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THE "SICK" BUILDING SYNDROME IN THE OFFICE ENVIRONMENT: THE DANISH TOWN HALL STUDY

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Measurements of the indoor climate were performed in 14 town halls in Greater Copenhagen, Denmark, together with a questionnaire study and a clinical study of 4369 employees in the town halls and 14 affiliated buildings. The return rate for the questionnaire study was 80% and the participation rate for the clinical study 77%.

The many indoor climate factors determined resulted in values mainly at the levels normally considered acceptable or in values in accordance with levels previously reported.

The prevalence of work-related mucosal irritation and of work-related general symptoms in the employees differed highly between the individual town halls. The lowest prevalences of symptoms were found for the oldest town halls, whereas there were no statistically significant difference between naturally and mechanically ventilated buildings.

The preliminary analyses showed that sex, job category, photoprinting, working with video display terminals, and handling carbonless paper correlated significantly with the presence of work-related mucosal irritation and general symptoms.

Introduction

During the last 10–15 years international studies have reported an increasing number of complaints about discomfort and health effects in relation to staying in residences and non-industrial workplaces. The increase in number of complaints synchronizes with the energy-efficient procedures in the form of tightening of buildings and reduction of the ventilation, and with the increasing industrialization of the building trade, involving the use of new building materials. The extent of complaints and their international occurrence have resulted in WHO (WHO, 1983) having defined the concept of the "sick" building syndrome, characterized by persons staying in the building having an extra frequency of a number of irritative symptoms from the eyes, nose, throat and lower airways, skin reactions, unspecific hypersensitivity reactions, mental fatigue, headache, nausea or dizziness.

Various exposures have been related to the "sick" building syndrome. They include chemical (Mølhave et al., 1984 a + b), physical (Alsbirk et al., 1983), biological (Nexø et al., 1985), and psychosocial (Colligan, 1981) conditions.

A few epidemiologic studies report that the prevalence of the "sick" building syndrome is high in institutions for the children (Rindel et al., 1985) and in offices (Valbjørn and Kousgård, 1986; Turiel et al., 1983; Finnegan et al., 1984), and that it differs significantly from one building to another without this being directly explainable by the results from determination of a number of indoor pollution components (Turiel et al., 1983; Robertson et al., 1985).

In these studies, the attention especially focussed on mechanically ventilated buildings in contrast to naturally ventilated ones, but indoor climate variables were determined in only one building of either type, and, consequently, the authors had no possibility of evaluating other building characteristics which a priori could be assumed to correlate with both the prevalence of the "sick" building syndrome and with the ventilation of the building, for instance the age of the building. Furthermore, no analysis was made on the influence on the prevalence of other factors such as photoprinting, working with video display terminals, psychosocial conditions, and lifestyle.

This paper presents design and methods, together with the first descriptive results from a cross-sectional

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Table 1. Participants by sex, age, years of office work, and job category.

	Men		Women	
	N	%	N	%
Age in Years				
Less than 20	8	0.7	34	1.4
20 – 29	197	17.8	462	19.7
30 – 39	309	27.9	735	31.3
40 – 49	267	24.1	610	26.0
50 – 59	213	19.2	395	16.8
60 – 69	115	10.4	110	4.7
Total	1109	100	2346	100
Years of Office Work				
0 – 9	306	27.8	692	30.1
10 – 19	324	29.4	755	32.9
20 – 29	234	21.2	585	25.5
30 or more	238	21.6	266	11.6
Total	1102	100	2298	100
Job Category				
Mayor, director, head of a department	85	7.7	6	0.3
Principal	171	15.5	25	1.1
Clerk	532	48.1	1863	79.7
Social worker	24	2.2	159	6.8
Technical assistant	25	2.3	47	2.0
Engineer/architect	187	16.9	19	0.8
Other	82	7.4	219	9.4
Total	1106	100	2338	100

study of employees in Greater Copenhagen town halls, with the purpose of examining the influence of various environmental factors on the prevalence of symptoms connected to the "sick" building syndrome.

The study includes a large population, many different buildings, and many indoor climate factors, and an elaborate 1-year follow up study of four of the town halls.

Material and Methods

The buildings

We made applications for participation in the study to the municipalities of Copenhagen, Frederiksberg, and the Copenhagen Amt (county), a total of 20 municipalities. Thirteen of them entered the study, 3 being excluded because comprehensive indoor climate studies recently had been carried out or were in progress, one answered too late for it to be entered during the data collection period, and 3 did not want to participate. The town hall in each municipality was selected as study building. In 2 municipalities, 2 buildings were considered to be of equal status, though structurally different, and therefore both buildings were included in the one case (No. 120 and 121), but only the newest in the other (No. 60), since a major reconstruction was to take place in the older building (No. 61) during the study period, which might affect the results.

