ORIGINAL ARTICLE

Office work exposures and respiratory and sick building syndrome symptoms

Maritta S Jaakkola, Liyan Yang, Antonia Ieromnimon, Jouni J K Jaakkola

Occup Environ Med 2007;**64**:178–184. doi: 10.1136/oem.2005.024596

For Appendix see <http://oem.bmjournals.com/supplemental>

See end of article for authors' affiliations

Correspondence to:
Dr M S Jaakkola, Institute of
Occupational and
Environmental Medicine,
University of Birmingham,
Edgbaston, Birmingham,
B15 2TT UK;
M.Jaakkola@bham.ac.uk

Accepted
22 September 2006

Objectives: To assess the relation between exposure to carbonless copy paper (CCP), paper dust, and fumes from photocopiers and printers (FPP), and the occurrence of sick building syndrome (SBS)-related symptoms, chronic respiratory symptoms and respiratory infections.

Methods: A population-based cross-sectional study with a random sample of 1016 adults, 21–63 years old, living in Pirkanmaa District in South Finland was conducted. This study focused on 342 office workers classified as professionals, clerks or administrative personnel according to their current occupation by the International Standard Classification of Occupations-88. They answered a questionnaire about personal information, health, smoking, occupation, and exposures in the work environment and at home.

Results: In logistic regression analyses adjusting for age, sex and a set of other confounders, all three exposures were related to a significantly increased risk of general symptoms (headache and fatigue). Exposure to paper dust and to FPP was associated with upper respiratory and skin symptoms, breathlessness, tonsillitis and middle ear infections. Exposure to CCP increased the risk of eye symptoms, chronic bronchitis and breathlessness. It was also associated with increased occurrence of sinus and middle ear infections and diarrhoea. A dose-response relations was observed between the number of exposures and occurrence of headache. The risk of tonsillitis and sinus infections also increased with increasing number of exposures. All chronic respiratory symptoms, apart from cough, were increased in the highest exposure category (including all three exposures).

Conclusions: This study provides new evidence that exposure to paper dust and to FPP is related to the risk of SBS symptoms, breathlessness and upper respiratory infections. It strengthens the evidence that exposure to CCP increases the risk of eye symptoms, general symptoms, chronic respiratory symptoms and some respiratory infections. Reduction of these exposures could improve the health of office workers.

The nature of work has been in a phase of change, especially in Western countries, and today a large proportion of the workforce works indoors in office environments. This trend is likely to continue in the future, and exposures in the office environment influence the health, well-being and productivity of more and more employees. Some case reports and a few studies have suggested that some common office environment exposures, such as exposure to carbonless copy paper (CCP)^{1–6} and fumes from photocopiers and printers (FPP) affect health adversely,^{4–9} whereas some reviews have challenged this view.^{10–11} Employees often raise health concerns related to exposure to paper dust in general, but only one Swedish study has previously investigated this exposure and sick building syndrome (SBS) symptoms.¹² Another Swedish study assessed exposure to a paper index that combined use of different types of paper, such as CCP, carbon paper, printer paper and photocopying paper.^{9–13} Apart from a study from Finland,⁶ no other study has assessed occurrence of respiratory infections in relation to such office exposures. From a systematic Medline search we found that no earlier study has investigated the effects of several simultaneous office exposures on respiratory health.

The objective of our study was to assess the relation between exposure to CCP, paper dust and FPP, and the occurrence of SBS-related symptoms, chronic respiratory symptoms and respiratory infections in a population-based cross-sectional study of professionals, clerks and administrative personnel in Finland.

METHODS

Study design

We conducted a population-based cross-sectional study of adults of working age. The source population consisted of

adults 21–63 years of age, living in a geographically defined administrative area in South Finland (Pirkanmaa). The population of Pirkanmaa was 440 913 in 1997. The study was approved by the ethics committees of the Finnish Institute of Occupational Health, Helsinki, Finland and the Tampere University Hospital, Tampere, Finland.

Study population

In 1997, we randomly selected 1500 subjects from the source population using the national population registry, which has full coverage of the population, as part of the Finnish Environment and Asthma Study.^{14–18} This random population sample served as the control population for the study of incident asthma, and was recruited through several rounds of invitation letters during a 2.5-year study period (1997–2000). It serves here as the study population for investigating the relation between workplace exposures and SBS, chronic respiratory symptoms and respiratory infections. Before sending each round of recruitment letters, we confirmed from the population registry that the person was still living in the Pirkanmaa region; those who were no longer living in the area were excluded. The final target population was 1270. Informed consent was sought for in the letter, and it was conveyed in a prepaid envelope to the research nurse along with the completed questionnaire. After up to three invitation letters and phone calls, 1016 individuals participated in the study (response rate 80%). Six people aged >63 years and two who

Abbreviations: CCP, carbonless copy paper; ETS, environmental tobacco smoke; FPP, fumes from photocopiers and printers; SBS, Sick Building Syndrome

returned incomplete questionnaires were excluded. As this study focused on exposures in the office work environment, we included only those people who were according to their current occupation professionals, clerks or administrative personnel, as classified by the International Standard Classification of Occupations-88. Thus, the final study population consisted of 342 office workers.

