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Indoor Air Quality (IAQ) and Related Risk Factors for Sick Building Syndrome (SBS) at the Office and Home: A Systematic Review

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Indoor Air Quality (IAQ) and Related Risk Factors for Sick Building Syndrome (SBS) at the Office and Home: A Systematic Review

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Abstract. The comfort and productivity of workers may be affected differently by the indoor air quality (IAQ) and related risk factors at the office and at home. Sick Building Syndrome (SBS) is one of the health issues usually faced by workers. SBS is generally associated with the time spent in a building, IAQ, and other related risk factors. The study reviewed papers published in journal articles and conferences regarding IAQ, environmental risk factors and SBS in the last ten years. The review employed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 items from two significant databases, Scopus and Web of Science. The review steps involved identification, screening, eligibility, data extraction and analysis. The study found that air quality in a building significantly influences work productivity and may contribute to SBS. Findings show that SBS symptoms are linked to various personal characteristics, sociodemographic, working environment and IAQ factors. The physical contaminants, chemical contaminants and ventilation rate have established relations with SBS symptoms. These findings can help to form interventions aiming to improve IAQ and the productivity of occupants.

1. Introduction
Air pollution is one of the most serious global environmental issues, especially for human respiratory health [1]. Air pollution can be classified into two groups depending on the environment: indoor air pollution and outdoor air pollution. It is a misconception that one is safe from dangerous contaminants at home. Indoor air pollution is significantly more serious than outdoor air pollution [2]. People spend 90% of their daily life indoors, subconsciously subject to various air pollutants [3]. Most people who spend most of their time indoors, especially children and the elderly, tend to be chronically exposed to indoor pollutants [4]. The pollutants inside a building can affect the IAQ.
This review focus on IAQ. IAQ is the term used to describe the air quality inside a building indicated by the concentration of the pollutant and temperature. It can impact the health, comfort, and productivity of the occupants. A healthy indoor environment requires good IAQ. The things inside a building and our daily activities can contribute to indoor pollutants, such as furniture, paint, electrical

appliances, cleaning and cooking activities. IAQ may also be affected by outdoor air pollutants such as fine particulate matter, carbon monoxide (CO), volatile organic compounds (VOCs) and ozone (O_3) [5]. Carbon dioxide (CO_2) is an indicator of the ventilation performance of a building.

Poor IAQ can cause discomfort and raise common health issues such as SBS among building occupants. The phrase "sick building syndrome" refers to circumstances in which people in the building experience health discomfort that appears to be related to time spent in the building, but no specific disease or cause can be determined. SBS is one of the health issues usually faced by workers. Department of Occupational Safety and Health Malaysia (DOSH) stated that no known causes and precise medical tests could identify and verify whether someone is dealing with SBS. It is a condition in which a person experiences various symptoms or general discomfort but does not have a specific diagnosis that characterises these symptoms. SBS is most likely a combination of symptoms linked to specific conditions of the building.

The symptoms of SBS are usually classified into three groups which are general, dermal, and mucosal. The general symptom is usually the most common [6]. These symptoms include feeling tired and headaches. Dermal symptoms are related to skin, such as irritations and skin dryness. Mucosal symptoms involve irritation or dryness of mucous membranes such as the nose, eyes, and throat. All these symptoms (general, dermal and mucosal) are common in the general population; the feature that distinguishes them as part of the SBS is their associations with certain buildings [6]. The SBS symptoms are usually temporary and subside within minutes after exiting the building. It is an indicator of SBS as it relates to time spent in a building.

In this review, we want to investigate the prevalence of SBS in the office and at home. The global pandemic of Coronavirus since 2019 has impacted the working environment, which shifted from offices to homes. Since then, many companies and businesses have shifted the working space to ensure business continuity and save costs. It benefits both employers and employees [7]. The shifted working environment makes assessments of IAQ and SBS at home equally significant as those taken at the workplace. Even at home, the well-being of the workers is vital to ensure the productivity of their work. Therefore, this research paper sought to study IAQ and associated risk factors of SBS from the previous studies at the office and home.

2. Methodology

This section discusses the method used to retrieve related articles with IAQ and SBS. The guide from Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 was used for this systematic review. PRISMA focuses on techniques that researchers can employ to ensure transparent and thorough reporting of systematic reviews and meta-analyses [8]. The review steps involved identification, screening, eligibility, data abstraction and data analysis.