In addition to these 14 study buildings, where both determinations of the indoor climate were performed and the employees were examined clinically and by use of a questionnaire, the material includes 13 other independent buildings affiliated to the town halls. For these buildings and the building No. 61, certain data were obtained, such as age of the building, building materials, heating and ventilation conditions, number of employees, and floorage, and the employees were included in the questionnaire study and the clinical study.

The age of the 14 town hall buildings ranged from 1 to 80 years, mean 18 years. Five buildings were situated in rural, 4 in urban, and 5 in residential areas. Six buildings had natural ventilation and 8 had mechanical ventilation. Of these 8, 5 had outside air intake, 3 only air exhaust. Of the 5 buildings with air intake, 2 systems provided recirculation and 2 had humidifiers, of which, however, only one was used.

Study population

The study population included 4,369 employees distributed in the 14 study buildings, the 14 additional buildings, and various smaller buildings and rooms (with 47 employees only). Among these persons 3,507 (2,347 women, 1,115 men, and 45 for whom sex was not stated) participated in the questionnaire study, 3,359 in the clinical study, 3,109 in both, 398 only in the questionnaire and 250 only in the clinical study, yielding a total of 3,757 participants. The numbers of employees in the 14 study buildings ranged from 84 to 419 (mean 251). In the additional 14 buildings the numbers ranged from 15 to 238 (mean 58). The distribution by age, years of office work, and job category of the participants in the questionnaire study is given in Table 1. The return percentage in the questionnaire study varied between 61% and 93% (mean 80%) in the town hall buildings, and between 57% and 100% (mean 79%) in the other 14 buildings. The reasons stated for non-participation in the study were: sick leave, maternity leave, vacation, and in at least 10% of the cases lack of want to participate. All who did not want to participate when first asked, were requested again over the telephone unless they were absent for some of the above-mentioned reasons or previously clearly had expressed their desire of non-participation.

Questionnaire study

The questionnaire included questions on the work,

Table 2. Prevalence of work related symptoms.

	Men (N = 1093–1115)		Women (N = 2280–2345)	
	n	%	n	%
Eye irritation	88	8.0	347	15.1[a]
Nasal irritation	132	12.0	463	20.0[a]
Blocked, runny nose	51	4.7	193	8.3[a]
Throat irritation	120	10.9	414	17.9[a]
Sore throat	21	1.9	57	2.5
Dry skin	39	3.6	172	7.5[a]
Rash	13	1.2	27	1.6
Headache	142	13.0	520	22.9[a]
Fatigue	235	20.9	714	30.8[a]
Malaise	54	4.9	211	9.2[a]
Irritability	59	5.4	155	6.3
Lack of concentration	41	3.7	109	4.7
Symptom groups				
Irritation of the mucous membranes[b]	226	20.3	756	32.3[a]
Skin reactions[c]	47	4.2	193	8.3[a]
General symptoms[d]	290	26.1	954	40.9[a]
Irritability[e]	88	7.9	221	9.5

[a]Difference between men and women statistically significant (χ^2-test, $p < 0.05$).
[b]Irritation of the eye, nose or throat.
[c]Dry skin or rash.
[d]Headache, fatigue or malaise.
[e]Irritability or lack of concentration.

its type, previous and present diseases, presence of symptoms from mucous membranes, presence of general symptoms, and the frequency and time variations of such symptoms. Furthermore, questions about various other symptoms, work-related complaints (draught, low temperature etc.), family and housing conditions, exercise habits, and consumption of beverage and tobacco were included.

The possible categories of answers to the questions about individual symptoms were: "No," "Yes, some times a year," "Yes, some times a month," "Yes, some times a week," and "Yes, daily." We also asked about variations in the intensity of symptoms employing the following categories of answers: "Yes, it improves at work," "Yes, it improves on days off/during week-ends or vacations," "No, it is always the same," and "Don't know." The work-related prevalence of symptoms includes only symptoms where the statements were "Yes, some times a week," or "Yes, daily" together with "Yes, it improves on days off/during week-ends or vacations." Besides single symptoms, we employed groups of work-related symptoms: "irritation of the mucous membranes," i.e., one or several symptoms of irritation of the mucous membrane of the eye, nose or throat; "skin reactions," i.e., dry skin or rash; "general symptoms," i.e., headache, abnormal fatigue or malaise; "irritability," i.e., irritability and lack of concentration.

The possible categories of answers to the questions about work-related complaints were: "Never or seldom," "Sometimes" and "Often." The prevalence of work-related complaints includes only complaints stated "Often."

Table 3. Prevalence of work-related complaints during the winter.

