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CASE STUDY ON PREVALENCE AND POSSIBLE CAUSES OF SICK BUILDING SYNDROME SYMPTOMS

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ABSTRACT

Offices are assumed to be more healthy places to work in than factories and thus problems with occupational health ought to be minimal. However, many maladies can be attributed to the modern office environment, to include legionnaires disease, Pontiac fever, humidifier fever and one for which as yet no specific cause has been identified i.e. Sick Building Syndrome (SBS). This paper assesses the prevalence and nature of symptoms of building sickness, together with possible causation of these symptoms. Incidence of SBS symptoms involving 36 occupants in their own offices were investigated in a naturally ventilated building based in Leicester, UK. Furthermore, an objective study was undertaken to include the measurements of the environmental variables within the space offices. The level of symptoms was found to be significant and strongly correlated with air temperature, stuffiness, odourless, air quality, noise and overall thermal comfort. The results suggest that indoor air pollution can be the prime casual agent behind symptoms, where source of the pollution is from within building materials. High level of dry eye symptoms was strongly associated with dust; headache symptoms were linked with noise level; and blocked nose with higher air temperatures. Air temperatures were strongly correlated with symptoms while ventilation rates were not found to be contributory factors. In addition, other possible causes for SBS symptoms are discussed.

KEYWORDS

Case studies, Sick building syndrome, Thermal comfort

INTRODUCTION

Sick Building Syndrome 'SBS' refers to a series of symptoms concerning irritation of the skin and mucous membranes and general symptoms such as headache and lethargy. These symptoms appear soon after an occupant enters a building with relief coming once the individual has vacated the building (WHO, 1983). It was initially thought that such problems were confined to modern air-conditioned buildings (Robertson et.al, 1985), but further research has revealed that all manners of buildings may be affected (Burge et al, 1987). To date, no specific causes for the incidence of SBS have been unearthed (Borbeau et al, 1997), but the phenomena is real as research has identified a number of risk factors which are heavily implicated in the aetiology of SBS.

Many of these risk factors are related to quality of the indoor environment; this work addresses such issues, based on full-scale measurements.

Over a period of time occupants of the *'X'* building generated a steady stream of complaints regarding affliction with SBS symptoms. This 3-storey building is naturally ventilated, with large areas of glazing; based in Leicester, UK; it houses 80 employees who may be considered as office workers. It was therefore decided to conduct an epidemiological study to ascertain the nature and extent of the problem. Therefore, a questionnaire produced by the Building Research Establishment (BRE) (Raw, 1995) was distributed to the occupants and objective measurements were conducted for our studies, the specific objectives of which were:

1. To determine whether the *'X'* building could be labelled as sick.
2. To ascertain the prevalence and level of suffering amongst the occupants if sickness is diagnosed.
3. To determine the effect of the environmental variables on the incidence of symptoms.
4. To identify the possible causal agents behind any sickness diagnosed.

THE QUESTIONNAIRE

The Royal Society for Health in conjunction with the Building Research Establishment (BRE) have produced a questionnaire for investigation into SBS (Raw, 1995) which is widely used and has proved its effectiveness in diagnosing cases of sick building. The questionnaire is based upon 5 symptoms (dry eyes, blocked or stuffy nose, dry throat, tiredness/lethargy and headache) and the calculations of Building Sickness Index (BSI); this index is a measure of the mean number of these symptoms suffered per person in an environment over the previous 12 months. Furthermore, the questionnaire includes people thermal comfort sensation, perception of the environment in summer and winter, the level of control people have over the environment, and other general information such as exposure to VDU screens, job type and smoking habits. The questions are designed for occupants to make their subjective rating of the indoor environment on a unipolar scale ranges from 1 as a satisfactory to 7 as unsatisfactory, or on a bipolar scale with 4 as an ideal score.

A total of 36 questionnaires (36 rooms) were collected representing a response rate of 45%. Figure 1 shows the distribution of symptoms for each occupant, expressed as the BSI; the overall average value of the *'X'* building is 1.61 (Raw (1995) suggests that a building with a BSI above 1.5 indicate a possible cause for concern). Figures 2 and 3 represent the distribution of each symptom experienced by occupants within the building and their satisfaction scores as a function of each symptom, respectively.