Measurement methods

Questionnaire

The study subjects answered a self-administered questionnaire modified from the Helsinki Office Environment Study questionnaire for use in a general population.^{6 14-19} The questionnaire had six sections:

1. personal characteristics;
2. health information, including respiratory symptoms, symptoms of SBS, respiratory infections, and previous respiratory and allergic diseases;
3. active smoking and environmental tobacco smoke exposure;
4. occupation and exposures in the work environment;
5. home environment; and
6. dietary questions.

Section 4 inquired about current occupation and previous occupations throughout the working history. It also included additional queries on indoor environment at work, including questions on exposure to paper dust, CCP, FPP, occurrence of dampness and mould problems, and other specific occupational exposures.

Statistical methods

Outcomes

Three types of outcomes were of interest in this study:

1. SBS-related symptoms, defined as symptoms experienced during the past year (12 months) at least 1–3 days per week and occurring mainly during workdays or work shifts. These SBS-related symptoms included nasal symptoms (ie, dryness or itching of the nose, blocked or runny nose, or sneezing), eye symptoms (ie, dryness or irritation of the eyes, itchy eyes, or watering or redness of the eyes), throat symptoms (ie, dryness, itching or irritation of the throat, dry irritative cough, sore throat or hoarseness), skin symptoms (ie, dryness, irritation or redness of the skin, itching skin, red patches on the skin, sore skin or urticaria), headache and fatigue (ie, non-specific tiredness). The term “general symptoms” will be used for headache and fatigue.
2. Chronic respiratory symptoms included cough, phlegm production, chronic bronchitis, wheezing and dyspnoea. Chronic cough was defined as cough on most days for at least 3 months in the past year. Chronic phlegm production was defined as mucus production on most days for at least 3 months in the past year. Chronic bronchitis was defined as chronic cough and chronic phlegm production persisting for at least 2 years. Wheezing was defined as recurrent wheezing in the past year. Breathlessness was defined as recurrent feeling of breathlessness during the past year.
3. Respiratory infections included common colds, tonsil infections, sinus infections, middle ear infections, bronchitis and pneumonia. One question on infections asked about the occurrence of diarrhoea, the number of these infections in the past year (12 months) was asked. For the analyses, all the infections were dichotomised into ≥ 1 infections (coded as 1) or 0 infections during the past year (coded as 0), with the exception of cold, for which a cut-off point of ≥ 2 was used.

Exposures

The office exposures of interest were exposure to paper dust, CCP and FPP. The subjects were asked to estimate their average exposure to each of these exposures in hours per week in their present job. In the analyses, the subjects were dichotomised into the exposed group (reported exposure for ≥ 1 h/week) and the unexposed group (reported exposure for < 1 h/week).

Data analysis

We compared the risk of the outcomes of interest among those exposed to one or several of the three exposures with that among those with no exposure. We used odds ratio (OR) to quantify the relationship between the occupational exposure and the occurrence of symptom or infection.

When adjusting for confounders in the logistic regression analysis, we started with a core model that controlled for sex and age, and then applied the principle of forward selection for other potential confounders, including education (as an indicator of socioeconomic status), smoking, exposure to ETS at home or at work, exposure to indoor moulds at home or at work, the number of people working in the same office, the type of ventilation, work stress, work atmosphere and interest in work. We added each potential confounder into the core model one at a time, and identified which of them influenced most the OR of the relationship between exposure and outcome. That covariate was added to the new model along with sex and age, and the process was iterated with other covariates until no change $> 10\%$ in the OR was observed.

RESULTS

Characteristics and symptoms of the study population

A higher proportion of women were observed among those with any exposure compared with those with no exposure ($\chi^2_{(df=1)} p = 0.001$) (see appendix A online at <http://oem.bmjournals.com/supplemental>). The differences in the other characteristics were smaller. Those with any exposure were somewhat younger ($\chi^2_{(df=1)} p = 0.025$), were more often never smokers ($\chi^2_{(df=1)} p = 0.201$), had more exposure to indoor moulds ($\chi^2_{(df=1)} p = 0.004$), and their office had more often natural ventilation but less often mechanical air supply and/or exhaust system ($\chi^2_{(df=3)} p = 0.018$) than those with no exposure. In addition, they were somewhat more stressed at work ($\chi^2_{(df=1)} p = 0.018$). In multivariate analyses, we adjusted for all of these covariates according to the principle described in Data analysis.

In the bivariate analysis, those with any exposure had more nose and throat symptoms as well as more headache and fatigue than those with no exposure (see appendix B online at <http://oem.bmjournals.com/supplemental>). Occurrence of breathlessness was also more common among the exposed compared with the unexposed. Some respiratory infections occurred more commonly among the exposed than among the unexposed subjects, including sinus infections and middle ear infections. None of the 342 study subjects reported having experienced pneumonia in the past year. There was some variability in the occurrence of symptoms according to the three individual exposure groups of interest.

Exposures in office environment, and SBS and respiratory symptoms and infections

Table 1 shows the ORs of health outcomes in relation to exposure to paper dust at work. Paper dust exposure was significantly related to headache (OR 5.15, 95% confidence interval (CI) 1.03 to 25.8) and fatigue (OR 2.49, 95% CI 1.06 to 5.89) when adjusted for sex and age. The OR was also increased for nasal, throat and skin symptoms, although the effect estimates did not reach statistical significance. When adjusting

for more confounders, the CIs were rather wide because of a small number of subjects in some subcategories. Among chronic respiratory symptoms, breathlessness was more common among the exposed (OR 1.87, 95% CI 0.97 to 3.61). In addition, the risks of chronic phlegm production and chronic bronchitis were higher in the exposed than in the unexposed. The risk of both tonsillitis and middle ear infections was increased in relation to this exposure, but the CIs were wide because these infections were rather rare.

