

Farming and the Prevalence of Non-Reversible Airways Obstruction—Results From a Population-Based Study

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Introduction Occupational exposure to noxious dusts, gases, and fumes most likely contributes to obstructive lung disease. We studied whether self-reported farming work is associated with non-reversible airways obstruction.

Methods Following the burden of obstructive lung disease (BOLD) study protocol, we surveyed a gender-stratified population-based sample of 2,200 adults aged 40 years and over. Pre- and post-bronchodilator spirometry, as well as information on smoking, occupation, and reported respiratory disease was recorded. According to GOLD criteria, non-reversible airways obstruction was defined as a post-bronchodilator forced expiratory volume (FEV₁)/forced vital capacity (FVC) < 0.70. Occupational and smoking history was based on questionnaire. Farming was defined as ever working in this occupation for 3 months or longer.

Results For 1,258 participants with complete data (post-bronchodilator spirometry and questionnaire data), 288 (=22.9%) reported farming. Among the 288 participants reporting farming, the prevalence of non-reversible airways obstruction was 30.2%. Farming was significantly associated with airways obstruction: chronic obstructive pulmonary disease (COPD) GOLD stage I or higher (OR 1.5; 95% CI 1.1–2.0) and COPD GOLD stage II or higher (OR 1.8; 95% CI 1.2–2.7). The latter estimate was unchanged when adjustment for competing risks gender, age, and smoking was done. In this population the risk for non-reversible airways obstruction attributable to farming was 7.7%.

Conclusion Farming should be considered a risk factor for non-reversible airways obstruction. *Am. J. Ind. Med.* 50:421–426, 2007. © 2007 Wiley-Liss, Inc.

KEY WORDS: airways obstruction; farming; COPD; agricultural exposure

INTRODUCTION

Obstructive airways disease is an important public health problem, affecting millions of people in developing

and developed countries. It is estimated that in 2020, non-reversible obstructive airways disease, also termed chronic obstructive pulmonary disease (COPD), will be the fourth leading cause of death world-wide [Murray and Lopez, 1997]. Although this increased burden of disease will mainly be attributed to active cigarette smoking and aging, obstructive airways disease is also prevalent in non-smokers. Chronic exposure to inhalable particles and gases besides active smoking, result from outdoor air-pollution, indoor second-hand smoke exposure, or cooking at open fire-places. Another possible cause of non-reversible obstructive airways disease is occupational exposure [Trupin et al., 2003]. This is particularly true for farming, where dusts and inhalable

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particles can be present in various forms. For a number of outcomes related to obstructive airways disease, such as symptoms, lung function, morbidity, and mortality, an association with farming has been described [Schencker et al., 1998].

As early as 1700, dust exposure in the agricultural workplace has been noted as a possible cause of respiratory disease [Ramazzini, 1940]. Although agricultural dusts can cause irritation and inflammation of the airways it is not yet clear whether COPD should be regarded as an occupational disease of farmers [Linaker and Smedley, 2002].

A population attributable risk (PAR) of 20% was reported for COPD (defined by self-reported physician's diagnosis) related to self-reported occupational exposure in US residents aged 55–75 years [Trupin et al., 2003]. The results of the European Farmers' project revealed a higher prevalence of chronic phlegm in animal farmers compared to the general population [Radon et al., 2003]. Another study from Switzerland has shown that agricultural work is associated with an elevated risk for reporting symptoms of chronic bronchitis and chronic phlegm compared with the general population [Danuser et al., 2001]. However, reporting chronic respiratory symptoms does not always match evidence of chronic airflow limitation as measured by spirometry.

In the Agricultural Health Study farmers did show a remarkable deficit in total mortality compared to the general population [Blair et al., 2005]. But the myth of the robust, reliably healthy farmer does not correspond with the reality of agricultural life and excess mortality for non-malignant respiratory conditions has been noted [Schencker et al., 1998]. According to Swiss mortality data, deaths from lung disease were more frequent among the farming population during the period 1988–1992 [Gassner and Spuhler, 1995].