	Men (N = 1100)		Women (N= 2328)	
	n	%	n	%
Draught	199	18.1	823	35.4[a]
Draught along the floor	145	13.2	847	36.4[a]
Change in temperature	283	25.7	854	36.7[a]
High temperature	193	17.5	437	18.8
Low temperature	160	14.5	544	23.4[a]
Stuffy air	264	24.0	944	40.5[a]
Odour	70	6.4	268	11.5[a]
Dry air	326	29.6	1220	52.4[a]
Dusty air	181	16.5	643	27.6[a]
Noise in the office	167	15.2	579	24.9[a]
Noise from other offices	91	8.3	277	11.9[a]
Noise from outside	81	7.4	186	8.0
Poor lighting	98	8.9	377	16.2[a]
Tobacco smoke	131	11.9	448	19.2[a]
Static electricity	125	11.4	363	15.6[a]

[a]Difference between men and women statistically significant (χ^2-test, $p \leq 0.05$).

Table 4. Prevalence of work-related symptom groups (%) in each building.

		The 14 Town Halls (Building No.)														The 14 Additional Buildings (Building No.)													
		10	20	30	40	50	60	70	80	90	100	110	120	121	130	31	41	61	62	63	64	65	91	101	102	103	131	132	133
Return Rate %		81	80	80	79	93	81	82	67	90	61	78	78	80	76	67	79	74	83	86	100	93	93	68	67	57	83	76	100
N =	Women	223	76	53	53	313	99	196	172	119	43	138	177	101	94	5	25	132	14	38	13	20	27	11	10	19	100	14	22
	Men	113	30	21	13	113	30	87	105	37	28	76	115	81	70	5	5	45	25	34	3	5	11	6	20	5	18	5	1
		Percentage														Percentage													
Irritation of the Mucous Membranes	Women	20	25	26	32	35	40	42	26	38	37	38	19	45	26	20	32	36	7	61	62	40	30	27	60	16	27	36	55
	Men	13	20	43	31	20	20	25	14	11	18	25	10	38	10	0	0	18	8	50	0	0	36	33	15	0	39	40	0
Skin Reactions	Women	7	5	8	9	6	10	10	8	7	12	8	5	18	11	0	0	10	0	18	31	10	4	0	20	0	8	21	5
	Men	4	3	5	0	2	7	6	4	3	7	9	2	7	0	0	0	2	4	9	0	20	9	0	5	0	11	0	0
General Symptoms	Women	34	32	35	38	38	44	50	33	40	54	47	30	66	32	60	24	48	7	50	69	45	48	45	30	32	50	57	41
	Men	23	27	29	15	25	27	32	20	25	32	30	17	37	24	20	20	31	16	44	0	0	64	33	5	20	39	20	0
Irritability	Women	8	9	11	4	5	8	11	8	19	7	12	11	5	2	20	4	18	0	13	8	10	8	0	20	0	20	7	9
	Men	4	17	10	8	5	7	12	8	14	18	5	4	6	3	0	0	11	8	18	0	0	36	0	0	40	17	0	0

The questionnaires were distributed in the town halls together with a written information about the study, stressing the importance of the answering being an independent, strictly personal matter. The questionnaires were returned in sealed envelopes. The questionnaire study was performed in the period February–June 1984.

Clinical study

Each employee personally was requested in writing to participate. The study took place at the individual town halls and the examination included: (1) Registration, (2) Measurement of the blood pressure, (3) Evaluation of the skin, (4) Collection of nasal secretion, (5) Determination of the lung function, (6) Determination of skin irritability.

This part of the study will be reported in a subsequent paper.

Measurements of indoor climate

In each of the 14 study buildings, we selected one office which the total study group considered representative of the building in respect to building material, equipment, size, activity, and technical installations. Clients did not have regular access to the rooms selected. Supplementary measurements of temperature, dust, and microorganisms in floor dust were made in other rooms. Except for a few variables, the measurements were performed on 3 consecutive days in each town hall during the period January 31–May 3, 1984.

Thermal environment and relative humidity. During 1 1/2 to 3 days, air temperature and relative humidity were measured at table level using a Lambrecht thermohygrograph. Measurements of the air temperature were also done 0.1 and 1.1 m from the floor with a Blichfelt electronic thermometer with thermocouple. Furthermore, the air temperature was registered in 2 other offices, and short-term measurements were done in about 20% of the offices — randomly selected — in the building. A person-weighted air temperature was calculated, where each measurement entered with a weight corresponding to the number of persons in the office. The velocity of the air was evaluated using a smoke ampoule and determined with a thermoanemometer in those offices where the velocity was estimated to be more than 0.15 m/s.

Carbon dioxide. The concentration of carbon dioxide was measured with an indicator tube (Dräger) in the morning and the afternoon. The time of the last measurement was set so that the maximum concentration even with a constant low air change (about 0.5 times per hour) would have been reached.

Static electricity. The static electrical charge of the persons in the office and of a member of the study group (O.V.) was measured with an electrometer (Keithley 602) while the persons were walking to-and-fro.