Table 2 displays the ORs of health outcomes in relation to exposure to CCP. The risk of headache was significantly increased in relation to this exposure (OR 4.16, 95% CI 1.15 to 15.0) after adjusting for sex and age. In addition, eye symptoms and fatigue were more common among the exposed compared with the unexposed. Exposure to CCP was related to the risk of chronic phlegm production, chronic bronchitis and breathlessness. Among respiratory infections, sinus infections and middle ear infections were more common among the exposed. Also, the OR of diarrhoea was increased in relation to exposure to CCP (OR 1.49, 95% CI 0.84 to 2.63). Exposure to CCP was the least common of these office work exposures ($n = 69$), and the subjects also reported the lowest number of hours of exposure to CCP among the three office exposures studied.

Table 3 presents the results for exposure to FPP. Fatigue was significantly increased in relation to exposure to such fumes (OR 2.69, 95% CI 1.18 to 6.14) after adjustment for age and sex. Also, the ORs of nasal and throat symptoms, skin symptoms, and headache were increased in relation to exposure to photocopiers and printers. Again, breathlessness and chronic bronchitis showed relation with the exposure. Risks of tonsillitis and middle ear infections were associated with exposure.

Effects of several exposures in the office environment

The three office work exposures of interest occurred often simultaneously, as shown in the Venn diagram (fig 1). A total of 11% of the study population reported all three exposures, and 23% reported two exposures, so altogether 34% of the population had >1 exposure concomitantly. This overlap of

exposures caused problems of collinearity when we tried to adjust the analysis of one exposure for the other two exposures. Thus, we decided to investigate separately the effect of any exposure (table 4) and that of a combination of two or three exposures (table 5).

The risk of fatigue and headache was significantly increased in relation to exposure to any of the three office exposures (fatigue OR 4.66, 95% CI 1.67 to 13, and headache OR 8.27, 95% CI 1.01 to 67.6, after adjustment for age and sex; table 4). In addition, after adjustment for a full set of covariates, the risk of nasal, throat and skin symptoms was increased in association with any exposure. Among chronic respiratory symptoms, breathlessness was related to any exposure (OR 1.36, 95% CI 0.71 to 2.62). Any exposure was also related to the risk of tonsillitis and middle ear infections.

When studying the symptom occurrence in relation to exposure to any combination of two exposures and to all three exposures (table 5), we found that there was a dose-response relationship between the number of exposures and the risk of headache, tonsillitis and sinus infections. In addition, the ORs for chronic respiratory symptoms, including phlegm production, chronic bronchitis, wheezing and breathlessness, were increased in the highest exposure category.

DISCUSSION

This population-based study of professionals, clerks and administrative staff in Finland shows that the health effects of exposure to paper dust, CCP and FPP are not insignificant, although office environments have been traditionally considered as workplaces free of health hazards.

A strikingly consistent finding was the relation of these exposures with headache and fatigue, even after adjustment was made for confounders such as psychosocial factors at work. The occurrence of headache showed a dose-response relationship with the number of exposures. These findings suggest that chemicals from office equipment and supplies may actually be absorbed into the circulation and dispersed to the central nervous system. Another possible explanation is that chemicals induce a low-grade inflammation, which in turn could entail production of cytokines that can pass through the blood-brain

Table 1 Crude and adjusted odds ratios of sick building syndrome-related symptoms, chronic respiratory symptoms and respiratory infections during the past 12 months in relation to exposure to paper dust

	Crude OR (95% CI)	Adjusted* OR (95% CI)	Adjusted† OR (95% CI)
Nasal symptoms	3.16 (0.80 to 12.4)	2.48 (0.61 to 10.2)	2.06 (0.50 to 8.56)
Eye symptoms	1.32 (0.26 to 6.62)	0.96 (0.18 to 5.19)	0.33 (0.04 to 3.07)
Throat symptoms	2.67 (0.48 to 14.8)	2.26 (0.39 to 13.3)	2.66 (0.45 to 15.7)
Skin symptoms	1.66 (0.44 to 6.30)	1.47 (0.37 to 5.82)	2.14 (0.50 to 9.23)
Headache	5.49 (1.15 to 26.2)	5.15 (1.03 to 25.8)	3.35 (0.59 to 19.2)
Fatigue	2.23 (0.98 to 5.07)	2.49 (1.06 to 5.89)	2.01 (0.82 to 4.95)
Cough	1.10 (0.46 to 2.62)	0.93 (0.38 to 2.30)	0.93‡ (0.38 to 2.30)
Phlegm production	1.27 (0.63 to 2.56)	1.31 (0.63 to 2.73)	1.31‡ (0.63 to 2.73)
Chronic bronchitis	1.32 (0.33 to 5.37)	1.07 (0.25 to 4.56)	1.41 (0.31 to 6.34)
Wheezing	1.04 (0.57 to 1.90)	0.95 (0.51 to 1.79)	0.95‡ (0.51 to 1.79)
Breathlessness	2.06 (1.09 to 3.86)	1.87 (0.97 to 3.61)	1.87‡ (0.97 to 3.61)
Common colds	0.95 (0.60 to 1.50)	0.85 (0.52 to 1.38)	0.85‡ (0.52 to 1.38)
Tonsillitis	1.60 (0.48 to 5.34)	1.40 (0.39 to 4.96)	1.40‡ (0.39 to 4.96)
Sinus infections	1.51 (0.84 to 2.70)	1.03 (0.56 to 1.92)	1.03‡ (0.56 to 1.92)
Middle ear infections	1.56 (0.51 to 4.73)	1.36 (0.43 to 4.28)	1.29 (0.38 to 4.32)
Bronchitis	0.41 (0.18 to 0.93)	0.39 (0.16 to 0.91)	0.35 (0.15 to 0.85)
Diarrhoea	1.13 (0.70 to 1.82)	0.95 (0.58 to 1.57)	0.95‡ (0.58 to 1.57)