Data from a cross-sectional study assessing lung function and air contaminants suggest that clinically significant COPD (defined by GOLD criteria) in never-smoking animal farmers working inside confinement buildings is related to indoor dust exposure [Monso et al., 2004]. Analyzing NHANES III data, Hnizdo et al. (2004) found differences in the fraction of airflow obstruction (defined as forced expiratory volume (FEV₁)/forced vital capacity (FVC) < 75% and FEV₁ < 80% predicted) cases associated with employment pattern among major US race/ethnic population groups; among Mexican-Americans the largest percentage of attributable cases came from agriculture (32.0%).

Mortality for non-malignant respiratory disease is not specific for COPD, and self-reported diagnosis of COPD and respiratory symptoms are likely to be biased. The gold-standard for the diagnosis of chronic airways obstruction is the measurement of post-bronchodilator lung function. To the best of our knowledge, this is the first population-based study assessing post-bronchodilator lung function and

questionnaire data in relation to occupational exposure. For a population sample of adults living in Salzburg, Austria, we investigated whether farming is a risk factor for the presence of non-reversible airways obstruction.

METHODS

From October 2004 until April 2005 we collected data in Salzburg according to the burden of obstructive lung disease (BOLD) protocol [Buist et al., 2005]. The BOLD initiative began in order to develop and use standardised methods to measure the prevalence of COPD and its risk factors in a number of countries world-wide. Salzburg was one of the first participating sites.

Study Population

We surveyed a gender-stratified random sample of the inhabitants of Salzburg County, aged 40 and older. For all subjects contacted, a minimal data questionnaire was obtained. Of the 2,200 individuals (1,100 men, 1,100 women) whom we attempted to contact, 118 were either age ineligible, untraceable, had permanently moved from the area, or were deceased. Of the 2,082 eligible participants, 90% participated: 1,349 individuals (65%) completed pre- and post-bronchodilator spirometry, while 529 (25%) provided only information on smoking history, respiratory symptoms, and co-morbidities. The latter group was either unable or unwilling to complete the full protocol. Only 130 individuals (6% of those eligible) formally declined any participation in the study, and another 74 individuals (4%) did not respond to repeated attempts to contact them.

The study was approved by the local Ethics Committee of Salzburg County, and all participants gave written informed consent.

Study Measures

Spirometry was done according to American Thoracic Society (ATS) criteria [American Thoracic Society Statement: Standardization of spirometry, 1995] by trained and certified technicians using the NDD Easy One™ spirometer with participants in a seated position. Separate measurements were made before and at least 15 min after two puffs of salbutamol (400 µg) metered dose inhaler, administered using a Volumatic spacer. Spirometry data were sent electronically to the Pulmonary Function Quality Control Centre in Salt Lake City, Utah, USA, where each spirogram was reviewed and graded using ATS guidelines [American Thoracic Society Statement: Standardization of spirometry, 1995]. Studies were only included if they met ATS acceptability and reproducibility criteria, which includes

the following: at least three trials, two acceptable (free from artefact, sudden stops, and back extrapolated volumes greater than 5.0% of FVC) and reproducible (difference between largest and second largest values less than 200 ml) tests for both the FEV₁ and the FVC. Of the 1,349 participants with post bronchodilator spirometry, 1,258 (93%) met the quality control criteria and are included in this analysis.

Questionnaire Data

The study questionnaire included information on respiratory symptoms and occupational exposure. The staff who administered the questionnaire were trained and supervised.

Occupation

Study subjects were asked if they worked for 3 months or longer in 1 of 11 occupations considered as risk factors for COPD. This list included hard-rock mining, coal mining, sandblasting, working with asbestos, chemical or plastics manufacturing, flour, feed or grain milling, cotton or jute processing, foundry or steel milling, welding, fire fighting, and farming.

Definitions

In accordance with the GOLD guidelines non-reversible airflow obstruction was defined as a post-bronchodilator FEV₁/FVC < 0.70, which corresponds to COPD GOLD stage I or higher. COPD GOLD stage II or higher was defined as a post-bronchodilator FEV₁/FVC < 0.70 and FEV₁ < 80% predicted. The NHANES III reference equations were used to calculate predicted values [Hankinson et al., 1999].

Doctor-diagnosed COPD was defined as self-reported physician’s diagnosis of chronic bronchitis, emphysema, or COPD.

Pack-years of cigarette smoking was defined as the average number of cigarettes smoked per day divided by 20 (i.e., packs/day) times the duration of smoking in years.

