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Health and Indoor Climate Complaints of 7043 Office Workers in 61 Buildings in the Netherlands

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Abstract

During the winter of 1988/1989, the relationships between the prevalence of work-related health and indoor climate complaints and a number of building, management, workplace and personal characteristics have been investigated in a study in more than 60 office buildings located throughout the Netherlands.

To collect the information, a questionnaire was prepared on health and indoor climate complaints and personal and workplace characteristics. A checklist was used to obtain information on building characteristics. More than 7000 questionnaires were completed by the regular users of the buildings investigated.

The results showed that the prevalence of symptoms was higher in air-conditioned buildings than in naturally or mechanically ventilated buildings. Some other variables were also related with most work-related complaints after adjustment for selected management, personal, workplace and job characteristics. These included gender, work satisfaction in general, presence of allergies and/or respiratory symptoms, and personal control over temperature at the workplace. No differences were found in symptom prevalences between buildings with spray and steam humidification. The combination of air-conditioning and humidification did not lead to further increases in the prevalence of complaints as compared to buildings with only air-conditioning or only humidification.

KEY WORDS:
Offices, Sick building syndrome, Health and indoor climate complaints, Epidemiology

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Introduction

During the last decade investigations from various countries have reported a high prevalence of health and indoor climate complaints among the regular users of office buildings (Burge et al., 1987; Finnegan et al., 1984; Robertson et al., 1985; Skov and Valbjørn, 1987; Turiel et al., 1983). These complaints are often referred to as the "Sick Building Syndrome", and they include irritative symptoms of eyes, nose, throat, lower airways and/or skin, and non-specific hyperreactivity, fatigue, headache and dizziness (WHO, 1983). Objective tests or a standardized questionnaire for measurement of these complaints are not available.

The type of ventilation system in particular has been reported to be related to the prevalence of complaints (Burge et al., 1987; Finnegan et al., 1984; Mendell and Smith, 1990; Robertson et al., 1985; Turiel et al., 1983). Hedge et al. (1989) found a significantly higher prevalence of complaints in air-conditioned buildings as compared to buildings with natural ventilation or mechanical ventilation without air cooling/heating. Significant associations were also found between the type of humidification and some complaints. No differences in complaint prevalence were found between buildings with natural ventilation and buildings with simple mechanical ventilation.

Mendell and Smith (1990) suggested in a re-analysis of six epidemiological studies of the "Sick Building Syndrome" conducted in the United Kingdom and Denmark that the prevalence of work-related complaints is higher in sealed, air-conditioned buildings than in naturally ventilated buildings. Mechanical ventilation without air-conditioning was not associated with a greater number of complaints. Furthermore, humidification was not a necessary factor for the higher prevalence associated with air-conditioning. No adjustments were made in this re- analysis, however, for potential confounding factors.

The background of the association between complaints and the type of ventilation system is still unclear. Potential risk factors related to the ventilation systems could be: migration of odors or chemical hazards between work areas within the building, reentrainment of exhaust from building fume hoods or through heat wheels, growth of microorganisms in the ventilation system, poor environmental control, insufficient fresh outdoor air, and heating, ventilation or cooling malfunctions (Hughes and O'Brien, 1986).

Fleecy materials (curtains, carpets), and the amount of floor dust and allergenic materials in the dust have also been found to be related to complaints in some studies (Skov et al., 1990; Nexoe et al., 1983; Norback and Torgen, 1989). Furthermore, Skov and Valbjørn (1987) suggested that gender, age, type of job, wearing of contact lenses, smoking, handling of carbonless copy paper, photo-copying, work at video display terminals, job satisfaction and health status are also related to typical "Sick Building" complaints. Some factors, such as gender, have commonly been found to affect symptom prevalence, but for others, such as the concentration of volatile organic compounds, a relationship with complaints was found in some studies only (for example, Norback et al., 1990 a + b). Hedge et al. (1989) suggested that job stress, environmental control, perceived ambient condition, perceived environmental satisfaction, sex, age, type of job, lighting control, type of organization and occupation duration are related to complaints.

Overall, the epidemiological studies conducted so far have suggested a relationship between the prevalence of complaints and the ventilation system of the building. Confounding factors, however, could affect this relationship. Buildings with mechanical ventilation systems, for example, are often also equipped with sealed windows, centralized control of heating/lighting/sunblinds, open-plan office layouts, etc. The present study was set up to examine the association between several building, ventilation, management, workplace, job and personal characteristics and the prevalence of health and indoor climate complaints, and to investigate the relative importance of these different factors in attempting to explain the "Sick Building Syndrome".

