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ORIGINAL ARTICLE

Work-related symptoms in indoor environments: a puzzling problem for the occupational physician

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Abstract

Purposes People who work indoors often manifest symptoms related to the work environment. Sick building syndrome (SBS) is a condition closely associated with sealed, air-conditioned workplaces and is especially frequent in countries with a cold climate. However, it is also present in Mediterranean countries where artificial ventilation accompanies the natural one. The significance of personal factors, air quality perception, and psychosocial work conditions in relation to SBS and other work-related symptoms needs to be clarified.

Methods Workers from 28 companies in the Latium region of Italy were invited to answer a questionnaire during their routine medical examination at the workplace. A total of 4,029 out of 4,129 took part in the survey, giving a response rate of 97.6 %.

Results A high percentage of workers (31.9 %) reported symptoms related to work, and two-thirds of the employees (65.4 %) complained of environmental problems. In logistic regression models, personal factors (gender, smoking habit, age, and atopy), anxiety and depression, environmental discomfort and job strain were associated both with symptoms of SBS and other work-related symptoms. There was a significant association between the perception of stuffy air, dry air, and electricity and cases of SBS. Some associations between symptoms and the work environment lacked biological plausibility.

Conclusions The occupational physician's task is to systematically monitor workers' symptoms and their perception of the work environment in order to analyze this relationship and indicates the best mode of preventing illness/discomfort. This paper provides a method and reference values.

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Introduction

The health surveillance of workers involves the systematic monitoring and analysis of both complaints relating to the occupational environment and of work-related symptoms. The occupational physician should concentrate on distinguishing between symptoms that are actually caused by exposure to work and those that can be attributed to other origins. Even if this information can be obtained in the course of an interview, it is better for physicians to use a questionnaire as this enables them to obtain a large set of data in a short time.

One of the most frequent conditions that can affect workers in indoor environments is known as sick building syndrome (SBS). This morbid condition, which was identified more than 30 years ago, is characterized by the occurrence of medical symptoms (neuropsychological, mucosal, and dermal) that are closely associated with occupational exposure to a specific environment (Burge 2004) and that have a significant effect on productivity (Fisk et al. 2011; Niemelä et al. 2006). This symptom pattern has been described in all kinds of non-industrial environments, such as offices, schools, day care centers, and hospitals as well as in dwellings and the general population (Norbäck 2009). Several investigations have been carried out in so-called problem-buildings where a high proportion of workers experienced symptoms (Letz

1990; Redlich et al. 1997; Meggs 2009). A high prevalence of symptoms has often been found even in "non-problem" buildings (Magnavita et al. 1995; Muzi et al. 1998; Niven et al. 2000). In most cases, researchers failed to find a precise cause for the disorders or explanation for the great variability in symptoms and discomfort in the various buildings. The etiology of SBS, therefore, remains largely unknown.

Although SBS symptoms are considered to be reversible, most workers express concern about the possible long-term health effects of indoor pollution. The subjective nature of the symptoms and the aforementioned difficulties encountered during investigation mean that the boundary between SBS and other medically unexplained conditions is slim, especially when we take into account the overlap of SBS with multiple chemical sensitivities (MCS) and psychogenic mass illness (PMI) (Magnavita 1998, 2000; 2001; Chang and Gershwin 2004). Despite the numerous studies on the subject, there is no research that takes into account both the perceptions of workers, their personal components (anxiety, depression, occupational stress) and objective state of health. For this reason, we need to clarify the role of individual characteristics and the psychosocial work environment in SBS.

It is the occupational physician's responsibility to assess occupational hazards and communicate to workers the extent of any occupational risk. In accordance with good practice in occupational medicine and with European Directives, at least once a year, he/she must report trends in epidemiological data collected through observation of workers and suggest possible improvements in the working environment. He/she must collect and analyze workers' symptoms and decide which of these are actually attributable to occupational exposure and which, on the other hand, are primarily due to the characteristics of the subject. This task, which may be easy in the presence of a single major pollutant, is particularly difficult when, as frequently occurs nowadays, workers are exposed to low/very low doses of a number of harmful agents of a physical, chemical, biological, and psychosocial nature. The doctor who is responsible for the medical surveillance of non-industrial workers must study the distribution of both SBS and non-SBS symptoms and their relationship with individual factors, such as gender, age, smoking habits, atopy, anxiety, depression, work-related stress and occupational exposure in the working environment.

Aims

Our main aim was to study the frequency of work-related symptoms in "healthy" workers (episodes of macroscopic pollution of their working environments were excluded), to investigate associations between work-related symptoms and psychosocial work conditions, individual psychological states (anxiety, depression), the level of job stress, and the perceived indoor environment, and to evaluate which of these factors were of greatest importance, in order to ascertain the correct action to be taken by the occupational physician responsible for the medical surveillance of workers.

A second aim of our study was to evaluate the frequency of SBS symptoms in a large working population in a region where climatic conditions do not require significant insulation to be used in indoor environments. We also aimed to determine which environmental hazards were most associated with symptoms in order to understand whether SBS in a Mediterranean country has the same characteristics as reported elsewhere.

Methods

Survey

The survey covered workers in 28 public and private companies in the Latium region of Italy, all of whom were engaged in activities that took place within confined spaces. Workers who had been employed for at least 1 year were invited to complete a two-page questionnaire before undergoing routine medical examination at the workplace. The questionnaire included questions on indoor air problems, symptoms, history of hypersensitivity, the psychosocial work environment, anxiety and depression.

A total of 4,029 out of 4,129 workers took part in the survey, yielding a response rate of 97.6 %. The main reason given for non-participation or for failing to complete the questionnaire was lack of time. Only in exceptional cases did workers refer to reasons of confidentiality or the fear that answers could be brought to the attention of management.

Perception of the environment, symptoms and personal history were examined in the questionnaire known as the MiljömedicinMM040 questionnaire in Sweden (Andersson and Stridh 1992) and the Indoor Air Questionnaire (IAQ) (Reijula and Sundman-Digert 2004) in Finland. This tool has been translated from English into Italian (Magnavita 2007b) and has been used for many years to study the history of workers employed in confined spaces (Magnavita 2014a b). The original purpose of the questionnaire was to study the "sick building syndrome" (SBS). The Italian version of the questionnaire includes an extensive list of symptoms, so it can be used to systematically collect symptoms before the routine medical examination.

The environmental section of the MM040/IAQ questionnaire was used to study the participants' experiences of environmental conditions at the workplace. The environmental factors evaluated by the questionnaire were as follows: draughts, uncomfortably high room temperature, sudden change in temperatures, uncomfortably low room temperature, stuffy air, dry air, unpleasant odors, static electricity often causing shocks, passive smoking, noise, lighting that is dim or causes glare and/or reflections, dust and dirt. Environmental complaints were investigated with the following question: "Have you been bothered by any of the following factors at your workplace during the last 3 months?". There were three possible responses to the question: 1, no, never; 2, yes, sometimes; 3, yes, often, every week. Exposures were regarded as relevant if they were present several times a week or daily (response = 3). A scale of "discomfort related to the environment" (Discomfort scale) was constructed by adding up the number of environmental factors an employee complained of every week. Main components confirmatory analysis showed that the Discomfort scale of MM040/IAQ was homogeneous, since all the variables composed a single factor (Magnavita 2007b). The reliability of the scale in this cohort, assessed using Cronbach's alpha, was high ($\alpha = 0.811$).

