Environmental, occupational, and personal factors related to the prevalence of sick building syndrome in the general population

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Abstract

Possible relations between prevalence of sick building syndrome (SBS) and environmental, occupational, and personal factors were studied in a random sample (0.1%) of the general population aged 20-65 in a three county region in middle Sweden. Childhood exposure to environmental tobacco smoke from smoking mothers and a childhood in urban areas was related to SBS symptoms. Current urban residency, fresh paint, and preschool children in the dwelling were also related to symptoms. Other residential factors such as age of building, type of building, degree of crowding, mechanical ventilation, or signs of moisture or mould growth were not related to symptoms. Other factors related to symptoms were history of atopy, allergy to nickel, proneness to infection, hyperreactivity, static electricity, work with video display units (VDU), work satisfaction, and climate of cooperation at work. Age, sex, marital state, education level, work stress, obesity, current or earlier smoking, regular physical exercise, or occupational exposure to chemicals did not correlate with symptoms. Women had a higher proportion of symptoms than men but these differences were not significant when adjusting for differences in allergy to nickel, hyperreactivity, and proneness to infection. Maternal smoking was related to a twofold increase of both atopy and allergy to nickel in the adult offspring. Eye symptoms were most common in administrative, managerial, and service work. Airway symptoms were most common in transport and communication work. Dermal symptoms were most common in professional and technical and related work. General symptoms were most common in service, health, hospital,

and social work. The lowest prevalence of symptoms was found in agricultural, forestry, and sales work. Women and subjects allergic to nickel worked more often in occupations without exposure to chemicals, but no evidence was found for selection mechanisms causing sensitive persons to move from exposed to unexposed occupations. It was concluded that symptoms included in SBS are common in the general population, and of multifactorial origin related to both personal, occupational, and residential factors, and certain environmental exposures such as maternal smoking, the urban environment, VDU work, and volatile organic hydrocarbons from newly painted dwellings.

One new area of occupational and environmental medicine concerns possible health effects related to poor indoor air quality in certain non-industrial buildings, sometimes described as "sick buildings." The sick building syndrome (SBS) is concerned with various non-specific symptoms such as eye, skin, and upper airway irritation, headache, and fatigue.¹ During recent years, several epidemiological investigations on the causes of SBS have been published.²⁻¹⁵ Most of these studies dealt with symptoms among office workers²⁻¹⁰ in large cities such as New York,⁹ San Francisco,¹⁰ Copenhagen,^{7,8} Helsinki,⁶ and Stockholm.^{2,5} Various factors, such as indoor concentration of volatile organic hydrocarbons,^{2,14-16} presence of wall to wall carpets^{13,17} or fleecy material,¹⁷ age of the building,^{7,17} type of ventilation system,^{3,4,17} degree of crowding,^{9,21} passive smoking,¹⁸ moulds,¹⁹ and building moisture²⁰ have been shown to influence the prevalence of SBS symptoms. These symptoms are not uncommon, however, in the general population,^{12,21} and may also be influenced by personal factors,^{8,11,14-15} industrial exposure to irritants,¹² and residential factors.²⁰⁻²¹ Also concern is growing about possible health effects of childhood exposures to such things as parental smoking,²²⁻²⁶ day care outside the home,²⁶⁻²⁷ lead in the urban environment,^{28,29} and other environmental pollutants.³⁰⁻³²

Our study was performed to consider relations

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between occupational, environmental, and personal factors and the prevalence of SBS symptoms. The main aim was to investigate to what extent relations shown in earlier studies among office workers or young children could be confirmed in a study performed in the general population. A second aim was to study selection mechanisms related to occupational exposure to chemicals and the SBS syndrome.

Material and methods

The study was carried out in a three county region in mid-Sweden (the counties of Gävleborg, Kopparberg, and Uppsala). The total population in the age group 20–65 in the region was 468 000 (162 000 in Gävleborg, 156 000 in Kopparberg, and 150 000 in Uppsala county). During December 1988, a random sample was drawn from the civil registration register by selecting 0.1% of the total population aged 20–65. This resulted in a study population of 633 subjects (209 from Gävleborg, 211 from Kopparberg, and 213 from Uppsala county). The study base is the study population observed during a three month period (January–March 1989).

ASSESSMENT OF SYMPTOMS AND PERSONAL FACTORS

The occurrence of symptoms was recorded by a self administered questionnaire mailed to the 633 subjects in April 1989. The questionnaire requested information on personal factors such as marital state, education level, smoking habits, body weight, body length, regular exercise, atopy, contact allergy, hyperreactivity, sick leave, work stress, work satisfaction, and climate of cooperation at work. It contained questions requiring “yes” or “no” answers on 16 different symptoms and covered the previous three months. No information on the severity or duration of symptoms was gathered. The symptoms were classified as either eye, airway, dermal, or general and the prevalence of subjects with at least one symptom in each group was calculated.

Work stress, work satisfaction, and climate of cooperation were measured with an analogue rating scale as used in earlier studies.^{11–15} A psychosocial dissatisfaction index ranging from 0 to 100% was calculated by adding the perceived degree of work dissatisfaction, work stress, and lack of cooperation at work and dividing by a factor of three. Reference weights were calculated from tables published by Bengtson *et al*¹³ and obesity was defined as a body weight exceeding the reference weight by more than 10%. Information on age and sex was obtained from the civil registration register.

ASSESSMENT OF OCCUPATIONAL EXPOSURE

Information on earlier and current occupation was

gathered by the questionnaire, which also requested information on the period of the occupations and the name of the workplaces. The questionnaire also requested information on current work with video display units (VDU), environmental tobacco smoke exposure at work, and number of work hours and shift work or night work.

