Pesticides and respiratory symptoms among farmers

Agrotóxicos e sintomas respiratórios entre agricultores

Neice Müller Xavier Faria[a], Luiz Augusto Facchini[b], Anaclaudia Gastal Fassa[b] and Elaine Tomasi[c]

[a]Programa de Pós-Graduação em Epidemiologia. Departamento de Medicina Social. Universidade Federal de Pelotas (UFPel). Pelotas, RS, Brasil. [b]Departamento de Medicina Social. UFPel. Pelotas, RS, Brasil. [c]Programa de Pós-Graduação em Saúde Pública. Universidade Católica de Pelotas. Pelotas, RS, Brasil

Keywords
Respiratory tract diseases, chronic. Pesticides. Occupational diseases. Agriculture. Asthma. Rural Population.

Abstract

Objective
Despite the intensive use of pesticides in agriculture there are few studies assessing the risk of respiratory conditions from this exposure. The study aimed at quantifying the prevalence of respiratory symptoms among farmers and evaluating its relationship with occupational use of pesticides and the prevalence of respiratory symptoms.
Methods
A cross-sectional study was conducted among 1,379 farmers from two municipalities of Southern Brazil in 1996. Frequency and type of chemical exposure and pesticide poisoning were recorded for both sexes. All subjects aged 15 years or older with at least 15 weekly hours of agricultural activity were interviewed. An adapted questionnaire developed by the American Thoracic Society was used for the assessment of respiratory symptoms. Multivariate logistic regression analysis was carried out.
Results
More than half (55%) of interviewees were male. The prevalence of asthma symptoms was 12% and chronic respiratory disease symptoms was 22%. Higher odds ratios for both asthma (OR=1.51; 95% CI: 1.07-2.14) and chronic respiratory disease (OR=1.34; 95% CI 1.00-1.81) symptoms were found in women. Logistic regression analysis identified associations between many forms of exposure to pesticides and increased respiratory symptoms. Occurrence of pesticide poisoning was associated with higher prevalence of asthma symptoms (OR=1.54; 95% CI: 1.04-2.58) and chronic respiratory disease symptoms (OR=1.57; 95% CI: 1.08-2.28).
Conclusions
In spite of causality limitations, the study results provide evidence that farming exposure to pesticides is associated with higher prevalence of respiratory symptoms, especially when the exposure is above two days per month.

Descritores
Doenças respiratórias, crônicas. Agrotóxicos. Doenças ocupacionais. Agricultura. Asma. População rural.

Resumo

Objetivo
Apesar do uso intensivo de pesticidas na agricultura, ainda são raros os estudos sobre avaliação de riscos respiratórios devidos a esses produtos. O objetivo do estudo foi dimensionar a prevalência de sintomas respiratórios entre agricultores e avaliar suas relações com o uso ocupacional de agrotóxicos.

Correspondence:
Neice M. X. Faria
Rua República, 80/1401 Cidade Alta
95700-000 Bento Gonçalves, RS, Brasil
E-mail: neicef@italnet.com.br

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Métodos
Foi desenvolvido um estudo transversal com 1.379 agricultores de dois municípios da Serra Gaúcha, Brasil, em 1996. Foram medidas a freqüência e as formas de exposição química aos agrotóxicos, além das intoxicações agudas para ambos os sexos. Foram entrevistados todos os indivíduos com 15 anos de idade ou mais, com no mínimo 15 horas semanais de atividade. Para investigar os sintomas respiratórios, foi usada uma adaptação do questionário da American Thoracic Society. *A análise multivariada foi realizada por meio de regressão logística.*
Resultados
Dos agricultores entrevistados, 55% eram do sexo masculino. A prevalência de sintomas de asma foi de 12% e 22% foram considerados como portadores de doença respiratória crônica. As mulheres apresentaram os odds ratios *mais elevados para sintomas de asma (OR=1,51; IC 95%: 1,07-2,14) e para sintomas de doença respiratória crônica (OR=1,34; IC 95%: 1,00-1,81). A regressão logística identificou associações entre várias formas de exposição aos agrotóxicos e aumento de sintomas respiratórios. A ocorrência de intoxicações por agrotóxicos mostrou-se associada com maior prevalência de sintomas de asma (OR=1,54; IC 95%: 1,04-2,58) e de doença respiratória crônica (OR=1,57; IC 95%: 1,08-2,28).*
Conclusões
Apesar das limitações de causalidade, os resultados evidenciaram que o trabalho agrícola envolvendo agrotóxicos está associado com a elevação da prevalência de sintomas respiratórios, especialmente quando a exposição é superior a dois dias por mês.

INTRODUCTION

Several studies[1,12,19,26] have reported increased risk of respiratory problems, such as asthma and chronic bronchitis, among agricultural workers. Exposure to pesticides has been associated with increased risk of respiratory symptoms in agricultural activities.[10,23] Workers are usually exposed to a wide range of different chemical substances. Contact with these substances is not restricted to product application, but also occurs during product preparation, helping with hoses, washing contaminated clothes and dispensing treatment to livestock.

