

Occupation and Asthma: A Population-based Incident Case-Control Study

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The authors assessed the relations between occupation and risk of developing asthma in adulthood in a 1997–2000 population-based incident case-control study of 521 cases and 932 controls in south Finland. The occupations were classified according to potential exposure to asthma-causing inhalants. Asthma risk was increased consistently for both men and women in the chemical (adjusted odds ratio (OR) = 5.69, 95% confidence interval (CI): 1.08, 29.8), rubber and plastic (OR = 2.61, 95% CI: 0.92, 7.42), and wood and paper (OR = 1.72, 95% CI: 0.71, 4.17) industries. Risk in relation to occupation was increased only for men—for bakers and food processors (OR = 8.62, 95% CI: 0.86, 86.5), textile workers (OR = 4.70, 95% CI: 0.29, 77.1), electrical and electronic production workers (OR = 2.83, 95% CI: 0.82, 6.93), laboratory technicians (OR = 1.66, 95% CI: 0.17, 16.6), and storage workers (OR = 1.57, 95% CI: 0.40, 6.19). Of the predominantly men's occupations, metal (OR = 4.52, 95% CI: 2.35, 8.70) and forestry (OR = 6.00, 95% CI: 0.96, 37.5) work were the strongest determinants of asthma. For women, asthma risk increased for waiters (OR = 3.03, 95% CI: 1.10, 8.31), cleaners (OR = 1.42, 95% CI: 0.81, 2.48), and dental workers (OR = 4.74, 95% CI: 0.48, 46.5). Results suggest an increased asthma risk both in traditional industries and forestry and in several nonindustrial occupations.

asthma; case-control studies; occupational diseases; occupations

Abbreviations: CI, confidence interval; EU, European Union; OR, odds ratio.

Asthma is a common chronic disease in adults and consequently has a substantial impact on public health and health care expenditures. Between 200 and 300 agents are encountered at work that have been reported to cause asthma through respiratory sensitization (1, 2). A few population-based epidemiologic studies have investigated the relations between long-term occupational exposures and the risk of asthma (3–15). They were reviewed recently by a working group of the American Thoracic Society (16).

Previous studies assessing the effect of occupational exposures on the risk of asthma have focused on prevalent asthma and applied a cross-sectional study design. Cross-sectional studies are known to be sensitive to selection bias. This bias has sometimes been referred to as the “healthy worker effect,” that is, selection to work according to health status, which means that subjects with early symptoms and signs of asthma leave their jobs before the diagnosis, masking an effect of exposure on asthma. A study of newly diagnosed—

incident rather than prevalent—cases would reduce such selection bias and provide more accurate effect estimates. We conducted a population-based incident case-control study in Finland to assess the relations between occupation and the risk of asthma.

MATERIALS AND METHODS

Study design

Ours was a population-based incident case-control study. The source population consisted of adults 21–63 years of age living in a geographically defined administrative area of south Finland, where the 1997 population was 440,913. The study was approved by the ethics committees of the Finnish Institute of Occupational Health and the Tampere University Hospital.

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TABLE 1. Lung function findings confirming reversibility of obstruction among asthma cases, The Finnish Environment and Asthma Study, 1997–2000

Lung function criteria
1. Significant improvement in response to short-acting bronchodilating medication in a bronchodilator test; the criteria for significant changes were FEV ₁ *: ≥15% FVC*: ≥15% PEF*: ≥23% and/or 2. ≥20% daily variation† and/or ≥15% improvement† in response to short-acting bronchodilating medication during at least 2 days in a 2-week diurnal PEF follow-up and/or 3. Significant improvement in spirometric lung function (for percentage criteria, refer to 1.) and/or ≥20% improvement in average PEF level in response to a 2-week oral steroid treatment

* FEV₁, forced expiratory volume in 1 second, FVC, forced vital capacity, PEF, peak expiratory flow.

† Calculated according to the standard practice of the Tampere University Hospital (19): maximum daily variation = (highest PEF value during the day – lowest PEF value during the day)/highest PEF value during the day; bronchodilator response = (highest PEF value after bronchodilating medication – highest PEF value before medication)/highest PEF value before medication.

