ORIGINAL ARTICLE

Prevalence and risk factors for work related asthma in young adults

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Objectives: To investigate the prevalence and predictors of work related asthma in young adults from the general population.

Methods: A total of 1922 subjects randomly selected from a birth cohort 1978/79 in Brazil, aged 23-25 years, completed a respiratory symptoms questionnaire based on the European Community Respiratory Health Survey, and underwent spirometry, bronchial challenge test with methacholine, and skin prick test. For subjects presenting with bronchial hyperresponsiveness, workplace exposure and its relationship with symptoms were assessed by a specific questionnaire and individualised job description to define cases of work related asthma.

Results: The prevalence of work related asthma was 4.2% (81 cases): 1.5% (29 cases) were classified as aggravated asthma and 2.7% (52 cases) as occupational asthma. Work related asthma was associated with atopy and education. Lower educational level (1-8 years of schooling) was associated with work related asthma (odds ratio 7.06, 95% CI 3.25 to 15.33). There was no association between work related asthma and smoking, gender, or symptoms of rhinitis.

Conclusion: The prevalence of work related asthma was high (4.2%), and was associated with low schooling, probably because of low socioeconomic level. The disease may therefore be a consequence of poverty.

The workplace can trigger or induce asthma, leading to work related asthma, that can be categorised into two distinct subsets: work aggravated asthma and occupational asthma. Patients with work aggravated asthma have a history of pre-existing asthma; occupational asthma develops as a direct result of workplace exposure.^{1 2}

Work related asthma is the most frequently reported occupational lung disease in a number of industrialised countries.^{3 4} Certain occupational groups are known to be at particularly high risk of developing occupational asthma, including western red cedar workers,⁵ chemical workers exposed to isocyanate,⁶ construction workers,⁷ bakers,⁸ cleaners,⁹ textile workers,¹⁰ animal handlers,¹¹ and woodworkers.¹² The risk factors and prevalence of occupational asthma have been extensively studied in these and some other risk groups. However, they have been much less studied in the general population.

Johnson *et al*¹³ evaluated a randomly selected population of 18 701, ranging in age from 20 to 44 years, in six communities in Canada. Of these individuals, 2974 attended the laboratory; 383 had asthma. Approximately one in three cases of adult onset asthma may have been caused by occupational exposure, and 18% of adult onset asthma may be prevented by eliminating exposure to known occupational inducing/sensitising agents. Occupational exposure as a cause of adult onset asthma may be more common than it is realised.

Studies on work related asthma at specific ages are necessary because risk factors and outcome may differ in varied age groups. Since the disease is a consequence of time of exposure, prevalence may vary among ages. In this case, the clinical manifestation of the disease may be less frequent in younger individuals than in older workers. Work related asthma in young adults is less well studied than in older age groups.¹⁴ Young population based studies are also important for preventive measures. Among workers with occupational asthma or at risk of developing occupational asthma, timely recognition, identification, and control of the occupational exposure causing asthma improve the chances of prevention or complete recovery. This primary prevention can greatly

reduce the high financial and human costs of chronic, disabling asthma.¹⁵

The aim of this cross-sectional study was to investigate the prevalence and predictors of work related asthma in young adults from the general population. The study focused on risk factors for work related asthma in two settings. First, the group of work related asthma was analysed in comparison with a random sample. Second, the group of work related asthma was compared with hyperresponsive individuals (with or without asthma) to determine which risk factors lead to work related asthma from a bronchial hyperresponsive background. Public policies could be based on the identification of bronchial hyperresponsiveness to prevent work related asthma and would benefit from these data on risk factors.^{16 17}

METHODS

This was a cross-sectional analysis of a Brazilian population. We recruited 2063 men and women (aged 23-25 years) randomly selected from a cohort of 6827 singleton babies born during the years of 1978/1979 in the city of Ribeirão Preto, a regional centre in the Northeastern region of the S. Paulo state, Southeastern Brazil. The main economic activities are the sugar cane industry, trading, services, and financing. The number of inhabitants in the city of Ribeirão Preto is approximately 550 000. Data collection was done between 2002 and 2004.

