

Work-related asthma in a population exposed to grain, flour and other ingredient dusts

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The purpose of the study was to determine the prevalence and causation of work-related asthmatic symptoms in a population exposed to grain, flour and other ingredient dusts. Where workers complained of asthmatic symptoms which were the result of dust exposure, follow-up aimed to identify whether the symptoms were the result of sensitisation or of non-specific irritation. A questionnaire was presented to 3,450 workers who had exposure to dust during the course of flour milling (528), bread baking (1,756), cake baking (209) and other activities in food preparation (957). Those with positive responses were followed-up by taking a formal history, examination, skin prick testing and serial peak flow measurement. The overall prevalence of work-related asthmatic symptoms was 4.4% (153 out of 3,450). In the group who were followed-up (128 out of 153), non-specific respiratory irritation was thought to be the cause in 90 (2.6%), whilst sensitisation was responsible for symptoms in 12 (0.3%). Of the 12 cases due to sensitisation, the agents responsible were: fungal amylase (10 cases, all associated with bread baking), flour (one case, associated with flour packing), and grain (one case, associated with flour milling). Non-specific irritation is considerably more common than sensitisation as the cause of work-related asthmatic symptoms in flour milling, baking and other flour-based industries. The prevalence of sensitisation to flour is very low (less than 1 in 1,000) in all these industries. The principal sensitizer encountered in modern plant bakeries appears to be fungal amylase. The most important source of exposure to fungal amylase is probably the debagging, sieving, weighing and mixing of bread improvers.

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INTRODUCTION

The association between asthma and both the milling of wheat to produce flour and the use of flour in baking, has been known for many years. In the United Kingdom, asthma due to flour or grain was one of the original 'prescribed' causes of occupational asthma under the Industrial Injuries Scheme.¹ Since the inception of the Scheme, flour/grain has been amongst the three commonest reported causative agents of occupational asthma and the annual incidence of new

cases has remained fairly constant over the last ten years.²

Despite the undoubted link between these substances and asthma, the mechanism by which asthma is caused and the exact nature of the agent or agents responsible, remain open to continued debate. An IgE-mediated hypersensitivity reaction can be implicated in some cases but, even where this is the case, the nature of the allergen is not always clear. Wheat flour itself is thought to contain some forty different antigens.³ Furthermore, a number of other potential allergens are now commonly added to flour to enhance the baking process. These include enzymes such as α -amylase derived from *Aspergillus oryzae*, which has been reported to be an important cause of baker's asthma.⁴

The purpose of this study is to report the findings of a health surveillance programme in a large food

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company. The programme was initially set up to meet statutory requirements, with the principal aim of identifying asthma. The activities covered by the health surveillance included:

- milling of wheat to produce flour
- bread baking
- cake and pastry baking
- preparation of food ingredients containing flour, spices and other additives

METHOD

Employees whose normal work resulted in potential exposure to grain, flour or other ingredient dusts were identified by local site management. Initial screening of these individuals was carried out by nursing staff using a standard questionnaire. Employees were asked whether they had symptoms suggestive of asthma, i.e. cough, wheezing, chest tightness and shortness of breath, or rhinitis, i.e. runny nose and sneezing. In addition, they were asked whether the symptoms, if present, were worse at work. If the answers were positive, a longer symptom questionnaire was completed.

The questionnaires were sent to an occupational physician who decided what further action was required. Those whose symptoms were compatible with asthma were seen by one of three occupational physicians. The purpose of the consultation was to determine whether symptoms were related to exposure to dust in the workplace and, if so, whether they were due to sensitisation or a non-specific irritant effect. This was determined principally by history but was supported by serial peak flow measurements and skin prick tests against both environmental and workplace

allergens, where considered relevant. The workplace allergens tested against were wheat bran, wheat flour, fungal amylase and whole hen's egg.

The differentiation between a history of sensitisation and respiratory irritation was based on the pattern of symptoms in relation to exposure. When employees gave a history of symptoms throughout the working day with partial or complete remission when away from work, sensitisation was considered to be the likely cause, particularly if backed up by positive skin prick tests to workplace allergens. In contrast, those employees whose symptoms were short-lived, i.e. up to one hour, following short-term exposure to particularly high dust levels, were considered to fall in the category of respiratory irritation.

RESULTS

A total of 3,450 employees was subject to initial screening by nursing staff. These employees were divided into four groups according to the type of activity giving rise to exposure to grain, flour or other ingredients: (1) flour milling; (2) bread baking; (3) cake and pastry baking; (4) other activities.

