAQ [12], [16], [33]. Questions that were repetitive and unnecessary questions were removed. The validated questionnaire used in this study contains 35 questions. The questionnaire provides clear and precise instructions. The questions were concise to maintain attention and accuracy throughout the survey. The survey also aims to gather information on demographics, workplace environment, health conditions, and the perception of IAQ from the workers' perspective, as well as SBS symptoms among building occupants. It examines the satisfaction, perception, and preferences for different work-from-home (WFH) environments. The blinding strategy was employed to decrease bias in the study by prohibiting respondents from understanding key aspects of the study. These blinding strategies serve to ensure that the research groups' subjective judgments, expectations, or prior information do not influence the results, increasing the validity of the findings.

The questionnaires were carefully designed for the survey, pre-tested, and emphasised participant anonymity and confidentiality. The questionnaire consists of several parts, namely: Part A, General Information (background information of the respondent); Part B, Nature of Occupation; Part C, Work Environment and PIAQ; and Part D,

Past/Present Symptoms (SBS symptoms). A total of ten questions were asked about the PIAQ, one of them to rate the comfort level of the indoor air quality on a 5-point Likert scale ranging from 1= 'Very bad' to 5= 'Very good'. Similarly, a total of 11 SBS symptoms were assessed, which were divided into three groups labelled as general (headache, feeling heavy-headed, fatigue, difficulty concentrating, and nausea), mucosal (cough, nose irritation, hoarse throat, and eye irritation), and dermal symptoms (skin dryness and skin rash). PIAQ and SBS have three alternative answers: 'Yes, often (every day)', 'Yes, sometimes (2-3 times weekly)', and 'No, never'. The two options: 'Yes, often (every day)' and 'Yes, sometimes (2-3 times weekly)' were merged and coded as 1, whereas 'No, never' answers were coded as 0 for statistical analysis [14], [34]. The respondents were classified as "SBS" if they reported at least one of the symptoms and indicated that the development of these symptoms was connected to their home environments [12], [16], [35].

The questionnaire used for this study has been tested for test-retest reliability in a pilot study. The pilot study was conducted among 51 WFH workers. The sampling frame of the pilot study is similar to the preliminary study. According to the pilot study, Cronbach's alpha values for the items ranged from 0.70 to 0.90, indicating that the reliability of the questions was exemplary. The Cronbach's alpha value for overall questions was 0.712, for questions related to SBS was 0.802, whereas the questions about PIAQ were 0.832. The questionnaire was distributed through face-to-face interviews and online via Google Forms through emails, social media, and personal contacts. Online surveying was favoured over self-administered questionnaires because it allowed respondents to access the survey via the company's website and their mobile phones. The reliability and validity of the PIAQ and SBS in the questionnaire were assessed using Cronbach's alpha test, which yielded values of 0.826 and 0.840, respectively. The values indicate adequate internal consistency of the given questionnaire, as they are above 0.70 [36].

SPSS statistical software for Windows (IBM SPSS Statistics, Version 27) was used as the data analysis tool. The data collected was cleaned up to ensure accuracy, consistency and readability for analysis. The data were reviewed to ensure no bias was introduced in the study's progression. The data from the questionnaire survey were checked for completeness by ensuring that all responses were complete and handling any blank answers. The data entries were double-checked for any duplicate responses or entries. Well-cleaned data provide an accurate basis for analysing and interpreting survey data. The descriptive data on demographics were analysed. Univariate analysis and the chi-square test were used to examine any associations between the two categorical variables. The Chi-square test was used to determine the association between gender and SBS symptoms, as well as between SBS and PIAQ comfort levels. The statistical test will be carried out at a 5% significance level. Multiple binary logistic regression models, adjusted for gender, were used to individually analyse the associations between the PIAQ and SBS symptoms. Any Odd Ratio (OR) lower than one will be transformed into an inversion value.

Google Earth Pro and QGIS Desktop 3.22.11 were used to map the distribution of SBS and PIAQ. The WFH locations were imported from the data spreadsheet into Google Earth Pro. In QGIS, the data were distributed and interpolated. Interpolation is an essential type of spatial analysis for estimating IAQ data [27], [37]-[39]. This study employed the Inverse Distance Weighted (IDW) interpolation method. IDW interpolation uses a linearly weighted combination of sample points to generate cell values. IDW assumes that every measured point has a local influence that decreases with distance [40]. IDW was chosen as the data interpolation method for this study due to its simplicity and ability to provide accurate spatial predictions. Furthermore, IDW has been widely employed in air quality studies due to its ability to forecast pollutant exposure levels [40]-[42]. The colours used in the spatial distribution of different PIAQ comfort levels were palleted with the colour ramp 'Reds'. The colour ranges from dark black red (very bad), dark red (bad), red (neutral), pinkish (good), to white (very good) in terms of PIAQ comfort levels. In this study, the PIAQ points based on the existing respondents will serve as the basis for the interpolation process, where locations with unknown PIAQ values in the entire Kuantan area will be assigned a value. The interpolation method applied creates a continuous function based on the variables. The PIAQ raster layer that resulted from the interpolation process was layered with SBS symptoms and other significant attributes (draught and dust). The ranges and the inter-relationship between the PIAQ and SBS were noted.

3. Results and Discussion

The study's findings are generated through statistical and geospatial analyses. Results of the statistical analyses (see Table 1 to Table 4) are presented. On the other hand, various maps of the geospatial analyses (see Fig. 1 to Fig. 3).

Table 1 shows the prevalence of SBS symptoms among the respondents. The proportion of respondents classified as 'having SBS' is 75.6%. The prevalence of the SBS symptoms answered 'Yes, often (every day)' and 'Yes, sometimes (2-3 times weekly) are shown in Table 2. The prevalence of general symptoms is 68.7%, mucosal symptoms is 46.6%, and dermal symptoms is 23.7%. The most prevalent symptom is difficulty concentrating, and it was agreed that the symptom was related to the home environment (42.7%). Meanwhile, the least prevalent symptom was nausea, which was agreed to be related to the home environment (9.2%).

Int. Journal of Integrated Engineering Vol. 17 No. 7 (2025) p. 247-262

In this study, the prevalence of SBS reported by WFH workers in Kuantan was 75.6%. This finding aligns with previous studies, which have reported SBS prevalence among house occupants to range from 26% to 80% [14]-[16]. In addition, a study reported that participants who worked from home reported more frequent SBS symptoms than those who worked from the office [18]. This may be due to the activities carried out by people at home, which could lead to increased indoor air pollution and other harmful health issues. The reported SBS symptoms in this study are consistent with those observed in previous studies. No specific studies focused on SBS among WFH workers.

