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Exploration of asthma risk by occupation — extended analysis of an incidence study of the Finnish population

by Antti Karjalainen, MD,¹ Kari Kurppa, MD,¹ Rami Martikainen, MSc,¹ Jussi Karjalainen, MD,² Timo Klaukka, MD³

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Objectives The objective of the study was to determine asthma risks at the most-detailed level of occupational classification in a previously described nationwide follow-up study that included the entire employed workforce of Finland.

Methods In Finland, persons with clinically verified persistent asthma are registered for medication reimbursement within the national health insurance scheme. Data were combined from three national registers, and all 25- to 59-year-old employed Finns were followed for asthma incidence in 1986–1998. Altogether 49 575 cases were detected. A log-linear model was used to estimate the relative risks of asthma for 275 nonadministrative occupations in comparison with administrative work (33 occupations).

Results A significantly increased risk was found for either men or women in 125 occupations. For the men, the risk was highest among bakers, laundry workers, shoemakers and repairers, tanners, fell mongers and pelt dressers, and metal plating and coating workers. For the women, the risk was highest among shoemakers and repairers, railway and station personnel, jewelry engravers, engine room crew, molders, round-timber workers, and bakers.

Conclusions The results suggest that the work-related excess of asthma incidence is much more widely spread across the labor force than has been previously thought. A great number of occupations deserves to be targeted for in-depth studies focusing on the determinants of asthma excess and on possibilities for better asthma control among asthmatics working in these occupations. The large work-relatedness of asthma incidence should also raise public health interest because of the economic losses incurred and the potential for prevention.

Key terms epidemiology, incidence, occupational asthma, risk.

Although more than 200 specific agents at worksites are known to cause asthma (1), knowledge on etiologies and risks for occupational asthma still remains incomplete, and the population burden is poorly known even for the recognized causative agents. One reason for such a limited understanding is that asthma epidemiology is hampered by peculiar methodological difficulties that distinguish it from the epidemiology of many other chronic diseases. (See reference 2.) Difficulties for epidemiologic studies are created by problems of definition, conclusive case ascertainment, and the variable clinical course of asthma.

Large population-based comparisons of asthma incidence between occupational groups could provide

deeper insight into the extent of work-related asthma. The variation of disease incidence among different occupational groups may suggest hypotheses on risks that have thus far remained unrecognized. Specific in-depth epidemiologic studies could then be focused on such occupations. Conventional strategies for such explorations are, however, ineffective, the annual incidence of adult-onset asthma being below 0.3%.

In Finland linkages of national registers allow for an efficient exploration of the differences in asthma incidence between occupational groups. Persons with clinically well-established persistent asthma are eligible for medication reimbursement within the national health insurance scheme and are therefore registered. We have

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conducted a nationwide population follow-up in order to calculate occupation-specific incidence rates and relative risks of adult-onset asthma. On the basis of this follow-up, we recently reported estimates of the attributable fraction for work-related factors in persistent adult-onset asthma (3). The attributable fraction of work was 29% for men and 17% for women. This excess was mainly due to an increased incidence rate in the major occupational categories of agricultural, manufacturing, and service work. The nearly 50 000 incident cases of asthma of the study make exceptionally detailed occupation-specific analyses possible. The aim of our present paper was to extend the previously reported coarse analysis to the most-detailed level of occupational classification in order to estimate the occupation-specific relative risks of asthma and to analyze the importance of certified occupational asthma in the occupation-specific excess.

Subjects and methods

Study population and design

The study consisted of a follow-up of the employed Finnish population during 1986–1998. Technically it consisted of three cohorts from consecutive national population censuses. All employed Finns without pre-existing asthma and between the ages of 25 and 59 years on 31 December 1985, 1990, and 1995 were classified according to their occupation and followed for asthma during 1986–1990, 1991–1995, and 1996–1998, respectively. There were 0.99, 1.01, and 0.88 million employed men and 0.90, 0.95, and 0.83 million employed women under follow-up in the 1985, 1990 and 1995 cohorts, respectively.

The follow-up was done using the unique personal identification code and two national registers (the Medication Reimbursement Register of the Social Insurance Institution of Finland and the Finnish Register of Occupational Diseases). Duplicate notifications between the registers were identified using the personal identification code. The matching of the registers to the population census according to the personal identification code failed in only 0.01% of the cases. For each follow-up period the cases and person-years were calculated according to the occupation the person held at the start of the follow-up. The study protocol was approved by the ethics committees of the participating institutions.

Definition and ascertainment of cases

In Finland, asthma is one of the chronic diseases that a person can receive compensation for medication at a higher than ordinary level. To receive the compensation

the patient has to apply for the entitlement from the Social Insurance Institution and provide a medical certificate written by a chest physician. (For children the physician must be a pediatrician.) For the application to be granted, the disease has to fulfill the diagnostic and severity criteria of asthma, including objective data of reversible bronchial obstruction and a typical and persistent pattern of disease (3). The national health insurance, which includes a drug reimbursement system, covers the entire population and consequently almost all Finnish patients with asthma fulfilling the criteria are identifiable in the register. The only exception concerns patients with recognized occupational asthma who receive full compensation for medication from Statutory Accident Insurance. The latter group of patients is centrally registered by the Finnish Register of Occupational Diseases. The recognition of occupational asthma necessitates a diagnosis of asthma made by a chest physician and individual evidence of a causal association between a specific workplace exposure and the disease.