The original version of the MM040/IAQ questionnaire investigated 12 symptoms typical of SBS: five neuropsychological symptoms (fatigue, feeling heavy headed, headache, nausea/dizziness, difficulty in concentrating), four mucosal symptoms (itching, burning or irritation of the eyes, irritated, stuffy or runny nose, hoarse or dry throat, cough), and three dermal symptoms (dry or flushed facial skin, scaling/itching scalp or ears, dry hands, itching or red skin). In the Italian version, six more questions were added concerning sensorial (3 items) and musculoskeletal symptoms (3 items), so as to make this instrument suitable for the systematic collection of symptoms in office and indoor workers. The additional questions referred to: decreased vision, buzzing or ringing in the ears, decreased hearing, neck or arm pain, back pain, tingling in the hands or legs. The participants answered whether they had been bothered by these 18 symptoms during the previous 3 months. Each question had four response options: 1, "no, never"; 2, "yes, sometimes"; 3, "yes, often"; 4, "yes, often, and I believe this is due to the work environment." Data were dichotomized so that a symptom occurring several times a week or daily was a positive answer. In this study, we considered only work-related symptoms (response 4). The factorial structure of the questionnaire was confirmed by principal component analysis with Varimax rotation (Magnavita 2007a, b). The dichotomized symptoms were grouped into five classes of work-related symptoms: neuropsychological, mucosal and dermal components of the SBS, musculoskeletal and sensorial symptoms. In this study, the reliability of the scale of symptoms was high (Cronbach's $\alpha = 0.878$).

The psychosocial work environment was investigated by means of the MM040/IAQ using the following four questions: A. "Do you regard your work as interesting and stimulating?"; B. "Do you have too much work to do?"; C. "Do you have any opportunity to influence your working conditions?"; D. "Do your fellow workers help you with problems you may have in your work?" For each question, there are four possible answers: 1: no, never; 2: no, rarely; 3: yes, sometimes; and 4: yes, often. As recommended by Finnish authors (Lahtinen et al. 2004), on the basis of these questions is possible to identify workers who: (A) do not consider the work interesting and challenging (=uninteresting job), (B) have too much work to do (=high demand), (C) are not able to control work conditions (=low control), and (D) do not receive help from colleagues (=low support), grouping the answers 1 and 2 (for B, responses 3 and 4).The questions B and C were based on Karasek's demand–control model [Karasek 1979], according to which job strain may be calculated as the ratio between demand and control, thus obtaining a continuous scale between 0.25 and 4.0, with the highest score indicating the greatest psychosocial stress at work. The psychosocial scale of the MM040/IAQ showed a good correspondence with other measurements of occupational stress and proved useful as a screening tool in field work for analyzing the role of the psychosocial work environment among the different background factors of an environmental problem (Lahtinen et al. 2004; Magnavita 2011).

The MM040/IAQ questionnaire also provided sociodemographic characteristics, such as age and gender, smoking habit, and history of immediate type allergy (atopy).

Anxiety and depression were screened using the Italian version (Magnavita 2007a) of the Goldberg questionnaire (Goldberg et al. 1988). This short interview, designed to be used by non-psychiatrists, is composed of two scales of 9 binary items; a score of one is recorded against each question answered in the affirmative. Each scale provides a variable with values ranging between 0 and 9. People with anxiety scores of five or depression scores of three have a 50 % chance of having a clinically important disturbance; for higher scores, the probability rises sharply (Gann et al. 1990). Consequently, workers who scored five or more on the anxiety scale were classified as "anxious," while workers who scored three or more on the depression scale were classified as "depressed." Cronbach's alpha in this cohort was 0.809 for the anxiety scale, and 0.765 for the depression scale.

Ethics

All participants were tested confidentially during their routine psychophysical assessment at the workplace. The study protocol was approved by the Ethics Committee of the Università Cattolica del Sacro Cuore, Faculty of Medicine, Roma (Italy).

Statistical analyses

First of all, we used the common statistics to calculate separately for males and females the distribution of both individual symptoms and environmental complaints, and psychosocial variables in the population. We also examined the prevalence range among different companies. Differences between males and females were calculated by chi-square and Student's *t* test.

We used hierarchical multiple logistic regression models in which the presence of any work-related symptom, or of at least five SBS symptoms were specified as criteria. In accordance with the current definition of the syndrome, the latter were considered to be "SBS cases." Odds ratios (OR) and their 95 % confidence intervals (95 %CI) were computed. In Model 1, only the control variables (age, gender, smoking habit, and atopy) were specified as predictors. In Model 2, the anxiety and depression scores were added to the regression model. In Models 3 and 4, environmental discomfort and the job strain score were, respectively, added as further predictors. The amount of variance in the regression score accounted for by the predictors (and the goodness of fit of the regression model) was indexed by the adjusted R^2.

Logistic regression was also used to examine the association between the perceived occupational indoor environment and symptoms. Analyses were carried out using a two-step process. First, we adjusted each of the indoor environment factors for sex, age, smoking habit, hypersensitivity (atopy), anxiety, depression, and job strain and tested this individually with the output (presence of symptoms) (Model 1). Then, we adjusted each indoor environment factor again for the other indoor environmental factors (Model 2). The results are reported as OR with their 95 % CI and *p* values.

Results

The characteristics of the study population are shown in Table 1. In the sample we observed, on average female workers were younger than their male counterparts. There were no other significant differences between the genders, with regard to atopy, prior diagnosis of asthma, or the smoking habit. Compared to Italian data (Pacifici 2012), the smoking prevalence was high, especially in women.

Most workers reported the presence of at least one cause of environmental discomfort and a third of workers complained of at least one work-related symptom. The most frequently reported causes of environmental discomfort were as follows: the presence of sudden changes in air temperature (23.1 %), stuffy air (21.9 %), unpleasant odors (21.6 %), passive smoking (20.9 %), and dust and dirt in the workplace (21.7 %). Female workers complained more often than males of dust and dirt and unpleasant odors in the workplace; they perceived the presence of electrostatic charges more often than male workers and reported an excessively low temperature in air-conditioned environments. Males complained of environmental tobacco smoke more often than female workers. There was considerable variability in the frequency of environmental complaints between one company and another.

Reports of anxiety and depression, as well as neuropsychological, dermal and musculoskeletal symptoms were more frequent among females than males. The psychosocial working environment also differed according to gender: A larger number of male workers reported excessive job demands, uninteresting work, and insufficient help from colleagues (low support), while the percentage of workers reporting low job control was higher among females. However, the job strain score did not vary between male and female workers (Table 1).

