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Sick Building Syndrome: An Emerging Stress-Related Disorder?

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Background. This study examined the role of work-related psychosocial stress in the aetiology of sick building syndrome and tested the hypothesis that in buildings with no recognized environmental problems, health complaints typical of the syndrome were primarily stress-related.

Method. A case-control study used data from confidential questionnaires to assess symptoms and perception of the physical and psychosocial environment among 2160 subjects in 67 offices. Working conditions were also inspected and indoor air quality monitored.

Results. We found an incremental trend in prevalence of sick building syndrome among office workers who reported high levels of physical and mental stress, and decreasing climate of co-operation. This association was confirmed after multivariate adjustment for significant personal and environmental exposure factors. Using a subsample, we further modelled interaction between stress and the other covariates but none achieved statistical significance.

Conclusion. Our study confirmed stress to be a significant and independent determinant of the health complaints, and that symptoms compatible with the sick building syndrome in many cases were stress-related. Our findings underscore the importance of personal and organizational stress management to prevent ill health at the office.

Keywords: sick building syndrome, stress-related disorder, risk factors, Singapore, tropics

Sick building syndrome, defined by the World Health Organization as an excess of work-related irritations of the skin and mucous membranes and other symptoms reported by workers in modern office buildings,[1] is an emerging problem in many countries.[2–4] Clinical features elicited during investigations of complaints among building occupants typically include eye, nose and throat problems, dermatitis, drowsiness/difficulty in concentrating, headache, and fatigue.[5,6] While these common ailments may be nonspecific with many possible causes, a consistent temporal relation can be established with symptoms increasing or becoming more apparent over the work shift and resolving upon leaving the premises.[7] Previous work on sick building syndrome tended to focus on the building as the predominant factor. However, it should be noted that the structure and organization of work in offices have changed over the past two decades as dramatically as the physical environment.[8] These two secular trends make it difficult to ascribe increases in the prevalence of health complaints only to changes in the physical environment. So far, investigations of indoor air quality have been unable to identify a precise cause for the ailments, and variations in office ventilation could only account for some of the symptoms.[9,10]

In 1992–1995, we conducted a survey on the morbidity of office workers in Singapore and found that symptoms attributed to the workplace were not reliable predictors of indoor air quality or ventilation problems.[11] Cases reported more stress at work, suggesting that health complaints typical of the sick building syndrome were induced by stress more than the building. Concern has grown that modern job demands could be subjecting office workers to high levels of stress with unintended health consequences.[12–14] While office automation and computer technology have improved work efficiency, workers are now faced with increased abstraction, less variety, and greater pressure to perform.[15] In the quest to move up the office hierarchy, they constantly need to upgrade their skills and even take on roles for which they are ill-suited. Workers have to cope increasingly with fewer staff, heavier workloads, deadlines that require a faster pace of work, more task specialization, and less autonomy. Other stressors include office politics, contact with the public, and responsibility for subordinates.

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The objective of this study was to examine the role of work-related psychosocial stress in the aetiology of sick building syndrome. Three aetiologically meaningful subgroups of buildings have been proposed:[8] problem buildings with a crisis of concern about the safety of the indoor environment, problem buildings without an atmosphere of crisis, and buildings not recognized to have an environmental problem. Specifically, we wished to test the hypothesis that in buildings with no recognized environmental problems, health complaints typical of sick building syndrome were primarily stress-related.

METHODS

This case-control study is one part of the 1992–1995 nationwide survey on office morbidity which comprised a self-administered questionnaire assessing symptoms and perception of the physical and psychosocial environment, inspection of offices and building plans, and measurement of specific indoor air parameters. The aims of the survey were to obtain baseline information on the air quality of office premises, to establish the prevalence of building-related symptoms among occupants, and to identify the relationship of these symptoms to personal and indoor environmental factors.