A person was defined as an asthmatic case if he or she had received the right to be reimbursed for asthma medication from the Social Insurance Institution (95% of the cases) or had been notified for recognized occupational asthma to the Finnish Register of Occupational Diseases (5% of the cases). The date of the application (Social Insurance Institution) or the date of the notification (Finnish Register of Occupational Diseases) was used as the date of diagnosis.

Among those with special reimbursement rights for asthma medication, the reliability of the asthma diagnosis is high. In a random sample of working-aged asthmatics with reimbursement rights, clinically established asthma was present for 99% (3).

Classification of occupation

Information on employment status and current occupation is recorded for every person in the Finnish population census. The occupation was known for 99% of the employed in each of the three censuses. The occupational code is an extended classification of the International Standard Classification of Occupations published by the International Labour Office in 1958. In the analyses we used the following 10 major occupational groups and their 307 occupational categories: technical, physical science, social science, humanistic and artistic work (73 occupations), administrative, managerial and clerical work (33 occupations), sales work (12 occupations), agriculture, forestry, commercial fishing (16 occupations), mining and quarrying work (4 occupations), transport and communications work (24 occupations), manufacturing and related work (114 occupations), service work (30 occupations), military work (1 occupation), and unknown occupation.

Statistical analysis

The tasks performed and the exposures in a given occupation may differ between men and women. There is also a gender difference in the overall incidence of adult-onset asthma (4). Therefore all the analyses were performed separately for both genders. The incidence rate for each major occupational group and each occupation was calculated by summing up the cases and person-years from the three census cohorts and dividing the total number of cases by the accumulated person-years under follow-up. Incidence rate ratios (hereafter referred to as relative risks) and their 95% confidence intervals were estimated for each of the 275 nonadministrative occupations by a log-linear model adjusted for age at the start of the follow-up (25–39, 40–49, 50–59 years). Those employed in administrative, managerial, and clerical work (hereafter referred to as administrative work) were used as a reference group with little exposure to dusts, fumes, vapors, or other workplace air pollution.

Control of confounding

Adjustment for the follow-up period did not influence the occupation-specific relative risks, and this variable was not included in the model. Separate analyses were performed using as reference only the lower-level administrative employees (secretaries, office clerks, bookkeepers, and similar occupations). The incidence rate of asthma in this reference group was similar to that of

administrative workers in general, and consequently the relative risks for the exposed occupations did not change. Hence only the results based on the reference group of all administrative work are presented.

Results

There were 20 777 incident cases of asthma among the men and 28 798 among the women during the follow-up, of which 1224 cases among the men and 1240 cases among the women were cases of recognized occupational asthma.

The relative risk (RR) was estimated for all 275 of the nonadministrative occupations. For 125 of them, a significantly increased risk was found for either the men or the women (table 1). In 45 of them, the risk was significantly increased for both genders, in 35 the risk was significantly increased for one gender and nonsignificantly increased for the other, and 32 represented occupations in which the workforce consisted mainly of one gender only (ie, less than 5 cases in the other gender). In 12 of the occupations listed in table 1, the risk was significantly increased for one gender but nonsignificantly decreased for the other. For only one of the occupations was the risk significantly increased for one gender and significantly decreased for the other (table 1).

Table 1. Risk occupations for adult-onset asthma among employed Finns (25–59 years of age) in 1986–1998. In addition to all major occupational groups, the table includes all occupations with a significantly increased relative risk (RR) and ≥ 5 cases for either gender. (RR = relative risk, 95% CI = 95% CI confidence interval)

