

Agents causing occupational asthma in Finland in 1986–2002: Cow epithelium bypassed by moulds from moisture-damaged buildings

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Summary

Background Occupational asthma is an avoidable form of asthma. In Finland, the diagnosis of occupational asthma entitles substantial compensation to the employee. The diagnostics are based on symptoms, exposure assessment, allergologic investigations, follow-up of peak expiratory flow (PEF) at work and at home and, in many cases, specific challenge tests.

Objective To study the causative agents of occupational asthma in Finland.

Methods The causative agents and the numbers of new occupational asthma cases notified to the Finnish Register of Occupational Diseases (FROD) during 1986–2002 are reported.

Results The number of occupational asthma cases increased from 1986 until 1995, after which a downward trend, stabilizing during the last few years, has been observed. The majority of the cases (59%) in the beginning of the period (1986–1990) were associated with agriculture, but the percentage has fallen thereafter (42% of the cases in 1998–2002) along with the fall in the total number of cases. Since 1995, indoor moulds from water-damaged buildings have caused an increasing number of cases and have become the most important causative agents (0.5% cases, in 1986–1990 and 18% of the cases in 1998–2002). Chemicals have caused 10–30% of the cases, a decreasing number since 1990. The most important chemicals causing occupational asthma have been diisocyanates and welding fumes, followed by hairdressing chemicals and formaldehyde.

Conclusions The number of occupational asthma cases in Finland reached its height in the mid-1990s. The decrease in the number of total cases is because of the decrease in agriculture-associated cases, reflecting the number of employees in agriculture-associated occupations, which has greatly decreased since Finland joined the EU in 1995. An epidemic of mould-induced asthma, affecting mostly white-collar employees working in moisture-damaged buildings, has taken place since 1995.

Keywords asthma, challenge tests, occupational asthma

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Introduction

Because of the heterogeneity in legislation, diagnostic approaches, reporting and compensation systems, the statistics of occupational asthma in different countries are difficult to compare. In many countries, there are lists of substances that have been defined as possible causative agents, and only asthma caused by them can be accepted and compensated [1]. In only a few countries is exact knowledge of the causative agent of occupational asthma demanded to attain the compensation benefits. In Finland, subjects with confirmed occupational asthma are allowed substantial compensation. The insurance company of the employer is obliged to compensate financially and to pay for the re-education, if relocation to a more suitable job at the present work place is not possible. For this reason, insurance companies do not accept cases without profound examinations. In reality, this usually means specific challenge tests, which is the interna-

tional 'golden standard' method for diagnosing 'classical' occupational asthma, caused by sensitizing agents at the workplace [2]. The diagnostics of occupational asthma in Finland is uniform, and physicians are obligated to notify each new case to the Finnish Register of Occupational Diseases (FROD) kept by FIOH.

Earlier, the occupational asthma figures from Finland from the years 1989 to 1995 have been published, focusing on the incidence figures, and animal epithelia were found to be the most important causative agents followed by flour, grain and fodder [3]. In statistics from the UK and Quebec, Canada, from the years 1989 to 1999 (the UK) and 1988 to 1997 (Quebec) diisocyanates have been the leading inducer [1, 4, 5]. In France, the most common causative agent in 1996–1999 was reported to be flour, followed by diisocyanates [6].

Here we report the numbers and causative agents of the occupational asthma cases diagnosed in Finland from 1986 to 2002.

Materials and methods

In Finland, physicians are obligated to report new cases of occupational diseases to the FROD. The diagnoses are made

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in a limited number of hospitals by pulmonary specialists. Cases caused by common organic agents such as animal epithelia and flour are diagnosed at pulmonary departments of central hospitals. The diagnosis of cases caused by less common organic agents (enzymes, latex, colophony, etc.), chemicals and new sensitizers is centralized at the FIOH. During the observation period, the cases diagnosed at the FIOH accounted for 20–30% of all cases. Because of the uniform diagnostic process, notifications to the FROD are regularly made and the coverage of the register is considered to be good.