Multiple logistic hierarchical regression analysis showed that the personal characteristics of the workers (age, gender, smoking habit and atopy) were significantly associated with the occurrence of at least five SBS symptoms, and with other sub-groups of non-SBS work-related symptoms (Table 2). These relationships were weak, however (less than 5 % of the variance), and tended to become weaker or nonsignificant when other variables were added to the predictive model. Female gender and the presence of atopy were most strongly related to SBS symptoms, even after correction for other variables. Atopy, however, appeared to be related only to mucosal and dermal symptoms, not to neuropsychological symptoms of SBS (data not shown). The risk of reporting mucosal and dermal symptoms was approximately double for atopic workers (data not shown). Age and tobacco smoking were mainly related to sensorial impairment.

Anxiety and, to a lesser extent, depression were significantly associated with all symptoms. After the introduction of these variables, the coefficients of determination of the predictive models more than doubled and sometimes reached a sixfold increase. Each point of increase on the anxiety scale corresponded to a 25 % increase in the probability of a worker reporting at least one SBS symptom. The presence of these variables was significantly associated with symptoms even in more complex models.

The further introduction of environmental discomfort into the model of logistic regression led to a substantial increase in the coefficients of determination. Discomfort

Table 1 Medical and demographic data for male and female participants

Characteristics	Males (42.3 %) ($N = 1{,}706$)	Females (57.7 %) ($N = 2{,}323$)	Two tailed p value	Whole group ($N = 4{,}029$)	Range (28 places)
Age	42.1 + 9.4	39.1 + 9.1	0.000[b]	40.3 ± 9.4	
Current smoker	673 (39.4)	896 (38.6)	n.s.[a]	1,569 (38.9)	13.6–73.9
History of physician's diagnosed asthma	162 (9.5)	245 (10.5)	n.s.[a]	407 (10.1)	0–31.3
Atopy (pollen or furry pet allergy)	394 (23.1)	582 (25.1)	n.s.[a]	976 (24.2)	0–50.0
Anxious (anxiety score ≥5)	571 (33.5)	921 (39.6)	0.000[a]	1,492 (37.0)	0–56.3
Depressed (depression score ≥3)	429 (25.1)	839 (36.1)	0.000[a]	1,268 (31.5)	0–52.4
Environmental complaints:					
Draughts	262 (15.4)	309 (13.3)	n.s.[a]	571 (14.2)	0–36.1
Excessively high temperature	314 (18.4)	380 (16.4)	n.s.[a]	694 (17.2)	0–55.6
Changes of air temperature	410 (24.0)	521 (22.4)	n.s.[a]	931 (23.1)	0–35.9
Excessively low temperature	155 (9.1)	260 (11.2)	0.030[a]	415 (10.3)	0–38.9
Stuffy air	350 (20.5)	531 (22.9)	n.s.[a]	881 (21.9)	4.3–54.5
Dry air	274 (16.1)	408 (17.6)	n.s.[a]	682 (16.9)	0–33.3
Unpleasant odors	331 (19.4)	540 (23.2)	0.003[a]	871 (21.6)	0–39.7
Static electricity	122 (7.2)	239 (10.3)	0.001[a]	361 (9.0)	0–55.6
Passive smoking	382 (22.4)	460 (19.8)	0.046[a]	842 (20.9)	0–34.1
Noise	253 (14.8)	350 (15.1)	n.s.[a]	603 (15.0)	0–35.7
Glare or reflections	252 (14.8)	373 (16.1)	n.s.[a]	625 (15.5)	4.8–35.9
Dust and dirt	324 (19.0)	552 (23.8)	0.000[a]	876 (21.7)	0–41.4
At least one environmental complaint	1,055 (61.8)	1,578 (57.9)	0.000[a]	2,633 (65.4)	25.0–91.7
Psychosocial variables:					
Uninteresting job	277 (16.2)	266 (11.5)	0.000[a]	543 (13.5)	0–39.0
Low support	341 (20.0)	349 (15.0)	0.000[a]	690 (17.1)	0–37.5
High job demands	605 (35.5)	727 (31.3)	0.005[a]	1,332 (33.1)	0–57.8
Low job control	751 (44.0)	1,110 (47.8)	0.018[a]	1,861 (46.2)	18.8–59.4
Job strain (demand–control ratio) (range 0.25–4.0)	1.5 ± 0.9	1.5 ± 0.9	n.s.[b]		
Work-related symptoms					
Neuropsychological SBS symptoms	280 (16.4)	497 (21.4)	0.000[a]	777 (19.3)	0–52.8
Mucosal SBS symptoms	220 (12.9)	341 (14.7)	n.s.[a]	561 (13.9)	0–41.7
Dermal SBS symptoms	95 (5.6)	215 (9.3)	0.000[a]	310 (7.7)	0–14.4
Musculoskeletal symptoms	201 (11.8)	374 (16.1)	0.000[a]	575 (14.3)	0–31.3
Sensorial symptoms	107 (6.3)	141 (6.1)	n.s.[a]	248 (6.2)	0–14.1
Any 12 SBS symptoms	420 (24.6)	670 (28.8)	0.003[a]	1,090 (27.1)	6.3–42.0
Five or more SBS symptoms	42 (2.5)	112 (4.8)	0.000[a]	154 (3.8)	0–10.3
Any of 18 work-related symptoms	501 (29.4)	785 (33.8)	0.003[a]	1,286 (31.9)	7.1–63.9

[a] Differences between males and females calculated by Chi square (2 × 2 contingency tables)

[b] Differences between males and females calculated by Student's t test. *n.s.* not significant

due to the work environment was strongly associated with symptoms. Workers who perceived environmental problems had a two- to fivefold increased risk of reporting all types of work-related symptoms. The highest increase in the odds ratio was observed for at least five SBS symptoms for which there was a more than 20-fold increased odds ratio in workers who perceived environmental problems.

In the final (fourth) model of hierarchical regression, job strain was significantly associated with all classes of work-related symptoms. The final model of regression which included job strain, environmental discomfort, anxiety and depression and other personal variables, accounted for about 20 % of the variance in all types of work-related symptoms (Table 2).

