BUILDING SICKNESS - A MEDICAL APPROACH TO THE CAUSES

P. Sherwood Burge
Occupational Lung Disease Unit
East Birmingham Hospital
Bordesley Green East
Birmingham B9 5ST
United Kingdom

The symptoms characteristic of sick building syndrome are common in the general population and have many possible causes. Their cause can be shown to be the building in some workers by the timing of their symptoms which regularly deteriorate in the building and improve away from the building. Workers identified on questionnaire can have their symptoms validated by medical interview and prospective diary cards, and sometimes by objective measurements, in the majority of those with headache, lethargy, blocked and stuffy noses, dry throat, wheeze and breathlessness. Symptoms of runny nose and flu-like symptoms however are less frequently validated by independent medical review. The epidemiological studies show a continuous variation in the prevalence of sick building syndrome between different buildings. All studies have shown that in general naturally ventilated buildings have less symptomatic workers than sealed air conditioned buildings, despite the fact that measures of environmental comfort are in general worse in the naturally ventilated buildings, suggesting that sick building syndrome is not directly related to air comfort measures. Any serious cause or causes for the syndrome should be measurably different in sick and healthy buildings. Environmental measurements in such buildings have excluded amongst others air change rates, formaldehyde, ozone, air ions, carbon monoxide, carbon dioxide, visual display units, legionella and infections as widespread causes. There is a consistent finding that buildings with microbiological contamination either from dampness or from chillers and humidifiers have increased numbers of symptomatic workers. However in most cases the airborne bacteria and fungi are not directly related to symptoms of sick building syndrome whereas soluble antigens in the air may be.

WHAT IS SICK BUILDING SYNDROME?

Building sickness comprised of 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 which deteriorate while working in a building and improve after leaving it. Different investigators have used different questionnaires. The symptoms can however be divided into four groups which may not necessarily have the same causes. The most common and general symptoms are tiredness, lethargy and headache. Nausea may also be a symptom in this group. Dryness, running or blockage of the nose or eyes are grouped together with thirst and dry throat, both dryness of the skin and symptoms of asthma (chest tightness, wheeze and breathlessness) are grouped separately. One of the most common symptoms is lethargy which may improve on walking out of the building, for instance at lunchtime, or after leaving work (Fig 1). Sometimes it is more profound, the worker needing to sleep for one to two hours after work as well as having a normal nights sleep. Headache is also frequent. The type of headache generally associated with building sickness occurs across both sides of the forehead and sometimes in the back of the neck. Migraine is not in general a feature of building sickness. Medical interview has confirmed blocked nose, dry throat and sore eyes as usually being work related. However runny nose and flu-like symptoms are more often thought by medical interview to be due to infection rather than to the sick building syndrome. Infections may be spread rapidly in some buildings. However the symptoms of sick building syndrome occur on a regular basis, usually most weeks at least, which is much more frequent than that associated with infections, which do not regularly improve on days away from the building. The eye, nose and throat symptoms could potentially be caused by allergy, by irritation, by physical factors such as low humidity or by infection. Apart from the exclusion of infection there is no data yet which helps separate the other three potential causes of the symptoms.

VALIDATION OF THE SYMPTOMS OF SICK BUILDING SYNDROME

Objective measurements are available for the least common symptoms such as wheeze and breathlessness where objective measures of airflow (peak expiratory flow rate) can be recorded every one to two hours during the daytime, both on days at work and on days away from work. Methods for assessing these measurements are well established and have documented occupational asthma in a few workers in office buildings, usually related to contamination of humidifiers or chillers. Examples are shown in figures 2 and 3. Objective measurements of eye dryness have been made by putting fluoroscein into the eye and recording the time taken for the uniform film to break up (tear film break up). Measurements of tear film break up time have been correlated with symptoms in the Danish Town Hall Study (Franc, 1986). We have attempted to make objective measurements of nasal blockage. However these are variable (even in other nasal diseases such as allergic rhinitis and hay fever). There is an association between symptoms of nasal blockage as assessed by visual analog scales at the time and nasal airways resistance measured immediately afterwards. However these measurements are not transportable and are therefor not suitable for measuring differences during days in a building and days away from a building. For this symptom scores have been used with workers recording their symptoms every 2 hours from waking to sleeping. Such diary cards have produced some evidence of symptoms relating to work in the majority of those who have questionnaires suggestive of work related blocked nose. Examples shown in figures 4 and 5. There are no objective tests for lethargy and headache where diary cards provide the only means of validation. These again have proved helpful validating symptoms in the majority (figures 1 and 6). THE SEARCH FOR A CAUSE The cause for an individuals symptoms could be related to something special about the person, something to do with the materials they handle at work, something to do with the organisation within which they work or something to do with the building.