Table 1 *Prevalence of SBS among WFH workers in Kuantan (N=131)*

SBS Symptoms	Number of WFH workers reported to have the symptoms, n (%)
General[a]	90 (68.7)
Headache	55 (42.0)
Dizziness	51 (38.9)
Fatigue	54 (41.2)
Difficulty in concentrating	56 (42.7)
Nausea	12 (9.2)
Mucosal[b]	61 (46.6)
Cough	37 (28.2)
Nose Irritation	37 (28.2)
Hoarse throat	33 (25.2)
Eyes Irritation	30 (22.9)
Skin[c]	31 (23.7)
Dry Skin	24 (18.3)
Skin rash	24 (18.3)
SBS[d]	99 (75.6)

[a]At least one general symptom (headache, dizziness, fatigue, difficulty concentrating, nausea)
[b]At least one mucosal symptom (cough, nose irritation, hoarse throat, eye irritation)
[c]At least one dermal symptom (dry skin, skin rash, scaling scalp)
[d]At least one symptom (General or mucosal, or skin symptom)

The most frequent symptoms are general symptoms, including difficulty concentrating (42.7%), headache (42.0%), and fatigue (41.2%). The prevalence of the general symptom in this study is supported by several studies that reported the same result [12], [14], [43], [44]. Studies conducted among office workers have reported that headache, fatigue, difficulty concentrating or breathing, feeling sleepy, and chest tightness are also common symptoms [44]-[46]. Another study reported that headaches and tiredness are the most prevalent symptoms of SBS [47]. This can be supported by several studies indicating that dermal symptoms were uncommon and rare in both the office and at home [12], [35], [48]. Skin-related symptoms are the least reported symptoms because they are often difficult to notice and may seem unrelated to the work environment. Based on the prevalence of SBS symptoms and the p-value of Chi-Square analysis, gender did not show a correlation with any of the symptoms (Table 2). This study identified several significant individual and environmental risk factors associated with SBS. The bivariate analysis showed no significant association between gender and SBS symptoms. This finding aligns with previous studies that reported no significant associations between gender and SBS symptoms [44], [49]. Both males and females experience SBS in a similar manner. However, some previous studies mentioned that SBS symptoms were more likely to affect women than men [43], [45], [50].

Table 2 *Prevalence and the association between gender and SBS among WFH workers (N=131)*

SBS Symptoms	Male n=44	Female n= 87	Total N=131	p-value
Headache	16	39	55	0.354
Dizziness	14	37	51	0.235
Fatigue	15	39	54	0.238
Difficulty in concentrating	17	39	56	0.499
Nausea	7	5	12	0.057
Cough	14	23	37	0.518
Nose Irritation	14	23	37	0.518
Hoarse throat	12	21	33	0.696
Eyes Irritation	14	16	30	0.084
Dry skin	5	15	20	0.377
Skin rash	10	14	24	0.354

The problems with the working environment of WFH workers (PIAQ) are shown in Table 3. The most frequently reported problems are varying room temperature (71.8%), followed by high room temperature (66.4%), and dust (61.85%). The least reported problem is passive smoking (25.2%).

Table 3 *PIAQ on Working Environment at Home (N=131)*

Working Environment (Have you been bothered by the following factors at your workstation while working from home?)	n (%)
Draught	72 (55.0)
High room temperature	87 (66.4)
Varying room temperature	94 (71.8)
Low room temperature	58 (44.3)
Stuffy air	63 (48.1)
Dry air	68 (51.9)
Unpleasant odour	57 (43.5)
Passive smoking	33 (25.2)
Dust	81 (61.8)

Multiple binary logistic regression analyses were conducted, adjusting for gender, to determine the PIAQ risk factors associated with SBS symptoms. Table 4 displays the adjusted Odds Ratio (OR) and 95% Confidence Interval (95% CI) for each symptom of SBS, along with the p-values from the multiple binary logistic regression. The ORs indicate the odds of developing SBS. The significant PIAQ risk factor of the general symptoms (headache, dizziness, fatigue, difficulty concentrating, nausea) is dust. Mucosal symptoms (nose irritation, hoarse throat, eye irritation) have no significant association with any PIAQ risk factors.

Meanwhile, skin symptoms (dry skin, skin rash) are significantly associated with dry air. SBS symptoms are significantly associated with draught and dust. Based on SBS symptoms, the respondents who faced draught and dust problems were 3.28 (95% CI: 1.007-10.594) and 2.82 (95% CI: 1.012-7.873) times more likely to be at risk of SBS symptoms.

Int. Journal of Integrated Engineering Vol. 17 No. 7 (2025) p. 247-262

Table 4 *Multiple binary logistic regression to identify risk factors of SBS with PIAQ among WFH workers (N=131)*

Working Environment (PIAQ)	General symptoms	Mucosal symptoms	Skin Symptoms	SBS symptoms
Draught	2.65(0.89-7.85)	1.24(0.49-3.08)	0.84(0.28-2.49)	3.28(1.01-10.59)*
High room temperature	1.82(0.56-5.94)	1.01(0.34-2.98)	1.64(0.36-7.41)	1.74(0.49-6.25)
Varying room temperature	0.89(0.31-2.58)	1.12(0.42-2.94)	0.98(0.26-3.73)	1.07(0.35-3.26)
Low room temperature	1.42(0.49-4.09)	1.49(0.61-3.68)	1.69(0.58-4.94)	0.87(0.27-2.83)
Stuffy air	0.66(0.20-2.19)	0.83(0.29-2.31)	0.71(0.20-2.45)	0.44(0.12-1.61)
Dry air	1.49(0.47-4.71)	1.24(0.46-3.37)	4.17(1.18-14.78)*	1.67(0.48-5.85)
Unpleasant odour	0.68(0.20-2.31)	1.21(0.44-3.31)	0.58(0.17-1.90)	0.86(0.22-3.28)
Passive smoking	0.32(0.10-1.03)	0.79(0.30-2.12)	0.73(0.24-2.27)	0.32(0.09-1.13)
Dust	2.78(1.07-7.21)*	1.14(0.49-2.62)	2.14(0.68-6.77)	2.82(1.01-7.87)*

Odd Ratio (95% CI)

The multiple binary logistic regression analysis on each symptom revealed that dust is a significant risk factor for the general symptoms (headache, dizziness, fatigue, difficulty concentrating, nausea) in the PIAQ. Mucosal symptoms (nose irritation, hoarse throat, eye irritation) are not significantly associated with PIAQ risk factors. Meanwhile, skin symptoms (dry skin, skin rash) are significantly associated with dry air. Based on previous studies, SBS can be influenced by inadequate ventilation, varying room temperatures, exposure to cold or dry conditions, or excessive air conditioning circulation [51]. A study revealed that the primary SBS concerns expressed by females were related to noise, fluctuating room temperature, dry air, and dust [45]. Ventilation plays a crucial role in the well-being of building occupants [52]. It contributes to maintaining adequate indoor air quality, diluting indoor pollutants, and promoting a healthy environment. The lack of proper air circulation and ventilation led to a build-up of contaminants, contributing to SBS. Ventilation with outside air has a significant impact on human exposure to indoor pollutants. Poor air exchange can prevent unclean air in the room from being replenished, leading to symptoms [53]. This can be supported by numerous studies that have reported lower ventilation rates can exacerbate health problems, particularly symptoms of SBS [44], [54], [55].