*Adjusted for age and sex.

†Adjusted for the set of covariates that changed the estimate of interest by >10% (for details, see Data analysis of the Methods section).

‡Adjusted OR did not change because no other covariate changed the estimate by >10% when added to the model including sex and age.

Table 2 Crude and adjusted odds ratios of sick building syndrome-related symptoms, chronic respiratory symptoms and respiratory infections during the past 12 months in relation to exposure to carbonless copy paper

	Crude	Adjusted*	Adjusted†
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Nasal symptoms	0.99 (0.21 to 4.77)	0.93 (0.19 to 4.55)	0.84 (0.17 to 4.19)
Eye symptoms	4.09 (0.81 to 20.7)	4.04 (0.75 to 21.7)	2.54 (0.40 to 15.9)
Throat symptoms	0.79 (0.09 to 6.86)	0.77 (0.09 to 6.73)	1.04 (0.11 to 9.59)
Skin symptoms	0.49 (0.06 to 3.96)	0.48 (0.06 to 3.89)	0.62 (0.07 to 5.18)
Headache	4.19 (1.18 to 14.9)	4.16 (1.15 to 15.0)	3.11 (0.80 to 12.1)
Fatigue	1.86 (0.77 to 4.47)	1.93 (0.80 to 4.69)	1.79 (0.70 to 4.57)
Cough	0.61 (0.18 to 2.12)	0.59 (0.17 to 2.09)	0.59‡ (0.17 to 2.09)
Phlegm production	1.68 (0.77 to 3.69)	1.76 (0.79 to 3.90)	1.76‡ (0.79 to 3.90)
Chronic bronchitis	2.44 (0.57 to 10.5)	2.33 (0.54 to 10.1)	2.84 (0.59 to 13.6)
Wheezing	1.14 (0.55 to 2.36)	1.13 (0.54 to 2.36)	1.13‡ (0.54 to 2.36)
Breathlessness	1.69 (0.84 to 3.42)	1.65 (0.81 to 3.37)	1.65‡ (0.81 to 3.37)
Common colds	0.86 (0.49 to 1.52)	0.78 (0.43 to 1.40)	0.78‡ (0.43 to 1.40)
Tonsillitis	0.88 (0.19 to 4.15)	0.79 (0.16 to 3.84)	0.79‡ (0.16 to 3.84)
Sinus infections	2.09 (1.09 to 3.99)	1.99 (1.01 to 3.95)	1.99‡ (1.01 to 3.95)
Middle ear infections	2.59 (0.82 to 8.18)	2.51 (0.79 to 7.96)	2.41 (0.73 to 7.95)
Bronchitis	0.91 (0.36 to 2.29)	0.93 (0.37 to 2.38)	0.87 (0.34 to 2.25)
Diarrhoea	1.59 (0.91 to 2.78)	1.49 (0.84 to 2.63)	1.49‡ (0.84 to 2.63)

*Adjusted for age and sex.

†Adjusted for the set of covariates that changed the estimate of interest by >10% (for details, see Data analysis of the Methods section).

‡Adjusted OR did not change as no other covariate changed the estimate >10% when added to the model including sex and age.

barrier, inducing general symptoms. CCP was also related to eye symptoms for which the exposure route could be handling CCP and after that touching the eyes with the chemicals on the fingers.

Exposure to paper dust and to FPP was related to the symptoms of upper airways and skin. Among chronic respiratory symptoms, the risk of breathlessness was consistently related to all three exposures of interest. Also, occurrence of chronic bronchitis was associated with all three exposures. These findings suggest that there is airborne exposure to irritant agents, or perhaps even to some sensitising agents.

Tonsillitis and middle ear infections were more common among those exposed to paper dust and to FPP, and tonsillitis

showed a dose-response relationship with the number of exposures. Exposure to CCP showed different associations with infections, the OR being increased for sinus infections, middle ear infections and diarrhoea. The relationship with diarrhoea suggests that this exposure may affect health also through the oral route: the person first handles CCP and then puts his or her hand in the mouth.