PERSONAL FACTORS

Several different studies have shown that females complain of more symptoms than males and workers lower down the office hierarchy complain of more symptoms than workers higher up (Burge et al 1987, Skov and Valbjorn,1987) . Women often have the poorer jobs than the men, however the effect of sex applies to all job categories. The differences between sexes has not been explained but it may be related to females having more body awareness than males. Reduced symptoms in workers higher up the office hierarchy may be due to better accommodation for the more senior workers, their greater ability to get changes made and also their greater mobility within the workplace, although senior members of the office staff are likely to be more stressed. Differences in sex and job status need to be taken into account when the occupants of different buildings are compared. There are less consistent changes relating to age but interesting changes relating to the length of occupancy of a building. Symptoms are less common within the first 6 months of working in a building and reach a plateau at about a year. There is also some evidence that symptoms do not completely resolve on leaving a building. In one study workers moving from a naturally ventilated building to an air conditioned building have increasing symptoms, whereas those moving from the air conditioned building have a much smaller change in symptoms (Robertson et al 1990), suggesting that some longer lasting effects were occurring. A delay in the onset of symptoms and the persistence afterwards would be in keeping with an allergic cause where a period of symptomless exposure is required while sensitisation occurs. Following sensitisation symptoms may be triggered by much smaller exposure. Although this is theoretically possible for symptoms of sick building syndrome there is no direct evidence for this in the great majority of workers.

MATERIALS HANDLED AT WORK

Symptoms have been attributed to ozone or solvents from photocopying machines or perhaps correcting fluids. Epidemiological studies have failed to find any consistent affects of these the exposure of which is usually confined to a small number of workers within a building. The possible exception to this is working with VDU's where those working on them for more than 7 hours a day have a small increase in symptoms. This may be related to the immobility of the worker and their lack of job control as much as any specific factor related to the VDU. There are no increases in symptoms between 1 and 6 hours which would be expected if some emission from the VDU itself was relevant. THE ORGANISATION Public sector building occupants in the UK have more symptoms than those working in private sector buildings, raising the possibility that the organisational structure may be relevant to the production of symptoms, or that the building service management or the type of building occupied by the two groups is different. Our work would suggest that the main factors relate to the poorer quality building occupied by some government organisations and a greater difficulty in making improvements to the building services in government buildings compared to the private sector buildings, as well as the differences in plant operation. We have studied one building with both a public and a private sector occupant, both occupational groups had similar symptoms of sick building syndrome. More studies of this type however are required.

FACTORS RELATING TO THE BUILDING

Studies of building unselected for known building sickness have all shown substantial differences in the symptom rates between buildings. After correcting for the differences in sex and job status for the building occupants substantial differences are still seen (figure 7). All studies so far have shown in general that naturally ventilated buildings have less problems than air conditioned buildings although there are some relatively good air conditioned buildings and some sicker naturally ventilated buildings. The main problem is to discover what factors related to air conditioning are responsible for the symptoms.