Statistical analysis identified that draught and dust were some risk factors associated with the SBS symptoms. A study mentioned that the SBS was linked to drafts from the air conditioner, which were related to thermal comfort [56]. According to a study, a significant predictor of satisfaction with air quality was the temperature [57]. A study found that complaints of varying room temperatures were less frequent with increased air exchange rates [22]. The study emphasises the importance of self-control, maintaining a suitable room temperature, and ensuring adequate ventilation in the home workspace. However, the temperature was not a significant risk factor in this study. The perception of poor air quality at home and in the workplace can be associated with symptoms at both locations [58]. A study mentioned that the home environment contributes about 96% of the average health risk [50]. Therefore, ensuring the building or house has good ventilation is essential. Air quality satisfaction can be improved if access to a window can be opened [59].

The prevalence of SBS symptoms, based on PIAQ comfort levels, is portrayed in Fig. 1. Most respondents who perceived good IAQ in the work environment reported experiencing SBS (36.6%). Respondents who perceived bad IAQ in the work environment reported having SBS (1.5%). Meanwhile, people who perceived bad IAQ in the work environment reported no SBS (0.8%). The PIAQ comfort levels and SBS do show a clear trend. Hence, there is no association between the variables.

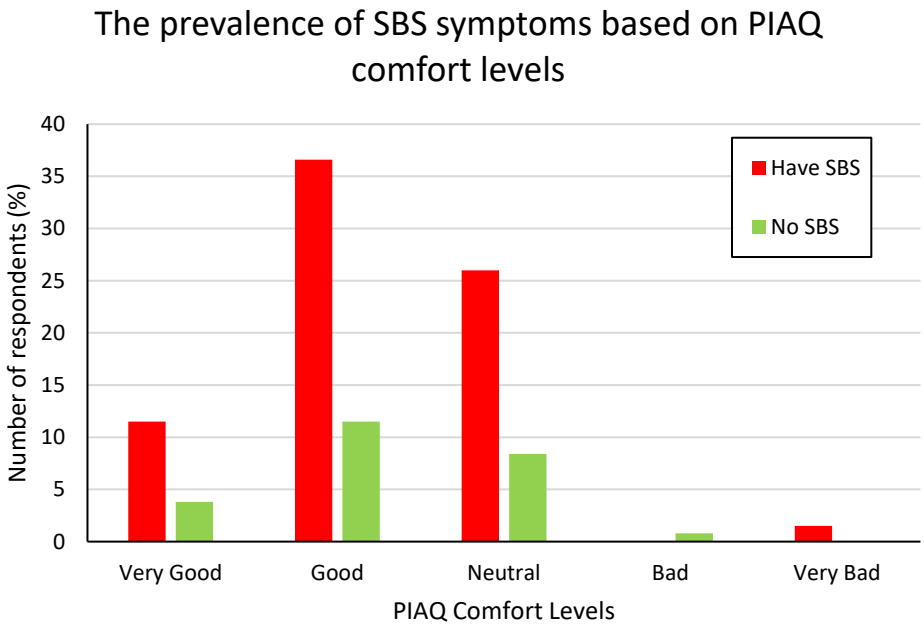

Fig. 1 *The prevalence of SBS symptoms was based on the PIAQ comfort levels reported by respondents in Kuantan (N = 131)*

SBS symptoms were further analysed using the geospatial approach (GIS) to determine the spatial correlation. Fig. 2 illustrates Kuantan's distribution mapping of SBS among respondents. The figure shows the respondents with SBS (red) and without SBS (green) while WFH. Most respondents reported SBS while WFH (75.6%). The percentage and distribution of the respondents' PIAQ comfort levels (ranging from 'very bad' to 'very good') based on their WFH location are presented in Fig. 3. It ranges between 'Very bad' (red), 'Bad' (orange), 'Neutral' (yellow), 'Good' (green) and 'Very good' (blue). Most respondents reported a 'Good' (48.1%) comfort level of PIAQ.

A geographical association between PIAQ comfort levels and SBS symptoms is depicted in Fig. 4. For the respondents with SBS symptoms while WFH, the locations have IDW interpolation values ranging between 1.84 and 4.82. Whereas, for the respondents who did not have problems with SBS while WFH, the locations have IDW interpolation values ranging between (2.03-4.99). The values show a similar range among respondents with SBS and without SBS. The values that do not overlap show a positive correlation between the PIAQ risk factor and SBS, where the red points (having SBS) are located in a dark red area (very bad PIAQ comfort levels). Some green points (no SBS) are in the white area (very good PIAQ comfort levels). These points visually show a positive correlation between SBS symptoms and spatial interpolation of PIAQ.

