Work related distal airway obstruction in an agricultural population

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Abstract

Objective—To assess the prevalence of distal airway obstruction and its risk factors in agricultural areas.

Methods—A cross sectional study of respiratory symptoms and lung function was performed among French farmers and their spouses (1122 subjects) who came for preventive medicine examinations. They answered a respiratory questionnaire and performed pulmonary function tests on a portable spirometer. Diagnoses of chronic bronchitis were made on the basis of reported chronic respiratory symptoms. Airway obstruction was determined from predicted values. Odds ratio (OR) and linear regression coefficients were calculated after stratification by smoking and history of cardiac and other respiratory diseases.

Results—Of respiratory symptoms prevalence of chronic cough was 8.47%, and chronic bronchitis 7.66%. Prevalence of distal airway obstruction was 11.4%, and overall airflow obstruction 3.2%. Smokers were 20.2% men, and 5.7% women. Linear regressions showed high association between pack-years in smokers or exsmokers and forced expiratory volume in one second/forced vital capacity (FEV₁/VC) and forced expiratory flow between 25% and 75% of vital capacity (FEF₂₅₋₇₅). In non-smokers without any history of cardiac or respiratory diseases, age and the size of farms had the highest correlations with these variables. OR for distal airway obstruction was 2.1 in subjects >50 years old *v* the younger ones and 3.02 in the smaller farms *v* the larger ones.

Conclusion—After stratification by smoking and history of cardiac and respiratory diseases, distal airway obstruction is present in agricultural areas. The age, and the size of farm are the highest respiratory risk factors in non-smokers.

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It is now well recognised that agricultural workers have an increased risk of respiratory diseases.¹ Most of the reported studies have dealt with parenchymatous diseases such as farmers' lung, although more recently, obstructive airway diseases have been

described in agricultural populations.²⁻⁶ As these conditions are the end result of a series of lung cell interactions involving inflammation and responses of the immune system, long term exposure may transform the acute condition into chronic bronchitis.⁷ For example, grain farmers and silo workers have been reported to have a high risk of development of respiratory symptoms.^{8,9} In fact, agricultural workers are exposed to a wide variety of toxic materials including dusts, gases, microbial products, toxins, and numerous chemical compounds (pesticides and fertilisers).¹ There is considerable variation in the reported prevalence of chronic bronchitis depending on the population studied and the nature of the agricultural activity.^{2-6,10-13} Although the prevalence of chronic bronchitis in the general population has been the subject of numerous studies, little has been reported on obstructive diseases in agricultural populations exposed to a wide range of respiratory hazards.¹ Although the prevalence of smoking is lower than in the general population,¹⁴ rates of chronic bronchitis are higher for several groups of agricultural workers than for controls in non-rural areas.^{6,15,16}

Injuries to peripheral airways may be induced by inhalation of small particles or endotoxins¹⁷ well before the appearance of respiratory symptoms.¹⁸ Peak expiratory flow rates (PEFRs) have been measured in grain elevator workers,¹⁹ and forced vital capacity (VC) and forced expiratory volume in one second (FEV₁) have been determined in workers in the grain industry.^{3,8,19} Do Pico *et al* found an adverse dose related acute respiratory effect.⁸ Although overall airflow obstruction is readily diagnosed from the results of lung function tests (FEV₁ or FEV₁/VC) with high correlations with symptoms,³ distal airway obstruction is less easily quantified. It can, however, be assessed from the forced expiratory flow between 25% and 75% of vital capacity (FEF₂₅₋₇₅), in the presence of a reduction in other instantaneous flow variables.^{20,21}

This study was designed to estimate the prevalence of distal airway obstruction and to identify risk factors for obstructive diseases, after stratification by confounding factors such as smoking habits and history of non-obstructive respiratory diseases.