ENVIRONMENTAL COMFORT MEASUREMENTS

It is often assumed that measures of environmental comfort outside the standard ranges are the cause of symptoms in the building occupants. There is however no evidence for this. Measurements of indoor air quality are almost always worse in naturally ventilated compared with air conditioned buildings, particularly in terms of increased temperature, increased carbon dioxide levels, lower air change rate, lower humidity (in temperate climates), increased levels of fungal spores and bacteria in the air, increased levels of suspended particles, etc.(Turner and Binnie,1990). It is therefore unlikely that any of these factors directly relate to the causes of sick building syndrome although there is some evidence that the increases in temperature, particularly over 23^To^TC, is associated with more symptoms (Jaacola et al 1987) . The role of humidity is likely to be substantially different in different climates. In temperate climates there is no evidence that low humidity (down to around 20%) is associated with increased symptoms. The situation may well be different in sub-arctic climates, where very low humidities are encountered in the winter and also in tropical areas where humidity levels may be exceedingly high. Both dehumidification and increased humidification increase the opportunity for microbial growth within the ducted air systems of air conditioned buildings which can lead to either the introduction of biocides which can then be aerosolised or the aerosolisation of soluble products from bacteria and fungi which have been shown to be the cause of some outbreaks of humidifier fever. There is an epidemiological association between the presence of humidifiers and chillers in sealed buildings and increased building sickness. In a few individuals exposure to antigens from chillers and humidifiers has reproduced the symptoms (Fig 8). There is increasing evidence that biocides such as isothiazolones, glutaraldehyde, chlorhexidine, benzalkonium chloride and chloramine, can cause symptoms similar to building sickness in low concentrations (Burge 1989). Their role in office buildings has not been evaluated. They may work by both irritant and allergic mechanisms.

When airborne levels of bacteria and fungi are measured there is no direct relationship between the symptoms of sick building syndrome and air levels. However within air conditioned buildings the sicker buildings have higher levels (Austwick et al 1989). The same applies in naturally ventilated buildings, suggesting a role for microbiological contaminants. It is likely that the fungal spores in naturally ventilated buildings have large numbers of normal outdoor fungi such as Cladosporium and Alternaria which may make total levels of fungal spores, or colony forming units on culture plates, relatively meaningless. It is more likely that the problems relate to mycotoxins or endotoxins. mycotoxins have been responsible for some outbreaks of symptoms in domestic dwellings. There has been a substantial search for individual chemicals in the air of sick buildings which may be associated with symptoms.

Very few of these studies have compared good and bad buildings. Those that have have found no difference in levels of carbon monoxide, carbon dioxide, ozone, formaldehyde, air ions, volatile organics etc. Our study has also failed to find differences in the measures but do suggest that there is a difference in the standards of maintenance of good and bad buildings. Poor standards of maintenance are associated with less controlled use of biocides, general mis-settings of controls and dirtier air conditioning systems. These factors are all fairly amenable to improvement without capital cost.

THE WAY FORWARD

It is unlikely that sick building syndrome will be solved in the law courts nor by designing buildings to conform with current indoor air standards. In temperate climates some problems can be prevented by building simple buildings with natural ventilation and good occupant control of the environment. This is not an appropriate method of building for city centre sites nor in more extreme climates. Building services should be designed for easy maintenance and flexible use. Greater status and training should be given to building services engineers who operate and maintain the systems that so many of us rely on for our continuing health.