Int. Journal of Integrated Engineering Vol. 17 No. 7 (2025) p. 247-262

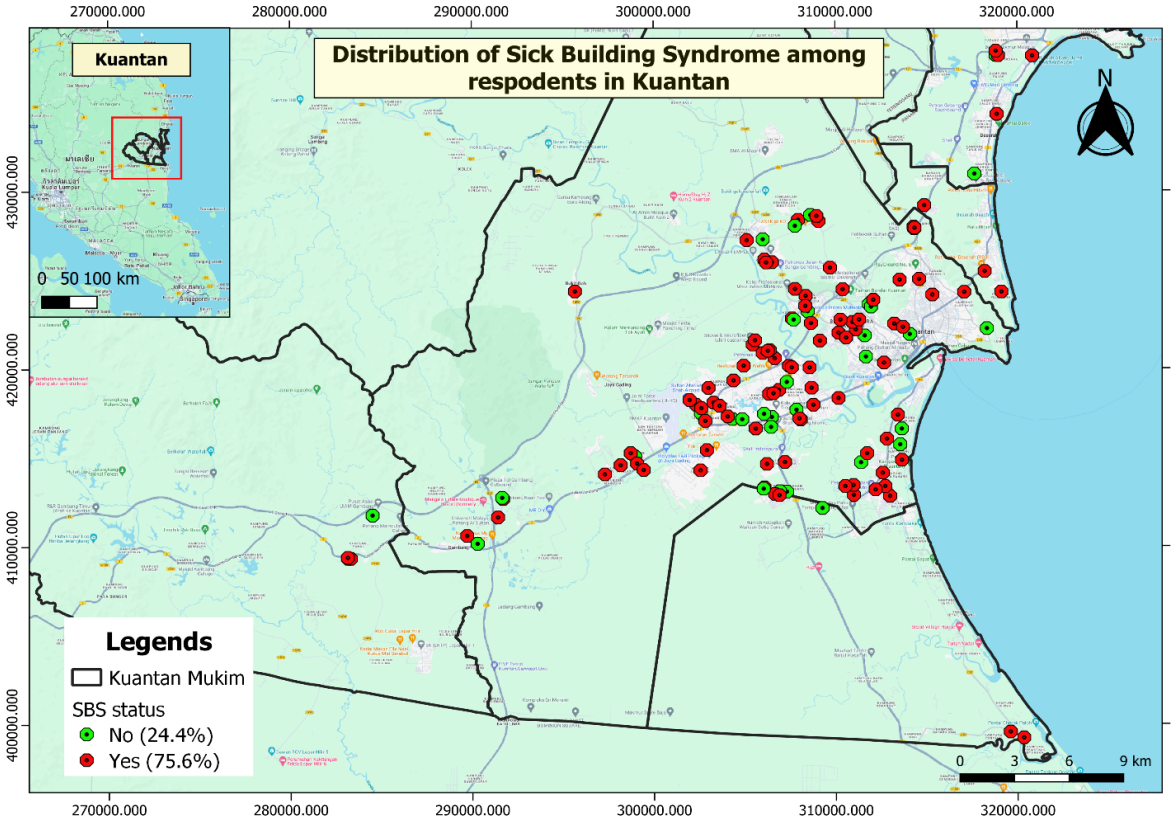

Fig. 2 *Distribution mapping of SBS in Kuantan*

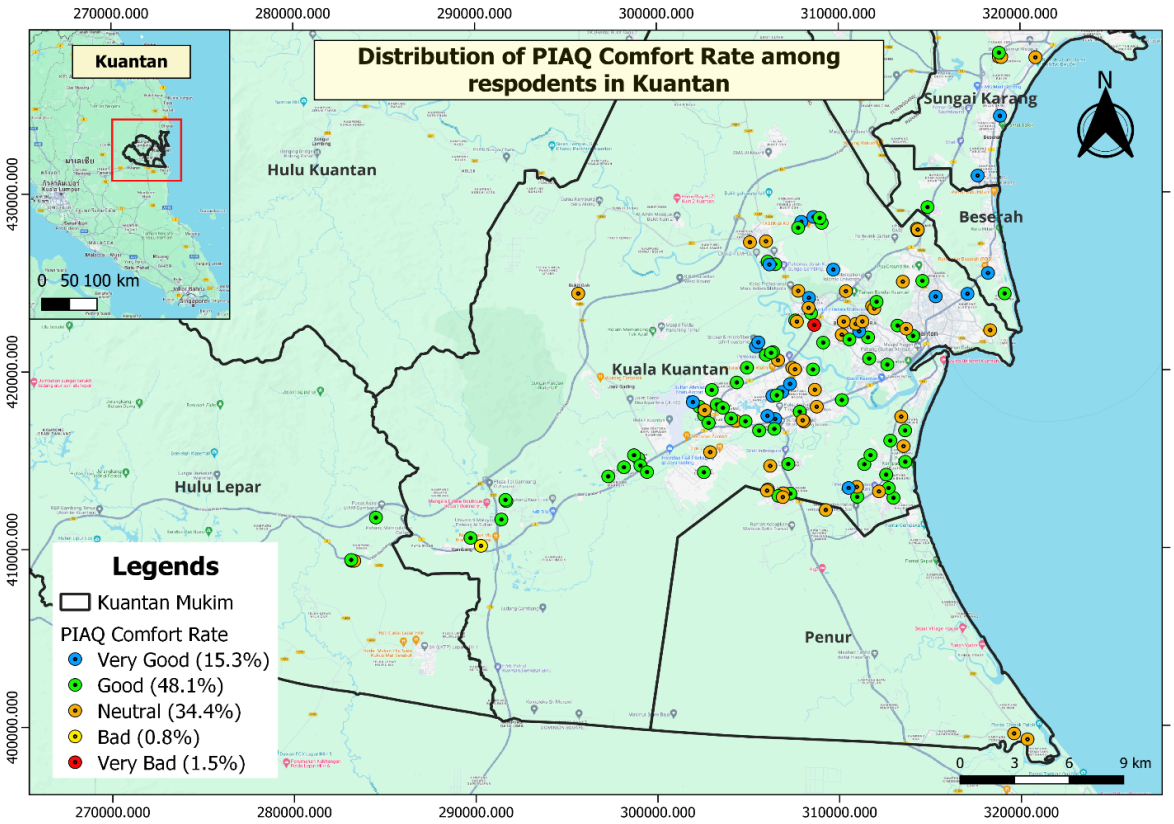

Fig. 3 *Distribution mapping of PIAQ comfort levels in Kuantan*

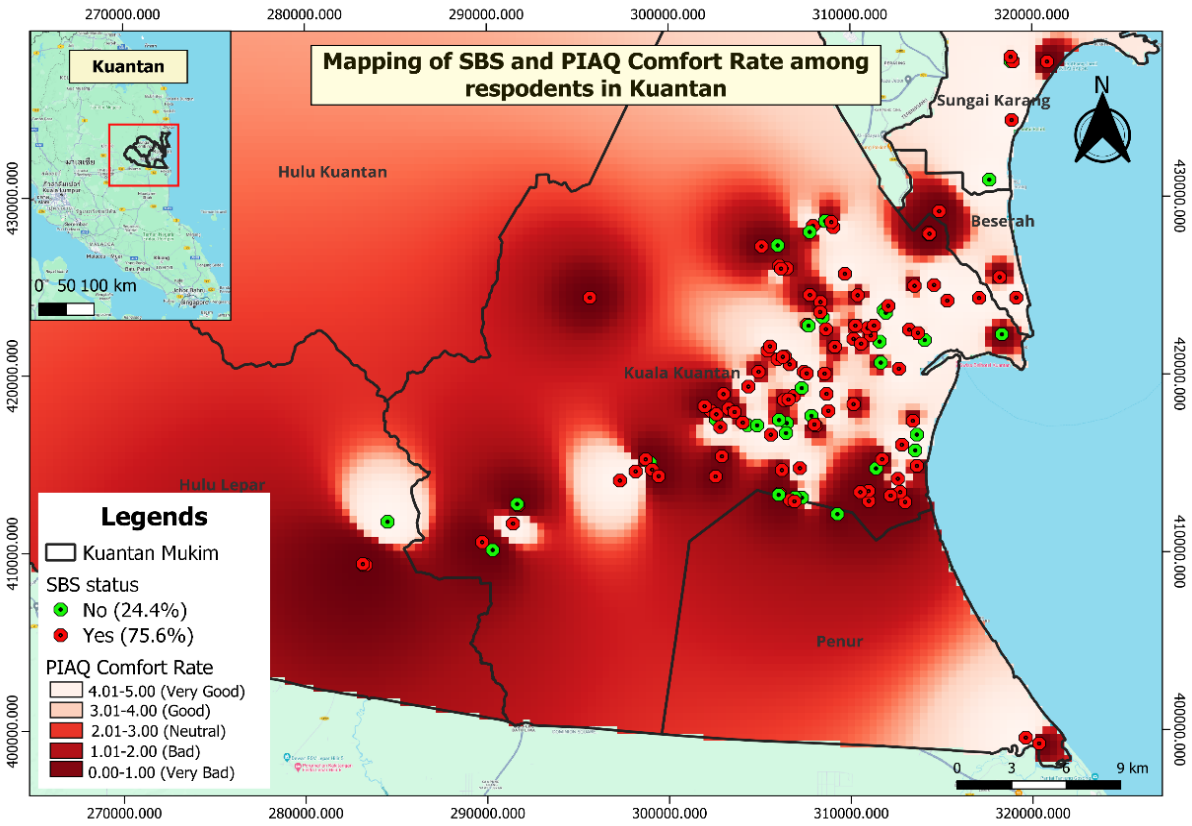

Fig. 4 *Mapping of SBS and PIAQ comfort levels among respondents in Kuantan*

The geospatial approach of this study provides a visual mapping of the hotspot of SBS symptoms and the correlation between the risk factors and SBS. The distribution mapping suggests it is possible to determine the hotspot of the SBS symptoms and the area affected by poor IAQ. It explains the spatial relationship between IAQ comfort level and SBS among WFH workers in Kuantan. Enhancing IAQ comfort levels is an essential strategy for mitigating SBS symptoms, with temperature regulation and ventilation emerging as crucial factors. The distribution mapping will provide data to the stakeholders regarding health issues such as SBS while WFH in Kuantan. The IAQ comfort level attribute was interpolated using IDW interpolation. The outcome is shown as the background on the Kuantan map layout in Fig. 4. Interpolation is the process of approximating the value of a variable at locations where it has not been directly measured using known values from surrounding sample points. The interpolation method applied creates a continuous function based on the variables. The interpolation estimates the IAQ comfort level values for the Kuantan area based on 131 points, ranging from 1.84 to 4.99. The interpolation colour ramp used is 'Reds'. The colour ranges from dark black red (very bad), dark red (bad), red (neutral), pinkish (good), to white (very good) in terms of PIAQ comfort levels. The figures are layered with other attributes to see the spatial correlation. Based on Fig. 4, it can be concluded that some points exhibit spatial correlation, while others do not appear to be spatially correlated visually. Respondents who reported having SBS were mostly located in the bad PIAQ comfort levels area, while respondents who reported no SBS were located in the good PIAQ comfort levels area. The interpolation revealed that respondents residing in green areas, such as Sakellaris, exhibited poor PIAQ comfort levels. Meanwhile, less vegetated or industrial areas in Kuala Kuantan are shown to have good PIAQ comfort levels. A significant association exists between PIAQ comfort levels and SBS status, with a p-value less than 0.001. A study found that poor perceived indoor air quality is associated with a higher risk of SBS symptoms [8], [10].

The absence of an apparent correlation between the findings and SBS symptoms could be due to several factors. SBS is a complex phenomenon. The complicated interaction between individual sensitivities, indoor air quality, and ventilation effectiveness gives rise to this complex condition. While some people may be more vulnerable to specific triggers, the result may be improved with more respondents and by examining other environmental and behavioural factors. On the other hand, the data used in the analysis are solely based on the questionnaire survey. Self-examination does not portray accuracy. Hence, the geospatial approach in this study visually illustrates the correlation between the SBS and the risk factors concerning the respondents' locations. GIS is crucial in linking geography and information technology to visualise data analysis. The GIS mapping helps visualise the PIAQ and SBS in the Kuantan area.

Int. Journal of Integrated Engineering Vol. 17 No. 7 (2025) p. 247-262

The scope of our research has several limitations. This study could not be generalised to the Kuantan area due to the small sample size. The small sample size may have reduced statistical power, making it more difficult to detect true effects and limiting generalizability to a broader population. It only portrayed respondents of this preliminary study who have experienced WFH. While the sample size may be insufficient, the study can still provide valuable insights into work-from-home practices and offer a perspective for future research. The data and attributes for this study were taken from the questionnaire only, and recall biases may result from using self-reported surveys to evaluate the health outcome of the workers and the PIAQ of the working environment at home. Recall bias can be a significant concern when data is obtained using self-reported questionnaires, as it relies on participants' ability to accurately