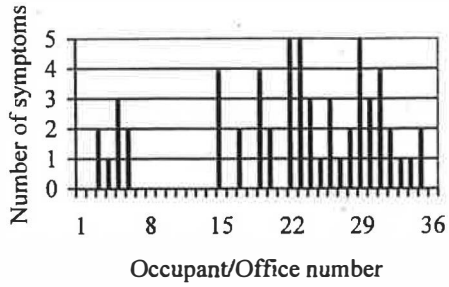

Figure1 Distribution of number of symptoms within the *'X'* building

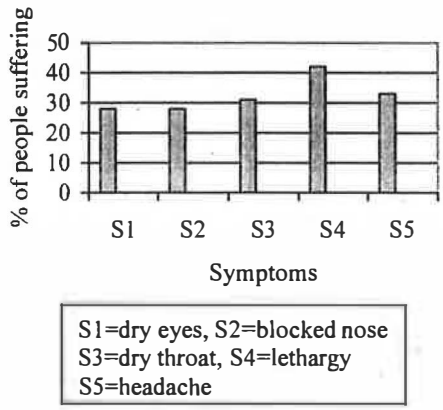

Figure 2 Distribution of each symptom

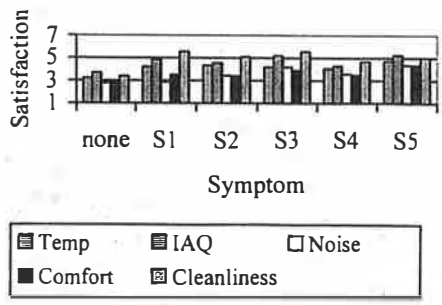

Figure 3 Satisfaction rate versus symptoms (none = no symptoms, score of 1 on y-axis indicates satisfactory and 7 indicates unsatisfactory)

Figures 4 and 5 show the comparison between the present study and the incidence of symptoms found by the Office Environment Survey (OES) (Wilson and Hedge, 1987), Wilson et al (1987) and Jaakkola et al (1995). It is clear that the *'X'* building appears to be particularly conducive to occupant ill health.

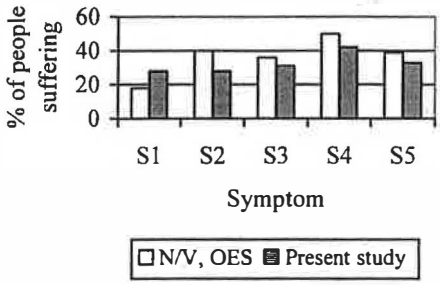

Figure 4 Comparisons between the distribution of symptoms in natural ventilated buildings

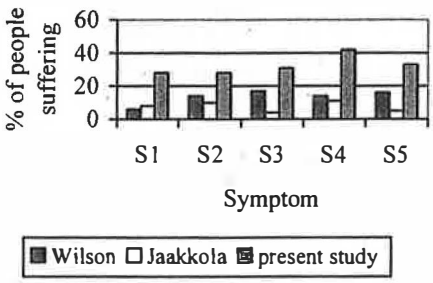

Figure 5 Distribution of symptoms: a comparison of surveys

PHYSICAL MEASUREMENTS

In addition to the above objective studies, a series of physical measurements for the environmental variables were carried out, including ventilation rates, resultant temperatures, air velocities, humidity, and illuminance levels. These measurements were conducted in offices representing three categories based on the number of symptoms reported by the occupant: 'best office' (office A of zero symptoms), 'worst office' (office C of 5 symptoms) and 'average office' (office B of 2 symptoms).

Figures 6 presents the satisfaction rate for such typical three offices, within the *'X'* building.

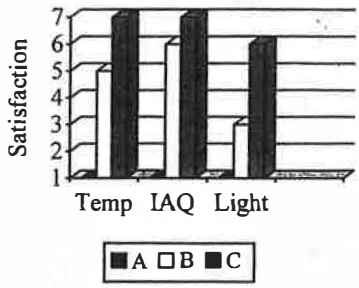

Figure 6 Satisfaction rate with ambient temperature, indoor air quality and lighting for three offices; A (comfortable with no symptoms, B (average with 2 symptoms) and C (uncomfortable with 5 symptoms).

To investigate the implications of the environmental variables upon the incidence of symptoms, an objective study was conducted in the above offices.

Ventilation rates were measured using a tracer gas technique and the results are presented in Figure 7. Table 1 summarises other results gathered from measurement of the environmental parameters.