Definition and selection of cases

We systematically recruited all new asthma cases, first in the city of Tampere beginning on September 15, 1997, and then from March 10, 1998, to March 31, 2000, in the whole Pirkanmaa Hospital District (17, 18). Patients were recruited at all health care facilities diagnosing asthma, including the Department of Pulmonary Medicine at the Tampere University Hospital, offices of the private-practicing pulmonary physicians in the region, and public health care centers. As an additional route of case selection, the National Social Insurance Institution of Finland invited all patients whose reimbursement rights for asthma medication began during the period September 1, 1997–May 1, 1999 and who had not yet participated.

At the Tampere University Hospital, cases were recruited at their first visit due to suspected asthma, and the diagnosis was verified in clinical examinations. At the other health care facilities, cases were recruited immediately when the asthma diagnosis was verified. The same protocol for diagnosing asthma was applied at all health care facilities. The National Social Insurance Institution invited the cases 6 months to 2 years after their diagnosis was established. For these patients, the date and criteria of the asthma diagnosis were confirmed from their medical records so that the diagnosis of asthmatics included in our study fulfilled our criteria. For all cases, we verified from their medical records that they did not have a previous asthma diagnosis. Eligible subjects were invited to participate in the study, and informed consent was asked by their physician or through a letter sent by the National Social Insurance Institution. The cases answered the questionnaire at the time of recruitment.

The diagnostic criteria applied for asthma included 1) presence of at least one asthma-like symptom (prolonged cough, wheezing, attacks of or exercise-induced dyspnea, or nocturnal cough or wheezing); and 2) demonstration of reversibility of airways obstruction in lung function investi-

gations, including spirometry and bronchodilation test, and a 2-week peak expiratory flow follow-up (19). The lung function criteria are presented in table 1.

A total of 362 cases (response rate, 90 percent) participated through the health care system and 159 cases through the National Social Insurance Institution (response rate, 78 percent). Thus, the total was 521 cases.

Selection of controls

We randomly selected 1,500 controls from the source population by using the national population registry, with full coverage of the population. The general eligibility criteria were also applied for controls. Controls were recruited at regular intervals throughout the study period. Before sending each round of recruitment letters, we used the population registry to check whether the person was still living in the Pirkanmaa region. Information on informed consent was sent in the letter, which was returned in a prepaid envelope to the study project research nurse. After as many as three invitation letters were sent and telephone calls were made, 1,016 controls participated in the study (response rate, 80 percent of those who had a telephone number in the Pirkanmaa area). Previous or current asthma was reported by 76 (7.5 percent), six were older than age 63 years, and two returned incomplete questionnaires. After we excluded these persons, our study population included 932 controls.

Occupational groups and exposures

Study subjects answered a self-administered questionnaire modified from the Helsinki Office Environment Study questionnaire for use in a general population (20, 21). The questionnaire included six sections: 1) personal characteristics, 2) health information, 3) active smoking and environmental tobacco smoke exposure, 4) occupation and work environ-

ment, 5) home environment, and 6) dietary questions. The section on occupation and work environment inquired about current occupation and previous occupations throughout a subject's working history, starting with the current one and recalling occupational history backward. Additional questions inquired about details of the indoor environment at work, including dampness and mold problems, exposure to environmental tobacco smoke, and some other specific occupational exposures. The subjects were asked whether they had changed their work because of respiratory problems and, in the case of a confirmatory answer, to indicate the job and describe the symptoms.

We applied International Standard Classification of Occupations-88 classification to code the reported occupations. On the basis of previous epidemiologic studies and the national reports of occupational asthma, we identified 25 groups of occupations with potential exposure to asthma-causing inhalants. The reference category included professionals, clerks, and administrative personnel. To classify each subject into an occupational group, we used the current job (at the time of asthma diagnosis or up to 3 months prior to it) or the most recent one that the subject had quit because of respiratory symptoms.

Statistical methods

We compared the risk of asthma between the selected occupational groups and the reference category, and we used odds ratios as a measure of the relation between an occupational group and the risk of asthma. We systematically adjusted for age, gender, and smoking in unconditional logistic regression analysis.