The occupations were classified in accordance with the Nordic Classification of Occupations (NYK 82), which is based on the International Standard Classification of Occupations (ISCO) with a few modifications.³⁴ An individual job matrix classification of earlier and current occupational exposure was made by an occupational hygienist with good knowledge of the exposure conditions in the three county region. This classification was performed without any knowledge of symptoms or other information from the questionnaires except current and earlier occupation, job classification codes, period of the occupation, and name of the workplaces. If available, measurements of hygienic exposure from the particular workplaces were used in the classification of exposure.

Each occupation was classified with respect to seven broad classes of chemical exposure—namely, inorganic dust, organic dust, organic solvents, irritating gases, combustion products, animal allergens, and other chemical exposures. Exposure to products of combustion and animal allergens was classified as either exposure or non-exposure. For other types of exposures, the degree of exposure to chemicals was classified into four categories in relation to current Swedish occupational threshold limit values (TLV).³⁵ The lowest exposure class (unexposed) was assigned if the subject was occupationally inactive, or if the expected average eight hour exposure was below 10% of the TLV values for all chemicals assigned to the occupation. The next exposure class was assigned if any of the expected average exposures were above or equal to 10% but below 100% of the corresponding TLV value, and without daily peak exposures above the TLV. The third exposure class was assigned if any of the expected average exposures were above or equal to 10% but below 100% of the TLV values, and with daily peak exposures above the TLV. The highest exposure class was assigned if any of the expected average exposures were expected to be equal to or to exceed the corresponding TLV value.

Subjects with at least one class of chemicals above or equal to 10% of TLV were considered “currently exposed.” Subjects with a current exposure below 10% of TLV for all chemicals, were considered “currently unexposed.” Currently unexposed subjects with at least one earlier exposure above or equal to 10% of TLV were considered “earlier exposed.” Subjects were considered “never exposed” if all classifications for all their occupations

were below 10% of TLV. The current workplaces were also classified as either public sector or private sector, according to the ownership of the building.

ASSESSMENT OF NON-OCCUPATIONAL EXPOSURE

Information on the address of the subject was obtained from the civil registration register. These addresses were classified into three categories with respect to the degree of urbanisation. The first category comprised rural areas or municipalities with a population below 10 000 inhabitants, the second municipalities with a population more than or equal to 10 000 but below 50 000, and the third those two municipalities with a population more than or equal to 50 000 but below 150 000 (the cities of Gävle and Uppsala). In this region, all cities had a population below 150 000.

Information on the dwelling was obtained from the questionnaire. This information comprised type of residence, type of ownership, building age, size of the dwelling and number of adults and children living in the dwelling, type of ventilation system, type of wall material, recent renovation, presence of house pets, moisture damage, and signs of mould growth.

The questionnaire also required information on environmental exposures during the subject's childhood (0–5 years of age). These questions covered parental smoking and child care outside the home. The questionnaire also requested information on the geographical areas and size of the municipalities where the subject lived during the first five years of life.

STATISTICAL METHODS

Crude odds ratios (ORs) were calculated from four-fold tables and were expressed as significantly enhanced OR ($p < 0.05$ calculated by χ^2 test for 2×2 contingency tables). Differences in mean values were calculated by Student's t test.

The influence of different factors on the prevalence of symptoms was analysed by both linear and logistic regression using the EPILOG statistical package. Both regression analyses were performed in seven steps. As a first step, all personal factors were forced into the model. Secondly, all significant personal factors were maintained in the model. Thirdly, non-occupational exposure variables were forced into the model one by one. As a fourth step, all significant non-occupational exposure variables were maintained in the model. Fifthly, occupational exposure variables were forced into the model one by one. As a sixth step, all significant occupational exposure variables were maintained in the model. Finally, all non-significant variables were excluded.

In all statistical analysis, two tailed tests and a 5% level of significance were used. Adjusted ORs with a 95% confidence interval (95% CI) were calculated from the logistic regression models.

Results

The response rate was 70% among men and 78% among women. When comparing responders and non-responders with respect to information available from the civil registration register, no significant differences were found between average age, proportion of subjects from the three counties, or degree of urbanisation. The proportion of women, however, was higher among responders compared with non-responders ($p = 0.02$). When comparing the sample and the total population, however, only a 2% difference in the proportion of women among responders was found compared with the total population. The proportion of women was 51% among responders, 41% among non-responders, and 49% in the total population. The mean age was 42 (SD 12) among the responders ($n = 466$), and the age distribution was similar among responders and the total population (figure).

During the previous three months, 83% of the responders were occupationally active. To study possible selection effects of occupational exposure to chemicals, currently exposed, previously exposed, and never exposed subjects were compared with respect to sex, tobacco smoking, atopy, allergy to nickel, hyperreactivity, and proneness to infection (table 1). No significant differences were found between currently exposed and previously exposed subjects. Both currently exposed and previously exposed subjects, however, had a lower prevalence of women and persons with allergy to nickel than those never exposed. Also, currently exposed workers had a lower proportion of never smokers than subjects classified as never exposed to chemicals at work.

Most subjects had spent their childhood in rural areas or small towns in Sweden with day care

Age distribution of the total population and responders in sample of general population in middle Sweden.

Table 1 Selected demographic data for occupationally exposed and non-exposed persons in a sample of general population in middle Sweden (n = 466)

Characteristic	Prevalence in currently exposed (%)† (n = 76)	Prevalence in earlier exposed (%)‡ (n = 79)	Prevalence in never exposed (%)§ (n = 311)
Women	16***	15***	68
Current tobacco smoker	34	30	29
Never smoked	37*	43	51
Subjects with signs of atopy	19	22	25
Subjects with signs of nickel allergy¶	3***	8**	22
Non-specific hyperreactivity‡‡	31	23	30
Infection prone subjects#	15	10	14

*Two tailed p < 0.05; **two tailed p < 0.01; ***two tailed p < 0.001 all in comparison with never-exposed subjects.