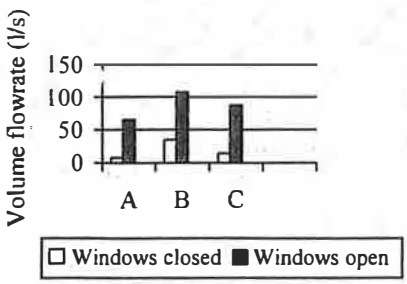

Figure 7 Ventilation flow rates for offices A, B and C

Table 1 summary of results: the environmental variables

Office	t_a (C)	V (m/s)	t_{res} (C)	∀ (l/s)	Rh (%)
A	21.5	0.05-0.2	21.4	8-65	59
B	24.0	0.05-0.1	24.1	35-107	47
C	26.0	0.1-0.5	25.2	14-87	43

where
t_a = air temperature
V = air velocity
t_{res} = resultant temperature
∀ = volume flow rate of air
Rh = relative humidity

SATISFACTION VERSUS SYMPTOMS

Occupants were in general uncomfortable and dissatisfied with the ambient temperatures experienced in the *'X'* building.

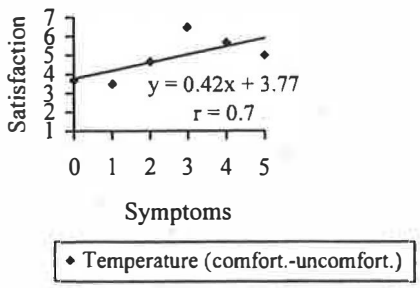

Figure 8 Satisfaction of ambient temperature versus number of symptoms: comfortable-uncomfortable

Figure 8 presents the correlation between the level of dissatisfaction with the number of symptoms (correlation coefficient, r=0.7). These results contrast with those found by Robertson et al (1985) who suggested that no significant variation in air temperatures between sick and healthy buildings. However, the present findings are alongside with those obtained by Jaakkola et al (1989) and Kjaergaard (1992). The air temperature in many part of the *'X'* building reached 26C, which could cause an increase in Volatile Organic Compounds (VOC's) concentration to the level of above 0.2mg/m^3 where incidence of symptoms became more likely as reported by Norback et al (1990). There is also evidence (Chandrakumar, 1994) to suggest that the symptoms of dry throat and blocked nose are associated with high temperatures; such findings are confirmed by this work. The sufferers of these symptoms rate the air temperature significantly worse than those who suffer of dry eyes and lethargy. Furthermore, the occupants with headache symptoms are strongly dissatisfied with the air temperature. It could be that temperature is responsible for producing the VOC's from within the *'X'* building to such concentration that symptoms are induced.

Figures 9, 10 and 11 show the relationship between the level of dissatisfaction with the air quality in terms of stuffiness (r = 0.84), odourless (r = 0.82), and overall satisfactory (r = 0.96) scales, respectively.

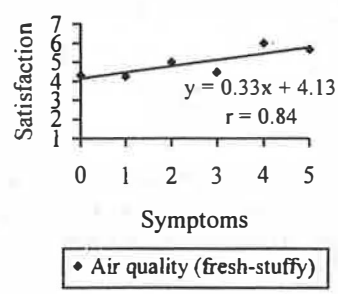

Figure 9 Satisfaction of air quality versus number of symptoms: fresh-stuffy

The perception of stuffiness could be due to high temperature, low air movement, and odour/pollution (Wallace et al, 1991). The experimental data reveal that the

environment variables are not associated with the perception of air stuffiness, however, it could be caused by the indoor air pollutants.

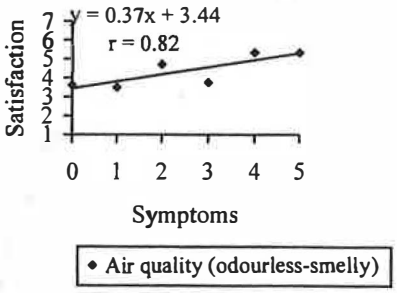

Figure 10 Satisfaction of air quality versus number of symptoms: odourless-smelly

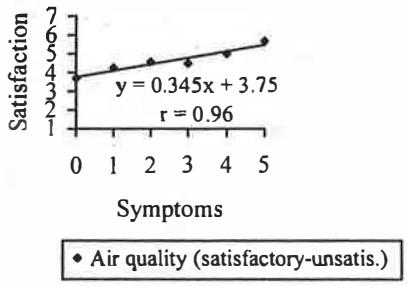

Figure 11 Satisfaction of air quality versus number of symptoms

It is well documented that people are able to detect the presence of VOC's and simple inorganic gases in the air even at very low concentrations (Forsberg et al, 1997). The air in the *'X'* building is generally perceived smelly due to the following possible sources of pollutants: a) the building and its furnishings may be generally be described as old; the rate of decay of their constituent materials increases (London Hazards Centre, 1990), b) exhaust fumes from road traffic along with high infiltration rate, and c) local sources of pollution, such dyelining machines which could be a source of methanol (Harrington and Gill, 1992). In addition, occupants with headache, dry throat, and blocked nose symptoms (these are associated with indoor air pollutants (Harrington and Gill, 1992)) report that the air is smellier than those with either dry eye or lethargy symptoms. Overall, the occupants express their dissatisfaction with the air quality, and Figure 11 illustrate a strong relationship (r = 0.96) between the overall satisfaction of the air quality and the number of symptoms.