Farming was defined as ever working in this occupation for 3 months or longer. The question asked to determine exposure to farming was: “Have you ever worked for 3 months or more in farming?”

Statistical Analysis

All statistical analyses were done with SAS 8.2 (SAS Institute, Inc., Cary, NC). Stratification and controlling for confounding was performed by multivariate logistic regression analysis. The PAR, an estimate of the proportion of all cases of a disease in a given population that would not have occurred in the absence of the exposure of interest, was

TABLE I. Subjects Characteristics According to Reported Farming

	N	Age Median, yr (range)	Sex, Male	Never smoker	Former smoker	Current smoker	Reported diagnosis of COPD	COPD GOLD I +	COPD GOLD II +
Reported farming	288 (22.9%)	59 (40–90)	172 (59.7%)	155 (53.8%)	84 (29.2%)	49 (17.0%)	15 (5.2%)	87 (30.2%)*	40 (13.9%)**
No farming	970 (77.1%)	56 (40–98)	513 (52.9%)	440 (45.4%)	337 (34.7%)	193 (19.9%)	53 (5.5%)	217 (22.4%)*	79 (8.1%)**
All	1258 (100%)	57 (40–98)	685 (54.5%)	595 (47.3%)	421 (33.5%)	242 (19.2%)	68 (5.4%)	304 (24.2%)	119 (9.5%)

COPD GOLD I +: FEV₁/FVC < 0.7; COPD GOLD II +: FEV₁/FVC < 0.7; and FEV₁ < 80% predicted;

*P = 0.006.

**P = 0.003.

estimated from the multivariate logistic model, controlling for smoking, age, and sex.

RESULTS

Farming was the only occupation associated with an increased prevalence of non-reversible airways obstruction. The characteristics of all study participants and the prevalence of non-reversible airways obstruction, defined as a post-bronchodilator FEV1/FVC < 0.7, are shown in Table I. Even though the proportion of never-smokers is greater among farmers, the prevalence of non-reversible airways obstruction exceeds the prevalence in non-farmers.

The data given in Table I show that non-reversible airways obstruction is significantly more frequent, and significantly more severe in subjects reporting farming.

As shown in Table II, the prevalence of non-reversible airways obstruction is consistently higher among farmers beyond 50 years of age. The distribution to age categories did not differ significantly between subjects reporting farming and those without farming.

The risk of non-reversible airways obstruction was elevated in farmers: COPD GOLD stage I or higher (OR 1.5; 95% CI 1.1–2.0) and COPD GOLD stage II or higher (OR 1.8; 95% CI 1.2–2.7). The latter estimate was unchanged when adjustment for competing risks gender, age, and smoking was done (OR 1.8; 95% CI 1.2–2.8).

In order to estimate the proportion of non-reversible airways obstruction attributable to farming, the PAR, an estimate of the proportion of all cases of a disease in a given population that would not have occurred in the absence of the exposure of interest, was calculated. $PAR = [Probability (disease) - Probability (disease given no exposure)] / Probability (disease)$. The PAR was 7.7%.

The comparison of never smoking farmers with never smoking subjects reporting other occupations showed a 1.6-fold elevated risk of non-reversible airways obstruction in farmers (OR 1.6, 95% CI: 1.0–2.6). The prevalence of COPD GOLD I or higher was 24.5% in never smoking subjects reporting farming, and 15.9% in never smoking subjects reporting other occupations ($P = 0.017$).

The average duration of exposures experienced during farming was similar for farmers with and without non-reversible airways obstruction, and even for those with more severe disease (Table III).

DISCUSSION

Our findings support an association between non-reversible airways obstruction and exposures experienced during farming. The proportion of non-reversible airways obstruction attributable to this exposure was considerable, with an estimated PAR of 7.7%. In other words, elimination of all farming related workplace exposures could prevent 1 in 13 cases of chronic airways obstruction, all other risk factors (including cigarette smoking) being equal.

The spirometry based prevalence of non-reversible airways obstruction (COPD) is high in both, farmers and non-farmers and might be due to some overdiagnosis in the elderly, a possible effect of following the current GOLD definitions of COPD (FEV1/FVC < 0.7). But, the prevalence of non-reversible airways obstruction is consistently higher among farmers beyond 50 years of age, and the proportion of severe airways obstruction is significantly higher among farmers.