Table 2 Association of work-related symptoms with individual, psychosocial, and environmental factors

Predictors	Model 1[a] OR (95 % CI)	Model 2[b] OR (95 % CI)	Model 3[c] OR (95 % CI)	Model 4[d] OR (95 % CI)
At least five SBS symptoms				
Age	1.039 (1.020–1.057)***	1.020 (1.001–1.040)*	1.021 (1.001–1.041)*	1.015 (0.995–1.036)
Sex (female vs. male)	2.256 (1.557–3.269)***	1.915 (1.307–2.807)***	1.882 (1.277–2.776)***	1.998 (1.341–2.947)***
Smoking (smoker vs. non-smoker)	1.087 (0.778–1.519)	0.886 (0.627–1.251)	0.945 (0.667–1.340)	0.953 (0.0669–1.358)
Atopy (atopic vs. non-atopic)	2.039 (1.456–2.855)***	1.660 (1.173–2.350)**	1.706 (1.200–2.424)**	1.687 (1.181–2.409)**
Anxiety		1.332 (1.215–1.459)***	1.268 (1.154–1.393)***	1.268 (1.151–1.397)***
Depression		1.151 (1.049–1.263)**	1.155 (1.048–1.272)**	1.128 (1.022–1.246)**
Discomfort related to environment (discomfort scale)			27.102 (6.673–110.063)***	23.776 (5.845–96.707)***
Job strain				1.565 (1.339–1.829)***
R^2	0.045	0.168	0.229	0.254
Musculoskeletal symptoms				
Age	1.020 (1.010–1.030)***	1.005 (0.994–1.016)	1.004 (0.993–1.015)	1.001 (0.990–1.012)
Sex (female vs. male)	1.524 (1.253–1.852)***	1.296 (1.055–1.591)*	1.251 (1.016–1.540)*	1.266 (1.027–1.561)*
Smoking (smoker vs. non-smoker)	1.166 (0.966–1.408)	0.986 (0.809–1.201)	1.032 (0.845–1.260)	1.042 (0.852–1.274)
Atopy (atopic vs. non-atopic)	1.606 (1.316–1.959)***	1.337 (1.085–1.648)**	1.339 (1.084–1.653)**	1.350 (1.092–1.670)**
Anxiety		1.282 (1.220–1.348)***	1.249 (1.187–1.314)***	1.247 (1.184–1.312)***
Depression		1.102 (1.041–1.167)***	1.100 (1.038–1.165)***	1.090 (1.028–1.156)**
Discomfort related to environment (discomfort scale)			2.788 (2.134–3.642)***	2.604 (1.990–3.407)***
Job strain				1.323 (1.199–1.461)***
R^2	0.024	0.156	0.184	0.197
Sensorial symptoms				
Age	1.052 (1.036–1.067)***	1.041 (1.025–1.057)***	1.040 (1.024–1.056)***	1.038 (1.022–1.054)***
Sex (female vs. male)	1.124 (0.858–1.472)	0.952 (0.721–1.256)	0.913 (0.689–1.209)	0.923 (0.696–1.223)
Smoking (smoker vs. non-smoker)	1.561 (1.199–2.034)***	1.381 (1.054–1.810)*	1.472 (1.120–1.934)**	1.490 (1.133–1.959)**
Atopy (atopic vs. non-atopic)	1.500 (1.129–1.994)**	1.226 (0.916–1.642)	1.242 (0.925–1.667)	1.240 (0.923–1.666)
Anxiety		1.192 (1.112–1.278)***	1.152 (1.074–1.236)***	1.149 (1.070–1.234)***
Depression		1.129 (1.045–1.220)***	1.126 (1.040–1.219)**	1.116 (1.030–1.209)**
Discomfort related to environment (discomfort scale)			4.502 (2.839–7.139)***	4.240 (2.669–6.734)***
Job strain				1.224 (1.093–1.417)***
R^2	0.045	0.118	0.156	0.162
Any work-related symptom				
Age	1.011 (1.003–1.018)**	1.000 (0.993–1.008)	0.998 (0.990–1.006)	0.995 (0.987– 1.003)
Sex (female vs. male)	1.255 (1.090–1.445)**	1.090 (0.940–1.263)	1.031 (0.885–1.200)	1.034 (0.887–1.205)
Smoking (smoker vs. non-smoker)	1.269 (1.104–1.458)***	1.132 (0.979–1.309)	1.199 (1.033–1.393)*	1.211 (1.042–1.408)*
Atopy (atopic vs. non-atopic)	1.615 (1.387–1.881)***	1.409 (1.202–1.652)***	1.418 (1.204–1.670)***	1.437 (1.218–1.695)***
Anxiety		1.175 (1.132–1.218)***	1.140 (1.098–1.184)***	1.135 (1.093–1.179)***

Table 2 continued

Predictors	Model 1[a] OR (95 % CI)	Model 2[b] OR (95 % CI)	Model 3[c] OR (95 % CI)	Model 4[d] OR (95 % CI)
Depression		1.103 (1.053–1.156)***	1.101 (1.049–1.155)***	1.097 (1.045–1.151)***
Discomfort related to environment (discomfort scale)			3.614 (3.021–4.322)***	3.452 (2.884–4.132)***
Job strain				1.279 (1.180–1.387)***
R^2	0.023	0.118	0.191	0.202

Hierarchical multiple logistic regression analysis

Logistic regression model used to investigate associations for each psychosocial factor (demand, control, support) separately, adjusted for personal factors (age, sex, smoking, atopy, anxiety and depression) and environmental discomfort

[a] Model 1: adjusted for sex, age, smoking, and atopy

[b] Model 2: adjusted for sex, age, smoking, atopy, and anxiety and depression score

[c] Model 3: adjusted for sex, age, smoking, atopy, anxiety and depression score, and environmental discomfort

[d] Model 4: adjusted for sex, age, smoking, atopy, anxiety and depression score, environmental discomfort, and job strain

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Logistic regression analyses were also used to study the relationship between perception of the work environment and each type of work-related symptom. All indoor environmental factors were associated with symptoms after taking into account sex, age, atopy, anxiety, depression, and job strain (Table 3, model 1). In model 2, we also adjusted for the other environmental factors. While in Model 1, almost all individual environmental factors were significantly associated with increased OR for symptoms, in Model 2, when all environmental factors were entered simultaneously, only some of them were associated with significantly increased ORs; this effect was due to the high inter-correlation between environmental factors. In Model 2, perception of dry air, static electricity, and glare or reflections were associated with dermal SBS symptoms. The same environmental factors and environmental tobacco smoke were associated with mucosal SBS symptoms, while neuropsychological SBS symptoms were also related to the perception of stuffy air, unpleasant odors, and noise. Musculoskeletal complaints were associated with draughts, static electricity, glare or reflections, dust and dirt, while an association was found between sensorial symptoms and noise, lighting problems (glare or reflections) and dry air. Dry air, static electricity, and stuffy air were associated with having five or more SBS symptoms (i.e., with the diagnosis of "a case of SBS") (Table 3, model 2).

Discussion

Principal findings

The systematic observation of indoor workers undergoing routine medical examination to assess their occupational fitness revealed that approximately one-third of them (31.9 %) reported work-related symptoms. These symptoms included those traditionally labeled as SBS, and others involving work-related musculoskeletal and sensorial disorders. Despite the fact that none of the buildings were associated with apparent problems of air quality, two out of three workers (65.4 %) complained about the presence of environmental risk factors in the workplace. A prevalence of complaints that reaches such a high level cannot be neglected and requires specific preventive action.