The subjects were taken from an office population survey of building-related health complaints among male and female adults aged 16–60+ years. We employed a randomized multistage cluster sampling procedure in which buildings located throughout the island were first chosen, followed by the offices. To test our hypothesis, we used only public sector workers in government offices with no known building-related problems at the time of sampling. This was to take advantage of the relative homogeneity of government offices and reduce the risks of bias from some unidentified environmental factor. Besides sharing similarities in the organizational hierarchy, job functions and design of workstations, it was also easier to ensure the prohibition of smoking and the absence of renovation works in these premises.

Data were collected by a team of trained health officers who explained the purpose and confidential nature of the survey before distributing the structured questionnaire forms and collecting them individually on completion. The subjects were asked if they suffered frequently from symptoms such as mucous membrane and skin irritation, fatigue, headache, or other ailments. The criteria we used to define a case of sick building syndrome were onset of two or more symptoms at least twice weekly while in the building over the past 4 weeks, overnight resolution of these symptoms after leaving the building or workstation, and exclusion of known medical causes (e.g. current respiratory illness, pregnancy) for the symptoms. Our criteria were compatible with the WHO definition of the syndrome.[1] At the time of the questionnaire survey, neither the office workers nor the investigators knew if a subject would be classified as a case or not.

Besides obtaining basic clinical data, the study was designed to establish any association with personal factors, and factors related to the physical and psychosocial environment. For comparison, occupants of the same buildings, who did not fulfil the case criteria, were selected as unmatched controls. The data included sex, age, race, current and past medical history, work characteristics and conditions, and other indoor environmental exposure factors. In the investigation of social and organizational factors, subjects were asked to rate how they felt about the climate of co-operation at work on a 10-point scale ranging from 0 (not stressful) to 10 (extremely stressful). Similarly, they were asked to rate their experience of work-related physical and mental stress. No attempt was made to explain the concept of stress, or define its meaning for the respondents. Details of their occupation, and the amount of time spent in the office were also obtained.

As far as possible, we acquired supplementary data for each subject by walk-through inspections of the premises, and indoor air quality measurements. During the inspections, basic details about the offices, air-conditioning system and other ventilation installations were gathered with the help of the building managers. The air quality parameters monitored during the work-shift included temperature, relative humidity, air movement, respirable particles, chemicals (carbon oxides, ozone, aldehydes, volatile organic compounds) and bioaerosols (bacteria, fungi). Using approved methods,[16–18] indoor air samples were collected in the breathing zone of occupants, while reference outdoor values were taken at the fresh air intake points of the buildings.

In the statistical analyses, the odds ratio (OR) was chosen to describe the strength of association between the outcome and the determinants.[19] Differences in the prevalence of risk factors between cases and controls were first compared by the χ^2 test. Significant findings were next verified by multiple logistic regression to simultaneously adjust for the potentially confounding influence of the other factors.[20] Stepwise forward and backward regression procedures were carried out to select risk factors for entry into a best fit model. The fit was assessed by the log likelihood and Hosmer and Lemeshow tests. Further regression procedures were carried out on a subsample of the subjects to test for effect modifiers and to identify any interaction terms. The analyses were performed using SAS (SAS Institute,

TABLE 1 *Frequency of building-related symptoms among 437 affected occupants of public sector offices in Singapore*

Symptoms	No. affected	Per cent
Mucosal and skin irritations		
Dry throat	253	57.9%
Eye irritation	225	51.5%
Stuffy nose	214	49.0%
Skin dryness/rash	103	23.6%
General/neurotoxic reactions		
Fatigue	242	55.4%
Drowsiness	163	37.3%
Headache	156	35.7%
Dizziness	62	14.2%
Other ailments or complaints		
Shortness of breath	52	11.9%
Nausea/vomiting	12	2.7%

North Carolina) and SPSS (SPSS Inc., Illinois) microcomputer based software.

