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A REVIEW OF STUDIES RELATED TO SICK BUILDING SYNDROME AMONG OFFICE PERSONNEL

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ABSTRACT

Background: The term "sick building syndrome" (SBS) had started to gain popularity in the 1980s. So far, studies on this subject have been conducted among office personnel and then extended to include healthcare workers working in hospitals, residents, and schoolchildren. The aim of this review is to identify the scope of research of the studies conducted on SBS in the last 15 years, particularly among office personnel, to determine the knowledge gap in the nature of illness, risk factors, individual and economic consequences, preventive strategies, and cost-effectiveness of the available intervention strategies.

Materials and Methods: PubMed and Medline database were used for the purpose of searching for articles published from January 2003 to May 2018. The search was based on the inclusion criteria and the keywords "sick building syndrome" and "office personnel". Twenty-three articles were assessed and reviewed in the final stage.

Results: Fourteen cross-sectional studies, three longitudinal studies, one cohort study, one case-control study, one case report, one systematic review, and epidemiological modelling, and one cost-benefit study were found. These studies were conducted in the US, Japan, Sweden, Finland, Germany, Norway, Malaysia, Taiwan, and Egypt. Twenty-one studies focus on epidemiology, mainly the prevalence on SBS symptoms, risk factors, and predictors. One study looked into the cost and benefit of environmental interventions to reduce SBS and the other study was on analytical chemistry.

Conclusion: Study areas related to long-term consequences of SBS, behavioural factors contributing to SBS, economic consequences due to SBS, and cost-effectiveness of environmental intervention strategies to minimise SBS have been covered in those studies but scarcity of data remains an issue. Meanwhile, studies in the area of knowledge and attitudes towards SBS, as well as individual preventive measures for SBS are lacking. Further research focusing on these particular domains is called for.

Keywords: Sick building syndrome, office personnel

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1.0 Introduction

Sick building syndrome (SBS) is an environmentally-related phenomenon. The term "sick building syndrome" was first defined by the World Health Organization (WHO) in the 1980s (World Health Organization, 1983). It is used to describe situations in which building occupants experience, more frequently than expected, a range of common symptoms causing them to feel unwell and creating a feeling of discomfort which appear to be linked to the time spent in a building, with no specific identifiable illnesses or aetiologies (United States Environmental Protection Agency, 1991). The term SBS has been used to describe symptoms that can be grouped into five major categories: skin irritation, eye irritation, upper respiratory symptoms, lower respiratory symptoms, and general or non-specific symptoms (Tsai, Lin, & Chan, 2012).

SBS was initially studied within office buildings and subsequently extended to residential buildings (Barmark, 2015; Smedje, Wang, Norbäck, Nilsson, & Engvall, 2017), hospitals (Gómez-Acebo et al., 2011; Vafaeenasab, Morowatisharifabad, Taghi Ghaneian, Hajhosseini, & Ehrampoush, 2014), and school buildings (Norbäck, Hashim, Hashim, & Ali, 2017; Salin et al., 2017; Takaoka, Suzuki, & Norbäck, 2015; Zhang, Li, Zhang, Zhao, & Norbäck, 2014). Office is defined as "a room or part of a building in which people work, especially sitting at tables with computers and phones, as a part of an organisation or as a part of a government department" (Office, 2018). Personnel is defined as "a body of persons usually employed in an organisation" (Personnel, 2018). Therefore, office personnel refer to the office staffs that carry out all the administrative as well as clerical functions jointly to achieve the objectives of an organisation. Office personnel are the human resources of an organisation, consisting of people working at the top level, middle level and lower level of the organisation in different positions.

The past review on studies conducted pertaining to SBS showed that the preferred areas of research were group investigations of SBS using self-administered questionnaire, physiological methods in epidemiological studies, risk factors for SBS, and practical prevention of SBS (Norbäck, 2009). The aim of this review is to identify the scope of research of the studies conducted on SBS, particularly among office personnel in the last 15 years, to have an overall view of the topic and subsequently determine the knowledge gap.

2.0 Materials and Methods

The literature search was conducted by the researcher using PubMed and Medline with an initial timeframe of 1st January 2003 until 30th May 2018, restricted to human study, and English language restriction. The Medline search terms were (((((sick building syndrome[Title/Abstract]) OR syndrome, sick building) OR sick building syndrome[MeSH Terms]) AND ("2003/01/01"[PDat]:"2018/05/30"[PDat]) AND Humans[Mesh])) AND ((((((office personal[Title/Abstract]) OR office personnel[Title/Abstract]) OR office worker[Title/Abstract]) OR office workers[Title/Abstract]) OR office employee*[Title/Abstract]) AND ("2003/01/01"[PDat]:"2018/05/30"[PDat]) AND Humans[Mesh]) Filters: Publication date from 2003/01/01 to 2018/05/30; Humans.

