

Wheat dust-associated respiratory disease in a farming community

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Abstract:

Sixty-six volunteers who considered themselves to have wheat dust-related respiratory disease, were reviewed from a farming community. A spectrum of disease was described ranging from a mild allergic rhinitis limited to periods of wheat dust exposure through to perennial asthma in which wheat dust was but one of several precipitating factors. Approximately half of those with asthma had symptoms limited to times of wheat dust exposure. Results of a limited survey of farmers showed patterns of symptoms similar to those in the volunteer group. Most subjects were atopic with elevated IgE levels, and had positive skin prick tests to environmental allergens. All but one of 65 subjects tested had a positive RAST test to wheat dust antigen. It is concluded that wheat dust associated respiratory tract disease is a significant problem in Australian farming communities, that a particular pattern of asthma can be described, and that IgE mediated reactions contribute to this disease pattern. (Aust NZ J Med 1991; 21: 211-215.)

Key words: Wheat, allergy, asthma, rhinitis.

INTRODUCTION

Exposure to grain dust as a cause of respiratory tract disease has been recognised for many years, particularly within the grain handling industry.^{1,2} The contents of the inhaled dust, the circumstances of exposure, and the reactivity of the recipient, vary considerably between the various exposed groups. Thus each group requires separate study. Cereal farmers however have not been properly assessed, largely due to their isolation.

Farmers tend to develop rhinitis and asthma, which contrasts with permanent silo workers who have a low incidence of atopy and asthma.¹ Although an allergic reaction to an allergen(s) in wheat dust is likely, a specific IgE antibody response to wheat dust antigens has not been clearly demonstrated. We have studied symptomatic subjects from a farming population in the NSW wheat belt and have described a seasonal effect on bronchial reactivity.³ Our studies indicate that wheat dust reactions are a major health problem for

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Australian grain farmers that to date has received little attention. We report the clinical spectrum of wheat dust related respiratory disease in a farming community and describe the presence of IgE antibody against allergens extracted from wheat dust.

METHODS

Clinical Data

Sixty-six residents of a small farming-grazing community in the Gulgambone-Coonamble district of New South Wales responded to a request for subjects with wheat dust associated respiratory symptoms. All were interviewed by a physician, who completed a questionnaire, which provided the data in Tables 1, 2 and 4. This study was in May 1983, a time of low wheat dust exposure. Clinical data and blood for IgE antibody tests were obtained at that time. Thirty-three subjects from the original group were further assessed during the 1983 harvest (December – a time of high wheat dust exposure) and the following winter (May, 1984) when wheat dust exposure was again at a low level. The selection of this subgroup was based on their ability to attend the assessments, and a history of asthma, made worse by inhalation of wheat dust, as assessed at the first interview. Asthma was diagnosed in subjects with a history of recurrent wheeze and chest tightness, associated with cough and breathlessness, variable over short time intervals and relieved by bronchodilators. Rhinitis was diagnosed as variable nasal obstruction with rhinorrhoea, conjunctival reaction and/or sneezing. Chronic bronchitis was diagnosed according to MRC criteria.⁴ Pulmonary function was assessed by spirometry, and bronchial reactivity was measured following inhalation of a histamine aerosol, as described by Yan *et al.*⁵

Skin Prick Tests

Allergen extracts were obtained from Dome Hollister-Stier Laboratories (USA). The following antigens were tested: cultivated wheat, *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, *Aspergillus fumigatus*, wheat smut, grass pollen mix and perennial rye (*Lolium perenne*). A positive control used 1 mg/mL histamine, and a negative control used normal buffered saline. A positive result was a wheal of ≥ 3 mm diameter. Aqueous extracts of wheat dust obtained from (i) storage silo, and (ii) header (or reaping machine) were prepared and standardised to a protein content of 5 mg/mL. Each wheat dust preparation was tested in two non atopic (negative controls) and two atopic individuals with known wheat dust sensitivity (positive controls) prior to use in this study. Non specific reactions were not produced in the non atopic controls.

IgE and IgE Antibody

IgE levels were quantitated by radioimmunoassay (Phadebas Total IgE, Pharmacia, Sweden). IgE anti-

body to wheat dust, and to wheat grain, protein was quantitated using a modified RAST technology using nitrocellulose as the solid phase, using an aqueous or alkaline extract of wheat dust.⁶ In these assays non atopic (cord) serum gave 0.6 to 0.9% binding. In addition, RAST score for 172 non-allergic bakers was $1.4\% \pm 0.06$ (mean $\pm$ SE). Results are expressed as the number with greater than 2% and 6% binding, with the latter level representing reasonably high antibody levels.

