Prevalence of the sick building syndrome symptoms in office workers before and after being exposed to a building with an improved ventilation system

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Abstract

Objective—To find if the prevalence of symptoms associated with sick building syndrome decreased among office workers after moving to a building with improved ventilation (after controlling for potential confounders).

Methods—Workers in five buildings in 1991 all moved in 1992 into a single building with improved design, operation, and maintenance of the ventilation system. All buildings had sealed windows with mechanical ventilation, air conditioning, and humidification. Workers completed a self administered questionnaire during normal working hours in February 1991 and February 1992. The questionnaire encompassed symptoms of the eyes, nose and throat, respiratory system, skin, fatigue, headache, and difficulty concentrating, personal, psychosocial, and work related factors. During normal office hours of the same week environmental variables were measured.

Results—The study population comprised 1390 workers in 1991 and 1371 workers in 1992 who represented more than 80% of the eligible population. The prevalence of most symptoms decreased when workers moved to the new building: skin (54%), respiratory system (53%), nose and throat (46%), fatigue (44%), headache (37%), eyes (23%). These findings were all significant and remained generally similar after controlling for personal, psychosocial, and work related factors. Furthermore, more than 60% of workers symptomatic in 1991 were asymptomatic in 1992 for all types of symptoms. In contrast, less than 15% of workers were asymptomatic in 1991 but symptomatic in 1992 for all types of symptoms.

Conclusion—In this study, the prevalence of most symptoms usually associated with the sick building syndrome decreased by 40% to 50% after workers were transferred to a building with an improved ventilation system. The results show that it is possible to diminish the prevalence of symptoms associated with the sick building syndrome among office workers occupying a building with mechanical ventilation, air conditioning, and sealed windows.

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As defined by the World Health Organisation, the sick building syndrome is characterised by an excessive prevalence of irritative symptoms of the skin and the mucous membranes and other symptoms including fatigue, headache, and difficulty concentrating in the people occupying a building.¹ Overall evidence suggests that these symptoms are relatively common among office workers. Studies on workers in buildings selected without regard to complaints about symptoms reported a prevalence of more than 20% of at least one work related symptom (usually defined as a symptom that improves when away from work).²⁻⁴ Such symptoms could have an impact on a worker's productivity.^{5,6} A study conducted in a stratified random sample of office workers in the United States showed that at least 20% reported a decrease in work performance as a consequence of their symptoms.⁷

Although specific aetiological exposures have not been shown to be the cause of these symptoms, in many studies, several factors have been associated with an increased prevalence of symptoms. In a reanalysis of six epidemiological studies,⁸ it was shown that the prevalence of symptoms was consistently two to three times greater in buildings with mechanical ventilation and air conditioning than in buildings with natural or simple mechanical ventilation. In these six studies, the presence of sealed windows was a usual feature of buildings with mechanical ventilation and air conditioning, being present in 47 of 48 buildings, whereas this feature was present in only five of the 57 buildings with natural or simple mechanical ventilation. Of other environmental factors assessed, an increase in symptoms has been consistently associated with a ventilation rate at or below 10 l/s/person, carpets, more workers in a space, and use of a video display terminal.⁹ Also, some well designed studies have shown high temperature and low relative humidity to be associated with an increased prevalence of symptoms.⁹ Personal factors, such as a history of allergies and asthma, female sex, and psychosocial factors have generally been

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associated with an increased prevalence of symptoms.⁹

The present paper describes the results of a natural experiment carried out in office workers occupying buildings with mechanical ventilation, air conditioning, and sealed windows. Workers occupied five buildings in 1991. In 1992, these workers moved to a single building with an improved ventilation system. The main objective of the study was to find if the prevalence of symptoms would be reduced in 1992, after controlling for potential confounders.

Methods

STUDY POPULATION AND BUILDINGS

The eligible population included all workers employed in a large public organisation in Quebec city. The five buildings occupied in 1991 and the building occupied in 1992 had heating, ventilation, air conditioning systems with humidification, and sealed windows. The buildings occupied in 1991, built in the 1960s, had two to 11 floors each. The building occupied in 1992 was newly constructed and had three towers of four to six floors. Table 1 shows the characteristics of the ventilation systems. The buildings occupied in 1991 had one or two ventilation systems and an outdoor air intake of less than 2.5 l/s/person. The building occupied in 1992 had nine systems and 30 units of distribution with an outdoor air intake of 7.5 l/s/person or more (mean of 21 l/s/person). Each half floor was ventilated independently and air from the photocopier rooms was not recirculated. The humidity could be maintained at 30% under normal conditions and the temperature, automatically controlled by numerous probes on each floor, was maintained within the narrow range of 23° to 23.5°C. The smoking policy in all the buildings allowed employees to smoke only in designated areas. However, in the new building, the designated smoking areas were clearly isolated and air was not recirculated in the entire building.