2.1 Study selection

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Upon obtaining the search results, the researchers read all retrieved titles and abstracts. The inclusion criterion was any type of study focusing on office personnel and SBS. The studies include observational studies, experimental studies, and reviews. Full texts of potentially eligible studies were retrieved and screened to determine their eligibility.

2.2 Search outcome

The search was conducted electronically according to the 2009 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009). Figure 1 describes the flow diagram for the study selection. The initial search identified 37 citations, with no duplicates. Based on the assessment of the titles and abstracts, 31 citations were deemed eligible and the full texts were evaluated. The remaining six articles were excluded from further review because the title and abstract were not related to the study objective. After further evaluation on the introduction, methodology, result, discussion, and conclusion, a total of eight more studies were excluded; the reason being that the full text of five of the studies were written in different languages (one in Russian, one in Hebrew, one in Japanese, and two in Polish) whereas the other three studies did not meet the inclusion criteria for this review. In total, 23 studies were eventually included in this review.

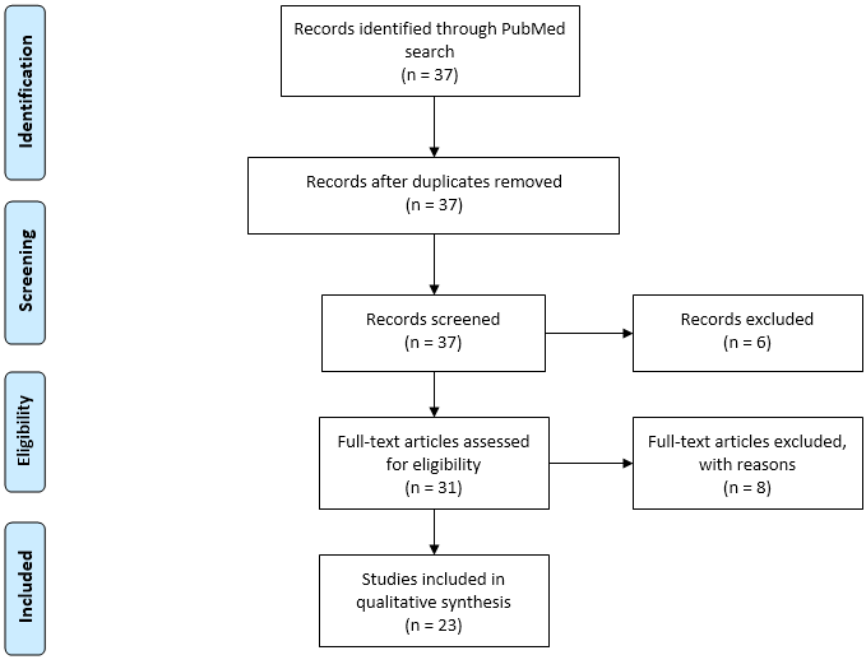

Figure 1: PRISMA 2009 flow diagram for the process of article selection

2.3 Quality assessment

The title, abstract, and full text of every article retrieved from the search were screened by one reviewer (Z.H.M.Z). To ensure rigour, a second set of reviewers (T.R.H. and S.M.S) assessed the retrieved study and provided clarification on any uncertainty regarding the eligibility of the articles. The articles were reviewed based on their relevance to SBS among office personnel.

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2.4 Data extraction

Information extracted from the articles includes study characteristics such as author, year of publication, study objectives, study design, study location, and sample size. The areas of research were determined by analysing the research objectives, results, discussion, and conclusion presented in the articles.

3.0 Result

A total of 23 articles were included in the final review and results are summarised in Table 1.

3.1 Types of study

Fourteen articles were reported as cross-sectional studies (Abdel-Hamid, Hakim, Elokda, & Mostafa, 2013; Azuma, Ikeda, Kagi, Yanagi, & Osawa, 2015; Brasche et al., 2004; Glas, Levin, Stenberg, Stenlund, & Sunesson, 2004; Jaakkola, Yang, Ieromnimon, & Jaakkola, 2007; Jung, Liang, Lee, Hsu, & Su, 2014; Kubo et al., 2006; Lim et al., 2015; Lu, Lin, Chen, & Chen, 2015a; Lu et al., 2007; Mendell, Lei-Gomez, Mirer, Seppänen, & Brunner, 2008; Mendell & Mirer, 2009; Reijula & Sundman-Digert, 2004; Skyberg et al., 2003), three were longitudinal studies (Azuma, Ikeda, Kagi, Yanagi, & Osawa, 2017; Mizoue, Andersson, Reijula, & Fedeli, 2004; Tsai et al., 2012), two were case-control studies (Glas, Stenberg, Stenlund, & Sunesson, 2008, 2015), one was a cohort study (Neuner & Seidel, 2006), one was a case report (Nakazawa et al., 2005), one was a systematic review together with epidemiological modelling (Fisk, Mirer, & Mendell, 2009), and one was a cost-benefit study (Fisk, Black, & Brunner, 2011).