In the United States, a study[10] in a large cohort of approximately 20,000 pesticide applicators provided evidence of the association between work with pesticides and the occurrence of wheezing in the previous year. A historical cohort conducted among Australian agricultural workers[2] involved in the control of ticks showed that occupational exposure to insecticides was associated with greater asthma mortality rates and prevalence of atopic disease among survivors.

In a mountain region in Southern Brazil (Serra Gaúcha), it is estimated that 95% of farms use some sort of pesticide and that at least three out of four agricultural workers are regularly exposed to pesticides. It is also estimated that only half of these workers use protective masks (face-shields) while working with these products.[8] Despite the large number of Brazilian agricultural workers exposed to agrochemicals, no population-based studies have been carried out to assess the impact of chemical exposure on their respiratory health.

The objective of the present study was to verify the prevalence of respiratory symptoms among farmers and to evaluate its association with occupational exposure to pesticides.

METHODS

A cross-sectional study including 1,379 agricultural workers of Serra Gaúcha, Souhtern Brazil, was carried out in 1996. All subjects aged 15 years or older with at least 15 weekly hours of agricultural activity were interviewed. This study is part of a larger project that evaluated several aspects of the agricultural workers exposures and health. The sampling process is presented in detail elsewhere.[8] Briefly, 20% of the rural properties in the region were randomly selected based on the official registry of agricultural producers in each city. Fieldwork lasted five weeks and took place during the 1996 summer harvest. The regions chosen are characterized by the predominance of family farming, small or average-sized properties, diversified agricultural activities and fruit production.

All information was obtained by interviewing workers at their place of work, using one questionnaire for collecting data on the characteristics of the farm and

a second one for data on each agricultural worker. Socioeconomic and agricultural data were collected, and properties were characterized according to area (agriculture, cattle and total), type of agricultural production (types of fruits, corn, beans, pumpkin, onions, horticulture, and others), animal production (number of birds, bovines, equines and others), and level of mechanization (types of agricultural machines, vehicles for crop transportation, automobiles and implements). Scores were established for the level of mechanization and gross income yielded by the agricultural production.[8]

The use of pesticides in the property was evaluated based on the main chemical groups used: organophosphates (fenthion, dimethoate, trichlorfon, methyl parathion, and methamidophos), pyrethroids (deltamethrin, cypermethrin), triazines (atrazine, simazine), copper sulfate, dithiocarbamates (mancozeb, maneb) alaninates, captan, dodine, benzimidazole, glyphosate and paraquat. The insecticides were classified according to their use in cattle raising and agricultural activities. Data on chemical fertilizer (almost exclusively nitrogen-phosphate-potassium (NPK) formulations) and industrial ration use (for bovines, swine and poultry) were also collected. These chemical groups were analyzed separately and grouped by class and frequency of use. Data on chemical types were obtained for the entire farm, and were estimated as collective environmental exposure.

The individual questionnaire characterized workers in terms of sociodemographic aspects (sex, age, schooling, marital status, ethnicity, labor relation, and smoking). Smokers were divided into three categories (non-smokers, former smokers and current smokers). The levels of 12 types of organic and mineral dust were assessed, based on the intensity perceived by the worker. Indicators were constructed by grouping types of dust with intense exposure for analysis as a confounder.

Self-reported individual exposure to pesticides was evaluated by investigating different forms of contact with chemicals (application, mixing, cleaning equipment, helping with hoses, washing contaminated clothes, transporting and loading pesticides, applying treatment to animals, re-entering recently treated fields, and working with pesticides in more than one property). These exposures were classified according to days per month of chemical contact. It was also considered the duration of exposure (average daily hours of agricultural and non-agricultural work, both during the harvest and in the period between harvests; years of exposure to chemicals; years living in the property). Self-reported lifetime poisoning with pesticides was considered as a marker of intense agrochemical exposure, enough to cause self-reported poisoning.[24] The use of protective masks specific for chemical products was also investigated among exposed agricultural workers. In the light of large number of exposures, it was chosen to construct synthetic indicators for certain factors, e.g., the class of pesticide used (insecticides, herbicides, and fungicides), major chemical groups; forms of intense exposure to agrochemicals (for exposures of more than two days per month); and intense use of any type of chemical fertilizer.

