



# SICK BUILDING SYNDROME

## Do we live and work in unhealthy environment?

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### Abstract

*The sick building syndrome (SBS) is defined as environmentally related condition with increased prevalence of non-specific symptoms among the populations of certain buildings, often without clinical signs and objective measures of symptoms. SBS complaints seem to be the result of the interaction of environmental, occupational, and psychological factors, and they are probably not caused by poor indoor air quality alone.*

*This review gives a brief overview of SBS, along with focusing on many of the causes of »sick« homes and buildings and discussing the research dedicated to solving this increasing problem. Relevant literature during the past 20 years was selected from Medline and discussed.*

*The overview focuses on the relationship between selected aspects of indoor environment quality and health and comfort outcomes related to sick building syndrome. Among environmental factors assessed, there were generally consistent findings associating increased symptoms with air-conditioning, many workers in a space, videoterminal use, and ventilation rates at or below 10 liters/second/person. Among personal factors assessed, there were generally consistent findings associating increased symptoms with female gender, job stress/dissatisfaction, and allergies.*

*Sick building syndrome generally affects people employed in offices or other buildings that house many workers in close proximity. Most frequently, it occurs in newer office buildings which are designed to be energy-efficient. A multi-disciplinary approach including personality aspects, allergic disorders and indoor exposures should be applied in investigations of human health problems related to staying in modern buildings.*

### INTRODUCTION

Although many of us think of air quality and air pollution as outdoor problems, they are becoming increasingly common in modern buildings. Previously, buildings were open to the outside air, a system that could be referred to as natural ventilation. However, technological advances have permitted to seal buildings tightly, recirculate the air within them, and fill them with a variety of particle- and chemical-emitting materials and devices. The spaces that contain sufficient levels of chemicals, allergens and other particles to make those who live or work in the space sick are »sick« homes and buildings. The world is experiencing a growing problem with a range of diseases collectively referred to as Sick building syndrome (SBS), Building-related illness (BRI) and Multiple chemical sensitivities (MCS).

**Sick building syndrome** is a term used to describe office worker discomfort and medical symptoms that are related to building characteristics, to pollutant exposures and to work organization, and that are mediated through personal risk factors (1). There is no agreed upon definition for a »sick building,« nor is it clear how to definitely diagnose a sick building but we use here the phrase »sick building syndrome« because of its widespread acceptance (2).

### Health complaints related to sick building syndrome

Although not precisely defined, SBS is evident in a building when symptoms are unusually severe, frequent, or widespread. This is a diverse group of specific and non-specific complaints (3, 4):

- eye, nose and throat irritation
- sensation of dry mucous membranes and skin
- erythema
- mental fatigue
- headache
- high frequency of airway infection and cough
- hoarseness, wheezing, itching and unspecific hypersensitivity
- nausea, dizziness

SBS is one of a number of workplace-related health complaints, often without clinical signs and objective measures of symptoms. All these symptoms are common in the general population; the distinguishing feature which makes them part of the sick building syndrome is their temporal relation with work in a particular building. When more than 20 percent of people working in one building have these symptoms and they disappear or decrease dramatically when employees leave the building, this can be an indication of »sick building syndrome« (5).

Sick building syndrome is distinguished from more medically serious building-related illness (asthma and hypersensitivity pneumonitis, carbon monoxide poison-

ing inhalation fever and infection), as well as from various other medically unexplained syndromes such as chronic fatigue syndrome, fibromyalgia, multiple chemical sensitivities, and even psychiatric conditions characterized by somatic symptoms by its subjective nature, reversibility, high prevalence and rapid resolution when affected persons leave. Work-related health symptoms and complaints that are commonly attributed to indoor air quality problems were assessed by means of standardized questions in all subjects (6, 7). Solving an indoor air problem requires systematic work, in which the indoor air questionnaire serves as an aid for the occupational health personnel to obtain symptom prevalence data, demographic information, and job and workspace characteristics. SBS-related symptoms show a wide variation between different buildings (Figure 1); »sicker« buildings often have conditions of air temperature, humidity, and lighting levels that fully comply with current standards.