3.2 Setting and samples

All studies were conducted among office personnel from different parts of the world, including Asian countries, Nordic countries, a European country, a Middle-Eastern country, and the United States (Table 1). Five articles studied office personnel in Japan (Azuma et al., 2015, 2017; Kubo et al., 2006; Mizoue et al., 2004; Nakazawa et al., 2005), four in Taiwan (Jung et al., 2014; Lu et al., 2015a, 2007; Tsai et al., 2012), four in the United States (Fisk et al., 2011, 2009; Mendell et al., 2008; Mendell & Mirer, 2009), two articles each in Sweden (Glas et al., 2004, 2008), Finland (Jaakkola et al., 2007; Reijula & Sundman-Digert, 2004), and Germany (Brasche et al., 2004; Neuner & Seidel, 2006), and one each in Norway (Skyberg et al., 2003), Egypt (Abdel-Hamid et al., 2013), and Malaysia (Lim et al., 2015). Another article studied office personnel in northern Sweden and northern Finland in the same setting (Glas et al., 2015).

Eight articles involved a nationwide study sample of office personnel; two from Japan (Azuma et al., 2015, 2017), four from the United States (Fisk et al., 2011, 2009; Mendell et al., 2008; Mendell & Mirer, 2009), and one each from Germany (Brasche et al., 2004), Finland (Reijula & Sundman-Digert, 2004), and Norway (Skyberg et al., 2003). Eleven articles involved office personnel from local regions such as cities (Jung et al., 2014; Kubo et al., 2006; Lu et al., 2015a, 2007; Skyberg et al., 2003; Tsai et al., 2012), districts (Jaakkola et al., 2007; Mizoue et al., 2004), and towns (Glas et al., 2004, 2008, 2015). Three other articles studied office personnel

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in academic institutions (Abdel-Hamid et al., 2013; Lim et al., 2015; Neuner & Seidel, 2006). In one article, the case report did not explicitly mention where the subject was from (Nakazawa et al., 2005).

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Table 1 *Literature summary for selected articles*

Author / Design / Country	Title	Objectives	Sample size Study location Study period	Study instruments, tools, and investigations	Area of research
Azuma et al. (2017) Longitudinal (nationwide) Japan	Evaluating prevalence and risk factors of building-related symptoms among office workers: Seasonal characteristics of symptoms and psychosocial and physical environmental factors	To evaluate the prevalence and risk factors of building-related symptoms and to evaluate the seasonal characteristics.	N = 3024 from 489 offices throughout Japan Jan – Mar 2012 Aug – Oct 2012	Self-administered questionnaire conducted twice, once in the winter and once in the summer.	Epidemiology - Prevalence of SBS - Risk factors of SBS
Lim et al. (2015) Cross-sectional Malaysia	Sick building syndrome (SBS) among office workers in a Malaysian university--Associations with atopy, fractional exhaled nitric oxide (FeNO) and the office environment	To study associations between SBS symptoms, selected personal factors, office characteristics, and indoor office exposure among office workers in a Malaysian university.	N = 695 from 40 offices in a major academic institution in Malaysia 2013	Self-administered questionnaire, skin prick test, FeNO test, endotoxin from office dust, (1,3)-β-glucan and house dust mites (HDM) allergens group 1, namely *Dermatophagoides pteronyssinus* (Der p 1) and *Dermatophagoides farinae* (Der f 1), indoor measurement of office temperature, relative air humidity (RH), carbon monoxide (CO), and carbon dioxide (CO2).	Epidemiology - Prevalence of SBS symptoms - Risk factors of SBS
Lu et al. (2015) Cross-sectional Taiwan	Building-related symptoms among office employees associated with indoor carbon dioxide and total volatile organic compounds	To study the prevalence of non-specific complaints about SBS, upper and lower respiratory symptoms and to examine the relationships between these symptoms and indoor concentrations of CO2 and total volatile organic compounds (TVOCs).	N = 417 from 87 office rooms of eight high-rise buildings in Taipei city Nov 2003 – June 2004	Self-administered questionnaire, physical measurement of CO2, temperature, humidity, and TVOCs in each office.	Epidemiology - Prevalence of SBS symptoms - Risk factors of SBS
Glas et al. (2015) Case-control Sweden & Finland	Exposure to formaldehyde, nitrogen dioxide, ozone, and terpenes among office workers and associations with reported symptoms	To compare the exposure to formaldehyde, nitrogen dioxide, ozone, and terpenes among office workers with and without SBS and the odds ratio for exposure.	N = 96 (cases) N = 113 (controls) from offices in Umea town, Sweden and Vasa town, Finland 2004 – 2006	Self-administered questionnaire, personal exposure measurement of formaldehyde, nitrogen dioxide, ozone, and terpenes.	Epidemiology - Risk factors of SBS