RESULTS

Characteristics of cases and controls

Characteristics of the cases and controls are presented in table 2. The proportion of women was greater among cases than controls, and the cases tended to be younger and have a higher level of education. Ex-smoking and smoking were more common among cases than controls.

Occupational groups and the risk of asthma

Table 3 presents the percentages of cases and controls in each occupational group. The proportions of students, housewives, and those on maternal or long-term sick leave, as well as those who were retired or unemployed, are also given. A total of 30 cases (5.8 percent) and 16 controls (1.7 percent) had changed jobs because of respiratory symptoms. These subjects were classified according to the most recent job they had quit because of these symptoms. Table 4 shows the adjusted odds ratios of asthma in different occupational groups; professionals, clerks, and administrative workers were considered the reference category.

We were able to calculate effect estimates for both men and women for 12 occupational groups, whereas six groups included mainly men and seven groups mainly women. The risk of asthma was increased consistently for both men and

TABLE 2. Characteristics of the study population, The Finnish Environment and Asthma Study, 1997–2000

Characteristic	Cases (n = 521)		Controls (n = 932)	
	No.	%	No.	%
Gender				
Male	175	33.6	438	47.0
Female	346	66.4	494	53.0
Age (years)				
21–29	108	20.7	141	15.1
30–39	107	20.5	224	24.0
40–49	125	24.0	254	27.3
50–59	140	26.9	240	25.8
60–64	41	7.9	73	7.8
Education*				
No vocational schooling	107	20.6	154	16.6
Vocational course	89	17.1	104	11.2
Vocational institution	149	28.7	271	29.2
College level	113	21.8	261	28.1
University or corresponding	61	11.8	138	14.9
Smoking†				
No	239	46.1	487	52.4
Ex-smoker	133	25.7	203	21.8
Current smoker (regular or occasional)	146	28.2	240	25.8

* Information on education was missing for three subjects.

† Information on smoking was missing for five subjects.

women in the chemical (adjusted odds ratio (OR) = 5.69, 95 percent confidence interval (CI): 1.08, 29.8), rubber and plastic (adjusted OR = 2.61, 95 percent CI: 0.92, 7.42), and wood and paper (adjusted OR = 1.72, 95 percent CI: 0.71, 4.17) industries.

The risk in relation to occupation was increased only for men among bakers and food processors (adjusted OR = 8.62, 95 percent CI: 0.86, 86.5), textile workers (adjusted OR = 4.70, 95 percent CI: 0.29, 77.1), electrical and electronic production workers (adjusted OR = 2.83, 95 percent CI: 0.82, 2.93), laboratory technicians (adjusted OR = 1.66, 95 percent CI: 0.17, 16.6), and storage workers (adjusted OR = 1.57, 95 percent CI: 0.40, 6.19). Among the predominantly men's occupations, the strongest determinants of asthma were forestry (adjusted OR = 6.00, 95 percent CI: 0.96, 37.5) and metal work (adjusted OR = 4.52, 95 percent CI: 2.35, 8.70). The adjusted odds ratios were elevated also for painters (adjusted OR = 1.62, 95 percent CI: 0.30, 8.80) and construction workers (adjusted OR = 1.37, 95 percent CI: 0.64, 2.96). For women, the risk of asthma was increased for waiters (adjusted OR = 3.03, 95 percent CI: 1.10, 8.31), cleaners (adjusted OR = 1.42, 95 percent CI: 0.81, 2.48), and dental workers (adjusted OR = 4.74, 95 percent CI: 0.48, 46.5).