Respiratory symptoms were characterized using an adapted questionnaire developed by the American Thoracic Society/Division of Lung Disease (ATS/DLD).[9] This version was used in chronic bronchitis prevalence study in Pelotas, Southern Brazil.[16] Although this version has not been validated in Brazil, this is an internationally recognized questionnaire, validated by epidemiological studies in others countries.[21]

The criterion used for defining asthma symptoms was reporting of having had two or more episodes of wheezing with shortness of breath at any time in their lifetime. Information on chronic bronchitis was based on self-reported symptoms of cough and phlegm during most days of the week, for three or more months per year, and lasting at least two years.[23] Chronic respiratory disease was defined as the presence of at least one of the following symptoms: cough or phlegm during most days of the week for three or more months per year, recurrent wheezing (most days and nights), or two or more episodes of wheezing with shortness of breath.[20]

Crude analyses evaluated associations through Chi-square and linear trend tests. The employees showed better socioeconomic conditions than farm owners, considering that all agricultural and socioeconomic indicators reflected the characteristics of the rural property and the employees (7% of the sample) worked in the richest farms. Therefore, the employees were excluded from the analysis. Multivariate analysis was performed through logistic regression based on a hierarchical conceptual model using SPSS-10 software. The variables included in the regression model were classified into two levels:

1. Sociodemographic and agroeconomic factors: sex, age, education, civil status, smoking, size of agricultural area, level of mechanization, gross income from agricultural production, production of fruits, onions, flocks of horses and birds.
2. Factors related to the rural work process: forms of pesticide exposure, pesticide poisoning, working hours during harvest, use of industrial rations, intense exposure to mineral and organic dust, and years of chemical exposure.

Table 1 - Frequencies of respiratory symptoms among farmers (N=1,379). Serra Gaúcha, Brazil, 1996.

Respiratory symptoms	N (%)
Usually has cough	201(14.6)
Chronic cough*	88 (6.4)
Usually coughs when waking up	108 (7.8)
Usually produces phlegm	240 (17.4)
Chronic phlegm*	119 (8.6)
Usually produces phlegm when waking up	171(12.4)
Has chronic bronchitis**	42 (3.1)
Had disabling disease with phlegm in the last 3 years	145 (10.6)
Has had wheezing without cold	98 (7.1)
Has had wheezing most days or nights (recurrent)	95 (6.9)
Has had wheezing and shortness of breath	246 (17.9)
Asthma symptoms***	168 (12.2)
Has used medication for wheezing with shortness of breath	152 (11.1)
Chronic respiratory disease symptoms****	303 (22.0)
Has relatives with asthma	429 (31.3)
Has relatives with respiratory allergy	256 (18.8)

*Most days of the week, during three or more months per year
**Chronic cough and phlegm, both lasting for two years or more
***Has had two or more crises of wheezing with shortness of breath
****Chronic cough or chronic phlegm or recurrent wheezing or symptoms of asthma

Two outcomes were examined in the logistic regression analysis: symptoms of asthma and chronic respiratory illness. For chemical exposure variables, the reference category in the regression analysis was the non-exposed or little-exposed group. The criterion for confounder inclusion was p-value up to 0.20. The interaction of the different types of exposure to agrochemicals and socioeconomic indicators (level of mechanization, gross production income, property size, and schooling) or smoking was analyzed.

RESULTS

Of the eligible workers, 5% could not be interviewed, totaling 1,379 farmers in 471 farms. Among the studied farmers, 55% were male, 93% were landowners and 7% were either tenants or partners. Mean age was 42.0 years old (standard deviation (sd)=15.6) and mean schooling was 4.8 years (sd=2.7). It was found that 12% were current smokers and 12% were former smokers (Kappa=0.89).

Of the interviewed farmers, 18% reported at least one episode of wheezing with shortness of breath. The cumulative prevalence of asthma symptoms was 12% and the prevalence of chronic respiratory disease was 22%. Table 1 shows the prevalence of major respiratory symptoms.

The frequency of smoking and the main symptoms among farmers aged 40 years or older (n=736) was higher than the sample average. Among this age group, 18% were former smokers, 14% were current smokers, 17% of subjects had asthma symptoms, 30% had symptoms of chronic respiratory illness, 9% had chronic cough, 13% had chronic phlegm, and 5% had chronic bronchitis.

Table 2 presents the results of the multivariate

Table 2 - Association between sociodemographic factors and respiratory symptoms using logistic regression. Serra Gaúcha, Brazil, 1996.