Of these 2063 subjects, 1922 performed the bronchial challenge test; 427 subjects had a positive result for bronchial hyperresponsiveness (PC₂₀ methacholine $\leq$ 4 mg/ml). This group with bronchial hyperresponsiveness was interviewed for the evaluation of work related symptoms using a specific questionnaire to define work related asthma (occupational asthma or aggravated asthma) (fig 1).

Respiratory and occupational questionnaires

Respiratory symptoms were assessed using the European Community Respiratory Health Survey (ECRHS) questionnaire translated into Portuguese and adapted to the Brazilian lexicon. We used questions of the ECRHS questionnaire to

Table 1 Characteristics of the sample (n = 1922), divided into work related asthma and non-work related asthma

Variable	Categories	Work related asthma	
		Yes (n = 81) n (%)	No (n = 1841) n (%)
Gender	Male	36 (44.4)	906 (49.2)
	Female	45 (55.6)	935 (50.8)
Smoking	Current or former smoker	22 (27.2)	483 (26.2)
	Never smoker	59 (72.8)	1358 (73.8)
Atopy	Positive to 1 or 2 allergens	38 (48.1)	660 (37.0)
	Positive to 3 or more allergens	17 (21.5)	256 (14.3)
	Negative	24 (30.4)	868 (48.7)
Rhinitis	Yes	28 (35.4)	479 (26.0)
	No	51 (64.6)	1361 (74.0)
Education	1–8 years	25 (30.9)	257 (14.0)
	9–11 years	47 (58.0)	931 (50.5)
	≥12 years	9 (11.1)	653 (35.5)
Self-reported exposure	Dust, vapour, humidity, gases	32 (40.5)	677 (37.1)
	Chemical products or paints	9 (11.4)	103 (5.6)
	More than one agent	24 (30.4)	341 (18.7)
	No reported exposure	14 (17.7)	706 (38.6)

Total may not add up to 81 or 1841 due to missing values. Self-reported exposure was assessed by a standardised question without individual job description.

explore asthma symptoms and a previous diagnosis of asthma. The symptoms necessary to define asthma were wheezing, chest tightness, or night-time or daytime breathlessness at rest within the last 12 months. The presence of any of these symptoms in association with bronchial hyperresponsiveness defined asthma. Thus, symptoms reported by non-hyperresponsive individuals were not enough to classify them as asthmatic. We assessed exposure to specific airborne pollutants directly from reported exposure to dusts, vapours, gases, fumes, chemical products, paints, and humidity in the whole sample of 1922 subjects by using the question: "Have you ever worked breathing dusts, gases, fumes, humidity or chemical products?". This response was used for statistical analysis as "self-reported exposure". For the subjects presenting with bronchial hyperresponsiveness, exposure was also assessed by an interview with more specific questions and individualised job description. This questionnaire included questions on employment history (job

description with dates, substances in the work environment), symptoms (duration, duration of employment prior to symptoms, temporal pattern of symptoms in relation to work, improvement away from work), and potential risk factors (smoking, symptoms preceding exposure, atopic disease, co-worker symptoms, and accidental exposure) (see Appendix 1).

The diagnosis of work related asthma was based on temporal association between asthmatic symptoms and work. We defined work aggravated asthma by a history of pre-existing asthma that worsened due to workplace exposure and occupational asthma by a history of asthma developed as a direct result of workplace exposure.^{1 2 18 19}

Bronchial responsiveness

The bronchial responsiveness to methacholine was measured using the 2 minute tidal breathing method. Increasing concentrations of methacholine (0.06, 0.125, 0.25, 0.5, 1, 2,

Figure 1 Flow chart of the study. Diagnosis of all subjects from the birth cohort.