TABLE 3. Percentages of cases and controls in each occupational group, The Finnish Environment and Asthma Study, 1997–2000

Occupational group	Men		Women		Total	
	Cases (n = 175)	Controls (n = 438)	Cases (n = 346)	Controls (n = 494)	Cases* (n = 521)	Controls* (n = 932)
Bakers and food processors	1.7	0.2	1.2	1.2	1.3	0.8
Chemical industry workers	1.1	0.2	0.9	0.2	1.0	0.2
Cleaners	0.0	0.5	9.3	6.5	6.1	3.7
Construction and mining workers	6.3	7.1	0.6	0.0	2.5	3.3
Day-care workers	1.1	0.0	2.3	3.2	1.9	1.7
Dentists and dental workers	0.0	0.0	0.9	0.2	0.6	0.1
Drivers	2.9	5.0	0.3	0.2	1.2	2.5
Electrical and electronic production workers	3.4	2.3	0.6	0.8	1.5	1.5
Engine workshop workers	3.4	4.8	0.3	0.0	1.3	2.3
Farmers and agricultural workers	2.9	4.8	2.9	2.8	2.9	3.8
Forestry and related workers	1.7	0.5	0.0	0.0	0.6	0.2
Fur and leather workers	0.6	0.0	0.9	1.2	0.8	0.6
Glass, ceramic, and mineral workers	1.1	1.4	0.0	0.0	0.4	0.6
Hairdressers	0.0	0.0	1.5	1.2	1.0	0.6
Laboratory technicians	0.6	0.7	0.3	0.8	0.4	0.8
Metal workers	14.9	5.3	0.3	0.0	5.2	2.5
Nurses and nursing associates	0.0	0.7	7.8	7.7	5.2	4.4
Painters	1.1	1.1	0.0	0.4	0.4	0.8
Physicians	0.6	0.9	0.3	0.8	0.4	0.9
Printers	0.6	0.7	0.3	1.0	0.4	0.9
Rubber and plastic workers	1.7	0.9	1.5	0.6	1.5	0.8
Storage workers	1.7	1.8	1.2	1.2	1.3	1.5
Textile workers	0.6	0.2	2.3	2.4	1.7	1.4
Waiters	0.0	0.2	3.8	1.2	2.5	0.8
Wood and paper workers	3.4	2.7	0.9	0.4	1.7	1.5
Professionals, clerks, and administrative†	23.4	37.2	26.9	31.2	25.7	34.0
Other	6.9	5.9	7.5	9.5	7.3	7.8
Students	5.7	2.1	5.8	4.1	5.8	3.1
Housewives	0.0	0.0	1.5	3.6	1.0	1.9
On maternity leave	0.0	0.0	0.3	1.4	0.2	0.8
On sick leave	0.6	0.2	0.0	0.0	0.2	0.1
Unemployed	4.6	2.5	4.9	6.3	4.8	4.5
Retired	5.1	5.9	9.3	7.1	7.9	6.6

* Information on occupation was missing for 18 (3.5%) cases and 32 (3.4%) controls.

† Reference category in the multivariate analyses.

DISCUSSION

Our results provide evidence that the risk of adult-onset asthma is greater than expected for several occupational groups. The risk increased among both male and female workers in the chemical, rubber and plastic, and wood and paper industries; for male forestry and metal workers; and for female waiters, cleaners, and dental workers.

Validity of the results

We reduced the likelihood of selection bias in both the design and analysis phases. We studied incident rather than prevalent cases of asthma and thus improved the validity of the risk estimates compared with many earlier cross-sectional studies. The incident case-control study is an efficient design compared with a cohort study yielding a similar

TABLE 4. Adjusted odds ratios of asthma in different occupational groups,* The Finnish Environment and Asthma Study, 1997–2000