Methods

STUDY POPULATION

Every five years, all people aged between 16 and 65 years and their families, either living in

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agricultural areas or contributors to the "Mutualité Sociale Agricole" (MSA) are eligible for a free medical examination after receiving written notification from the relevant hospital department. Salaried employees undergo an obligatory annual medical examination. Farmers, employees, and their spouses were included in the study if they were engaged in mixed farming, livestock breeding, horticulture, or fruit growing. Workers in banks, dairy industries, sawmills, and forestry were systematically excluded.

QUESTIONNAIRE

The questionnaire was designed with the British Medical Research Council guide lines, and the French version was drawn up by the World Health Organisation.²² We added three questions: one about agricultural activity, one about the size of farm, and the last about working conditions (average time spent a week in agricultural activities, but it was not possible to assess average exposures for a working day from the questionnaire). The questionnaire was given before the lung function examination.

Chronic bronchitis was defined as cough and expectoration for three months a year for two consecutive years according to the criteria of the American Thoracic Society (1960). Atopy was defined from a history of infantile eczema, hay fever, asthma, or rhinitis. Smoking was classified into non-smokers, ex-smokers (abstinence for previous three months), and current smokers. The amount smoked annually in pack-years was recorded for the two smoker groups. Cardiac and respiratory history was defined as history of cardiac disease, pulmonary surgery, pleurisy, pneumonia or tuberculosis, and restrictive respiratory diseases.

LUNG FUNCTION TESTS

Lung function was measured with portable spirometers (flowmate Hellige, Jaeger France). Three measurements were taken for all subjects by operators experienced with this instrument. The VC, FEV₁, and FEF₂₅₋₇₅ were recorded. The best of the three curves was selected. Curves with poor reproducibility or of bad quality were rejected. Values were expressed as a percentage of the normal values of the European Coal and Steel Community (ECSC) values, which are calculated according to the age, sex, and height of the person.²³

The lower limit for distal airway obstruction in people with a normal FEV₁ was a normal value of FEF₂₅₋₇₅ less 1.74 l/s in men and less 1.39 l/s in women (1.64 SD).²³ Distal airway obstruction was considered to be present if values were under these thresholds. The lower limit for overall airflow obstruction was the normal value of FEV₁/VC less 11.75% in men, and less 10.68% in women (1.64 SD).²³ Overall airflow obstruction was considered to be present if values were under these thresholds. A restrictive ventilatory impairment was defined as normal FEV₁/VC with a more than 20% reduction in FVC.

LABORATORY INVESTIGATIONS

Plasma samples from all subjects were tested for the presence of *Micropolyspora faeni* antigen (Outcherlony technique, Mercia diagnosis, FSK3, Immunogenetics, Anvers, Belgium) as screening for farmers' lung. A positive result was taken as the presence of at least one precipitation arc.

STATISTICAL ANALYSIS

Prevalence indicates the number of subjects in the population under study who had a symptom or lung function abnormality. In a cross sectional study, prevalence is expressed as a percentage of the whole population investigated. Analysis of variance (ANOVA Statworks software) was used to compare the means of the parametric values, and the χ^2 test was used to assess associations between discrete variables. Odds ratios (ORs) were used to indicate the degree of association between two dichotomous variables in stratified analysis. The ORs and confidence intervals (95% CIs) were calculated with the Mantel-Haenszel method.²⁴ The factors influencing FEF₂₅₋₇₅ and FEV₁/VC were analysed by linear regression (Statworks software). The variables included were those that significantly correlated with the airway disease ($P < 0.05$).

Results

CHARACTERISTICS OF THE POPULATION

From 1 November 1992 to 31 July 1993, 1473 subjects were sent written notifications (1270 for the free five yearly examination, and 203 employees for the obligatory annual medical examination). From the first group 952, and from the second 170, went to these preventive medical tests. The final sample comprised 1122 subjects (718 men and 404 women), 76.2% of the initial sample. They all agreed to participate and filled in the questionnaire. There were no differences in sex and age between initial and final samples. The mean (SD) age was 48.4 (12.9) years, and 619 people (55.2%) were over 50 years old. Average weight was 72 (13.1) kg. There were 203 smokers (18.1%), 152 (13.5%) ex-smokers, and 774 (66%) non-smokers, and smoking habits were unknown in 27 (2.4%) cases. Body mass index (BMI) was 26.0 (4.5) in the men, and 26.1 (4.3) in the women.