DATA COLLECTION

The workers completed a self administered questionnaire during working hours in

February 1991 and in February 1992. The workers moved in August 1991 to the building occupied in 1992, thus allowing six months before measurements. February is a winter month in Quebec, with outside temperatures averaging -10°C. At that time of the year, workers are mostly confined inside, and outside air supply is likely to be decreased. The impact of indoor air contaminants was thus probably at its highest at that time of year. Questionnaires were completed by each worker at their workplace and usually returned to the research team the same day. Measurements of environmental variables were conducted during normal office hours in the same week as the questionnaire.

QUESTIONNAIRE

Symptoms

The questionnaire encompassed seven types of symptoms: eyes (dryness, irritation, or burning), nose and throat (dryness, runny nose, nose congestion), respiratory system (breathlessness, chest tightness, wheezing), skin (dryness, irritation, itching), fatigue, headache, and difficulty concentrating. For each type of symptom, workers were asked whether it ever occurred or not. If so, workers were asked to indicate its frequency (less than once a month, once weekly to once monthly, two to three times weekly, or almost every day) and the place where it occurred (at work only, at work and at home, at home only, others). In the present study, a symptom was defined as occurring when it occurred only at work two to three times a week or more often.

Factors associated with symptoms in previous studies

A history of respiratory disease was assessed with a question inquiring whether workers had ever experienced asthma or chronic pulmonary disease (chronic bronchitis or emphysema). Number of hours of use of a video display terminal, proximity to a photocopier, and smoking were also assessed by questionnaire. Two main components of the psychosocial work environment were measured: job strain, a combination of high psychological job demands and low job decision latitude, and social support at work.¹⁰ Psychological job

Table 1 Characteristics of the ventilation system in the buildings occupied in 1991 and in the building with an improved ventilation system occupied in 1992

Characteristic	1991		
	Buildings* 1 and 2	Buildings 3 to 5	1992 Single building
Ventilation system:			
Type of system	HVAC	HVAC	HVAC
Number of systems	Constant air 1(B1) 2(B2)	Variable air 1	Constant air 9 (with 30 units of distribution)
Humidification	Evaporative(B1) Steam(B2)	Evaporative	Steam
Exhaust fan	Present	Absent	Present
Outdoor air intake (l/s/person)	≤ 2.5	≤ 2.5	> 7.5
Maintenance and inspection			
Filter replacement	4/y	Not done	4/y
Thermostat calibration and control	2/y	1/y	Automatically controlled by probes on each floor
Cleaning of system duct	Never	Never	New building

* B1 = building 1; B2 = building 2; HVAC = heating ventilation and air conditioning systems.

demands and job decision latitude were measured with the Karasek 18 item questionnaire.¹¹ The French version of this questionnaire has good internal consistency, one year reproducibility, factorial validity, and discriminant validity.¹² Social support at work was measured with the five item scale recommended in the MONICA psychosocial survey.¹³

Other factors

Other work related factors that could potentially be associated with symptoms and could vary from 1991 to 1992 were also considered as potential confounders. These are ambient noise, intensity of lighting, reflected light, comfort at the work station, and workplace intimacy. These factors were evaluated by questionnaire with an adapted version of the tenant survey assessment questionnaire developed by Dillon and Vischier.¹⁴ The answers for each question were presented on a five point Likert type scale.

Environmental measurements

In each building, the environmental variables were measured on each or every other floor during one day of the same week that the questionnaire was completed. Carbon dioxide, temperature, and relative humidity were measured hourly with a portable direct reading instrument at five sites (on the four corners and the centre of the floor) between 7 00 and 18 00 during work hours. Total volatile organic compounds, formaldehyde, and total airborne particulates were measured at one site (in the centre of the floor) during work hours. The threshold of the analytical method was 275 µg for total volatile organic compounds, 1.4 µg for formaldehyde, and 25 µg for total airborne particulates, which were measured according to the Institut de recherche en santé et en sécurité du travail du Québec (IRSST)¹⁵ and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standards.¹⁶

ANALYSIS

The analysis first involved assessing the crude association between the prevalence of symptoms measured in 1991 and factors associated with symptoms in previous studies. Each type of symptom was analysed separately. The prevalence of symptoms at each level of the factors was compared with the prevalence ratio and its 95% confidence interval (95% CI).¹⁷ The second part of the analysis involved comparing the prevalence of a symptom measured in 1991 with that measured in 1992. The prevalence found in 1991 was used as the reference category. This analysis first involved crude prevalence ratios and prevalence odds ratios¹⁷ and 95% CI to evaluate comparability of these two effect measures in our data. Then prevalence odds ratios were calculated in a matched analysis among workers who completed the questionnaire in February 1991 and in February 1992 to control confounding effects of unmeasured personal factors.