Occupational group	Men		Women		Total	
	OR†,‡	95% CI†	OR‡	95% CI	OR§	95% CI
Bakers and food processors	8.62	0.86, 86.5	0.83	0.22, 3.05	1.71	0.58, 5.10
Chemical industry workers	5.56	0.48, 64.7	5.69	0.58, 55.8	5.69	1.08, 29.8
Cleaners			1.42	0.81, 2.48		
Construction and mining workers	1.37	0.64, 2.96				
Day-care workers			0.82	0.34, 1.99		
Dentists and dental workers			4.74	0.48, 46.5		
Drivers	0.92	0.33, 2.57	2.04	0.13, 33.1	1.23	0.54, 2.15
Electrical and electronic production workers	2.83	0.82, 6.93	0.61	0.11, 3.51	1.52	0.61, 3.80
Engine workshop workers	1.04	0.39, 2.77				
Farmers and agricultural workers	1.01	0.36, 2.84	1.23	0.52, 2.91	1.12	0.59, 2.14
Forestry and related workers	6.00	0.96, 37.5				
Fur and leather workers			0.63	0.15, 2.66		
Glass, ceramic, and mineral workers	1.14	0.22, 5.95				
Hairdressers			0.88	0.24, 3.27		
Laboratory technicians	1.66	0.17, 16.6	0.44	0.05, 4.00	0.75	0.15, 3.74
Metal workers	4.52	2.35, 8.70				
Nurses and nursing associates			1.00	0.58, 1.75		
Painters	1.62	0.30, 8.80				
Physicians	1.14	0.12, 10.6	0.39	0.04, 3.64	0.62	0.13, 3.04
Printers	1.02	0.10, 10.2	0.31	0.04, 2.70	0.52	0.11, 2.52
Rubber and plastic workers	2.70	0.58, 12.7	2.52	0.58, 10.9	2.61	0.92, 7.42
Storage workers	1.57	0.40, 6.19	0.98	0.27, 3.60	1.21	0.47, 3.12
Textile workers	4.70	0.29, 77.1	0.88	0.34, 2.26	1.19	0.49, 2.88
Waiters			3.03	1.10, 8.31		
Wood and paper workers	1.73	0.60, 4.99	2.03	0.33, 12.4	1.72	0.71, 4.17
Other occupations	1.83	0.85, 3.92	0.80	0.46, 1.37	1.09	0.70, 1.70
Professionals, clerks, and administrative	1.00					

* Professionals, clerks, and administrative workers were considered the reference category.

† OR, odds ratio; CI, confidence interval.

‡ Adjusted for age and smoking.

§ Adjusted for age, gender, and smoking.

amount of information. The present study corresponds to a follow-up of approximately 100,000 adults for 5 years if we assume a realistic asthma incidence of one case per 1,000 person-years. The confidence intervals for the risk estimates were relatively wide, indicating low precision due to a small number of workers in many of the 25 occupational groups assessed. Our study took into account a change in job after appearance of respiratory symptoms to reduce potential bias related to avoidance of occupational exposures.

We attempted to reduce information bias by introducing the study to the participants as a study on environmental factors in general, with no special emphasis on occupational exposures. Information on exposures was collected from cases and controls in a similar way. The possibility of differ-

ential information on current or previous occupations cannot be fully excluded, but occupational category is likely to be less sensitive to bias than reported information on the presence of some specific occupational exposures per se. We defined asthma on the basis of clinical and lung function findings to eliminate information bias concerning the outcome, which could result if persons with occupational exposures interpreted their respiratory symptoms as asthma. Information bias could also result from basing the diagnosis solely on registries, but, for our cases ($n = 159$) recruited through the National Social Insurance Institution, we verified the diagnosis by reviewing the medical records of each potential case.

In multivariate analyses, we were able to adjust for age, smoking, and gender. However, we cannot totally exclude the possibility of confounding due to other personal or environmental factors.

Synthesis with previous knowledge

We identified nine studies that investigated the relations between occupational exposures and the risk of prevalent asthma in population-based settings (3–8, 10, 12, 13). The first cross-sectional studies from Italy, Norway, and China provided estimates for the relation between the risk of asthma and self-reported occupational exposure to dust, chemicals, or gases (3–5). These studies were followed by cross-sectional studies conducted in Singapore (6), Spain (7), New Zealand (8), the United States (10), and, in collaboration, in 12 European Union (EU) countries (12), where the risks of asthma in different occupational groups were compared. Recently, results of a registry linkage of the Medical Reimbursement Register and the Finnish Register of Occupational Diseases for 1986–1998 were published (14). This study provided age-adjusted incidence rate ratios for men and women in different occupational groups using administrative workers as a reference category. This study based the diagnosis of asthma, as well as the classification of occupation, on register data only, thus being vulnerable to misclassification of both exposure and outcome. In addition, study investigators were not able to adjust for smoking because of a lack of individual information on smoking habits.

