

Allergic Sensitization, Symptoms, and Lung Function Among Bakery Workers as Compared With a Nonexposed Work Population

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Only few studies have assessed relative risks on occupational asthma and allergy among bakery workers, and none of them have included respiratory and work-related symptoms as well as sensitization to occupational allergens and pulmonary function. A random sample of 246 workers from traditional and industrial bakeries in two regions of Belgium were compared with a reference population of 251 workers from a petrochemical plant in the same region. Data on skin test positivity, symptoms, and lung function were collected by standardized procedures. Differences between the two subpopulations were analyzed using multiple logistic and linear regression analyses. On average, bakery workers did not more often have skin test positivity than reference workers (39.4% and 42.6%, respectively). However, bakery workers had a strongly increased risk of sensitization to specific bakery allergens (OR 22.0, 95% CI = 6.3–77.1.), whereas their risks of positive skin tests to common allergens, including wheat pollen and storage mite, were significantly decreased (OR 0.6, 95% CI = 0.4–0.9). Bakery workers had significantly more often respiratory and work-related symptoms. Accordingly, they had lower lung function parameters. Atopy and sensitization to bakers' allergens were independent and additional risk factors for work-related symptoms. Bakery workers are at increased risk of respiratory and allergic symptoms and skin test reactivity to specific bakers' allergens wheat flour and α -amylase. Wheat pollen and storage mite should not be regarded as baker's allergens. Nevertheless, pulmonary function of bakery workers can be characterized as mild airway obstruction only. (J Occup Environ Med. 2003;45:648–655)

It is estimated that 10 to 25% of all adult asthma cases are occupationally related.¹ Among those, baker's asthma is one of the most frequent types of occupational asthma.² Furthermore, it appears that the risk of bakers for developing baker's asthma is still increasing.³ In the past decade, many studies have been published in which prevalence rates of work-related respiratory symptoms and sensitization to allergens were reported.^{4–6} Also the association between work-related respiratory symptoms and exposure levels has also been well documented.^{7–9} However, very few studies looked at these findings in a proper context by including a reference population of workers not exposed to a particular occupational environment. One study among Swedish bakers used a population control group to compare incidence rates of asthma and rhinitis based on questionnaire data on symptoms only.⁷ Furthermore, one study among Italian bakers compared skin-prick test results with those of white-collar workers, showing a decreased risk of skin test positivity to common allergens (pollen, housedust mite and animal danders) among bakers and an increased risk for sensitization to wheat flour only.¹⁰ Finally, one study from Southern Africa compared pulmonary function only of bakery workers with that of a control population of bottling plant workers.¹¹ Each of these studies examined only one type of outcome characteristic between both study populations, whereas in

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the present study we examined data from symptom questionnaires as well as skin test results and lung function measurements of both bakery and control populations. The aim of our study was to estimate the risk among bakery workers of respiratory and allergic disorders relative to that of a reference group of workers without a particular occupational exposure.

Subjects and Methods

Study Design

The current study is a cross-sectional study among workers from small traditional bakeries as well as larger industrial bakeries in the provinces of Antwerp and East-Flanders in the northwest of Belgium; in both areas bakeries were randomly selected from regional trade registries. All workers involved in the baking process who were working for at least 4 hours a day were eligible to participate in the study. The index population under study consisted of 246 workers from 74 participating bakeries. Of these, four were industrial bakeries with a total of 102 workers, whereas the remaining 144 workers came from 70 small traditional bakeries. The participation rate of the bakeries approached was 36%, among industrial bakeries lower than traditional bakeries. The main reason of nonresponse of the bakeries was concern about the use of data for occupational health inspection and concern about interference with production routine. Because the owners/bakers of small bakeries in particular decided to participate or not, including their work staff, the response rate within the participating bakeries was between 90 and 100%.