Occupation ^a	Men				Women			
	N	Population ^b	RR ^c	95% CI	N	Population ^b	RR ^c	95% CI
Technical, physical science, social science, humanistic and artistic work (0)	3 369	214 450	1.05	0.98–1.12	7 024	262 063	1.06	1.03–1.10
Civil engineering technicians (010)	349	16 610	1.28	1.14–1.45	77	2 533	1.28	1.02–1.60
Technicians in chemical engineering (014)	132	6 400	1.24	1.04–1.49	24	637	1.51	1.01–2.25
Technicians in mining and metallurgy (015)	43	1 534	1.65	1.22–2.23	2	33	2.41	0.60–9.64
Draftsmen and survey assistants (018)	43	2 081	1.62	1.20–2.20	63	2 542	0.98	0.77–1.26
Laboratory assistants (028)	47	2 729	1.19	0.89–1.59	231	7 682	1.20	1.05–1.37
Psychiatric nurses (035)	43	1 757	1.78	1.31–2.41	81	3 006	1.01	0.81–1.25
Assistant nurses and attendants (036)	24	1 208	1.72	1.15–2.57	784	24 525	1.27	1.18–1.37
Other occupations related to medical and nursing work (039)	42	1 433	1.84	1.35–2.50	16	675	0.90	0.55–1.48
Health inspectors (042)	6	619	0.59	0.26–1.30	16	340	1.87	1.14–3.05
Directors and nursing staff at child day care centers (055)	4	436	0.88	0.33–2.35	236	9 089	1.16	1.02–1.32
Other occupations in education and training (059)	33	1 314	1.56	1.10–2.21	53	2 022	1.16	1.02–1.32
Lay preachers (061)	11	272	2.41	1.33–4.36	6	139	1.43	0.64–3.17
Religious social work (062)	14	746	1.34	0.79–2.27	77	2 230	1.34	1.07–1.68
Performing artists and vocalists (086)	21	596	2.43	1.58–3.74	16	572	1.13	0.69–1.85
Social workers, child day care center staff, etc (091)	81	4 226	1.34	1.07–1.67	1 255	38 474	1.27	1.19–1.35
Administrative, managerial and clerical work (1)	1 275	79 087	1.00 (reference)		5 235	202 751	1.00 (reference)	
Sales work (2)	1 106	66 541	1.14	1.05–1.23	2 429	79 116	1.13	1.08–1.18
Retailers and leaseholders (201)	209	10 462	1.22	1.05–1.41	359	9 657	1.32	1.19–1.47
Commercial travelers and salesmen (220)	236	13 579	1.17	1.02–1.35	62	2 808	0.89	0.69–1.14
Shop personnel (231)	343	21 448	1.15	1.02–1.30	1 663	52 014	1.15	1.09–1.21
Service station attendants (234)	46	2 325	1.37	1.02–1.83	36	1 397	1.00	0.72–1.74

(continued)

Table 1. Continued.