Confidence intervals of the matched odds ratios were calculated with a McNemar test.¹⁸ To control confounding effects of personal, psychosocial, and work related factors, adjusted prevalence odds ratios were obtained by logistic regression for all workers.¹⁹ The last part of the analysis evaluated the proportion (%) of workers whose symptoms improved from 1991 to 1992 and the proportion (%) of workers whose symptoms deteriorated from 1991 to 1992. Data were analysed with the statistical analysis system (SAS).²⁰

Results

A total of 1798 workers were on the payroll in February 1991 and 1878 in February 1992. After excluding workers on long term leave, on sick leave, and those whose place of work was outside the buildings under study, the eligible population was 1669 workers in 1991 and 1717 workers in 1992. After excluding refusals, untraced workers, and those who did not complete the section on symptoms in the questionnaire, 1390 workers were available for study in 1991 and 1371 in 1992, which represents 80% of the eligible population. The sub-population comprised 1010 matched workers (72.7%).

Table 2 shows the prevalence of symptoms reported by questionnaire in 1991. Symptoms affecting the nose and throat were the most frequent (23.0%), followed by difficulty concentrating (18.4%), eyes (17.7%), and fatigue (15.0%). Other symptoms were less frequent: headache (7.3%), skin (6.9%), and respiratory (3.1%).

Table 3 shows the relation of some personal, psychosocial, and work related factors to the prevalence of symptoms in 1991. Women had higher prevalences of symptoms than men for all symptoms except respiratory and concentrating. Workers who reported chronic pulmonary disease or asthma had higher prevalences of symptoms of the nose and throat, eyes, and skin, and difficulty concentrating. Current smokers had higher prevalences than non-smokers of all symptoms except respiratory, headache, and concentrating. Workers exposed to high job strain, a combination of high psychological demands, and low job decision latitude had higher prevalences of all symptoms except eyes, respiratory, and skin. Workers with low social support at work had higher prevalences for all symptoms except eyes, respiratory, and concentrating. Those working 20 hours or more a week on a video display terminal had higher

Table 2 Prevalence of symptoms in 1991

Symptom	Total workers* n	Workers with symptoms n (%)
Nose-throat	1359	313 (23.0)
Eyes	1352	239 (17.7)
Respiratory	1357	42 (3.1)
Skin	1345	93 (6.9)
Headache	1362	99 (7.3)
Concentrating	1340	247 (18.4)
Fatigue	1337	201 (15.0)

*Total workers do not = 1390 because of missing values.

Table 3 Crude association* between the prevalence of symptoms measured in 1991 and some personal, psychosocial, and work related factors