The reference population was recruited from a petrochemical plant in Antwerp and included 251 randomly selected employees, ranging from technical workers to office staff. In order to minimize the risk of exposure to irritating agents, workers directly involved in the production of polycyclic aromatic hydrocarbons

were excluded. The examinations were incorporated in the annually conducted routine checkup of the entire personnel and continued until the earlier defined number of participants was reached. All participants gave their written consent. Data collection was carried out between January 1997 and August 1999.

Questionnaire

Data on respiratory and allergy-related symptoms were collected by means of a validated respiratory questionnaire (MRC 1966),¹² supplemented with questions on work related symptoms, demographic and occupational characteristics. Questions on smoking history were based upon the ECRHS questionnaire.¹³

Respiratory symptoms used in the present analyses were as follows: chronic cough, chronic, production of phlegm, wheeze ever and in the last 2 years, asthma attacks, breathing problems, allergic symptoms ever and during or after work. Attacks of shortness of breath were considered as asthma attacks. Breathing problems were defined as problems with breathing when going from a warm into a cold room or vice versa, being in misty, smoky, or frosty circumstances or in baking or frying odor. Work-related allergic symptoms were defined as sneezing or a running nose, itchy or watering eyes, shortness of breath, or eczema, during or shortly after contact with work-related substances.

Smoking status was categorized as never smoker, ex-smoker, or current smoker. Current smokers were defined as those who smoked at least one cigarette daily or one cigar weekly for a period of 1 year and who were still smoking 1 month before the examination. Ex-smokers were all smokers who quit smoking at least 1 month before the examination. All other subjects were considered never-smokers.

Skin Prick Testing

Skin prick testing with 10 common aeroallergens and specific bak-

er's allergens was performed by standard procedures. The allergens tested for were *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae* (house dust mite HDM), storage mites (*L. destructor*, *T. putrescentiae*, *A. siro*), cat, dog, mixed grass pollen (timothy grass, foxtail grass, rye-grass, meadow grass, cocksfoot), mixed trees pollen (alder, birch, hazel), wheat flour, wheat pollen, rye flour and fungal α -amylase, using histamine chloride and allergen diluent as positive and negative controls, respectively (ALK Laboratory, Copenhagen, Denmark). Wheal diameters were recorded 15 minutes after application of the antigens. Mean diameters were calculated as the mean of the widest diameter and the perpendicular diameter measured at its midpoint.

Based upon the distribution of the responses to the positive control a mean wheal response diameter of at least 2 mm was considered a positive response. Responders to the negative control (>1 mm; $n = 1$) and nonresponders to the positive control (< 2 mm; $n = 3$) were excluded from the analyses. Atopy was defined as having one or more positive skin test response on common allergens housedust mite, grass or tree pollen, cat, and dog.

Spirometry

Baseline spirometry was performed by trained assistants in the bakeries (bakery workers) or in an occupational health unit (control workers), using ECCS guidelines.¹⁴ Flow-volume measurements were performed with a Vicatest VCT-5 spirometer (Jaeger GmbH, Hoechberg, Germany). All forced expiratory maneuvers were performed standing up using a plastic mouthpiece without toothgrips. Lung function parameters forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), peak expiratory flow (PEF), and forced expiratory flow between 25 and 75% of vital capacity (MMEF) were recorded from at least three of up to eight

TABLE 1

Population Characteristics of Bakery and Reference Workers, in Numbers (%) (Unless stated Otherwise)

Characteristic	Bakery workers	Reference workers	P Value
Number of subjects	246	251	
Mean age in years (SE)	32.6 (0.6)	40.1 (0.6)	<0.01
Gender			
Male	230 (93.5)	235 (93.6)	0.95
Female	16 (6.5)	16 (6.4)	
Smoking status			
Never	95 (42.8)	113 (45.0)	0.04
Ex	41 (18.5)	65 (25.9)	
Current	86 (38.7)	73 (29.1)	
Parental asthma	15 (7.5)	22 (9.9)	0.40
Parental allergy	47 (24.0)	52 (25.5)	0.73
Mean number of years (SE) Employed	8.9 (0.6)	16.5 (0.6)	<0.01

technically satisfactory maneuvers. Subjects were not asked to interrupt medication, but type and time of medication use was recorded if appropriate. Subjects were instructed not to smoke within 1 hour before spirometry.