### Factors related to increased prevalence of sick building syndrome

Research suggests that each person's health can be influenced by a variety of environmental and workplace factors, not all of which are physical. Each factor describes a risk which can affect health: indoor environment conditions; building characteristics; work characteristics; and personal characteristics. Based on the summaries by Apter *et al.* (9), Redlich *et al.* (10), Burge (11) and Menzies and Bourbeau (2), the following factors seem to be among the most frequent causes of the sick building syndrome:

#### Building Factors

- Air conditioned building (6, 12)
- Fresh air ventilation rates < 10 liters/second/person (13, 14)
- High indoor temperature (over 23 °C in air conditioned buildings) (11, 15)
- Poor individual control of temperature and lighting (16)
- Poor building service maintenance and cleaning (11)
- Relative humidity < 30% (17, 18)

#### Specific Environmental Factors & Pollutants

- Volatile organic compounds (VOCs): formaldehyde, solvents, etc. (19, 20)
- Carbon monoxide: stoves, heaters, and furnaces (21)
- Dust and fibres: asbestosis, fiberglass, dirt (22-24)
- Bioaerosols: Bacteria, moulds, viruses, pollen, dust mites, animal danders, animal excreta (16, 25-27)
- Trapped outdoor pollutants: vehicle or industrial exhausts (28, 29)
- Physical factors: Lighting, vibration, noise, temperature, crowding, photoduplication (30)
- Cigarette smoke (14)
- Increased use of computers (31, 32)

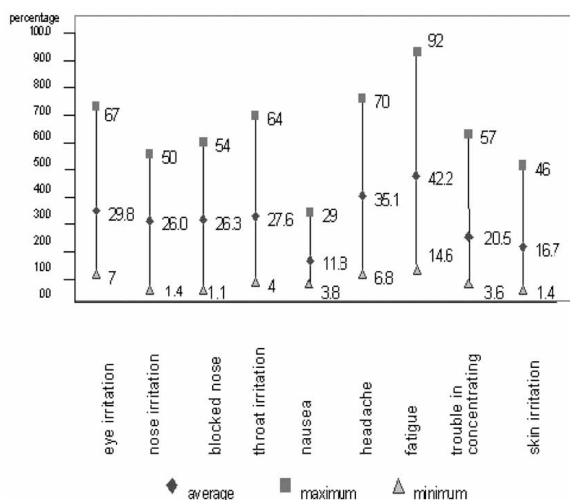


Figure 1. Prevalence of SBS-related health symptoms (8).

### Personal Factors

- Female gender (33)
- History of being allergic (atopic) (34, 35)
- Job dissatisfaction (32, 36)

SBS complaints are influenced by various non-environmental variables, such as personal, occupational, and psychological factors, which can either directly or indirectly alter the stress load on a person, which in turn influences susceptibility and reports of SBS symptoms by individual workers (37). Psychosocial processes may act directly as stressors, causing symptoms through psycho-physiological mechanisms. Furthermore, they may render the individual more sensitive to normally tolerated physical and chemical factors in the environment (9, 38).

### Epidemiological studies on the sick building syndrome

One of the reasons that sick building syndrome is so difficult to investigate is that people's symptoms are often relatively mild or can result from a variety of causes. A number of factors have been identified in experimental and field studies which contribute to SBS, although there remains much uncertainty about specifics of exposure, dose, susceptibility, and in particular the development of chronic symptoms (11, 21, 39).

In the study of environmentally related non-specific conditions, such as SBS, there are methodological difficulties related to the apparently unknown associations between symptoms and exposure, and the resulting difficulties in defining either disease or cause (40).