†Subjects with current average occupational exposure above 10% of corresponding Swedish occupational TLV for at least one chemical.

‡Currently unexposed subjects with previous exposure above 10% of current TLV, in earlier occupations.

§Subjects never working in occupations with an average exposure above 10% of current TLV.

||Subjects with a history of asthma, hayfever, or eczema in childhood.

¶Subjects experiencing itch or rashes from dermal contact with base metals (jewellery, buttons, etc).

‡‡Easily irritated eyes or respiratory tract during exposure to non-specific irritants (tobacco smoke, exhaust gases, organic solvents).

#Subjects reporting that they often catch a cold or get infections.

provided by the parents (table 2). Environmental exposure to tobacco during the first five years of childhood was common (19% of the mothers and 55% of the fathers were smokers at that time). Most of the subjects lived in detached houses in rural areas or small towns (table 3). Most of the buildings were older houses; the mean age of the buildings was 39 years. Most (72%) had mechanical ventilation, usually in the kitchen or in the bathroom. Many (46%) were made of wood; 17% had signs of water damage or building moisture and 5% of the subjects reported visible moulds or mouldy odour in their dwelling. House pets were common (42%). Few subjects (14%) had preschool children at home. Data

on occupational exposure showed that most (60%) worked in the private sector. Work with VDUs was common (26%). Few subjects were exposed to environmental tobacco smoke or different types of chemical compounds (table 4).

The prevalence of SBS symptoms was in the range of 10–30% for many common symptoms such as headache, fatigue, and upper airway irritation. Nausea and dermal symptoms were less common (table 5). Table 6 presents the prevalence of symptoms in different occupations. Eye symptoms were least common in sales, transport, and communication work, and most common in administrative, managerial, and service work. Airway symptoms were least

Table 2 Selected demographic and childhood exposure data for a sample of general population in middle Sweden (n = 466)

Characteristic	Prevalence (No (%))
Marital state:	
Married	356 (77)
Never married	73 (16)
Divorced	31 (7)
Widow/widower	5 (1)
Education level:	
Primary school	179 (38)
Secondary school	186 (40)
University	202 (22)
Regular physical exercise:	
Less than 1 h/week	226 (50)
Moderate exercise > 1 h/week	202 (44)
Strenuous exercise > 1 h/week	26 (6)
Obesity (> 10% of mean weight)	80 (17)
Childhood (< 5 y) residency in:	
Rural area	177 (38)
Town (< 10 000 inhabitants)	135 (29)
Small city (10 000–100 000 inhabitants)	99 (21)
Large city (> 100 000 inhabitants)	50 (11)
Childhood childcare (< five years old):	
By parents in the child's own home	413 (89)
In other home environments	40 (9)
In day care centres	7 (2)
Maternal smoking during childhood (< five years old)	85 (19)
Paternal smoking during childhood (< five years old)	252 (55)
Childhood (< five years old) outside Sweden	43 (9)

Table 3 Selected residential data for a sample of general population in middle Sweden (*n* = 466)

Characteristic	Prevalence (No (%))
Site of residency:	
Rural area/town < 10 000 inhabitants	207 (44)
Town (10 000 to 50 000 inhabitants)	142 (30)
City (50 000 to 150 000 inhabitants)	117 (25)
No of small children (< five years old) at home:	
None	388 (86)
One	47 (10)
Two	17 (4)
More than two	0 (0)
Current dwelling:	
New building (built after 1974)	103 (24)
Detached house	263 (56)
Wooden house	218 (46)
House pets (furry animals or birds) in dwelling	194 (42)
Mouldy odour or visible signs of indoor moulds	24 (5)
Water damage or signs of building moisture	80 (17)
Interior of dwelling painted during last year	121 (26)
Type of ventilation in dwelling:	
Natural ventilation only	126 (28)
Mechanical ventilation in kitchen/bathroom only	265 (59)
Mechanical ventilation in kitchen, living rooms as well as in other rooms	61 (13)

common in agricultural or forestry work, and most common in transport and communication work. Dermal symptoms were least common in agricultural, forestry, transport, and communications work, and most common in professional and technical and related work. General symptoms were least common in sales, agricultural, and forestry work, and most common in service, health, hospital, and social work.

Initially, women reported a significantly higher prevalence of airways symptoms ($OR = 1.7$; $p < 0.01$), dermal symptoms ($OR = 1.7$; $p < 0.05$), and general symptoms ($OR = 1.6$; $p < 0.01$). They also reported a higher prevalence of allergy to nickel ($OR = 24.2$; $p < 0.001$), non-specific hyper-

reactivity ($OR = 1.7$; $p < 0.01$), and proneness to infection ($OR = 1.8$; $p < 0.05$). After adjusting for these three factors in the final regression models, no significant differences in symptom prevalences between men and women could be shown.