Wheat Dust Analysis

Wheat dust from both header and the local silo was examined by light and scanning electron microscopy.

Demographic Data

A postal questionnaire was sent to the 191 registered owners of farms supplying wheat to the local silo. Questions concerned asthma, rhinitis, seasonality of symptoms and interference with work, as well as basic demographic data.

RESULTS

In the initial study of 66 volunteers, a family history of asthma, rhinitis, and eczema was obtained in 53%, 55% and 23% respectively. Asthma was diagnosed in 57 (86.5%), rhinitis in 54 (82%) and chronic bronchitis in six (9%) of those interviewed. General characteristics are summarised in Table 1.

Asthma

Fifty-seven of the 66 subjects assessed gave a history of asthma (Table 2). Of the 16 with year round symptoms, 13 had a seasonal variation, with asthma worst at harvest time (November-January). One also noted a worsening of asthma prior to harvest during the period of grass pollination (August-November). Of the 41 subjects noting only seasonal asthma, 36 (or 63% of all asthmatics) had symptoms confined to the harvest period. Overall, fifty-one (90%) of the asthma group identified wheat dust as a significant precipitant. In 96% of the asthma group symptoms occurred within minutes of exposure, followed in 51% of

TABLE 1
Characteristics of Subjects with Wheat Dust Associated Respiratory Disease

Number of subjects studied	66
Mean age (yrs)	29
Range of age (yrs)	9-63
Sex (M:F)	60:6
Subjects by occupation (number)	
farmer	51
wheat-associated industry	12
previous wheat association farming or associated industry	2
office work	1

TABLE 2
Characteristics of Asthma

Number with asthma (%)*	57 (82)
Duration of symptoms (yrs) (mean and range)	15.5(4-50)
Perennial symptoms (%)†	16 (28.1)
Seasonal symptoms (%)†	41 (71.9)
Relation of symptoms to wheat dust exposure:	
wheat only (%)*	28 (49.1)
wheat + other precipitants (%)†	23 (40.4)
not related to wheat (%)†	6 (10.5)

*Percentage of subjects assessed.

†Percentage of asthma group (N=57).

subjects with delayed symptoms some hours later. Two subjects (4%) developed delayed symptoms without identifying a prior acute episode. Of those who linked asthma to exposure to wheat dust, 18 (35%) noted an exacerbation while working with a header at harvest, while 43 (81%) developed asthma working with stored wheat, usually in a confined space. Eighteen (32%) required regular bronchodilator therapy, with eight (14%) of this group also requiring corticosteroid therapy taken orally or as an aerosol. One subject with asthma had required hospitalisation for acute asthma. No subject took regular disodium cromoglycate prophylaxis. A variety of masks were used, intermittently and with variable benefit. The severity of symptoms varied from discomfort through to a level which prevented normal work and which caused major sleep disruption.

Pulmonary function was assessed at a time of low wheat dust exposure when only six had symptoms of current asthma, although 29 (44%) had an FEV₁ of less than 80% of predicted values. Two-thirds of the asthma group had normal values of histamine-induced bronchial reactivity (>3.9 u Moles). There was no difference in the proportion PD₂₀ values of those claiming only wheat as a cause of asthma (49% with a measurable PD₂₀ <3.91 u Moles), compared with those with wheat and other precipitating factors (41% with a PD₂₀ <3.9 u Moles) (normal bronchial reactivity was PD₂₀ >3.91 u Moles).

TABLE 3
Wheat Dust Induced Rhinitis

Total number with rhinitis (%)*	54 (82%)
Perennial (%)†	9 (17%)
Seasonal (%)†	45 (83%)
Duration of symptoms in years (mean and range)	17.5 (3-30)
Relationship to wheat dust exposure	
— wheat only (%)†	15 (28%)
— wheat plus other precipitants (%)†	37 (68.5%)
— not related to wheat (%)†	2 (3.5%)

*Percentage of subjects studied. †Percentage of rhinitis group (N = 54).