Occupation ^a	Men				Women			
	N	Population ^b	RR ^c	95% CI	N	Population ^b	RR ^c	95% CI
Agriculture, forestry, commercial fishing (3)	3 670	97 052	2.12	1.99–2.26	3 279	58 617	1.84	1.76–1.92
Farmers, silviculturists, horticulturists (300)	2 774	64 180	2.32	2.17–2.48	1 912	34 070	1.90	1.80–2.00
Farm supervisors (302)	12	354	1.98	1.12–3.49	–	27	.	.
Forestry supervisors (303)	91	3 613	1.39	1.12–1.72	–	43	.	.
Livestock breeders (305)	4	306	1.06	0.40–2.82	23	630	1.94	1.29–2.93
Fur farmers (306)	56	1 435	2.35	1.80–3.08	16	291	1.83	1.12–3.00
Reindeer breeders (307)	17	560	1.87	1.16–3.02	–	21	.	.
Agricultural workers (310)	273	7 323	2.31	2.03–2.64	1 227	20 230	1.89	1.77–2.01
Gardeners and park workers (311)	43	1 775	1.62	1.19–2.19	57	2 017	1.03	0.79–1.33
Other occupations in agriculture, horticulture and animal husbandry (319)	3	89	2.44	0.79–7.58	11	170	2.54	1.41–4.59
Forestry workers and log floaters (340)	346	14 287	1.54	1.37–1.74	7	192	1.20	0.57–2.52
Mining and quarrying work, etc (4)	93	3 028	1.95	1.58–2.40	2	69	1.01	0.25–4.02
Miners, shot firers, etc (400)	38	1 049	2.16	1.56–2.98	–	6	.	.
Concentration plant workers (420)	12	329	2.36	1.34–4.17	–	6	.	.
Other miners and quarrymen (490)	29	1 045	1.83	1.27–2.65	1	30	1.21	0.17–8.58
Transport and communications work (5)	1 938	94 398	1.31	1.22–1.40	796	23 331	1.22	1.13–1.31
Engineroom crew (511)	11	477	1.51	0.83–2.73	7	108	2.58	1.23–5.41
Motor vehicle and tram drivers (540)	1 321	61 700	1.35	1.25–1.46	86	2 380	1.33	1.07–1.65
Railway and station personnel (traffic department) (550)	117	5 069	1.43	1.19–1.73	13	137	3.25	1.89–5.60
Road transport supervisors (563)	59	2 426	1.49	1.15–1.94	5	562	0.37	0.16–0.90
Telephone switchboard operators (572)	6	263	1.72	0.77–3.84	142	4 117	1.24	1.05–1.46
Newspaper delivery work (581)	16	931	1.21	0.74–1.99	100	2 190	1.57	1.29–1.92
Office receptionists (concessionaires) and messengers (582)	56	2 416	1.48	1.13–1.93	52	1 162	1.63	1.24–2.14
Manufacturing and related work (6/7)	7 836	334 935	1.56	1.47–1.65	3 270	88 555	1.33	1.27–1.39
Weaving machine operators (602)	7	261	1.84	0.87–3.86	54	1 244	1.50	1.15–1.97
Textile inspectors (606)	1	12	5.99	0.84–42.6	18	355	1.62	1.02–2.57
Tailors, salon seamstresses (610)	7	161	1.83	0.87–3.85	64	1 762	1.31	1.02–1.67
Industrial sewers, etc (615)	5	123	2.63	1.09–6.33	394	13 044	1.10	0.99–1.22
Other cutting, sewing and upholstering occupations (619)	6	153	2.73	1.23–6.09	36	1 269	1.02	0.73–1.42
Shoemakers and shoe repairers (620)	12	284	2.79	1.58–4.93	6	50	4.32	1.94–9.61
Shoe sewers, leather cutters for footwear and other footwear workers (621)	20	694	1.87	1.20–2.91	48	2 210	0.77	0.58–1.02
Metal smelting furnacemen (630)	51	2 040	1.62	1.22–2.14	3	61	6.31	2.03–19.6
Smiths (633)	19	430	2.37	1.51–3.74	1	26	1.22	0.17–8.69
Molders (634)	26	1 271	1.33	0.90–1.97	12	166	2.56	1.45–4.51
Wire and pipe drawers (635)	10	305	2.11	1.13–3.94	2	42	1.59	0.40–6.35
Other occupations in smelting, metallurgical and foundry work (639)	44	1 580	1.84	1.36–2.49	8	301	0.91	0.45–1.82
Jewelry engravers (645)	3	104	1.73	0.56–5.38	6	79	2.77	1.25–6.18
Turners, toolmakers and machine-tool setters (650)	328	14 800	1.52	1.35–1.72	30	842	1.25	0.87–1.79
Fitter-assemblers, etc (651)	352	17 413	1.41	1.25–1.59	7	321	0.84	0.40–1.76
Machine and engine mechanics (652)	389	20 584	1.30	1.16–1.45	7	283	0.94	0.45–1.97
Sheet metal workers (653)	385	14 615	1.86	1.66–2.08	6	185	1.21	0.54–2.70
Plumbers (654)	309	11 128	1.78	1.57–2.01	–	37	.	.
Welders and flame cutters (655)	395	14 288	1.91	1.71–2.14	23	523	1.60	1.06–2.41
Metal plating and coating work (656)	22	598	2.71	1.78–4.12	12	214	1.97	1.12–3.47
Assemblers and other machine and metalware occupations (657)	115	6 113	1.29	1.07–1.56	122	3 445	1.25	1.04–1.49
Electricians (660)	375	21 285	1.24	1.10–1.39	7	272	1.03	0.49–2.17
Electronics and telecommunications workmen (663)	118	7 321	1.25	1.03–1.51	15	706	0.90	0.54–1.49
Telephone installation crew, linemen and cable joiners (664)	116	5 582	1.38	1.14–1.67	5	229	0.84	0.35–2.01
Electrical and electronic equipment assemblers (665)	21	1 363	1.25	0.81–1.92	188	5 346	1.40	1.21–1.62
Round-timber workers (670)	19	654	1.70	1.08–2.67	12	155	2.56	1.45–4.51
Timberworkers (671)	175	5 505	2.05	1.75–2.40	44	769	1.96	1.46–2.64
Plywood and fiberboard workers (672)	34	1 314	1.75	1.24–2.46	73	1 412	1.77	1.41–2.23
Construction carpenters (673)	616	23 966	1.59	1.44–1.75	6	166	1.43	0.64–3.91
Bench carpenters (675)	42	1 779	1.59	1.17–2.17	5	124	1.53	0.64–3.67
Cabinetmakers and joiners etc (676)	98	4 882	1.39	1.13–1.71	10	550	0.67	0.36–1.25
Woodworking machine operators, etc (677)	86	3 878	1.55	1.24–1.92	30	692	1.49	1.04–2.13
Painters, lacquerers and floor layers (680)	324	10 609	1.92	1.70–2.17	34	843	1.45	1.03–2.03
Bricklayers, plasterers and tile setters (690)	108	3 648	1.87	1.54–2.27	2	48	1.56	0.39–6.26
Rod layers (692)	29	1 018	1.66	1.15–2.40	–	4	.	.
Concrete shutterers and finishers (693)	43	1 435	1.67	1.23–2.26	–	10	.	.
Asphalt roofing workers (694)	11	338	2.11	1.16–3.82	–	0	.	.
Insulation workers (695)	60	2 361	1.69	1.31–2.19	3	74	1.37	0.44–4.26
Assisting building workers and other assisting construction workers (697)	431	16 204	1.66	1.49–1.85	34	713	1.62	1.16–2.27

(continued)

Table 1. Continued.

