A survey of sick building syndrome: Workplace design elements and perceived indoor environmental quality

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SUMMARY

The design factors (indoor plants, workstation partitions, and operable windows) that predict sick building syndrome (SBS) were described for architects and interior designers. For facility management, the indoor environmental characteristics (thermal comfort, air quality, noise and lighting) that contribute to SBS symptoms were investigated. This study used a standard Building Use Studies (BUS) questionnaire that included sick building syndrome symptoms, environmental satisfaction and perception, and background information about the respondent and their office space. There were 469 Chinese office workers who participated. More than half of the participants reported one or more sick building syndrome symptoms. The most common symptoms were head symptoms, whereas skin symptoms were least common. Indoor plants and operable windows were related to a reduction of SBS symptoms. Workstation partitions did not affect the incidence of SBS symptoms. There were fewer sick building syndrome symptoms reported in the more satisfied respondents. This study highlights a perception-based IEQ solution for SBS issues, which has been validated through identified relationships between the perceived IEQ and the SBS symptoms. By examining these responses, the facility management can change influential IEQ aspects. For design professionals, indoor plants and operable windows should be used to reduce SBS symptoms.

KEYWORDS

Sick building syndrome; workplace design elements; indoor environmental quality

1 INTRODUCTION

In the past years, numerous studies in Europe and North America have indicated that non-specific symptoms related to office building occupancy are common in office workers. These symptoms are generally referred to as sick building syndrome (SBS), which has been described as ‘a group of symptoms of unclear etiology (Burge 2004).’ According to a World Health Organization working group (WHO 1983), SBS symptoms can be divided into symptoms related to the mucous membranes (i.e., the eyes, nose and throat), dry skin, and headache and lethargy. These symptoms are temporally related to working in or occupying a particular building. Although these symptoms improve within hours of leaving the building, SBS could decrease productivity at work and cause economic losses (Seppanen and Fisk 2006). Poor indoor environmental quality (IEQ) is often blamed for causing SBS. Although it is difficult to determine the single cause of a particular symptom, interdisciplinary studies (Berglund and
Lindvall 1986; Hedge, Burge et al. 1989; Au Yeung, Chow et al. 1991; Burge 1992; Apter, Bracker et al. 1994; Bachmann and Myers 1995; Hedge, Erickson et al. 1995; Burt 1996; Crawford and Bolas 1996; Ooi, Goh et al. 1998; Bholah, Fagoonee et al. 2000; Berglund, Gunnarson et al. 2002; Cheong, Yu et al. 2006; Gül, Işsever et al. 2007; Gupta, Khare et al. 2007) explored the prevalence of SBS in office buildings and related it to specific indoor environmental conditions. These studies showed a wide variance in the prevalence of SBS symptoms. Additionally, the selected indoor variables were not reliable symptom predictors. SBS was associated with a variety of individual characteristics, occupational factors, and psychological processes. These studies indicate that satisfaction and perception are important predictors of SBS. The studies also indicate a need for SBS studies in places outside of temperate and tropical office environments.

This research focused on office environments in subtropical cities and surveyed 469 office workers in Hong Kong and Shenzhen. The aim of this study was to investigate the potential SBS predictors of workplace design elements and perceived indoor environment quality because these are two important issues in SBS studies. Workplace elements, such as indoor plants, workstation partitions, and operable windows, influence psychological stress at work (Evans and McCoy 1998), but these aspects were seldom examined in the SBS literature. Demonstrating that there are less SBS symptoms in offices with indoor plants, workstation partitions, or operable windows may convince architects and interior designers to design healthy working environments. The perceived indoor environmental quality is an important index that measures the physical environment by combining subjective expectations and experiences (Vischer 1985; Vischer 1996). Office workers reporting symptoms expressed a susceptibility to an environmental burden of many factors. Therefore, a psychosocial approach to indoor environmental quality must be researched.