Table 2 Unadjusted and adjusted odds ratios (OR) of work related asthma in 1922 subjects

Variable	Categories	Unadjusted		Adjusted	
		OR	95% CI	OR	95% CI
Gender	Male	0.83	(0.53 to 1.29)	0.59	(0.35 to 0.97)
	Female	1		1	
Smoking	Current or former smoker	1.05	(0.64 to 1.73)	0.86	(0.50 to 1.50)
	Never smoker	1		1	
Atopy	Positive to 1 or 2 allergens	2.08	(1.24 to 3.51)	2.19	(1.27 to 3.78)
	Positive to 3 or more allergens	2.40	(1.27 to 4.54)	2.99	(1.46 to 6.13)
	Negative	1		1	
Rhinitis	Yes	1.56	(0.97 to 2.50)	1.44	(0.84 to 2.46)
	No	1		1	
Education	1–8 years	7.06	(3.25 to 15.33)	6.82	(2.99 to 15.57)
	9–11 years	3.66	(1.78 to 7.53)	3.41	(1.64 to 7.10)
	≥12 years	1		1	
Self-reported exposure	Dust, vapour, humidity, or gases	2.38	(1.26 to 4.51)	2.27	(1.15 to 4.49)
	Chemical products or paints	4.41	(1.86 to 10.44)	4.71	(1.92 to 11.58)
	More than one agent	3.55	(1.81 to 6.95)	4.65	(2.22 to 9.75)
	No reported exposures	1		1	

Self-reported exposure was assessed by a standardised question without individual job description.

4, 8, and 16 mg/ml) were aerosolised with a DeVilbiss 646 nebuliser (Sunrise Medical HHG Inc, Somerset, PA, USA) driven by a computer activated dosimeter (Koko Digidoser System, PDS Instrumentation, Inc., Louisville, CO, USA) with an output of 9 µl per 0.6 second (total delivery of 0.045 ml). Forced expiratory volume in the first second (FEV₁) was measured at baseline and 2 minutes after each tidal breathing period. The test was stopped when either a 20% fall in FEV₁ was achieved or the final concentration was reached. The provocative concentration causing a 20% fall in FEV₁ (PC₂₀) was calculated with Koko software. We considered PC₂₀ ≤ 4 mg/ml to indicate bronchial hyperresponsiveness.

The contraindications to methacholine challenge test were all conditions that might compromise the quality of the test or that might subject the patient to increased risk or discomfort, including FEV₁ <60% predicted, pregnancy, nursing mothers, and inability to perform acceptable quality spirometry. During preparation, patients were questioned about factors that could increase or decrease bronchial responsiveness, such as current respiratory infection or asthma medication. When a factor was present, the tests were postponed.²⁰

The tests and measurements were carried out in a healthcare setting with easy access to medical facilities. The examination was performed at the University Hospital (Medical School of Ribeirão Preto, University of S. Paulo). The participants signed a consent form after reading and listening to the aims and procedures included in the study. The study was approved by the institutional ethics committee.

Skin test

Skin tests for allergy were done by the skin prick method using a group of eight extracts of inhalant allergens (*D pteronyssinus*, *D farinae*, cat fur, dog hair, *Penicillium notatum*, *Alternaria alternata*, grass pollens, and *Aspergillus fumigatus*) together with normal saline as a negative control and histamine (1 mg/ml) as a positive control. A test was considered to be positive when the mean length and width of the papula was 3 mm or more in response to one or more allergens.²¹

Statistical analysis

Simple exploratory analyses were used to describe the study population and to calculate the prevalence, expressed as percentage, of work related asthma, bronchial hyperresponsiveness, asthma, atopy, and smoking. Comparisons between genders were performed using χ^2 statistics. Due to the

numerically low prevalence of work related asthma (4.2%) in our sample (n = 1922) and to the cross-sectional design, a univariate logistic regression was employed,²² followed by multivariate analysis to evaluate the risk factors schooling and exposure adjusted by gender, smoke, atopy, and rhinitis. Another analysis was performed in a subgroup (n = 427) of our sample. This subgroup included individuals with bronchial hyperresponsiveness, divided into work related asthma and non-work related asthma. Since the prevalence of work related asthma among hyperresponsive individuals was high (19%), Cox regression analysis with constant time at risk was carried out to assess the association between risk factors and work related asthma, adjusting for the variables gender, atopy, smoke, and rhinitis.^{23–25}