Both logistic and linear regression analyses showed that three personal and one childhood exposure factor were related to the prevalence of eye symptoms—namely, proneness to infection ($p < 0.001$), atopy ($p < 0.001$), non-specific hyperreactivity ($p < 0.001$), and exposure to tobacco smoke in childhood from smoking mothers ($p < 0.05$; table 7). Similar analyses showed that three personal factors and two non-occupational exposures were signifi-

Table 4 Occupational exposure data for a sample of occupational active population in middle Sweden (*n* = 384)

Characteristic	Prevalence (No (%))
Private sector workplace	230 (60)
Public sector workplace	154 (40)
Shift or night work	70 (18)
Work with VDUs	101 (26)
Occupational contact with animals	13 (3)
Environmental tobacco smoke exposure at work	50 (13)
Occupational exposure to combustion products	37 (8)
Occupational exposure to static electricity	43 (11)
Inorganic dust:	
Mean exposure above 10% of TLV	45 (12)
Daily peak exposure above TLV	21 (5)
Organic dust:	
Mean exposure above 10% of TLV	35 (9)
Daily peak exposure above TLV	29 (8)
Organic solvents:	
Mean exposure above 10% of TLV	32 (8)
Daily peak exposures above TLV	6 (2)
Irritating gases:	
Mean exposure above 10% of TLV	19 (4)
Daily peak exposure above TLV	5 (1)
Other chemical compounds:	
Mean exposure above 10% of TLV	9 (2)
Daily peak exposure above TLV	1 (0.2)

Table 5 Three month prevalence of symptoms in a sample of general population ($n = 466$) in a mid-Swedish three county region

Type of symptom	Prevalence of symptoms (%)
Eye irritation	16
Swollen eyelids	6
Nasal catarrh	15
Blocked up nose	19
Dryness in the throat	13
Sore throat	10
Irritative cough	10
Headache	19
Abnormal tiredness	30
Sensation of getting a cold	23
Nausea	7
Facial itching	6
Facial rash	6
Itching on the hands	9
Rashes on the hands	8
Eczema	11

cantly related to airway symptoms in both regression models—namely, proneness to infection ($p < 0.001$), atopy ($p < 0.001$), non-specific hyperreactivity ($p < 0.001$), current urban residency ($p < 0.05$), and exposure to fresh paint in the dwelling during the last year ($p < 0.05$) (table 8).

Multiple regression analysis of dermal symptoms showed that atopy ($p < 0.001$), hyperreactivity ($p < 0.01$), and allergy to nickel ($p < 0.05$) were related to such symptoms (table 9). Three personal and two environmental factors were related to the prevalence of general symptoms—namely, proneness to infection ($p < 0.001$), non-specific hyperreactivity ($p < 0.05$), allergy to nickel ($p < 0.05$), urban residency in childhood ($p < 0.01$), and number of preschool children in current dwelling ($p < 0.05$) (table 10). Table 11 presents the adjusted ORs calculated from the logistic regression models for significant personal factors and non-occupational exposures.

Childhood exposure to tobacco smoke from

smoking mothers was related to eye symptoms (table 7). A relation also existed between maternal smoking and both atopy ($OR = 2.0$; $p < 0.01$), and allergy to nickel ($OR = 2.4$; $p < 0.01$). Among subjects with non-smoking mothers, the prevalence of atopy was 22% and the prevalence of allergy to nickel was 14%. The corresponding prevalences for subjects with smoking mothers were 35% for atopy and 28% for allergy to nickel. No relation between the fathers' smoking habits and atopy or allergy to nickel was found. No significant relation was seen between the subjects' current smoking habits and the mothers' or fathers' smoking habits. Maternal smoking, however, was more common in urban areas. Among subjects who had spent their childhood in rural areas, only 8% had smoking mothers, whereas 44% of those growing up in larger cities ($> 100\,000$ inhabitants) had smoking mothers ($p < 0.001$). Because atopy and allergy to nickel could be induced by maternal smoking, these two factors were excluded from the model when calculating the ORs for SBS symptoms and maternal smoking presented in table 11. By excluding these two factors a significant relation between maternal smoking and airway, eye, and general symptoms was found ($p < 0.05$). The exclusion of atopy and allergy to nickel also resulted in somewhat higher ORs for eye symptoms and maternal smoking ($OR = 2.3$ compared with $OR = 2.0$ when adjusting for atopy and allergy to nickel in the regression models).

Further analysis of the relation between occupational factors and symptoms showed that VDU work was related to both eye symptoms and dermal symptoms ($p < 0.01$), and also self reported exposure to static electricity was related to eye symptoms ($p < 0.001$). Initially, we found a relation between general symptoms and the psychosocial dissatisfaction index ($p < 0.01$). Different aspects of the psychosocial climate, however, were found to have different influences on symptoms. Poor work satisfaction was related to a higher prevalence of

Table 6 Three month prevalence (%) of symptoms in different types of occupations (NYK classification) ($n = 465$)*

Type of occupation	Type of symptoms				
	No	Eye (%)†	Airway (%)‡	Dermal (%)§	General (%)
Professional, technical, and related work (0)	74	18	36	31	43
Health, hospital, and social work (1)	69	20	36	25	55
Administrative and managerial work (2)	66	23	30	23	42
Sales work (3)	19	5	26	26	21
Agricultural and forestry work (4)	19	11	16	16	26
Transport and communications work (6)	25	4	44	8	48
Production work (7–8)	80	18	30	15	39
Service work (9)	35	29	31	20	51
Occupationally inactive subjects	78	13	26	16	46

*One subject in mining/quarrying work (5) excluded from the table.

†Eye irritation or swollen eyelids.

‡Nasal catarrh, blocked up nose, dry or sore throat, or irritative cough.

§Eczema, facial itching, facial rash, itching or rashes on the hands.

||Headache, abnormal tiredness, sensation of getting a cold or nausea.