Lung function parameters were expressed as percentages of predicted normal values (%FVC, %FEV1, and %MMEF), according to ECCS reference values.¹⁴ Subjects with technically unsatisfactory spirometry and/or with lower respiratory infections were excluded from the analyses ($n = 156$).

Data Analysis

Prevalences of respiratory symptoms, work-related symptoms, lung function parameters, and skin test positivity were compared between bakery workers and control workers (reference group). To identify potential confounders, associations between population characteristics (age, gender, number of years employed, smoking history, parental allergy, and parental asthma) and outcome variables were investigated using 2×2 tables. Differences between categorical variables were tested by Chi-square test or Fisher exact test (in case of low numbers), differences between continuous variables (lung function parameters, normally distributed) were tested by t test. In multivariate analyses associations between the outcome variables respiratory and work-related symp-

toms, lung function, skin test results and occupation were examined using logistic and linear regression models. To control for differences between the two subpopulations potential confounding variables included in the logistic regression models were age, smoking status, and number of years employed and in the linear regression models age and smoking status. The associations between sensitization to bakers' allergens, atopy and work-related symptoms were examined among bakers only by logistic regression analyses with adjustment for age, smoking status, work duration and lung function level. In order to estimate the individual effects of atopy and sensitization to bakers' allergens on work-related symptoms 4 subgroups of bakery workers were identified based on their skin test results on common allergens (atopy $\pm$) and bakers allergens ($\pm$).

All tests were two-sided, P values <0.05 were considered to be statistically significant, as well as odds ratios with 95% confidence intervals not including the value 1 and linear regression coefficients with 95% confidence intervals not including the value 0. Statistical analyses were performed using SPSS-PC+ V10.0 (SPSS, Chicago, IL).

Results

Characteristics of both subpopulations are shown in Table 1. Bakery workers were significantly younger

and worked significantly less long as compared with the reference workers. There were significantly more current smokers among bakers, whereas reference workers had more frequently stopped smoking. No differences were seen in the prevalence of parental asthma or parental allergy between both subpopulations.

Skin Prick Testing

Overall skin test positivity (STP) for any allergen tested did not differ significantly between bakery workers and the reference group. However, large differences were noticed in the sensitivities to the various allergens (Table 2). Not unexpectedly, prevalences of STP to bakery allergens were considerably higher in bakery workers (15.4%), whereas almost none of the control subjects (1.2%) had a positive skin test on wheat flour, rye flour, or fungal α -amylase. Among bakers sensitivity for wheat flour was more prevalent (12.4%) than for α -amylase (7.5%) or rye flour (3.3%). In contrast, the risk of STP for common allergens was significantly lower in bakery workers as compared with control subjects (adjusted OR 0.6, 95% CI = 0.4–0.9). In particular, skin test positivity for pollen, including wheat pollen allergen, was much less prevalent in bakers. No significant differences were found in the prevalences of housedust mite and storage mite sensitivity.

TABLE 2

Prevalences of Positive Skin Tests for Common and Baker's Allergens Among Bakery and Control Workers in Numbers (%). Crude and Adjusted Odds Ratios (95% Confidence Interval)