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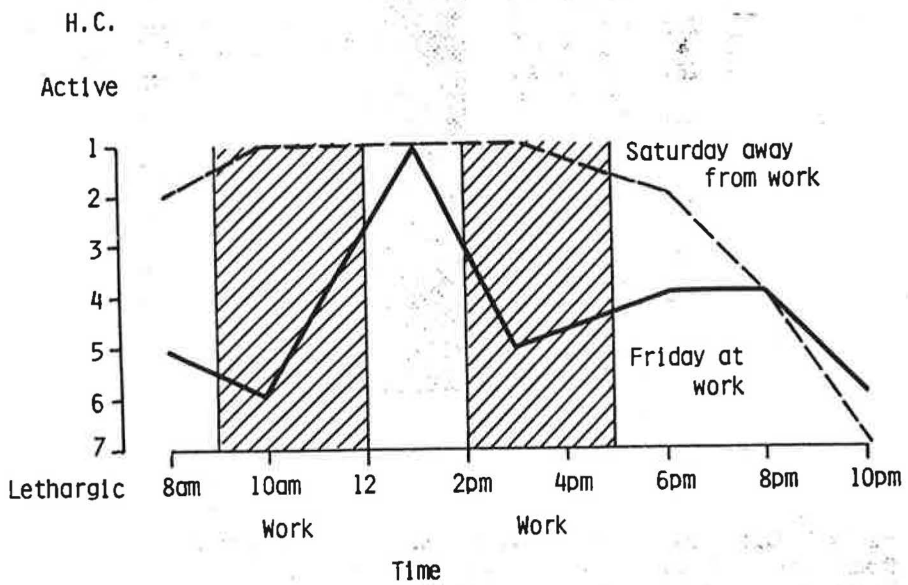
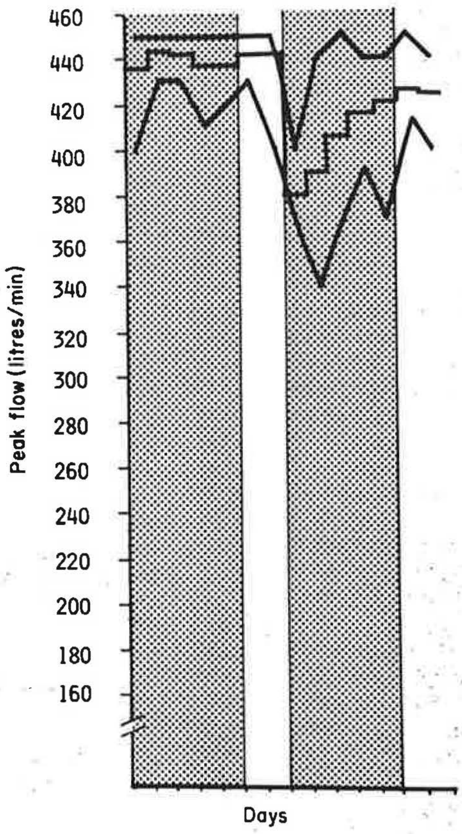
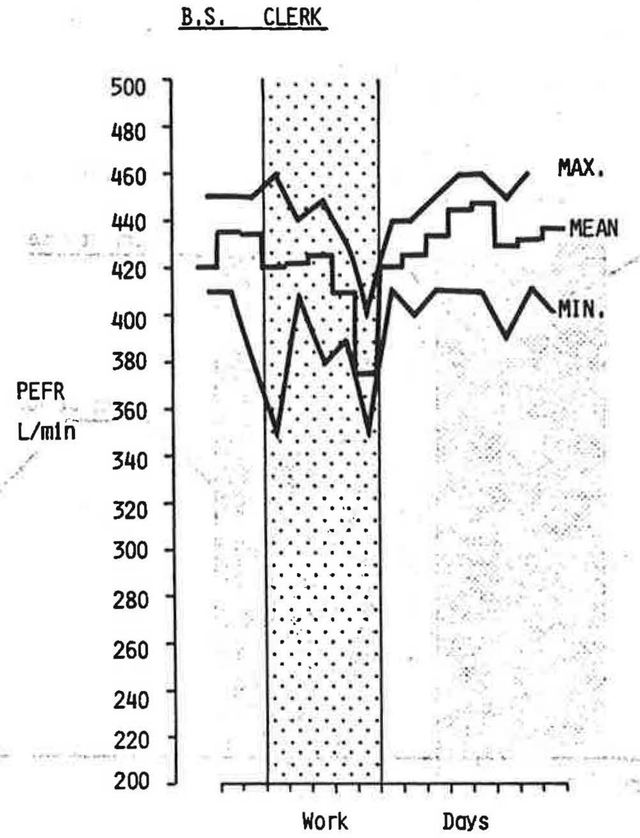


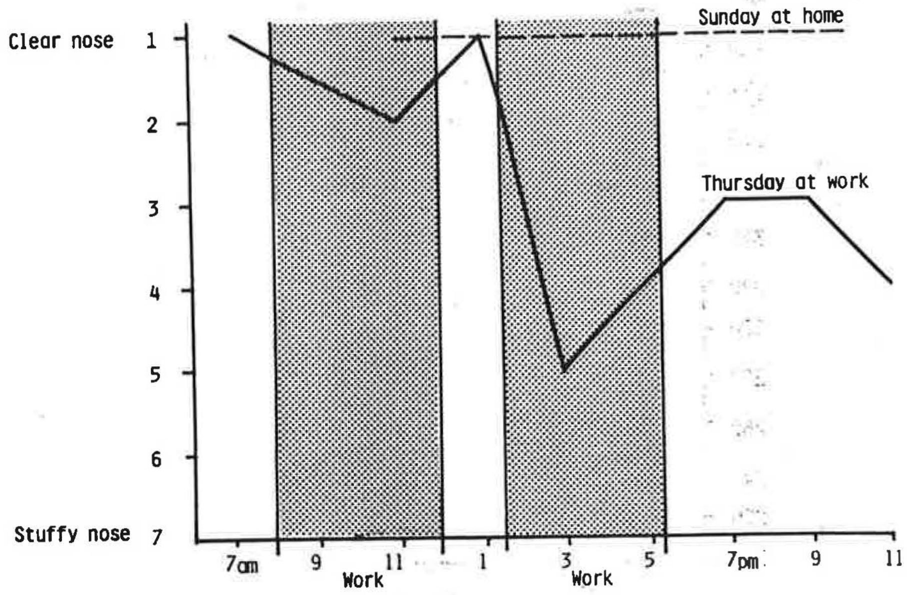
.pa Fig 1. Two hourly plot of lethargy scores from waking to sleeping in an office worker on a Friday at work (9-12, 2-5), and on a Saturday at home. The period at work has a hatched background. The worker experiences lethargy while occupying the office building (and at night), with rapid improvement when away from the building at lunchtime