The farms were <20 hectares (ha) in 196 (15%) cases, 21–49 ha in 357 (31.8%) cases, 50–69 ha in 186 (16.6%) cases, >70 ha in 294 (26.2%) cases, and unknown in 89 (7.9%) cases. The farming activities were classified as follows (multiple answers allowed): fruit farming 31/1122 (2.7%), horticulture 35 (3.1%), sheep and cattle breeding 969 (86.4%), and mixed farming 472 (42.1%). The distribution of risk activities was (multiple answers allowed): grain milling 397/1122 (35.4%), silage making 426 (38%), grain silo work 59 (5.2%), hay storage 934 (83.2%), fertilising 475 (42.3%), and exposure to pesticides 345 (31.7%). For 1043 people (93%) who answered the questionnaire,

exposure was divided into the following categories: exposure < 3 months a year (class 1, $n = 73$, (6.5%)), intermittent exposure < 3 months a year (class 2, $n = 30$ (2.7%)), exposure < 7 hours a week (class 3, $n = 241$ (21.5%)), exposure > 7 hours a week (class 4, $n = 699$ (62.3%)).

There were sex differences for certain classes of activity (table 1).

Table 1 Characteristics and occupational activities of both men and women ($n = 1122$)

	Women ($n = 404$)	Men ($n = 718$)
Age	52.7 (10.3)	46.0 (13.7)
> 50 y (%)	0.667	0.458
Body mass index	26.18 (4.7)	26.0 (4.6)
Non-smokers	0.896	0.5265
Ex-smokers	0.0173	0.2507
(mean (SD) pack-y)	10.5 (6.7)	14.6 (13.1)
Current smokers	0.057	0.202
(mean (SD) pack-y)	13 (13.3)	14.3 (12.3)
Fruit farmers	0.0025	0.042
Horticulture	0.0025	0.047
Cattle breeding	0.928	0.827
Mixed farming	0.418	0.422
Grain milling	0.245	0.415
Silage making	0.269	0.441
Silo work	0.025	0.0682
Gathered hay	0.8812	0.805
Fertilisers	0.0546	0.631
Pesticides use	0.0371	0.4596
Size of farms		
< 20 ha	0.255	0.1295
21–49 ha	0.404	0.274
50–69 ha	0.166	0.1657
> 70 ha	0.166	0.316
Exposure intensity		
1	0.0545	0.071
2	0.0198	0.031
3	0.255	0.192
4	0.621	0.624

Table 2 Lung function tests between men and women

Predicted values (%)	Women ($n = 355$) mean (SD)	Men ($n = 672$) mean (SD)
FEV ₁	106 (15.9)	103.2 (23.3)
FEV ₁ /VC	101.6 (7.2)	100.6 (9.38)
FEV _{25–75}	79.1 (22.3)	90.3 (28.6)
FEV ₅₀	85.3 (24.8)	96.8 (32.6)
FEV ₂₅	69.4 (27)	85.4 (37.5)

Table 3 Respiratory symptoms and lung function in the whole sample by rural activity (n (%))

