

Small bakeries — a cross-sectional study of respiratory symptoms, sensitization and dust exposure

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This cross-sectional study investigated the prevalence of respiratory symptoms and sensitization to dust components in 224 individuals in 18 small bakeries in Scotland. Each work practice in the bakeries was characterized by an assessment of dust exposure and assigned to a category with either a direct exposure to flour dust or an indirect exposure to flour dust. We found that work-related respiratory symptoms were significantly associated with specific IgE to wheat flour and amylase but not to exposure category (except for nasal/eye symptoms). However, specific IgE to wheat flour was significantly associated with exposure category. There was a higher prevalence of immunological sensitization, reporting of work-related respiratory symptoms and exposure to dust than in other studies and of the 144 personal dust sample results taken, 21 (14.6%) of the total exceeded 10 mg/m³, the substantial dust concentration as outlined by the COSHH Regulations. Follow-up of those with work-related asthma symptoms (questionnaire response) was inconclusive of the work-relatedness of their symptoms, although it did confirm respiratory morbidity.

Key words: Bakers; flour dust; occupational asthma.

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INTRODUCTION

Respiratory disease in bakers has been known since the days of ancient Rome,^{1,2} and Ramazzini described the development of symptoms in bakers in the early 18th century through their exposure to bakery dust. De Besche in 1929, introduced the idea of baker's asthma as an allergic occupational disease,³ and a number of researchers have described 'sensitization' to bakery substances in workers in the trade.^{4,5,6,7} More recently, alpha-amylase, a bakery additive derived from *Aspergillus oryzae*, has been shown to be a potent sensitizer in its own right.^{8,9,10}

Between two and 15 per cent of all asthma cases are occupational in origin.¹¹ In theory, they are preventable, and the costs can be significant: for the sufferer there is ill-health and change or loss of employment; employers lose valued workers and face the prospect of litigation and society bears the cost of social security benefits and the loss of revenue from income tax.¹² Asthma due to flour and grain dust has consistently accounted for between 20 and 30% of cases of occupational asthma

compensated under the Industrial Injuries Compensation Scheme.¹³ Asthma in bakers was the second most prevalent cause of occupational asthma in an HSE-sponsored voluntary reporting scheme for occupational and respiratory physicians (SWORD).¹⁴

Most previous research work attempting to correlate prevalence of symptoms with exposure to airborne dust or airborne allergens has concentrated on employees in large bakeries.^{15,16} One study has been carried out in small establishments (less than 50 employees) in Italy¹⁷ but no occupational hygiene assessments were made.

Our study was concerned with small craft bakeries and aimed to identify the prevalence of symptoms and sensitization in workers in such bakeries, measure occupational exposure to bakery dust, and examine the inter-relationship of symptoms, sensitization, occupational history and dust exposure.

MATERIALS AND METHODS

This cross-sectional project was performed during 1990–91 in bakeries with fewer than 50 employees located in the central belt of Scotland. Premises were systematically selected from a list of those registered with the Health and Safety Executive (HSE), every fifth

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bakery being included. All employees with three months or more experience in the bakery industry were asked to participate. Those involved solely in collection and delivery of the product were excluded.

Questionnaire

A physician-administered questionnaire¹⁸ was put to each subject. The questionnaire covered nasal and eye, and upper and lower respiratory symptoms and their relationship to work and leisure activities. Further questions covered past medical history, smoking status and occupational history. Smokers were defined as those currently smoking or who had stopped within the last 12 months. Ex-smokers were regarded as those who had smoked at least one cigarette per day or equivalent for at least one year, prior to the previous 12 months.

Asthma symptoms were defined as wheeze, chest tightness and shortness of breath, and chronic bronchitis as cough productive of sputum on most days for at least three months of the year.

Exposure ranking

Job categories were ranked in order of perceived dustiness independently of measured dust concentrations. We based the ranking on a collective subjective assessment in consultation with bakery staff. Table 1 shows the ranking of tasks from 1–10, with the least dusty as 1 and the dustiest as 10. Numbers in several of the job categories were small and so the list was divided into two larger groups: A — those who handled flour directly *i.e.*, categories 6–10 and B — those in categories 1–5 whose exposure was likely to arise inadvertently from general contamination of workrooms.