Table 7 Regression analysis of prevalence of at least one eye symptom in general population ($n = 434$)† as a function of three significant personal factors and one significant exposure variable ($p < 0.05$)

Variable	Logistic model (coefficient (SE))	Linear model (coefficient (SE))
Atopy‡	1.34*** (0.28)	0.20*** (0.040)
Proneness to infection‡	1.30*** (0.33)	0.21*** (0.051)
Hyperreactivity‡	1.07*** (0.28)	0.16*** (0.038)
Maternal smoking‡	0.68* (0.31)	0.092* (0.043)
Constant	-2.82	0.03

*Two tailed $p < 0.05$; ***two tailed $p < 0.001$.

SE = Standard error of coefficient.

†Incomplete answers from 32 subjects.

‡0 = Absence, 1 = presence.

Nine personal factors were non-significant ($p > 0.05$) predictors of eye symptoms—namely, age, sex, marital state, education level, allergy to nickel, current tobacco smoking, earlier tobacco smoking, weight index, and regular physical exercise.

Four childhood exposures were non-significant predictors of eye symptoms—namely, paternal smoking during childhood, childcare outside the home, childhood residency outside Sweden, and childhood residency in urban areas.

Ten current residential exposures were non-significant predictors of eye symptoms—namely, residency in urban areas, age of dwelling, population density in the dwelling, type of dwelling (flat/own house), wall material (wood/stone), mechanical ventilation, moisture damage or mould growth, newly painted interior, presence of house pets, and number of preschool children at home.

general symptoms ($p < 0.0001$). Poor climate of cooperation at work was related to eye symptoms ($p < 0.001$) and general symptoms ($p < 0.001$). No significant relation was found between degree of work stress and any type of symptom. Other factors such as night or shift work, public sector work, occupational activity, or exposure to environmental tobacco smoke, combustion products, organic or inorganic dust, organic solvents, irritating gases, or occupational contact with animals were not related to symptoms. Table 12 presents the adjusted ORs with 95% CIs for occupational exposures.

Discussion

These results indicate a relation between SBS symptoms and urban residency, VDU work, static electricity, psychosocial work environment, exposure to fresh paint, and presence of preschool children at

home. Furthermore, childhood exposure to maternal tobacco smoke and urban environments might enhance the prevalence of SBS symptoms. Also, a relation was shown between maternal smoking and atopy as well as allergy to nickel among adults.

Many methodological problems are inherent in an epidemiological study, particularly with regard to internal validity. Selection bias can occur as a result of both a low response rate and incorrect study design. The subjects included in this study were randomly selected from the civil registration register. These registers have a high quality and the proportion of subjects not found in the registers is negligible. The non-response rate was 26% and thus a selection bias could occur. No difference in age or degree of urbanisation occurred, however, between responders and non-responders. Also the proportion of occupationally active responders (83%) was nearly identical to the proportion of occupationally active

Table 8 Regression analysis of prevalence of at least one airway symptom in general population ($n = 446$)† as a function of three significant personal factors and three significant exposure variables ($p < 0.05$)

Variable	Logistic model (coefficient (SE))	Linear model (coefficient (SE))
Atopy‡	0.87** (0.27)	0.15*** (0.044)
Hyperreactivity‡	0.96*** (0.26)	0.14*** (0.044)
Proneness to infection‡	3.39*** (0.46)	0.62*** (0.056)
Current urban residency§	0.30* (0.14)	0.044* (0.023)
Childhood residency abroad‡	NS	0.14* (0.064)
Dwelling painted during last year‡	0.66* (0.26)	0.11* (0.042)
Constant	-2.21	0.21

*Two tailed $p < 0.05$; **two tailed $p < 0.01$; ***two tailed $p < 0.001$.

SE = Standard error of coefficient; NS = non-significant.

†Incomplete answers from 20 subjects.

‡0 = Absence, 1 = presence.

§0 = Rural area or town with < 10 000 inhabitants, 1 = town with 10 000–50 000 inhabitants, 2 = city with 50 000–150 000 inhabitants.

Nine personal factors were non-significant ($p > 0.05$) predictors of airway symptoms—namely, age, sex, marital state, education level, weight index, regular physical exercise, current tobacco smoking, earlier tobacco smoking, and allergy to nickel.

Four childhood exposures were non-significant predictors of airway symptoms—namely, maternal smoking during childhood, paternal smoking during childhood, childcare outside the home, and childhood residency in urban areas.

Eight current residential exposures were non-significant predictors of airway symptoms—namely, age of dwelling, population density in the dwelling, type of dwelling (flat/own house), wall material (wood/stone), mechanical ventilation, moisture damage or mould growth, presence of house pets, and number of preschool children at home.

Table 9 Regression analysis of prevalence of at least one dermal symptom in general population ($n = 451$)† as a function of three significant personal factors ($p < 0.05$)

Variable	Logistic model (coefficient (SE))	Linear model (coefficient (SE))
Atopy‡	0.99*** (0.25)	0.17*** (0.043)
Hyperreactivity‡	0.75** (0.25)	0.11** (0.040)
Allergy to nickel‡	0.70* (0.29)	0.12* (0.050)
Constant	-2.03	-0.02

*Two tailed $p < 0.05$; **two tailed $p < 0.01$; ***two tailed $p < 0.001$.

SE = Standard error of coefficient.

†Incomplete answers from 15 subjects.

‡0 = Absence, 1 = presence.

Nine personal factors were non-significant ($p > 0.05$) predictors of dermal symptoms—namely, age, sex, marital state, education level, current tobacco smoking, earlier tobacco smoking, proneness to infection, weight index, regular exercise.

Five childhood exposures were non-significant predictors of dermal symptoms—namely, maternal smoking during childhood, paternal smoking during childhood, childcare outside the home, childhood residency outside Sweden, and childhood residency in urban areas.