RESULTS

The age of the sample of 1922 individuals (980 women) that completed the protocol (mean ± SD) was 23.9 ± 0.7 years and asthma prevalence was 11.8%. Bronchial hyperresponsiveness was detected in 22.2% of the sample, i.e. 427 subjects, 61.6% (263) women and 38.4% (164) men (p < 0.0001). Current smoking was reported by 17.4% of the individuals, 14.2% females and 20.7% males (p < 0.0001); current or ex-smoking prevalence was 26.3%, 21.9% for women and 30.8% for men (p < 0.0001). Slightly more than one third of the individuals belonged to the categories of qualified and semi-qualified manual workers, 21.5% to the unqualified manual category, 21.1% to the non-manual category; 22.7% did not belong to the economically active population. Regarding the educational background, 14.7% had 1–8 years of schooling, 50.9% had 9–11 years, and 34.4% had more than 11 years.

The prevalence of atopy in the population studied was 52%; the most frequent allergens were *D pteronyssinus* (47%), *D farinae* (41%), and cat fur (11%). Among the 427 people with bronchial hyperresponsiveness, the prevalence of atopy was 76%. We detected 81 cases of work related asthma, i.e. a prevalence of 4.2% (81/1922): 1.5% identified as aggravated asthma and 2.7% as occupational asthma.

Sample characteristics are shown in table 1, with prevalences described by group (work related asthma and non-work related asthma). In table 2, we noticed associations between work related asthma and atopy, education, and self-reported exposure in the whole sample of 1922 individuals. The proportion of the lowest educational level (1–8 years) was greater and the proportion of the highest was smaller in the work related asthma group. There was an association between educational level and work related asthma, with an increase in the OR with lower schooling. After adjustment,

Table 3 Characteristics of subjects with bronchial hyperresponsiveness divided into work related asthma and non-work related asthma

Variables	Categories	Work related asthma	
		Yes (n = 81) n (%)	No (n = 346) n (%)
Gender	Male	36 (44.4)	128 (37.0)
	Female	45 (55.6)	218 (63.0)
Smoking	Current or former smoker	22 (27.2)	84 (24.3)
	Never smoker	59 (72.8)	262 (75.7)
Atopy	Positive to 1 or 2 allergens	38 (48.1)	155 (47.6)
	Positive to 3 or more allergens	17 (21.5)	97 (29.8)
	Negative	24 (30.4)	74 (22.7)
Rhinitis	Yes	28 (35.4)	135 (39.0)
	No	51 (64.6)	211 (61.0)
Education	1–8 years	25 (30.9)	50 (14.5)
	9–11 years	47 (58.0)	189 (54.6)
	≥12 years	9 (11.1)	107 (30.9)
Self-reported exposure	Dust, vapour, humidity, or gases	32 (40.5)	133 (38.7)
	Chemical products or paints	9 (11.4)	18 (5.2)
	More than one agent	24 (30.4)	34 (9.9)
	No reported exposure	14 (17.7)	159 (46.2)

Total may not add up to 81 or 346 due to missing values. Self-reported exposure was assessed by a standardised question without individual job description.

schooling and atopy continued to be associated with work related asthma (table 2). Associations for the type of self-reported exposure were also analysed; a specific risk was found for all categories: chemical products or paints; dust, vapour, humidity, or gases; as well as more than one agent (table 2).

Table 3 shows the characteristics of the hyperresponsive population, divided into work related asthma and non-work related asthma. Table 4 showed an association between work related asthma and education as well as self-reported exposure in the group with bronchial hyperresponsiveness (n = 427).

DISCUSSION

We showed that, among 23–25 year old persons, the prevalence of bronchial hyperresponsiveness detected by the methacholine challenge was 22.2%, with an asthma prevalence of 11.8% and a prevalence of work related asthma of 4.2%. In the group of subjects with work related asthma, two thirds were classified as having work related new onset asthma (occupational asthma) and one third as having work aggravated asthma, which is pre-existing asthma that is exacerbated by workplace exposures. The present data demonstrate that schooling, atopy, and the self-reported

general characteristics of the workplace were associated with work related asthma.