RESULTS

The six major government buildings surveyed were modern multistorey (7–42 floors) complexes equipped with central air-conditioning, fluorescent lighting and wall-to-wall carpeting, with an age of occupancy ranging from 4–8 years. The 67 selected offices typically utilized open concept workstations, and a few enclosed rooms for senior staff. A total of 2189 questionnaires were returned by the occupants, giving a response rate of 74.3%. As 29 of these were grossly incomplete, the final sample consisted of 2160 subjects. They comprised 69 (3.2%) managers, 750 (34.7%) professionals, 68 (3.2%) secretaries, 722 (33.4%) clerks, and 551 (25.5%) technical/other officers.

After excluding 238 (11%) subjects with ailments attributable to known medical conditions, 437 (20.2%) individuals reported symptoms fitting our criteria for the sick building syndrome. The frequency of building-related symptoms among the 437 affected occupants is shown in Table 1. Most of the cases did not notice a trend in time but 112 (25.6%) felt that their symptoms occurred more often in the afternoon. During our walk-through inspections of the buildings, no irregularities which could affect air quality by releasing pollutants or reducing ventilation were identified. The chemical, microbial and physical parameters of indoor air remained largely within acceptable standards[21,22] and correlated poorly with the prevalence of symptoms. The methodology and results of these investigations will be published elsewhere.

Comparison between cases and controls confirmed that the health complaints were influenced by both personal and environmental exposure factors (Table 2). The cases were more likely to be females aged <35 years. They also tended to give a history of medical conditions (e.g. sinus problems, migraine, asthma or other allergies) which could have increased their sensitivity. In addition, those affected had more problems related to low thermal comfort. These included feeling extreme cold requiring extra clothing for comfort, stuffiness, and insufficient air movement. Also implicated were ergonomic factors such as noise, lighting, and the frequent use of visual display units.

We observed the effect of social and organizational factors in the form of work-related psychosocial stress. There was an increasing prevalence of ailments in employees who perceived increasingly poorer climate of co-operation at work (Table 3). This trend was consistently seen with incremental changes in physical and mental stress experience. The rise in OR was suggestive of a dose-response relationship. There was no demonstrable threshold below which the occurrence of illness was unaffected by changes in the risk factor. No differences in prevalence by occupation or the amount of time spent in the office were noted.

Stepwise selection of statistically significant covariates yielded our final fitted logistic regression model (Table 4). In order of decreasing OR, factors associated with the occurrence of symptoms were high self-reported stress experience, low thermal comfort, history of a medical condition, poor acoustics, poor lighting, and younger age groups. Criteria for assessing the final fitted model suggested that the fit was satisfactory (log likelihood test revealed a χ^2 for covariates of 286.2 with 7 d.f., $P = 0.0001$, while the Hosmer and Lemeshow test gave a goodness-of-fit statistic of 7.5 with 8 d.f., $P = 0.483$). This indicated that work-related stress, independent of other risk factors, was significantly associated with the sick building syndrome.

In addition, we modelled the interaction of work-related stress with each of the covariates in a subsample using logistic regression analysis. Perception of stress was considered as the principal factor of interest and other covariates (thermal discomfort, medical condition, noise, lighting, age) as potential effect modifiers. None of the interaction terms achieved statistical significance.

DISCUSSION

The scope of health complaints associated with office buildings can be very wide. Based on current medical knowledge, the majority of illnesses are classifiable under two broad categories, namely building-related

TABLE 2 *Case-control comparison of prevalence of significant risk factors with corresponding unadjusted odds ratios*

Factor	Cases n = 437	Controls n = 1485	Odds ratio[a]
Sex			
Female	276	786	1.52 (1.22–1.91)
Age[b]			
16–25 years	87	207	1.53 (1.15–2.04)
26–35 years	147	376	1.50 (1.18–1.89)
36–45 years	97	450	0.66 (0.51–0.85)
>45 years	27	200	0.42 (0.27–0.65)
History of medical condition			
Sinus problems	96	151	2.49 (1.86–3.33)
Migraine	97	169	2.22 (1.67–2.96)
Allergies (incl. asthma)	55	88	2.29 (1.58–3.31)
Thermal comfort at workstation			
Extreme cold requiring extra clothing for comfort	136	282	1.93 (1.50–2.47)
Stuffiness	91	88	4.18 (3.00–5.80)
Insufficient air movement	199	342	2.79 (2.22–3.52)
Other environmental exposures			
Too much noise	151	282	2.25 (1.77–2.87)
Poor lighting	68	105	2.42 (1.73–3.40)
Use of visual display unit	226	636	1.43 (1.15–1.78)