Table 1 Some characteristics of the 61 buildings studied

Variable	Category	Number of buildings
Sector	private	33
	public	28
Ventilation	natural	21
	mechanical	40
Humidification	no	36
	spray	11
	steam	14
Cooling	no	34
	yes	27
Age of building (mean and range, years)		16 (1- 98)
Number of floors (mean and range)		5 (1- 19)
Number of respondents (mean and range)		110 (16-273)

Materials and Methods

Selection of Office Buildings and Study Population

The buildings were mostly identified with the help of regional occupational or public health services. None of the buildings had recently been subjected to an investigation of this type and only some of the buildings were known in advance to have indoor climate problems. There is no database in the Netherlands that would allow a strictly random selection of office buildings. Our contact persons in the health services (most were trained occupational hygienists) were instructed to provide us with "ordinary" office buildings without specific or special problems. As the buildings were thus mostly identified through informal contacts, no meaningful response or non-response rate can be given. Buildings were selected which had at least 50 office workers. In addition, the selection was such that the buildings were spread over the country, and had different ventilation systems and different types of organisation (private/government). Table 1 shows some details of the buildings. There were two buildings with mechanical exhaust only (no mechanical supply), and these were included in the "natural ventilation" category; the prevalence of complaints in these two buildings was similar to those in the buildings with natural ventilation. The study population consisted of approximately 10,500 office workers distributed over 61 buildings (the exact number is unknown because building managers were not always able to specify the number of workers precisely; 10,500 questionnaires were distributed, which was probably somewhat more than the number of subjects eligible for the study). Non-office workers and office-workers employed for less than two months in the building were excluded.

Data Collection

To collect data on symptoms and other personal and workplace characteristics, a self-administered questionnaire was used. A checklist served to gain information on building characteristics. In addition, some indoor climate measurements were performed. The investigation was made in the period November 1988 – February 1989.

Questionnaires and checklists were distributed a few days before the site visit with the help of the building management. The investigation was completed in each building in the course of one day. The participants were asked to complete the questionnaire before or on the day of the investigation. The questionnaires could be returned either to the investigators directly on the day of the site visit, or by mail in a pre-stamped and -addressed envelope. The building service manager completed the building characteristics checklist before the day of the investigation. It was checked with him on the day of the site visit by one of the investigators. Furthermore, some indoor climate measurements were performed.

The questionnaire was based partially on questionnaires used by Skov and Valbjørn, (1987) and Burge et al. (1987). The questionnaire was pre-tested in one building before finalization. This building was not included in the study. The questionnaire included approximately 115 questions about gender, age, work-related health and indoor climate complaints, general health complaints, sickness leave, job characteristics, job satisfaction, workplace characteristics, level of education, smoking habits, etc. Work-related health questions included questions about the skin, eyes, nose/throat, nervous system and about fever. Inquiries about work-related indoor climate complaints included questions concerning temperature, humidity, perceived air quality, lighting, noise, static electricity, and organoleptic environmental quality. Appendix 1 lists the major questions. The answer categories for the various symptom and complaint frequencies were: almost daily, weekly, now and then, never. In addition, subjects were asked whether symptoms improved when at home, away from work.

The building characteristics checklist was based partially on a checklist used by Burge et al. (1987). The checklist was pre-tested in one building and was improved on the basis of the results. The checklist included questions about the type of organization, ventilation and heating installation, maintenance of installations, and characteristics of office rooms.

In every building, the CO_2 concentration was measured and in most buildings the air-temperature and the relative humidity were measured at five selected locations at four different times during the day. The noise level (during one hour) and the general and workplace luminance were also measured at these locations. The selection of the locations was based on a building blue-print, sent by the building services manager, and a walk-through survey of the building in the morning of the site visit. The locations were selected as being representative of the technical installations in the building and the working conditions in general. The locations were spread over the different floors, sites of the heating and ventilation system. Only locations where typical office work was performed were selected. The locations were continuously occupied during the day and most had a high number of office workers. Details of the methods of measurement are given in Appendix 2.