In the pulmonary hospitals, the diagnosis is based on symptoms, exposure assessment, sensitization to the offending agent (when possible), regular peak expiratory flow (PEF) measurements during periods at work and away from work and, in many, although not all cases, also on specific challenge tests. Sensitization to the usual organic agents has routinely been investigated by commercially available skin prick tests (SPTs), and in some cases, SPTs to less common work-related compounds [7]. In the cases diagnosed at the FIOH, the diagnosis is always confirmed by specific challenge tests. This means that most of the cases induced by chemicals and less common organic agents have been confirmed by challenge tests conducted at the FIOH. These tests have been individually planned and performed in the challenge chamber designed for this purpose.

The diagnoses of mould-induced occupational asthma (OA) have been performed at the central hospitals as well as at the FIOH. The diagnoses have been based on the same kind of assessment that is carried out for other agents. Specific SPTs to the mould species found in many moisture-damaged buildings (*Aspergillus fumigatus*, *Acremonium kiliense*, *Cladosporium cladosporioides*, *Geotrichum candidum*, *Penicillium brevicompactum*, *Rhodotorula rubra*, *Mucor racemosus*, *Penicillium expansum*, *Phoma herbarum*, *Aspergillus versicolor*, *Chaetomium globosum*, *Fusarium culmorum*) have been performed. Specific IgE antibodies to the same mould species have been determined, if available. PEF follow-up has been performed during working days and days off. In many cases, the definite diagnosis has been based on specific challenge tests. The challenge tests have been performed with the commercial allergen extracts defined for bronchial challenges (AKL, AbelloSA, Spain) as described earlier [8]. The challenge tests have been performed with the mould species found in the material (preferentially) or in the indoor air (subsidiary) samples from the workplace, taking into account the amount of growth/spores, as well. In practice, challenge tests have been performed with *Aspergillus fumigatus*, *Cladosporium cladosporioides* and *Acremonium kiliense* extracts, all known to be markers of exceptional moisture, if found indoors. From 20% to 50% of the mould-induced OA

Table 1. Occupational asthma cases reported to the FROD in 1986–2002. Age, sex distribution and the causative agents

	1986	1987	1988	1989	1990	1991	1992	1993	1994
Age (min., max., median)	19–64	18–63	17–63	16–62	17–65	18–64	18–64	17–71	18–68
	43	43	44	42	42	44	42	44	42
Sex (M/F, %)	53/47	54/46	46/54	51/49	53/47	50/50	54/46	53/47	53/47
Causative agents									
Animal epithelia	56	99	118	136	159	132	146	140	120
Flours	54	49	64	74	56	89	95	108	89
Moulds	1	2	2	2	1	1	3	5	13
Storage mites	1	0	6	5	7	12	23	25	31
Wood dusts	7	6	5	11	9	11	6	9	9
Decorative flowers, plants	5	1	3	3	4	2	5	5	4
Textile dusts	4	4	5	6	7	5	4	4	3
Colophony	2	0	7	2	5	1	0	3	3
Enzymes	2	1	0	3	2	2	2	8	5
Natural rubber	0	0	1	0	0	0	1	3	2
Organic agents total	132	162	211	242	250	255	285	310	279
Diisocyanates	22	28	21	19	34	24	11	13	11
Welding fumes	11	12	10	18	22	8	17	14	13
Hairdressing chemicals	2	2	10	3	5	2	4	6	4
Formaldehyde	10	2	7	8	17	7	9	2	5
Metal salts	4	3	1	2	9	7	3	1	6
Synthetic resins, paints, glues	2	5	4	7	5	6	10	7	9
Acid anhydrides	2	3	1	5	1	3	1	1	2
Acrylates	2	1	1	6	3	3	4	2	3
Amines	2	1	0	0	0	1	0	1	4
Dyes	2	4	0	2	0	1	3	1	1
Photographic chemicals	0	0	2	0	2	1	0	0	1
Drugs	2	0	0	0	1	3	2	1	0
Disinfection chemicals	0	0	2	0	0	0	0	1	0
Azodicarbonamide	0	0	0	0	0	1	0	1	1
Phthalates	0	0	0	0	0	0	0	1	0
Chemicals total	61	61	59	70	99	67	64	52	60
Other	34	43	20	31	29	31	31	24	26
Total	227	266	290	343	378	353	380	386	365

Table 1. (Contd.)