2 METHODS

SBS studies should use occupants as a sensing device because people are the best measuring instruments to discover SBS sources; however, people are harder to calibrate. This study used a standard Building Use Studies (BUS) questionnaire that included sick building syndrome symptoms, environmental satisfaction and perception, and background information about the respondent and their office space. Supplementary data were also collected using a checklist that contained information about the office design and indoor plants, workstation partitions and operable windows. The questionnaire was conducted in 30 offices of building-related professionals in subtropical cities of China (Hong Kong and Shenzhen). There were 469 Chinese office workers that participated. There were 241 respondents under 30 years old, and 258 were male. Most participants had worked in the office more than one year, worked 5 or more days per week and 8 or more hours per day. They all worked in open-plan offices with different settings. To study the impact of indoor plants, responses were divided into the following two groups: offices with indoor plants (n=155) and offices without indoor plants (n=314). To study the impact of workstation partitions, respondents were divided into the following two groups: offices with partitions around each workstation (n=320) and offices without partitions (n=139). To study
the impact of operable windows, the following two groups were formed: offices with operable windows (n=246) and offices with inoperable windows (n=223).

3 RESULTS

Prevalence of SBS

A total of 204 participants (43%) reported no symptoms, whereas 72 participants (15%) reported only one symptom, 81 participants (17%) reported two symptoms, 54 participants (12%) reported three symptoms, 24 participants (5%) reported four symptoms, and 34 participants (7%) reported five symptoms. More than half of the respondents reported that they experienced one or more sick building syndrome symptoms. One hundred and fifty participants (32%) reported eye symptoms, 136 participants (29%) reported nose symptoms, 106 participants (23%) reported throat symptoms, 169 participants (36%) reported head symptoms, and 102 participants (22%) reported skin symptoms. The most common symptoms were head symptoms, followed by eye symptoms. Skin and throat symptoms were least common in this study.

Workplace design elements

Table 1 shows a comparison of the incidence of SBS symptoms when design elements were and were not present. Respondents in offices with indoor plants reported a lower prevalence of eye, nose, throat, head and skin symptoms. Participants in offices with partitions reported a lower prevalence of eye, nose, and throat symptoms. However, the prevalence of skin symptoms was slightly higher in offices with partitions. Respondents in offices with operable windows reported a lower prevalence of eye, nose, throat, head and skin symptoms. T-tests were conducted to determine the relationship between the incidence of SBS and the three workplace elements. Eye (p=0.040), nose (0.027), and skin (0.030) symptoms were related to indoor plants, but throat (0.089) and head symptoms (0.394) were not. Eye (0.786), nose (0.089), throat (0.675), head (0.394), and skin (0.693) symptoms were not related to workstation partitions. Nose (0.023), head (0.027) and skin (0.020) symptoms were related to operable windows, but eye (0.114) and throat (0.206) symptoms were not.

Table 1 Incidence of SBS symptoms and the presence of design elements

<table>
<thead>
<tr>
<th>Incidence of SBS</th>
<th>Presence of design elements</th>
<th>Indoor plants</th>
<th>Partitions</th>
<th>Operable windows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Eye</td>
<td>Frequency</td>
<td>40</td>
<td>110</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>Percentage</td>
<td>25.8%</td>
<td>35%</td>
<td>30.9%</td>
</tr>
<tr>
<td>Nose</td>
<td>Frequency</td>
<td>35</td>
<td>100</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>Percentage</td>
<td>22.6%</td>
<td>31.8%</td>
<td>26.3%</td>
</tr>
</tbody>
</table>
### Perceived indoor environmental quality

A correlation analysis was conducted (see Table 2) to identify any relationship between the IEQ item ratings (From 1 to 7) and the number of SBS symptoms (0, 1, 2, 3, 4, and 5). A Pearson correlation coefficient (a number between -1 and +1) measured the degree of association between two variables. A positive value for the correlation implies a positive association, whereas a negative value implies a negative or inverse association. Participants reporting smelly, stuffy, still, or dry air were more likely to have sick building syndrome symptoms. Respondents reporting noise from colleagues, other people, other inside sources or unwanted interruptions showed more signs of sick building syndrome. Additionally, respondents reporting a varied or cold temperature in the summer were more likely to report sick building syndrome. A glare from lights or the sun and sky was also related to the self-report of sick building syndrome. However, respondents who were more satisfied with the summer temperature and air, the winter air, noise and lighting were less likely to report sick building syndrome symptoms. Respondents who felt that air was more humid or draughty in the winter or summer were also less likely to report sick building syndrome symptoms.