Factor	Workers† (n)	Nose and throat	Eyes	Respiratory	Skin	Headache	Concentrating	Fatigue
Sex:								
Men	585	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Women	801	1.7 (1.4-2.1)	1.9 (1.5-2.5)	1.3 (0.7-2.5)	3.3 (2.0-5.5)	2.0 (1.3-3.0)	1.1 (0.9-1.3)	1.6 (1.2-2.0)
COPD or asthma:								
No	974	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Yes	141	1.3 (1.0-1.7)	1.4 (1.0-2.0)	1.9 (0.9-4.4)	1.8 (1.0-3.2)	1.1 (0.6-2.1)	1.4 (1.0-2.0)	1.3 (0.9-2.0)
Smoking habits:								
None	1053	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Occasional	78	1.2 (0.8-1.8)	1.0 (0.6-1.7)	0.9 (0.2-3.7)	1.9 (0.9-3.8)	1.3 (0.7-2.7)	0.8 (0.5-1.4)	0.8 (0.4-1.6)
Current	247	1.4 (1.1-1.7)	1.4 (1.1-1.8)	1.4 (0.7-2.8)	2.0 (1.3-3.1)	0.7 (0.4-1.2)	1.0 (0.8-1.4)	1.6 (1.2-2.2)
Job strain:								
Low	938	1.0	1.0	1.0	1.0	1.0	1.0	1.0
High	360	1.3 (1.0-1.6)	1.2 (0.9-1.5)	1.7 (0.9-3.1)	1.4 (0.9-2.2)	1.5 (1.0-2.3)	1.6 (1.3-2.1)	1.7 (1.3-2.2)
Social support:								
High	416	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Medium	667	1.2 (0.9-1.5)	1.1 (0.8-1.5)	0.9 (0.4-2.0)	1.0 (0.6-1.7)	1.2 (0.7-1.9)	0.8 (0.6-1.1)	1.3 (0.9-1.7)
Low	270	1.7 (1.3-2.2)	1.3 (0.9-1.8)	2.0 (0.9-4.3)	1.7 (1.0-2.9)	1.6 (1.0-2.7)	1.2 (0.9-1.6)	1.6 (1.1-2.4)
Video display terminal:								
< 20 h/week	852	1.0	1.0	1.0	1.0	1.0	1.0	1.0
≥ 20 h/week	536	1.2 (1.0-1.5)	1.5 (1.2-1.9)	1.1 (0.6-2.0)	1.8 (1.2-2.7)	1.2 (0.9-1.8)	0.9 (0.7-1.1)	1.4 (1.1-1.8)
Photocopier nearby:								
≥ 5 m	1129	1.0	1.0	1.0	1.0	1.0	1.0	1.0
< 5 m	260	1.3 (1.0-1.6)	1.1 (0.8-1.5)	2.0 (1.0-3.7)	1.3 (0.8-2.1)	1.7 (1.1-2.6)	1.1 (0.8-1.4)	1.3 (0.9-1.7)

*Values are crude prevalence ratios (95% CIs); †Number of workers do not total 1390 because of missing values; COPD = chronic obstructive pulmonary disease.

Table 4 Prevalence ratios (PR) and prevalence odds ratios (POR) of symptoms in 1992 compared with 1991*

Symptom	PR (95% CI) Crude unmatched analysis	POR (95% CI) Crude unmatched analysis	POR (95% CI) Crude matched analysis	POR (95% CI) Adjusted† unmatched analysis
Nose and throat	0.54 (0.45-0.64)	0.47 (0.38-0.58)	0.38 (0.28-0.52)	0.45 (0.35-0.58)
Eyes	0.77 (0.65-0.92)	0.74 (0.60-0.91)	0.59 (0.43-0.80)	0.75 (0.59-1.00)
Respiratory	0.43 (0.25-0.74)	0.42 (0.24-0.73)	0.30 (0.13-0.71)	0.34 (0.17-0.68)
Skin	0.46 (0.32-0.66)	0.44 (0.31-0.64)	0.43 (0.27-0.69)	0.52 (0.34-0.80)
Headache	0.63 (0.46-0.85)	0.61 (0.44-0.84)	0.62 (0.39-0.98)	0.59 (0.40-0.87)
Concentrating	1.02 (0.87-1.20)	1.03 (0.85-1.25)	1.03 (0.79-1.34)	0.91 (0.72-1.16)
Fatigue	0.56 (0.45-0.70)	0.52 (0.41-0.67)	0.39 (0.28-0.55)	0.50 (0.37-0.67)

*The numbers of workers were 1390 in 1991, 1371 in 1992 in the unmatched analysis, and 1010 in the matched analysis.

†Adjusted for ambient noise and lighting in the room, comfort at the workstation, workplace intimacy, smoking at work, proximity of a window, time spent at a video display terminal, job strain, and social support at work.

prevalences of all symptoms except respiratory, headache, and concentrating. Workers located less than five metres from a photocopier had higher prevalences of symptoms of the nose and throat and respiratory tract, and headache.

Table 4 shows the prevalence ratios and the prevalence odds ratios of symptoms in 1992 when in the building with an improved ventilation system, compared with 1991. In the crude unmatched analysis conducted among all workers (first column) the prevalence of symptoms diminished by 40% to 50% in 1992 for four of the seven types of symptoms: nose and throat, respiratory, skin, and fatigue. The prevalence diminished by 37% for headache and by 23% for symptoms of the eyes. There was no decrease in the prevalence of difficulty in concentrating. The crude prevalence odds ratios (second column) were generally similar

to the crude prevalence ratios thus indicating the comparability of the two effect measures in our data. Further analyses presented in this table involve prevalence odds ratios. The crude matched analysis conducted in the subpopulation of workers who completed the questionnaire in 1991 and in 1992 produced prevalence odds ratios (third column) similar to those obtained in the crude unmatched analysis among all workers. Also, logistic regression conducted among all workers in an unmatched analysis (fourth column) showed that the effect measures remained similar when adjusted for personal, psychosocial, and work related factors.