Data Analysis

Health complaints were classified as work-related when they were reported to occur daily or weekly during the last 12 months or some period thereof, and when improvement occurred when at home, away from work. Indoor climate complaints were classified as work-related when they were reported to occur daily or weekly during the last 12 months or some period thereof. Health and indoor climate complaints were grouped in 13 categories of complaints for further analysis (see Appendix 1). The grouping was based on similarity of organ system affected or similarity of environmental factor associated with the complaint. A subject was counted as a "prevalent case" for a complaint category when he or she reported one or more of the work-related complaints grouped into that category.

In a preliminary analysis, symptom and complaint prevalences were compared between categories of 67 separate, independent variables selected from the questionnaire, checklist and indoor climate measurements (results not shown). Partly on the basis of the results, 21 of the 67 variables were selected to estimate the multifactorial influence of building, workplace, job and personal characteristics on complaints, using logistic regression analysis. Other criteria for inclusion were findings from other epidemiological studies. All independent variables were classified into a limited number of categories (usually two). The 21 selected variables were: type of ventilation system (simple mechanical vs natural, simple

mechanical + air cooling vs natural, simple mechanical + humidification vs natural, simple mechanical + air cooling + spray humidification vs natural, simple mechanical + air cooling + steam humidification vs natural), gender (female vs male), age (<30 vs >40, <30 vs 30-39), contact lenses (yes vs no), smoking (yes vs no), having allergic or respiratory symptoms (yes vs no), job satisfaction (negative vs positive), number of people in room (>=10 persons in room vs <10 persons in room), VDU-work (>=4 hours/day vs <4 hours/day), personal control over temperature at workplace (no vs yes), education (high vs low, high vs medium), Environmental Tobacco Smoke exposure (yes vs no), presence of fleecy materials (yes vs no), presence of openable windows (no vs yes), handling of carbonless copy paper (more than zero per day vs zero per day).

Building characteristics were presumed to be valid for all office workers in a building. When more than one ventilation system was present in a building, the system that was valid for most office workers in the building was selected. Seven different questions were asked about job satisfaction; satisfaction was considered to be low when subjects were not satisfied with four or more of the job satisfaction items. Subjects were considered to have allergic and/or respiratory symptoms when they answered one or more of the questions on chronic respiratory symptoms and allergy to house dust, pollen or animals positively. "Fleecy" materials were considered to be present when two or three of the factors "wall-to-wall carpeting", "curtains" or "open bookshelves" were present at the workplace.

Table 2 Some characteristics of the study population, work and workplace (N = 7043)

Variable	Category	% of participants
Gender	female	65
Job category	manager	12
	professional	33
	secretarial	44
	other	11
Allergy/resp. sympt.	yes	36
Current smoking	yes	35
Education	high	33
	medium	59
	low	8
Number of persons in room	>10	30
Openable windows	yes	63
Temperature control	central	40
Sunblind control	central	68
"Fleecy" factors	yes	82

Results

Of the 10,500 questionnaires distributed, 7,043 were completed and returned (response approximately 67%). The response rate in the buildings varies from 27% to 100%. The reasons stated for non-participation were mostly: no time, dissatisfaction with work or management, perceived lack of anonymity. Table 2 gives details of the study population. The mean age was 38.9 years, with a range of 17-66 years.

In Table 3 the reported prevalence of health and indoor climate complaints is given. The most frequently reported health complaints were eye (mean 19.5%), nose/throat (mean 23.5%) and nervous sys-

Table 3 Prevalence (%) of work-related health and indoor climate complaints reported by 7043 regular users of 61 office buildings in the Netherlands.

Complaint	Mean prevalence (%)	Range over buildings
Health		
Skin	6.8	0.0-17.0
Eye	19.5	3.2-39.5
Oronasal	23.5	0.0-45.5
Nervous system	20.3	3.8-51.3
Fever	8.8	0.0-33.3
Indoor climate		
Temperature	54.6	5.9-89.3
Air quality	45.7	17.6-82.4
Lighting	30.0	8.3-53.3
Dry air	43.5	5.4-80.2
Humid air	2.4	0.0-19.3
Noise	25.1	5.4-50.0
Static electricity	10.5	0.0-35.5
Organoleptic environmental quality	7.2	0.0-20.5

"Work-related" in the context of this paper means that subjects explicitly mentioned that their complaints decreased or disappeared when at home, away from work.

Table 4 Results of indoor climate measurements in 61 office buildings in the Netherlands.