### Table 2 Correlation between the IEQ item ratings and the number of SBS symptoms

<table>
<thead>
<tr>
<th>Indoor Environmental Quality</th>
<th>Positive correlation</th>
<th>Negative correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air in winter (1 = Odorless, 7 = Smelly)</td>
<td>0.267*</td>
<td>Air in summer (1 = unsatisfactory, 7 = Satisfactory)</td>
</tr>
<tr>
<td>Air in winter (1 = Fresh, 7 = Stuffy)</td>
<td>0.254*</td>
<td>Temperature in summer (1 = Unsatisfactory, 7 = Satisfactory)</td>
</tr>
<tr>
<td>Air in summer (1 = Fresh, 7 = Stuffy)</td>
<td>0.248*</td>
<td>Air in winter (1 = Still, 7 = Draughty)</td>
</tr>
<tr>
<td>Air in summer (1 = Odorless, 7 = Smelly)</td>
<td>0.244*</td>
<td>Air in winter (1 = Unsatisfactory, 7 = Satisfactory)</td>
</tr>
<tr>
<td>Other noise from inside (1 = Too little, 7 = Too much)</td>
<td>0.225*</td>
<td>Noise (1 = Unsatisfactory, 7 = Satisfactory)</td>
</tr>
<tr>
<td>Noise from other people (1 = Too little, 7 = Too much)</td>
<td>0.205*</td>
<td>Air in summer (1 = Still, 7 = Draughty)</td>
</tr>
<tr>
<td>Noise from colleagues (1 = Too little, 7 = Too much)</td>
<td>0.186*</td>
<td>Lighting (1 = Unsatisfactory, 7 = Satisfactory)</td>
</tr>
<tr>
<td>Glare from lights (1 = None, 7 = Too much)</td>
<td>0.184*</td>
<td>Air in winter (1 = Dry, 7 = Humid)</td>
</tr>
<tr>
<td>Unwanted interruptions (1 = Too little, 7 = Too much)</td>
<td>0.162*</td>
<td>Air in summer (1 = Dry, 7 = Humid)</td>
</tr>
<tr>
<td>Temperature in summer (1 = Stable, 7 = Varied)</td>
<td>0.150*</td>
<td>&quot;Correlation is significant at the 0.01 level;&quot;</td>
</tr>
</tbody>
</table>
Temperature in summer (1 = Hot, 7 = Cold) 0.113b
Glare from sun and sky (1 = None, 7 = Too much) 0.111b

4 FINDINGS

More than half of the participants reported one or more sick building syndrome symptoms. Head symptoms were most commonly reported, whereas skin symptoms were the least common. The incidence of eye, nose and skin symptoms was significantly lower in offices with indoor plants. The incidence of nose, head and skin symptoms was significantly lower in offices in which windows could be opened. The incidence of SBS symptoms was not significantly lower in offices with workstation partitions. Satisfaction with indoor environmental quality was significantly associated with SBS symptoms. Summer temperatures were related to SBS symptoms whereas winter temperatures were not. More SBS symptoms were reported with colder or more varied temperatures in the summer; however, winter temperature perception was not related to SBS symptoms. The indoor summer and winter air both are related to SBS symptoms. More sick building syndrome symptoms were reported with stuffier, smellier, drier or stiller air. Noise from colleagues, other people, other inside sources, and unwanted interruptions were significantly associated with the number of sick building syndrome symptoms; however, noise from outside was not associated with SBS symptoms. A glare from the sun, sky and artificial lights was also significantly related to SBS symptoms. More SBS symptoms were reported with more glares from the sun, sky and artificial light; however, the amount of natural or artificial light was not related to the SBS symptoms. All of these findings indicate possible measures for building operations and management to tackle SBS.

5 CONCLUSIONS

This study has important implications for SBS management in the design and the operation stages. The current interior design of offices is focused on aesthetic issues. Indoor plants and operable windows are replaced by the more important man-made interior decorations and continuous exterior appearance. A healthy workplace design should address these two issues. Second, the current SBS management is focused on an adjustment of the physical environment according to the engineering standards of temperature settings, illuminance levels and decibel control. However, SBS symptoms may not be improved if occupants remain unsatisfied with their IEQ. This study highlights a perception-based IEQ questionnaire that has been validated through identified relationships between the perceived IEQ and SBS symptoms. By examining the collected responses in the SBS report, facility management can change influential IEQ aspects.

6 REFERENCES