Formaldehyde. The content in the air of formaldehyde was measured during 2 hours with a spectrophotometer after absorption in acetyl acetone (Regeno field analyzer).

Airborne dust. The concentration of dust in the air was determined by use of a Dupont pump (P4000) and a membrane filter (Millipore FSLW,37mm). The determination was done 1.1 m from the floor near a working place in the middle of the office over a period of about 10 hours during working hours, distributed on 2 days. The sample volume was about 2.5 m^3 of air. The filter-holder was turned downwards and the air velocity in the intake was 1.25 m/s. The determination was repeated over 1–2 hours in October-December 1984 in connection with the determination of mineral fibres with a sampled volume of 1.7–3.4 m^3. The number and size of particles in the indoor air was measured with a

Table 5. Prevalence of the work-related symptom groups (%) by sex, age, seniority, job category and number of occupants in the office.

		Age			Years of Office Work				Job Category							Number of Occupants in the Office			
		<30	30–49	>49	0–9	10–19	20–29	>29	Mayor, Director, Head of a Department	Principal	Clerk	Social Worker	Technical Assistant	Engineer/ Architect	Other	1	2–4	5–30	>30
		Percentage																	
Irritation of the Mucuous Membranes	Women	33	32	33	31	31	35	32	33	24	34[a]	25	17	11	30	31	29	37	49[a]
	Men	32[a]	19	15	23	22	20	16[a]	8	19	26[a]	17	20	10	20	18	17	26	51[a]
Skin Reactions	Women	7	7	12	7	8	10	9	0	17[a]	9	8	2	0	8	8	7	10	13
	Men	5	4	4	4	5	3	5	7	4	5	8	0	1	5	4	4	5	2
General Symptoms	Women	46[a]	41	36	45[a]	39	40	38	0	32	42	51[a]	23	21	34	41	38	44	63[a]
	Men	36[a]	23	25	28	26	22	28	20	21	30	54[a]	12	18	29	24	24	30	51[a]
Irritability	Women	11	10	8	12	10	8	6	0	8	9	27[a]	0	0	6	14	8	8	17[a]
	Men	10	8	6	10	7	6	9	8	6	9	21[a]	12	5	9	8	8	7	16[a]

[a]Difference between this category and the other categories statistically significant (χ^2-test, $p < 0.05$).

Table 6. Prevalence of work-related symptom groups (%) by work functions.

	N		Irritation of the Mucous Membranes		Skin Reactions		General Symptoms		Irritability	
	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men
			(%)	(%)	(%)	(%)	(%)	%)	(%)	(%)
Photoprinting										
Monthly or Less	249	106–108	28	17	7	6	33	19	6	4
Weekly or Daily	2057–2067	1000–1001	33	21	8	4	42[a]	27	10[a]	10[a]
VDT Work										
Monthly or Less	1422–1426	805–808	30	19	8	4	39	26	10	8
Weekly or Daily	871–878	298–299	36[a]	23	8	4	44[a]	26	9	9
Handling										
Carbonless Paper										
Monthly or Less	1160–1164	666–669	29	17	7	5	37	21	8	7
Weekly or Daily	1099–1105	424–425	36[a]	26[a]	9	4	45[a]	34[a]	12[a]	10[a]
Handling										
Carbon Paper										
Monthly or Less	1224–1230	849–852	30	18	8	4	39	25	9	8
Weekly or Daily	1068–1074	260	35[a]	27[a]	9	5	43[a]	30	10	9

[a]Difference between "Monthly or less" and "Weekly or daily" statistically significant (χ^2-test, $p < 0.05$).

Climet optic particle counter 1.1 m from the floor near a working place in the middle of the office. The counting was made over 20–30 minutes in the afternoon. Each size of particle (>0.5, >1, >5 and >10 μm) corresponding to the number in 0.14 l of air was counted every third minute.

Dust on the floor. In the study office and in an office with many daily clients, the amount of removable dust on the floor was determined by vacuum-cleaning (Hoover S-1015-011) of 12 m² of the floor during 4 minutes towards the end of a working day. The amount of organic macromolecular material per g of dust was determined as described by Løwenstein (1980).

Microorganisms. Airborne microorganisms were collected in the afternoon 1.1 m from the floor near a working place in the middle of the office using a BIAP Slit sampler. Samples were collected for determination of microfungi, bacteria, and thermophilic actinomycetes (Gravesen et al., 1985). The microfungi were identified as to genus and, in some cases, as to species. The numbers of colony-grown units, microfungi, bacteria, and actinomycetes per 30 mg of dust were determined.