2.1 Identification

The following search terms were used, which contain different combinations: IAQ, SBS, office and home via Scopus and Web of Science (WoS) databases to identify journal publications. The inclusion and exclusion requirements were established, as shown in table 1. Only articles in journals with empirical data were chosen as the category of literature. Therefore, review articles, book chapters, and conference proceedings were excluded. The search attempted to exclude non-English publications and focused only on English articles to avoid any misconceptions and difficulties with translation. Regarding the timeline, ten years were considered (between 2013 and 2022), sufficient time to observe the recent development of research and related publications.

2.2 Screening

The identified records' titles, abstracts, keywords, authors' names and affiliations, journal names, and year of publication were exported to an MS Excel spreadsheet. After the searches were completed, the titles and abstracts were screened based on the criteria. In all cases, a conservative strategy was adopted; where the relevance or otherwise of a paper was not apparent from the title/abstract, the paper was retained for full-text scanning. Any title or abstract not involving IAQ assessment of home or office and SBS are excluded. The copies of the full papers were obtained for those included following the screening of the titles and abstracts.

Table 1. The search setting with inclusion and exclusion criteria used in the systematic review process

Databases	Keywords used	Inclusion	Exclusion
Scopus	TITLE-ABS-KEY (sick AND building AND syndrome AND indoor AND air AND quality AND office OR home)	• Journal articles • 2013-2022	• Review, Data • Book chapter • <2013 • non-English articles
Web of Science (WoS)	Topic- Sick AND building AND syndrome AND indoor AND air AND quality AND (office OR home) https://www.webofscience.com/wos/woscc/summary/da17a10a-dd92-44f4-b3a1-1cbed3711ce6-3fb2bb6c/relevance/1	• Journal Articles • 2017-2022	• Review articles

2.3 Eligibility
Then, the full texts of the remaining papers were assessed based on the eligibility criteria. Inclusion criteria for the journal selection: a) IAQ information of the office or home either collected from walkthrough home inspection or the survey, b) studies of perceived IAQ and SBS, c) study conducted at the office or home. For exclusion criteria: a) studies conducted at a simulated office space, b) microbial assessment of IAQ, c) study population that involved students or children, d) studies focus on instrumentation and e) review articles.

2.4 Data extraction and analysis
The data extraction template was developed and applied to the included papers. Appropriate themes and sub-themes were identified by reading the abstracts first, followed by the entire articles (in-depth) to extract the data. The themes and sub-themes focused on achieving the study's main objective. The final data extraction template included the publication title, authors, method(s) of measurement, physical or chemical measurement of IAQ, perception of IAQ, the prevalence of SBS building syndrome and the associated risk factors. The study's objectives were achieved based on the scope of work that has been formulated. The reports are included to be a review if it has any information on IAQ or SBS at either home or office.

3. Result
The review analysis resulted in three major themes. The themes are the IAQ of the environment, the prevalence of SBS among the respondents and the factors associated with SBS. Overall, 168 titles were identified and screened, and 73 full-text articles were obtained and assessed for eligibility, with 49 in the review analysis. Figure 1 shows the trend of the studies over the past ten years. The figure shows that many studies focused on office settings compared to home settings over the past ten years. In addition, studies that review SBS and IAQ at both the office and home were only four for the last ten years. 2019 recorded the highest number of studies at the office and home. Studies being reviewed were from 27 countries, including a high proportion of research from China, Malaysia, and Japan.
Overall, the studies used IAQ measurement, questionnaire survey, or both as assessment methods. The data analysis of physical and chemical parameters in this review was based on the Industrial Code of Practice-Indoor Air Quality (ICOP-IAQ) 2010 standards. The physical parameters analysed from the reports are temperature, relative humidity (RH) and air movement. The chemical contaminants analysed from the reports are Carbon monoxide (CO), formaldehyde (CH_2O), Ozone (O_3), respirable particulates (PM2.5 and PM10) and total volatile organic compounds (TVOC). In addition, carbon dioxide (CO_2) is an indicator of ventilation performance. Figure 2 shows an illustration of the review process (PRISMA).