Table 1. The job categories in bakeries ranked according to perceived dustiness

Rank	Work practice	Job category
10	Dough break/roll machine	Category A
9	General cleaning/bag collection	
8	Weighing and mixing	
7	Dividing and moulding	
6	Cake mixing	
5	Hot plate	Category B
4	Lidding/filling	
3	Pie shell making	
2	Sugar confectionery	
1	Proving and baking finishing/packing/glazing/shop/office	

Current dust exposure

In each bakery a number of workers were asked to wear dust samplers in order to obtain representative measurements of dust exposure for all tasks performed there. Simultaneous full shift (normally 8–10 hours) personal sampling was carried out for total inhalable and respirable dust. Results were expressed as 8-hour Time Weighted Average (TWA) exposures. The sampling and analysis were in accordance with the HSE method described in the document MDHS14.¹⁹ Sampling equipment consisted of United Kingdom atomic energy authority 7-hole or Casella cyclone heads fitted with 25 mm GFA filters, located in the worker's breathing zone and connected to portable battery pumps (Rotheroe and Mitchell L2SF or Casella SKC Aircheck). Dust concentrations were determined by gravimetric analysis.

Radio-allergosorbent testing

Blood was taken for radio-allergosorbent testing (RAST): sera were tested for specific IgE to bakery allergens and a screen for common environmental allergens. Twenty per cent w/v extracts of various flours (wheat, rye, barley, oat and soya) and egg, milk, cat fur (Allergon, Sweden), *Festuca pratense* (Allergon, Sweden), *Phleum pratense* (Allergon, Sweden), *Dactylis glomerata* (Allergon, Sweden) and amylase from *Aspergillus oryzae* (Sigma, UK) were made according to the method of Thomas *et al.*, 1991.²⁰ Extracts of *D. pteronissinus* (Allergon, Sweden) were made according to the method of Griffin *et al.*, 1989.²¹

The protein concentration of the extracts was measured using the method of Smith *et al.*, 1985²² adapted for use with microtitre plates.

Extracts were coupled to paper discs activated with cyanogen bromide using the following amount of allergen extract, as measured by protein estimation, per gram of discs: 30 mg of an equal mixture of three extracts (rye, barley, oat; egg, milk, soya; *D. pteronissinus*, grass pollens and cat fur) to make multiple allergen discs. Discs coated with a single allergen were incubated with 10 mg of extract. Sera were initially screened with multiple allergen discs and singly for wheat flour and amylase. Samples that were positive for multiple allergen discs were then screened with single allergen discs.

Specific IgE was measured using the RAST according to the method of Thomas *et al.*, 1991.²⁰ To establish background levels of binding within the assays, 105 blood samples from workers in an electronics factory, not occupationally exposed to bakery allergens, were used. Any sera with a per cent binding equal to or greater than the mean plus 2.5 standard deviations of the background levels were defined as a positive RAST.

Statistical procedures

All calculations were performed in 2 × 2 contingency tables with one degree of freedom and analysed using Fisher's exact test (Graphpad, Prism). Dust exposure data was described in terms of arithmetic and geometric means.

RESULTS

A total of 224 individuals in 18 premises completed the questionnaire, whilst 205 gave blood samples. Of the population, 55.4% were male and 74.5% were under 45 years old. Men tended to have been employed for a longer period than women. We found that 57% of men and 38% of women were in exposure group A.

Table 2 shows the numbers reporting symptoms and those considered work-related, *i.e.*, worse at work or better when away from work for a week or more.

Table 3 shows the prevalence of immunological sensitization to the various allergens tested. Nine workers had IgE to amylase but not to wheat flour. Table 4 shows the number of workers reporting one or more work-related respiratory symptoms (asthma type, bronchitic, cough, nasal) compared to the number of workers with specific IgE. There was a significant association between the number of workers reporting work-related respiratory symptoms and those with specific IgE to wheat flour

($p < 0.001$), amylase ($p < 0.001$), one or more occupational allergens ($p = 0.01$) and common environmental allergens ($p = 0.03$).