Occupation ^a	Men				Women			
	N	Popula- tion ^b	RR ^c	95% CI	N	Popula- tion ^b	RR ^c	95% CI
Manufacturing and related work (continued)								
Printers (701)	46	3 455	0.98	0.73–1.32	27	584	1.72	1.18–2.51
Grain millers (720)	18	451	2.40	1.51–3.83	2	41	1.65	0.41–6.61
Bakers (721)	118	2 236	3.78	3.13–4.57	293	4 080	2.54	2.26–2.86
Chocolate and confectionery manufacturers (722)	6	181	2.34	1.05–5.22	22	556	1.38	0.91–2.10
Brewers, beverage makers and kilnmen (723)	14	445	2.14	1.27–3.63	15	380	1.37	0.83–2.28
Cannery workers (724)	6	310	1.26	0.57–2.82	19	339	2.03	1.29–3.18
Butchers and sausage makers (725)	74	2 687	1.97	1.56–2.49	23	1 140	0.76	0.50–1.15
Dairy workers (726)	24	713	2.30	1.54–3.44	76	1 802	1.41	1.13–1.77
Paper and cardboard mill workers (735)	160	7 930	1.35	1.15–1.59	60	1 411	1.46	1.13–1.88
Refinery workers, other occupations in the chemical industry (736)	81	3 231	1.71	1.36–2.14	43	1 161	1.40	1.04–1.89
Tobacco industry workers (740)	–	28	.	.	11	171	2.20	1.22–3.98
Plastic product workers (752)	67	3 134	1.56	1.22–2.00	87	2 059	1.52	1.23–1.88
Tanners, fell mongers and pelt dressers (753)	12	286	2.74	1.55–4.83	18	318	1.88	1.19–2.99
Musical instrument makers, etc (755)	7	228	2.11	1.00–4.43	2	63	1.26	0.31–5.03
Concrete-mixer operators and cast concrete product workers (758)	58	2 430	1.58	1.21–2.05	9	130	2.38	1.24–4.58
Other occupations in manufacturing (759)	35	1 264	1.93	1.38–2.70	55	1 447	1.38	1.06–1.80
Packers and labelers, etc (760)	73	2 691	1.74	1.38–2.21	271	7 427	1.24	1.09–1.40
Crane operators, etc (770)	61	2 349	1.56	1.21–2.02	41	807	1.75	1.29–2.39
Forklift operators, etc (771)	148	5 491	1.66	1.40–1.97	20	528	1.33	0.86–2.07
Construction machinery operators, etc (772)	268	12 946	1.32	1.16–1.51	4	136	1.04	0.39–2.78
Stationary engine and machinery operators (not on vessels) (773)	118	4 234	1.65	1.37–2.00	12	262	1.66	0.94–2.92
Maintenance crews and supervisors (774)	45	1 810	1.71	1.27–2.30	19	425	1.61	1.03–2.53
Machine setter operators (not in textile industry) and riggers (775)	187	7 222	1.69	1.45–1.97	3	52	2.22	0.71–6.88
Stevedores, etc (780)	70	2 933	1.53	1.20–1.95	2	132	0.54	0.14–2.17
Warehouse workers (781)	310	13 613	1.54	1.36–1.74	199	4 495	1.58	1.37–1.82
Other manual workers (790)	127	4 834	1.62	1.35–1.95	42	821	1.80	1.33–2.43
Service work (8)	1 177	51 982	1.53	1.42–1.66	6 475	169 193	1.41	1.35–1.46
Firemen (800)	81	4 300	1.35	1.07–1.68	1	37	1.32	0.19–9.36
Policemen (801)	148	7 191	1.38	1.17–1.64	13	325	1.91	1.11–3.29
Customs officers and border guards (802)	47	2 663	1.19	0.89–1.60	11	217	2.15	1.19–3.88
Prison guards, etc (803)	50	1 562	2.03	1.53–2.69	8	149	2.27	1.13–4.53
Other guards (civil duties) (804)	116	4 572	1.65	1.36–1.99	28	603	1.70	1.17–2.46
Other occupations and guarding security (809)	9	306	2.23	1.16–4.30	11	193	2.21	1.22–3.99
Cooks, etc (811)	45	2 553	1.63	1.21–2.20	495	15 390	1.23	1.12–1.35
Kitchen assistants (812)	9	384	2.01	1.04–3.87	536	14 778	1.33	1.22–1.46
Housekeepers, child care in families and at home (813)	–	29	.	.	718	22 451	1.23	1.14–1.33
Home helps (municipal) (814)	5	214	1.70	0.71–4.09	451	12 052	1.44	1.31–1.59
Hotel and restaurant matrons (816)	1	65	1.55	0.22–11.0	33	751	1.67	1.18–2.35
Headwaiters, restaurant waiters (820)	39	2 695	1.26	0.92–1.74	393	9 815	1.62	1.46–1.80
Waiters in bars and cafes, etc (821)	14	743	1.40	0.83–2.37	273	7 404	1.36	1.20–1.53
Building caretakers (830)	408	14 787	1.65	1.48–1.84	187	4 720	1.37	1.19–1.59
Cleaners and headcleaners (831)	27	1 776	1.13	0.77–1.66	2414	53 708	1.52	1.45–1.60
Chimney sweeps (832)	28	781	2.34	1.61–3.41	–	3	.	.
Hairdressers and barbers (840)	10	372	2.09	1.12–3.89	376	9 494	1.61	1.45–1.79
Beauticians and pedicurists (841)	–	14	.	.	51	1 513	1.39	1.05–1.83
Laundry workers (850)	16	360	2.96	1.81–4.84	87	2 505	1.19	0.96–1.47
Pressing workers, etc, in laundries (851)	–	9	.	.	11	161	2.07	1.14–3.73
Hotel hall porters (890)	41	1 475	1.77	1.29–2.41	20	992	0.94	0.60–1.45
Burial service workers (892)	8	306	1.64	0.82–3.28	9	137	2.41	1.25–4.64
Military work (9)	112	9 243	0.95	0.78–1.15	2	121	0.82	0.21–3.28
Unknown occupation (X)	201	9 781	1.36	1.17–1.58	286	8 535	1.27	1.13–1.43
All	20 777	960 497	.	.	28 798	892 351	.	.