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Table 1 (*Continued*)

Author / Design / Country	Title	Objectives	Sample size Study location Study period	Study instruments, tools, and investigations	Area of research
Azuma et al. (2015) Cross-sectional (nationwide) Japan	Prevalence and risk factors associated with non-specific building-related symptoms in office employees in Japan: Relationships between work environment, indoor air quality, and occupational stress.	To estimate the prevalence of building-related symptoms (BRSs) and determine the risk factors related to work environment, indoor air quality, and occupational stress.	N = 3335 from 320 offices throughout Japan Jan – Mar 2012	Self-administered questionnaire.	Epidemiology - Prevalence of SBS symptoms - Risk factors of SBS
Jung et al. (2014) Cross-sectional Taiwan	Allostatic load model associated with indoor environmental quality and sick building syndrome among office workers.	To determine whether indoor environmental quality (IEQ) influences allostatic load (AL). To assess and compare the associations between AL and SBS versus 8-hydroxydeoxyguanosine (8-OHdG) and SBS.	N = 115 from 21 office spaces in Kaohsiung and Tainan, Taiwan Jul 2011 – Dec 2012	Study conducted from July 2011 to December 2012. Self-administered questionnaire, indoor and outdoor levels of CO, CO2, TVOC, particulate matter 2.5 micrometres, fungi, bacteria and illumination, and multisystem physiological measurements to estimate allostatic load.	Epidemiology - Risk factors of SBS
Abdel-Hamid et al. (2013) Cross-sectional Egypt	Prevalence and risk factors of sick building syndrome among office workers.	To measure the prevalence of SBS symptoms among office workers in the Faculty of Medicine, Ain Shams University, Cairo, Egypt, and to determine the possible risk factors.	N = 826 from Ain Shams Faculty of Medicine, Egypt	Self-administered questionnaire.	Epidemiology - Prevalence of SBS symptoms - Risk factors of SBS
Tsai et al. (2012) Longitudinal Taiwan	Office workers' sick building syndrome and indoor carbon dioxide concentrations.	To determine whether any association exists between SBS and indoor CO2 concentrations.	N = 111 from office buildings in Hsinchu, Taiwan August 2003 Nov 2003	Self-administered questionnaire and environmental measurement [CO2 concentrations, temperature, relative humidity, and fine particulate matter (PM) 2.5] conducted twice.	Epidemiology - Prevalence of SBS symptoms - Risk factors of SBS

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Table 1 (*Continued*)

Author / Design / Country	Title	Objectives	Sample size Study location Study period	Study instruments, tools, and investigations	Area of research
Fisk et al. (2011) Cost-benefit study (nationwide) United States (US)	Benefits and costs of improved IEQ in US offices.	To estimate benefits and costs of implementing scenarios that improve indoor environmental quality (IEQ) in the building stock of US office buildings (increasing ventilation rates when they are below 10 or 15 l/s per person, adding outdoor air economisers and controls when absent, eliminating winter indoor temperatures >23°C, and reducing dampness and mould problem).	Office workers in US office buildings (USEPA BASE Study) 1994 - 1998	Analysis of ventilation rate, indoor temperatures, and SBS prevalence data from other sources.	Interventions - Quantification of benefits and costs of selected improvements in indoor environmental quality
Mendell & Mirer (2009) Cross-sectional (nationwide) US	Indoor thermal factors and symptoms in office workers: findings from the US EPA BASE study.	To investigate the association between thermal factors and SBS symptoms.	N = 4166 from 95 building stock of US buildings (US EPA BASE Study) 1994 - 1998	Self-administered questionnaire, measurement of temperature, relative humidity, ventilation rate, thermal stress metrics, and building characteristics.	Epidemiology - Risk factors of SBS
Fisk, et al. (2009) (nationwide) Systematic review and epidemiological modelling study US	Quantitative relationship of sick building syndrome symptoms with ventilation rates.	To develop best-fit equations and curves quantifying the change in SBS symptom prevalence in office workers with ventilation rates.	Data collected from 8 studies	Establishment of criteria for input data, searching and obtaining data, extraction and analysis of applicable data, statistical analyses to fit questions into the resulting data, and integration of the best-fit equations to provide equations for the change in relative SBS symptoms prevalence versus ventilation rates.	Epidemiology - Prevalence of SBS symptoms - Risk factors of SBS
Glas et al. (2008) Case-control Sweden	A novel approach to evaluation of adsorbents for sampling indoor volatile organic compounds associated with symptom reports.	To compare the ability of 3 different adsorbents in diffusive air samplers to detect differences in chemical exposure between SBS cases and controls.	N = 15 (control) N = 15 (cases) in 8 office buildings in Umea, Sweden Nov 2000 – Apr 2001	Self-administered questionnaire, measurement of VOC using 3 different adsorbents, and analysis by gas chromatography/mass spectrometry.	Analytical chemistry