	1995	1996	1997	1998	1999	2000	2001	2002
Age (min., max., median)	19–63	18–64	19–63	19–65	18–75	18–72	21–63	18–73
	42	43	41	42	44	44	44	44
Sex (M/F, %)	43/57	47/53	43/57	43/57	53/47	44/56	42/58	44/56
Causative agents								
Animal epithelia	151	107	122	85	71	62	50	22
Flours	75	84	67	47	62	40	31	43
Moulds	46	84	56	38	34	48	63	79
Storage mites	34	41	22	16	26	14	14	19
Wood dusts	9	12	7	9	12	5	4	9
Decorative flowers, plants	3	6	10	9	11	7	6	1
Textile dusts	3	2	1	7	2	3	1	0
Colophony	3	1	0	0	1	1	1	0
Enzymes	2	2	2	1	1	5	0	1
Natural rubber	3	3	0	3	4	3	0	1
Organic agents total	329	342	287	215	224	188	170	175
Diisocyanates	12	8	7	6	7	4	3	6
Welding fumes	13	17	7	5	7	3	8	12
Hairdressing chemicals	15	9	7	5	3	10	6	6
Formaldehyde	4	6	6	3	7	0	0	4
Metal salts	6	0	4	2	7	1	5	3
Synthetic resins, paints, glues	5	5	4	1	5	8	5	2
Acid anhydrides	6	1	0	0	1	3	0	2
Acrylates	5	5	2	3	1	3	2	4
Amines	2	3	3	1	3	0	1	2
Dyes	2	0	2	1	0	0	0	0
Photographic chemicals	1	0	0	1	0	0	0	1
Drugs	0	2	0	1	0	0	0	1
Disinfection chemicals	1	1	0	0	0	0	0	0
Azodicarbonamide	0	0	2	1	2	0	0	1
Phthalates	1	0	0	0	0	1	2	0
Chemicals total	73	57	44	30	43	33	32	44
Other	19	18	17	14	33	57	72	87
Total	421	417	348	259	300	278	274	306

min., minimum; max., maximum; FROD, Finnish Register of Occupational Diseases.

cases have been diagnosed at the FIOH, and all these cases have been confirmed by specific challenge tests.

The data on the causes of occupational asthma and the number of cases were collected from the annual reports of the FROD from 1986 to 2002. We also compared the reported cases from Finland with those from Quebec, by the causative agent.

Results

The age, sex distribution, causative agents and numbers of new occupational asthma cases notified to the FROD during 1986–2002 are shown in Table 1. The occupations of the subjects with mould-induced OA during 1995–2002 are shown in Table 2. The comparison between Finland and Quebec according to the causative agent is shown in Table 3.

The number of OA cases has increased from 1986 to 1995, when a turning point can be seen. A sharp decrease took place between 1995 and 1998. Thereafter, the number has remained stable, being 250–300 new cases per year. The substantial decrease is explained by the decrease in cases caused by the most common organic agents, i.e. animal epithelia, flour and grain. The number of chemical-induced

cases has not decreased to the same extent. Men were mostly affected until 1995, but since then a predominance among women has been noted (Table 1). Cases are diagnosed at working age (16–73 years), concentrating in the fourth and fifth decades of life.

The most important agents causing occupational asthma in Finland have been animal epithelia until the year 2001, when they were bypassed by moulds. The overwhelming majority of animal epithelia occupational asthma cases are caused by cow epithelia (over 90%). Yearly, a few cases are registered to be caused by other animal epithelia, mostly laboratory and other test animals. The second most important agents causing occupational asthma in Finland have been flour and grain, affecting farmers and other agricultural workers, as well as bakers and food and beverage workers. The same workers may also develop occupational asthma from storage mites, present in the same work environments.

From the mid-1990s, an increasing number of mould-induced OA cases have been diagnosed. The epidemic has affected mostly white-collar employees without exposure to work-related sensitizing agents, but working in water-damaged buildings (Table 2). Other organic agents that have caused OA in Finland include natural rubber, wood dust,

Table 2. Occupations of patients with mould-induced occupational asthma in Finland in 1995–2002

Occupation	Number of cases	% of total mould cases (N = 448)
Teachers	54	12
Nurses	46	10
Office workers, secretaries	38	8
Nursery workers, childminders	38	8
Other health care and social workers	36	8
Farmers and agricultural workers	19	4
Food-processing workers	18	4
Cleaners	14	3
Social workers	13	3
Sales persons	12	3
Researchers	11	2
Supervisors, foremen	9	2
Doctors/dentists	8	2
Laboratory workers	8	2
Library and museum workers	7	2
Construction workers	7	2
Gardeners, greenhouse workers	6	1
Carpenters, woodworkers	5	1
Warehouse workers	5	1
Animal keepers	4	1
Packers	4	1
Officers	3	1
Papermaking industry workers	3	1
Technicians, mechanics	3	1
Occupation not defined	14	3
Total	381	85