^a Occupational code in parentheses.^b Population = arithmetic mean of the employed population without preexisting asthma and between the ages of 25 and 59 years in the 1985, 1990, and 1995 censuses.^c Significantly increased relative risks are presented in boldface.

Among the men, the risk was significantly increased (5% level) in 98 occupations (table 1). The risk was highest among bakers (RR 3.78), laundry workers (RR 2.96), shoemakers and repairers (RR 2.79), tanners, fell

mongers and pelt dressers (RR 2.74), and metal plating and coating workers (RR 2.71). The study population covered the entire employed population. Therefore some of the occupation-specific risk estimates of table 1

represent occupations in which the excess risk was not very high, but still statistically significant due to the large number of cases. Table 2 lists a more restricted selection of high-risk occupations (ie, those with the

Table 2. Restrictive selection of risk occupations for adult-onset asthma among employed Finnish men (25–59 years) in 1986–1998. Only occupations were included for which the lower limit of the 95% confidence interval (95% CI) of the relative risk (RR) exceeded 1.50 and there were at least 5 cases.

Occupation ^a	N	Population ^b	RR	95% CI
Bakers (721)	118	2 236	3.78	3.13–4.57
Laundry workers (850)	16	360	2.96	1.81–4.84
Shoemakers and shoe repairers (620)	12	284	2.79	1.58–4.93
Tanners, fell mongers and pelt dressers (753)	12	286	2.74	1.55–4.83
Metal plating and coating work (656)	22	598	2.71	1.78–4.12
Performing artists and vocalists (086)	21	596	2.43	1.58–3.74
Grain millers (720)	18	451	2.40	1.51–3.83
Smiths (633)	19	430	2.37	1.51–3.74
Fur farmers (306)	56	1 435	2.35	1.80–3.08
Chimney sweeps (832)	28	781	2.34	1.61–3.41
Farmers, silviculturists, horticulturists (300)	2 774	64 180	2.32	2.17–2.48
Agricultural workers (310)	273	7 323	2.31	2.03–2.64
Dairy workers (726)	24	713	2.30	1.54–3.44
Miners, shot firers, etc (400)	38	1 049	2.16	1.56–2.98
Timberworkers (671)	175	5 505	2.05	1.75–2.40
Prison guards, etc (803)	50	1 562	2.03	1.53–2.69
Butchers and sausage makers (725)	74	2 687	1.97	1.56–2.49
Painters, lacquerers and floor layers (680)	324	10 609	1.92	1.70–2.17
Welders and flame cutters (655)	395	14 288	1.91	1.71–2.14
Bricklayers, plasterers and tile setters (690)	108	3 648	1.87	1.54–2.27
Sheet metal workers (653)	385	14 615	1.86	1.66–2.08
Plumbers (654)	309	11 128	1.78	1.57–2.01

^a Occupational code in parentheses.

^b Population = arithmetic mean of the employed population without preexisting asthma and aged 25–59 years in the 1985, 1990, and 1995 censuses.

Table 3. Restrictive selection of risk occupations for adult-onset asthma among employed Finnish women (25–59 years of age) in 1986–1998. Only occupations were included for which the lower limit of the 95% confidence interval (95% CI) of the relative risk (RR) exceeded 1.50 and there were at least 5 cases.

Occupation ^a	N	Population ^b	RR	95% CI
Shoemakers and shoe repairers (620)	6	50	4.32	1.94–9.61
Railway and station personnel (traffic department) (550)	13	137	3.25	1.89–5.60
Bakers (721)	293	4 080	2.54	2.26–2.86
Farmers, silviculturists, horticulturists (300)	1 912	34 070	1.90	1.80–2.00
Agricultural workers (310)	1 227	20 230	1.89	1.77–2.010

^a Occupational code in parentheses.

^b Population = arithmetic mean of the employed population without preexisting asthma and aged 25–59 years in the 1985, 1990 and 1995 censuses.

lower limit of the 95% confidence interval of the RR exceeding 1.5 for the men). There were 22 such occupations. Of the 98 occupations with a significantly increased risk at the 5% level among the men, 79 had a relative risk that was still significant at the 1% level.