	Cough	Expectoration	Chronic bronchitis	History*	Distal obstruction	Overall obstruction
Cattle breeding ($n = 974$)	89 (9.1)	80 (8.2)	80 (8.2)	214 (22)	99 (10.9)	27 (3)
Gathering hay ($n = 940$)	89 (9.36)	75 (8)	74 (7.87)	213 (22.7)	101 (11.7)	27 (3.1)
Mixed farming ($n = 476$)	39 (8.1)	36 (7.56)	35 (7.35)	108 (24.7)	56 (12.8)	17 (3.9)
Grain milling ($n = 398$)	40 (10.05)	40 (10.05)	36 (9.05)	93 (23.4)	43 (11.7)	11 (3)
Fertilising ($n = 477$)	45 (9.4)	44 (9.2)	43 (9)	45 (24.1)	44 (9.8)	13 (2.9)
Silage making ($n = 427$)	32 (7.5)	37 (8.6)	35 (8.2)	90 (21.1)	41 (10.3)	13 (3.3)
Pesticide use ($n = 347$)	30 (8.65)	30 (8.65)	26 (7.5)	79 (22.8)	32 (9.8)	8 (2.45)
Silo work ($n = 60$)	6 (10)	3 (5)	2 (3.3)	13 (21.7)	5 (8.6)	1 (1.72)

*History of cardiac or non-obstructive respiratory diseases.

Table 4 Respiratory symptoms and lung function by smoking (n (%))

	Cough	Expectoration	Chronic bronchitis	History*	Distal obstruction	Overall obstruction
Non-smokers ($n = 740$)	58 (7.83)	53 (7.1)	53 (7.1)	157 (21.22)	72 (9.7)	14 (1.9)
Ex-smokers ($n = 152$)	11 (7.24)	13 (8.55)	11 (7.23)	45 (29.6)	16 (11.1)	2 (1.4)
Smokers ($n = 203$)	23 (11.3)	21 (10.3)	21 (10.3)	36 (17.7)	25 (13.9)	16 (7.9)

*History of cardiac or non-obstructive respiratory diseases.

RESPIRATORY SYMPTOMS AND LUNG FUNCTION TESTS

The prevalence of the various respiratory symptoms in the whole population was: chronic cough (> 3 months) 95 (8.47%), chronic expectoration 86 (7.66%), moderate shortness of breath 234 (20.85%), notable shortness of breath 67 (5.4%), cough or expectoration 146 (13%), chronic bronchitis as defined from the questionnaire 86 (7.66%), history of cardiac or non-obstructive respiratory disease 244 (21.75%). All farmers had been raised on a farm and had worked in farming since their youth. The duration of employment in farming was roughly the same as chronological age minus 15 years. Table 2 shows the lung function results for men and women; the curves were interpretable in 1062 (95%) subjects. The prevalence of distal airway obstruction was: 117 (11.4%), overall airflow obstruction 33 (3.2%). Tables 3 and 4 summarise the respiratory symptoms and lung obstruction by smoking behaviour and nature of farm activity.

LABORATORY TESTS

The 14 subjects with positive serology (1.25%) were excluded from the OR and linear regression analyses as it was thought that lung function might have been affected by hypersensitivity pneumonia. The final sample thus comprised 1108 (75.5%) people.

DATA ANALYSIS

Respiratory symptoms and airway obstruction (discrete variables) were analysed by OR after stratification by confounding factors. We thus analysed the relative risk (measured by OR) between symptoms, airway disease, and some variables (age, size of farm, and exposure) after stratification by smoking habits. The following variables were studied: respiratory symptoms (cough, expectoration, chronic bronchitis, moderate dyspnoea), overall airflow obstruction, and distal airway obstruction (dichotomous variables).

In smokers, no differences were found in ORs between exsmokers and current smokers

Table 5 Relative risk of symptoms and lung function by age and farm size in non-smokers with no history of cardiac or non-obstructive respiratory diseases

	Age	Size of farm
	≥ 50 y v < 50 y OR (95% CI)	< 50 ha v ≥ 50 ha OR (95% CI)
Cough	1.32 (0.9–1.93)	0.97 (0.96–1.02)
Expectoration	1.12 (0.95–1.19)	1.29 (1.1–1.83)
Chronic bronchitis	1.33 (1.12–1.98)	1.29 (1.08–1.79)
Dyspnoea	2.03** (1.23–3.39)	1.51* (0.36–6.42)
Distal obstruction	2.30* (1.09–4.96)	2.21* (1.06–4.66)
Overall obstruction	0.71 (0.5–1.01)	1.84 (0.64–5.28)