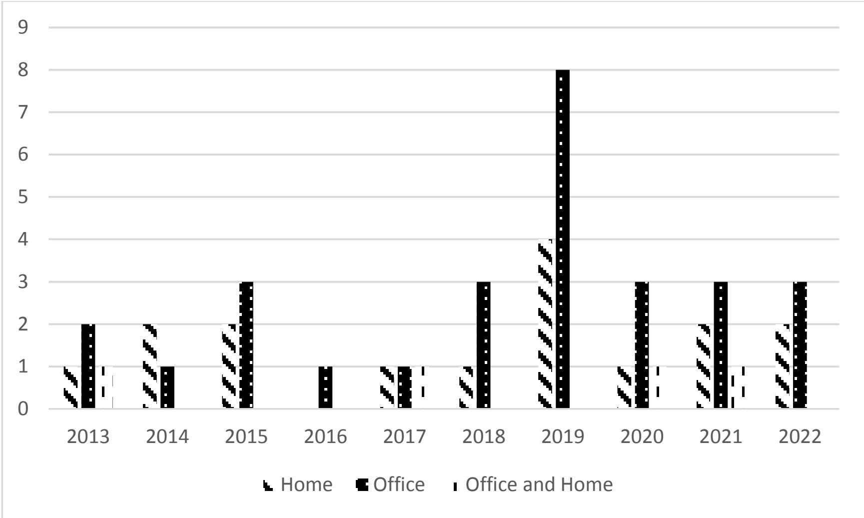

Figure 1. Number of studies according to place setting throughout the past ten years.

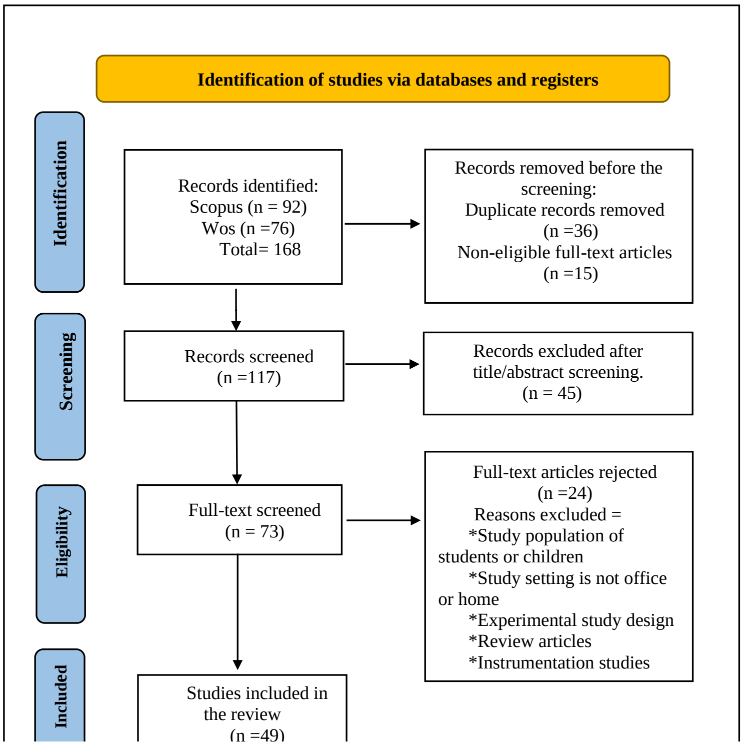

Figure 2. Numbers of papers at each stage of the review process (PRISMA 2020 flow diagram).

Table 2 provides an overview of the 49 studies, emphasising the country, methods of assessment, physical and chemical measurements of IAQ, the perception of IAQ, the prevalence of SBS and risk factors associated with SBS. Most of the studies included for review analysed the risk factors associated with SBS with the physical measurement of the IAQ or the perception of IAQ by respondents. Some of the studies only analysed the IAQ of the environment. These studies are still included in the review as they give an overview of the IAQ at the office or home.

Table 2. Summary of eligible study findings.

No	Authors	Country	Place setting	Method(s) of Assessment	IAQ measurement	Perception of IAQ	SBS self-assessment	Risk factors
1.	El-Batrawy et al., 2019 [9]	Egypt	Home	Questionnaire survey, IAQ measurement	PM10	-	/	/
2.	Colton et al., 2014 [10]	USA	Home	Questionnaire survey, IAQ measurement	PM2.5, CO_2	-	/	/
3.	Lin et al., 2014 [11]	China	Home	Questionnaire survey	-	/	/	/
4.	McGill et al., 2015 [12]	UK	Home	Questionnaire survey, IAQ measurement	Temperature, RH, CO_2	/	/	/
5.	Abdul-Wahab et al., 2015 [13]	Oman	Home	Questionnaire survey, IAQ measurement	Temperature, RH, CO, PM, CO_2	-	/	/
6.	Song et al., 2017 [14]	China	Home	Questionnaire survey, IAQ measurement	Temperature, RH, TVOC	-	/	/
7.	Belachew et al., 2018 [15]	Ethiopia	Home	Questionnaire survey	-	-	/	/
8.	Cheung & Jim, 2019 [16]	China	Home	IAQ measurement	Temperature, RH, airspeed, CO, VOC, PM2.5, PM10, CO_2	-	-	-
9.	Sun et al., 2019 [17]	China	Home	Questionnaire survey, IAQ measurement	Temperature, RH, CH_2O, TVOC, PM2.5, CO_2	/	/	/
10.	Nakayama et al., 2019 [18]	Japan	Home	Questionnaire survey	-	/	/	/
11.	Hildebrandt et al., 2019 [19]	Indonesia	Home	Questionnaire survey, IAQ measurement	Temperature, RH, TVOC	/	-	-
12.	Mentese et al., 2020 [20]	Turkey	Home	Questionnaire survey, IAQ measurement	Temperature, RH, VOCs, CO_2	/	/	/
13.	Hou et al., 2021 [21]	China	Home	Questionnaire survey, IAQ measurement	Temperature, RH, CO_2	/	/	/
14.	Suzuki et al., 2021 [22]	Japan	Home	Questionnaire survey	-	/	/	/