Skin test positive	Bakery	Reference	Crude OR	Adj. OR (95% CI)*
Housedust mite	58 (24.1)	66 (26.3)	0.9 (0.6–1.3)	0.7 (0.5–1.2)
Grass pollen	25 (10.4)	46 (18.3)	0.5 (0.3–0.9)	0.4 (0.2–0.8)
Tree pollen	15 (6.2)	31 (12.4)	0.5 (0.2–0.9)	0.5 (0.2–0.9)
Cat	22 (9.1)	30 (12.0)	0.7 (0.4–1.3)	0.5 (0.3–1.1)
Dog	25 (10.4)	33 (13.1)	0.8 (0.4–1.3)	0.7 (0.4–1.4)
Wheat pollen	21 (8.7)	38 (15.1)	0.5 (0.3–0.9)	0.4 (0.2–0.8)
Wheat flour	30 (12.4)	1 (0.4)	35.5 (4.8–262)	63.2 (8.1–490)
Rye flour	8 (3.3)	2 (0.8)	4.1 (0.9–19.8)	6.0 (1.1–31.3)
α -Amylase	18 (7.5)	2 (0.8)	9.8 (2.2–42.6)	11.6 (2.4–55.1)
Storage mite	30 (12.4)	26 (10.9)	1.2 (0.7–2.0)	1.1 (0.6–2.1)
Any common†	72 (29.9)	103 (41.0)	0.6 (0.4–0.9)	0.6 (0.4–0.9)
Any baker's‡	37 (15.4)	3 (1.2)	14.6 (4.4–48.0)	22.0 (6.3–77.1)
Any allergen	95 (39.4)	107 (42.6)	0.9 (0.6–1.3)	0.8 (0.5–1.2)

* adjusted for age and smoking status.

† common allergens: housedust mite, grasses, trees, cat, dog,

‡ bakers' allergens: wheat flour, rye flour, α -amylase

TABLE 3

Spirometry Parameters Among Bakery and Control Workers as Means of % Predicted (SEM). Crude and Adjusted Differences (regression coefficient, limits of 95% confidence interval)

Lung function	Bakers	Reference	P Value*	Adj. difference†
FVC (%pred)	99.6 (0.9)	99.9 (0.9)	0.82	1.7 (–1.1, 4.4)
FEV1 (%pred)	94.4 (0.9)	100.4 (0.9)	<0.01	–4.4 (–7.1, –1.6)
MMEF (%pred)	76.7 (1.7)	91.7 (1.6)	<0.01	–15.7 (–20.7, –10.7)
FEV1/FVC (%)	79.5 (0.6)	83.0 (0.5)	<0.01	–4.6 (–6.2, –3.1)

* P value for unadjusted difference.

† Linear regression coefficient (95% CI), adjusted for age and smoking status.

Lung Function Measurements

Spirometry results are shown in Table 3. Each regression coefficient represents the mean difference in lung function parameters (adjusted for differences in age and smoking history) between the two populations under study. In bakery workers pulmonary function appeared to be decreased in all spirometric parameters except for FVC. As compared to the reference group, bakery workers had a 4.4% lower FEV1 (as %predicted) and a 15.7% lower MMEF (as %predicted). Also the FEV1/FVC ratio was significantly lower among bakery workers (–4.6%).

Respiratory and Work-Related Symptoms

In general, respiratory symptoms were reported more often by bakery workers (Table 4). Recent wheeze

(adjusted OR 3.0) and breathing problems (adjusted OR 6.1) in particular were much more prevalent among bakery workers. The highest relative risk among bakers was seen for use of asthma medication (adjusted OR 18.8). However, the confidence interval was wide because only 6.3% of bakers and less than 1% of the control group currently used asthma medication. Although no differences were seen in the prevalence overall of allergic symptoms, the risk for allergic symptoms during or after work was strongly related to working in bakeries (adjusted OR 6.9). The proportion of work-related symptoms among bakery workers was 76% (56 of 74), whereas only 18% (15 of 84) of the control subjects reported their allergic symptoms occurring during or directly after work ($P < 0.001$). Furthermore, after strat-

ification of the study populations by atopic status (Table 5) it appeared that bakery workers who were atopic (sensitized for common allergens) were more at risk of having work-related symptoms than non-atopic bakery workers (OR 3.7), whereas no such relationship existed among the reference workers (OR 1.0).