*p < 0.05; **p < 0.01 by Mantel-Haenszel χ^2 test.

of their symptoms and lung function abnormalities for age, size of farm, or exposure. In non-smokers, values of OR showed significant differences related to age for all symptoms and distal airway obstruction but not for overall airflow obstruction. For these subjects, there was a higher risk of shortness of breath and distal airway obstruction for people who lived on the smaller farms. No differences were found for exposure. In non-smokers with no history of cardiac or respiratory diseases, the ORs were only significant for dyspnea and distal airway obstruction for age and size of farm (table 5). We analysed the OR for size of farm after age adjustment. There were no significant differences for the symptoms and overall airflow obstruction, but the risk was still present for distal airway obstruction (OR = 2.66 (1.39 – 5.16), P < 0.001)

Analysis of quantitative airway obstruction by correlation coefficient and linear regression

Linear regression was used to assess the factors that influenced the values of FEV₁/VC (overall airflow obstruction) and FEF_{25–75} (distal airway obstruction). In the whole sample, smokers and non-smokers (table 6) the results are given by sex and history of cardiac and respiratory diseases. For FEV₁/VC, in men without a history of cardiac and respiratory disease, pack-years was the only significant variable, exposure and pack-years were significant in those with a history of cardiac and respiratory disease. In women without a history of cardiac and respiratory disease body mass index was significant, and age was significant in those with a history.

For FEF_{25–75} we found that in men with and without a history of cardiac or respiratory disease size of farms and pack-years were significant. Age and size of farms were the significant variables of the model in women without cardiac or respiratory disease, but age was the only significant variable in those with a history.

In the non-smokers with interpretable curves (n = 649, table 7) it was not possible to separate men and women (the number of women with lung function abnormalities was too small). The size of farm was the only significant variable in the model for overall airflow obstruction, age, and size of farm for distal airway obstruction.

The link between some variables was assessed from correlation coefficients. There was no correlation between the size of farm and the category of exposure, but there was a negative and strong correlation between age and size of farm (β = -4.05, SEM 11.77, r 0.36): the older farmers worked on the smaller farms.

Discussion

This study shows that the prevalence of distal airway obstruction is higher than overall airflow obstruction in agricultural workers after stratification by smoking habits and history of cardiac or respiratory disease. Older people, who work on smaller farms, have the higher risk of distal airway obstruction.

FACTORS THAT MAY HAVE INFLUENCED OUR RESULTS

(1) *Selection bias*—Our sample comprised farmers, farm workers, and their spouses, who were all engaged in agricultural activities. Among the employees, the rates were higher as the examinations were obligatory. Of the people notified 23.8% did not come to preventive examinations. It was not possible to obtain any information about respiratory symptoms from these subjects. This is the usual rate of attendance for free medical examinations of farmers' insurance companies. The characteristics of our subjects (age, sex, smoking habits) are similar to other studies.^{4 27}

(2) *Reporting bias*—Chronic bronchitis was

Table 6 Linear regression analysis of percentage of predicted values of FEV₁/VC and FEF_{25–75} as dependent variables in the whole sample according to history (selected variables are those significantly correlated with the dependent variable)

Smokers and non-smokers	Linear regression equation regression coefficient, constant (SEM of estimate)	P value	Explained variance (%)
Women without history* (n = 283)	FEV ₁ /VC = 0.213 (body mass index) + 96.1 (7.025) FEF _{25–75} = -0.55 (age) + 3.29 (size of farm) + 100 (21)	body mass index 0.024 age 0.001 size of farm 0.012	3 11
Women with history* (n = 65)	FEV ₁ /VC = -0.182 (age) + 111.1 (7.68) FEF _{25–75} = -0.78 (age) + 115.6 (26.9)	age 0.004 age 0.004	6 12.8
Men without history* (n = 559)	FEV ₁ /VC = -0.114 (pack-y) + 101.54 (9.06) FEF _{25–75} = 3.89 (size of farm) - 0.55 (pack-y) + 83.89 (26.9)	pack-y 0.002 size of farm 0.001 pack-y 0.0001	3 7.5
Men with history* (n = 155)	FEV ₁ /VC = 1.286 (exposure intensity) - 0.167 (pack-y) + 95.81 (9.41) FEF _{25–75} = -0.57 (age) - 0.41 (pack-y) + 113.75 (27.2)	exposure intensity 0.013 pack-y 0.011 age 0.002 pack-y 0.037	7 9.8