Variable[a]	Mean	Range	No. of measurements[b]
CO_2 (ppm)	730	485-1,329	1,194
L_{eq} (dB(A))	62	56-69	193
E room (lux)	745	320-1,340	228
E workplace (lux)	621	150-1,120	228
Temperature (°C)	21.5	17.9-24.9	1,091
Relative humidity (%)	37.0	23.7-52.5	1,109

[a] CO_2 = carbon dioxide, Leq = Noise level, E = Luminance, T = temperature, RH = relative humidity.
[b] L_{eq} was measured in 40 buildings, E in 48 buildings, T in 55 buildings, RV in 56 buildings, CO_2 in 61 buildings.

Table 5 Prevalence (%) of non-specific health symptoms and discomfort in a population of Dutch office workers.

Symptom/discomfort	Air handling system					
	Natural n = 2280	Mechanical n = 729	Air cooling n = 526	Humidification n = 599	Cooling + spray hum. n = 1566	Cooling + steam hum. n = 1293
Skin symptoms	4.2	4.3	8.2	8.7	9.3	8.6
Eye symptoms	12.8	13.8	23.4	17.2	24.8	26.2
Oronasal symptoms	12.3	16.0	20.2	23.2	26.3	28.1
Nervous system symptoms	13.6	21.9	27.9	24.1	30.7	27.6
Fever symptoms	4.7	9.0	8.6	10.1	13.0	10.2
Temperature complaints	43.8	50.3	56.9	54.1	67.2	60.4
Lighting complaints	26.5	31.7	34.4	30.6	30.6	32.7
Air quality complaints	40.9	39.5	51.9	49.4	49.5	49.2
Dry air complaints	33.5	38.1	48.3	49.6	51.3	49.9
Noise complaints	23.0	23.1	31.7	20.6	27.7	26.4
Static electricity complaints	7.0	14.1	13.2	16.0	13.1	7.9
Organoleptic environmental quality complaints	4.3	6.9	8.9	7.0	9.8	8.8

tem complaints (mean 20.3%). The most frequent indoor climate complaints were temperature (mean 54.6%), dry air (mean 43.5%) and air quality complaints (mean 45.7%). There was a considerable variation between the reported prevalence of different complaints within buildings, and the reported prevalences for the same complaints between buildings.

Table 4 shows the results of indoor climate measurements in the 61 buildings. During the measurement period, the outdoor temperature varied from -5 °C to 15 °C, and the external relative air humidity was not lower than 50%. The measurements of CO_2 concentration showed that the variation between the buildings was high. In 8 buildings, the mean of the highest CO_2 concentrations measured in each workplace was greater than 1000 ppm. Of these 8 buildings, 7 had natural or simple mechanical ventilation. In 6 buildings a mean relative humidity lower than 30% was measured. The mean air temperature in the buildings varied from 17.9 °C to 24.9 °C. The variation of luminance within and between buildings was high. High lighting levels were mostly caused by direct sunlight in the offices. The mean general luminance was over 1000 lux in 7 buildings and 2 buildings had a mean workplace luminance of over 1000 lux. ISO (1989) recommends for general and deep-plan offices a luminance varying from 300-1000 lux. All buildings used fluorescent lighting for the offices, and 22 buildings used fluorescent lighting with a colour rendering index < 80. The noise level (L_{eq}) in the offices was fairly high, varying from 56 to 69 dB(a). The recommended limit for the noise level in offices is < 60 dB(A) in the Netherlands. Overall, the indoor climate measurements in the buildings showed no extreme conditions. Relationships between indoor climate variables and complaints were generally weak and inconsistent. The prevalence of complaints was somewhat lower when CO_2 was higher, due to the finding that CO_2 was higher in naturally ventilated buildings than in air-conditioned buildings.

Relationships between Health and Indoor Climate Complaints and Building, Workplace, Job and Personal Characteristics

Table 5 shows the prevalence of work-related complaints in buildings for different types of ventilation system. Table 6 shows the adjusted odds ratios with type of air-handling system relative to naturally ventilated buildings. Multiple logistic regression analysis was performed to examine the association between complaints and the type of ventilation system after adjustment for various building, management, workplace, job and personal characteristics which may have confounded the association between the complaint prevalence and the type of ventilation system in the building. From these tables it is clear that the complaint prevalence in buildings with natural ventilation is somewhat lower than in buildings with simple mechanical ventilation, except for skin, air quality and noise complaints. The complaint prevalence in buildings with air cooling only or humidification only is higher than in buildings

Table 6 Adjusted[a] association between air handling system and non-specific health symptoms and discomfort in a population of Dutch office workers.