In addition, one to two cases of each of the following: doorman, rail traffic officer, artist, photographer, journalist, police officer, postman, plumber, draughtsman, mechanic, laundry worker, telegraph operator, agent, designer, hair-dresser, bookbinding worker, printing trade worker, plywood worker, butcher, engineer.

colophony, textile and fur dust, various food stuffs (e.g. spices and vegetables), enzymes and decorative flowers, but only a few cases per agent yearly.

Low-molecular-weight chemicals have caused 30–100 cases per year, up to one-fourth of all. The most common causative chemicals have been diisocyanates and welding fumes. The number of cases because of diisocyanates was the highest in 1990, but has decreased thereafter significantly. Hairdressing chemicals have become an important group, whereas the number of welding fume and formaldehyde-induced cases has gradually fallen. Other less common asthma-inducing chemicals have been metal salts, synthetic resins, paints and glues, acid anhydrides, acrylates, amines, dyes, drugs, disinfection chemicals, photographic chemicals, azodicarbonamide and phthalates.

Compared with Quebec, an over-representation of animal epithelia- and formaldehyde-induced cases in Finland is seen, as well as cases caused by mould, storage mites and welding fumes, which are not represented in the Quebec material at all. At the same time, diisocyanate-, synthetic resin-, metal salt-, natural rubber-, drug- and seafood-induced cases form a larger part of cases in Quebec than in Finland (Table 3).

Table 3. Causative agents of occupational asthma in Finland (total reported cases, of which 75–90% are compensated) and in Quebec, Canada (compensated cases), 1988–1997 (12)

	Finland		Quebec	
	N	%	N	%
Animal epithelium	1331	36	34	6
Flours, cereals	801	22	130	23
Moulds	213	6	NR	
Storage mites	206	6	NR	
Welding fumes	139	4	NR	
Wood dusts	88	2	56	10
Diisocyanates	160	4	149	26
Hairdressing chemicals	65	2	11	2
Formaldehyde	71	2	2	<1
Synthetic resins, paints, glues	62	2	37	6
Metal salts	39	1	39	7
Natural rubber	13	<1	18	3
Drugs	9	<1	22	4
Photographic products	7	<1	2	<1
Seafood	NR		38	7
Others	477	13	32	6
Total	3681		570	

NR, not reported.

Discussion

The number of occupational asthma cases diagnosed in Finland has increased from 1986 to 1995, after which there was first a sharp decrease until 1998, and then a stabilizing trend. The reporting system in Finland is extensive, and most cases are confirmed by specific challenge tests. Notification to the register is sometimes made already at the time when the suspicion of the disease rises. As some cases do not turn out to be occupational asthmas on further examination, some over registration to FROD is possible. In Finland, the insurance cover of the employee is good, so the threshold for people to seek help for work-related symptoms is usually low and the fear of losing one's job does not play a central role. Unfortunately, from the year 2000, the coding system has enabled a more imprecise coding of the causing agent, which has increased the number of cases reported to be caused by unspecified agents, making the statistics more inaccurate from this year on.

The represented figures relate only to the 'classical' OA, caused by respiratory sensitizers. Reactive airways dysfunction syndrome, irritant-induced asthma or worsening of asthma in the work environment are not included.

The extraordinary trait in the epidemiology of OA in Finland has been the abundance of cases caused by cow epithelium. Dairy farming has been the primary source of livelihood among Finnish farmers until the end of the 1990s [9]. Because of climatic conditions, cattle must be kept inside during the long winter, which causes extended exposure to the animal dander during feeding and milking. Many Finnish farmers still brush their cows regularly, an action that concentrates the epithelial dust into the breathing zone of the keeper. These facts possibly account for the abundance of cases because of cow epithelium.