A summary of the initial screening is given in Table 1. In the table, the columns headed Work-Related Symptoms refer to individuals whose responses to the questionnaire suggested asthma or rhinitis. On further follow-up by occupational physicians, not all these employees had symptoms which could be attributed to exposure to dusts at work. Employees who had both asthma and rhinitis symptoms generate entries in both columns.

An analysis of the subsequent follow-up findings from the group with work-related asthma symptoms is shown in Table 2. The column headed Occupational Asthma refers to individuals whose asthma was thought to be the result of sensitisation to an agent present in the workplace. The term Respiratory Irritation refers to individuals with asthmatic symptoms which related to dust exposure and were thought to arise from non-specific irritation or aggravation of pre-existing asthma, rather than sensitisation. The category termed Other included individuals who described asthmatic symptoms which could not reasonably be attributed to exposure to dust at work.

The prevalence of atopy in each of the diagnostic categories is shown in Table 3. For the purposes of this study atopy is defined as a positive skin prick test

Table 1. Overall analysis of initial screening according to symptoms reported

Activity	No. screened	Work-related symptoms	
		Asthma	Rhinitis
Flour milling	528	27 (5.1%)	37 (7.0%)
Bread baking	1,756	91 (5.2%)	150 (8.5%)
Cake baking	209	2 (1.0%)	5 (2.4%)
Other food preparation activities	957	33 (3.4%)	50 (5.2%)
Total	3,450	153 (4.4%)	242 (7.0%)

Table 2. Follow-up findings from work-related asthmatic symptom group

Activity	Asthmatic symptoms	Followed up	Occupational asthma	Respiratory irritation	Other problems
Flour milling	27	23	1 (0.2%)	19 (3.4%)	3
Bread baking	91	79	10 (0.6%)	53 (3.0%)	16
Cake baking	2	2	0 (0.0%)	1 (0.5%)	1
Other food preparation activities	33	24	1 (0.1%)	17 (1.8%)	6
Total	153	128	12 (0.3%)	90 (2.6%)	26

to either house dust mite, grass pollens or cat fur.

The mean duration of exposure in the group with occupational asthma was 14.9 years, with a range of 4–31 years. The mean latent period between first exposure and onset of symptoms in this group was 9.0 years. The mean duration of exposure in the group with respiratory irritant symptoms was 12.1 years, with a range of 1–32 years. The mean latent period between first exposure and onset of symptoms in this group was 7.6 years. A comparison of the latent periods for the two groups is shown in Table 4.

Of the twelve cases of occupational asthma, all ten associated with bread baking were thought to be due to allergy to fungal amylase. In each of these cases there was not only a history suggestive of occupational sensitisation, but an accompanying strongly positive skin prick test to fungal amylase. In some of these there was also a positive skin prick test to wheat flour but, where present, this was much smaller than the fungal amylase response. A positive skin prick test to fungal amylase was also observed in some of the respiratory irritant group but this arose in the absence of symptoms suggestive of allergic asthma.

At the time of onset of symptoms, eight of the ten individuals with occupational asthma associated with bread baking were process operatives whose work required them to debug, sieve, weigh or mix powdered bread-making ingredients. The other two were hygiene operatives whose work involved cleaning in areas where powdered ingredients were handled.

The case of occupational asthma associated with flour milling arose in a silo man. The suspected sensitising agent in this individual was grain rather than flour. The remaining case of occupational asthma occurred in a flour packer, with flour being the

suspected sensitiser.

DISCUSSION

The prevalence of asthma in the adult population has been variously reported.⁵ Perhaps a figure of between 2% and 5% might be appropriate. The overall prevalence of work-related asthmatic symptoms in this survey (4.4%) falls within this range. The rates for flour milling and bread baking, as distinct activities, were slightly higher at 5.1% and 5.2% respectively.

The rate of reported symptoms for bread baking is considerably lower than figures recorded in other studies in UK bakeries. For example, two recent reports, one from a single bakery⁶ and another from a group of small bakeries,⁷ reported rates for work-related asthmatic symptoms of 13% and 21% respectively. There are a number of possible explanations for the lower prevalence of symptoms in this study. These include lower levels of dust exposure and a policy of excluding asthmatics at pre-employment selection.

The problems associated with the use of questionnaires in the diagnosis of workplace asthma have been well described in the past.⁸ This study further illustrates the point by the fact that although 4.4% of those questioned initially reported work-related asthmatic symptoms, at follow-up only 2.9% appeared to have asthmatic symptoms which could be attributed to exposure to dust in the workplace. Taking the bread baking group alone, 5.2% complained initially of work-related symptoms, but only 3.6% were subsequently thought to have symptoms due to dust exposure. This 3.6% was made up of 0.6% with occupational asthma and 3.0% with non-specific respiratory irritation.