Symptom/discomfort	Adjusted[a] odds ratio (95% confidence limits) with air handling system, relative to naturally ventilated buildings				
	Mechanical	Air cooling	Humidification	Cooling + spray hum.	Cooling + steam hum.
Skin symptoms	0.87 (0.51-1.47)	1.61 (1.01-2.56)*	2.18 (1.44-3.30)***	1.73 (1.09-2.74)*	1.75 (1.19-2.59)***
Eye symptoms	1.13 (0.83-1.52)	1.66 (1.24-2.22)***	1.32 (0.99-1.77)#	1.68 (1.25-2.25)***	1.77 (1.38-2.27)***
Oronasal symptoms	1.07 (0.79-1.46)	1.65 (1.22-2.24)**	2.07 (1.58-2.72)***	1.69 (1.26-2.26)***	2.22 (1.74-2.82)***
Nervous system symptoms	1.35 (1.03-1.75)*	1.62 (1.23-2.14)***	1.54 (1.19-2.00)**	1.80 (1.37-2.37)***	1.37 (1.08-1.74)*
Fever symptoms	1.59 (1.04-2.45)*	1.73 (1.12-2.69)*	2.02 (1.34-3.05)***	2.24 (1.47-3.43)***	1.78 (1.23-2.58)**
Temperature complaints	1.04 (0.83-1.30)	1.41 (1.10-1.81)**	1.26 (1.00-1.58)*	1.47 (1.15-1.88)**	1.21 (0.99-1.49)#
Lighting complaints	1.27 (1.01-1.60)*	1.08 (0.83-1.39)	1.08 (0.85-1.37)	0.95 (0.74-1.23)	0.99 (0.80-1.23)
Air quality complaints	0.70 (0.55-0.87)**	1.11 (0.87-1.41)	1.15 (0.92-1.44)	0.89 (0.70-1.13)	0.89 (0.72-1.10)
Dry air complaints	0.98 (0.78-1.23)	1.60 (1.25-2.03)***	1.75 (1.40-2.19)***	1.40 (1.10-1.77)**	1.36 (1.11-1.67)**
Noise complaints	1.02 (0.80-1.31)	1.38 (1.06-1.79)*	0.81 (0.62-1.06)	0.85 (0.65 – 1.11)	0.80 (0.63-1.01)#
Static electricity complaints	2.35 (1.70-3.25)***	1.93 (1.34-2.77)***	2.67 (1.93-3.68)***	2.14 (1.46-3.14)***	0.99 (0.69-1.42)
Organoleptic environmental quality complaints	1.29 (0.82-2.02)	1.46 (0.93-2.30)	1.48 (0.95-2.30)#	1.64 (1.04-2.59)*	1.53 (1.03-2.25)*

a. Adjusted for gender, age, educational level, wearing of contact lenses, active smoking, passive smoking, reported allergic or respiratory symptoms, job satisfaction, number of people in the room, presence of "fleecy" material, hours of VDU work, handling of carbonless copy paper, personal control over temperature, presence of openable windows at the workplace.
# p < 0.10 *p < 0.05 **p < 0.01 ***p < 0.001.

with natural or simple mechanical ventilation, except for noise complaints. The complaint prevalence in buildings with air conditioning and humidification (spray or steam) is, except for the prevalence of oronasal and fever complaints, no higher than in buildings with air cooling only or humidification only.

Table 7 shows the adjusted odds ratios for relationships between complaints and personal and job characteristics. Being dissatisfied with the job, having allergic or respiratory symptoms or having no personal control over temperature at the workplace were associated with an increased prevalence of nearly all health and indoor climate complaints. Environmental Tobacco Smoke (ETS) exposure was associated with an increased reporting of complaints about air quality and organoleptic environmental quality, and with eye, oronasal and nervous system symptoms. When office workers performed VDU work more than half of their time they reported more eye, nervous system, lighting and static electricity complaints. The number of people in one's room was associated significantly with more oronasal, nervous system, temperature, air quality and dry air complaints. The presence of openable windows was associated significantly with fewer skin, temperature and noise complaints. There were no clear relationships between the prevalence of complaints and age, education, active smoking, the presence of fleecy materials (carpets, curtains or open shelves) and the handling of carbonless copy paper.

