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Sick Building Syndrome, epidemiological studies and medical aspects

P Sherwood Burge
Director, Occupational lung disease unit
East Birmingham Hospital
Bordesley Green East
Birmingham B9 5ST, England

Abstract

The sick building syndrome comprises a group of symptoms that are common in the general population, but which are more prevalent in some buildings than others. The principal symptoms are lethargy, headache, blocked nose, runny nose, dry eyes, sore eyes, dry throat and sometimes dry skin and asthma. These problems have usually been studied in office workers, where there are less confounding factors, but similar symptoms occur in other indoor environments such as schools and hospitals. All studies so far have shown that naturally ventilated buildings have less symptomatic workers than air conditioned buildings, despite conditions which conform less to indoor environmental standards, which have been developed for comfort rather than health. Women are more susceptible than men, and public sector workforces have more problems than those in the private sector. The mechanisms for the symptoms are not yet defined, their elucidation will provided clues to the causes.

## EPIDEMIOLOGICAL STUDIES IN EUROPEAN OFFICE WORKER POPULATIONS

The first study of a number of buildings unrelated to known building sickness was by Finnegan et al in 1984 The study looked predominantly at the role of humidifiers but included the first systematic sick building enquiry of nine buildings. Doctor administered questionnaires were used. Five of the buildings had air conditioning with humidifiers, three were naturally ventilated and one had mechanical ventilation without humidification. Work-related symptoms of sick building syndrome were substantially more common in the air conditioned buildings than in the naturally ventilated buildings. The prevalence of nasal symptoms, headache and lethargy were two to three times higher once the buildings were sealed (compared with naturally ventilated buildings). The addition of humidification would further increase the eye irritation, nasal symptoms, asthma, humidifier fever and dry skin. This study suggested that not all the symptoms of building sickness had the same cause and that sealing the building and the introduction of humidification and chilling were associated with symptoms.

A similar questionnaire, this time self administered, was used in the study of 4,373 office workers in 47 different working groups in the UK with different ventilating conditions (Burge et al 1987). This study confirmed that in general, naturally and mechanically ventilated buildings

without humidification or chilling had fewer symptomatic workers than buildings with any kind of full air conditioning. They also investigated the individual factors which contributed to symptoms, in particular females had more symptoms than males and workers lower down the office hierarchy had more symptoms than those higher up, irrespective of sex. These factors need to be taken into account when comparing different workforces. An adjusted figure for the average number of work-related symptoms for occupants of the building (the building symptoms index) was developed to make each worker equivalent to a male manager (the class of workers with the least symptoms). The results for the 47 buildings are shown in Fig 1. This shows that the best buildings are naturally ventilated but that some of the naturally ventilated buildings have more symptomatic workers and some of the air conditioned buildings have less. However, there is a great variation within each ventilation class. The study also showed that in general workers in public sector buildings had more symptoms than workers in private sector buildings. One building was studied with both a public sector and a private sector workforce, each had similar building symptom indices, suggesting that the reason for the difference between the two sectors was in the buildings and their maintenance rather than the management structure. This needs to be confirmed in larger studies.

A study of public sector work is in and around Copenhagen (Skov and Valbjorn 1987) removed the confounding factor of type of employer. Fourteen town halls were studied, six were naturally ventilated, only two had re-circulated air and two humidification. Most of them had predominant natural ventilation. Their study confirmed findings of the previous two studies, again there were substantial differences between different buildings. They grouped their symptoms into lethargy and headache on one hand, and eye, nose and throat symptoms on the other. In most buildings the prevalences of the two groups of symptoms correlated reasonably well. However, there were a group of buildings where eye, nose and throat symptoms predominated over lethargy and headache, suggesting that the causes were different, at least in these buildings. Their study contacted 3,507 out of a possible 4,369 employees. Their work suggested that the amount of dust and absorbent material in the environment contributed to building sickness. They introduced the term 'fleece' factor (the area of fabric such as carpets, curtains, soft furnishings, divided by the volume of the room) and 'shelf factor' (the length of open shelves and cupboards divided by the room volume). Both of these correlated with symptoms. Symptoms are also related to the concentration of dust that could be extracted from the carpets but not related to personal factors such as drinking coffee (which actually reduced symptoms).