Our study demonstrates that symptoms reported as being caused by the working environment are significantly associated with a number of personal characteristics, such as gender, age, smoking habits, and atopy, with common mental disorders such as anxiety and depression and also with occupational stress and with discomfort due to physical factors in the environment. The contribution of environmental factors to the onset of symptoms related to work

Table 3 The association of the perceived indoor environment with the prevalence of work-related symptoms

Environmental factor	Neuropsychological		Mucosal		Dermal	
	Model I	Model II	Model I	Model II	Model I	Model II
Draughts	1.63 (1.31–2.04)***	0.97 (0.75–1.25)	1.67 (1.31–2.12)***	0.93 (0.70–1.24)	1.48 (1.08–2.02)*	0.74 (0.52–1.06)
Excessively high room temperature	2.03 (1.66–2.48)***	**1.27 (1.01–1.59)***	1.95 (1.56–2.42)***	1.05 (0.81–1.36)	2.76 (2.11–3.61)***	**1.66 (1.22–2.26)*****
Sudden change in temperatures	1.79 (1.49–2.15)***	1.05 (0.84–1.32)	2.18 (1.79–2.67)***	1.23 (0.96–1.58)	2.42 (1.87–3.13)***	**1.41 (1.03–1.93)***
Excessively low room temperature	1.77 (1.39–2.25)***	0.97 (0.74–1.27)	2.33 (1.82–3.00)***	1.22 (0.91–1.63)	1.82 (1.32–2.52)***	0.87 (0.60–1.26)
Stuffy air	2.47 (2.06–2.97)***	**1.32 (1.05–1.67)***	2.49 (2.04–3.04)***	1.02 (0.79–1.34)	2.42 (1.87–3.13)***	0.93 (0.67–1.31)
Dry air	2.59 (2.19–3.15)***	**1.52 (1.20–1.92)*****	4.29 (3.49–5.27)***	**2.87 (2.23–3.68)*****	3.50 (2.70–4.55)***	**2.03 (1.48–2.78)*****
Unpleasant odors	2.11 (1.75–2.55)***	**1.29 (1.03–1.60)***	1.61 (1.31–1.99)***	0.87 (0.67–1.19)	2.56 (1.98–3.31)***	**1.64 (1.21–2.23)*****
Static electricity	2.63 (2.05–3.73)***	**1.75 (1.34–2.29)*****	2.57 (1.97–3.35)***	**1.51 (1.13–2.03)****	4.23 (3.15–5.67)***	**2.61 (1.89–3.59)*****
Passive smoking	1.93 (1.59–2.33)***	**1.37 (1.11–1.68)****	2.67 (2.17–3.27)***	**1.96 (1.57–2.45)*****	1.99 (1.53–2.59)***	1.32 (0.99–1.76)
Noise	1.95 (1.59–2.39)***	**1.33 (1.06–1.67)***	1.73 (1.39–2.17)***	1.11 (0.86–1.44)	1.36 (1.01–1.83)*	0.79 (0.56–1.10)
Glare, reflections	2.08 (1.70–2.54)***	**1.40 (1.12–1.75)****	2.77 (2.34–3.43)***	**1.87 (1.47–2.38)*****	2.34 (1.78–3.07)***	**1.63 (1.20–2.22)****
Dust and dirt	1.74 (1.45–2.09)***	1.16 (0.94–1.44)	1.63 (1.33–2.00)***	1.01 (0.80–1.29)	1.66 (1.28–2.15)***	1.07 (0.79–1.45)

Environmental factor	Musculoskeletal		Sensorial		Any work-related symptom		>5 SBS symptoms	
	Model I	Model II	Model I	Model II	Model I	Model II	Model I	Model II
Draughts	2.31 (1.82–2.94)***	**1.62 (1.23–2.12)*****	1.28 (0.91–1.78)	0.73 (0.49–1.07)	2.09 (1.71–2.55)***	1.17 (0.93–1.48)	2. 41 (1.65–3.52)***	1.32 (0.85– 2.05)
Excessively high room temperature	1.51 (1.19–191)***	0.92 (0.70–1.21)	1.99 (1.47–2.69)***	1.27 (0.89–1.78)	2.00 (1.67–2.40)***	1.10 (0.89–1.36)	3.16 (2.20–4.52)***	1.44 (0.95–2.18)
Sudden change in temperatures	1.90 (1.54–2.35)***	1.17 (0.91–1.51)	1.90 (1.43–2.52)***	1.35 (0.96–1.89)	2.20 (1.87–2.60)***	**1.25 (1.03–1.53)***	2.67 (1.87–3.80)***	1.04 (0.67–1.60)
Excessively low room temperature	1.90 (1.46–2.48)***	1.17 (0.87–1.57)	1.64 (1.14–2.34)**	0.87 (0.58–1.30)	2.03 (1.63–2.54)***	1.01 (0.78–1.30)	2.38 (1.58–3.59)***	1.09 (0. .69–1.73)
Stuffy air	2.03 (1.64–2.50)***	1.18 (0.90–1.54)	2.05 (1.54–2.73)***	1.02 (0.70–1.49)	2.54 (2.15–3.01)***	1.18 (0.96–1.46)	4.87 (3.39–6.99)***	**1.82 (1.15– 2.90)***
Dry air	1.80 (1.44–2.26)***	1.06 (0.81–1.39)	2.48 (1.86–3.32)***	**1.63 (1.14–2.33)****	3.53 (2.79–4.03)***	**1.96 (1.58–2.44)*****	5.13 (3.59–7.32)***	**2.37 (1.55–3.62)*****
Unpleasant odors	1.86 (1.51–2.31)***	1.16 (0.90–1.49)	1.45 (1.07–1.95)*	0.88 (0.62–1.26)	2.13 (1.79–2.52)***	**1.23 (1.01–1.50)***	2.85 (2.01.4.06)***	1.20 (0.78–1.83)
Static electricity	2.26 (1.71–2.99)***	**1.67 (1.24–2.25)*****	1.89 (1.29–2.78)***	1.20 (0.78–1.83)	2.92 (2.30–3.70)***	**1.81 (1.40–2.34)*****	4.34 (2.91–6.47)***	**2.29 (1.48–3.55)*****
Passive smoking	1.76 (1.41–2.19)***	1.26 (0.99–1.60)	1.53 (1.13–2.06)**	1.13 (0.82–1.58)	2.42 (2.04–2.87)***	**1.71 (1.42–2.06)*****	2.16 (1.51–3.09)***	1.22 (0.82–1.81)
Noise	1.52 (1.19–1.92)***	1.01 (0.78–1.31)	2.78 (2.07–3.74)***	**1.98 (1.43–2.73)*****	1.95 (1.61–2.35)***	**1.29 (1.05–1.60)***	2.35 (1.62–3.41)***	1.27 (0.84–1.93)
Glare, reflections	1.97 (1.57–2.47)***	**1.43 (1.11–1.84)****	3.46 (2.60–4.60)***	**2.60 (1.90–3.56)*****	2.22 (1.84–2.68)***	**1.44 (1.17–1.78)****	2.77 (1.94–3.96)***	1.49 (0.99–2.23)
Dust and dirt	2.00 (1.63–2.47)***	**1.45 (1.15–1.83)****	1.56 (1.16–2.08)**	0.99 (0.72–1.38)	1.77 (1.49–2.09)***	1.13 (0.93–1.16)	2.08 (1.46–2.95)***	1.15 (0.76–1.72)

Odds ratios (confidence intervals 95 %)

Results from logistic regression analyses adjusted for: sex, age, smoking, atopy, anxiety and depression score, and job strain (Model I) and further adjusted for other environmental factors (Model II). The associations that are still significant in Model II, after adjustment, are evidenced in bold

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

is of considerable importance when a worker complains of five or more symptoms of SBS, whereas it is slight and comparable to that of personal factors when we examine the musculoskeletal and sensorial symptoms, or all of the symptoms related to work. Although these symptoms were most strongly associated with the perception of environmental problems, the occupational physician cannot overlook the importance of other factors when analyzing the way symptoms evolve.