*History of cardiac or non-obstructive respiratory diseases.

Table 7 Linear regression analysis of percentage of predicted values of FEV₁/VC and FEF₂₅₋₇₅ as dependent variables in non-smokers by history (selected variables are those significantly correlated with the dependent variable)

Non-smokers (men and women)	Linear regression equation regression coefficient, constant, (SEM of estimate)	P value	Explained variance (%)
With or without history* (n = 649)	FEV ₁ /VC = 0.575 (size of farm) + 100.07 (8.37) FEF ₂₅₋₇₅ = -0.45 (age) + 5.0 (size of farm) + 95.96 (25.06)	size of farm 0.06 age 0.0001 size of farm 0.0001	5 11.2
Without history* (n = 511)	FEV ₁ /VC = 0.77 (size of farm) + 100 (8.44) FEF ₂₅₋₇₅ = -0.40 (age) + 5.44 (size of farm) + 93.5 (24.98)	size of farm 0.027 age 0.0001 size of farm 0.0001	10 11.1

*History of cardiac or non-obstructive respiratory diseases.

diagnosed on the basis of the reported respiratory symptoms. The questionnaire was given by a physician to reduce the recording errors. Subjects might have been reluctant to report smoking habits, in view of the recent legislation against smoking in France. As all studies use a questionnaire of this type, our results should be comparable with those of other workers.

(3) *Measurement bias*—Lung function measurements were carried out by trained operators in an attempt to reduce variability. Curves that were not reproducible or interpretable were excluded from the analysis.

(4) *Definition of airway obstruction*—It was based on FEV₁/VC and FEF₂₅₋₇₅ with criteria extracted from Quanjer.²³ These two dependent variables were expressed as a percentage of predicted values, adjusted for sex, age, height. These variables must not seem to be explicative, except in the case of correlation with another factor. Reference values are widely used in the European Community, unlike the United States.²¹ The FEF₂₅₋₇₅ has a higher sensitivity than FEV₁ for distal airway obstruction,^{20,26} and a reduced FEF₂₅₋₇₅ in a rural population has been reported by other workers.^{2,8,11} Lung function is a more objective way of assessing the influence of occupational factors and it is not unexpected that distal airway obstruction would be detected before any onset of symptoms. Lung function of subjects with distal airway obstruction and no symptoms could profitably be compared with those of the symptomatic patients in a longitudinal study.

Rate of chronic bronchitis in agricultural areas

A recent epidemiological study, conducted by the National Center for Health Statistics, found a low prevalence of chronic obstructive pulmonary disease (COPD) in the general population of 5.7% (6.4% in males, 5.2% in females).²⁵ Brackbill and coworkers studied

2681 farmers in the United States for five years; they found an age adjusted prevalence for chronic respiratory disease of 6.7%.²⁸ Results are higher in agricultural studies (table 8). The rates differ considerably depending on smoking habits and occupational activities.^{4,6,15} All studies except two^{9,12} found an increased incidence of respiratory symptoms and chronic bronchitis among agricultural workers. Some of them^{2,8,11} found impaired lung function (lower FEV₁, VC, FEF₂₅₋₇₅), whereas others only found a reduction in FEV₁ and VC, but not FEV₁/VC and FEF₂₅₋₇₅.^{3,10} The high proportion of smokers might have influenced the results of some studies.^{5,26} In a cross sectional study of an agricultural population in Finland, Terho and coworkers found a similar incidence of chronic bronchitis to that found in our study (8% in the whole population, 7.6% in cattle farmers).¹⁶ In that study, smokers made up 35.4% of the population (58.6% of the men, 10.2% of the women).¹⁶ Daphin *et al.*, in another French agricultural area, found similar results: a prevalence of chronic bronchitis of 9.3% with a smoker rate of 16.5% (18.1% in our study).²⁷