When we analysed the subgroup with bronchial hyperresponsiveness, the association with work related asthma was also observed for schooling, but not for atopy, which was present in about 75% of the individuals with bronchial hyperresponsiveness. Atopy may have been a more relevant predisposing factor for bronchial hyperresponsiveness or asthma than for work related asthma. Atopy is a known risk factor for specific sensitisation to high molecular weight occupational allergens such as wheat flour and animal dander.²⁶ Neither atopy nor smoking appears to be an important determinant of asthma in studies of low molecular weight agents. Different agents, including agents of high and low molecular weight, were responsible for the cases of work related asthma reported here.

In this study, regardless of atopic status, subjects with a lower educational level had a higher risk of work related asthma. This association may be the consequence of environmental exposure at the workplace. Low educational level may be associated with a lower professional qualification, limiting the working options and rendering the individuals more predisposed to working in high risk places. Another explanation for the association between

Table 4 Unadjusted and adjusted hazard ratios (HR) of work related asthma in 427 subjects with bronchial hyperresponsiveness

Variable	Categories	Unadjusted HR	95% CI	Adjusted HR	95% CI
Gender	Male	1.28	(0.83 to 1.99)	0.94	(0.57 to 1.54)
	Female	1		1	
Smoking	Current or former smoker	1.13	(0.69 to 1.84)	0.77	(0.44 to 1.36)
	Never smoker	1		1	
Atopy	Positive to 1 or 2 allergens	0.80	(0.48 to 1.34)	0.82	(0.48 to 1.41)
	Positive to 3 or more allergens	0.61	(0.33 to 1.13)	0.71	(0.36 to 1.41)
	Negative	1		1	
Rhinitis	Yes	0.88	(0.56 to 1.40)	1.02	(0.61 to 1.71)
	No	1		1	
Education	1–8 years	4.30	(2.00 to 9.20)	2.99	(1.32 to 6.76)
	9–11 years	2.57	(1.26 to 5.24)	2.07	(1.00 to 4.28)
	≥12 years	1		1	
Self-reported exposure	Dust, vapour, humidity, or gases	2.40	(1.28 to 4.49)	2.02	(1.04 to 3.94)
	Chemical products or paints	4.12	(1.78 to 9.52)	3.69	(1.54 to 8.83)
	More than one agent	5.11	(2.64 to 9.88)	4.88	(2.40 to 9.94)
	No reported exposures	1		1	

Self-reported exposure was assessed by a standardised question without individual job description.

Main messages

- Atopy and low educational level are associated with work related asthma.
- Among young adults in Brazil, prevalence of work related asthma is high (4.2%).
- Pre-existing aggravated asthma represents one third of cases of work related asthma; occupational asthma, two thirds (or 2.7% prevalence).
- Young adults could be screened for early onset bronchial hyperresponsiveness as a powerful preventive tool.

low educational level and work related asthma may be that poor patients, instead of going to school, have to work earlier in life, with an increase in the risk for work related diseases by increasing the duration of exposure. In other words, the finding of the association between work related asthma and education might simply be a reflection of the fact that the non-work related asthma group contained a higher proportion of people still in full time education or only recently out of university, with little exposure yet for the development of work related asthma.

The association between socioeconomic status and asthma (general asthma) has been addressed by several authors who employed different asthma parameters and socioeconomic indicators. These authors demonstrated that a low socioeconomic level leads to a greater risk of having asthma, of having more severe asthma, or of having a worse control of the disease.^{27–30} There are no previous studies on the impact of poverty on the development of work related asthma. On the basis of our results, it is possible that workplace exposure is one of the determinants of the increased prevalence/risk of asthma in underprivileged populations. In addition to social condition being a factor leading to asthma, it may also be that asthma leads to low socioeconomic level. There are also data indicating lower salaries, unemployment, or difficulties in obtaining a promotion for individuals with work related asthma.^{31–34} These findings, taken together with the present results, permit us to propose the theory of a vicious cycle in which work related asthma leads to lower earnings and is also the consequence of lower socioeconomic level in combination with lower educational level.