One hundred and forty-four dust samples were analysed for total inhalable and for respirable dust levels. Results were, where appropriate, converted to their 8-hour equivalents. The dust exposure results reflect uncontrolled flour releases (there was no evidence of control measures) from the various jobs and activities performed over the sampling period. Total inhalable dust concentrations ranged from 0.1–23.7 mg/m³, demonstrating wide variation in occupational exposures. Concentrations measured on average (geometric mean) 2.8 (SD = 3.3) mg/m³ with 51 (35%) values > 5 mg/m³ and 21 (15%) exceeding 10 mg/m³. Respirable dust exposure showed a similar diversity, ranging from 0.01–3.6 mg/m³ (GM = 0.17, SD = 0.28 mg/m³). In addition, respirable dust constituted a small proportion of total dust, measuring on average 11–14%. The results categorized into exposure groups A and B are shown in Table 5.

The distribution of work-related symptoms and specific IgE between high (A) and low (B) exposure categories is shown in Table 6. There was a significant association between the number of workers in each

Table 2. Questionnaire response of the number of workers reporting symptoms and whether they attributed the symptoms to work

Symptoms groups	Total reporting symptom		Number reporting symptoms as work-related	
	No.	(%)	No.	(%)
Chronic bronchitis	20	(8.9%)	15	(6%)
Cough and cough attacks	102	(45.5%)	46	(20.5%)
Asthma-type symptoms	104	(46.4%)	47	(20.9%)
Nasal/eye symptoms	105	(46.4%)	60	(26.8%)
At least one of the above symptoms	162	(72.3%)	98	(43.7%)
No symptoms	62	(27.7%)		

Table 3. The prevalence of specific IgE to various allergens

Allergen	Number of workers with specific IgE
Wheat	49 (24%)
Rye	33 (16%)
Barley	32 (16%)
Oats	9 (4%)
Egg	7 (3%)
Milk	5 (2%)
Soya	6 (3%)
Amylase	31 (15%)
Common environmental allergens	71 (34%)

Table 4. A comparison of the number of workers reporting work-related respiratory symptoms with those with specific IgE

Allergen	Number with specific IgE	Number with IgE and symptoms attributed to work	Number with IgE and symptoms not attributed to work, or asymptomatic
Wheat flour	49	31 (38)	18 (15)
Amylase	31	18 (22)	13 (11)
IgE to one or more occupational allergens	57	31 (38)	26 (21)
Common environmental allergens	71	36 (44)	35 (28)

The figures in brackets are the numbers as a percentage of the total number of workers who provided a blood sample and reported work-related respiratory symptoms (82) or reported no symptoms or symptoms not attributable to work (123).

Table 5. Total inhalable dust concentrations (8-hour TWA mg/m³) for exposure categories A and B

	Category A Directly exposed Job Cat > 6	Category B Indirectly exposed Job Cat < 6
Number	87	57
Maximum	23.7	5.5
Minimum	0.6	0.1
Arith. mean	6.7	1.5
SD	5.3	1.5
Geom. mean	4.9	1.0
SD	2.3	2.7
No. exceeding 5 mg/m ³	49 (56%)	2 (3.5%)
No. exceeding 10 mg/m ³	21 (24%)	0

SD = Standard Deviation

Table 6. Work-related symptoms by job category

Exposure category	Chronic bronchitis	Asthma	Nasal/eye	Specific IgE to wheat flour
A	10 (9.3%)	27 (25%)	36 (33.3%)	31 (30%)
B	5 (4.3%)	20 (17.4%)	24 (20.8%)	72 (18%)

(Percentage is of the total number in that category)

exposure group and those reporting nasal/eye symptoms ($p = 0.049$). There was no such significance for the other symptom groups. There was a significant association between the number of workers with specific IgE to wheat flour and the number in each exposure category ($p = 0.049$).