Exposures to paper dust and FPP showed a similar profile regarding their relation with symptoms and infections, suggesting that the effects related to paper dust in general could be due to printing chemicals. Printing chemicals have been reported as causes of occupational respiratory diseases in printing houses,^{20, 21} but their potential effects on office workers with

Table 3 Crude and adjusted odds ratios of sick building syndrome-related symptoms, chronic respiratory symptoms and respiratory infections during the past 12 months in relation to exposure to fumes from photocopiers and printers

	Crude	Adjusted*	Adjusted†
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Nasal symptoms	1.99 (0.57 to 7.02)	1.72 (0.48 to 6.20)	1.38 (0.37 to 5.09)
Eye symptoms	0.38 (0.04 to 3.33)	0.37 (0.04 to 3.33)	0.26 (0.02 to 3.07)
Throat symptoms	10.1 (1.17 to 87.8)	10.0 (1.13 to 89.1)	14.4 (1.42 to 146.9)
Skin symptoms	1.58 (0.42 to 6.00)	1.44 (0.37 to 5.60)	2.21 (0.51 to 9.55)
Headache	1.99 (0.57 to 7.02)	1.99 (0.55 to 7.18)	1.49 (0.36 to 6.20)
Fatigue	2.45 (1.09 to 5.48)	2.69 (1.18 to 6.14)	2.13 (0.90 to 5.03)
Cough	1.12 (0.46 to 2.76)	1.08 (0.43 to 2.71)	1.08‡ (0.43 to 2.71)
Phlegm production	0.88 (0.42 to 1.87)	0.94 (0.44 to 2.02)	0.94‡ (0.44 to 2.02)
Chronic bronchitis	1.17 (0.28 to 5.00)	1.12 (0.26 to 4.87)	1.72 (0.37 to 8.10)
Wheezing	0.90 (0.48 to 1.72)	0.90 (0.47 to 1.73)	0.90‡ (0.47 to 1.73)
Breathlessness	1.60 (0.85 to 3.01)	1.57 (0.82 to 3.00)	1.57‡ (0.82 to 3.00)
Common colds	1.31 (0.82 to 2.10)	1.19 (0.73 to 1.93)	1.19‡ (0.73 to 1.93)
Tonsillitis	2.41 (0.72 to 8.07)	2.41 (0.69 to 8.40)	2.41‡ (0.69 to 8.40)
Sinus infections	1.29 (0.71 to 2.36)	1.07 (0.57 to 2.01)	1.07‡ (0.57 to 2.01)
Middle ear infections	1.71 (0.56 to 5.20)	1.58 (0.51 to 4.87)	1.54 (0.48 to 4.99)
Bronchitis	0.88 (0.40 to 1.92)	0.90 (0.40 to 1.98)	0.86 (0.39 to 1.91)
Diarrhoea	1.22 (0.75 to 1.99)	1.09 (0.66 to 1.80)	1.09‡ (0.66 to 1.80)

*Adjusted for age and sex.

†Adjusted for the set of covariates that changed the estimate of interest by >10% (for details, see Data analysis of the Methods section).

‡Adjusted OR did not change because no other covariate changed the estimate by >10% when added to the model including sex and age.

Figure 1 Venn diagram showing the occurrence of the three office exposures independently and jointly.

lower exposure levels have not been studied to the same extent. Photocopiers and printers are known to emit chemicals^{22–24} such as volatile organic compounds, ozone, formaldehyde and resin, as well as particles. These include both allergens and irritants, and the relation with neurological symptoms suggest even a possible toxic effect.

CCPs contain solvents and colour-forming chemicals^{25–27} that are potentially harmful for health. In this study, exposure to CCP was related to a different symptom and infection profile, where exposure through contact of fingers, after handling the chemicals, with eyes and mouth seemed to be a possible route. However, associations with phlegm production, chronic bronchitis, breathlessness and upper respiratory infections suggest that airborne exposure is also of importance.

Validity of the results

The population-based design of this study guards against the potential source of bias affecting studies of SBS in which the study population was selected from problem buildings. We achieved a good response rate (80%), which further reduced the likelihood of selection bias. This study was part of a large research project, the “Finnish Environment and Asthma Study”, so there was no special emphasis on exposures to different types of paper or to FPP in the data collection phase. This reduces the concern for reporting bias, although not excluding it completely, as our exposure assessment was based on self-report. Our exposure assessment could have been supported by measurements of indoor chemicals to obtain objective measures. However, the exposures of interest consist of mixtures of agents, and currently it is not well understood which chemicals are the most relevant to health. Indeed, exposure to a mixture may be more relevant than exposure to any individual agent. Thus, our exposure assessment approach based on reporting of exposure sources has its strengths. Concomitant occurrence of the three exposures of interest made it difficult to study their independent effects, but this problem is generic to office work. On the other hand, this enabled us to address the question of effects related to several exposures.

We had collected data on several potential confounders in the self-administered questionnaire, including education (as an indicator of socioeconomic status), smoking, exposure to ETS at home or at work, exposure to indoor moulds at home or at work, the number of people working in the same office, the type of ventilation, work stress, work atmosphere and interest in work, and were able to adjust for them in the multivariate analyses.