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Table 1 (*Continued*)

Author / Design / Country	Title	Objectives	Sample size Study location Study period	Study instruments, tools, and investigations	Area of research
Mendell et al. (2008) Cross-sectional (nationwide) US	Risk factors in heating, ventilating, and air-conditioning systems for occupant symptoms in US office buildings: The US EPA BASE study.	To investigate aspects of HVAC systems for associations with SBS symptoms.	N = 4326 from 97 air-conditioned office buildings in the US (US EPA BASE Study) 1994 - 1998	Self-administered questionnaire, indoor environment measurement, and inspection of ventilation system, buildings, and occupied spaces.	Epidemiology - Prevalence of SBS symptoms - Risk factors of SBS
Jaakkola et al. (2007) Cross-sectional Finland	Office work exposures and respiratory and sick building syndrome symptoms.	To assess the relation between exposure to carbonless copy paper (CCP), paper dust, and fumes from photocopiers and printers (FPP), and the occurrence of SBS-related symptoms, chronic respiratory symptoms, and respiratory infections.	N = 342 office workers living in Pirkanmaa District in South Finland 1997	Self-administered questionnaire	Epidemiology - Risk factors of SBS
Lu et al. (2007) Cross-sectional Taiwan	Oxidative stress associated with indoor air pollution and sick building syndrome-related symptoms among office workers in Taiwan.	To investigate whether SBS complaints and indoor air pollution for office workers are associated with oxidative stress indicated by urinary 8-hydroxydeoxyguanosine (8-OHdG).	N = 398 from eight buildings in Taipei city Nov 2003 – Jun 2004	Self-administered questionnaire, urinary 8-OHdG, urinary cotinine, and air pollutants, both outdoor and indoor.	Epidemiology - Prevalence of SBS symptoms - Predictors of SBS
Neuner & Seidel (2006) Cohort Germany	Adaptation of office workers to a new building - Impaired well-being as part of the sick building syndrome.	To assess the effects of spatial relocation on office staff. To investigate whether psychosocial or personal factors are better predictors of the occurrence of impaired well-being manifested as symptoms related to SBS.	N = 225 in University of Ulm, Germany Sept 2001 – Nov 2003	Self-administered questionnaire and chemical and physical parameters measurement.	Epidemiology - Prevalence of SBS symptoms - Risk factors of SBS
Kubo et al. (2006) Cross-sectional Japan	Visual display terminal work and sick building syndrome-The role of psychosocial distress in the relationship.	To investigate the association between visual display terminal (VDT) work and SBS and the role of psychosocial factors in the relationship.	N = 1881 in offices in Kitakyushu, Japan 2001	Self-administered questionnaire	Epidemiology - Risk factors of SBS

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Table 1 (*Continued*)

Author / Design / Country	Title	Objectives	Sample size Study location Study period	Study instruments, tools, and investigations	Area of research
Nakazawa et al. (2005) Case report Japan	A case of sick building syndrome in a Japanese office worker.	To describe a case of SBS in an office worker.	A 36 year-old female office worker Clinical course Feb 2001 – Aug 2002	Medical history, physical examination, and laboratory investigations.	A case report
Mizoue et al. (2004) Longitudinal Japan	Seasonal variation in perceived indoor environment and non-specific symptoms in a temperate climate.	To clarify seasonal variation in a perceived indoor environment and SBS symptoms in a temperate climate.	N = 116 in offices in southern Japan Apr 1999, Aug 1999, Oct 1999, Dec 1999	Self-administered questionnaire given 4 times at the end of each season, data from weather stations, and measurement of indoor temperature and humidity.	Epidemiology - Prevalence of SBS symptoms - Risk factors of SBS
Glas et al. (2004) Cross-sectional Sweden	Variability of personal chemical exposure in eight office buildings in Sweden.	To measure air quality variability between buildings and among individual office workers. To determine whether chemical exposure differences exist across genders.	N = 79 in 8 buildings in Umea, Sweden Nov 2000 – Apr 2001	Self-administered questionnaire, individually attached air samplers to measure VOC, aldehydes, NO2, amines, ozone and particles, and building characteristics.	Epidemiology - Risk factors of SBS
Brasche et al. (2004) Cross-sectional (nationwide) Germany	Comparison of risk factor profiles concerning self-reported skin complaints and objectively determined skin symptoms in German office workers.	To assess the association between the risk factor profiles of the self-reported skin symptoms with the risk factor profiles of objectively examined low skin humidity and low sebum content of the skin to test.	N = 925 from 14 German office buildings (ProKlima project) 1995 – 1998	Self-administered questionnaire, medical examination of the skin using sensory perception score, skin sebum content and hydration of stratum corneum, and indoor environment measurement.	Epidemiology - Prevalence of SBS symptoms - Risk factors of SBS
Reijula & Sundman-Digert (2004) Cross-sectional (nationwide) Finland	Assessment of indoor air problems at work with a questionnaire.	To assess the extent of indoor air problems in office environments in Finland.	N = 11154 from 122 offices in Finland 1996 – 1999	Self-administered questionnaire	Epidemiology - Prevalence of SBS symptoms
Skyberg et al. (2003) Cross-sectional Norway	Symptom prevalence among office employees and associations to building characteristics.	To determine the association between symptom prevalence and building characteristics such as dry air, stuffy air, dust, and temperature.	N = 3562 from 32 office buildings in Oslo, Norway March – April	Self-administered questionnaire for office workers and building engineers	Epidemiology - Prevalence of SBS symptoms - Risk factors of SBS