However, large European surveys (4, 16, 41, 42) as well as meta-analysis of Mendell and Smith (40), have provided insight into the epidemiology of the sick building syndrome. Among environmental factors assessed, there were generally consistent findings associating increased symptoms with air-conditioning, carpets, and many workers in a space, videoterminal use, and ventilation rates at or below 10 liters/second/person. Studies with particularly strong designs found decreased symptoms associated with low ventilation rate, short-term humidification, negative ionization, and improved office cleaning, although the studies reviewed showed little consistency of findings for humidification and ionization. Relatively strong studies associated high temperature and low relative humidity with increased symptoms, whereas less strong studies were not consistent. Among personal factors assessed, there were generally consistent findings associating increased symptoms with female gender, job stress/dissatisfaction, and allergies/asthma. It remains uncertain whether report of asthma and allergies is an outcome, a confounder or a predisposing factor for reports of mucous membrane irritation symptoms. For other environmental or personal factors assessed, findings were too inconsistent or sparse for current interpretation, and there were no findings from strong studies. Overall evidence suggested that work related symptoms among office workers were relatively common, and

that some of these symptoms represented preventable physiologic effects of environmental exposures or conditions.

Inadequate ventilation has been considered to be a causal factor in 50 percent of sick buildings in the United States and in 68 percent of Canadian investigations (7,8). However, ventilation would in turn reduce the amount of contamination with chemicals or micro-organisms, so that increased ventilation can be seen as an effective treatment rather than a cause. As summarized by Fisk *et al.* (23), there is evidence that ventilation systems could be sources of bioaerosols, fibers, and volatile organic compounds.

Women report symptoms more frequently than men, a difference that may be due to the fact that women are employed predominantly in clerical/secretarial jobs, they need a lesser dose of a chemical or pollutant to become ill. Also, women tend to be more aware of how they feel than men (33, 41, 43).

In the opinion of some World Health Organization experts, up to 30 percent of new or remodelled commercial buildings may have unusually high rates of health and comfort complaints from occupants that may potentially be related to indoor air quality (44, 45). At least 20 to 35 percent of workers report SBS symptoms, even in non-problem buildings.

Of the symptoms listed in the survey, headache, stuffy nose, and fatigue were each reported by more than 40 percent of all participants.

In a study of 4373 people working in 46 buildings (32) the questionnaire analysis indicated that the main symptoms prevailing were lethargy (57%), followed by stuffy nose (47%), dry throat (46%), headache (43%), and itching eyes (28%). The most common indoor air related symptoms reported by the Croatian population (46) were fatigue (48%), itching, burning, or irritation of eyes (42%), headache (37%), as well as hoarse or dry throat (30%). The most common environmental problems reported that had occurred during last two weeks were poor air quality (63%), and thermal discomfort (39%). This finding was found to be consistent with the results in studies based on different kinds of samples (16, 26, 32, 41).

A research study conducted by Hedge (32) showed that the SBS is the outcome of complex processes initiated by a set of stressful multiple risks which create personal strain. Study on sick building syndrome has shown that 80 percent had SBS symptoms and only 4 percent of people in air-conditioned buildings feel that they have any control over ventilation and over temperature, compared with 33 percent and 17 percent, respectively, in naturally/ mechanically ventilated buildings. Psychological variables and personality traits may play a prominent role in workplace-related disorders like sick building syndrome (47-49).

Sick building syndrome is considered an important problem of occupational medicine, bearing in mind that

50% of the entire workforce in industrialized countries works in this type of buildings, and nearly 20-30% of this group of workers report symptoms, suggesting the prevalence of sick building syndrome. The people with clerical/secretarial jobs have 50 percent more symptoms than those with managerial posts, and 30 percent more than »professionals« (50, 51). Sick building syndrome is often not taken seriously by the management since managers are less likely to suffer from the symptoms. Managers often have larger offices, furnished with more expensive materials such as natural wool and real wood which are less likely to give off noxious gases, less equipment such as photocopiers and word-processors, and the freedom to move about and out of the building.