Airborne fibres. Owing to errors in the first samplings, the concentration of airborne fibres was measured in the period October-December 1984. The dust was collected with a Reciprotor vacuum unit (VABI) on a membrane filter (Millipore RAWP) in a 37 mm open-faced filterholder with its opening facing upwards and examined for man-made mineral fibres (MMMF) and other fibres by optic microscopy. The sample volume — 1.7–3.4 m³ of air — was determined with a dry gasmeter (IGA-ACSMTC). The sampling was done near a working place in the middle of the office during 1–2 hours and with an air velocity of the intake of 1.25 m/s (Schneider, 1986).

Fibres sedimented on surfaces. Two special adhesive foils were pressed 4 or 8 times against the surface of a table or a shelf. The number and size distribution of MMF per cm² was determined in a polarisation microscope (× 500) with special equipment to projecting the image on a digitizer (Schneider, 1986).

Volatile organic compounds. A known volume of air was sucked in through an adsorbent. The adsorbent Tenax was employed in all buildings, charcoal in 6. The samples were collected 1.1 m from the floor during 25–50 minutes with the Tenax absorbent, during approximately 5 hours with charcoal. The adsorbed gases and vapours were analyzed with a gas-chromatograph, and the results given as the total concentration of volatile organic components, which for Tenax is based on pentadecane and for charcoal on toluene (Mølhave, 1984).

Lighting. The general room illuminance was measured with a luxmeter. An evaluation was made of the distribution of the luminance, the adequacy of working

Table 7. Prevalence of grouped symptoms (%) related to work by working hours per week and smoking habits.

	N		Irritation of the Mucous Membranes		Skin Reactions		General Symptoms		Irritability	
	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men
			(%)	(%)	(%)	(%)	(%)	%)	(%)	(%)
Working Hours per Week										
30 Hours or Less	576–581	15	27	20	6	0	33	40	6	7
More than 30 Hours	1741–1749	1087–1090	34[a]	21	9[a]	4	44[a]	26	11[a]	8
Smoking										
Non-smokers	1205–1212	542–544	31	20	8	3	37	24	10	7
Smokers	1121–1124	570–568	34	21	9	5	45[a]	28	9	9

[a]Difference between "30 hours or less" and "More than 30 hours" or "Smoker" and "Non-smoker" statistically significant (χ^2-test, $p < 0.05$).

lamps, if any, the risk of bothering reflections, both at the work tables and at displays, if any, the amount of daylight, and glare from the windows.

Noise and time of reverberation. Over 24 hours, the statistical distribution of the A-weighted sound pressure level was measured using a statistical noise analyzer and a microphone. The frequency distribution and time of reverberation were measured with a 1/3-octave-parallel-analyzer via a microphone. In town halls with mechanical ventilation systems, the frequency distribution was also measured in the empty room under different working conditions for the system.

Evaluation of materials. The building materials and the materials used for the equipment were recorded for each study office. On this basis we calculated a "fleecy" factor and a "shelf" factor, respectively, expressed as the area of all textile floorings, curtains, and seats divided by the volume of the room, and the length of all open shelves and cupboards divided by the volume of the room.

Cleaning factor. We collected data on cleaning methods, materials, frequency, and other relevant data and calculated an index of the quality of the cleaning.

Statistical methods. The Chi-square and Mann-Whitney tests were used for the statistical analyses with a level of significance of $p < 0.05$. The Spearman rank correlation coefficient was used to analyze the association between the prevalences of the various symptom groups, and between prevalence and the age of town halls.

Results

Prevalences of work-related symptoms

Among the symptoms of mucosal irritation, work-related nasal irritation was most frequently stated (men 12% and women 20%). Fatigue was the most frequently stated general symptom (men 21%, women 31%). The prevalences of work-related skin and irritability symptoms were relatively low. Generally, women had higher prevalences with significant differences as to several of the symptoms (Table 2).

Prevalences of work-related complaints

The prevalences of work-related complaints during the winter are given in Table 3. Draught, draught along the floor, changing temperature, stuffy air, and dry air were the most frequently stated complaints. The latter was stated by 52% of the women who generally had more complaints than the men.

Prevalences of symptoms in the buildings

Table 4 shows the prevalences of the work-related symptom groups for each of the 14 town halls and the 14 additional buildings. The individual symptom groups show relatively great differences between the highest and the lowest prevalence, also when only the town halls are considered. For the town halls, the correlations between the prevalences of various symptoms were calculated as the Spearman rank correlation coefficient. The correlation between mucosal irritation and general symptoms was 0.52 ($p < 0.10$) for men and 0.92 ($p < 0.001$) for women. The correlation between mucosal irritation and skin symptoms was 0.49 ($p < 0.10$) for men and 0.64 ($p < 0.05$) for women. The correlation between general symptoms and skin symptoms was 0.81 ($p < 0.001$) for men and 0.63 ($p < 0.05$) for women. The correlation between the prevalence of irritability and the prevalences of the other symptom groups was low.