A weakness of this study is that, because it focused on office workers only, the study sample was smaller than the rather large total population, and adjustment for multiple confounders sometimes led to wide CIs. Another weakness is the cross-sectional study design, owing to which the temporal relationship between exposure and outcome cannot be deduced. This same problem applies to all previous studies. If

Table 4 Crude and adjusted odds ratios of Sick Building Syndrome-related symptoms, chronic respiratory symptoms and respiratory infections during the past 12 months in relation to exposure to any of the three office exposures (paper dust, carbonless copy paper, and fumes from photocopiers and printers)

	Crude	Adjusted*	Adjusted†
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Nasal symptoms	2.12 (0.54 to 8.33)	1.67 (0.41 to 6.78)	1.30 (0.31 to 5.44)
Eye symptoms	0.89 (0.18 to 4.46)	0.75 (0.14 to 3.98)	0.28 (0.03 to 2.45)
Throat symptoms	4.55 (0.53 to 39.3)	4.08 (0.46 to 36.6)	5.56 (0.59 to 52.8)
Skin symptoms	1.12 (0.29 to 4.22)	0.96 (0.25 to 3.79)	1.54 (0.35 to 6.69)
Headache	8.37 (1.05 to 66.8)	8.27 (1.01 to 67.6)	4.91 (0.56 to 43.4)
Fatigue	4.10 (1.51 to 11.1)	4.66 (1.67 to 13.0)	3.56 (1.24 to 10.2)
Cough	0.88 (0.37 to 2.09)	0.78 (0.32 to 1.90)	0.78‡ (0.32 to 1.90)
Phlegm production	0.94 (0.47 to 1.88)	0.98 (0.47 to 2.01)	0.98‡ (0.47 to 2.01)
Chronic Bronchitis	0.89 (0.22 to 3.61)	0.77 (0.18 to 3.25)	1.10 (0.25 to 4.93)
Wheezing	0.83 (0.42 to 1.61)	0.76 (0.38 to 1.52)	0.76‡ (0.38 to 1.52)
Breathlessness	1.45 (0.77 to 2.74)	1.36 (0.71 to 2.62)	1.36‡ (0.71 to 2.62)
Common colds	1.07 (0.68 to 1.67)	0.96 (0.60 to 1.54)	0.96‡ (0.60 to 1.54)
Tonsillitis	1.58 (0.45 to 5.50)	1.55 (0.42 to 5.66)	1.55‡ (0.42 to 5.66)
Sinus infections	1.24 (0.69 to 2.23)	0.91 (0.49 to 1.71)	0.91‡ (0.49 to 1.71)
Middle ear infections	1.44 (0.46 to 4.50)	1.28 (0.40 to 4.09)	1.21 (0.36 to 4.07)
Bronchitis	0.37 (0.17 to 0.81)	0.36 (0.16 to 0.80)	0.30 (0.13 to 0.70)
Diarrhoea	1.04 (0.65 to 1.67)	0.90 (0.55 to 1.46)	0.90‡ (0.55 to 1.46)

*Adjusted for age and sex.

†Adjusted for the set of covariates that changed the estimate of interest by >10% (for details, see Data analysis of the Methods section).

‡Adjusted OR did not change because no other covariate changed the estimate by >10% when added to the model including sex and age.

Table 5 Adjusted odds ratios of sick building syndrome-related symptoms, chronic respiratory symptoms and respiratory infections during the past 12 months in relation to exposure to one, two or three of office exposures (paper dust, self-copying paper, and fumes from photocopying and printers)

	One exposure*	Two exposures*	Three exposures*
	Adjusted†‡	Adjusted†	Adjusted†
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Nasal symptoms	0.68 (0.07 to 6.88)	2.65 (0.59 to 12.0)	1.54 (0.14 to 16.4)
Eye symptoms	—	1.17 (0.18 to 7.79)	1.23 (0.11 to 13.8)
Throat symptoms	1.92 (0.11 to 32.7)	4.89 (0.47 to 51.2)	3.75 (0.22 to 62.9)
Skin symptoms	0.58 (0.06 to 5.43)	1.37 (0.28 to 6.64)	1.04 (0.11 to 9.96)
Headache	5.40 (0.46 to 62.9)	10.1 (1.08 to 95.1)	11.9 (0.92 to 155.9)
Fatigue	5.25 (1.66 to 16.6)	2.62 (0.76 to 9.01)	4.56 (1.21 to 17.2)
Cough	0.60 (0.16 to 2.25)	0.97 (0.33 to 2.83)	0.73 (0.15 to 3.54)
Phlegm production	0.68 (0.24 to 1.95)	0.78 (0.28 to 2.13)	2.23 (0.82 to 6.09)
Chronic bronchitis	—	0.85 (0.14 to 5.04)	2.07 (0.34 to 12.5)
Wheezing	0.85 (0.37 to 1.96)	0.67 (0.28 to 1.62)	1.58 (0.63 to 3.97)
Breathlessness	1.03 (0.42 to 2.53)	0.85 (0.34 to 2.12)	3.85 (1.61 to 9.21)
Common colds	0.95 (0.50 to 1.80)	1.11 (0.61 to 2.01)	0.75 (0.34 to 1.69)
Tonsillitis	1.50 (0.25 to 8.99)	1.74 (0.38 to 8.96)	1.97 (0.33 to 11.8)
Sinus infections	0.35 (0.12 to 1.03)	1.18 (0.56 to 2.52)	1.41 (0.55 to 3.60)
Middle ear infections	—	2.29 (0.64 to 8.14)	1.62 (0.29 to 8.93)
Bronchitis	—	0.53 (0.20 to 1.40)	0.74 (0.23 to 2.32)
Diarrhoea	0.50 (0.24 to 1.05)	1.17 (0.64 to 2.15)	1.23 (0.57 to 2.67)

*One exposure, two exposures and three exposures are contrasted to no exposure.

†Adjusted for age and sex.