Table 5 shows the proportion of workers whose symptoms improved or deteriorated from 1991 to 1992. The proportion of workers with symptoms in 1991 who did not have symptoms in 1992 was greater than 60% for all types of symptoms. On the other hand, the proportion of workers who did not have symptoms in 1991 and had symptoms in 1992 was below 15% for all types of symptoms and below 8% for all symptoms except difficulty concentrating.

The figure shows the mean concentrations of CO₂, humidity, and temperature for each year of the study. The concentrations of CO₂ presented are the means of the highest daily values at the different sites. The concentrations of CO₂ (which reflect occupancy of workspace and ventilation capacity) were less in 1992 than in 1991. In the buildings

Table 5 Proportion of workers with improvement or deterioration of symptoms from 1991 to 1992 (n = 1010)

Symptom	Workers with symptoms in 1991		Workers without symptom in 1991	
	n	Proportion (%) without symptom in 1992	n	Proportion (%) with symptoms in 1992
Nose and throat	217	70.1	767	7.4
Eyes	178	61.2	806	7.9
Respiratory	27	85.2	967	0.7
Skin	61	95.1	922	2.7
Headache	69	68.1	919	3.2
Concentrating	179	61.5	790	14.3
Fatigue	149	77.2	821	5.5

Mean concentrations of CO₂, humidity, and temperature in the buildings occupied in 1991 and 1992.

occupied in 1991, the concentration of CO₂ depending of the site and the time of the day, could sometimes reach 900 ppm, compared with 650 ppm in the building occupied in 1992. However, in the buildings occupied in 1991, the concentration of CO₂ was similar between buildings. The mean humidities were better in 1992 than in 1991. The humidities ranged from 13% to 35% in the buildings occupied in 1991 and from 23% to 42% in the building occupied in 1992. In buildings 1 and 2, the humidities were less than 20%, and in buildings 3, 4, and 5, the humidities were more than 20%. However, the prevalences of symptoms in buildings 1 and 2 were similar to those of buildings 3, 4, and 5. The mean temperatures were comparable in both years. However, in the buildings occupied in 1991, the temperature ranged from 22.5 to 24°C and was similar between buildings compared with a narrow range of 23 to 23.5°C in the building occupied in 1992. Although not presented here, the volatile organic compounds, formaldehyde, and airborne particulates were either comparable in 1991 and 1992 or under the threshold of the analytical methods.

Discussion

In the present study, the prevalence of most symptoms decreased by 40% to 50% after workers moved to the new building with an improved ventilation system. The proportion of workers symptomatic in 1991 but asymptomatic in 1992 was more than 60% for all types of symptoms. In contrast, the proportion of workers asymptomatic in 1991 but symptomatic in 1992 was less than 15% for all types of symptoms.

Measuring the symptoms by questionnaire is one potential limitation of the present study. This limitation is also found in most studies of the sick building syndrome.⁹ However, studies comparing perceptual and objective measurements of symptoms related to the sick building syndrome were significantly correlated,^{21,22} which provides some support for the validity of measurements made by questionnaire.

The healthy worker effect is a possible source of selection bias in prevalence studies in that workers who have most symptoms may have left the workplace.²³ If such selection occurred it led to an underestimation of the

prevalence of symptoms each year of the study. However, it is reasonable to postulate that if the selection factor occurred it operated equally each year of the study and thus did not bias the effects.

One strength of the present study was that its follow up allowed for measurement of symptoms in the same population before and after working in a building with an improved ventilation system. This allowed a matched analysis among workers who completed the questionnaire in 1991 and in 1992. Results obtained from the matched analysis were similar to those obtained from the unmatched analysis indicating that there was no confounding effect related to unmeasured personal factors. The similarity of results from the matched and unmatched analyses also indicates that matched workers who constitute a subpopulation are representative of the entire population. This provides support for the validity of our findings on the proportions of workers symptomatic in 1991 but asymptomatic in 1992 and vice versa which were also obtained among matched workers.