The highest coefficient for the correlation between the prevalence of symptoms in men and women was found for general symptoms (0.77, $p < 0.01$). Inclusion of the additional 14 buildings, which had fewer em-

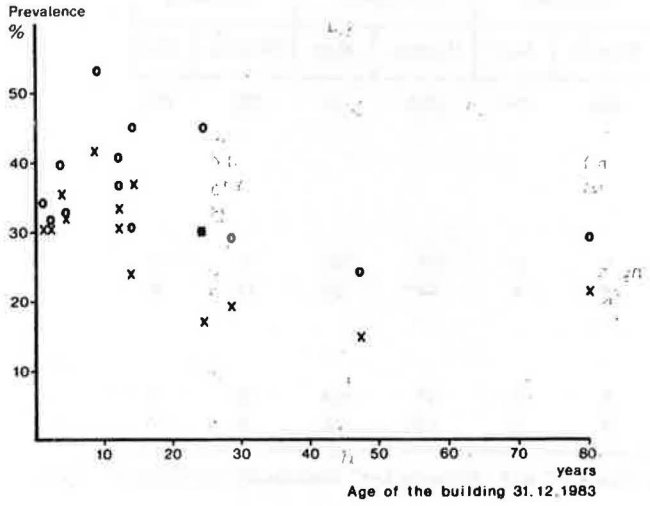

Fig. 1. Prevalence of work-related symptoms in relation to the age of the 14 town halls. × = Irritation of the mucous membranes o = General symptoms (Spearman rank correlation coefficient; $r_s = -0.65$ ($p < 0.01$) for irritation of the mucous membrane; $r_s = -0.48$ ($p < 0.08$) for general symptoms.)

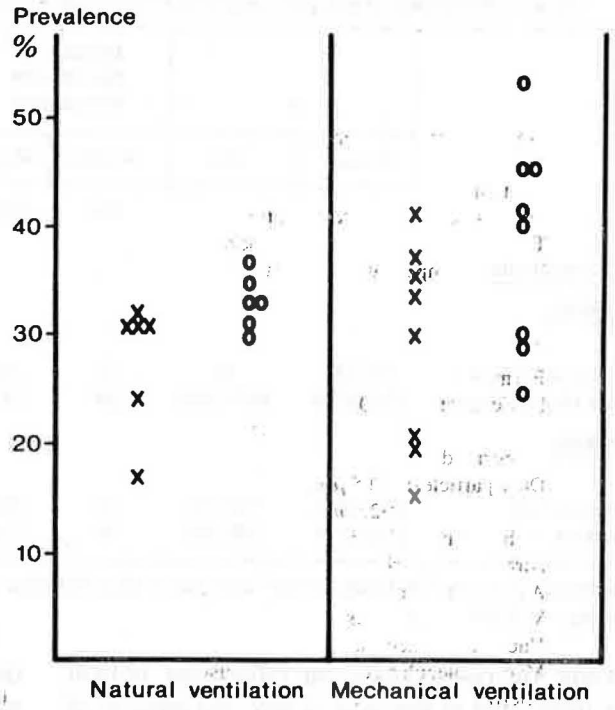

Fig. 2. Prevalence of work-related symptoms in relation to ventilation system. × = Irritation of the mucous membranes o = General symptoms (Difference between natural ventilation and mechanical ventilation $p > 0.05$, Mann-Whitney test.)

ployees and were more hetrogeneous, resulted in almost unchanged or lower correlation coefficients, except a correlation coefficient of 0.59 ($p < 0.001$) for men between the prevalence of general symptoms and of irritability.

Prevalences of symptoms in relation to population characteristics and work functions

Men under 30 years stated mucosal irritation and general symptoms more often than men in the older age groups. The same applies to the women as to general symptoms, though less markedly. Women in the age group above 49 years stated skin symptoms more often than the younger women. Apart from these findings, there were no marked differences between the age groups (Table 5).

There was no clear correlation between years of office work and prevalence of symptoms. The prevalence of mucosal irritation, though, was lowest in men with more than 29 years of office work, and that of general symptoms highest in women with 0–9 years of office work (Table 5).

The prevalences of symptoms differed considerably between men and women within the individual job category, especially for mucosal irritation and general symptoms. The lowest prevalences were stated by mayors, directors, engineers, and architects. Clerks had the highest prevalences of mucosal irritation, both for men and women. Social workers had the highest prevalence of general symptoms and irritability, both for men and women (Table 5).

As to type of office, the prevalences were highest in offices in which more than 30 persons were working (Table 5), but only 2 of the town halls and one of the other buildings had this type of office.

The prevalences of mucosal irritation and general symptoms were higher among both men and women working weekly or daily with photoprinting, video display terminals (VDT) and carbonless paper than in employees who less often used these procedures, though the difference was not very marked. As to all three procedures, the prevalence of work-related skin symptoms did not differ between persons weekly or daily exposed and persons less often exposed (Table 6). The prevalence of irritability or lack of concentration was increased in persons working with carbonless paper or photoprinting weekly or daily (Table 6).