Factors	N	Symptoms of asthma		Chronic respiratory disease	
		Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Sex		p=0.003	p=0.02	p=0.09	p=0.05
Male	764	1	1	1	1
Female	615	1.63 (1.18–2.26)	1.51(1.07–2.14)	1.25 (0.96–1.61)	1.34 (1.00–1.81)
Age		p<0.001*	p=0.003*	P<0.001	p<0.001*
15-29 years	330	1	1	1	1
30-40 years	349	1.48 (0.83–2.62)	1.47 (0.73–2.98)	1.24 (0.80–1.94)	1.00 (0.59–1.67)
41-53 years	353	2.36 (1.38–4.04)	2.05 (0.99–4.22)	2.44 (1.62–3.68)	1.88 (1.11–3.17)
54+ years	347	3.47 (2.07–5.82)	2.95 (1.35–6.45)	3.98 (2.68–5.92)	3.33 (1.87–5.93)
Schooling		p<0.001	p=0.04*	p<0.001	p=0.06*
<1 year	115	1	1	1	1
2-4 years	545	0.65 (0.39–1.08)	0.76 (0.44–1.33)	0.64 (0.42–0.98)	0.87 (0.54–1.39)
5-7 years	500	0.42 (0.24–0.71)	0.61 (0.33–1.11)	0.41 (0.27–0.64)	0.74 (0.46–1.23)
8+ years	219	0.26 (0.13–0.52)	0.48 (0.21–1.05)	0.25 (0.15–0.44)	0.57 (0.30–1.10)
Smoking		p=0.31	p=0.30	p=0.004	p=0.14
Never	1,042	1	1	1	1
Former	169	1.35 (0.85–2.15)	1.32 (0.79–2.21)	1.78 (1.24–2.56)	1.45 (0.96–2.19)
Smoker	168	1.30 (0.81–2.08)	1.43 (0.86–2.39)	1.38 (0.95–2.01)	1.33 (0.87–2.04)

*p-value, linear trend test
Odds ratio adjusted by: sex, age, schooling, marital status, smoking, area for agriculture, level of mechanization, gross income, agricultural production, exposure to dust, years living in the farm, and poisoning by pesticides

analysis of associations between sociodemographic factors and respiratory symptoms. The prevalence of these symptoms was found to be higher among women, older subjects, and agricultural workers with low schooling. No differences were observed with respect to marital status or ethnicity. Smoking (analyzed in three categories) was not significantly associated with the outcomes (Table 2).

Among the farmers, almost 60% worked with pesticides more than two days per month and 162 (12%) reported pesticide poisoning during their lifetime. Several forms of exposure to pesticides, including the synthetic indicators of frequent exposure (grouping exposures greater than two days per month), showed a positive linear association between frequency of chemical exposure and respiratory symptoms (Table 3). Applying pesticides, helping with hoses, cleaning equipment, and washing contaminated clothes roughly doubled the risk of having asthma symptoms. As to symptoms of chronic respiratory illness, a 70-90% increase in risk was observed among subjects who worked in more than one farm, prepared chemical mixtures, and washed contaminated clothes, when compared to those who did not perform these activities. After grouping forms of exposure which exceeded two days per month, it was observed a linear increase in asthma symptoms along with an increase in forms of exposure. Likewise, the occurrence of pesticide poisoning (indicating intense exposure) was associated with greater prevalence of both asthma and chronic respiratory disease symptoms.

None of the major classes of chemicals used were associated with increased prevalence of the symptoms evaluated, neither when examined according to specific chemical groups nor when pooled into classes of agricultural usage (insecticides for livestock or agriculture, fungicides, and herbicides). Associations between the use of fertilizers in the farm and respiratory symptoms were also not found (Table 4).

The use of respirators against chemical products showed no association with the prevalence of respiratory symptoms. It was not observed interactions between socioeconomic indicators or smoking and the forms of exposure to pesticides.

DISCUSSION

The present study showed that the occupational use of pesticides is associated with increased respiratory symptoms, especially those of asthma.

Table 3 - Association between main exposure to pesticides and respiratory symptoms using logistic regression. Serra Gaúcha, Brazil, 1996.