remember and report previous events, behaviours, or exposures. Respondents may underreport or overreport certain behaviours because of faulty memory or changes in their lifestyle since the time of the event. Finally, this study only focuses on PIAQ factors. Other behavioural aspects may impact the SBS symptoms. The respondents' health may affect their comfort and response. A study mentioned that a combination of allergies is a risk factor for SBS [60]. Specific symptoms, such as headaches or dry eyes, may be attributed to the increased screen time from telework. A study suggested that more sedentary habits and less exercise may increase the likelihood of adverse health effects [61]. The limitations mentioned above should be considered when conducting additional large-scale experiments.

The outcomes show that the PIAQ in the working environment has a significant relationship with the SBS symptoms. A study also mentioned that IAQ in the house affects SBS symptoms [62]. Employers can provide IAQ awareness training to WFH workers on creating and maintaining good IAQ at home to improve their health and productivity. The widespread adoption of remote work, particularly during events like the COVID-19 pandemic, has underscored the crucial importance of IAQ in home environments. Prolonged periods of working from home place an increased emphasis on maintaining good indoor air quality in residential spaces, where people spend most of their time.

WFH is necessary to allow workers to open up more work opportunities for people with barriers to working in an office environment and decrease the commute. While working from home is essential, ensuring the workspace is comfortable for staff members is crucial. Research has indicated that telecommuting might yield favourable and unfavourable consequences for workers' productivity and welfare. WFH policies benefit worker performance if they are correctly followed, reasonable workloads are met, and appropriate workspace and equipment are provided [63]. However, WFH can negatively affect an employee's well-being and productivity if an unsuitable workspace is used for working at home [64]. In the WFH paradigm, regulating working conditions, managing occupational stress, and providing a healthy home environment all contribute to enhanced productivity and well-being [65].

Businesses should focus on aspects of the remote work environment that enhance employees' psychological well-being and adjust their policies on work-from-home arrangements accordingly [66]. The authority and the employer play a crucial role in ensuring the well-being of WFH workers. According to Section 15(1) of the Occupational Safety and Health Act 1994, (Laws of Malaysia Act 514) [67], employers and self-employed individuals are obligated to ensure the safety, health, and welfare of their employees as much as is reasonably practicable. The Amended OSHA extends to all places of work throughout Malaysia, including the public services and statutory authorities [68]. The well-being of employees remains paramount for ensuring sustained productivity, even within the home setting. Additionally, employers can encourage regular IAQ monitoring, provide resources for creating healthy home office setups, and incorporate IAQ-related questions into well-being surveys to gather feedback. By taking these steps, employers can enhance the health, productivity, and well-being of their remote workforce, demonstrating a commitment to long-term employee satisfaction and performance.

The study emphasises the significance of IAQ in mitigating the risk of SBS. However, it also suggests a lack of comprehensive research on how specific PIAQ factors impact SBS development, particularly in occupational settings like WFH environments. This highlights a critical gap in research regarding SBS prevalence, specifically among WFH workers and in-home settings. Understanding the prevalence and associated factors in these contexts is essential for mitigating health risks and improving work conditions among WFH workers. Despite the potential of GIS in health research, its application in studying associations between SBS and IAQ appears to be underexplored. This study signifies a gap in utilising spatial analysis tools to understand the geographical distribution of SBS cases and their relationship with PIAQ. Addressing these gaps would enhance our understanding of SBS and its associated factors, facilitating the development of effective strategies to promote healthy indoor environments, particularly in remote work settings.