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Table 2. Cont.

No	Authors	Country	Place setting	Method(s) of Assessment	IAQ measurement	Perception of IAQ	SBS self-assessment	Risk factors
15.	Gonzalo et al., 2022 [23]	Switzerland	Home	IAQ measurement	Temperature, RH, PM2.5, TVOC, CO_2	-	-	-
16.	Wang & Norbäck, 2022 [24]	Sweden	Home	Questionnaire survey, IAQ measurement	Temperature, RH	/	-	-
17.	Chen et al., 2013 [25]	China	Office	Questionnaire survey, IAQ measurement	Temperature, RH, air velocity, CO_2	/	/	/
18.	Zamani et al., 2013 [26]	Malaysia	Office	Questionnaire survey, IAQ measurement	Temperature, RH, CO, TVOC, PM2.5, PM10, CO_2	-	/	/
19.	Rahman et al., 2014 [27]	Malaysia	Office	Questionnaire survey	-	/	/	/
20.	Azuma et al., 2015 [28]	Japan	Office	Questionnaire survey	-	/	/	/
21.	Lu et al., 2015 [29]	Taiwan	Office	Questionnaire survey, IAQ measurement	Temperature, RH, TVOC, CO_2	-	/	/
22.	Tham et al., 2015 [30]	Singapore	Office	Questionnaire survey, IAQ measurement	Temperature, RH, air speed, CO, CH_2O, TVOC, CO_2	/	/	/
23.	Baharum et al., 2016 [31]	Malaysia	Office	Questionnaire survey	-	-	/	-
24.	Azuma et al., 2017 [32]	Japan	Office	Questionnaire survey	-	/	/	/
25.	Lu et al., 2018 [33]	Taiwan	Office	Questionnaire survey, IAQ measurement	Temperature, T VOC, CO_2	/	/	/
26.	Shin et al., 2018 [34]	Korea	Office	Questionnaire survey	-	/	/	/
27.	Tähtinen et al., 2018 [35]	Finland	Office	Questionnaire survey, IAQ measurement	CO, TVOC	/	-	-

Table 2. Cont.

No	Authors	Country	Place setting	Method(s) of Assessment	IAQ measurement	Perception of IAQ	SBS self-assessment	Risk factors
28.	Gladyszewska-Fiedoruk, 2019 [36]	Poland	Office	Questionnaire survey, IAQ measurement	Temperature, RH, PM10, PM2.5, CO_2	/	/	/
29.	Halid Abdullah et al., 2019 [37]	Malaysia	Office	Questionnaire survey, IAQ measurement	Temperature, RH, airspeed, CO, CO_2	-	/	/
30.	Meir et al., 2019 [38]	Israel	Office	Questionnaire survey, IAQ measurement	Temperature, RH	/	/	/
31.	Nunes et al., 2019 [39]	Spain	Office	IAQ measurement	Temperature, RH, TVOC	-	-	-
32.	Park et al., 2019 [40]	UK	Office	Questionnaire survey, IAQ measurement	Airspeed, CO, VOCs, PM2.5, PM10, CO_2	/	-	-
33.	Sun et al., 2015 [41]	China	Office	Questionnaire survey, IAQ measurement	Temperature, RH, air speed, CH_2O, TVOC, CO_2	/	/	/
34.	Vasile et al., 2019 [42]	Romania	Office	IAQ measurement	Temperature, RH, TVOC	-	-	-
35.	Zainal et al., 2019 [43]	Malaysia	Office	Questionnaire survey, IAQ measurement	Temperature, RH, airspeed, CO, CH_2O, PM10, TVOC, CO_2	-	/	/
36.	Alomirah & Moda [44]	UK	Office	Questionnaire survey, IAQ measurement	Temperature, RH, CO, TVOC, CO_2	/	/	/
37.	Ha et al., 2020 [45]	Vietnam	Office	Questionnaire survey, IAQ measurement	Temperature, RH, airspeed, CO, TVOC, PM2.5, CO_2	/	/	-
38.	Ola et al., 2020 [46]	India	Office	Questionnaire survey, IAQ measurement	Temperature, RH, PM, CO_2	/	/	/