Forms of exposure	N	Symptoms of asthma		Chronic respiratory disease	
		Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Work with pesticides		p=0.27	p=0.09	p=0.12	p=0.03
Up to 1 farm	1,267	1	1	1	1
2 or + farms	68	1.45 (0.75-2.83)	1.84 (0.92-3.69)	1.54 (0.90-2.64)	1.92 (1.08-3.41)
Pesticide application		p=0.72	p=0.02*	p=0.65	p=0.48
No	413	1	1	1	1
Up to 2 days/month	484	0.85 (0.57-1.28)	1.59 (0.87-2.90)	0.86 (0.63-1.18)	0.87 (0.62-1.24)
>3 days/month	465	0.97 (0.65-1.44)	2.11 (1.14-3.92)	0.93 (0.68-1.27)	1.06 (0.75-1.52)
Mixing of pesticides		p=0.17	p=0.13*	p=0.03	p=0.02*
No	512	1	1	1	1
Up to 2 days/month	691	0.81 (0.57-1.16)	1.06 (0.71-1.57)	0.94 (0.71-1.24)	1.11 (0,80-1.53)
>2 days/month	159	1.27 (0.77-2.09)	1.67(0.96-2.90)	1.58 (1.06-2.36)	1.85 (1.18-2.91)
Pesticide spreading aid		p=0.57	p=0.005*	p=0.49	p=0.76
No	458	1	1	1	1
Up to 2 days/month	569	1.01 (0.69-1.49)	2.12 (1.19-3.75)	0.86 (0.64-1.16)	0.93 (0.68-1.28)
>2 days/month	334	1.23 (0.80-1.87)	2.54 (1.36-4.72)	1.02 (0.73-1.43)	1.05 (0.74-1.51)
Equipment cleaning		p=0.41	p=0.02*	p=0.31	p=0.25
No	495	1	1	1	1
Up to 2 days/month	670	0.85 (0.60-1.22)	1.52 (0.92-2.52)	0.88 (0.66-1.17)	1.07 (0.77-1.48)
>2 days/month	197	1.15 (0.71-1.85)	2.06 (1.13-3.77)	1.16 (0.79-1.71)	1.43 (0.93-2.22)
Washing of working clothes		p=0.02	p=0.04*	p=0.04	p=0.01*
No	802	1	1	1	1
Up to 2 days/month	425	1.63 (1.14-2.31)	1.82 (1.10-3.02)	1.22 (0.92-1.62)	1.21 (0.89-1.64)
>2 days/month	137	1.53 (0.91-2.60)	1.94 (0.96-3.92)	1.66 (1.10-2.49)	1.78 (1.15-2.75)
Forms of exposure**		p=0.47	p=0.002*	p=0.58	p=0.46
None/little	563	1	1	1	1
1	253	0.87 (0.54-1.41)	1.45 (0.80-2.61)	0.85 (0.59-1.22)	0.95 (0.64-1.41)
2	182	1.32 (0.82-2.15)	2.78 (1.52-5.05)	0.85 (0.56-1.28)	1.12 (0.72-1.77)
>2	381	1.16 (0.78-1.71)	2.13 (1.26-3.61)	1.06 (0.78-1.45)	1.28 (0.90-1.81)
Pesticide poisoning		p=0.02	p=0.03	p=0.004	p=0.02
No	1,216	1	1	1	1
Yes	162	1.71 (1.10-2.65)	1.64 (1.04-2.58)	1.71 (1.19-2.45)	1.57 (1.08-2.28)

*p-value, linear trend test
**Exposure over 2 days per month
Odds ratio adjusted by sex, age, schooling, marital status, smoking, socioeconomic indicators, agricultural production, exposure to dust, industrial rations, years of chemical exposure.

The validity of this study is supported by a high response rate (95%), a representative sample size, agile fieldwork, trained interviewers, quality control, and double data entry, among others.

In this region, biological markers were not available for several of the used pesticides. The estimate pesticide exposure based just on worker perception could present low accuracy or misclassification. So, other analytical methods, such as biomarkers of internal dose, could improve the chemical exposure accuracy. On the other hand, the information provided by workers was advantageous, since it allowed to estimate several simultaneous exposures to airborne substances, such as dusts and different types of chemical products. Besides, it makes possible to approach the occurrence of poisonings.

The study cross-sectional design limits inferences on the causality of the associations between occupational exposures and respiratory symptoms. As the symptoms evaluated referred to a long period of time, temporal ambiguity and/or recall biases may have occurred underestimating the associations.

The prevalence of asthma symptoms found (12%) was strengthened by the fact that 11% of the agricultural workers had already used medication during episodes of wheezing with shortness of breath. Despite the variations in the criteria used to define asthma symptoms in other studies, there was a reasonable level of consistency with results obtained in other countries: New Zealand,[6,11] USA[10] (Iowa and North Caroline), Switzerland,[7] Sweden,[13] Brazil[5] (Pelotas) and an multicenter study[3] – European Community Respiratory Health Survey (ECRHS). There was a substantial difference in the prevalence of respiratory symptoms according to region. In the ECRHS,[3] the prevalence of wheezing with shortness of breath varied from 3% to 16%. In Canada, using ECRHS methodology, was 10-12% among men and 11-19% among women, depending on the site studied.[14]

The prevalence of symptoms of chronic respiratory illness (22%) was consistent with Norway study,[15] but higher than the Lebanese study.[20] This could be explained by the younger age of the interviewees in the Lebanese study. Another study compared the results of two different databases using three criteria: the prevalence of airways obstruction was 13% according to the European criterion, 45% according to the American criterion, and 23% according to clinical

Table 4 - Association between major chemical types used in the farms and respiratory symptoms using logistic regression. Serra Gaúcha, Brazil, 1996.