The largest study to date has taken place in Holland in 61 buildings largely contacted through their Occupational Health Service (Preller et al 1990). Nineteen of the

buildings were naturally ventilated, 42 had some sort of air conditioning, 13 had steam-humidification and 12 water-spray humidifiers. Completed questionnaires were returned from 7,030 out of 10,500 workers (74% response rate). The study confirmed the increased number of symptoms in females compared with men and the increased number of symptoms in air conditioned versus naturally ventilated buildings. They were unable to demonstrate any effect of humidification or any difference between steam or water spray humidifiers and were unable to confirm the shelf and fleece factor hypothesis from the Copenhagen study. They showed that subjects reporting allergy had increased risk of symptoms. As many of the symptoms could be regarded as allergic (such as runny noses and sore eyes) it is difficult to know whether the allergy reported was preceding the sick building syndrome symptoms or was reported because the symptoms of sick building syndrome were thought to be allergic. The study also showed an increased number of symptoms in those dissatisfied with the procedure for handling complaints within the building (this was in fact the strongest risk factor) increased symptoms with those who were unable to adjust temperature locally and a small increase in those using VDU's. The study was unable to find any effect of active smoking (present in 35% of the workforce), opening windows, age, education, the number of people in the room or the presence of carpet, shelves or curtains (i.e., the 'fleece' factor and 'shelf' factor of the Copenhagen study could not be reproduced).

A preliminary report has appeared of a large study from Northern Sweden (Stenberg et al 1990) which studied 6,000 office workers in buildings with at least 10 workers per building (the other studies have usually had a minimum of 50 per building). The study involved a screening questionnaire and case control studies nested within the responders, 4,943 questionnaires were processed. Again females have more work-related symptoms than males. The study showed that atopy (defined as a history of asthma or hay fever) doubled the risk of being a sick building syndrome case (not defined). Symptoms were also about 20% more common in VDU users but these were more often female and this was not adjusted for. A nested study investigated 584 rooms in 192 buildings, the rooms selected either for cases of sick building syndrome or controls (Sundell et al 1990). The rooms containing those with building sickness had the same fresh air supply rate, the same relative humidity, temperature, shelf factor and fleece factor as the buildings from these who were asymptomatic. However, the variation of these factors between the buildings studied was not very large (for instance mean temperature varying from 22.4 to 23.2°C and mean relative humidity from 22.1 to 28.8%). We also have been unable to demonstrate that "sick" buildings have poorer standard indoor air quality measures than healthier buildings, but did show that plant maintenance was worse in the sicker buildings (Burge et al 1990).

None of the above studies have used a random selection of buildings and some would argue that they have picked out buildings where symptoms were known to occur (although this wasn't stated at the time). It is attractive to designate buildings as either sick or healthy, in fact the evidence suggests there is a continuous gradation. An interesting study has taken place in Germany using a market research company to contact adults away from the workplace (Kroeling 1987). Those who worked in offices and schools were asked whether they worked in an air conditioned or naturally ventilated building. The symptoms of building sickness were all significantly more common in those working in air conditioned buildings (420 workers) compared with those working in naturally ventilated buildings (699 workers). Workers from air conditioned buildings also rated their environment as less satisfactory than those working in naturally ventilated buildings.

Several of the above studies have used different interview techniques and different definitions of work-related symptoms. Some reported symptoms which had to have a frequency of at least once a week whereas others only required the symptoms to be present at least twice a year. The interviewer administered questionnaires have generally produced lower prevalences of symptoms than self-administered questionnaires. This is the general finding related to inhibitory effects of an interviewer that is not confined to the sick building syndrome. The number of workers who have severe building related disease (in medical terms) is likely to be small. The severity of disease required to count as a case of sick building syndrome during epidemiological surveys is likely to affect the comparisons between buildings. The more severe the requirement the more unusual occurrences, such as mould growth following flooding and water leaks, will feature as a cause. The less stringent the requirements the more relatively trivial features, such as general dustiness, may feature. If weekly symptoms throughout the year are required it is unlikely that disease due to humidification and chilling will be prominent, as humidification and chilling may only be required for part of the year. Despite this some consistent factors emerge.

1. Females have more symptoms than males.

2. Workers in naturally ventilated buildings are in general less symptomatic than those in air conditioned buildings.

3. Buildings that are hotter have more symptomatic workers than those that are cooler.

4. Some humidification and chilling systems are associated with disease

5. There is an association between the perception of the environment that has been poor and unsatisfactory in symptoms.

6. Poor job satisfaction is associated with more symptoms.

Other factors which are found in some but not all studies are an association particularly in naturally ventilated buildings, between symptoms and extractable floor dust and perhaps the shelf factor and fleece factor. Some studies show more symptoms in VDU workers also the risk factor is not strong. The Dutch workers using a linear aggression were able to 'account' for only 5-20% of a variation in complaints using the factors that they studied. They wondered whether this was the way to proceed.