In general, individuals with irritant symptoms attributed the problem to short-term exposures to relatively high dust levels. Moreover, they could often implicate a particular substance or activity as the cause. For most materials, the key determinant of irritant potential was physical form, i.e. fine particle size, rather than chemical nature. This applied to flour and virtually all the other materials used in bread baking. On the other hand, in flour milling, grain dust from the wheat intake possessed a significantly greater potential to produce irritation.

Table 3. Prevalence of atopy in different diagnostic categories

Category	Total number	Number of atopics	% Atopic
Occupational asthma	12	9	75%
Respiratory irritation	90	36	40%
Other problems	26	11	42%

Table 4. Latent period between first exposure and onset of symptoms

Number of years exposure	Occupational asthma		Respiratory irritation	
	Number developing symptoms	Cumulative % with symptoms	Number developing symptoms	Cumulative % with symptoms
<1	1	8%	24	29%
1–2	0	8%	10	38%
2–3	1	17%	4	42%
3–4	1	25%	2	44%
4–5	2	42%	6	51%
5–10	4	75%	17	70%
10–15	2	92%	11	82%
15–20	0	92%	7	90%
20 +	1	100%	9	100%

With the increase in recognition of asthma associated with work has come a tendency to blur the distinction between conditions which result from either sensitisation or irritation. Whilst differentiation of these possible aetiologies is relatively unimportant from the patient's viewpoint, it does have important implications with regard to control strategies in the workplace. In industries such as milling and baking, where most dusts encountered have little irritant potential other than at high levels of exposure, the principal strategy must be the reduction in these high levels, in order to reduce symptoms of respiratory irritation. In contrast, the strategy with respect to sensitisers is somewhat different in that, once identified, these substances need to be controlled to very low levels of exposure.

In this study, non-specific respiratory irritant symptoms were considerably more common than symptoms from occupational asthma due to sensitisation. Overall the ratio of respiratory irritation to occupational asthma was 7.5:1. However, in the flour milling group this ratio rose to 19:1, with the highest prevalence of respiratory irritation (3.4%) of any of the individual workgroups. A possible explanation for this finding is that flour milling is the only group where there is exposure to grain dust, which is inherently more irritant than flour.

The occupational asthma and respiratory irritation groups displayed significant differences with respect to the latent period between first exposure and onset of symptoms. In general, irritant symptoms appeared earlier than those due to sensitisation (Table 4). A significant number of those who experienced irritant symptoms (28%), did so within the first year of exposure. In contrast, only one of the individuals with occupational asthma (8%) had experienced symptoms as a result of sensitisation within the first two years of exposure.

The other difference between the two groups was the prevalence of atopy (Table 4). In the respiratory irritation group this was similar to that of the general population (40%). However, in the occupational asthma group the coexistence of atopy was far more common (75%). This finding has been described previously in connection with baker's asthma.^{4,9}

The nature of allergens responsible for sensitisation in bread baking has been the subject of research for some time. It is indeed possible that the relative importance of individual allergens has changed over the years, along with changing patterns of exposure. The importance of enzymes added to the bread making process as workplace allergens, has been raised by a number of authors^{4,9,10} in recent years. We think that fungal amylase may well have the leading role as a sensitiser in current bread baking practice.

Fungal amylase is used in the bread making process to ensure consistency of proving. It consists mainly of α -amylase but also possesses some amyloglucosidase and protease activity. Its main action during proving is to ensure continuous production of dextrins and

maltose as a substrate for yeast, resulting in an even structure of the bread crumb and a large volume loaf. It is then inactivated in the oven before the starch gelatinises, preventing formation of a sticky crumb.

There are two potential sources of exposure to fungal amylase in bread making. Firstly it is added to certain flours used in the production of morning goods, i.e. rolls, muffins, crumpets, etc. Here, addition takes place before the flour leaves the mill in a proportion of around 0.001% by weight. The second and probably more important source of exposure is from bread improvers. Improvers typically contain around 1% fungal amylase by weight, in a carrier which is mainly soya flour. The improver arrives at the bakery in bags and significant dust exposures are possible during debagging, sieving, weighing and mixing.

Observation of the baking process suggests that the most significant dust exposures are currently associated with handling bagged additions in the procedures described above. In contrast, exposure to wheat flour has diminished over the years. The main reason for this is that much of the wheat flour is now handled in bulk and is therefore largely contained in silos and pipework. This change in pattern of exposure over the years may have reduced the importance of cereal allergens and increased the relative importance of enzyme additions as sensitisers in the baking industry.

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