Chemical types	N	Symptoms of asthma		Chronic respiratory disease	
		Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Insecticides-agriculture		p=0.10*	p=0.78	p=0.13	p=0.43
None	417	1	1	1	1
One type	329	1.01 (0.66-1.54)	1.09 (0.70-1.70)	1,23 (0.88-1.73)	1.22 (0.84-1.76)
Two types	259	0.73 (0.44-1.19)	0.82 (0.49-1.38)	0.82 (0.56-1.22)	0.86 (0.56-1.31)
3 or + types	351	0.74 (0.47-1.15)	0,99 (0.62-1.59)	0.85 (0.60-1.21)	1.04 (0.71-1.52)
Fungicides		p=0.001*	p=0.26	p=0.003*	p=0.06*
None	382	1	1	1	1
One type	186	0.71 (0.42-1.20)	0.74 (0.43-1.27)	1.08 (0.72-1.61)	1.04 (0.68-1.60)
Two types	280	0.81 (0.52-1.25)	0.92 (0.57-1.50)	0.93 (0.65-1.34)	1.00 (0.68-1.48)
3 or + types	518	0.49 (0.32-0.74)	0.65 (0.40-1.04)	0.62 (0.45-0.86)	0.71 (0.49-1.02)
Herbicides		p=0.04*	p=0.88	p=0.06*	p=0.49
None	613	1	1	1	1
One type	504	0.71 (0.49-1.03)	0.95 (0.64-1.43)	0.72 (0.54-0.96)	0.83 (0.61-1.13)
Two or + types	258	0.65 (0.41-1.05)	0.87 (0.51-1.48)	0.77 (0.54-1.10)	0.88 (0.61-1.29)
Organophosphate		p=0.06*	p=0.70	p=0.10*	p=0.78
None	282	1	1	1	1
1-3 types	637	0.76 (0.50-1.14)	0.86 (0.56-1.33)	0.90 (0.64-1.25)	0.89 (0.62-1.29)
4 or + types	440	0.64 (0.41-1.01)	0.82 (0.51-1.33)	0.74 (0.52-1.01)	0.87 (0.59-1.30)
Pyrethroids		p=0.30	p=0.37	p=0.74	p=0.60
None	584	1	1	1	1
One type	516	0.76 (0.53-1.10)	0.76 (0.51-1.11)	0.90 (0.67-1.20)	0.89 (0.66-1.21)
Two or + types	263	0.79 (0.50-1.24)	0.89 (0.55-1.43)	0.92 (0.65-1.31)	1.07 (0.74-1.56)
Copper sulfate		p=0.02	p=0.45	p=0.06*	p=0.10*
None	476	1	1	1	1
Uses little	487	0.59 (0.40-0.88)	0.76 (0.50-1.16)	0.71 (0.52-0.96)	0.78 (0.56-1.08)
Uses much	403	0.68 (0.46-1.01)	0.86 (0.53-1.40)	0.75 (0.55-1.03)	0.76 (0.54-1.06)
Dithiocarbamates		p=0.004*	p=0.33	p=0.006*	p=0.27
None	593	1	1	1	1
Uses little	360	0.80 (0.54-1.18)	0 .93 (0.61-1.42)	0.88 (0.64-1.19)	0.99 (0.71-1.38)
Uses much	416	0.54 (0.36-0.82)	0 .70 (0.44-1.12)	0.64 (0.47-0.88)	0.77 (0.54-1.08)
Glyphosate		p=0.02	p=0.54	p=0.005*	p=0.46
None	694	1	1	1	1
Uses little	335	0.72 (0.48-1.08)	0.92 (0.59-1.44)	0.72 (0.48-1.08)	0.85 (0.60-1.19)
Uses much	336	0.55 (0.35-0.85)	0.75 (0.45-1.25)	0.55 (0.35-0 .85)	0.82 (0.58-1.17)

*p-value, linear trend test
Odds ratio adjusted by: sex, age, schooling, marital status, smoking, socioeconomic indicators, agricultural production, intense exposure to dust, industrial rations

symptoms.[25] The latter result was in agreement with the present study. However, the study acknowledged a lack of standardization in the classification criteria, which hampers epidemiological comparisons.

The prevalence of chronic phlegm (9%) was compared to other studies: 11% in a study in Ohio, USA,[26] 11-17% among European farmers,[17-19] and 4% in California, USA.[18]

The results on the prevalence of chronic cough (6%) and wheezing without cold (7%) were relatively similar to Ohio study[26] but lower than the Canadian study, whose prevalence was 14% for morning cough and 27% for wheezing without cold.[22]

Different forms of occupational exposure to pesticides showed a dose-response relationship with respiratory symptoms, especially those of asthma. The pesticide exposure, at a high enough concentration to cause self-reported pesticide poisoning, was considered an indicator of intense exposure and showed a clear association with symptoms of asthma and chronic respiratory illness. These data are consistent with results found in other countries. In the Canadian study,[22] pesticides were associated with physician-diagnosed asthma. Among American pesticide applicators, it was observed associations between several types of pesticides and wheezing in the previous year.[10] Two studies on family farming found results indicative of the respiratory risk of pesticide use: in Iowa, work involving pesticides, showed a clear association with respiratory symptoms.[23] In Ohio, rural work involving pesticides was related to the increased chronic cough ($p<0.10$).[26] In Lebanon, a study using similar criteria to those of the present study, revealed an association between several types of pesticide exposure – domestic, environmental, and occupational (parents) – and respiratory symptoms among rural students.[20]