THE SYMPTOMS OF SICK BUILDING SYNDROME

Building sickness comprises a group of symptoms which are common in the general population, but which are more common in workers in some buildings than in others, and are temporarily related to work within these buildings. Most of the studies have identified similar symptoms, the most common are usually lethargy and tiredness and headache followed by a blocked nose, runny nose, sore eyes, difficulty with wearing contact lenses, dry eyes, dry throat, dry skin and sometimes symptoms suggestive of asthma. A much wider range of symptoms was investigated in the German market research study, the ones that were different between workers in air conditioned and naturally ventilated buildings were similar to the ones just described.

Lethargy has two different time patterns. In some workers the lethargy comes on during the day at work and improves within a few minutes of walking outside the building or going out at lunch-time. In others the symptoms are more profound, the worker needing to sleep for 1-2 hours after work as well as having a normal night's sleep. The headache is usually described in medical terms as a 'tension' headache, it occurs across both sides of the forehead and sometimes at the back of the neck. Migraine is not in general a feature of building sickness.

Many have wondered whether the symptoms are 'real'. Several different attempts have been made to validate the symptoms but as there received, in random order, a self-administered questionnaire similar to the usual sick building questionnaire, and a medical opinion based on questionnaire at the time. The average number of work-related symptoms for workers (building symptom index) which is used to compare one building with another, showed a good agreement between the two methods. There were, however, consistent differences between their two assessments and individual symptoms. The self-administered questionnaire produced a higher prevalence of work-related runny nose and flu-like symptoms, hich were often regarded as being due to infections from the medical opinion. Work-related symptoms on the self-administered questionnaire were validated by the medical opinion in over

75% of cases with eye and throat symptoms, lethargy and headache, but only 31% of those with a runny nose and 21% with flu-like symptoms were regarded as work related in the medical interview. The medical opinion identified an extra 5% of work-related symptoms that were missed by the self administered questionnaire. The self-administered questionnaire therefore, produced a satisfactory estimate of work-related symptoms, removing the potential bias from an interviewer. The questions on runny nose and flu-like symptoms would be improved by including only those that occurred at least weekly.

There are no absolute tests for lethargy, headache and dry throat. Objective measurements have, however, been used to validate dry eyes, blocked nose and asthma symptoms. Dry eyes can be investigated by putting fluoricine into the eye and measuring the time taken between putting the drops in and the breakup of the fluoricine film. Those reporting dry eyes more frequently were shown to have a greater proportion in which the tear film broke up in under five seconds (Franc, 1986).

An attempt has been made to measure nasal inspiratory flows serially using an inverted peak flow meter with a nasal mask. This technique has is in general, been found to be too complicated for workers to master as the nostrils need to be flared when making the measurements, otherwise the major source of resistance is in the alae nasae. Measurements of nasal resistance have been made at a single point in time and correlated with a self assessment of nasal patency at the same time in office workers, who have subsequently kept serial diary cards of symptoms (Robertson, personal communication). Work-related patterns in these diary cards can often be seen (Fig.2). It is unlikely that further physiological measurements will prove rewarding in symptom validation.

## RESEARCH NEEDED RELATING TO THE MEDICAL PROBLEMS OF SICK BUILDING SYNDROME.

### Mechanism of Symptom Production

It is unclear whether sick building syndrome relates to an agent or agents in the environment, and if so whether these are specific chemicals. There is some suggestion that allergic individuals are more likely to be more symptomatic than non-allergic individuals (for instance from the Dutch and Swedish studies). The mechanism of action at least of the nasal symptoms should be definable by studying individuals with symptoms, for instance by looking for eosinophils in nasal smears which would favour an allergic cause. If the cause is thought to be allergic then a detailed search for allergens in the environment would be the next stage (for instance house dust, mites, biocides, de-scalers etc.). If the nasal changes do not look allergic then both

physical factors (such as temperature in the humidity) and irritant factors (such as fibres and general environmental dirt) would be more likely.

Some studies have identified passive cigarette smoking as a risk factor. Passive cigarette smoking may occur both at work and away from work and is amenable to study in the workplace, particularly looking at buildings where smoking policies are being introduced and smoking prohibited in the workplace. Passive cigarette smoking exposure can be determined in individuals by several means (for instance urinary or salivary cotinine measurements, or measuring nicotine in hair samples, Nilsen and Zahlsen 1990).

There are suggestions that fungi (and perhaps bacteria) are associated with sick building syndrome, particularly in air conditioned buildings (Austwick et al 1989). There are a number of well documented cases where major fungal colonisation has occurred and where symptoms have increased. The mechanism may be via allergy or by mycotoxins. The fungal levels in naturally ventilated buildings in total are usually higher than in air conditioned buildings, so it is likely to be specific fungi rather than fungi in general that are related to symptoms. Further characterisation of the fungi present in the indoor environment and the search for specific IgE antibodies in affected individuals, would be worthwhile. Very similar symptoms occur in humidifier fever (although these are more severe) where an IgG mechanism is likely.