DISCUSSION

Our questionnaire results showed a higher prevalence of work-related respiratory symptoms than have been reported in other publications^{15,16,23} and, in contrast to published data,²³ we found that wheat flour and amylase were both sensitizers. These studies were carried out on populations from large industrial bakeries. The level of exposure to flour and amylase in these larger premises may have been lower because a smaller proportion of the workers were involved in handling flour and the automation of the plant may result in less dust being evolved. In an early study of immunological sensitization Herxheimer²⁴ commented that sensitization to flour dust occurs less often in large factories where there is suitable ventilation. However of more recent studies, only those of Musk *et al.*¹⁵ and Cullinan *et al.*¹⁶ made occupational hygiene measurements in the work place. In a prevalence study,¹⁵ personal dust exposure ranged from 0.8 mg/m³, 8-hour TWA in the lowest occupational category to 1.84–13.03 (GM = 6.59 mg/m³) in the highest. Chronic bronchitis and work-related chest and nasal symptoms were all more common in those exposed to higher levels of dust. A more recent prevalence study¹⁶ assessed the prevalence of respiratory and eye symptoms, by questionnaire, of 344 workers in seven large bakeries in the UK. Occupational hygiene measurements were made and workers were classified as having low (<1 mg/m³ total airborne dust or <100.9 µg/m³ airborne wheat flour allergen), medium (1–5 mg/m³ total airborne dust or 101–215.3 µg/m³ airborne wheat-flour allergen) or high (>5 mg/m³ total dust or >215.3 µg/m³ airborne allergen). As in our study the strongest correlation was between airborne dust and nasal/eye symptoms and the prevalence of chest related symptoms was higher in higher dust exposure categories, although the relationship was not significant. However, Cullinan *et al.*¹⁶ did not find a significant trend between dust exposure and skin prick test to wheat flour, in contrast to our results, but did find a correlation between workers with positive skin prick tests and airborne allergen. A possible reason for this is that Cullinan *et al.*¹⁶ looked at 194 workers in a group who had no or indirect exposure to dust and 62 workers exposed directly to dust. The classification is similar to that used in our study where the majority of workers were in the high category. It has previously been shown that at low dust levels the aeroallergen content does not correlate well with total dust,²⁵ so in our study the aeroallergen content would be expected to correlate better with the dust concentrations than in Cullinan's study where the dust concentrations were lower leading to an overall reduced level of sensitization and aeroallergen being the predominant correlating factor for

sensitization. This demonstrates that the level of allergen exposure was higher in the smaller bakeries examined in our study. There may also have been health surveillance of the population in larger bakeries with relocation of workers showing respiratory symptoms. Overall the comparison with our results indicate that there was a higher risk of sensitization in small bakeries.

Zotti *et al.*¹⁷ examined workers from small bakers and confectioners and found a lower prevalence of symptoms. Whilst this population is more analogous with that in our study, no estimate was made of flour dust exposure so the discrepancy in results may be because the level of exposure was different in the two studies.

No specific occupational exposure limit exists for flour dust at the moment in the UK. Nevertheless, occupiers are required to make a risk assessment of exposure under the Control of Substances Hazardous to Health (COSHH) Regulations, 1994.²⁶ In our study, 15% of total dust results exceeded 10 mg/m³ — the 'substantial dust concentration' as described in the Approved Code of Practice to the COSHH Regulations. No 'no-effect' level or clear dose-response relationship emerged in this population. The setting of a workplace standard is further complicated by the role of flour dust as a sensitizer, so that even a small exposure might produce symptoms in a previously sensitized worker. The Working Group for the Assessment of Toxic Chemicals (WATCH) is currently collecting information as part of the process of establishing a workplace exposure limit and the results of this and other investigations will be taken into consideration. This group will then report to the Advisory Committee on Toxic Substances (ACTS) for a decision to be made.

The specificity of questionnaires in epidemiological studies has been called into question.¹² In this study an attempt was made to obtain confirmatory evidence of occupational asthma in the 47 individuals whose initial questionnaire responses indicated such a diagnosis. Thirty-eight agreed to keep PEF records (as above); unfortunately only thirteen did so. None gave a pattern typical of occupational asthma, although eight records were abnormal. No respondent had a vacation during the period of recording, and the picture was further complicated as some were receiving bronchodilator or other therapy.