Ten current residential exposures were non-significant predictors of dermal symptoms—namely, residency in urban areas, age of dwelling, population density in the dwelling, type of dwelling (flat/own house), wall material (wood/stone), mechanical ventilation, moisture damage or mould growth, newly painted interior, presence of house pets, and number of preschool children at home.

subjects (82%) in the total population.³⁶ The proportion of women, however, was higher in responders than in non-responders. As only a 2% difference existed in the proportion of women between responders and the total population, we consider this overrepresentation of women to be of minor significance.

The study base covered both occupationally active and inactive subjects, and retrospective exposure information was gathered. This design made it possible to detect selection effects, which a cross-sectional study comparing an exposed and non-exposed group of workers would not be able to study. Although women and subjects with allergy to nickel more often avoided occupations with chemical exposures, we were not able to show any selection effects of occupational chemical exposure causing sensitive subjects to move from exposed to non-exposed occupations.

Response bias due to awareness of the exposure may also influence the result when information on both exposure and outcome variables are gathered by questionnaires. We found, however, relations only for specific exposures and specific types of symptoms. Another problem is the possible response bias related to retrospective exposure information such as maternal smoking and earlier occupations. In two earlier investigations, questions on parental smoking have been validated by comparing the subjects' answers with information from other sources.^{37,38} Both studies showed that people can reliably recall whether or not their parents smoked but they cannot accurately recall the amount of smoking. In a Swedish thesis, retrospective occupational history obtained by retrospective interview questions was compared with prospective occupational information obtained from censuses.³⁹ A good agreement was found between self reported occupational history and census data.

Table 10 Regression analysis of prevalence of at least one general symptom in general population ($n = 439$)† as a function of three significant personal factors and two significant exposure variables ($p < 0.05$)

Variable	Logistic model (coefficient (SE))	Linear model (coefficient (SE))
Infection proneness‡	3.15*** (0.53)	0.50*** (0.067)
Hyperreactivity‡	0.63** (0.24)	0.10* (0.049)
Allergy to nickel‡	0.77** (0.30)	0.14* (0.059)
Childhood urban residency§	0.28** (0.10)	0.057** (0.021)
Preschool children at home	0.51* (0.22)	0.10* (0.045)
Constant	-1.25	0.24

*Two tailed $p < 0.05$; **two tailed $p < 0.01$; ***two tailed $p < 0.001$.

SE = Standard error of coefficient.

†Incomplete answers from 27 subjects.

‡0 = Absence, 1 = presence.

§0 = Rural area; 1 = town ($< 10\,000$ inhabitants); 2 = small city ($10\,000$ – $100\,000$ inhabitants); 3 = larger city ($> 100\,000$ inhabitants).

||Number of preschool children (< 5 years old) at home.

Nine personal factors were non-significant ($p > 0.05$) predictors of general symptoms—namely, age, sex, atopy, marital state, education level, current tobacco smoking, earlier tobacco smoking, weight index, and regular physical exercise.

Four childhood exposures were non-significant predictors of airway symptoms—namely, maternal smoking during childhood, paternal smoking during childhood, childcare outside the home, and childhood residency in urban areas.

Nine current residential exposures were non-significant predictors of general symptoms—namely, residency in urban areas, age of dwelling, population density in the dwelling, type of dwelling (flat/own house), wall material (wood/stone), mechanical ventilation, moisture damage or mould growth, newly painted interior, and presence of house pets.

Table 11 Adjusted ORs (95% CI) for significant personal factors and non-occupational exposures in the general population (n = 466)

Type of factor	Type of symptoms			
	Eye*	Airway†	Dermal‡	General§
Proneness to infection	3.7 (2.0-7.0)	29.4 (12-72)	1.3 (0.7-2.5)	23.3 (8.0-66)
Atopy	3.8 (2.2-6.6)	2.4 (1.4-4.1)	2.7 (1.6-4.4)	1.1 (0.7-1.7)
Allergy to nickel	1.3 (0.7-2.5)	1.8 (0.99-4.1)	2.0 (1.1-3.5)	2.2 (1.2-3.9)
Hyperreactivity	2.9 (1.7-5.0)	2.7 (1.6-4.4)	2.1 (1.3-3.4)	1.9 (1.2-3.0)
Maternal smoking	2.3 (1.3-4.1)	1.9 (1.1-3.4)	0.8 (0.4-1.5)	1.8 (1.01-3.0)
Urban childhood (> 10 000 inhabitants)	1.5 (0.9-2.6)	1.5 (0.9-2.5)	1.6 (0.95-2.5)	1.6 (1.1-2.5)
Current urban residency (> 10 000 inhabitants)	1.3 (0.7-2.2)	1.7 (1.02-2.7)	1.1 (0.7-1.7)	1.1 (0.7-1.7)
Newly painted dwelling	1.6 (0.9-3.0)	1.9 (1.1-3.2)	1.2 (0.7-2.0)	1.1 (0.7-1.8)
Preschool children at home	0.6 (0.2-1.3)	0.7 (0.5-1.3)	1.2 (0.6-2.4)	2.0 (1.1-3.5)

*Eye irritation or swollen eyelids.

†Nasal catarrh, blocked up nose, dry or sore throat or irritative cough.

‡Eczema, facial itching, facial rash, itching or rashes on the hands.

§Headache, abnormal tiredness, sensation of getting a cold or nausea.

||Adjusted for all significant factors except allergy to nickel and atopy.

Moreover, similar morbidity patterns were obtained for different exposure categories constructed by a job exposure matrix either from a retrospective interview or longitudinally through censuses.