We found a prevalence of work related asthma of approximately 4% for the general population or 35% for asthma cases. Other population based studies have reported lower percentages.^{16 35 36} The proportion of asthma attributed to occupation among adults was 5–10% in European and other industrialised countries, corresponding to 0.2–0.5% of all adults becoming asthmatics or having their asthma exacerbated because of their occupations.¹⁶ An American study¹⁷ reported a 3.7% prevalence of work related asthma, whereas 11.5% of survey respondents reported work related wheezing. These rates are within the wide range reported in various countries.^{16 37–40}

Estimates of the proportion of asthma that is attributed to workplace exposures vary widely, probably due to several factors, including lack of recognition of occupational factors,³⁸ variations in the case definitions for work related asthma,⁴¹ and differences among denominator populations.¹⁷ Although there are some well validated epidemiological questionnaires for investigating asthma, there is no validated tool for work related asthma.⁴² Moreover, questionnaire derived identification of work related asthma may provide higher estimates because of the high sensitivity of the

Policy implications

- Preventive interventions for work related asthma should be aimed especially at people with low schooling.

instrument, but may produce a large proportion of false positive results.⁴³ A stepwise approach has been suggested with further investigation of subjects reporting symptoms suggestive of work related asthma.^{44 45} Selecting a subset of respondents at random from a population sample has been an alternative method for obtaining extended information by detailed questionnaires, skin prick tests, spirometry, and methacholine challenge.⁴⁶ According to Gautrin *et al*,⁴² it will be important in the future to ensure uniformity of the methods used to assess the prevalence of work related asthma (i.e. uniform criteria to define work related asthma and the same diagnostic tools to allow comparison of the results from different studies).

We defined asthma on the basis of symptoms in association with pulmonary function tests. Most of the asthmatic patients studied had few symptoms, 43% were unaware of the diagnosis of asthma, and the frequency of individuals who had already used some medication for asthma was 25% (data not shown). These data suggest that the asthma detected in these individuals is intermittent or in an early phase. Another explanation for the fact that the individuals are unaware of the diagnosis is that they are young and possibly less worried about health questions. This supports the need for more sensitive evaluations in young individuals which would detect cases of asthma that might be false negative (presence of few symptoms) in studies with a methodology based only on questionnaires.

An advantage of the kind of study performed (cross-sectional) is the possibility of creating a cohort to be followed. A follow up of this cohort will permit the future evaluation of the prevalence of work related asthma when the individuals will be older, as well as the evaluation of prognostic factors or of the natural history in patients who do not comply with treatment. On the other hand, this study design is prone to survivor bias. The well described survivor bias effect (which may result from exclusion of workers who left the workplace before the study was conducted) is probably the most important bias affecting prevalence estimates from cross-sectional surveys.⁴²

This study is innovative by demonstrating the relations between work related asthma and low educational level in young adults. In addition, among the few studies carried out on the general population, this is the first one to be conducted in South America. In conclusion, the prevalence of work related asthma is high among young people (4.2%) and, in addition to the environment, low educational level, probably associated with low socioeconomic level, is a risk factor. The disease may be the consequence of poverty and may induce more poverty. Finally, programmes of prophylaxis of work related asthma could be based on the determination of bronchial hyperresponsiveness as a screening test among young workers. These programmes may have an impact on the global prevalence of asthma since, according to our results, a significant proportion of asthmatic individuals (35%) become asthmatics or have their asthma exacerbated because of their occupations.

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APPENDIX 1: QUESTIONS USED TO DETECT WORK RELATED ASTHMA

- Current job and past job description: year started and year ended.
- List of chemical or other substances encountered in the workplace: year started and year ended.
- Have you ever been transferred from a job for health reasons?
- While working at your current job, have you had: wheezing; cough; shortness of breath; runny nose; itchy eyes; or tearing?
- What month/year did the symptoms start?
- Do your co-workers present these symptoms?
- Do these symptoms begin immediately after starting work (less than 1 hour)?
- Are these symptoms better at weekends?
- Are these symptoms better on vacation?
- Are symptoms associated with exposure to a substance or process at work? What substance or process?
- Do you smoke cigarettes?
- Do you cough on most days for at least 3 months out of the year?
- Do you have a past history of asthma?
- Have you been close to any accidents or spills of substances or chemicals at work?
- Are these symptoms worsened by work?
- Are these symptoms started by work?
- Is there a relationship between symptoms and work?