It could be argued that the workers, unblinded to the change in exposure, were likely to underreport their symptoms in 1992 because of a presumed positive psychological impact of moving to a new building. If this were the case, the measured associations would have been biased away from the null. However, the fact that not all types of symptoms decreased in 1992 does not support the existence of such an effect. Indeed, if a positive psychological impact associated with moving existed, one would expect it to exist for all types of symptoms. Our data on psychosocial factors do not support the idea of a positive psychological impact associated with moving. Indeed, in 1992, the reported prevalences of job demands, decision latitude, job strain, and social support at work were similar to those reported in 1991.

Efforts were made in planning the study to measure potential confounding factors and to control them in the analysis. Confounders are factors other than the study variables (changes in the design, operation, and maintenance practices of the ventilation system) that could be different in the building occupied in 1992 compared with the buildings occupied in 1991 and that could potentially be associated with

the prevalence of symptoms. Such factors may be related to the characteristics of the study population, the physical work environment, and the psychosocial work environment. As for characteristics of the study population such as age, sex, biomedical factors, and personality characteristics, they could either not change or change very little over one year. These factors were thus inherently controlled by the design. Smoking habits were controlled in the analysis. This may have had an effect on the reduction of prevalence of symptoms. Factors related to the physical work environment are potentially numerous. In this study, the analysis controlled for ambient noise, lighting, comfort at the workstation, workplace intimacy, proximity of a window, and number of hours at a video display terminal. Factors related to the psychosocial work environment are also potentially numerous. In this study we controlled for two important psychosocial factors at work: job strain, the simultaneous presence of high psychological job demands and low job decision latitude, and social support at work.¹⁰ These two factors are recognised to be important in the development of adverse health effects.^{10,24} The effects measured remained similar after controlling for all these factors in the analysis.

The absolute prevalence of symptoms measured in our study is generally lower than that measured in previous studies.⁸ This finding is consistent with our definition of a prevalent symptom, which we considered more restrictive than the definitions generally used in previous studies. Indeed, our definition of symptoms required that they be present only at work, which is probably more restrictive than including symptoms that improve away from work, as used in most studies. The order in which the prevalence of most types of symptoms ranked in our study is consistent with previous studies.⁸ Indeed, in 1991, symptoms related to the nose and throat (21.8%), the eyes (18.1%), or fatigue (15.4%) were the most prevalent, whereas skin (6.2%) and respiratory (2.7%) symptoms were the least prevalent.

Our results show that female sex, personal medical history of asthma and allergy, high job strain, low social support at work, and working for more than 20 hours on video display terminal were associated with an increased prevalence of many symptoms. These results are consistent with previous studies.⁹

A 40% to 50% decrease in the prevalence of most symptoms was measured in 1992 when workers were in the building with an improved ventilation system. The magnitude of this effect is consistent with the twofold increased prevalence of symptoms found in previous studies when buildings with mechanical ventilation and air conditioning were compared with buildings with natural or simple mechanical ventilation.⁸

This study was not designed to assess specific aetiological exposures. Although limited, the environmental measurements were of interest. The decreased concentration of CO₂ found in 1992 corroborates the improvement

of ventilation in the building occupied in 1992 and could contribute to the lower prevalence of symptoms. This finding is of importance given that the occupancy per square metre was on average higher in the building occupied in 1992 than the buildings occupied in 1991. The fact that air from the smoking area was not recirculated in the new building could also contribute to the lower prevalence of symptoms in 1992 as could the higher humidity and the more stable temperature in the building occupied in 1992. Indeed, in several studies, an increased humidity has been associated with a reduction in the prevalence of symptoms,^{21,25} and an increased temperature, even within the range of the present study, has been associated with a reduction in the prevalence of symptoms.²⁶ Despite a difference of humidities between buildings 1 and 2 (humidity less than 20%) and 3, 4, and 5 (humidity more than 20%) in the building occupied in 1991, there was no difference in the prevalence of symptoms in these buildings. However, the analysis of the effect of humidity was relatively crude as the environmental measures were not specific to each occupant.

Conclusion

Buildings with mechanical ventilation and air conditioning, which usually means buildings with sealed windows, are the work environment of great numbers of office workers worldwide. The results of the present study corroborate previous findings showing that the prevalence of symptoms is associated with many factors. The results also showed that it is possible to decrease the prevalence of symptoms among workers occupying this type of building. Indeed, the prevalence of most symptoms decreased by 40% to 50% after workers were moved to a building with an improved ventilation system. Until the identification of more specific causes, prevention of or intervention in the sick building syndrome should be at the level of reasonable design, operation, and maintenance practices of the ventilation system.

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