The interpretation of work-related symptoms

The complexity of work-related symptoms is difficult to describe since we must take into consideration all these personal, environmental, and work-related factors. In our study, percentages of explained variance in symptoms indicated by hierarchical multiple logistic regression models range from 2 to 5 % in the simplest Model 1 based on four predicting variables to 20–25 % in Model 4 containing eight variables. Seen from the opposite perspective, even in the best cases of prediction, there is a mass of unexplained variances since approximately 75 % of the symptom variance remains outside the model used. With the instruments currently available for assessing the subjectivity of workers in indoor environments, it is not easy for the occupational physician to interpret this variability. As Brauer and Mikkelsen correctly observed (2010), symptom reporting may be influenced by contextual factors, so that the symptoms are related to employment if the survey is conducted in the workplace, while the opposite occurs if the survey is conducted in another place.

Both the presence of symptoms and the perception of the environment would be lost if the physician did not undertake a systematic collection of data. The occupational physician should, therefore, use a questionnaire such as the one described above and routinely carry out an epidemiological analysis of data. By collecting symptoms during medical examinations and not during an ad hoc survey designed to study SBS, there is less likelihood of influencing the response of workers, and the physician will be more confident of the result. Medical tests, such as breakup time (a measure of tear film stability), and analysis of sebaceous secretion and of skin hydration, performed shortly after the completion of the questionnaire, can easily objectify eye and skin symptoms, and other tests can be conducted for non-SBS symptoms. Previous studies have shown that self-reported symptoms are significantly related to medical tests, although there is not always an exact correspondence between the latter and sensory perception, so questionnaires should be used as indicators, not as substitutes for medical test data (Brasche et al. 2001a).

Factors influencing symptoms reporting

The analysis of data provided by workers is a highly complex matter. Many earlier studies have shown the importance of gender (Burge et al. 1987; Brasche et al. 2001a, b; Bakke et al. 2007), atopy (Andersson and Stridh 1992; Reijula and Sundman-Digert 2004), and other personal and psychosocial factors (Lahtinen et al. 2004) in symptom prevalence. The doctor will, therefore, take into account the fact that the symptoms reported depend not only on physical problems in the work environment, but also on the subjective state of the workers. He/she will provide accurate information on the environmental situation and reassure workers about the relative harmlessness of SBS symptoms. In this way, he/she will try to prevent, as far as possible, anxiety occurring about unknown danger or the onset of depression due to physical disorders, which may in turn lead to an increase in the frequency of reported symptoms, thus triggering a vicious circle. Furthermore, a reduction in the levels of work-related stress will certainly help to prevent work-related symptoms.

The task of providing accurate information about the meaning of work-related symptoms also entails a critical analysis since the causal pathway from environmental exposure to outcome is not straightforward. Studies on SBS symptoms have shown that nonspecific symptoms may be more related to personal and psychosocial factors than to environmental factors (Runeson-Broberg and Norbäck 2013). Moreover, awareness of a potential environmental hazard has been shown to affect self-reported illness (Moffatt et al. 2000). Conversely, illness may also affect the perception of the indoor environment (Lundin 1999). An increase in work-related stress may worsen the perception of the indoor environment (Magnavita et al. 2007). Reverse causation, i.e., the possibility that environmental complaints are due to the presence of symptoms, has also been demonstrated. In a longitudinal study, both SBS symptoms and general symptoms predicted the onset of complaints about the indoor environment (Brauer et al. 2006a, b). The interplay between health outcome and feeling exposed can be very complex and even act reciprocally. This does not mean that the indoor environment cannot cause health problems. However, it suggests that many people experience symptoms for reasons other than those arising from problems in the indoor environment (Brauer et al. 2006a, b). In conclusion, since the perceived indoor environment may be associated not only with symptoms that may be plausibly attributed to environmental factors, but also with other symptoms, the intervention of the occupational physician must not only be timely, but also cautious. He/she must neither underestimate the problems of the workers nor attribute to the employer responsibility for all the symptoms workers report.

The role of the occupational physician in a "sick" building

Although many years have passed since the first cases of SBS were identified, researchers have failed to reach unanimous agreement regarding the definition of SBS. And since consensus is lacking over what incidence of symptoms should be considered abnormal, which symptoms should be investigated and which methods used to collect information, the decision to define a building as "sick" or "with problems" is still, to a certain degree, an arbitrary one. Moreover, once a building has been defined as "sick", it becomes impossible thereafter to conduct a scientifically valid study, as none of the figures involved (workers, management, or investigators) are any longer in a position to operate "blind ", i.e., without being aware of information that could lead to conscious or unconscious bias. The physician who observes a cluster of SBS cases, i.e., a significant number of workers who are complaining of numerous SBS symptoms and are employed in the same workplace, must verify the situation, carry out an inspection and, if necessary, instruct the industrial hygienist to conduct environmental evaluations. He/she must also promptly inform the employer of action that can be taken to improve air quality in the workplace. As a recent review points out, improving ventilation rates could be the easiest way to reduce symptom prevalence, unless alternative effective measures, such as source control or air cleaning, are introduced to limit indoor pollutant levels (Sundell et al. 2011). The physician who receives reports of other work-related symptoms (not included in SBS), such as musculoskeletal disorders or sight and hearing impairment, should take similar action. In this case too, the first line of action should be to assess and reduce environmental hazards, bearing in mind the concept of plausibility. It is biologically plausible that hearing impairment is associated with noise and that muscular complaints are related to draughts that favor myalgias or to lighting problems that cause incorrect posture and muscle pain. It is more difficult to find a connection between sensorial impairment and dry air, or between muscular symptoms and static electricity, or dust and dirt. The physician should interpret these inconsistent associations as indicative of a less than optimal relationship between employees and their work and conclude that specific intervention is needed on the part of management to improve work organization and the psychosocial climate.