The relationship between sensitization to bakers' allergens, atopy and work-related symptoms was studied among the bakers population only and is shown in Table 6. It demonstrates that both bakers' allergens and atopy were significantly associated with symptoms during or immediately after work (OR 4.9 and 2.7, respectively). In addition, as both variables were entered simultaneously in the regression model, both associations were independent from one another. After aggregation of

TABLE 4

Prevalences of Respiratory and Work-Related Symptoms Among Bakery and Control Workers, in Numbers (%). Crude and Adjusted Odds Ratios (95% Confidence Interval)

Symptoms	Bakers	Reference	Crude OR	Adj. OR (95% CI)*
Chronic cough	25 (11.3)	20 (8.0)	1.5 (0.8–2.7)	1.5 (0.8–3.1)
Chronic phlegm	16 (7.3)	10 (4.0)	1.9 (0.8–4.3)	2.7 (1.1–6.5)
Ever wheeze?	50 (23.3)	46 (18.4)	1.3 (0.9–2.1)	1.7 (1.0–2.8)
Recent wheeze	30 (13.6)	14 (5.6)	2.6 (1.4–5.1)	3.0 (1.4–6.3)
Asthma attack	27 (12.3)	17 (6.8)	1.9 (1.0–3.6)	2.1 (1.1–4.3)
Current asthma med.	14 (6.3)	2 (0.8)	8.4 (1.9–37.2)	18.2 (3.8–88.0)
Breathing problems	51 (23.0)	13 (5.2)	5.5 (2.9–10.4)	6.1 (3.1–12.3)
Allergic symptoms				
Ever	74 (33.9)	84 (33.5)	1.0 (0.7–1.5)	1.1 (0.7–1.6)
During/after work	56 (25.3)	15 (6.0)	5.3 (2.9–9.8)	6.9 (3.6–13.2)

* adjusted for age, number of years employed, and smoking status.

TABLE 5

Prevalence of Work-Related Allergy Symptoms by Atopic Status (Atopy Defined as 1 or More Positive Skin Test on Common Allergens) in Bakery Workers and Control Population Separately. Crude Odds Ratios (95% Confidence Interval)

Category	Nonatopic <i>n</i> (%)	Atopic <i>n</i> (%)	Crude OR* (95% CI)
Bakery workers	26/152 (17.1)	28/65 (43.1)	3.7 (1.9–7.0)
Control workers	9/148 (6.1)	6/103 (5.8)	1.0 (0.3–2.8)

* OR unchanged after adjustment for age, smoking status, or number of years employed.

TABLE 6

Association Between Work-Related Symptoms and Sensitization for Bakers' Allergens (Wheat Flour, Rye Flour, and α -Amylase), and Common Allergens (Atopy) Among Bakers. Odds Ratios (95% Confidence Interval) Adjusted for Age, Smoking Status, Work Duration, and Lung Function

Sensitization	<i>n</i> (%)	Work-related symptoms	
		Prev. (%)	OR (95% CI)*
Bakers' allergens	33 (15.9)	58.8	4.9 (2.0–12.0)
Atopy	62 (29.8)	43.1	2.7 (1.3–5.7)
Atopy –/bakers all –	133 (63.9)	13.5	1 (ref.)
Atopy +/bakers all –	42 (20.2)	33.3	3.1 (1.3–7.3)
Atopy –/bakers all +	13 (6.3)	53.8	6.8 (1.9–24.1)
Atopy +/bakers all +	20 (9.6)	65.0	11.5 (3.8–35.1)

* dependent variable: work-related symptoms (yes/no); independent variables: age, smoking, number of years worked, number of hours working/week, FEV1 (%pred) and sensitization to common (atopy) and bakers' allergens.

these two variables (Table 6, lower part) it appeared that 13.5% of nonatopic workers without sensitization to bakers' allergens yet reported work-related symptoms. Nonatopic workers who were sensitized to bakers' allergens had more often work-related symptoms than workers who were atopic but not sensitized to bakers' allergens (54% and 33% respectively). Risk of symptoms was highest among workers with both atopy and sensitization to bakers'

allergens (prevalence rate 65%, Odds Ratio 11.5 when compared with nonatopic, nonsensitized workers).

