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Workplace air-conditioning and health services attendance among French middle-aged women: a prospective cohort study

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Objectives To assess the relationship between type of ventilation in the workplace, health services attendance, and sickness absence among middle-aged women.

Methods In a national sample of 920 professionally active women aged 49–65 yr from the SU.VI.MAX cohort, recruited from the general population in France, health services attendance and sickness absence were assessed prospectively during 1999.

Results Being exposed to heating, ventilation, and air-conditioning (HVAC) systems in the workplace proved to be a risk factor for attendance at global and several specialist medical services. The adjusted odds ratio for otorhinolaryngologist attendance was 2.33 (95% CI = 1.35–4.04) in the HVAC group compared with the natural ventilation group, and 1.70 (1.13–2.58) for sickness absence. Dermatologist and global medical services attendance rates may also be higher in this group ($P = 0.06$ in both cases).

Conclusions Exposure to HVAC systems was a strong and significant risk factor for otorhinolaryngologist attendance and sickness absence. HVAC systems are prevalent in recent office buildings and have been shown to be associated with several adverse health effects in terms of morbidity and mortality. From a public-health perspective, our results outline the need for a quantitative assessment of the health impact of ventilation systems, taking into account the possible loss of production that exists in addition to the direct costs of medical services use.

Keywords Epidemiology, air-conditioning systems, women's health, medical attendance, sickness absence

Heating, ventilation, and air-conditioning (HVAC) systems are increasingly prevalent in new or renovated professional settings. Their advantage is energy efficiency. They are also advertised as increasing productivity through improvement of workers' comfort in hot weather. From a medical point of view, they may help to prevent heat-related illness in weakened subjects.

On the other hand, they are involved in several well-defined building-related illnesses,[1] such as legionnaires' disease, caused by the spread of specific pathogens, allergens, or irritants. They are also likely to play a major role in the poorly defined sick building syndrome (SBS). Many studies have considered possible causes and preventive measures for SBS,[1–18] yet no attempt has been made to assess the overall health effects and economic impact of air-conditioning use in professional buildings.

This study of workplace exposure to HVAC, compared with natural ventilation (NV), among middle-aged women aimed to investigate its impact on such aspects of health services attendance as the rates of medical attendance, hospital stay, and sickness absence during 1999.

Materials and methods

Participants

Subjects were participants in the SU.VI.MAX study, which is a controlled trial aiming to assess the preventive effect of

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antioxidant nutrients on the incidence of cancer and cardiovascular disease. The study's design and participant characteristics have been published elsewhere.[19,20] Complete data were available for 920 women, scattered across the whole French territory and professionally active throughout 1999.

Outcomes

Health services attendance was routinely measured in SU.VI.MAX via a monthly paper or electronic questionnaire in which participants reported all health events that had occurred in the preceding month, along with health care use. General and specialized (otorhinolaryngologist, ophthalmologist, pneumologist, and dermatologist) medical attendance, sickness absence, and hospital stays were extracted from these reports and codified by medical doctors.

The type of ventilation (HVAC or NV) in their workplace was ascertained in January 1999 through a paper questionnaire directly addressed to each participant with the following question: 'Is air-conditioning in use in your workplace?'.

Table 1 Baseline characteristics of participants

	HVAC (n = 139)	NV (n = 781)
Age [mean (SD), yr]	53.0 (13.4)	54.9 (4.2)
Menopause (%)	69.9	70.7
Education level (%)		
Elementary school	12.7	17.3
Secondary school	54.5	45.6
University or equivalent	32.8	37.1
Occupation (%)		
Self-employed	5.0	6.2
Managers, intermediate	64.8	68.2
Employees, labourers	30.2	25.6
Smoking status (%)		
Never	60.2	46
Former	29.2	37.4
Current	10.6	16.6

Statistical methods

The effect of type of ventilation on global medical and general practitioner attendance was tested by analysis of covariance of the log-transformed count of visits. The effect on less frequent events (specialist medical attendance, hospital stays, sickness absence) was tested by logistic regression analysis modelling the probability of one or more yearly occurrence. All tests were adjusted for age and current smoking.

Results

HVAC systems were in use in the workplaces of 15.1% of participants. Baseline characteristics of the sample, according to the type of workplace ventilation, are shown in Table 1. The annual global medical attendance rate was slightly higher in the HVAC group than in the NV group (4.67 vs 4.01, P = 0.06) (Table 2). A similar trend was observed for annual dermatologist attendance rates (P = 0.06). A significantly higher risk of otorhinolaryngologist attendance (odds ratio = 2.33, 95%

Table 2 Risk of one or more yearly medical attendance, hospital stay, or sickness absence according to type of workplace ventilation

	Group	Percentage of subjects	Geometric mean (95% CI)	Odds ratio (95% CI)	P
Medical attendance					
Otorhinolaryngology	NV	7.6	1.07 (1.05–1.09)		
	HVAC	15.1	1.14 (1.08–1.21)	2.33 (1.35–4.04)	0.002[a]
Ophthalmology	NV	16.3	1.14 (1.12–1.17)		
	HVAC	19.4	1.18 (1.11–1.26)	1.32 (0.83–2.11)	0.24[a]
Pneumology	NV	1.5	1.01 (1.02–1.00)		
	HVAC	2.9	1.01 (1.02–0.99)	2.10 (0.65–6.82)	0.21[a]
Dermatology	NV	11.8	1.11 (1.08–1.13)		
	HVAC	17.3	1.15 (1.09–1.21)	1.61 (0.98–2.65)	0.06[a]
General practice	NV	72.6	2.58 (2.45–2.72)		
	HVAC	72.7	2.89 (2.52–3.30)	0.99 (0.65–1.48)	0.11[b]
All	NV	85.7	4.01 (3.78–4.25)		
	HVAC	88.5	4.67 (4.06–5.37)	1.18 (0.67–2.07)	0.06[b]
Hospital stay	NV	12.4	1.21 (1.16–1.26)		
	HVAC	18.0	1.26 (1.14–1.38)	1.51 (0.92–2.45)	0.10[a]
Sickness absence	NV	18.1	1.51 (1.40–1.61)		
	HVAC	30.2	2.08 (1.68–2.58)	1.70 (1.13–2.58)	0.01[a]

[a] Derived from logistic regression analyses adjusting for age and current smoking.