Table 7 shows that women with more than 30 working hours per week had higher prevalences of all group of symptoms than women working less than 30 hours per week.

Female smokers had a significantly higher prevalence of general symptoms, but otherwise the prevalences did not differ much between smokers and non-smokers (Table 7).

Prevalences of symptoms in relation to age of building and type of ventilation

Even if there was a fairly good inverse correlation between age of building and the prevalence of mucosal irritation ($r_s = -0.65$) and that of general symptoms ($r_s = -0.48$); it was not always the youngest buildings that showed the highest prevalences (Fig. 1). The highest prevalences of mucosal irritation and general

Table 8. Indoor climate measurements in the 14 town halls.

		Mean	Maximum	Minimum
Mean external temperature	(24 hours) (°C)	2.4	11.4	−1.2
Sunshine hours, daily average	(hours)	2.3	6.4	0
Air temperature	(°C)	22.7	24.1	20.5
Person-weighted air temperature	(°C)	23.0	24.4	22.0
Temperature rise during a work day	(°C)	2.5	8.0	1.0
Vertical temperature gradient	(°C/m)	0.9	2.0	0.4
Air velocity	(m/s)	0.15	0.20	<0.15
Relative humidity	(%)	32	40	25
CO_2 max.	(%)	0.08	0.13	0.05
Formaldehyde	(mg/m³)	0.04	0.08	0
Static electricity: Observer	(kv)	1.4	4.8	0
Occupants max.	(kv)	1.7	4.0	0
Airborne dust	(mg/m³)	0.201	0.382	0.086
Dust particles: >0.5 μm	(1^{-1})	48×10^3	119×10^3	19×10^3
>2.0 μm	(1^{-1})	25×10^2	116×10^2	8×10^2
Airborne microfungi	(col/m³)	32	111	0
Airborne bacteria	(col/m³)	574	2100	120
Airborne actinomycetes	(col/m³)	4	15	0
Vacuum-cleaned dust[a]	(g/12 m²)	3.67	11.56	0.32
Vacuum-cleaned dust[b]	(g/12 m²)	6.14	17.04	0.66
Macromolecular content in the dust	(mg/g)	1.53	5.24	0
Microfungi in the dust[a]	(col/30 mg)	33	90	11
Microfungi in the dust[b]	(col/30 mg)	32	192	6
Bacteria in the dust[a]	(col/30 mg)	199	380	41
Bacteria in the dust[b]	(col/30 mg)	296	680	160
Man-made mineral fibres in the air (MMMF)	(f/m³)	5	60	0
Not MMMF (< 3 μl) in the air	(f/m³)	33.2×10^3	59.1×10^3	18.5×10^3
Not MMMF (> 3 μm) in the air	(f/m³)	3.1×10^3	5.0×10^3	0.7×10^3
Volatile organic compounds (charcoal)[c]	(mg/m³)	1.56	2.63	0.43
Volatile organic compounds (Tenax)[d]	(mg/m³)	0.5	1.2	0.1
A-weighted equivalent noise level, $L_{A,eq}$	(dB)	56.7	60.3	51.3
A-weighted background noise level, L_{95}	(dB)	36.2	44.1	28.2
Reverberation time	(s)	0.41	1.05	0.28

[a] In the office where all the measurements were performed.
[b] In an office with a considerable load of clients during the day.
[c] Mean of readings in 6 buildings.
[d] Mean of readings in 13 buildings, in one building we measured 32 mg/m³.

symptoms were found among mechanically ventilated buildings (Fig. 2), but no statistically significant differences could be demonstrated as to the prevalences between naturally and mechanically ventilated buildings.

Indoor climate measurements

Tables 8 and 9 give the results from the indoor climate measurements in the 14 town halls. As to the 13 of them, the measurements were carried out during February and April, as to the last one during May. The mean external 24-hour temperature at the study days varied from −1.2 to 6.5°C for the 13 town halls and was 11.4°C for the last one. These temperatures are typical of the Danish winter/spring.

The mean air temperature and the person-weighted air temperature of an approximately 20% sample of the offices ranged in most of the buildings from 20–24°C, which is the recommended temperature (NKB, 1981). Temperatures above 23°C were measured in only 4 town halls. In all rooms studied, the vertical temperature gradient was less than 3 °C/m, which is the acceptable limit (NKB, 1981). The rise in temperature during a work day was acceptable, except in the town hall studied in May, where it was 8°C. In 6 of the buildings, the air velocity was between 0.15 and 0.20 m/s, in the others less than 0.15 m/s.