Although there are 23 articles, they are actually from only 18 different studies. Articles by Azuma et al. (2017) and Azuma et al. (2015) are from the same study conducted in multiple office buildings in all 47 prefectures throughout Japan. Articles by Lu et al. (2015) and Lu et al. (2007) are also from the same study conducted much earlier, from 2003 to 2004, involving office personnel from eight high-rise buildings located in Taipei city. Three articles used data obtained from the United States Environmental Protection Agency Building Assessment Survey and Evaluation Study (US EPA BASE Study) which was conducted from 1994 until 1998 involving 100 US building stocks (Fisk et al., 2011; Mendell et al., 2008; Mendell & Mirer, 2009). Two articles by Glas et al. (2008) and Glas et al. (2004) are from the same case-control study conducted between November 2000 and April 2001 in eight office buildings in Umea city, Sweden.

From the 18 different studies, 12 studies were conducted between 1994 and 2004 (Brasche et al., 2004; Glas et al., 2004, 2008, 2015; Jaakkola et al., 2007; Kubo et al., 2006; Lu, Lin, Chen, & Chen, 2015b; Lu et al., 2007; Mendell et al., 2008; Mendell & Mirer, 2009; Mizoue et al., 2004; Nakazawa et al., 2005; Neuner & Seidel, 2006; Reijula & Sundman-Digert, 2004; Tsai et al., 2012). However, only three studies were conducted between 2011 and 2013 (Azuma et al., 2015, 2017; Jung et al., 2014; Lim et al., 2015). The other two studies did not mention regarding their study period in the published articles (Abdel-Hamid et al., 2013; Skyberg et al., 2003), and another one article was an analysis of eight different studies, all conducted before 2004 (Fisk et al., 2009).

3.3 Scope of research

Twenty-one articles are epidemiological studies which focused on the prevalence of SBS symptoms, risk factors, and predictors of SBS (Table 1). One article focused on the cost and economic benefit of selected interventions in indoor environmental quality for office buildings (Fisk et al., 2011). Another article looked into analytical chemistry to compare the ability of three different adsorbents in diffusive air samplers to detect differences in chemical exposures among office personnel (Glas et al., 2008). The scope of research in these articles are summarised in Table 2.

In the studies on the prevalence of SBS symptoms, the symptoms were often pooled into five different groups: eye irritation, skin irritation, upper respiratory, lower respiratory, and non-specific or general symptoms. Some studies did not measure the prevalence of lower respiratory symptoms such as shortness of breath or dyspnoea, wheezing, or chest tightness (Abdel-Hamid et al., 2013; Glas et al., 2008, 2015; Kubo et al., 2006; Mizoue et al., 2004; Nakazawa et al., 2005; Neuner & Seidel, 2006; Reijula & Sundman-Digert, 2004; Skyberg et al., 2003).

With regard to the risk factors and predictors of SBS, they can be categorised into several broad groups, which are mainly personal factors, work environment, indoor environmental factors (including chemical and biological), outdoor environment, building characteristics, job stressors, and ergonomics. Factors that have been less studied among office personnel (three studies and below in 15 years) include the use of contact lenses, static electricity, thermal comfort, the number of people in an office room, indoor workplace installation such as fragrance, air freshener, or insect repellent, office location, traffic near the office, ergonomics, sun protection, heating, cooling and humidification system, age of the building, lighting control, spatial factors, biological factor and effects of certain chemicals such as sulphur dioxide (SO2),

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nitric oxide (NO2) and ozone, illness prevention and intervention, as well as measurements of physiological changes related to SBS such as skin hydration, sebum content, level of urine 8-OHdG, and fractional exhaled nitric oxide.