Noise is another suspected causal factor for SBS; its correlation with the number of symptoms is shown in Figure 12 (r = 0.63). The occupants of headache symptoms rate the noise level of 4.36 in comparison with 2.55 reported by those with other symptoms. This could confirm the fact that effects of noise could be responsible for headaches.

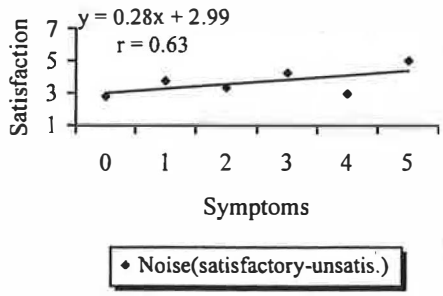

Figure 12 Satisfaction of noise level versus number of symptoms

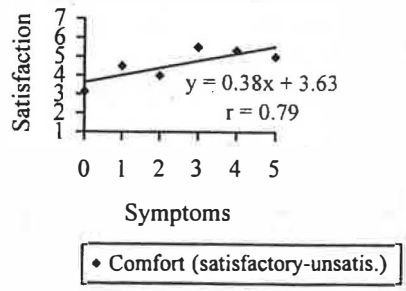

Figure 13 Satisfaction of overall comfort versus number of symptoms

Figure 13 shows that comfort and incidence of symptoms are linked (r = 0.78); such relationship highlights the point that SBS is unlikely to have a single cause, but is more likely to be multifactorial in origin.

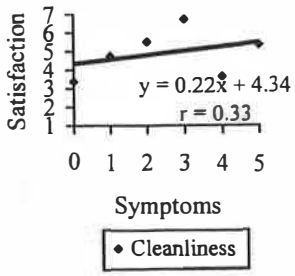

Figure 14 Cleanliness versus symptoms

Figure 14 presents the relationship between the level of satisfaction of the cleanliness and the number of symptoms (r=0.33). There is evidence to support the proposition that Indoor Surface Pollution (ISP) (Raw, 1994) and dust may at least in part be responsible for ill health in the *'X'* building. It has been reported that the air was too dry, when it fact relative humidity was measured to be 40 to 60%. Such a perception of dryness can be caused by the presence of dust (Leaman, 1994) which causes a drying of the eyes (Norback, 1992). The percentage of occupants suffering from dry eyes in the *'X'* building is significantly higher than that found in many other studies; those people express extreme dissatisfaction with regards to cleanliness rate of 5.56. Furthermore, dust is known to cause irritation to the upper respiratory tract (McIntyre, 1993); the people reported the symptoms of dry throat in this study, rated the cleanliness at 5.55. This could indicate that the level of dust may well be a serious problem in the *'X'* building.

CONCLUSIONS

A field study into the sick building syndrome was undertaken within the *'X'* building in Leicester, UK. This involved both subjective and objective studies; the following conclusions may be drawn from this work:

1. The *'X'* building was found to have BSI of 1.6 (based on 5 named symptoms). This indicated that the building could be labelled as 'sick' according to BSI scale suggested by Raw (1995).
2. The prevalence of symptoms agreed with those results of the Office Environment Survey (Wilson and Hedge, 1987); the *'X'* building appeared to be particularly prone to ill health as compared with similar findings by Jaakkola (1995).
3. Correlations have been developed between the symptoms experienced by the occupants and the following elements a) air temperature, b) air quality including air odour, stuffiness, and c) overall comfort. In contrast, the ventilation rate was found to be not associated with the symptoms.
4. Ambient temperatures were found to be unsatisfactory (from both subjective and objective measurements) and strongly correlated with symptoms. Such correlation could be due to the fact that such higher temperature generate indoor air pollutants such as VOC's that could cause the symptoms dry throat, blocked nose and headache (Harrington and Gill, 1992). The strong association between dry eyes and dissatisfaction with cleanliness may indicate that, dust as an air pollutant, is a particular problem in the *'X'* building. The incidence of symptom of dry eyes is large in comparison with those results found by Borbeau et al (1997).

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