Among the women, the risk was significantly increased in 72 occupations (table 1). The risk was highest among shoemakers and repairers (RR 4.32), railway and station personnel (RR 3.25), jewelry engravers (RR 2.77), engineroom crew (RR 2.58), molders (RR 2.56), round-timber workers (RR 2.56), and bakers (RR 2.54). Table 3 lists the occupations with the lower limit of the 95% confidence interval of the relative risk exceeding 1.5 for the women. There were five such occupations. Of the 72 occupations with a significantly increased risk at the 5% level among the women, 49 had a relative risk that was still significant at the 1% level.

In order to quantify the contribution of already established occupational risk factors in the overall work-related asthma excess, we performed separate analyses excluding all cases recognized as occupational asthma. Recognized cases of occupational asthma contributed importantly to very few of the occupation-specific risk estimates. For male bakers, 42% of the total cases of asthma and, for some agricultural occupations, about 20% of the cases had been recognized as occupational asthma (tables 4 and 5). In occupations not presented in tables 4 and 5, the contribution of recognized cases of occupational asthma was negligible.

For the men there were seven occupations with a relative risk slightly, but statistically significantly below unity, and for the women there were eight such occupations. They included physicians, judges, automatic data processing occupations, teachers, mechanical engineers, and some other occupations, mainly in the major occupational group of technical, physical science, social science, humanistic, and artistic work. For both the men and the women, two of the occupation-specific relative risks were significantly below unity at the 1% level.

Discussion

The case identification was done through two national registers that rely on diagnoses that have been made by chest physicians on the basis of physiological criteria and that represent a persistent form of asthma. This definition of asthma (ie, clinical assessment) is the standard used to validate the other definitions used in epidemiologic studies (5). The examination of the asthma diagnoses (see the Methods section) indicated that the positive predictive value of our definition was very high, but, on the other hand, our definition only covered

persistent forms of asthma. Consequently our results applied only to the work-related risk of persistent asthma.

We estimated the occupation-specific relative risks based on the occupation of the persons at the start of each of the 5-year follow-ups. Change of job due to respiratory symptoms is frequent before the diagnosis of asthma (6). Such changes would cause bias towards unity because people would probably move from occupations with exposure to occupations with less exposure. The assumption of a lack of exposure in our reference group is not fully tenable (eg, exposure to paper dust, emissions from office equipment or other impurities due to poor ventilation), however, and would again have caused underestimation of the occupation-specific risk estimates in the remaining occupations. Exposure to workplace air pollution occurs more often in occupations associated with a low socioeconomic status. Such

an association could introduce confounding due to life-style factors or housing environment and possibly result in overestimation of the work-related risk. A separate analysis using lower-level administrative workers as a reference group did not indicate such confounding of the work-related risk estimates.

There is conflicting evidence as to whether smoking is a risk factor for adult-onset asthma, although there are more studies showing no association (7–11). Recent studies of the work-related risks of asthma have reported that adjustment for smoking had only a minimal or no effect on the risk estimates (6, 11–13). We could not adjust for smoking, but it is unlikely that differences in the prevalence of smoking between occupations would have significantly biased our risk estimates.

Only a few population-based studies have previously estimated occupation-specific risks of asthma. The

Table 4. Comparison of the occupation-specific relative risk of asthma with and without recognized cases of occupational asthma among Finnish men in 1986–1998. Only occupations were included for which occupational asthma accounted for at least 10% of the cases and there were at least 5 cases. (95% CI = 95% confidence interval, RR_1 = relative risk based on all cases of asthma, RR_2 = relative risk after the exclusion of cases of occupational asthma)

Occupation ^a	Total asthma cases (N)	Recognized cases of occupational asthma		RR_1	95% CI ^b	RR_2	95% CI ^c
		N	%				
Farmers, silviculturists, horticulturists (300)	2774	664	24	2.32	2.27–2.48	1.76	1.64–1.89
Fur farmers (306)	56	12	21	2.35	1.80–3.08	1.87	1.39–2.53
Agricultural workers (310)	273	52	19	2.31	2.03–2.64	1.90	1.65–2.19
Painters, lacquerers and floor layers (680)	324	30	9	1.92	1.70–2.17	1.77	1.56–2.01
Bakers (721)	118	50	42	3.78	3.13–4.57	2.13	1.74–2.83
Butchers and sausage makers (725)	74	14	19	1.97	1.56–2.49	1.63	1.26–2.12
Plastic product workers (752)	67	10	15	1.56	1.22–2.00	1.36	1.04–1.77
Cooks, etc (811)	45	5	11	1.63	1.21–2.20	1.51	1.10–2.07

^a Occupational code in parentheses.

^b 95% CI for RR_1 .

^c 95% CI for RR_2 .