The decrease in the total amount of cases since 1995 is mostly explained by the fall in the quantity of cow-induced

cases. This seems to be a reflection of the fact that Finland joined the European Union in 1995. After this, the number of active farms has dramatically fallen, and especially small farms and livestock farms have been abolished. During 1990–2000, the number of active farms fell by 38% and most of the farms that discontinued their production were livestock farms [9]. The remaining farms have installed automated processes, resulting in better working conditions and lower exposure levels. Along with this development, the number of occupational asthma cases caused by cow epithelium, flour, grain and storage mites has fallen.

At the same time as the agriculture-associated cases have decreased, the number of mould-induced cases has dramatically increased. This is mainly because of the widespread moisture damages in Finnish buildings. The people affected are mostly white-collar employees working in these buildings, and only a minority are agricultural workers, exposed to mouldy hay (Table 2). During this period, in Finland, moisture damages and mould growth have been found in numerous official as well as private buildings [10–12]. The moisture damages mostly stem from errors during construction and/or maintenance of the buildings [12]. The climatic conditions during winter in Finland set specific requirements for construction. The moisture damage caused by faulty construction or maintenance defaults may take many years to evolve. In Finland, the most forceful construction period took place after the Second World War and during the 1960s and 1970s. So there are several equally old buildings, whose moisture damages seem to have started to show now.

The number of chemical-induced cases was at its height in the 1990s and has thereafter fallen slowly along with the decreasing number of cases caused by diisocyanates, welding fumes and formaldehyde. Hairdressing chemicals have become an important inducing group. The number of cases induced by other individual chemicals per year is so small that it is not feasible to draw any conclusions on their trends. The decreasing total number of chemical-induced cases may be attributed to better knowledge of the risks and more effective occupational hygienic measures. The possibility of underdiagnosing nevertheless exists. The suspicion requires profound knowledge of the characteristics of the chemicals. Unfortunately, the safety data sheets of the chemicals are not always informative enough. Moreover, as IgE-mediated sensitization is only rarely found in the case of chemicals, no simple clues to diagnosing exist. The most useful way to proceed when chemical-induced OA is suspected is to perform the PEF surveillance at work and on days off [13]. This, if well done, provides a direct clue for making the diagnosis, and for further examinations.

The focus of this analysis is on the causative agents of occupational asthma. Incidence figures for this same material for the years 1989–1995 have been presented earlier by Karjalainen et al. [3]. During that period, the incidence rate among men was the highest in bakers, followed by painters and laquerers, veterinary surgeons, other chemical-processing workers, farmers and animal husbandry workers, as well as food and beverage-manufacturing workers. Among women, the highest incidence rate was also found in bakers, followed by plywood and fiberwood workers and agricultural workers, painters, laquerers and other chemical-processing workers [3]. Since 1995, the mould epidemic and the decreasing number of agriculture-associated workforce have affected the incidence figures.

The comparison of OA-inducing agents from different countries has many pitfalls. The agents causing occupational diseases typically depend on the industrial structure of the country. Because of different legislation and data collection systems, the comparison of statistics is difficult. In Quebec, Canada, the diagnosis of OA is limited to specific sensitizing agents, and the diagnostics resemble that in Finland. Even this comparison is not completely valid, as the cases from Quebec represent compensated cases, whereas the cases from Finland represent all notified cases, irrespective of the compensation decision [1]. Of all the cases notified in Finland to FROD, 75–90% are accepted and compensated [1]. Compared with Quebec, in Finland more cases caused by animal epithelia, mould, storage mite, formaldehyde and welding fume are diagnosed, whereas cases induced by diisocyanates, wood dust, seafood, synthetic resins and metal salts form a larger proportion of the cases in Quebec. In the United Kingdom as well as in France, a reporting system based on voluntary reporting has been in use, in the UK since 1989 and in France since 1996 [14, 15], but only a minority of the diagnoses is based on challenge tests. In the UK, diisocyanates have remained the most important causative agent throughout the period 1989–1999 (14–22% of reported cases), followed by flour and grain (7–9%), laboratory animals (4–7%) and an increasing number caused by enzymes (8%) and cobalt (6%) in 1999 [4, 5]. In France, the most common causative agents in 1996–1999 were flour (about 20% of the cases), followed by diisocyanates (about 14%), natural rubber (about 7%), aldehyde and persulphate salts (both about 6%) and wood dusts (about 4%). During this 4-year period, there was a downward trend in cases caused by diisocyanates, whereas cases caused by persulphates and natural rubber showed an increasing trend [6]. The numbers in UK and France have remained more stable than in Finland.