Explanatory analysis

Pack-years emerged as the main variable to influence airway obstruction in the smokers. As in all studies of chronic bronchitis, smoking is the main confounding factor. There was a comparable prevalence of chronic bronchitis in the exsmokers and current smokers as they had the same cumulative exposure (pack-years). We also wished to eliminate another confounding factor—namely, history of cardiac and non-obstructive respiratory diseases—that could alter both the perception of symptoms by the patients and the lung function tests. This factor has seldom been taken into account in other studies. In these selected subjects, distal airway obstruction was still present, with age and size of farm being the two main explanatory variables.

The exposure definition we used was invalid as more than two thirds of the population fell into class 4. It was not possible to define another group after the first results as the questionnaire only provided information on weekly activities. This is another limitation of the study, but it was not the main objective. In some selected occupational activities such as grain milling, it is possible to assess exposure from variables such as dust concentration,^{3,10} but in agriculture several agents may

Table 8 Prevalence of chronic bronchitis and smoking in some epidemiological studies

	Population	n	Smokers (%)	Chronic bronchitis (%)
Do Pico <i>et al</i> ⁸	Cereal workers	300	49	37
Dosman <i>et al</i> ²	Cereal workers	90	0	23
Saia <i>et al</i> ⁴	Farmers	293	57	9.6
Milosevic <i>et al</i> ⁵	Farmers	414	63	21
Iversen and Pedersen ¹³	Pig farmers	124	20	24
Pariente <i>et al</i> ²⁶	Rural workers	1904	60	17.5
Daphin <i>et al</i> ⁶	Farmers	250	29	12
Pham <i>et al</i> ¹⁵	Farmers	755	21	16.5
Gamsky <i>et al</i> ¹⁴	Farm workers	759	29	5.1
Terho <i>et al</i> ¹⁶	Farmers	9853	35	8
Daphin <i>et al</i> ²⁷	Farmers	5703	16.5	9.3

be responsible for chronic injury to airways (cattle feeding, grain milling, hay storage, inhalation of pesticides, as well as climatic conditions). Although exposure can be quantified, it does not provide a picture of total exposure to risks. Some studies have attempted to assess exposure in terms of time spent in certain activities—for example, threshing or cattle feeding—although they failed to detect any correlation between chronic bronchitis and the duration of exposure.^{4,6,14}

Despite the fact that observed values were related to the predictive values, age appeared in the analysis. It is possible that age represents an indirect measurement of the duration of exposure. Some studies have the same results: age may be a reflection of cumulative exposure.^{10,11} We found a relative risk for distal obstruction of 3.02 for the smaller farms (<50 hectares) v the larger farms, which is in line with the findings of Saia *et al.*⁴ This risk was still present, after stratification by age (OR = 2.66). It may be that the smaller farms employ less mechanised equipment, thereby increasing exposure to certain risks. Analysis of characteristics of agricultural activities obtained from a more detailed questionnaire could perhaps provide an answer to this question.

In summary, this study shows that the prevalence of distal airway obstruction is higher than the prevalence of chronic bronchitis in an agricultural population, after stratification by smoking habits and history of cardiac and other respiratory diseases. Age and size of farms, which are negatively correlated, emerge as the two main explanatory variables. These results indicate that farming populations may have an early propensity to distal airway obstruction. The next steps should be to define agricultural exposure by creating a more detailed questionnaire, and to provide more evidence for the hypothesis that size of farm is a risk factor for respiratory diseases.

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