4. Conclusion

In conclusion, this preliminary study assessed the workplace PIAQ and SBS symptoms among WFH workers in Kuantan, providing insights into a previously understudied area. The prevalence of SBS reported by WFH workers in Kuantan was 75.6%. The most common SBS symptoms reported among WFH workers were general symptoms: headache, fatigue, and difficulty concentrating. These weekly reported symptoms could result in discomfort for

the workers and influence their work efficiency while working from home. The study underscores the importance of addressing environmental factors to enhance their well-being and productivity. The significant PIAQ risk factors for general symptoms include high room temperature, low room temperature, noise, and light. Mucosal symptoms are closely linked to high room temperatures, varying room temperatures, stuffy air, odours, dust, and IAQ comfort levels. On the other hand, skin symptoms are significantly related to draught, low room temperature, stuffy air and IAQ comfort level. Utilising GIS, the mapping offers valuable insights into the SBS symptoms hotspot, IAQ comfort level and spatial correlations, paving the way for targeted interventions.

In practical terms, this study emphasises the importance of taking immediate action to enhance IAQ for remote workers, thereby reducing SBS symptoms. Employers should take the initiative to create healthier and more productive work environments by encouraging the use of air purifiers, improving ventilation, and maintaining a clean office space. This aligns with Sustainable Development Goal 8, focusing on labour rights and safe workplaces. The findings not only support the well-being of remote workers but also provide valuable insights for stakeholders, including government and non-government organisations, to develop policies and review work-from-home practices. Future research could explore the long-term impacts of IAQ improvements on worker health and productivity among WFH workers.

Acknowledgement

The authors thank Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA) for providing the Fundamental Research Grant UMPSA (RDU210356) to conduct this study. We also thank the Malaysia Geospatial Data Infrastructure (MyGDI) and Kuantan City Hall, Pahang, for the GIS database.

Conflict of Interest

The authors declare that they have no conflict of interest regarding the publication of this paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***Conceptualisation, methodology, supervision, project administration, and funding acquisition:*** *Mohammad Adam Adman;* ***Analysis and data curation, and writing:*** *Norsaffarina Aziz, Lim Fang Lee;* ***Investigation:*** *Nurud Suria Suhaimi, Md Mobarak Hossain Khan;* ***Data curation and visualisation****: Syarifuddin Misbari; and* ***Manuscript review:*** *Azrina Abd Aziz.*

References

[1] Adman, M. A., Hashim, J. H., Manaf, M. R. A., & Norback, D. (2020). Associations between air pollutants and peak expiratory flow and fractional exhaled nitric oxide in students. The International Journal of Tuberculosis and Lung Disease, 24 (2), 189–195. https://doi.org/10.5588/ijtld.19.0096

[2] Amouei, A., Aghalari, Z., Zarei, A., Afsharnia, M., Geraili, Z., & Qasemi, M. (2019). Evaluating the relationships between air pollution and environmental parameters with sick building syndrome in schools of Northern Iran. Indoor and Built Environment. https://doi.org/10.1177/1420326X19842302

[3] Liu, J., Yang, X., Meng, X., & Liu, Y. (2018). Effects of indoor temperature and air movement on perceived air quality in the natural ventilated classrooms. International High Performance Buildings Conference. https://docs.lib.purdue.edu/ihpbc/275

[4] Cheng, Z., Lei, N., Bu, Z., Sun, H., Li, B., & Lin, B. (2022). Investigations of indoor air quality for office buildings in different climate zones of China by subjective survey and field measurement. Building and Environment. https://doi.org/10.1016/j.buildenv.2022.108899

[5] Shajahan, A., Culp, C. H., & Williamson, B. (2019). Effects of indoor environmental parameters related to building heating, ventilation, and air conditioning systems on patients' medical outcomes: A review of scientific research on hospital buildings. Indoor Air. https://doi.org/10.1111/ina.12531

[6] Burge, P. S. (2004). Sick building syndrome. Occupational and Environmental Medicine. https://doi.org/10.1136/oem.2003.008813

[7] Department of Occupational Safety and Health (2010). Industry Code of Practice on Indoor Air Quality. Ministry of Human Resources Department of Occupational Safety and Health: Putrajaya, Malaysia.

[8] Afrina, N., Aziz, M., Adman, M. A., Aziz, N., & Misbari, S. (2023). Distribution mapping of house type, house age and sick building syndrome among work-from-home workers by using a GIS-based approach. MAEH Journal of Environmental Health, 5, 16-18.

[9] Reuben, U., Ismail, A. F., Ahmad, A. L., Maina, H. M., & Daud, A. (2019). Indoor air quality and sick building syndrome among Nigerian laboratory university workers. Journal of Physical Science. https://doi.org/10.21315/jps2019.30.1.13

[10] Aziz, N., Adman, M. A., Suhaimi, N. S., Misbari, S., Alias, A. R., Aziz, A. A., Lee, L. F., & Khan, M. M. H. (2023). Indoor air quality (IAQ) and related risk factors for sick building syndrome (SBS) at the office and home: A systematic review. IOP Conference Series: Earth and Environmental Science. https://doi.org/10.1088/1755-1315/1140/1/012007

[11] Alwi, N. S., Hassim, M. H., & Hamzah, N. A. (2021). Indoor air quality and sick building syndrome among garment manufacturing workers in Kota Bharu, Kelantan. Malaysian Journal of Medicine and Health Sciences, 17, 51–58.

[12] Zainal, Z. A., Hashim, Z., Jalaludin, J., Lee, L. F., & Hashim, J. H. (2019). Sick building syndrome among office workers in relation to office environment and indoor air pollutant at an academic institution, Malaysia. Malaysian Journal of Medicine and Health Sciences, 15, 126–134.

[13] Zubir, N., Jalaludin, J., & Rasdi, I. (2022). Indoor air quality and psychosocial factors related to sick building syndrome among office workers in new and old buildings of a public university in Klang Valley, Malaysia. Malaysian Journal of Medicine & Health Sciences, 18, 1–9.