4.0 Discussion

When the interest in SBS had reached its peak in the 1990s, nationwide studies on SBS among office personnel were conducted in the US (US EPA BASE Study), Nordic countries, and Germany. However, they were cross-sectional studies and had no long-term follow-up planned for the participants. For the past 15 years, most studies on SBS among office personnel have been cross-sectional studies and a few longitudinal studies, with the exception of a nationwide study on office personnel and SBS in Japan, conducted in 2012 (Azuma et al., 2015, 2017). This apparent decline of studies (12 studies between 1994 and 2004 and only three studies between 2011 and 2013) among office personnel and their work environment may be caused by an upsurge in the interest to study SBS among populations other than office personnel, including healthcare workers who are not working in office settings, pregnant women, residents, and schoolchildren, in which the effects of SBS could be more pronounced.

Although the WHO had tried to define SBS in the 1980s, currently, the term SBS is still loosely defined and each study has its own operational definition. The assessment of SBS symptoms is normally done through self-administered questionnaire. Recall period varies between studies and it can be as short as a week or as long as 12 months. Symptoms are commonly pooled into five main groups which are skin irritation, eye irritation, upper respiratory, lower respiratory, and general symptoms. There were studies which did not include the lower respiratory symptoms such as wheezing, shortness of breath, or chest tightness in their assessments of SBS (Abdel-Hamid et al., 2013; Glas et al., 2015; Jaakkola et al., 2007; Kubo et al., 2006; Neuner & Seidel, 2006). This disaccord may be attributed to the fact that lower respiratory symptoms were normally associated with other common diseases such as asthma, chronic obstructive pulmonary disease, or cardiovascular disease. Questionnaires such as the MM 040 NA Office questionnaire for indoor climate in office environment which was developed in Sweden included questions on allergies, asthma, and smoking in order to exclude these factors as the causes for lower respiratory symptoms (Andersson, 1998). On grounds of discrepancies in the investigated symptoms and varied recall periods, there would be a difficulty in making a direct comparison on the prevalence of SBS symptoms between those studies.

Interesting factors such as seasonal variation has been reported to affect SBS symptoms (Azuma et al., 2017; Mizoue et al., 2004). However, the two studies which reported this association were conducted in the same country, Japan. Japan has temperate and continental climate with four seasons (Peel, Finlayson, & McMahon, 2007); thus, findings by Azuma et al. (2017) and Mizoue et al. (2004) may not apply in a tropical country such as Malaysia, which has dry and rainy seasons, or Mediterranean countries such as Spain and Monaco. The studies on SBS among office personnel seem to concentrate in countries such as the Nordic countries, Japan, the US, and a few other countries in Asia. There are no studies from Latin America, Northern America, Africa, the United Kingdom (UK), Australia, and other countries in Asia such as China and India. Australia, for example, has no specific control on indoor air quality apart from

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workplace areas which are being regulated under the National Occupational Health and Safety Commission. This may be one of the reasons why there have been no studies on SBS and indoor quality among office personnel in Australia for the past 15 years. It would certainly be interesting to study the effects of different climates and seasonal variations on SBS.

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Table 2 *Scope of research in articles*

	Azuma et al. (2017)	Lim et al. (2015)	Lu et al. (2015)	Glas et al. (2015)	Azuma et al. (2015)	Jung et al. (2014)	Abdel-Hamid et al. (2013)	Tsai et al. (2012)	Fisk et al. (2011)	Mendell & Mirer (2009)	Fisk et al. (2009)	Glas et al. (2008)	Mendell et al. (2008)	Jaakkola et al (2007)	Lu et al. (2007)	Neuner & Seidel (2006)	Kubo et al. (2006)	Nakazawa et al. (2005)	Mizoue et al (2004)	Glas et al (2004)	Brasche et al. (2004)	Reijula & Sundman-Digert (2004)	Skyberg et al. (2003)
Symptoms associated with SBS																							
Eye irritation	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	-	+	-	-	+	+
Skin irritation	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+
Upper respiratory	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	-	-	+	+
Lower respiratory	+	+	+	-	+	+	-	+	-	+	+	-	+	+	+	-	-	-	-	-	-	-	-
Non-specific	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	-	-	+	+
Risk factors and predictors																							
Personal factors																							
Gender	+	+	+	-	+	+	+	+	-	+	-	-	+	+	+	+	+	+	+	+	+	+	+
Age	+	+	+	-	+	+	+	+	-	+	-	-	+	+	+	+	+	+	+	-	+	+	+
Tobacco smoking	+	+	+	-	+	+	+	+	-	+	-	-	+	+	+	-	+	-	+	-	-	-	+
Allergy	-	+	+	-	-	+	-	+	-	+	-	-	+	+	+	-	+	-	-	-	+	+	+
Contact lens use	+	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Working hours	-	-	+	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Working experience	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Work environment																							
Laser printer/copy machines	+	-	-	-	+	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+
Video display unit (VDU)	+	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	+	+	+
No. of people in a room	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indoor workplace installation (fragrance/air freshener/repellent)	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carpet	+	+	+	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+