After examining an employee who reports health problems in the indoor environment, the occupational physician should avoid removing the worker from that specific environment, or limiting his/her suitability. In fact, if the cause of the health problem is the environment, avoiding the exposure of one worker would only mean exposing another to the same occupational hazards. On the other hand, if the issue is personal, it will not be resolved by a judgment of suitability. When he/she hears about environmental hazards that cause a problem for workers' health, the occupational doctor should urge the management to improve the workplace conditions. On the contrary, if he/she discovers behavioral problems, common mental disorders or job strain, he/she must give the individual worker support and make the employer aware of the need to implement a program of stress management and health promotion.

Sick building syndrome in warm climate

The second aim of our study was to evaluate the characteristics of SBS in our country, that is, in a warm climate where buildings do not need to be insulated. We can conclude that this phenomenon is distributed according to the same characteristics as observed in Northern European countries: it is more prevalent in women than in men, there is a high prevalence in atopic people and an association with anxiety, depression and work-related stress. However, in our sample, complaints and symptoms prevalence were very different from that in Northern European countries. Finnish researchers (Reijula and Sundman-Digert 2004) reported a very high prevalence of complaints regarding dry (35 %) and stuffy air (34 %), dust or dirt (25 %), and draughts (22 %) in a sample of 11,154 employees in 122 workplaces, while the same authors observed a significantly lower prevalence of complaints regarding environmental tobacco smoke (4 %), unpleasant odors (17 %) and sudden changes in air temperature (16 %) than was found in our study. The most common environmental risk factors identified in Danish buildings were dry and stuffy air (Skov and Valbjorn 1987), and in a Dutch study covering over 7,000 workers and 61 buildings, the most common complaints concerned dry air (Zweers et al. 1992). Even in a more recent, longitudinal study on Danish employees, dry air was significantly associated with mucous membrane and neuropsychological symptoms at baseline, and with mucosal symptoms even in the prospective analyses (Brauer et al. 2006a, b). In our study, the most frequent complaints regarded sudden changes in indoor temperature (23.1 %), stuffy air (21.9 %), bad smells (21.6 %), tobacco smoke (20.9 %), dust and dirt (21.7 %). Dry air and static electricity were reported by only 16.9 % and 9.0 % of our population, respectively, although these environmental problems accounted for the strongest association with SBS symptoms. Bearing in mind methodological differences between the studies which hinder comparison, and doubts about the relationship between exposure and symptoms, we can conclude that the perception of excessively dry air is significantly associated with SBS symptoms in both Italian and European surveys, and in buildings classified as "sick" and those that are "not sick". Furthermore, as was expected, the frequency of SBS symptoms in this sample was much lower than that found in surveys of buildings deemed to be "sick", at least as regards mucosal and dermal SBS symptoms that generally dominate the clinical picture (Burge et al. 1987; Finnegan et al. 1984; Jaakkola et al. 1991; Skov and Valbjorn 1987; Reijula and Sundman-Digert 2004).

Which symptom is really part of SBS?

In our experience, the most frequently reported symptoms (e.g., back pain and cervical–brachial pain) were not attributable to SBS or, even if they were part of the SBS framework, could also be related to completely different causes: The most frequent of which is fatigue. In important studies conducted in Northern European countries (Andersson and Stridh 1992; Reijula and Sundman-Digert 2004; Burge et al. 1987; Jaakkola et al. 1991; Skov and Valbjorn 1987), the incidence of fatigue, heaviness of the head, headache, and other neuropsychological disorders is often comparable to that found in our study and can be considered endemic. This poses the question of whether these neuropsychological symptoms, which are always seen to constitute one of the components of the clinical picture of SBS, may in fact stem, at least partially, from a different origin.

Even the most recent studies on indoor workers have reported the presence of symptoms without expressing absolute certainty regarding their cause. Some kind of work-related SBS symptom was reported by 18 % of Swedish employees (Runeson-Broberg and Norbäck 2013). In a random study of Danish manual and non-manual workers, Brauer et al. (2006a, b) found a 25 % prevalence of mucous membrane symptoms and general (neuropsychological) symptoms of SBS, and a 10–15 % incidence of new symptoms in the 1-year follow-up period. They also found a high prevalence and incidence of symptoms that are not usually connected with the indoor environment, such as muscle tension, depression, and nervousness. This figure was significantly higher than that found among Japanese employees, where at least one mucocutaneous or neuropsychological symptom of SBS was reported by 7.9 % of female and 3.9 % of male office workers (Kubo et al. 2006). Clearly, longitudinal studies that take into account simultaneously environmental, occupational, and personal factors could be useful in disentangling the possible pathways and putting the subjective factor into perspective. The present study had some limitations: Firstly, its cross-sectional nature limited the causal conclusions that could be drawn from its findings and secondly, exposure levels and symptoms were self-reported.

A positive aspect of this study was that all participants underwent a medical examination after completing the questionnaire. We could, therefore, exclude symptoms arising from a specific disease or from non-occupational factors and could evaluate symptoms objectively. Another advantage was the administration of questionnaires during routine medical examinations since this resulted in a high participation rate and reduced the contextual bias that is typical of surveys focused on indoor air quality problems.

Conclusion

Sick building syndrome, i.e., the presence of symptoms related to indoor environment, has so far been studied to date mainly with ad hoc surveys conducted as a result of environmental problems. This may lead to over-reporting of symptoms and difficulty in understanding the relationship between symptoms, psychosocial, and environmental factors.

In this study, the Scandinavian questionnaire on indoor air quality was systematically used in its Italian version by the occupational physician during the routine medical examination of workers. The administration of the questionnaire immediately before the medical examination reduced the possibility of responses being influenced by the opinions of other workers and enabled us to carry out immediate and objective verification of most of the symptoms.

The prevention of work-related complaints does not depend only on physical measures, but must involve organizational changes designed to improve workers' well-being and mental health.

The occupational physician's task is to systematically collect data on symptoms and observe the workers' perception of the work environment so as to analyze this relationship and indicate the best mode of preventing discomfort.

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References

Andersson K, Stridh G (1992) The use of standardized questionnaires in building related illness (BRI) and sick building syndrome (SBS) surveys. In: Levy F, Maroni M (eds) NATO/OCCM pilot study on indoor air quality. National Institute of Occupational Health, Oslo, pp 47–64

Bakke JV, Moen BE, Wieslander G, Norbäck D (2007) Gender and the physical and psychosocial work environments are related to indoor air symptoms. J Occup Environ Med 49(6):641–650

Brasche S, Bullinger M, Bronisch M, Bischof W (2001a) Eye- and skin symptoms in German office workers–subjective perception vs. objective medical screening. Int J Hyg Environ Health 203(4):311–316

Brasche S, Bullinger M, Morfeld M, Gebhardt HJ, Bischof W (2001b) Why do women suffer from sick building syndrome more often than men? Subjective higher sensitivity versus objective causes. Indoor Air 11(4):217–222

Brauer C, Mikkelsen S (2010) The influence of individual and contextual psychosocial work factors on the perception of the indoor environment at work: a multilevel analysis. Int Arch Occup Environ Health 83(6):639–651. doi:10.1007/s00420-010-0511-9