. **Table 2**. Cont

No	Authors	Country	Place setting	Method(s) of Assessment	IAQ measurement	Perception of IAQ	SBS self-assessment	Risk factors
39.	Farizly et al., 2021 [47]	Indonesia	Office	Questionnaire survey, IAQ measurement	Temperature, RH, air velocity, TVOC, CH_2O, CO_2	-	/	/
40.	Roskams & Haynes, 2021 [48]	UK	Office	Questionnaire survey, IAQ measurement	Temperature, RH, CO_2	/	-	-
41.	Sakellaris et al., 2021 [49]	Europe	Office	Questionnaire survey, IAQ measurement	PM2.5, O_3, CH_2O. TO	/	/	/
42.	Cheng et al., 2022 [50]	China	Office	Questionnaire survey, IAQ measurement	Temperature, RH, air speed, CH_2O, TVOC, CO_2	/	-	-
43.	Fan & Ding, 2022 [51]	China	Office	Questionnaire survey	-	/	/	/
44.	Nezis et al., 2022 [52]	Greece	Office	Questionnaire survey, IAQ measurement	Temperature, RH, PM2.5	/	/	/
45.	Runeson-Broberg & Norbäck, 2013 [53]	Sweden	Office, Home	Questionnaire survey	-	/	/	/
46.	Chen et al., 2017 [54]	China	Office, Home	IAQ measurement	CH_2O, TVOC	-	-	-
47.	Afolabi et al., 2020 [55]	Nigeria	Office, Home	Questionnaire survey, IAQ measurement	Temperature, RH, CH_2O, PM2.5, PM10, TVOC	/	/	/
48.	Guo & Chen, 2020 [56]	USA	Office, Home	Questionnaire survey	-	/	/	/
49.	Roh et. al, 2021 [5]	USA	Office, Home	Questionnaire survey, IAQ measurement	Temperature, RH, PM2.5, TVOC	/	/	/

4. Discussion

This study has attempted to comprehensively review the existing literature on IAQ and related risk factors for SBS at the office and at home. In this section, a detailed discussion of the result is discussed.

4.1 IAQ parameters measured at the office and home

IAQ describes the air condition inside and surrounding buildings. It can be associated with the well-being and comfort of those who live there. This review focuses on three primary parameters: physical, chemical, and ventilation rate. Thirty-eight studies conducted a physical measurement of IAQ, 23 studies at the office, 13 studies at home and two at both the office and home.

4.1.1 Physical parameters

According to a study, a significant predictor of satisfaction with air quality was the temperature [48]. A study stated that complaints of varying room temperature were less with increased air exchange rates [24]. Some studies stated that climate zone and seasons could significantly impact indoor temperature and RH [39, 50]. A study stated that higher indoor air temperatures and lower RH were recorded in summer compared to winter [41]. The type of buildings may also affect the indoor air temperature. Often, the temperature inside Kampong houses is hotter than the outdoor environment compared to apartments [19]. The higher temperature may be due to different building designs and ventilation systems. In a comparison study of office and home environments, individuals were more comfortable with thermal conditions at home compared to the office as they can adjust the temperature [56].

4.1.2 Ventilation rate

IAQ conditions are generally caused by increased internal air pollutant emissions and ventilation rates [23, 45]. Satisfaction with the air quality can be improved if access to a window can be opened [40]. Bedrooms with open windows had much better ventilation rates than rooms with closed windows as it enhanced the effectiveness of the air distribution and lowered the contaminants present [17,36]. Most commonly, CO_2 levels are employed as a measure of proper ventilation [20]. The number of occupants is significantly associated with CO_2 levels [29,45].
The usage of AC in a small area also has terrible impacts on the IAQ, especially CO and CO_2 levels [16]. The accumulated pollutant inside the room cannot be discarded and accumulated. An increased number of individuals without ventilation reported high CO_2 levels in a building [16,45]. A study reported that as the floor height increased, the levels of CO_2 in the indoor atmosphere increased. The increased levels of CO_2 may occur due to the different layouts of the office building and the habit of opening windows [50]. Ventilation is an essential factor that contributes to the level of VOCs. Low ventilation rates can lead to higher levels of CH_2O [20]. Hence, CO_2 is an essential indicator of the ventilation rate. It is crucial to open windows and doors for natural ventilation or use the AC. The pollutants will be discarded through ventilation.