‡No estimate could be calculated because of too few symptomatic subjects in the group with only one exposure.

exposures had been avoided because of symptoms experienced, the effect estimates of our study would underestimate the real effects.

Synthesis with previous knowledge

Our study is the first to consider the role of paper dust exposure in the office environment for general symptoms, chronic respiratory symptoms and respiratory infections, and does provide evidence of the importance of paper dust exposure for such symptoms. Our finding of increased risk of nasal symptoms in relation to paper dust exposure is consistent with a previous Swedish study showing a significant relationship between paper dust exposure and reported nasal blocking and episodes of sneezing.¹²

We found increased risks of nasal, throat and skin symptoms in relation to exposure to FPP, which is in line with previous studies from Denmark,⁴ Sweden¹³ and USA.⁸ In addition, we found significant relationships with the general symptoms such as headache and fatigue, chronic bronchitis, breathlessness, and tonsillitis and middle ear infections, which earlier studies did not investigate at all, or for which no significant association, as found.

This study confirmed the previous findings on the use of CCP and occurrence of eye symptoms,^{6, 8, 26} general symptoms,^{4, 6, 8, 9} chronic phlegm production and chronic bronchitis,⁶ breathlessness,⁸ and sinus infections.⁶ In addition, in this study, we found that handling CCP was also related to an increased risk of diarrhoea. Thus, there is accumulating evidence on the harmful effects of CCP on respiratory health, eyes, general symptoms and even on the gastrointestinal system. A review supported by the CCP manufacturers published in 2000 questioned these health effects, but its conclusions seem to be based on some erroneous inferences.¹² The review claimed that the strongest evidence against the adverse health effects of CCP comes from the patch tests carried out by the manufacturers of CCP, although these results have not been published in peer reviewed journals and are not relevant to respiratory or mucosal systems. Patch test results are relevant for delayed hypersensitivity, and thus for some forms of dermatitis,

whereas the mechanisms relevant for the respiratory system, mucosa and central nervous system are immediate hypersensitivity, irritation and toxic mechanisms. The review also claimed that few reactions detected among manufacturing workers speak against potential effects, which have been detected mainly in office workers and to some extent in printing facilities. It does not mention that, in industry, extensive protective measures have to be taken according to law when workers handle potentially harmful chemicals, whereas office

Main messages

- Exposures to paper dust and to FPP in office environments increase the risk of headache and fatigue, chronic breathlessness, chronic bronchitis, tonsillitis and middle ear infections.
- Exposure to paper dust and to FPP in offices is related to upper airways symptoms.
- Exposure to CCP is related to headache, fatigue, eye symptoms, breathlessness, chronic phlegm production and bronchitis, sinus infections and middle ear infections.
- There is a dose-response relationship between the number of these office exposures and the risks of headache, tonsillitis and sinus infections.

Policy implications

- Reduction of exposures to CCP, paper dust and FPP in office work environments is likely to improve the health of office workers.
- The measures that can be introduced to reduce the exposures include reduced handling of the sources of exposure, improved ventilation where such handling is necessary, and locating printers and photocopiers away from working areas.

workers are traditionally not subject to such protective measures. The review also stated that CCP cannot be a cause of symptoms observed in epidemiological studies, because studies have also identified other causes for SBS symptoms. It thus ignores the extensive controlling of confounders in the more recent epidemiological studies on this topic. There also seems to be some confusion over the meaning of hypersensitivity, as the review states that CCP cannot be a cause of disease in some individuals when others are not affected, although a typical feature of hypersensitivity diseases is that only a fraction of the exposed develop the disease.

This study is to our knowledge the first to investigate the effects of two or three concomitant office exposures. We found a dose-response relationship between the number of exposures and the risks of headache, tonsillitis and sinus infections.

CONCLUSION

This study provides new evidence that exposure to paper dust and to FPP in office environments increases the risk of headache and fatigue, chronic breathlessness, and chronic bronchitis. It also provides evidence that the risks of tonsillitis and middle ear infections are higher in employees exposed to these sources. The study strengthens the evidence that such exposures are related to upper airway symptoms and that exposure to CCP is related to headache, fatigue, breathlessness, chronic phlegm production and bronchitis, sinus infections, and middle ear infections. Exposure to CCP is also associated with increased risk of eye symptoms and diarrhoea, suggesting that direct contact of fingers, after touching CCPs, with eyes and mouth may be an important exposure route. Irritative and neurotoxic effects seem to have importance as mechanisms, but immunological reactions cannot be excluded and they can be operating as well. This study suggests that reduction of these exposures in office work environments is likely to improve the health of office workers. The measures that can be introduced to reduce the exposures include reduced handling of the sources of exposure, improved ventilation where such handling is necessary, and locating printers and photocopiers away from working areas.

ACKNOWLEDGEMENTS

We thank our research nurses Ms Leena Yrjänheikki, Marika Soukkanen and Marita Aalto for their work in recruiting study subjects. We also thank Dr Ritva Piipari at the Finnish Institute of Occupational Health and Dr Niina Jaakkola at the University of Helsinki for their contribution to the data collection and management. The data collection was supported by grants from the Ministry of Social Affairs and Health of Finland, the Finnish Work Environment Fund, and the analyses by a grant from the West Midlands Levy Board of UK.