Some buildings had low response rates on the questionnaire. Exclusion of buildings with response rates under 50% or under 60% did not affect the findings.

Discussion

The results of this study show that the prevalence of health and indoor climate complaints in offices is associated with several building, ventilation, management, workplace, job and personal characteristics. Within categories of certain ventilation systems, a distinct variation in the prevalence of reported complaints was observed between office buildings. This suggests that ventilation systems function better in some buildings than in others; however, other factors could also be responsible for this observed variation.

The multivariate analysis showed that being female, being dissatisfied with the job or having allergies and/or respiratory symptoms was associated

Table 7 *Adjusted association between personal, workplace and job characteristics and non-specific health symptoms and discomfort in a population of Dutch office workers*

Symptom/discomfort	Adjusted[a] odds ratio (95% confidence limits) with personal, workplace and job characteristics.				
	ETS exposure	Allergic or respiratory symptoms	Low job satisfaction	No.of people in room	Presence of "fleecy" material
Skin symptoms	1.01 (0.73-1.41)	1.64 (1.31-2.05)***	1.65 (1.32-2.06)***	1.01 (0.77-1.31)	0.89 (0.70-1.12)
Eye symptoms	1.29 (1.05-1.60)*	1.73 (1.49-2.00)***	1.66 (1.44-1.92)***	1.14 (0.96-1.35)	1.11 (0.96-1.29)
Oronasal symptoms	1.26 (1.02-1.55)*	1.93 (1.68-2.23)***	1.49 (1.29-1.72)***	1.23 (1.04-1.46)*	1.00 (0.86-1.16)
Nervous system symptoms	1.27 (1.04-1.54)*	1.60 (1.40-1.84)***	2.46 (2.15-2.82)***	1.33 (1.13-1.57)**	1.01 (0.87-1.16)
Fever symptoms	1.15 (0.84-1.58)	1.65 (1.34-2.02)***	2.07 (1.69-2.53)***	1.00 (0.79-1.21)	0.98 (0.79-1.21)
Temperature complaints	1.40 (1.19-1.64)***	1.50 (1.32-1.70)***	1.59 (1.40-1.80)***	1.35 (1.16-1.58)***	1.13 (1.00-1.58)#
Lighting complaints	1.24 (1.04-1.48)*	1.46 (1.29-1.66)***	1.76 (1.55-1.99)***	1.02 (0.87-1.19)	1.09 (0.95-1.24)
Air quality complaints	2.72 (2.32-3.18)***	1.63 (1.44-1.84)***	1.66 (1.47-1.88)***	1.58 (1.36-1.83)***	1.05 (0.93-1.19)
Dry air complaints	1.32 (1.12-1.56)***	1.61 (1.43-1.82)***	1.50 (1.33-1.70)***	1.38 (1.19-1.60)***	1.09 (0.96-1.23)
Noise complaints	1.09 (0.91-1.30)	1.21 (1.06-1.39)**	2.33 (2.05-2.66)***	1.17 (1.00-1.38)#	0.84 (0.74-0.97)*
Static electricity complaints	1.48 (1.13-1.93)**	1.43 (1.19-1.72)***	1.49 (1.25-1.79)***	0.89 (0.71-1.10)	1.11 (0.92-1.35)
Organoleptic environmental quality complaints	2.47 (1.68-3.62)***	2.14 (1.71-2.67)***	2.02 (1.62-2.51)***	0.89 (0.69-1.16)	1.00 (0.80-1.26)

[a]Adjusted for gender, age, educational level, wearing of contact lenses, active smoking, air handling system and other variables in the table.
# p < 0.10 *p < 0.05 **p < 0.01 ***p < 0.001.

Table 7 (continued) Adjusted association between personal, workplace and job characteristics and non-specific health symptoms and discomfort in a population of Dutch office workers