(+) Factor studied (-) Factor not studied

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Indoor environment																							
Humidity	+	+	-	-	+	-	+	+	-	+	-	-	+	-	-	+	-	-	+	-	+	+	+
Room temperature	+	+	-	-	+	-	+	+	-	+	-	-	+	-	-	+	-	-	+	-	+	+	+
Odour	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
Static electricity	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Environmental tobacco smoke	+	-	+	-	+	-	+	-	-	-	-	-	-	+	+	-	+	-	+	-	-	-	+
Noise	+	-	-	-	+	-	+	-	-	-	-	-	-	-	-	+	-	-	+	-	+	-	-
Lighting	+	-	-	-	+	+	+	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-
Dust and dirt	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
Ventilation rate	+	-	-	-	+	-	+	-	+	-	+	-	+	-	-	-	-	-	-	+	+	-	+
Thermal comfort	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Outdoor environment																							
Office location	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Traffic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Garage/parking	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Seasonal variation	+	-	+	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	+	-	-	-	-
Building characteristics																							
Sun protection	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Heating system	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	+
Cooling system	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	+
Temperature control	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	+	-	-	-	-	-	-	+
Ventilation system	-	-	-	-	-	-	+	-	+	-	-	-	+	+	-	+	-	-	+	+	+	+	+
Age of building	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-
Lighting control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Spatial factors	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Humidification system	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-

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Job stressors	+	-	+	+	+	-	+	-	-	-	-	-	+	+	+	+	+	+	-	-	-	+	+
Ergonomics	+	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Chemicals																							
VOC	-	-	+	+	-	+	-	-	-	-	-	-	+	-	+	+	-	-	-	+	+	-	-
CO2	-	+	+	-	-	+	-	+	-	-	-	-	-	-	+	-	-	-	+	-	+	-	-
CO	-	+	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-
SO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
NO2	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-
Particulate matters	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-
Ozone	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Formaldehyde	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	-	-	-
Biological																							
Fungi/mould	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-
Bacteria	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Endotoxin	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Dust mites	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Prevention and intervention																							
Cost	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Economic benefit	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Technical equipment																							
Air samplers		-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Physiological methods to measure SBS																							
Skin hydration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Sebum content	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Oxidative stress (urine 8-OHdG)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Allostatic load	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fractional exhaled nitric oxide	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Symptoms of SBS are mostly non-specific and may overlap with other illnesses. These symptoms have been regarded as minor although some quarters have debated on the importance of studying SBS. However, earlier studies had suggested that office personnel who are affected by SBS may have reduced work productivity and an increase in absenteeism (Singh, 2005). Nakazawa et al. (2005) reported a case of SBS in which a worker was severely affected by the illness to the extent that it prevented her from going to work. The particular worker had been visiting several medical facilities for her problem before eventually being diagnosed by Nakazawa's team. It took six months and various doctors, clinics, and hospital visits before the diagnosis was finally made, and another six months before an environmental survey was conducted at the worker's office. The worker submitted a claim for payment of compensation under Workmen's Accident Compensation Insurance and her application was approved two years later after a year of follow-up, various biological investigations, and environmental investigation. This case illustrates the importance of educating not only employers and employees, but also medical practitioners on SBS and the nature of illness, so that this illness would be thought of as a differential diagnosis during management of such a case. Illness recognition is important so that the affected office personnel who seek appropriate medical help would receive timely diagnosis followed by appropriate individual intervention. At the same time, workplace intervention can be initiated by the employer after a thorough environmental investigation. The case study by Nakazawa et al. (2005) has also shown that SBS could affect individuals differently. Certain individuals can be severely affected that the absence of an appropriate intervention may cause their health to deteriorate significantly, to the extent that it would affect their work performance.

5.0 Conclusion and recommendation

The areas of research on SBS among office personnel for the past 15 years have concentrated on the prevalence of SBS symptoms, risk factors, and predictors. Our recommendation is to conduct studies determining seasonal variations in the occurrence of SBS symptoms among office personnel. These seasonal variations may include rainy and dry seasons in the tropical rainforest climate or tropical monsoon climate, the warm, dry summers and cool, mild winters in the Mediterranean, as well as the four different seasons in the temperate and continental climates in the African, Asian, European, and North American continents. The second recommendation is to conduct a large cohort study to look into the nature of the illness, including its short-term, medium-term, and long-term consequences to office personnel who spend about 30% of their day at the workplace, starting from the first day of employment. This can be done as part of work surveillance under the occupational safety and health unit. Finally, the third recommendation is to conduct studies focusing on the economic consequences of SBS, individual and environmental preventive strategies to reduce SBS, as well as the cost-effectiveness of SBS intervention strategies at the workplace.

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Declaration

The authors declare no conflict of interest.

Authors' contribution

Author 1: Information gathering, preparation, and editing of manuscript
Author 2: Review of manuscript and editing
Author 3: Review of manuscript and editing

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