[a] In the interpretation of odds ratios, the value for each specific category (e.g. 1.53 for age group 16–25 years) is obtained in comparison with all other categories (i.e. all other age groups). 95% confidence intervals are provided in parentheses.
[b] This variable was missing for 79 cases and 252 controls.

TABLE 3 *Case-control comparison of prevalence of psychosocial stress[a] with corresponding unadjusted odds ratios*

Factor	Cases n = 437	Controls n = 1485	Odds ratio[b]
Climate of co-operation at work			
High stress levels	90	129	2.73 (2.01–3.70)
Moderate stress levels	185	521	1.36 (1.09–1.70)
Low stress levels	162	835	0.46 (0.37–0.57)
Physical stress experience at work			
High stress levels	99	132	3.00 (2.23–4.04)
Moderate stress levels	157	438	1.34 (1.06–1.69)
Low stress levels	181	915	0.44 (0.35–0.55)
Mental stress experience at work			
High stress levels	183	306	2.78 (2.20–3.51)
Moderate stress levels	174	552	1.12 (0.89–1.40)
Low stress levels	80	627	0.31 (0.23–0.40)

[a] Self-reported scores of 0–3 on a 10-point scale were arbitrarily classified as low stress levels; 4–6, moderate stress levels; and 7–10, high stress levels (see text).
[b] 95% confidence intervals are provided in parentheses.

TABLE 4 *Logistic regression model of independent variables predicting the sick building syndrome among office workers*

Significant variable	Adjusted odds ratio[a]	95% confidence limits	*P*-value
High self-reported stress experience (physical, mental, climate of co-operation)	2.56	2.02–3.24	0.0001
Low thermal comfort (extreme cold requiring extra clothing for comfort, stuffiness, insufficient air movement)	2.54	2.00–3.22	0.0001
History of medical condition (sinus problems, migraine, allergies)	2.25	1.78–2.85	0.0001
Poor acoustics (too much noise)	1.86	1.44–2.41	0.0001
Poor lighting (too much light, too little light)	1.84	1.29–2.63	0.0008
Age 16–25 years	1.92	1.40–2.64	0.0001
Age 26–35 years	1.62	1.24–2.11	0.0004

[a] Adjusted for mutual confounding between significant independent variables.

illnesses and sick building syndrome.[23] Building-related illness is said to occur when occupant exposure to indoor contaminants results in a clinically defined illness, disease or infirmity. After excluding these conditions, the remaining health complaints constitute a group of ailments collectively attributed to working in the building and referred to as the sick building syndrome. By far the most common health problem in our study population, this syndrome is said to occur when a substantial proportion of the occupants of a building experience symptoms associated with acute discomfort that are relieved upon leaving the premises. Because clinical consensus on what constituted sick building syndrome was lacking, we chose to use the WHO definition which dealt exclusively with perceived symptoms.

The sick building syndrome was found to be significantly associated with several personal and environmental exposure factors, including age, allergy or other medical conditions, thermal comfort, noise and lighting. Our univariate analysis showed a higher prevalence of building-related health complaints among workers who used visual display units frequently compared to others. However, the difference disappeared after adjustment for other determinants such as poor lighting. This finding suggested that visual display unit users could have been affected largely because they were more exposed to glare from the video screen, or some other lighting problem.