4.1.3 Chemical parameters

TVOC and CH_2O are the most studied chemical contaminants in the IAQ measurement of a building. Indoor air temperature and season are the primary factors affecting VOC and CH_2O component concentration in indoor air [14,39,41]. Seasonal weather is regarded as human ventilation behaviour. Studies in China stated that most residents kept their windows closed during winter to maintain their thermal comfort, contributing to the build-up of indoor VOCs [14,41] A study also stated that the winter season has higher TVOCs and CH_2O levels than the summer [20].
In a high-traffic area, ventilation may contribute to the rising level of VOCs as it enters the indoor environment from the outside [39]. Bedrooms have the highest level of TVOC compared to kitchens, living rooms and even workplaces [14,54]. A study reported higher TVOC levels in homes compared to offices [5]. The high TVOCs level in the bedroom may be because of the gaseous emission from the furniture and carpeting in the room. A high level of CH_2O at the office was noticed as the number of occupants and electronic equipment usage (such as photocopy machines) increased [41].
According to a study conducted in Greece, the printing room was measured with the highest indoor PM2.5 levels during working hours [52]. PM2.5 concentration levels at home during the pandemic

were much more significant than PM2.5 levels at their workplaces before the epidemic [5]. The mean PM10 and PM2.5 concentrations were unaffected when the air conditioning (AC) was used [16]. Sufficient air filtration by the heating, ventilation and air conditioning (HVAC) system is crucial to keep particle concentrations within acceptable limits.

4.2 Prevalence of SBS among the respondents

The phrase SBS does not imply that a building has a disease. It is based on the complaints of the occupants with health issues or discomfort in a particular building, and these symptoms disappear after they leave the building. Thirty-eight studies included in the review contained SBS self-assessment, 22 at the office, 12 at home, and four at the office and home. The SBS self-assessment in the studies was collected through questionnaires. Most studies reported general symptoms as the most prevalent. Then followed by mucosal and dermal symptoms, the least prevalent symptom [17,21,28]. The dermal symptoms were uncommon in office and home environment studies [9,53]. Skin-related symptoms were the least reported, which may be due to the symptoms being pretty hard to notice and may relate to individual allergic reactions.

4.2.1 SBS at the Office

The most typical SBS symptoms in the office studies were dry throat and exhaustion [30]. A study reported that employees experience nasal irritation, headache, difficulty concentrating and sneezing while at the office [47]. At the office, the most typical SBS symptom that staff members experienced was headache [44]. Meanwhile, a study stated that lethargy is the most prevalent SBS among office workers [27]. Another study stated that the respondents' most prevalent SBS symptom is dizziness [37]. Headache and tiredness are the dominant SBS symptoms [38]. Nevertheless, headache, fatigue, difficulty concentrating or breathing, feeling sleepy, and chest tightness were also some of the general symptoms reported by the office staff [29,41,44].

Respondents tend to complain about headaches and eye irritation after working a day at the office [29,36]. Another study in the office setting also said nose and throat irritation are the most common SBS symptom [34]. However, a study shows that nose irritation was the least reported SBS symptom at the office [38]. In the comparison of seasons, the majority of general symptoms like fatigue, irritation, nervousness, or tired eyes were reported to be higher in the summer than in winter [32].

4.2.2 SBS at Home

A study reported that the most typical symptoms were exhaustion, cold and flu-like symptoms, and attention problems at home. Feeling tired or drowsiness, followed by headache and nose irritation, were the main SBS symptoms reported in an indoor home study [9]. Meanwhile, A study reported that the top three symptoms at home were tiredness, sore throat, and cough [17]. Mucosal irritation was much more likely for occupants to experience than the other symptoms [51]. Irritation of the eyes and stuffy nose are the mucosal symptoms usually reported at home [5]. A study also reported nasal symptoms as the highest prevalent SBS symptom among occupants at home [17]. A study reported dry throat as the most reported symptom at home [12].

4.2.3 SBS at the Office and Home

A few studies also reported mucosal symptoms as the most prevalent SBS among the respondents, both at home and office [11, 43]. Studies conducted at the office and at home mentioned that the most typical SBS symptoms were fatigue, headache, stuffy or runny nose, and eye irritation [52, 56]. Participants who worked from home reported more frequent SBS symptoms than work from the office [5]. A study stated the opposite, where SBS occurrences were fewer at home than at the office [56]. Eye and throat symptoms were the most typical work-related SBS symptoms, while nasal and throat irritation and tiredness are common symptoms reported at home [53]. Significant indications of weakness, arm or hand muscular soreness, feeling cold in the hands or feet, and a heavy air sensation were the predominant symptoms of SBS among residential occupants [55]. Meanwhile, cold or flu, back pain, and weakness are typical signs among office workers [55]. SBS symptoms were less severe for participants in green homes than normal homes [10]. A study revealed that the proportion of those living in apartments has a higher prevalence of SBS than those residing in Kampongs [19].