Authors' affiliations

Maritta S Jaakola, Liyan Yang, Antonia Ieromnimon, Jouni J K Jaakkola, Institute of Occupational and Environmental Medicine, University of Birmingham, Birmingham, UK

Maritta S Jaakkola, Finnish Institute of Occupational Health, Helsinki, Finland

Jouni J K Jaakkola, Respiratory Epidemiology Unit, Department of Public Health, University of Helsinki, Helsinki, Finland

Competing interests: None.

REFERENCES

- 1 Morgan MS, Camp JE. Upper respiratory irritation from controlled exposure to vapor from carbonless copy forms. *J Occup Med* 1986;**28**:415-19.
- 2 Shehade SA, Beck SA, Chalmers RJG. Allergic contact dermatitis to crystal violet in carbonless copy paper. *Contact Dermatitis* 1987;**17**:310-26.
- 3 LaMarte FP, Merchant JA, Casale TB. Acute systemic reactions to carbonless copy paper associated with histamine release. *JAMA* 1988;**260**:242-4.
- 4 Skov P, Valbjørn O, Pedersen BV. Influence of personal characteristics, job-related factors and psychosocial factors on the sick building syndrome. *Scand J Work Environ Health* 1989;**15**:286-95.
- 5 Kanerva L, Estlander T, Jolanki R, et al. Occupational allergic contact dermatitis caused by diethylenetriamine in carbonless copy paper. *Contact Dermatitis* 1993;**29**:147-51.
- 6 Jaakkola MS, Jaakkola JJK. Office equipment and supplies: a modern occupational health concern? *Am J Epidemiol* 1999;**150**:1223-8.
- 7 Yassi A, Warrington RJ. Allergic eye reaction to photocopier chemicals. *J Occup Med* 1988;**30**:457-8.
- 8 Fisk WJ, Mendell MJ, Daisey JM, et al. Phase 1 of the California Healthy building study: a summary. *Indoor Air* 1993;**3**:246-54.
- 9 Stenberg B, Mild K, Sandström M, et al. A prevalence study of the sick building syndrome (SBS) and facial skin symptoms in office workers. *Indoor Air* 1993;**3**:71-81.
- 10 Buring JE, Hennekens CH. Carbonless copy paper: a review of published epidemiologic studies. *J Occup Med* 1991;**33**:486-95.
- 11 Graves CG, Matanovski GM, Tardiff RG. Carbonless copy paper and workplace safety: a review. *Regul Toxicol Pharmacol* 2000;**32**:99-117.
- 12 Hellgren J, Lillienberg L, Jarlstedt J, et al. Population-based study of non-infectious rhinitis in relation to occupational exposure, age, sex, and smoking. *Am J Ind Med* 2002;**42**:23-8.
- 13 Stenberg B, Eriksson N, Höög J, et al. The sick building syndrome (SBS) in office workers. A case-referent study of personal, psychosocial and building-related risk indicators. *Int J Epidemiol* 1994;**23**:1190-7.
- 14 Jaakkola MS, Nordman H, Piipari R, et al. Indoor dampness and molds and development of adult-onset asthma: a population-based incident case-control study. *Environ Health Perspect* 2002;**110**:543-7.
- 15 Jaakkola JJK, Jaakkola N, Piipari R, et al. Pets, parental atopy and asthma in adults. *J Allergy Clin Immunol* 2002;**109**:784-8.
- 16 Jaakkola MS, Piipari R, Jaakkola N, et al. Environmental tobacco smoke and adult-onset asthma: a population-based incident case-control study. *Am J Public Health* 2003;**93**:2055-60.
- 17 Jaakkola JJK, Piipari R, Jaakkola MS. Occupation and asthma: a population-based incident case-control study. *Am J Epidemiol* 2003;**158**:981-7.
- 18 Piipari R, Jaakkola JJK, Jaakkola N, et al. Smoking and asthma in adults. *Eur Respir J* 2004;**24**:1-6.
- 19 Jaakkola JJK, Miettinen P. Type of ventilation system in office buildings and sick building syndrome. *Am J Epidemiol* 1995;**141**:755-65.
- 20 Kidney J, Fitzgerald M. Occupational asthma. *Ir Med J* 1991;**84**:22-3.
- 21 Cuthbert OD. Investigation into an outbreak of rhinitis and asthma in a printing works. *Ann Occup Hyg* 1973;**16**:203.
- 22 Hansen TB, Andersen B. Ozone and other air pollutants from photocopying machines. *Am Ind Hyg Assoc J* 1986;**47**:659-65.
- 23 Tuomi T, Engström B, Niemeä R, et al. Emission of laser printers and photocopiers. *Appl Occup Environ Hyg* 2000;**15**:629-34.
- 24 Stefaniak AB, Breyse PN, Murray MP, et al. An evaluation of employee exposure to volatile organic compounds in three photocopy centers. *Environ Res* 2000;**A83**:162-73.
- 25 Mølhave L, Grunnett K. Addendum: headspace analysis of gases and vapors emitted by carbonless paper. *Contact Dermatitis* 1981;**7**:76.
- 26 Marks JG Jr. Allergic contact dermatitis from carbonless copy paper. *JAMA* 1981;**245**:2331-2.
- 27 Norbäck D, Wieslander G, Göthe C-J. A search for discomfort-inducing factors in carbonless copying paper. *Am Ind Hyg Assoc J* 1988;**49**:117-20.