TABLE 4
Results of Questionnaire sent to Addresses Registered with Gula Silo

	Number (%)
Number of questionnaires distributed	191
Number of households returning questionnaire	67
Total number of returned questionnaires	137
Male:female	101:36
Cigarette smokers (%)‡	26 (19%)
Asthma*†(%)	28 (20.5%)
Rhinitis (%)	75 (55%)
Seasonal exacerbation in September-February (%)	63 (73.5%)
Level of symptoms	
difficulty with work (%)	52 (60.5%)
difficulty with sleep (%)	48 (56%)
takes therapy (%)	51 (59.5%)
changed job (%)	1

*19 had associated rhinitis; †63% of responders had asthma and/or rhinitis; ‡Percentage of total numbers of returned questionnaires.

Rhinitis

Fifty-four of the 66 subjects gave a history of rhinitis. Of the nine with year round symptoms, five had an exacerbation during the harvest period (Table 3). The remaining subjects with rhinitis had seasonal symptoms, with 39 (72%) having symptoms during the harvest season, 18 (33%) also noting symptoms prior to harvest during the grass pollination season. Six (11%) developed symptoms confined to the grass pollination season. All but two subjects claimed wheat dust as a precipitating factor for rhinitis (although 68% noted additional precipitating factors). Symptoms were worse when working with a header in 17 (31.5%) and worse with stored wheat in 32 (59%). Two noted rhinitis only when working with stored wheat. Onset of symptoms occurred immediately on exposure to wheat dust in 25 (46%), while in 16 (30%) symptoms occurred with delay. Only one subject gave a dual immediate and delayed response with recurrence after several hours free of symptoms. Symptoms were judged to be severe in ten (18.5%), moderate in 13 (24%) and mild in 30 (56%). This assessment correlated with therapy used. Antihistamines were used occasionally in 17 (31.5%), with only ten (18.5%) taking regular medications (antihistamines, topical corticosteroid, or topical disodium cromoglycate). No therapy was used by 27 (50%).

Results of Questionnaire Sent to Silo Users (Table 4)

Of 191 questionnaires sent to households registered with the local silo, 67 householders (35%) provided 137 individual responses. The profile of respiratory disease was similar to that observed in the study population with 63% of the responding subjects reporting asthma and/or rhinitis associated with wheat dust exposure.

TABLE 5
Skin Prick Tests
(July 1984. 33 subjects)

Allergen Test Group	Positive (%)	Number negative to all groups (%)
Wheat		
wheat grain dust	26 (79)	
wheat straw dust	28 (85)	1 (3%)
cultivated wheat	17 (51.5)	
Mite		
<i>D. pteronyssinus</i>	15 (45.5)	
<i>D. farinae</i>	17 (51.5)	13 (40%)
Mould		
<i>Aspergillus</i>	18 (54.5)	
wheat smut	15 (45.5)	14 (42.5)
Grass		
grass mix	22 (67)	
perennial rye	20 (60.5)	10 (30%)

Assessment of Atopy

Forty-five of 65 tested (70%) had IgE levels of greater than 100 kU/l (upper limit of normal). There was no difference in level between those with asthma only when exposed to wheat dust, compared with those in whom wheat dust was only one of a number of precipitants.

Skin prick tests

Results of skin prick tests are grouped according to wheat, housedust mite, fungal, and grass pollen allergens. The non-wheat allergens gave 45-67% positivity rates, as did the cultivated wheat extract (predominantly endosperm soluble protein) (Table 5). Wheat dust from both storage and header gave high (79-85%) positivity, with only one subject being negative to both preparations (data not shown).

IgE Antibodies to Wheat Antigens

IgE antibody was considered positive when >2% binding was noted, which was two to three times the level of binding found in cord blood. The 2% cut-off was also greater than values for direct binding of test sera to discs not absorbed with antigen (1.4-1.8%). Subjects with high antibody levels (>6% binding) are identified. The results (Table 6) show no significant

TABLE 6
IgE-Antibody to Wheat Related Antigen (65 subjects tested)

RAST assay (% binding)	Number positive (%)
Wheat grain protein	
>2% binding	24 (37)
>6% binding	8 (12.3)
Wheat dust (aqueous extraction)	
>2% binding	50 (77)
>6% binding	33 (51)
Wheat dust (KOH extraction)	
>2% binding	49 (75.5)
>6% binding	30 (46.2)

differences between the two extraction procedures (aqueous or alkali). Positive results were obtained in a high percentage (75-77%) of test subjects. Endosperm protein antibody was present in only 12% of samples. There was no significant difference in level of antibody between those with asthma only when exposed to wheat dust, and those where wheat dust was only one of several precipitating factors.