In conclusion, this study shows the prevalence of occupational respiratory disease among bakers employed in small bakeries and highlights the need to control exposure to allergens and to institute health surveillance in work places where sensitizers are handled.

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REFERENCES

1. Ramazzini B. *De morbis artificum diatriba*. 1700. [English Translation] London: 1705.
2. Anonymous. Editorial. *Br Med J* 1981; 282: 678.
3. Besche AD. Serologische Untersuchungen uberallergische Krankheiten. *Acta Path Microbiol Scand* 1929; 6: 115.
4. Theil H. Problems of occupationally induced respiratory allergies as exemplified in baker's asthma. *Dermatosen in Beruf und Umwelt* 1987; 35: 81–90.
5. Block G, *et al.* Baker's asthma. Clinical and immunological studies. *Clin Allergy* 1983; 13: 359–370.
6. Davies RK, Green M, Schofield MMC. Recurrent nocturnal asthma after exposure to grain dust. *Am Rev Res Dis* 1976; 114: 1011–1019.
7. Revsbech P, Dueholm M. Storage mite allergy among bakers. *Allergy* 1990; 45: 204–208.
8. Baur X, *et al.* Role of *Aspergillus* amylase in baker's asthma. *Lancet* 1986; i: 43.
9. Wutrich B, Baur X. Backmittel, insbesondere alpha-amylase als berufliche Inhalations-allergene in der Backwarenindustrie. *Schweiz Med Wschr* 1990; 120(13): 446–450.
10. Brisman J, Belin L. Clinical and immunological responses to occupational exposure to alpha-amylase in the baking industry. *Br J Ind Med* 1991; 48: 604–608.
11. *Collecting Information on Diseases Caused by Work*. London, UK: Health and Safety Executive, 1988.
12. Gordon SB, Curran AD. Screening questionnaires for bakers' asthma — are they worth the effort? *Occup Med* 1997; 47: 361–366.
13. HMSO. *Health and Safety Statistics*. Employment Gazette Occasional Supplements. London, UK: HMSO.
14. Ross DJ, Keynes HL, McDonald JC. SWORD '96: Surveillance of work-related and occupational respiratory disease in the UK. *Occup Med* 1997; 47: 377–381.
15. Musk AW, *et al.* Respiratory symptoms, lung function and sensitisation to flour in a British bakery. *Br J Ind Med* 1989; 46: 636–642.
16. Cullinan P, *et al.* Work related symptoms, sensitisation, and estimated exposure in workers not previously exposed to flour. *Occup Environ Med* 1994; 51: 579–583.
17. Zotti RD, Larese F. Allergic airway disease in Italian bakers and pastry makers. *Occup Environ Med* 1994; 51: 548–552.
18. Love RG, *et al.* Respiratory and allergic symptoms in wool and textile workers. *Br J Ind Med* 1988; 45: 727–741.
19. Health and Safety Executive. *General Methods for the Gravimetric Determination of Respirable and Total Inhalable Dust*. Health and Safety Executive. MDHS 14 (rev), 1989.
20. Thomas KE, *et al.* Factors relating to the development of respiratory symptoms in coffee process workers. *Br J Ind Med* 1991; 48: 314–322.
21. Griffin P, *et al.* Allergenic and antigenic relationship between three species of storage mite and the house dust mite, *Dermatophagoides pteronyssinus*. *J Allergy Clin Immunol* 1989; 84: 108–117.
22. Smith PK, *et al.* Measurement of protein using bicinchoninic acid. *Analytical Chem* 1985; 150: 76–85.
23. Smith TA, Lumley KPS. Work-related asthma in a population exposed to grain, flour and other ingredient dusts. *Occup Health* 1996; 46: 37–40.
24. Herxheimer H. The skin sensitivity to flour of bakers apprentices. A final report of a longterm investigation. *Acta Allergologica* 1973; 28: 42–49.
25. Tee RD, Gordon DJ. Immune response to flour and dust mites in a United Kingdom bakery. *Br J Ind Med* 1992; 49: 581–587.
26. Health and Safety Executive. *Control of Substances Hazardous to Health Regulations 1994: Approved Codes of Practice*. HSE: HMSO Publications, 1994.