Symptom/discomfort	Adjusted[a] odds ratio (95% confidence limits) with personal, workplace and job characteristics.			
	VDU work	Handling of carbonless copy paper	No personal control over temperature at workplace	Absence of openable windows
Skin symptoms	1.11 (0.96-1.28)	0.96 (0.83-1.12)	1.70 (1.49-1.95)***	1.24 (1.03-1.49)*
Eye symptoms	1.87 (1.59-2.19)***	1.13 (0.96-1.33)	1.46 (1.23-1.74)***	1.04 (0.84-1.29)
Oronasal symptoms	1.04 (0.88-1.23)	1.18 (1.00-1.39)#	1.34 (1.13-1.59)***	1.12 (0.90-1.38)
Nervous system symptoms	1.38 (1.17-1.62)***	1.09 (0.93-1.28)	1.32 (1.13-1.55)***	1.09 (0.89-1.34)
Fever symptoms	1.58 (1.26-1.98)***	1.22 (0.97-1.54)#	2.00 (1.53-2.61)***	0.98 (0.72-1.33)
Temperature complaints	1.11 (0.96-1.28)	0.96 (0.83-1.12)	1.70 (1.49-1.95)***	1.24 (1.03-1.49)*
Lighting complaints	1.89 (1.64-2.18)***	1.30 (1.12-1.51)***	1.27 (1.10-1.47)**	1.10 (0.90-1.33)
Air quality complaints	1.19 (1.03-1.36)*	1.21 (1.05-1.40)**	1.19 (1.04-1.36)*	1.08 (0.90-1.30)
Dry air complaints	1.11 (0.96-1.27)	1.10 (0.95-1.27)	1.48 (1.29-1.69)***	1.04 (0.87-1.24)
Noise complaints	1.25 (1.07-1.46)**	0.95 (0.81-1.11)	1.29 (1.11-1.50)**	1.57 (1.29-1.92)***
Static electricity complaints	1.44 (1.17-1.77)***	0.99 (0.80-1.23)	1.24 (1.00-1.54)*	0.88 (0.66-1.17)
Organoleptic environmental quality complaints	1.40 (1.09-1.79)**	1.48 (1.15-1.89)**	1.38 (1.05-1.81)*	1.01 (0.73-1.41)

[a]Adjusted for gender, age, educational level, wearing of contact lenses, active smoking, air handling system and other variables in the table.
# p < 0.10 *p < 0.05 **p < 0.01 ***p < 0.001.

with an increased prevalence of nearly all complaints, as reported earlier by Skov et al. (1989). It should be noted that the effect of gender could be due to uninvestigated job characteristics. Subjects with allergies and/or chronic respiratory symptoms could be more sensitive to several indoor climate or other factors inducing a higher prevalence of complaints. Dissatisfaction with the job had a stronger relation with the nervous system complaints than with skin, eye or nose/throat complaints. As reported by Skov et al. (1989), we also found that respondents performing VDU work had a higher prevalence of some health complaints. This study also showed that active smoking was not associated with the health complaints that were investigated. ETS exposure was associated significantly with air quality complaints, organoleptic environmental quality complaints and also with eye, oronasal and nervous system complaints. Others have not found consistent associations between ETS exposure complaints (Sterling et al., 1987). Burge et al. (1987) and Skov et al. (1989) both found that the job category was associated with the prevalence of complaints. Instead of job category, the level of education was used in our study. It was not found to be associated with the prevalence of complaints.

This study also suggests that personal control over workplace temperature is associated significantly with a lower prevalence of all health and indoor climate complaints. The presence of openable windows near the workplace, however, was associated significantly only with a lower prevalence of skin, temperature and noise complaints.

The presence of "fleecy" factors close to the office worker such as wall-to-wall carpeting, curtains, or open bookshelves was not associated with health or indoor climate complaints, which contrasts with the findings of Skov et al. (1990). In our study, fleecy factors were present for 82% of the office workers, so that the power of the analysis was limited. We also did not adjust for the volume of the room, as was done by Skov et al. (1990).

There was little association between the results of the indoor climate measurements and complaints. There was an inverse relationship between indoor CO_2 levels and complaints, due to the fact that CO_2 levels were highest in the naturally ventilated buildings which had the lowest complaint rates for other reasons. In no building were CO_2 levels reached that are considered excessive (all values less than 1,500 ppm). The relationships between the results of the indoor climate measurements and the various complaints were not further analyzed in multivariate models. The measurements were not performed in all buildings, and they were conducted on one day only, which limits their value as indicators of long-term exposure. The noise levels in this study were somewhat higher than the noise levels found by Skov et al. (1987). This was probably due to the fact that we selected locations with a relatively high number of occupants. No extreme values in indoor climate were found in the buildings, even in buildings with a very high number of complaints. This suggests that in the buildings investigated, other factors than common indices of indoor climate were responsible for the observed variation in the prevalence of health and indoor climate complaints.