The relative humidity was normal (25–30%) and corresponded to the temperature of the season. In the building with a functioning humidifier, the relative humidity was 40%.

For all town halls, the concentration of carbon dioxide was below the normally acceptable upper limit of 0.15%, exceeding 0.10% in only one of them. In all town halls, the formaldehyde concentration was far lower than the normally acceptable upper limit of 0.15 mg/m³ (Valbjørn, 1983).

In 8 town halls, the electrostatic charge of persons was above 1.5 kV, which may cause annoying discharge (Valbjørn, 1983).

The concentration of airborne dust varied between 0.086–0.382 mg/m³, mean 0.200 mg/m³, which is fairly high for offices. The numbers of airborne and dustbound colonies of microfungi, bacteria, and ac-

Table 9. Lighting factors in the 14 town halls.

General Room Illuminance (lux)	Mean	164
	Maximum	450
	Minimum	35
Glare	Not Recognizable	11 town halls
	Recognizable	3 town halls
Risk for Bothering Reflection	Low	5 town halls
	Average	7 town halls
	High	2 town halls
Use of General Room Illumination	Almost never	2 town halls
	As Required	3 town halls
	Almost Always	8 town halls

Workplace illumination and luminance were evaluated to be good in all town halls.

tinomycetes corresponded fairly well to reported values in offices (Gravesen et al., 1985; Gravesen et al., 1986), and so did the amount of vacuum-cleaned dust and organic macromolecular components in the dust (Gravesen et al., 1986).

For a single town hall the content of airborne man-made mineral fibres was 60 fibres/m^3 (95% confidence limits 13–721). For the other town halls no fibres were detected in the sample from the collecting filter examined (95% confidence limits 0–500).

Volatile organic compounds determined with the Tenax adsorbent gave low values, from 0.1–1.2 mg/m^3, except in one town hall (No. 60) (32 mg/m^3).

The noise and lighting conditions were evaluated as good.

Discussion

The epidemiology of the "sick" building symdrome is only sparingly elucidated as yet. Besides having a large study population, the present work on the prevalence of the "sick" building syndrome in office employees is the first to include measurements of a long number of indoor climate factors in relatively many buildings.

Town halls and their employees were chosen, because we wanted to examine a uniform population with equal socioeconomic status and type of work, but exposed to different indoor climate conditions. Since the town halls in Greater Copenhagen have been built concurrently with the growth of the area and, therefore, differ as to age, construction, and building materials, we considered them an ideal choice.

The questionnaire was returned by 80% of the employees in the participating town halls, and this population of office employees was found to have a high prevalence of work-related mucosal irritation (28%) and of general symptoms in the form of headache, abnormal fatigue of malaise (36%), which is in agreement with reported findings in the office environment (Valbjørn and Kousgård, 1986; Turiel et al., 1983; Finnegan et al., 1984). Women had a higher prevalence of these symptoms than men and complained more often of the quality of the indoor climate, findings that are common for several studies. Thus, in an interview study of a sample of the adult Danish population, the frequency of mucosal irritation at work was twice as high in women as in men (Valbjørn and Kousgård, 1986).

The prevalence of mucosal irritation and of general symptoms in the employees differed highly between the individual town halls.

High prevalences of health effects have previously been related to easily observable building characteristics, such as age and ventilation systems (WHO, 1983). We found the lowest prevalences of symptoms for the oldest town halls, a correlation that has not previously been elucidated in studies on the office environment.

Reported studies have shown a higher symptom prevalence in mechanically ventilated buildings than in naturally ventilated ones (Finnegan et al., 1984; Robertson et al., 1985), a finding which the present study could not directly corroborate.

The analyses performed showed that the individual town hall and job category correlated significantly with the presence of work-related mucosal irritation and general symptoms. The prevalence of symptoms differed highly within the various job categories, the highest prevalence being found for the subordinate categories.

Photoprinting, working at video display terminals, and handling carbonless paper correlated with the frequency of mucosal irritation and of general symptoms, and so did — though less markedly — the number of weekly working hours for the women. These findings agree with reported results (Knave et al., 1985; Marks et al., 1984; Taylor et al., 1984).

The many indoor climate factors determined, expressing the indoor climate conditions, resulted in values mainly at the levels normally considered acceptable from recommendations on indoor climate standards (NKB, 1981) or in values in accordance with those previously reported by Robertson et al. (1985) and Turiel et al. (1983). Both groups of authors failed

to identify one single indoor climate factor as the possible obvious explanatory cause of the high symptom prevalence in some of the buildings. However, in a single town hall (No. 60), we found a high concentration of organic gases and vapours, which may, at least partly, account for its high prevalence of irritation of the mucous membrane and general symptoms.

The correlations found, which must be interpreted with a certain caution, will be further analyzed together with other factors such as psychosocial conditions at the workplace and other occupational environment conditions.

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