It is likely that the most useful studies will be interventional where individual factors are changed, particularly important factors to look at would be :

1. General cleaning.

2. Improving the maintenance of the plant, particularly making it clean.

3. Improving the quality of filter maintenance.

4. Removing biocides and de-scaling agents from contact with the circulating air.

5. Removing humidifiers.

6. Providing local individual control of temperature, airflow and lighting.

7. Improving the communication between plant managers and workers and setting up a confidential system for dealing with complaints and getting action taken.

Other questions which have a medical input would include looking at sickness absence related to symptoms (there is some early work on this). Investigating productivity and

symptoms, looking at the effects of menstrual cycle on symptoms in females, looking at the effects of season on symptoms.

It is quite likely that the causes of sick building syndrome will be different in different environments. Most of the studies described have taken place in the more temperate areas of Europe where air conditioning is often unnecessary. Those in sub-arctic regions (for instance the Swedish study) take place in environments where humidity levels are extremely low in the winter. In some tropical regions the humidity is exceedingly high. The role of humidity may be different in these two extreme circumstances.

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Figure 1
The average number of work related symptoms (the building symptom index) in 47 different workgroups divided into office ventilation category. The rates have been adjusted for sex and job. The naturally ventilated buildings had opening windows and radiator heating, the mechanically ventilated buildings had some ducted air supply, which was usually warmed, but never chilled or humidified, some of these buildings were sealed. Air conditioned buildings either used induction systems, where room air was passed over heated or chilled induction units, or used an all air system with supply of heated or chilled air to the office space from a central plant room.

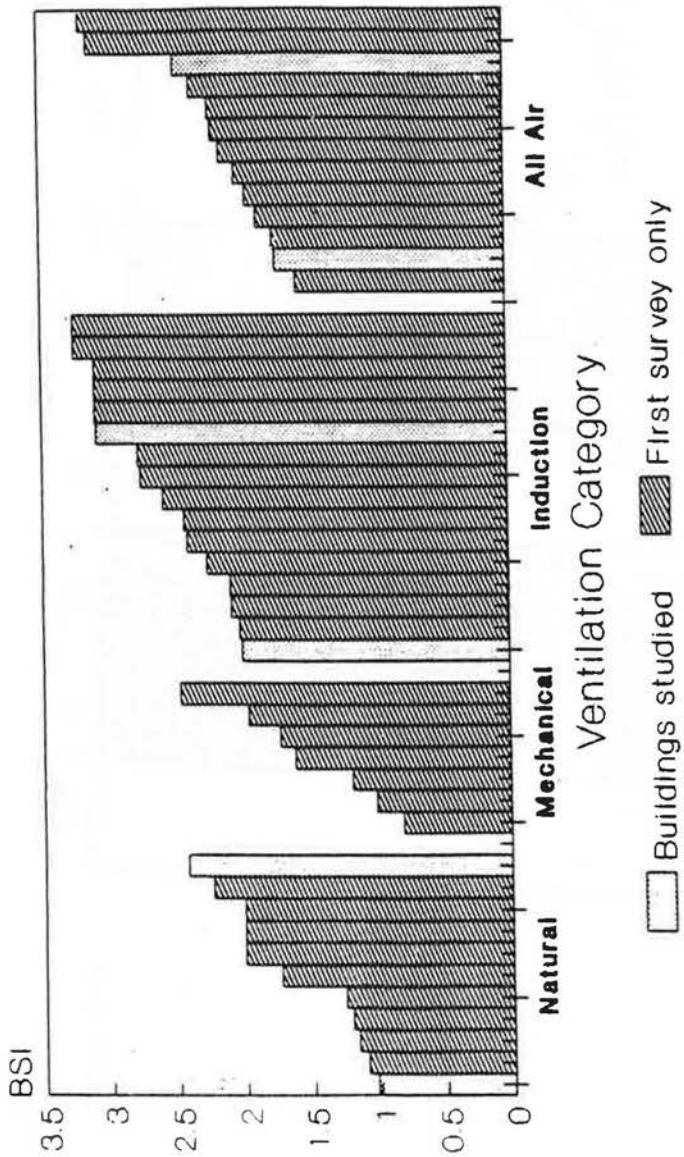

Figure 2
Diary card showing two hourly assessments of nasal symptoms on a day at work and a day off work in a worker with work related rhinitis. The nose is patent throughout the Sunday at home, on the Thursday at work there is a little nasal stuffiness during the morning at work (shaded background), some improvement at lunchtime away from the building, and more severe nasal blockage in the afternoon at work which continues into the evening at home.