[14] Hou, J., Sun, Y., Dai, X., Liu, J., Shen, X., Tan, H., Yin, H., Huang, K., Gao, Y., Lai, D., Hong, W., Zhai, X., Norbäck, D., & Chen, Q. (2021). Associations of indoor carbon dioxide concentrations, air temperature, and humidity with perceived air quality and sick building syndrome symptoms in Chinese homes. Indoor Air. https://doi.org/10.1111/ina.12810

[15] Mentese, S., Mirici, N. A., Elbir, T., Palaz, E., Mumcuoğlu, D. T., Cotuker, O., Bakar, C., Oymak, S., & Otkun, M. T. (2020). A long-term multi-parametric monitoring study: Indoor air quality (IAQ) and the sources of the pollutants, prevalence of sick building syndrome (SBS) symptoms, and respiratory health indicators. Atmospheric Pollution Research. https://doi.org/10.1016/j.apr.2020.07.016

[16] Suzuki, N., Nakayama, Y., Nakaoka, H., Takaguchi, K., Tsumura, K., Hanazato, M., Hayashi, T., & Mori, C. (2021). Risk factors for the onset of sick building syndrome: A cross-sectional survey of housing and health in Japan. Building and Environment. https://doi.org/10.1016/j.buildenv.2021.107976

[17] Indah, F. P. S., Ratnaningtyas, T. O., Haifah, D. N., Pratiwi, R. D., & Ismaya, N. A. (2021). Symptom of sick building syndrom at employees who work by online during pandemic Covid 19. Proceeding of the 1st International Conference on Research in Social Sciences and Humanities (ICoRSH 2020), Advances in Social Science, Education and Humanities Research. https://doi.org/10.2991/assehr.k.211102.101

[18] Roh, T., Moreno-Rangel, A., Baek, J., Obeng, A., Hasan, N. T., & Carrillo, G. (2021). Indoor air quality and health outcomes in employees working from home during the Covid-19 pandemic: A pilot study. Atmosphere. https://doi.org/10.3390/atmos12121665

[19] Guo, X., & Chen, Y. (2020). Evaluation of occupant comfort and health in indoor home-based work and study environment. HCI International 2020 – Late Breaking Papers: Digital Human Modeling and Ergonomics, Mobility and Intelligent Environments, HCII 2020, Lecture Notes in Computer Science. https://doi.org/10.1007/978-3-030-59987-4_34

[20] Debnath, T. (2023). Work-from-home provides benefits to family and workplace that impact on job satisfaction: An evidence from Bangladesh. American Journal of Interdisciplinary Research and Innovation. https://doi.org/10.54536/ajiri.v1i3.1118

[21] Pullokaran, L. J., & Paulachan, K. J (2023). Working remotely: Employees benefits and challenges. International Journal of Engineering Technology and Management Sciences. https://doi.org/10.46647/ijetms.2023.v07i01.007

[22] Saran, S., Singh, P., Kumar, V., & Chauhan, P. (2020). Review of geospatial technology for infectious disease surveillance: Use case on COVID-19. Journal of the Indian Society of Remote Sensing. https://doi.org/10.1007/s12524-020-01140-5

[23] Shaw, N. T., & Mcguire, S. K. (2017). Understanding the use of geographical information systems (GISs) in health informatics research: A review. Innovation in Health Informatics. https://doi.org/10.14236/jhi.v24i2.940

[24] Khashoggi, B. F., & Murad, A. (2020). Issues of healthcare planning and GIS: A review. ISPRS International Journal of Geo-Information. https://doi.org/10.3390/ijgi9060352

[25] Baliga, B. S., Jain, A., Koduvattat, N., Kumar, B. G. P., Kumar, M., Kumar, A., & Ghosh, S. K. (2019). Indigenously developed digital handheld android-based Geographic Information System (GIS)-tagged tablets (TABs) in malaria elimination programme in Mangaluru city, Karnataka, India. Malaria Journal. https://doi.org/10.1186/ s12936-019-3080-8

[26] Brissette, I., Casper, M., Huston, S. L., Jordan, M., Karns, B., Kippes, C., Kramer, M. R., Peacock, J. M., & Vaughan, A. S. (2019). Application of geographic information systems to address chronic disease priorities: Experiences in state and local health departments. Preventing Chronic Disease. https://doi.org/10.5888/pcd16.180674

[27] Hsu, S., Mavrogianni, A., & Hamilton, I. (2017). Comparing spatial interpolation techniques of local urban temperature for heat-related health risk estimation in a subtropical city. Procedia Engineering. https://doi.org/10.1016/j.proeng.2017.07.091

[28] Vyas, L., & Butakhieo, N. (2021). The impact of working from home during COVID-19 on work and life domains: an exploratory study on Hong Kong. Policy Design and Practice. https://doi.org/10.1080/ 25741292.2020.1863560

[29] Pietrogrande, M.C., Casari, L., Demaria, G. & Russo, M., (2021). Indoor air quality in domestic environments during periods close to Italian Covid-19 lockdown. International Journal of Environmental Research and Public Health. https://doi.org/10.3390/ijerph18084060

[30] Baker, E., Lester, L. H., Bentley, R., & Beer, A. (2016). Poor housing quality: Prevalence and health effects. Journal of Prevention & Intervention in the Community. https://doi.org/10.1080/10852352.2016.1197714

[31] 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, 2017, 94–105.

[32] Andersson, K., Fagerlund, I., & Aslaksen, W. (2008). The perceived indoor climate in Swedish schools. Indoor Air, 17–22.

[33] Akova, İ., Kiliç, E., Sümer, H., & Keklikçi, T. (2020). Prevalence of sick building syndrome in hospital staff and its relationship with indoor environmental quality. International Journal of Environmental Health Research. https://doi.org/10.1080/09603123.2020.1862067

[34] Wang, J., & Norbäck, D. (2022). Subjective indoor air quality and thermal comfort among adults in relation to inspected and measured indoor environment factors in single-family houses in Sweden-the BETSI study. Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2021.149804

[35] Huo, X., Sun, Y., Hou, J., Wang, P., Kong, X., Zhang, Q., & Sundell, J. (2020). Sick building syndrome symptoms among young parents in Chinese homes. Building and Environment. https://doi.org/10.1016/ j.buildenv.2019.106283

[36] Aithal, A., & Aithal, P. S. (2020). Development and validation of survey questionnaire & experimental data – a systematical review-based statistical approach. International Journal of Management, Technology, and Social Sciences. https://doi.org/10.47992/ijmts.2581.6012.0116

[37] Jovanovska, M. E., Bozinova, M., & Mitreski, K. (2020). Analyzing and visualisation of indoor air pollution. International Scientific Journal Science, Business, Society, 5, 3-6.

[38] Kumar, P. M., & Aithal, P. S. (2016). Working from home-a transition in the concept of workplace. International Journal of Current Research and Modern Education. https://ssrn.com/abstract=2779236

[39] Shukla, K., Kumar, P., Mann, G. S., & Khare, M. (2020). Mapping spatial distribution of particulate matter using Kriging and Inverse distance weighting at supersites of megacity Delhi. Sustainable Cities and Society. https://doi.org/10.1016/j.scs.2019.101997

[40] Khouni, I., Louhichi, G., & Ghrabi, A. (2021). Use of GIS based inverse distance weighted interpolation to assess surface water quality: Case of Wadi El Bey, Tunisia. Environmental Technology and Innovation. https://doi.org/10.1016/j.eti.2021.101892

[41] Jumaah, H. J., Ameen, M. H., Mahmood, S., & Jumaah, S. J. (2023). Study of air contamination in Iraq using remotely sensed Data and GIS. Geocarto International. https://doi.org/10.1080/10106049.2023.2178518

[42] Saha, J., Barman, B., & Chouhan, P. (2020). Lockdown for COVID-19 and its impact on community mobility in India: An analysis of the COVID-19 community mobility reports, 2020. Children and Youth Services Review. https://doi.org/10.1016/j.childyouth.2020.105160