Discussion

The results of the present analyses show that, on average, bakery workers did not show more skin test positivity than reference workers. However, differences did appear between allergens within the two subpopulations. Bakery workers showed higher prevalence rates in specific

bakery allergens, whereas positive skin tests to common allergens, including housedust mite, pollen and animal danders were significantly less frequent. Among bakery workers asthma-related respiratory symptoms and work-related allergy symptoms in particular were significantly more prevalent as compared to a group of workers without exposure to occupational allergens. Accordingly, bakery workers had lower lung function parameters FEV1 and

MMEF, implying more frequent mild airway obstruction.

In the last two decades, many epidemiologic studies, mostly cross-sectional, have been performed in which prevalence rates of respiratory symptoms or allergy tests were presented for bakery workers. As shown in a comprehensive review by Houba et al,² prevalence rates of work-related allergic symptoms have a wide variation, which can largely be explained by the use of different methodologies with respect to symptom definitions, study population, type of questionnaire and type of bakeries. Therefore, there is little benefit in comparing crude prevalence rates between different studies, unless studies were carried out using the same methodology. For instance, prevalence rates of respiratory symptoms and positive skin tests in our study strongly agree with the results from a Dutch study among 393 bakers, in which the same questionnaire, test allergens and definitions were applied.¹⁵ In addition to the index population, we examined a reference population of workers without exposure to occupational allergens, using the same questionnaires, measurements and definitions. This enabled us to estimate relative risks on respiratory symptoms, lung function and sensitization to occupational and common allergens between bakery workers and the reference population. The reference population consisted of workers and employees from a variety of departments (certain production workers excluded) of a petrochemical plant, who represent a population not only unexposed to specific bakers allergens, but also with a low risk of exposure to dust and allergenic or non-allergenic agents because of its liability to strict industrial hygiene regulations and close monitoring by an in-house industrial medicine service. For bakery workers, the highest relative risks were found with work-related allergic symptoms and breathing problems occurring in cold or misty circumstances. The latter symptoms

may be related to bronchial hyperresponsiveness, which is also shown to be associated with working in the baking industry.¹⁶ In addition, as shown in other studies,¹⁰ atopy to common allergens appeared to represent a risk factor for work-related symptoms, however, among bakery workers only. Although atopy was more prevalent among reference workers, the prevalence of work-related symptoms was low and not associated with atopic status. This finding confirms the relatively sound and unexposed nature of the control population and makes it more likely that, in contrast with bakery workers, the reported work-related symptoms among the control workers are from nonallergic origin.

In addition, independent from atopy sensitization to bakers' allergens constitutes a strong risk factor for work-related symptoms. The increasing risk of symptoms associated with the increase of atopic and/or allergic status is similar to a finding of the Italian study by De Zotti et al¹⁰ and confirms the significance of sensitization to common as well as bakers' allergens as important risk factors for work-related symptoms. Nonetheless, a small proportion (13%) of non-atopic, non-sensitized bakery workers also reported symptoms during or after work. This may be explained by the nonallergic effect of inhalable dust, or may be the result of misclassification (ie, bakery workers may be sensitized to bakers' allergens that were not tested).

Our findings on individual skin test responsiveness agree with results of many previous studies showing a high prevalence of sensitization to specific bakery allergens. Unlike some recent studies reported,^{17,18} wheat flour appeared to be a more prevalent allergen among bakery workers than α -amylase. This corresponds with the skin test results by De Zotti et al,¹⁰ who also found a higher prevalence of wheat flour reactivity than α -amylase reactivity (11.9 and 7.5%, respectively); however, these results are largely deter-

mined by the products used by the bakery workers. In addition, in their comparison between 226 bakery workers and 119 white-collar workers they found in the former a decreased risk of sensitization for common allergens (OR 0.53), an increased risk for flour allergens (OR 1.93) and an indifferent risk for storage mite allergen (OR 1.01), which strongly matches our results. A similar divergence in skin test responses, according to duration of work, between common and wheat allergens was also found by Prichard and co-workers.¹⁹