4.3 Risk factors associated with SBS

The risk factors associated with SBS usually can be divided into three subgroups which are the sociodemographic factors (sex, age, smoking status, psychological), working environment (odour, cleanliness) and indoor air parameters (temperature, RH, air pollutants, ventilation). Thirty-six studies in the review studied risk factors associated with SBS, 20 at the office, 12 at home and four at both the office and home.

4.3.1 Sociodemographic factors

Regarding the sociodemographic factors, gender and age are significant factors contributing to SBS symptoms at the office and at home [43, 49]. Many studies mentioned that SBS symptoms were more likely to affect women than men [9,11,32,44,53]. The main SBS concerns mentioned by females were related to noise, shifting room temperature, dry air, and dust [44]. A study stated that this might be related to the exposure time inside a building, as females spend more time inside a building (home) than males [54].

However, some studies stated no significant associations between gender and the symptoms [17,18]. Male has SBS experiences similar to females [18]. In terms of age group, younger respondents reported SBS symptoms at a higher rate than those older [43]. Individuals aged 20 to 49 were more likely to experience SBS symptoms than those aged 50 to 59 [9,18]. However, a study mentioned that older age groups tend to experience general symptoms of SBS [21].

Long-term smoking status and psychological work stress are significant risk factors for SBS symptoms [20,49]. Significant correlations have been reported between current smoking with worsened skin problems and upper respiratory symptoms [28, 43]. According to a study, most smokers tend to report "eye discomfort," "stuffy or runny nose," and "respiratory symptoms" (cough) as compared to non-smokers [52]. Non-smokers that are sensitive to tobacco are more likely to experience eye symptoms than those who are not. Increased SBS was substantially correlated with allergic history or allergies (cat and dust) [21,49]. Mucosal symptoms were linked to doctor-diagnosed asthma workers [43]. A study also revealed that contact lenses significantly increased the likelihood of ocular irritation, upper respiratory issues, and skin symptoms [28].

Regarding the associations between the existence of SBS symptoms and workplace psychosocial factors, a few studies reported that excessive workload, severe mental effort, intense interpersonal conflict, unsuitability for employment, and unsatisfactory work were associated with the general symptoms [28,33]. Office workers who spend much time inside a building working have subjective symptoms such as eyes, ears, respiratory systems, skin, and headaches [34]. The relationship between computer usage and eye discomfort was highly significant [32]. Meanwhile, using printers, photocopiers, or fax machines was strongly correlated with skin complaints [43]. A study reported that employees working in the printing room were more likely to experience upper respiratory, non-specific, and eye irritation symptoms than those working in the office and archive rooms [52].

4.3.2 Working environment

According to studies, IAQ and SBS were substantially correlated [5,33,34]. A study stated that the home environment contributes about 96 per cent of the average health risk [54]. The perception of bad air quality at work, at home, and outside is linked to symptoms both at home and office [53]. A similar perception of IAQ demonstrates a connection between home and work surroundings. A study revealed that itchy noses and sneezes are consistent SBS of poor air quality at the workplace [31]. Another study revealed that SBS correlates with poor housing conditions and buildings' cleanliness [15]. Eye discomfort was strongly linked to congested workplaces [32]. There was a substantial correlation between eye irritation, overall symptoms, and upper respiratory symptoms with carpeting and uncomfortable seats at the workplace [32]. Residents who used charcoal as a cooking fuel had an increased risk of developing SBS [15]. A study revealed SBS's significant relationship with thermal comfort and perceived IAQ [12,30].

4.3.3 Physical conditions

RH and temperature impact the SBS symptom [20]. A room with an unstable temperature substantially impacted the general symptoms and skin complaints [28]. Reduced skin and mucosal SBS symptoms were closely correlated with higher RH [21]. High air temperature at home or office may contribute to several SBS symptoms, including fatigue and headaches, as well as worse work performance and alertness [13,43].

SBS symptoms were significantly correlated with the perception of odour and dry air, which are classic signs of a polluted indoor environment [11,17,20]. People who worked in offices with dry air-conditioned were more likely to experience upper respiratory illnesses and general symptoms than those who did not [33]. Eye discomfort, general, upper respiratory, and skin complaints were all strongly linked with air dryness [28]. Body odour, food odour, and perfume (unpleasant odour) were all substantially linked to upper respiratory and general symptoms [28]. Eye irritation was substantially associated with the increased usage of harsh odorous chemicals [32].