[43] Azuma, K., Ikeda, K., Kagi, N., Yanagi, U., & Osawa, H. (2017). Evaluating prevalence and risk factors of building-related symptoms among office workers: Seasonal characteristics of symptoms and psychosocial and physical environmental factors. Environmental Health and Preventive Medicine. https://doi.org/10.1186/s12199-017-0645-4

[44] Sun, Y., Hou, J., Cheng, R., Sheng, Y., Zhang, X., & Sundell, J. (2019). Indoor air quality, ventilation and their associations with sick building syndrome in Chinese homes. Energy and Buildings. https://doi.org/10.1016/ j.enbuild.2019.05.046

[45] Alomirah, H. F., & Moda, H. M. (2020). Assessment of indoor air quality and users perception of a renovated office building in manchester. International Journal of Environmental Research and Public Health. https://doi.org/10.3390/ijerph17061972

[46] Lu, C., Deng, Q., Li, Y., Sundell, J., & Norbäck, D. (2016). Outdoor air pollution, meteorological conditions and indoor factors in dwellings in relation to sick building syndrome (SBS) among adults in China. Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2016.04.033

[47] Meir, I. A., Schwartz, M., Davara, Y., & Garb, Y. (2019). A window of one's own: A public office post-occupancy evaluation. Building Research and Information. https://doi.org/10.1080/09613218.2018.1434366

[48] Belachew, H., Assefa, Y., Guyasa, G., Azanaw, J., Adane, T., Dagne, H., & Gizaw, Z. (2018). Sick building syndrome and associated risk factors among the population of Gondar town, northwest Ethiopia. Environmental Health and Preventive Medicine. https://doi.org/10.1186/s12199-018-0745-9

[49] Nakayama, Y., Nakaoka, H., Suzuki, N., Tsumura, K., Hanazato, M., Todaka, E., & Mori, C. (2019). Prevalence and risk factors of pre-sick building syndrome: Characteristics of indoor environmental and individual factors. Environmental Health and Preventive Medicine. https://doi.org/10.1186/s12199-019-0830-8

[50] Chen, X., Li, F., Liu, C., Yang, J., Zhang, J., & Peng, C. (2017). Monitoring, human health risk assessment and optimized management for typical pollutants in indoor air from random Families of University staff, Wuhan City, China. Sustainability (Switzerland). https://doi.org/10.3390/su9071115

[51] Azuma, K., Ikeda, K., Kagi, N., Yanagi, U., & Osawa, H. (2015). Prevalence and risk factors associated with nonspecific building-related symptoms in office employees in Japan: Relationships between work environment, Indoor Air Quality, and occupational stress. Indoor Air. https://doi.org/10.1111/ina.12158

[52] Vaughn, M. (2020). ASHRAE research report: 2019-2020. ASHRAE Journal, 62, 73-89.

[53] Farizly, H. R., Munir, A., Sari, L. H., & Zahriah. (2021). Evaluation of air quality in office rooms (case study: The rector's office building of Syiah Kuala University). IOP Conference Series: Earth and Environmental Science. https://doi.org/10.1088/1755-1315/881/1/012032

[54] Ismaeel, W. S. E., & Mohamed, A. G. (2022). Indoor air quality for sustainable building renovation: A decision-support assessment system using structural equation modelling. Building and Environment. https://doi.org/ 10.1016/j.buildenv.2022.108933

[55] Sarkhosh, M., Najafpoor, A. A., Alidadi, H., Shamsara, J., Amiri, H., Andrea, T., & Kariminejad, F. (2021). Indoor air quality associations with sick building syndrome: An application of decision tree technology. Building and Environment. https://doi.org/10.1016/j.buildenv.2020.107446

[56] Fan, L., & Ding, Y. (2022). Research on risk scorecard of sick building syndrome based on machine learning. Building and Environment. https://doi.org/10.1016/j.buildenv.2021.108710

[57] Roskams, M. J., & Haynes, B. P. (2021). Testing the relationship between objective indoor environment quality and subjective experiences of comfort. Building Research and Information. https://doi.org/10.1080/ 09613218.2020.1775065

[58] Runeson-Broberg, R., & Norbäck, D. (2013). Sick building syndrome (SBS) and sick house syndrome (SHS) in relation to psychosocial stress at work in the Swedish workforce. International Archives of Occupational and Environmental Health. https://doi.org/10.1007/s00420-012-0827-8

[59] Park, S., Seo, J., & Kim, J. T. (2015). A study on the application of sorptive building materials to reduce the concentration and volume of contaminants inhaled by occupants in office areas. Energy and Buildings. https://doi.org/10.1016/j.enbuild.2014.12.056

[60] Sakellaris, I., Saraga, D., Mandin, C., de Kluizenaar, Y., Fossati, S., Spinazzè, A., Cattaneo, A., Mihucz, V., Szigeti, T., de Oliveira Fernandes, E., Carrer, P., & Bartzis, J. (2021). Association of subjective health symptoms with indoor air quality in European office buildings: The OFFICAIR project. Indoor Air. https://doi.org/10.1111/ina.12749

[61] Koohsari, M. J., Nakaya, T., Shibata, A., Ishii, K., & Oka, K. (2021). Working from home after the COVID-19 pandemic: Do company employees sit more and move less? Sustainability (Switzerland). https://doi.org/10.3390/su13020939

[62] Kamaruzzaman, S. N., & Azmal, A. M. (2019). Evaluation of occupants' well-being and perception towards indoor environmental quality in Malaysia affordable housing. Journal of Facilities Management. https://doi.org/10.1108/JFM-11-2017-0070

[63] Aspita, D. N. P., & Edastama, P. (2023). the influence of work from home, workload and work environment on employee performance. Jurnal Simki Economic, 6, 213-223.

[64] Okawara, M., Ishimaru, T., Igarashi, Y., Matsugaki, R., Mafune, K., Nagata, T., Tsuji, M., Ogami, A., & Fujino, Y. (2023). Health and work performance consequences of working from home environment: A nationwide prospective cohort study in Japan. Journal of Occupational and Environmental Medicine. https://doi.org/10.1097/JOM.0000000000002771

[65] Ekpanyaskul, C., Padungtod, C., & Kleebbua, C. (2023). Home as a new physical workplace: A causal model for understanding the inextricable link between home environment, work productivity, and well-being. Industrial Health. https://doi.org/10.2486/indhealth.2022-0083

[66] Sander, E. L. J., Rafferty, A., & Jordan, P. J. (2021). Escaping the Cubicle: Exploring the Physical Work Environment of the Home. IGI Global Scientific Publishing. https://doi.org/10.4018/978-1-7998-6754-8.ch011

[67] OSHA (1994). Laws of Malaysia Act 514. Occupational Safety and Health Act 1994. Part IV-General Duties of Employers and Self-Employed Persons.

[68] OSHA (2022). Laws of Malaysia Act A1648. Occupational Safety and Health (Amendment) Act 2022. Admendment Section 1.