The use of multivariate analysis based on a hierarchical model revealed the independent effects of several agricultural activities. Grouping pesticide exposure in different forms to what a subject is exposed to showed that the group of farmers not exposed to pesticides had a high prevalence of respiratory symptoms. On the other hand, in the group exposed to pesticides, a gradual increase in risk was observed with increasing exposure. This pattern may reflect the "healthy worker effect", by which healthier individuals are more likely to be involved in productive activities. The healthy worker effect has been confirmed among pesticide applicators in Iowa and North Carolina, where subjects with more severe respiratory symptoms were excluded from agricultural work or had their exposure to agents that can potentially worsen their symptoms restricted.[10] Therefore, the magnitude of the respiratory risks of pesticides could be reduced due to this effect.

Several studies have reported the risk to the respiratory system posed by pesticides of specific chemical types. In the Agricultural Health Study,[10] of 40 products tested, 11 types of compounds, mostly insecticides and herbicides, showed increased risk of wheezing. Chemical groups associated with respiratory symptoms included organophosphates, thiocarbamates, paraquat,[10] and carbamates.[22] Other publications also indicate the risks associated with other chemical groups such as fumigants, including methyl bromides, pyrethroids and others.[1,2] In the present study, even though several products were tested, alone and in groups, none of the chemical types showed an association with increased respiratory symptoms. However, data on chemical types were collected for the farm as a whole. By individualizing this information for each of the property's workers, chemical exposure was attributed to unexposed (or little exposed) individuals, thus producing a measurement bias directed towards the unit (null hypothesis). Moreover, richer and more productive properties are those that employ agrochemicals the most. It is possible that the control of the effect of socioeconomic indicators was insufficient, and a residual confounder effect may remain.

In addiction, agricultural workers are generally exposed to several products simultaneously. Therefore, the unexposed group or with little exposure to a certain chemical type could potentially be in contact with another type, reducing the difference between groups. Another factor that may have influenced the estimated exposure to pesticides is the lack of data on the non-occupational forms of exposure to agrochemicals, especially domestic exposure, present in the majority of households, which has already been associated with respiratory symptoms in an earlier study.[20]

The higher prevalence of asthma among women, in both crude and adjusted analysis, corroborates other studies conducted using similar methodology.[6,14] In fact, women used lower protection during pesticide exposure and had other risks such as house dust mite or clean up products. Besides, it is possible that, in addition to the exposure to household dust, the use of domestic insecticides may also contribute to the increased prevalence among women.

The finding that cumulative prevalence of asthma symptoms increased with age does not agree with some studies that found no differences in terms of age.[7,11,26] One study[4] compared reported cases of wheezing with

or without medical diagnosis of asthma, finding higher frequency of symptoms and lower frequency of medical diagnosis among the >50 years age group. This study also suggested a different pattern of asthma symptoms among older adults, in which wheezing without evidence of atopy would predominate.

The present study showed that work with pesticides is associated with an increased prevalence of respiratory symptoms, especially asthma. This risk was more evident when occupational chemical exposure was greater than two days per month. Nevertheless, due to the limitations in terms of the definition of causality, it is recommended that further studies be conducted on the subject, including more detailed accounts of the intensity of chemical exposure. It is identified the need of future studies that would be able to document the subject's past pesticide exposure, detailing the use of protective equipment, as well as concentration and toxicological classification of the pesticides used and non-occupational exposures.

Moreover, it is also necessary to consider that the characterization of the socioeconomic factors in the rural area remains a challenge for epidemiological research. It is an important determinant factor for several relationships, including quality life and work conditions. The low accuracy of the socioeconomic estimates make it difficult the evaluation of its impact on health and its control as confounding factor for the association between other exposures of interest and health problems.

The conclusions of the present study indicate that the development of policies aimed to reduce exposure to pesticides of different types may contribute towards the prevention of respiratory conditions among agricultural workers.

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REFERENCES

1. American Thoracic Society (ATS). Respiratory health hazards in agriculture. *Am J Respir Crit Care Med* 1998;158(5 Pt 2):S1-S76.

2. Beard J, Sladden T, Morgan G, Berry G, Brooks L, McMichael A. Health impacts of pesticide exposure in a cohort of outdoor workers. *Environ Health Perspect* 2003;111(5):724-30.

3. Burney P, Chinn S, Luczynska C, Jarvis D, Vermeire P, Bousquet J, et al. Variations in the prevalence of respiratory symptoms, self-reported asthma attacks, and use of asthma medication in the European Community Respiratory Health Survey (ECRHS). *Eur Respir J* 1996;9(4):687-95.

4. Court CS, Cook DG, Strachan DP. Comparative epidemiology of atopic and non-atopic wheeze and diagnosed asthma in a national sample of English adults. *Thorax* 2002;57(11):951-7.