Brauer C, Kolstad H, Ørbaek P, Mikkelsen S (2006a) No consistent risk factor pattern for symptoms related to the sick building syndrome: a prospective population based study. Int Arch Occup Environ Health 79(6):453–464

Brauer C, Kolstad H, Ørbaek P, Mikkelsen S (2006b) The sick building syndrome: a chicken and egg situation? Int Arch Occup Environ Health 79(6):465–471

Burge PS (2004) Sick building syndrome. Occup Environ Med 61:185–190. doi:10.1136/oem.2003.008813

Burge S, Hedge A, Wilson S et al (1987) Sick building syndrome: a study of 4373 office workers. Ann Occup Hyg 31:493–502

Chang C, Gershwin ME (2004) Indoor air quality and human health: truth vs mass hysteria. Clin Rev Allergy Immunol 27(3):219–239

Finnegan MJ, Pickering CAC, Burge PS (1984) The sick building syndrome: prevalence studies. BMJ 289:1573–1575

Fisk WJ, Black D, Brunner G (2011) Benefits and costs of improved IEQ in U.S. offices. Indoor Air 21(5):357–367. doi:10.1111/j.1600-0668.2011.00719.x

Gann M, Corpe U, Wilson I (1990) The application of a short anxiety and depression questionnaire to oil industry staff. J Soc Occup Med 40(4):138–142

Goldberg D, Bridges K, Duncan-Jones P, Grayson D (1988) Detecting anxiety and depression in general medical settings. BMJ 297(6653):897–899

Jaakkola JJK, Heinonen OP, Seppänen O (1991) Mechanical ventilation in office buildings and the sick building syndrome. An experimental and epidemiological study. Indoor Air 1:111–117

Karasek RA (1979) Job demands, job decision latitude, and mental strain. Implication for job redesign. Adm Sci Q 24:285–308

Kubo T, Mizoue T, Ide R, Tokui N, Fujino Y, Minh PT et al (2006) Visual display terminal work and sick building syndrome—the role of psychosocial distress in the relationship. J Occup Health 48(2):107–112

Lahtinen M, Sundman-Digert C, Reijula K (2004) Psychosocial work environment and indoor air problems: a questionnaire as a means of problem diagnosis. OEM Occup Environ Med 61:143–149

Letz GA (1990) Sick building syndrome: acute illness among office workers—the role of building ventilation, airborne contaminants and work stress. Allergy Proc 11(3):109–116

Lundin L (1999) Allergic and non-allergic students' perception of the same high school environment. Indoor Air 9(2):92–102

Magnavita N (1998) From mass psychosis to multiple sensitivity: models of interpretation of women's discomfort. Folia Med 69(3):1657–1670

Magnavita N (2000) Industrial mass psychogenic illness: the unfashionable diagnosis. Br J Med Psychol 73(3):371–375

Magnavita N (2001) Cacosmia in healthy workers. Br J Med Psychol 74(1):121–127

Magnavita N (2007a) Anxiety and depression at work. The A/D Goldberg Questionnaire. G It Med Lav Ergon 29(3):670–671

Magnavita N (2007b) Health surveillance in ridden work environments by means of the MM040/IAQ Questionnaire. G Ital Med Lav Ergon 29(3):479–481

Magnavita N (2011) Work-related stress in the indoor environment: how might we assess it? G It Med Lav Ergon 33(3, Suppl. B):B28–B32

Magnavita N (2014a) Health surveillance of workers in indoor environments. Application of the Italian version of the MM040/IAQ Questionnaire. Med Lav 105(2):174–186

Magnavita N (2014b) Psychosocial factors in indoor work-related symptoms. Application of the MM040/IAQ questionnaire. Med Lav 105 (in press)

Magnavita N, Sacco A, De Lorenzo G (1995) Occupant complaints in healthy building. Healthy building '95, Proceedings of the ISIAQ International Conference, Milan 11–14 Sep 1995, Vol III, p 1825–1830

Magnavita N, Ferraro P, Vincenti F (2007) Influence of work climate on the sick building syndrome. G Ital Med Lav Ergon 29(3):658–660

Meggs WJ (2009) Epidemics of mold poisoning past and present. Toxicol Ind Health 25(9–10):571–576. doi:10.1177/0748233709348277

Moffatt S, Mulloli TP, Bhopal R, Foy C, Phillimore P (2000) An exploration of awareness bias in two environmental epidemiology studies. Epidemiology 11(2):199–208

Muzi G, Abbritti G, Accattoli MP, dell'Omo M (1998) Prevalence of irritative symptoms in a nonproblem air-conditioned office building. Int Arch Occup Environ Health 71(6):372–378

Niemelä R, Seppänen O, Korhonen P, Reijula K (2006) Prevalence of building-related symptoms as an indicator of health and productivity. Am J Ind Med 49(10):819–825

Niven RM, Fletcher AM, Pickering CA, Faragher EB, Potter IN, Booth WB, Jones TJ, Potter PD (2000) Building sickness syndrome in healthy and unhealthy buildings: an epidemiological and environmental assessment with cluster analysis. Occup Environ Med 57(9):627–634

Norbäck D (2009) An update on sick building syndrome. Curr Opin Allergy Clin Immunol 9(1):55–59. doi:10.1097/ACI.0b013e32831f8f08

Pacifici R. Report on Smoking in Italy 2012. National Institute of Health, 31 May 2013. [in Italian]. http://www.iss.it/binary/fumo4/cont/Rapporto_Annuale_sul_Fumo_31_maggio_2013_PACIFICI.pdf

Redlich CA, Sparer J, Cullen MR (1997) Sick-building syndrome. Lancet 349(9057):1013–1016

Reijula K, Sundman-Digert C (2004) Assessment of indoor air problems at work with a questionnaire. OEM 61:33–38

Runeson-Broberg R, Norbäck D (2013) Sick building syndrome (SBS) and sick house syndrome (SHS) in relation to psychosocial stress at work in the Swedish workforce. Int Arch Occup Environ Health 86(8):915–922. doi:10.1007/s00420-012-0827-8

Skov B, Valbjorn O (1987) The, "sick buiding syndrome" in the office environment. The Danish Town Hall Study. Environ Int 13:339–349

Sundell J, Levin H, Nazaroff WW, Cain WS, Fisk WJ, Grimsrud DT, Gyntelberg F, Li Y, Persily AK, Pickering AC, Samet JM, Spengler JD, Taylor ST, Weschler CJ (2011) Ventilation rates and health: multidisciplinary review of the scientific literature. Indoor Air 21(3):191–204. doi:10.1111/j.1600-0668.2010.00703.x

Zweers T, Preller L, Brunekreef B, Boleij JSM (1992) Health and indoor climate complaints of 7043 office workers in 61 buildings in the Netherlands. Indoor Air 2:127–136. doi:10.1111/j.1600-0668.1992.00001.x