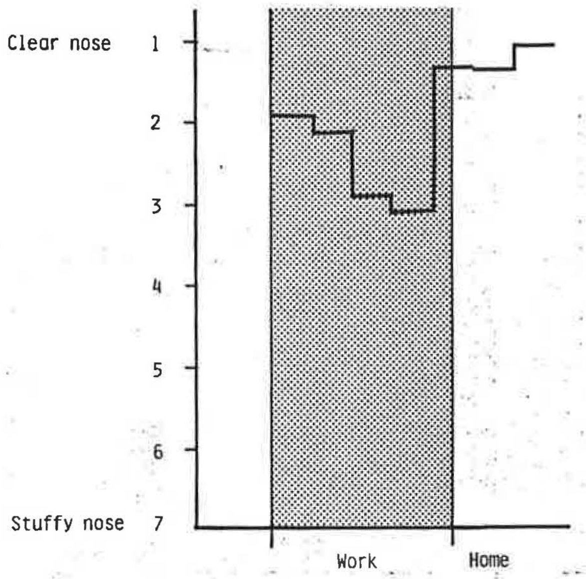
.pa Fig 2. Daily maximum (top line), mean (middle line) and minimum (bottom line) peak expiratory flow rate in an office worker in a building whose humidifier was heavily contaminated with bacteria and fungae. There is no problem in the first workweek (shaded background), but a fall in peak flow on the first day back at work with subsequent improvement on successive workdays. This type of reaction is similar to that seen in cotton mills and is thought to be due to endotoxin exposure



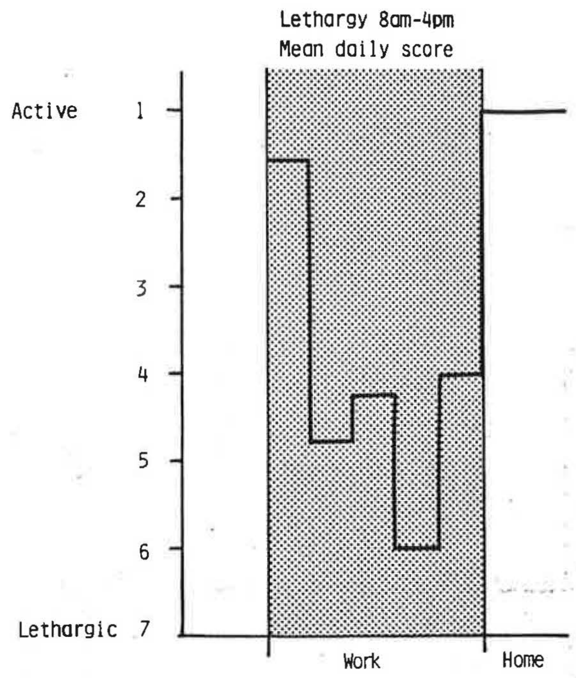
.pa Fig 3. Daily maximum (top line), mean (middle line) and minimum (bottom line) peak expiratory flow rate in an office worker in a building with a cooling unit which had no water drainage. There is progressive deterioration in peak flow during the working week (shaded background) with recovery away from work (clear background). Progressive deterioration with each subsequent days exposure is usually due to an allergic mechanism. She had IgE antibodies to the material in the chiller drip tray, which had not been cleaned regularly.