The strikingly lower risk of sensitization for common allergens may be due to bias resulting from the "healthy worker effort," by which workers with a preexisting atopy to common allergens (ie, hay fever) are more likely to change work or stay away from the bakery trade at all. This may have led to an underestimation of the relative risk of work-related symptoms among bakery workers. Furthermore, as sensitization to bakery allergens is associated with atopy, the relative risk of sensitization to these allergens may also be higher than estimated in the present study. Another explanation may be found in the possibility that the reference population was not as indifferent regarding common allergens as initially assumed. However, the higher-than-expected prevalence of so-called "common" atopy was not sustained by a higher prevalence of respiratory symptoms or lower lung function parameters. Moreover, even though not a very reliable indicator for asthma, the use of asthma medication was very low among the reference population.

Like the study by De Zotti et al,¹⁰ we found no association between working in a bakery and storage mite sensitization. Among the subjects in our study population positive to storage mite approximately 70% were positive also to housedust mite, among bakers as well as control subjects. It seems conceivable that cross-reactivity exists between stor-

age mite and housedust mite allergens, although results from previous studies are contradictory.^{20–22} Storage mite allergens may be almost as widespread in the indoor environment as housedust mite allergens. Our findings thus support the conclusion by De Zotti et al that storage mite is not a specific bakery allergen, but should be considered a common allergen.¹⁰ Similar results emerged regarding skin test reactivity to wheat pollen allergen. The significantly lower risk of wheat pollen sensitization among bakery workers in our study corresponds with the lower risk of sensitization to common allergens. Among subjects with a positive skin test on wheat pollen 86% also had a positive skin test on grass pollen, suggesting a strong cross-reactivity between wheat pollen and grass pollen. Given these results, wheat pollen should also no longer be regarded as a specific bakers' allergen.

As compared with the reference group without allergen or dust exposure, bakery workers showed a small but significantly decreased lung function pointing toward mild air-flow obstruction. These findings agree with the outcome of a study by Shamssain, in which black male bakery workers from Transkei showed significantly lower pulmonary function than their control subjects.¹¹ The differences in lung function parameters, however, were much larger in that study (between 10 and 30%), possibly explained by concurrently higher prevalences of respiratory symptoms, ie a "worse" population. Lung function measurement in our bakers population may also be biased by the healthy worker effort by which bakers abandoned their occupation because of an impaired pulmonary function. Therefore, the only moderately lower lung function parameters may be underestimated because of this selection bias.

Inherent to a cross-sectional epidemiological study the participation rate may influence results. In theory, a response rate of 36% of the bakeries

contacted may induce a nonresponse bias through a greater willingness of symptomatic subjects to participate, leading to an overestimation of relative risks. However, the reasons most frequently mentioned for non-response were not related to symptoms or disease but to organizational problems. Also, in most cases the owner/baker alone decided whether to participate or not, resulting in a response of either none or all workers. Therefore, the individual response rate was much higher, between 90 and 100%. Among the reference group a similar effect of nonresponse bias could have occurred. However, the relatively high prevalence of sensitization to common allergens disagreed with the prevalence of 'ever allergic symptoms' among the reference workers, which was almost equal between the two study groups. Furthermore, measurements were incorporated in the obligatory annual checkup, which was already scheduled for each control worker. Therefore, nonresponse will probably have only little effect on results.

In conclusion, our study demonstrated that bakery workers have an increased risk of respiratory and work-related allergic symptoms, particularly in the presence of underlying atopy and sensitization to bakers' allergens. Bakery workers have increased skin test reactivity to specific bakers' allergens like wheat flour and α -amylase. In contrast, sensitization to common allergens was significantly less prevalent among bakery workers. In addition, our findings indicate that wheat pollen and storage mite allergens may be considered as common allergens rather than specific bakers' allergens. Finally, despite high prevalence rates of respiratory symptoms and sensitization to baker's allergens, pulmonary function of bakery workers was only moderately but significantly affected.

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