Finally, in multivariate modelling of epidemiological data, the type of regression model⁴⁰ or mass significance may influence the results. In our study, both linear and logistic regression analysis resulted in the same significant parameters, except in one case. With regard to the discussed aspects of internal validity, we do not think that the results of our study are due to response bias, selection bias, mass significance, or the selection of a particular regression model.

Proneness to infection was strongly related to both eye, airway, and general symptoms. In an earlier study we found that sick leave due to airway illness was related to prevalence of symptoms in sick buildings.¹⁴ Also, changes in the frequency of sick leave owing to respiratory illness corresponded to

changes of sick building symptoms among primary school personnel.¹⁵

Signs of hyperreactivity were related to eye, airway, dermal, and general symptoms. In two of our earlier studies, self reported hyperreactivity was related to SBS symptoms in sick buildings¹⁴ and primary school personnel.¹⁵ Besides hyperreactivity, atopy and allergy to nickel were also related to the prevalence of SBS symptoms.

Allergy to nickel is the most common contact allergy in Sweden.⁴¹ The question used in our questionnaire was selected since it was found to be the single question best related to a positive patch test to nickel (67% sensitivity and 97% specificity; L Widström, personal communication). We found that nickel is a predictor not only of dermal symptoms but also of general symptoms. Moreover, selection effects in relation to occupational exposure to chemicals seem to be related to this contact allergy rather than to IgE mediated atopy.

Table 12 Adjusted ORs (95% CI) for occupational exposures and type of symptoms

Type of exposure	Type of symptoms			
	Eye*	Airway†	Dermal‡	General§
Psychosocial dissatisfaction index	2.0 (0.6-7.3)	2.0 (0.6-6.1)	2.1 (0.7-6.5)	3.3 (1.2-9.1)
Work stress	1.2 (0.4-3.9)	1.5 (0.5-4.4)	0.7 (0.3-2.1)	1.5 (0.6-3.5)
Work dissatisfaction	3.4 (0.9-12)	1.8 (0.5-5.7)	1.9 (0.6-6.0)	13.4 (4.5-40)
Poor climate of cooperation at work	4.7 (1.4-16)	2.0 (0.7-5.9)	2.6 (0.9-7.7)	5.7 (2.2-15)
Work with video display terminals	1.6 (1.03-2.5)	1.2 (0.8-1.8)	1.7 (1.2-2.6)	1.0 (0.7-1.4)
Electrostatically charged at work	1.9 (1.1-3.2)	1.5 (0.9-2.4)	1.3 (0.7-2.2)	0.9 (0.6-1.4)
Environmental tobacco smoke at work	1.3 (0.8-2.2)	1.1 (0.7-1.8)	1.3 (0.7-2.2)	0.8 (0.5-1.2)
Current chemical exposure at work	1.3 (0.6-2.7)	0.8 (0.4-1.7)	1.2 (0.6-2.4)	0.7 (0.4-1.3)
Earlier chemical exposure at work	1.1 (0.6-2.1)	1.0 (0.6-1.8)	0.9 (0.5-1.7)	1.2 (0.7-2.0)
Public sector workplace	1.0 (0.6-1.7)	1.1 (0.7-1.8)	1.0 (0.6-1.6)	0.9 (0.6-1.5)
Night work or shift work	1.1 (0.5-2.2)	0.9 (0.5-1.9)	1.0 (0.5-2.0)	1.1 (0.6-1.9)
Occupationally active¶	1.3 (0.6-2.8)	1.2 (0.6-2.3)	1.5 (0.7-2.8)	0.7 (0.4-1.2)

*Eye irritation or swollen eyelids.

†Nasal catarrh, blocked up nose, dry or sore throat or irritative cough.

‡Eczema, facial itching, facial rash, itching or rashes on the hands.

§Headache, abnormal tiredness, sensation of getting a cold or nausea.

||Odds ratio was calculated for the extremes of this continuous variable ranging from 0 to 1.

¶At work during the last three months.

A relation between current exposure to urban environments and airway symptoms was found even when controlling for confounders such as tobacco smoking, atopy, and occupational and residential exposure. This indicates that air pollution in the urban environment from vehicle exhausts or industrial pollution may be of significance for the SBS syndrome. In urban areas a higher prevalence of asthma and rhinitis in conscripts³² and a higher prevalence of respiratory symptoms in children³¹ has been reported. Air pollution from a paper pulp plant has also been shown to be related to hyperreactivity symptoms in children.³⁰ To our knowledge, there are no earlier investigations showing a relation between the urban environment and SBS symptoms in adults.

We found a covariation between certain childhood exposures and SBS symptoms. The relation between spending childhood abroad and airway symptoms may be because many immigrants in Sweden come from warmer and more humid climate zones where mite allergies are more common than in the Nordic countries.⁴² The relation between urban childhood and general symptoms indicates that factors exist related to an urban childhood that lead to persistent health impairments. An earlier investigation has shown a relation between traffic intensity and the concentration of lead in deciduous trees.²⁸ A relation between environmental exposure to lead from traffic and neurobehavioural effects in children has also been found.²⁹ This indicates that the relation may be due to earlier lead exposure, in utero or during childhood. The possibility, however, that persistent effects of non-chemical factors in the urban environment, such as more stress or less social control, are responsible for the observed difference, cannot be excluded.