Our study can be compared to the Town Hall study from Denmark (Skov et al., 1987) and the Office Environment study from the UK (Burge et al., 1987) in some respects. In these studies, different definitions of work-related complaints and different complaint groupings were used. In general, however, our study findings are in line with the findings from Denmark and the UK.

It could be argued that adjustment for reported allergies and job (dis)satisfaction could have weakened the relationships between work-related complaints and exposure factors, when allergies and job (dis)satisfaction are influenced by these very exposure factors. However, comparison of the adjusted analysis with the results from the unadjusted analysis suggested that there were no clear indications of this type of over-adjustment in our data.

Intervention studies and more detailed assessment of specific exposure factors are needed to confirm the relationship between complaints found in this study and other studies, and to learn more about the etiology of the "Sick Building Syndrome".

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Appendix 1

Questions about Health and Indoor Climate Complaints

A. Health Complaint Questions

1a. During the last 12 months (or some part thereof), did you suffer at work from an itchy or prickly skin?
1b. Do these complaints usually diminish or disappear when at home?
2a. During ... itchy, prickly or teary eyes?
2b. Do these ... home?
3a/b. ... weary eyes?
4a/b. ... congested or runny nose?
5a/b. ... dry throat?
6a/b. ... sore throat?
7a/b. ... dry skin?
8a/b. ... skin rash?
9a/b. ... shivering?
10a/b. ... mucle or joint aches not caused by sport?
11a/b. ... tiredness?
12a/b. ... headache?
13a/b. ... heavy feeling in the head?
14a/b. ... lethargy?
15a/b. ... dizziness?
16a/b. ... concentration problems?
17a/b. ... forgetfulness?
18a/b. ... irritability?

B. Indoor Climate Complaint Questions

19. During the last 12 months (or some part thereof), did you suffer at work from:

a. draught?
b. cold feet?
c. cold hands?
d. temperature changes?
e. too high temperature?
f. too low temperature?
g. stale air?
h. humid air?
i. unpleasant odors?
j. dry air?
k. dusty air?
l. inconvenient sunlight?
m. disturbing sounds?
n. disturbing shadows?
o. insufficient daylight?
p. insufficient lighting?
q. too much lighting?
r. flickering lights?
s. annoying reflections on table or paper?
t. reflections on computer screen?
u. tobacco smoke?
v. static electricity?
w. a bad taste in the mouth?

Health and Indoor Climate Complaint Groupings:

Health Complaints:

dry skin skin rash itchy or prickly skin	skin complaints
weary eyes itchy, prickly or teary eyes	eye complaints
congested or runny nose dry throat sore throat	oronasal complaints
fatigue headache heavy feeling in the head lethargy dizziness problems with concentration forgetfulness irritability	nervous system complaints
shivering muscle or joint pain not caused by sports	fever complaints

Indoor Climate Complaints:

draught cold feet cold hands changes in temperature too high temperature too low temperature	temperature complaints
stale air unpleasant odor dusty air tobacco smoke	air quality complaints
inconvenient sunlight disturbing shadows insufficient daylight insufficient lighting too much lighting flickering lighting reflections on table or paper reflections on VDU-screen	lighting complaints
dry air	dry air complaints
humid air	humid air complaints
noise	noise complaints
static electricity	static electricity complaints
bad taste in the mouth	organoleptic environmental quality

Appendix 2

Methods of Measurement of CO_2, Temperature, Humidity, Luminance and Noise Level

Carbon dioxide: Air samples were collected 1.1 m above the floor with air bags (Tecobag, Tesseraux container GmbH) and pumps (Metal bellows Co., MB-21E). The samples were analyzed with a gas-chromatograph (HP5710, 1/8 inch sst 2m. chromosorb 102, Ni katalyzer). Before sampling, the bags were flushed with air from the room. Ten per cent of the measurements were made in duplicate.

The coefficient of variation of CO2-duplicate measurements was 8.8%.

Air temperature, relative humidity: short-term measurements of air temperature and relative humidity were performed 1.1 m above the floor (Solomat MPM 2000, Vaissala HM11).

Luminance: the general and workplace luminance were measured with a Hagner S2 measuring device.

Noise level: L_1, L_5, L_{50}, L_{90}, L_{95}, L_{99}, L_{eq} were measured 1.1 m above the floor using a Noise Level Analyzer (B&K, type 4426).