A weakness in the study was that self-reporting of symptoms and certain exposures could lead to biased observations of association. This is because the recognition and reporting of building-related health complaints is influenced not just by the ambient environment, but also by the individual's perception of his or her environment. For example, many cases reported stuffiness and insufficient air movement, suggesting thermal comfort problems. However, the cause for their symptoms might actually have been indoor pollutants, undetectable by human senses, which accumulated because of the insufficient air movement.[6] We attempted to address the problem by sampling the indoor air but it remains possible that some unidentified agents were ventilated out of the building before monitoring began. The need to wear extra clothing for comfort was probably a more direct indicator of thermal comfort, but significant results observed should still be interpreted with caution. Another explanation might be that low job satisfaction could make the individual not only more susceptible to other risk factors in the environment but also more aware, and critical of different aspects of the surroundings.

In any case, factors related to the physical environment were insufficient by themselves to account for the reported symptoms. We confirmed a significant and independent relationship between these illnesses and psychosocial stress. Although physicians have long recognized that people were more susceptible to sickness when subjected to high levels of stress,[24–27] medical research in this area is limited. Ailments brought on or worsened by psychosocial stressors commonly involve hormone-mediated responses as well as the autonomic nervous system which controls the body's internal organs. Known stress-related disorders include some kinds of headache, peptic ulcers, ulcerative colitis, irritable bowel syndrome, diabetes, coronary heart disease, high blood pressure, bronchial asthma, and eczema.[12,28,29] Under stress, the body makes rapid physiological changes, called adaptive responses, to deal with threatening situations. If the stressful situation continues and the body's adaptive capability runs out, illness could result.

While a suspected cause must always precede the ailments in time, this is difficult to verify in a retrospective study. Nonetheless, a number of well established epidemiological criteria[30,31] could be used to infer a causal relationship between work-related stress and sick building syndrome. The strength of the observed association, as indicated by the adjusted OR compared to the other variables, was a major consideration. The stronger the association, the less likely that it could be explained by chance. Next, our findings were consistent with those of other investigators. High psychosocial workload has been reported as a risk factor in investigations of sick building syndrome under different settings.[32–34] In addition, we could demonstrate a clear dose-response relationship indicating a greater risk of illness with increased levels of stress. Furthermore, the role of stress in the aetiology of sick building syndrome was coherent with known biological processes and reasoning by analogy.

The exact mechanisms that could produce the sick building syndrome are still not fully understood, but it is plausible that the health complaints we observed were manifestations of stress-related illness. On the other hand, more severe degrees of physical or mental stress, or the perception of a poor climate of co-operation might be influenced by the physical environment and symptoms associated with building performance. We tried to identify these interactions through statistical modelling, but none were significant. A psychogenic origin to the syndrome would still be consistent with the diversity of the health complaints, and the inability to identify any environmental cause despite extensive investigation. This psychosocial component might also explain why 'feng-shui' (translation, wind-water), the Chinese practice of geomancy using natural elements to bring good health and fortune, commands a strong following in Singapore and Hong Kong offices and appears to work in some cases.[35,36]

Today, sick building syndrome is used to describe a complex of acute nonspecific symptoms caused by working in buildings with an adverse indoor environment. Over time, we believe the psychosocial component to the syndrome will increase. One reason is that if scientific research identifies specific indoor contaminants and re-labels their effects as building-related illness, these will be removed from the pool of contributions to the syndrome, leaving behind a larger psychosocial component. Another reason is that when the media provide publicity and raise the issue of compensation for those allegedly exposed, health complaints become progressively enmeshed with complaints of psychosocial origin.[37,38] This latter problem has already complicated investigations into the 'Gulf War syndrome'.[39,40]

Our study confirmed the role of work-related psychosocial stress as a significant and independent determinant of the health complaints, and that symptoms compatible with sick building syndrome in many cases were stress-related. To elucidate even more clearly the relationship between cause and effect, additional studies comparing the individual's perception of symptoms and experiences in various work environments are needed. Nevertheless, our findings underscore the importance of personal and organizational stress management to prevent ill health and improve productivity at the office.

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