Consistent with the EU study, the risk of asthma according to the present study was increased for workers in the chemical industry and the rubber and plastic industry. The effect estimates in the present study were substantially higher (OR = 5.69 for the chemical and OR = 2.70 for the rubber and plastic industry) than in the EU study (OR = 1.33 and OR = 2.20, respectively), although the confidence intervals included the EU study estimates. The focus on prevalent cases of asthma in the EU study may have led to some underestimation in the presence of selection of occupation or change of job due to early symptoms and signs of asthma. The Finnish registry linkage study reported incident rate ratios of 1.36 and 1.41 for men and women, respectively, in the chemical industry (14).

We also found an increase in the risk of asthma related to the wood and paper industry (adjusted OR = 1.72, 95 percent CI: 0.71, 4.17). The paper and pulp industry constitutes the major branch of traditional industry in Finland. Most pulp mills produce sulfate cellulose and emit malodorous sulfur compounds, such as hydrogen sulfides, methylmercaptans, and sulfur dioxide. Handling of pulp and paper is likely to result in exposure to paper dust. Cross-sectional studies from Finland have shown an increased risk of lower respiratory symptoms, such as cough and wheezing, in relation to living in the vicinity of pulp mills (22, 23).

Our finding of an increased risk of asthma among male metal workers (adjusted OR = 4.52, 95 percent CI: 2.35, 8.70) is consistent with findings from the population-based study conducted in Spain (7). In addition, the EU study reported a slight, nonsignificant increase in the risk of asthma among welders (12). The Finnish registry linkage

study provided a somewhat lower risk estimate of 1.70 (95 percent CI: 1.40, 2.00) for men, but it also reported an increased risk of 1.63 for women (95 percent CI: 1.14, 2.33) (14).

Studies conducted in Singapore (adjusted OR = 1.91, 95 percent CI: 1.22, 2.99) and Spain (adjusted OR = 1.82, 95 percent CI: 0.78, 4.22), as well as the EU study (adjusted OR = 1.97, 95 percent CI: 1.33, 2.97), reported an increased risk of asthma among cleaners (6, 7, 12). In the present study, we found a 42 percent increase in the risk of asthma among female cleaners. This observation supports the hypothesis about the occupational hazards related to cleaning work. Potential mechanisms include a strong irritative effect on the airway epithelium due to a mixture of several irritative chemicals, as well as an interaction between irritative chemicals and dust exposure. The risk estimates from the Finnish registry-linkage study were of the same magnitude (adjusted OR = 1.50, 95 percent CI: 1.43, 1.57) (24).

The asthma risk was also increased substantially among female waiters (adjusted OR = 3.03, 95 percent CI: 1.10, 8.31). To our knowledge, this finding is original, since previous epidemiologic studies on occupation-related asthma did not focus on this occupational group. Exposure to environmental tobacco smoke has been a predominant occupational hazard for waiters, and some evidence suggests that such exposure in adulthood increases the risk of asthma (25). Workplace exposure to environmental tobacco smoke has been linked with asthma in some previous studies (26–28).

Conclusion

The present results provide evidence of the role of several occupations in the development of asthma. Research identifying previously unknown causes of asthma is warranted so that workers' protection measures can be developed. For example, the role of environmental tobacco smoke and chemicals used by cleaners should be evaluated further.

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REFERENCES

1. Chan-Yeung M, Malo J. Occupational asthma. *N Engl J Med* 1995;333:107–12.
2. Cullinan P, Newman Taylor AJ. Aetiology of occupational asthma. *Clin Exp Allergy* 1997;27(suppl 1):41–6.