5. Crane J, Lewis S, Slater T, Crossland L, Robson B, D'Souza W, et al. The self reported prevalence of asthma symptoms amongst adult new zealanders. *N Z Med J* 1994;107(988):417-21.

6. Costa Lima R, Victora CG, Menezes AM, Barros FC. Do risk factors for childhood infections and malnutrition protect against asthma? A study of Brazilian male adolescents. *Am J Public Health* 2003;93(11):1858-64.

7. Danuser B, Weber C, Kunzli N, Schindler C, Nowak D. Respiratory symptoms in Swiss farmers: an epidemiological study of risk factors. *Am J Ind Med* 2001;39(4):410-8.

8. Faria NMX, Facchini LA, Fassa AG, Tomasi E. Processo de produção rural e saúde na serra gaúcha: um estudo descritivo. *Cad Saúde Pública* 2000;16(1):115-28.

9. Ferris BG. Epidemiology standardization project (American Thoracic Society). *Am Rev Respir Dis* 1978;118(6 Pt 2):1-120.

10. Hoppin JA, Umbach DM, London SJ, Alavanja MC, Sandler DP. Chemical predictors of wheeze among farmer pesticide applicators in the agricultural health study. *Am J Respir Crit Care Med* 2002;165(5):683-9.

11. Kimbell-Dunn M, Bradshaw L, Slater T, Erkinjuntti-Pekkanen R, Fishwick D, Pearce N. Asthma and allergy in New Zealand farmers. *Am J Ind Med* 1999;35(1):51-7.

12. Kimbell-Dunn MR, Fishwick RD, Bradshaw L, Erkinjuntti-Pekkanen R, Pearce N. Work-related respiratory symptoms in New Zealand farmers. *Am J Ind Med* 2001;39(3):292-300.

13. Kronqvist M, Johansson E, Pershagen G, Johansson SG, van Hage-Hamsten M. Increasing prevalence of asthma over 12 years among dairy farmers on Gotland, Sweden: storage mites remain dominant allergens. *Clin Exp Allergy* 1999;29(1):35-41.

14. Manfreda J, Becklake MR, Sears MR, Chan-Yeung M, Dimich-Ward H, Siersted HC, et al. Prevalence of asthma symptoms among adults aged 20-44 years in Canada. *CMAJ* 2001;164(7):995-1001.

15. Melbostad E, Eduard W, Magnus P. Chronic bronchitis in farmers. *Scand J Work Environ Health* 1997;23(4):271-80.

16. Menezes AM, Victora CG, Rigatto M. Prevalence and risk factors for chronic bronchitis in Pelotas, RS, Brazil: a population-based study. *Thorax* 1994;49(12):1217-21.

17. Monso E, Magarolas R, Radon K, Danuser B, Iversen M, Weber C, et al. Respiratory symptoms of obstructive lung disease in european crop farmers. *Am J Respir Crit Care Med* 2000;162(4 Pt 1):1246-50.

18. Monso E, Schenker M, Radon K, Riu E, Magarolas R, McCurdy S, et al. Region-related risk factors for respiratory symptoms in European and Californian farmers. *Eur Respir J* 2003;21(2):323-31.

19. Radon K, Danuser B, Iversen M, Jorres R, Monso E, Opravil U, et al. Respiratory symptoms in european animal farmers. *Eur Respir J* 2001;17(4):747-54.

20. Salameh PR, Baldi I, Brochard P, Raherison C, Abi Saleh B, Salamon R. Respiratory symptoms in children and exposure to pesticides. *Eur Respir J* 2003;22(3):507-12.

21. Senthilselvan A, Dosman JA, Chen Y. Relationship between pulmonary test variables and asthma and wheezing: a validation of self-report of asthma. *J Asthma* 1993;30(3):185-93.

22. Senthilselvan A, McDuffie HH, Dosman JA. Association of asthma with use of pesticides: results of a cross-sectional survey of farmers. *Am Rev Respir Dis* 1992;146(4):884-7.

23. Sprince NL, Lewis MQ, Whitten PS, Reynolds SJ, Zwerling C. Respiratory symptoms: associations with pesticides, silos, and animal confinement in the Iowa farm family health and hazard surveillance project. *Am J Ind Med* 2000;38(4):455-62.

24. Stallones L, Beseler C. Pesticide poisoning and depressive symptoms among farm residents. *Ann Epidemiol* 2002;12(6):389-94.

25. Viegi G, Pedreschi M, Pistelli F, Di Pede F, Baldacci S, Carrozzi L, et al. Prevalence of airways obstruction in a general population: European Respiratory Society vs American Thoracic Society definition. *Chest* 2000;117(5 Suppl 2):339S-45S.

26. Wilkins JR 3rd, Engelhardt HL, Rublaitus SM, Crawford JM, Fisher JL, Bean TL. Prevalence of chronic respiratory symptoms among Ohio cash grain farmers. *Am J Ind Med* 1999;35(2):150-63.