Table 5. Comparison of the occupation-specific relative risk of asthma with and without recognized cases of occupational asthma among Finnish women in 1986–1998. Only occupations were included for which occupational asthma accounted for at least 10% of the cases and there were at least 5 cases. (95% CI = 95% confidence interval, RR_1 = relative risk based on all cases of asthma, RR_2 = relative risk after the exclusion of cases of occupational asthma)

Occupation ^a	Total asthma cases (N)	Recognized cases of occupational asthma		RR_1	95% CI ^b	RR_2	95% CI ^c
		N	%				
Farmers, silviculturists, horticulturists (300)	1912	463	24	1.90	1.80–2.00	1.42	1.34–1.51
Livestock breeders (305)	23	5	22	1.94	1.29–2.93	1.52	0.96–2.42
Agricultural workers (310)	1227	276	23	1.89	1.77–2.01	1.45	1.35–1.55
Plywood and fiberboard workers (672)	73	9	12	1.77	1.41–2.23	1.55	1.21–1.98
Painters, lacquerers and floor layers (680)	34	5	15	1.45	1.03–2.03	1.23	0.86–1.78
Bakers (721)	293	77	26	2.54	2.26–2.86	1.86	1.62–2.13
Plastic product workers (752)	87	10	12	1.52	1.23–1.88	1.35	1.07–1.69

^a Occupational code in parentheses.

^b 95% CI for RR_1 .

^c 95% CI for RR_2 .

European Community Respiratory Health Survey calculated odds ratios for 30 aggregated sets of occupations based on a population sample of 15 637 people aged 20–44 years (14). A case-referent study from Singapore (787 cases, 1591 referents, aged 20–54 years) reported odds ratios for 9 major occupational groups and 30 of their subcategories according to the national classification of occupations (15). Due to the size of the studies, both used a classification of occupations that was less detailed than the one used by us. In addition, even at a broader level, the classifications were not fully comparable with each other or with ours. Nevertheless some comparisons can be made. Farmers and agricultural workers, as well as cleaners, had a roughly twofold relative risk in both of the other studies as well as in ours. In addition, the risks observed for manufacturing occupations in the metal industry, for the wood industry, for the food industry, for plastics production, and for welders and painters were similar between the European Community Respiratory Health Survey and our study.

Our epidemiologic approach to work-related asthma excess is broader than the definition of occupational asthma used for most surveillance or medicolegal purposes (16). As in a previous Finnish study (17), recognized cases of occupational asthma accounted for only 5% of all cases of adult-onset asthma in our study, and their contribution to the overall excess of asthma was minor for occupations other than bakers and some agricultural occupations. Most of the cases of occupational asthma in Finland (including those in our study) are related to exposure to sensitizing agents like flour dust and animal epithelia (18). In general it can be concluded that, with respect to occupational asthma, well-established causative agents are more likely to be compensated and reported and it is easier to justify causality at the individual level for sensitizing than for non-sensitizing agents. Therefore the information on work-related asthma excess from compensation or notification systems for occupational asthma is likely to be biased towards well-established sensitizing causative agents. For many of the risk occupations of our study, exposure to irritative indoor or outdoor pollutants or factors (eg, dusts, welding or soldering fumes, disinfectants, components of traffic or combustion exhaust, cold air, etc) may be more a plausible explanation for the excess risk. The aim of our study was not, however, to study specific work-related causative factors of asthma, but instead to determine systematically the occupation-specific relative risks. It is interesting, however, that, even for well-established risk occupations of sensitizer-related occupational asthma, the cases recognized for occupational asthma had only a minor contribution to the overall excess in asthma incidence.

Our only *a priori* assumption with respect to the risk occupations was that persons in administrative and

clerical work were considered “unexposed” to harmful air pollution at work. In other words, all the remaining occupations were considered as potentially having some harmful exposure, and a large number of comparisons was thereafter made to estimate the relative risk. In explorative studies covering a large number of occupations, some of the “significant” results are likely to be due to chance rather than due to true associations. In independent testing at the significance level of 5%, only 7 (2.5%) of the 275 occupation-specific tests of non-administrative workers would become “significant” in both directions merely by chance (or one or two occupations at the 1% level). For the reasons already pointed out, the relative risks observed in our study were, however, more likely to be underestimates than overestimates of the true relative risks. For most of the identified risk occupations, the risk was increased for both genders. It is also noteworthy that the major occupational groups of technical, physical science, social science, humanistic, and artistic work and sales work were not defined *a priori* as unexposed, because, although most of the workers in these occupations work under conditions resembling those of administrative and clerical work, in some of the occupations, specific exposures may occur (eg, laboratory work, pharmacies). It is noteworthy, however, that finally the overall relative risk of these major occupational groups and most of their subcategories was close to that of the reference group. Interestingly, the numbers of “significant” low-risk occupations found for each gender corresponded to the preceding estimates of the “chance” findings. Yet there may as well have been other reasons for the observed low risk, for example, a reduced need to seek reimbursement rights (physicians) or out-selection of symptomatic persons during obligatory military service (military work).

Our study is the first population-based nationwide study that has systematically determined the occupation-specific incidence and relative risk of adult onset asthma. The study included the entire employed workforce of Finland and covered 13 years and nearly 50 000 incident cases of asthma. Consequently it was possible to estimate the risks at a much more detailed level of occupational classification than before. A large number of risk occupations was identified, especially in manufacturing, service, and agricultural work. This information will be used to target studies focusing on the determinants of the asthma excess and to explore possibilities for better asthma control among asthmatics working in risk occupations.

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