Electron and Light Microscopy

Scanning electron microscopy and light microscopy of wheat dust from both silo and header showed only wheat fragments, without evidence of contaminants such as mite or insect fragments, or fungal spores.

DISCUSSION

This study of wheat dust-associated respiratory disease in an Australian farming-grazing area identifies asthma and rhinitis as significant health problems in cereal growing communities. There was a spectrum of probable allergic reactions to wheat dust with asthma in some subjects precipitated by wheat dust only.

The majority of those with wheat dust-associated respiratory symptoms had lived on farms which cropped and stored wheat, and thus had been exposed intermittently to high concentrations of wheat dust over a number of years. Most were atopic as assessed by elevated IgE levels or positive immediate skin reactions to one or more common allergens. Typically subjects developed rhinitis and asthma between ten and 30 years of age, with rhinitis being seasonal and including both the grass pollen (spring) and harvest (early summer) periods. About half of those with asthma, however, only developed symptoms when exposed to wheat dust, suggesting that an isolated form of occupational asthma with symptoms restricted to the period of wheat dust exposure is common within the farming community. This is consistent with the observation that many subjects with wheat dust-associated asthma had abnormal bronchial hyperreactivity to histamine inhalation challenge only when tested in the harvest season.³ In these circumstances bronchial hyperreactivity would be secondary to inflammation within the bronchus following inhalation of high concentrations of wheat dust allergen, similar to the sequence observed following controlled inhalation of allergen.⁷

The frequency and pattern of asthma described in farmers differed from the symptoms in other occupational groups working with grain dust, such as is found in bakers with asthma⁸ and in grain handlers.⁶ In bakers rhinitis and asthma are linked to an occupational exposure to flour, while grain handlers in transport silos tend to have a significant incidence of chronic bronchitis. Although the latter group is exposed to similar dusts to those inhaled on farms, the presence

of both atopy and asthma in grain handlers is uncommon, possibly due to the avoidance of dusty industrial environments by atopic individuals.⁶

The study of a selected symptomatic population does not allow an accurate assessment of either prevalence within, or impact upon, the community. However the results of the questionnaire sent to owners of farms selling wheat through one local silo provide some evidence about both the frequency of asthma caused by inhalation of wheat dust, and the significant impact being made by wheat dust-related respiratory problems on the community. Unfortunately, several factors limit the interpretation of the questionnaire's results, including a probable response bias by symptomatic subjects, a high incidence of non residential owners who did not respond and a lack of objective validation of diagnosis. Finally, a 35% response rate (with respect to addresses) is unlikely to sample a representative population. However, the observation that 63% of responding subjects had asthma and/or rhinitis, most with symptoms confined to or worse in the harvest season, is consistent with a significant presence in the farming community of a form of asthma triggered predominantly by the inhalation of wheat dust.

Specific IgE antibody to wheat dust allergens was demonstrated in most subjects tested, by both prick tests and RAST assays. The sources of the water extracted antigens used in the prick tests were straw dust from a header, and stored wheat dust from a local silo. Neither of these dusts contained fungal spores, insect or mite fragments, indicating that the putative allergen was wheat-associated rather than a contaminant. Scanning electron microscopy of the wheat dust identified essentially only wheat fragments, including endosperm and bran particles, and structural components of the grain such as brush ends and husks. A low incidence of IgE antibody detected by RAST to water soluble endosperm protein antigens suggests that the allergens responsible for allergic respiratory disease in wheat farmers relate to structural or supportive structures. The high incidence of antibody to rye grass pollen may reflect the recognised cross reactivity between rye grass and wheat antigens.¹

The IgE antibody profile of wheat farmers differs from others who work with wheat products, such as

silo workers and bakers. Thus grain handlers in silos have a low incidence of asthma, are generally not atopic, and have negative RAST tests for wheat antigens.¹ Bakers are at risk of developing an allergic reaction to wheat flour, where the relevant antigens are endosperm protein, specifically the albumins⁸ and glutenins.⁹ Isolated studies have indicated that wheat dust may contribute to allergic disease in wheat handlers^{2,10} but the current study is the first to clearly demonstrate specific IgE antibody in most symptomatic subjects in a symptomatic farming population. ■

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