There was a direct correlation between indoor environments, such as air conditioning systems, and residents' symptoms, such as headaches and fever [28,55]. A study mentioned that the SBS was linked to the draughts from the air conditioner that were associated with thermal comfort [51]. Buildings with centralised air-conditioner systems had a higher prevalence of SBS symptoms than those with split-unit air-conditioning systems [43]. Insufficient ventilation, fluctuating room temperatures, and air that is too cold, too dry, or excessive air conditioner airflow can affect SBS [28]. Individuals tend to experience more SBS symptoms when using air-conditioning than natural ventilation [13]. The use of fans was linked to SBS [15]. The study revealed that participants who did not use fans had a greater chance of acquiring SBS.

4.3.4 Chemical pollutants

Significant correlations exist between the indoor air pollutants of CO_2, CO, TVOC, PM10, and PM2.5 with the occurrence of SBS [26,49]. VOCs were responsible for respiratory symptoms, while CH_2O was associated with respiratory and general symptoms. [43,49]. However, there were not enough correlations between TVOCs and the risks of eye irritation, stuffy nose and dry throat, difficulty breathing, dry skin, irritability, and dizziness. A study also mentioned that CH_2O could increase the occurrence of SBS [14].

CH_2O poses a higher health risk at home than at the office [54]. A study discovered that ozone was the pollutant that had impacted the most symptoms [49]. Ozone and ultrafine particles were significant risk factors for skin symptoms [17]. PM2.5, a type of tiny particulate matter, is frequently referred to as an air pollutant related to respiratory and cardiac conditions like asthma, bronchitis, and other respiratory illnesses [20,55]. Meanwhile, a study by [9] showed that PM and SBS had a weaker association. Exposure to indoor air contaminants and insufficiently supplied air may increase the chance of developing health issues [26].

4.3.5 Ventilation system

The ventilation system is a significant risk factor for SBS in both offices and homes [12,15]. A study mentioned that SBS could be substantially reduced with the natural ventilation of a building [51]. When indoor air is not effectively exchanged, poor air exchange can cause dirty air in the room not to be replaced and induce symptoms [47]. It was discovered that symptoms of SBS, such as fatigue, sleepiness, headaches, and focus, were anticipated by insufficiency in ventilation, lack of windows and fresh air [25,33,38]. The presence of windows and the rate of openable windows impacted the occupants' SBS symptoms [15,51]. Low ventilation and airborne chemicals could cause eye discomfort [33]. According to ASHRAE, ventilation plays an essential part in the well-being of building occupants. It contributes to the preservation of adequate IAQ. Ventilation removes pollutants from indoor sources, simultaneously lowering their concentrations in dynamic environments.

Indoor CO_2 levels can impact SBS symptoms [20]. The acceptable limit of CO_2 concentration recommended by ICOP-IAQ 2010 is 1000 ppm. A study mentioned that indoor CO_2 concentration in an office with >1000 ppm was correlated to SBS [46]. Skin SBS symptoms and general SBS symptoms were both considerably elevated by CO_2 concentration, although not by much [21]. Several studies revealed that building occupants were exposed to a high level of CO_2. They were likely to experience general symptoms like headaches, loss of judgement, dizziness, drowsiness, and rapid breathing [37,43]. These symptoms may also be due to VOCs or respirable dust [37]. CO_2, air movement and respirable dust were linked to mucosal symptoms [43]. Sociodemographic, work environment and IAQ show a significant relationship with SBS. Based on most studies reviewed, the associated risk factors of SBS must be minimised to improve building occupants' health risks and comfort.

5. Conclusion

There is limited research on SBS and IAQ in a home setting. The majority of the studies reviewed have been focused on office settings. The most common SBS symptoms reported in studies are general, followed by mucosal symptoms. Dermal symptoms are the least reported at both the office and at home. SBS can, increase stress, decrease productivity, disrupt attention, necessitate moving homes or offices, and reduce worker commitment. IAQ might vary depending on the environment and surrounding area. The physical pollutants, chemical pollutants and especially the ventilation rate can affect the IAQ. Physical parameters such as RH and temperature impact the SBS symptom. The chemical pollutants such as CO, CH_2O, TVOC, PM10, and PM2.5 show significant relationship with the occurrence of SBS. CO_2 level is an indicator of ventilation rate. The increase of CO_2 can cause health discomfort. The review study demonstrates significant relationships between SBS and risk factors associated such as sociodemographic factors, working environment and IAQ. Since people spent most of their time indoors, maintaining good IAQ was crucial for occupants' well-being and comfort.

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