In conclusion, OA cases induced by agriculture-associated agents have decreased along with the decrease in the total number of cases but an epidemic of new cases affecting employees from moisture-damaged buildings has emerged during the observation period in Finland. Nevertheless, underdiagnosing of occupational asthma is likely to exist [15]. Cases may be overlooked because of inappropriate knowledge of exposure, or because of the known difficulties in the diagnostics based on challenge tests [16, 17]. The epidemic of mould-induced OA cases is challenging to the construction industry, for these cases might be prevented by better construction and maintenance techniques. Despite the diminishing number of chemical-induced cases, new inducing chemicals will continue to emerge, challenging health care professionals working in this field.

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References

- 1 Bernstein LI, Keskinen H, Malo J-L. Medicolegal and compensation aspects. In: Bernstein IL, Chan-Yeung M, Malo J-L, Bernstein DI, eds. *Asthma in the workplace*. New York: Marcel Dekker, Inc., 1999; 279–97.

- 2 Allergy practice forum. Guidelines for the diagnosis of occupational asthma. *Clin Exp Allergy* 1992; 22:103–8.
- 3 Karjalainen A, Kurppa K, Virtanen S, Keskinen H, Nordman H. Incidence of occupational asthma by occupation and industry in Finland. *Am J Ind Med* 2000; 37:451–8.
- 4 McDonald JC, Keynes HL, Meredith SK. Reported incidence of occupational asthma in the United Kingdom, 1989–97. *Occup Environ Med* 2000; 57:823–9.
- 5 Meyer JD, Holt DL, Chen Y, Cherry NM, McDonald JC. SWORD '99: surveillance of work-related and occupational respiratory disease in the UK. *Occup Med* 2001; 51: 204–8.
- 6 Ameille J, Pauli G, Observatoire National des Asthmes Professionnels et al. Reported incidence of occupational asthma in France, 1996–99: the ONAP programme. *Occup Environ Med* 2003; 60:136–41.
- 7 Kanerva L, Estlander T, Jolanki R. Skin testing for immediate hypersensitivity in occupational allergology. In: Menne T, Maibach HI, eds. *Exogenous dermatoses: environmental dermatitis*. Boca Raton: CRC Press, 1991; 103–26.
- 8 Piipari R, Piirilä P, Keskinen H, Tuppurainen M, Sovijärvi A, Nordman H. Exhaled nitric oxide in specific challenge tests to assess occupational asthma. *Eur Respir J* 2002; 20: 1532–37.
- 9 Strategy for Finnish Agriculture, Final Report of the Steering Group, Working Group Report Ministry of Agriculture and Forestry 2001:16b, Helsinki, 2001.
- 10 Pirhonen I, Nevalainen A, Husman T, Pekkanen J. Home dampness, moulds and their influence on respiratory infections and symptoms in adults in Finland. *Eur Respir J* 1996; 9:2618–22.
- 11 Jaakkola MS, Nordman H, Piipari R et al. Indoor dampness and molds and the development of adult-onset asthma: a population-based incident case-control study. *Environ Health Perspect* 2002; 110:543–7.
- 12 Reijula K. Health risks of moisture and mould damaged buildings and the diagnostics of diseases (in Finnish). *Duodecim* 1996; 15:1390–7.
- 13 Burge BS. Single and serial measurements of lung function in the diagnosis of occupational asthma. *Eur J Respir Dis* 1982; 63 (Suppl. 123):47–59.
- 14 Meredith SK, Taylor VM, McDonald JC. Occupational respiratory disease in the United Kingdom 1989: a report to the British Thoracic Society and the Society of Occupational Medicine by the SWORD project group. *Br J Ind Med* 1991; 48:292–8.
- 15 Kopferschmitt-Kubler MC, Ameille J, Members of Observatoire National de Asthmes Professionnels Group et al. Occupational asthma in France: a 1-yr report of the Observatoire National de Asthmes Professionnels project. *Eur Respir J* 2002; 19:84–9.
- 16 Karjalainen A, Kurppa K, Martikainen R, Klaukka T, Karjalainen J. 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.
- 17 Cartier A. Occupational asthma: what have we learned? *J Allergy Clin Immunol* 1998; 102:S90–5.