There are few publications on SBS symptoms in relation to domestic exposure (17, 20, 52, 53), and there is the need to study the relationship of different aspects of home environment and medical symptoms.

SBS is considered a multifactorial health problem, being at the same time a medical, psychological and social phenomenon (54).

### Recommendations for improvement of indoor air quality

Indoor environment should be designed to meet basic human requirements for a healthy and comfortable indoor environment while at the same time ensuring low energy consumption. A healthy indoor environment includes the following:

- adequate rate of fresh outdoor air supply
- acceptably low levels of dusts, gases, vapours, and biological contaminants
- adequate temperature and relative humidity
- workstation design that promotes the physical and mental well-being of workers (8).

WHO has set guidelines for proper management of building ventilation systems to minimize introduction of contaminants and prevent SBS in building occupants (45). Nine statements and comments were established at a WHO Working Group Meeting in Bilthoven, the Netherlands, May 15–17, 2000 (55).

1. Under the principle of the human right to health, everyone has the right to breathe healthy indoor air.

2. Under the principle of respect for autonomy (self-determination), everyone has the right to adequate information about potentially harmful exposures, and to be provided with effective means for controlling at least part of their indoor exposures

3. Under the principle of non-maleficence (doing no harm), no agent at a concentration that exposes any occupant to an unnecessary health risk should be introduced into indoor air.

4. Under the principle of beneficence (doing good), all individuals, groups and organizations associated with a building, whether private, public or governmental, bear responsibility to advocate or work for acceptable air quality for the occupants

5. Under the principle of social justice, the socio-economic status of occupants should have no bearing on their access to healthy indoor air, but health status may determine special needs for some groups

6. Under the principle of accountability, all relevant organizations should establish explicit criteria for evaluating and assessing building air quality and its impacts on the health of the population and on the environment

7. Under the precautionary principle, where there is a risk of harmful indoor air exposure, the presence of uncertainty shall not be used as a reason for postponing cost-effective measures to prevent such exposure

8. Under the »polluter pays principle«, the polluter is accountable for any harm to health and for welfare resulting from unhealthy indoor air exposures. In addition, the polluter is responsible for mitigation and remediation

9. Under the principle of sustainability, health and environmental concerns cannot be separated, and the provision of healthy indoor air should not compromise global or local ecologic integrity, or the rights of future generations

The best way to prevent sick building syndrome is proper design of buildings and ventilation systems so that people have plenty of natural light and individual control over heating and ventilation. The EPA publication entitled »Indoor Air Pollution: A Introduction for Health Professionals« is a guide for physicians that specifically addresses the issues of evaluating building-related symptoms (56).

The steps taken to help identify if an office or a building has an indoor air quality problem may vary from situation to situation but will include:

- Investigate the ventilation system to make sure it is operating properly
- Look for possible causes (e.g., source of a chemical, renovations, mould, etc.).
- Rule out common causes of the symptoms such as noise, thermal comfort, humidity, ergonomics, lighting, etc.
- Use the SBS questionnaire in health survey in consultation with a health and safety professional or other expert(s) (56, 57).
- Modify or customize this questionnaire to address the conditions and work practices at your workplace.
- Analyze the responses in consultation with an expert

1) comfort problems due to improper temperature and relative humidity conditions, poor lighting and unacceptable noise levels, adverse ergonomic conditions (poorly designed work stations and tasks) and job-related psychosocial stressors, and

2) adverse health effects including typical symptoms (headaches, unusual fatigue, itching or burn-

ing eyes, skin irritation, nasal congestion, dry or irritated throats and nausea) and laboratory findings.

- Consider help and/or air testing by qualified professionals.

A multi-disciplinary approach should be applied in investigations of human health problems related to staying in modern buildings. Future research on this problem should include blind experimental and case-control studies, using improved measurements of both environmental exposures and health outcomes.

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