The results suggest an effect of maternal but not paternal smoking during childhood on the prevalence of atopy, allergy to nickel and SBS symptoms in the adult population. This relation was significant even when adjusting for childhood exposure to the urban environment, which was related to maternal smoking. The lack of effect of paternal smoking could be explained by a more intensive environmental exposure from the mother, but it may also indicate that tobacco smoke exposure in utero rather than airborne exposure in childhood is responsible for the effects. The findings concerning atopy are in agreement with other findings showing that maternal smoking during pregnancy leads to an increased IgE concentration in cord blood and increases the risk for subsequent allergy.²³ We are not aware of other studies on the relation between maternal smoking and SBS symptoms or contact allergies in adults. Female smoking has increased in Sweden during the period 1950–80.⁴³ Our results suggest that this increase could lead to an increase in atopy, contact allergy, and SBS symptoms in the generation born during this period. During the

period 1969–80, an increase of some contact allergies, in particular allergy to nickel and cobalt, was seen in a Swedish study based on standardised patch testing.⁴¹ Although this increase could be explained by an increase of ear piercing, the effect of maternal smoking on the development of contact allergies could be another explanation. Our findings support the view that maternal smoking should be minimised. Also, as maternal smoking and degree of urbanisation were related to each other, these factors must be carefully controlled in epidemiological studies.

Several personal factors such as age, sex, marital state, occupational activity, educational level, obesity, and regular physical exercise were not related to SBS symptoms when controlling for other factors significantly related to the syndrome. Also, several factors related to the dwelling such as building age, population density, type of dwelling, material of the dwelling, mechanical ventilation, mould growth, moisture damage, or presence of house pets were not significantly related to SBS symptoms. In the home environment, only two factors were significantly related to SBS symptoms—namely, newly painted surfaces and presence of preschool children.

Chemical stimulation of the trigeminal or olfactory nerves has been suggested as an explanation of the sick building syndrome.⁴⁴ In two earlier studies, we have shown a relation between SBS symptoms and the total indoor concentration of volatile organic hydrocarbons in sick buildings¹⁴ and in primary schools.¹⁵ Sensory nerve stimulation may also occur in industrial environments, and a good correlation between TLV values and irritative response in animal tests has earlier been shown.⁴⁵ In the present study, we found no relation between current or earlier occupational exposure to chemicals and SBS symptoms when controlling for significant personal factors and non-occupational exposures. This may be due to selection mechanisms in adolescence causing sensitive persons to avoid exposed jobs or to the fact that current exposure levels are fairly low in Swedish workplaces. The last view is supported by the fact that no occupation in our sample could be classified as having a current average exposure above the present TLV values. Our findings agree with an earlier study comparing SBS symptoms in sick buildings and polluted industrial environments and in unexposed reference groups,¹² which suggested that the modern non-industrial indoor environment may induce more symptoms than current industrial environments. The finding of a positive relation between current chemical exposure and a history of tobacco smoking agrees with another investigation,⁴⁶ and shows the importance of controlling for smoking habits in occupational epidemiology.

The results indicate an effect of residential exposure to newly painted surfaces on airway symp-

toms. Paint contains different types of volatile organic hydrocarbons that continue to be emitted into the environment after painting. In the past, indoor paint contained high concentrations of organic solvents, mostly non-polar compounds such as toluene, xylene, or white spirit. Nowadays, water soluble paints are used in most indoor painting in Sweden.⁴⁷ Such paints contain mostly polar organic solvents at low concentrations and occupational measurements have shown that several components such as glycols, glycol ethers, white spirit, ammonia, formaldehyde, acrylate monomers, and higher esters are emitted to the air both during painting and months after the painting is finished.^{48,49} Volatile organic compounds from fresh paint in dwellings may induce airway irritation. The findings in the present study are in agreement with earlier investigations in schools¹⁵ and sick buildings,^{2,14} showing a relation between SBS symptoms and indoor concentration of volatile organic compounds.

More than a fourth of the total work force used VDUs, and a relation between such work and eye and dermal symptoms was found, even when controlling for other factors such as atopy, allergy to nickel, static electricity, and psychosocial factors. A relation between VDU terminal work and dermal symptoms^{50,51} and mucosal irritation⁸ has been shown. Electrostatic fields may be generated from VDUs and may lead to an enhanced accumulation of dust.⁵²

Wall to wall carpeting might be related to both electrostatic shocks^{5,13} and SBS symptoms.¹³ In two earlier studies,^{11,14} a relation between static electricity and SBS symptoms has been shown. In two other studies in office workers, however, no such relation was shown.^{3,5} We found a higher prevalence of eye symptoms among subjects who often experienced electrostatic shocks, even when controlling for other factors. As we lack information on presence of wall to wall carpets, we cannot exclude the possibility that the effect may be due partly to the presence of such carpets. In conclusion, indications exist for a relation between static electricity and SBS symptoms, but it is still unclear to what extent this is causal, and at what levels of electrostatic charge symptoms are induced.

The psychosocial climate at work, measured by a psychosocial dissatisfaction index, was related to general symptoms. In two other investigations^{14,15} this index has been shown to be related to both prevalence and incidence of SBS. A further analysis showed that work satisfaction and climate of cooperation but not stress at work were related to symptoms. In earlier studies, psychosocial factors were shown to be related to general symptoms.^{8,11} We could also show a relation between climate of cooperation at work and eye symptoms. This agrees with the results of a study on Danish office workers, in which a relation was found between psychosocial factors and mucosal irritation.⁸

One aim of our study was to explore relations between SBS symptoms and environmental factors in a broader sense than reported in current publications on SBS. Some of our results support earlier findings suggesting that indoor concentrations of volatile hydrocarbons, VDU work, static electricity, and psychosocial factors play an important part in the development of SBS. Also, the results indicate that environmental exposures in childhood, as well as from those currently found outdoors should be taken into consideration in epidemiological investigations on SBS. Preventive measures intended to reduce the prevalence of SBS should not exclusively focus on indoor air problems in new office buildings, but should also take other possible exposures and personal factors into account.

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