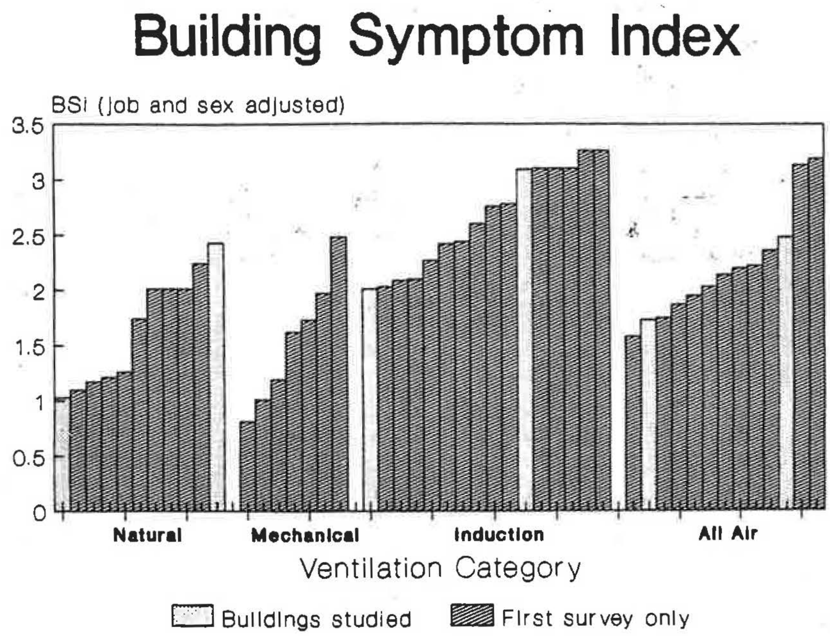
.pa Fig 4. Two hourly plot of nasal patency scores from waking to sleeping in an office worker on a Thursday at work (8-12, 1.30-5.15), and on a Sunday at home. The nose is clear throughout the day at home, but starts to get stuffy during the morning at work, improves away from the building at lunchtime, and deteriorates in the afternoon at work.



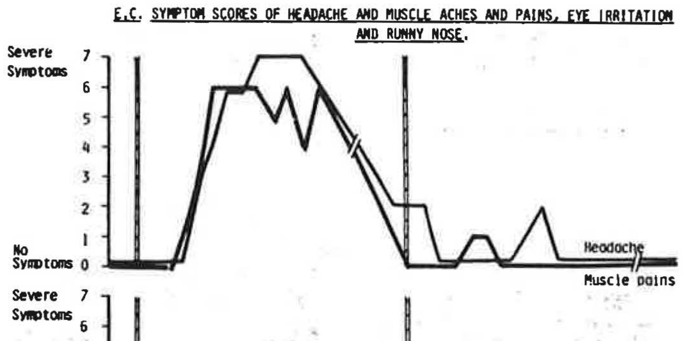
.pa Fig 5. Plot of mean daily nasal patency score in an office worker working four full days (shaded background) and one half day per week. There is progressive deterioration with each workday similar to the worker with asthma shown in fig 3.



.pa Fig 6. Plot of mean daily lethargy scores of records during the daytime only (to exclude the evening tiredness before sleep) in an office worker from an air conditioned building, showing increasing lethargy as the week progressed (shaded background) with recovery at the weekend away from the office (clear background).



.pa Fig 7. The average number of work related symptoms per worker (the building sickness index, an index of the sickness of a building), corrected for sex and job status, in 47 building selected for study without knowledge of occupant complaints. There is a continuous spectrum of BSI's, with the natural and mechanically ventilated buildings in general having the lower BSI's.



.pa Fig 8. Hourly symptom scores of headache, muscle pains, runny nose and eye irritation in a worker from the same building as in fig 2, which had a heavily contaminated humidifier. An extract of the water (without particulates) was nebulised for 5 minutes (time 0), no further exposure occurred until a second 5 minute exposure 24 hours later. There was an increase in symptoms starting 4 hours after exposure on the first day, with few symptoms after the second exposure. This worker had symptoms suggestive of humidifier fever, but it does show that symptoms seen in the sick building syndrome can be induced by exposure to water soluble extracts of microbiologically contaminated humidifiers, the exposure avoiding whole bacteria or fungae.