[b] Derived from analysis of covariance of the log-transformed count of visits adjusting for age and current smoking.

CI = 1.35–4.04) and sickness absence (odds ratio = 1.70, 95% CI = 1.13–2.58) was observed in the HVAC group compared with the NV group. HVAC also appeared to be substantially, although non-significantly, related to global medical attendance, dermatologist attendance, and hospital stays. These figures were not modified by adjustment for other potential confounding factors such as geographic area or occupation.

Discussion

Exposure to HVAC systems was a strong and significant risk factor for otorhinolaryngologist attendance and sickness absence. Given the limitations of the study sample (women only, narrow age range, low and unbalanced sample size) and the crudeness of the information about ventilation type, these results should be regarded as preliminary. They could be affected by bias caused by misclassification of ventilation type leading to underestimation of HVAC effects. On the other hand, overestimation bias could be caused by over-reporting in the HVAC group. Such a bias appears unlikely, however, since the health impact of air-conditioning is not a generally debated issue in France. In addition, in the SU.VI.MAX study, health services use was routinely measured before and after the ventilation questionnaire. The possibilty of a connection between these two sets of information was not explicitly mentioned to participants.

Despite its drawbacks, this work is, to our knowledge, the first description of a link between ventilation type and health care indicators. Several works have shown higher rates of upper respiratory tract, eye, or skin symptoms in air-conditioned offices, as well as non-specific symptoms (e.g. headache, lethargy).[2,4,6–8,10–12,14,21] These findings are consistent with higher rates of medical attendance (Table 2), and workplace discomfort might also account for a higher rate of sickness absence.

In conclusion, these results outline the need for quantitative knowledge of the health impact of ventilation systems, and its economic corollary, in order to assist in the decision-making of office building designers and issuers of guidelines, as recommended in a recent WHO report.[22] In temperate areas, characterized by mild winters and cool summers, the benefits yielded by HVAC energy efficiency and alleged productivity gains might be outweighed by losses resulting from sickness absence and SBS-related discomfort. In more varied climates, these results could stimulate research into ventilation-related health.[23]

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KEY MESSAGES

- Sick building syndrome (SBS), including eye, skin, and upper airway irritation, headache, and fatigue, is common in the general population and especially among women.
- SBS is known to be associated with exposure to heating, ventilation, and air-conditioning (HVAC) systems, which are often present in modern offices.
- No studies have assessed the health–economic burden of exposure to HVAC systems in the workplace among women from the general population.
- Exposure to HVAC systems in the workplace is a strong and significant risk factor for otorhinolaryngologist attendance and sickness absence in middle-aged women. HVAC is also substantially, although non-significantly, related to global medical services attendance and dermatologist attendance.
- It may be important to assess the economic health impact of ventilation systems in future studies because of the possible loss of production that exists in addition to the direct costs of medical services use.

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Commentary: Air conditioning as a risk for increased use of health services

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Background

Occupants of office buildings with air conditioning (AC) systems (e.g. central ventilation with cooling of air) consistently report, on average, more symptoms in their buildings than do occupants of buildings with natural ventilation. This has been the finding in individual studies from many studies over the last 20 years, and in three reviews.[1–3] The symptoms in these studies have included mucous membrane irritation, breathing difficulties, irritated skin, and constitutional/neurological symptoms such as headache and fatigue. This set of non-specific symptoms, often referred to as building-related symptoms or sick building syndrome, has not been linked to specific known diseases. The association of AC with increased symptoms has received little recognition outside the world of indoor environmental research. This may be because the health outcomes studied have been subjectively assessed and limited to acute, non-specific symptoms, and because specific environmental exposures have still not been clearly implicated as the causal factors.

Available evidence, although not conclusive, suggests that this pattern is not due to an association of AC systems to either less outdoor air ventilation, poorer thermal control, or lack of openable windows.[3] An explanation is that ventilation systems in buildings, especially those with AC systems or humidification systems, disseminate contaminants into the indoor air. What these contaminants might be, and through what biological response mechanisms they cause a constellation of non-specific symptoms, is not yet clear.

A more likely explanation is that the moisture in AC and humidification systems results in microbiological exposures that cause health effects through mechanisms that are irritant, toxic, or allergic. Very substantial evidence now exists that the presence of visible moisture and mould in many kinds of buildings (associated with condensation, leaks, floods, or other moisture incursions into the interior or envelopes of buildings) is consistently associated with increased risk of respiratory symptoms and asthma.[4–7] It is only recently, however, that researchers have linked specific metrics of exposure to microbiological materials of various kinds in indoor air and dust (e.g. endotoxin[8] and beta-1–3-glucans[9,10]) with increased health risks; the metrics used historically for measuring exposures to