3. Viegi G, Prediletto R, Paoletti P, et al. Respiratory effects of occupational exposure in a general population sample in north Italy. *Am Rev Respir Dis* 1991;143:510–15.
4. Bakke P, Eide GE, Hanoa R, et al. Occupational dust or gas exposure and prevalences of respiratory symptoms and asthma in a general population. *Eur Respir J* 1991;4:273–8.
5. Xu X, Christiani DC. Occupational exposures and physician-diagnosed asthma. *Chest* 1993;104:1364–70.
6. Ng TP, Hong CY, Goh LG, et al. Risks of asthma associated with occupations in a community-based case-control study. *Am J Ind Med* 1994;25:709–18.
7. Kogevinas M, Anto JM, Soriano JB, et al. The risk of asthma attributable to occupational exposures. A population-based study in Spain. *Am J Respir Crit Care Med* 1996;154:137–43.
8. Fishwick D, Pearce N, D'Souza W, et al. Occupational asthma in New Zealanders: a population based study. *Occup Environ Med* 1997;54:301–6.
9. de la Hoz RE, Young RO, Pedersen DH. Exposure to potential occupational asthmogens: prevalence data from the National Occupational Exposure Survey. *Am J Ind Med* 1997;31:195–201.
10. Forastiere F, Balmes J, Scarinci M, et al. Occupation, asthma, and chronic respiratory symptoms in a community sample of older women. *Am J Respir Crit Care Med* 1998;157:1864–70.
11. Monso E, Munoz-Rino F, Izquierdo J, et al. Occupational asthma in the community: risk factors in a western Mediterranean population. *Arch Environ Health* 1998;53:93–8.
12. Kogevinas M, Anto JM, Sunyer J, et al. Occupational asthma in Europe and other industrialised areas: a population-based study. *Lancet* 1999;353:1750–4.
13. Johnson AR, Dimich-Ward HD, Manfreda J, et al. Occupational asthma in adults in six Canadian communities. *Am J Respir Crit Care Med* 2000;162:2058–62.
14. Karjalainen A, Kurppa K, Martikainen R, et al. Work is related to a substantial portion of adult-onset asthma incidence in the Finnish population. *Am J Respir Crit Care Med* 2001;164:565–8.
15. Blanc PD, Toren K. How much adult asthma can be attributed to occupational factors? *Am J Med* 1999;107:580–7.
16. Balmes J, Becklake M, Blanc P, et al. American Thoracic Society Statement: occupational contribution to the burden of airway disease. *Am J Respir Crit Care Med* 2003;167:787–97.
17. 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.
18. Jaakkola JJK, Jaakkola N, Piipari R, et al. Pets, parental atopy and asthma in adults. *J Allergy Clin Immunol* 2002;109:784–8.
19. Committee on National Asthma Program in Finland. Asthma program 1994–2004. (In Finnish). Helsinki, Finland: Ministry of Social Affairs and Health, 1994. (Publication no. 16).
20. Jaakkola JJK, Miettinen P. Type of ventilation system in office buildings and sick building syndrome. *Am J Epidemiol* 1995;141:755–65.
21. Jaakkola MS, Jaakkola JJK. Office equipment and supplies: a modern occupational health concern? *Am J Epidemiol* 1999;150:1223–8.
22. Jaakkola JJK, Vilkkä V, Marttila O, et al. The South Karelia Air Pollution Study: the effects of malodorous sulfur compounds from pulp mills on the respiratory symptoms and other symptoms in adults. *Am Rev Respir Dis* 1990;142:1344–50.
23. Partti-Pellinen K, Marttila O, Vilkkä V, et al. The South Karelia Air Pollution Study: low-level exposure to malodorous sulfur compounds as a determinant of eye, respiratory and central nervous symptoms in adults. *Arch Environ Health* 1996;51:315–20.
24. Karjalainen A, Martikainen R, Karjalainen J, et al. Excess incidence of asthma among Finnish cleaners employed in different industries. *Eur Respir J* 2002;19:90–5.
25. Jaakkola MS, Jaakkola JJK. Effects of environmental tobacco smoke on respiratory health in adults. *Scand J Work Environ Health* 2002;28(suppl 2):54–72.
26. Greer JR, Abbey DE, Burchette RJ. Asthma related to occupational and ambient air pollutants in nonsmokers. *J Occup Med* 1993;35:909–15.
27. Flodin U, Jönsson P, Ziepgler J, et al. An epidemiologic study of bronchial asthma and smoking. *Epidemiology* 1995;6:503–5.
28. Jaakkola MS, Piipari R, Jaakkola N, et al. Environmental tobacco smoke and development of adult-onset asthma: a population-based incident case-control study. *Eur Respir J* 2001;14(suppl):P1906.