There is evidence that exposures experienced during farmings are associated with the development of chronic airway disease, as distinct from asthma and asthma-like reversible airway changes [Schencker et al., 1998]. To exclude asthma and asthma-like syndromes we performed post-bronchodilator spirometry in all participants. We therefore report prevalence of non-reversible airways obstruction. We are well aware of the fact, that there might be some chronic asthma cases (long term sequel of asthma with airways remodeling), but it is reasonable to assume that almost all is COPD.

Our results are consistent with other published data. An epidemiological study in Swiss farmers shows that in comparison with the general population farmers are at risk for reporting symptoms related to chronic lower airway inflammation [Danuser et al., 2001]. Another study identifies dust exposure in animal confinement buildings as main determinant of COPD (defined by GOLD criteria) in never smoking animal farmers [Monso et al., 2004]. Data obtained from a community based sample of older adults in Australia show a significantly increased risk of respiratory symptoms and COPD associated with occupational exposure to biological dust [Matheson et al., 2005].

A current hypothesis proposes that the pathogenesis of COPD and its associated emphysematous lesions follows that of a chronic inhalational dust-induced disease. Aluminum silicate or kaolinite could be the causative

TABLE II. Prevalence of Non-Reversible Airways Obstruction (FEV1/FVC < 0.7, COPD GOLD I+) According to Age and Reported Farming

	40–50 Years (%)	51–60 Years (%)	61–70 Years (%)	71–80 Years (%)	>80 Years (%)
FEV1/FVC < 0.7 (COPD GOLD I+)					
Reported farming (n = 288)	9.59	28.2	29.9	57.5	76.9
No farming (n = 970)	10.8	19.6	25.0	45.0	70.6

TABLE III. Duration of Agricultural Exposure in Subjects Reporting Farming (n = 288)

Post-bronchodilator lung function	N (%)	Mean (SD) years	Median (Range) years
FEV1/FVC \geq 0.7	201 (69.8)	18.2 (16.0)	10.0 (0–60)
FEV1/FVC < 0.7 and FEV1% pred. \geq 80% (COPD GOLD I)	47 (16.3)	18.7 (16.8)	10.0 (1–60)
FEV1/FVC < 0.7 and FEV1% pred. < 80% (COPD GOLD II+)	40 (13.9)	18.8 (17.9)	10.0 (0–60)

respirable dust contained in cigarette smoke [Girod and King, 2005].

Usually agricultural dust is a mixture of organic and inorganic dusts. Organic dusts originate from plant and animal sources and are commonly the source of allergic diseases such as asthma. Inorganic dusts originate predominantly from the soil, and tend to result in non-allergic reactions to the lung [Schenker, 2000]. The inorganic fraction of soils is usually dominated by silicates.

It goes without saying that smoking is the predominant risk factor for COPD and has to be at the forefront of public health efforts to prevent lung disease. Nonetheless, our findings support the observations of other studies, suggesting an important role of exposures experienced during farming in causing chronic obstructive pulmonary disease.

To better define the biological plausibility of farming related chronic airways injury, the type of farming (dairy farming, fieldwork, fruit farming), the size of the farm (small mixed farms versus large mono-cultural farms) as well as the duration and intensity of exposure has to be considered. Furthermore, as has been reported for almost any job-related exposure, becoming a farmer and staying in farming results from health related selection, with less healthy subjects being less likely to go into or stay within a hazardous occupation. This so called healthy-worker effect, decreases the likelihood of finding a positive association between farming and obstructive airways disease.

This is the first population-based study assessing post-bronchodilator lung function and questionnaire data on occupational exposure. While post-bronchodilator lung function is the “gold-standard” for the diagnosis of chronic airways disease, we are well aware of the possible limitations of self-reported farming work (defined as ever working in agriculture for more than 3 months). Another limitation is the lack of information on the exact type of farming in each subject reporting farming work. A total of about 25,000 persons on 10,000 farms are working in agriculture in Salzburg. Farms are small to medium sized (on average 11.2 hectar; 1 hectar = 10,000 m²) and mainly of a mixed type, that is, animals are kept and plants cultivated. The individual type and load of exposure was not assessed in this study. Therefore, we cannot even speculate on the causative inhalable agents in agriculture, but our data confirm the urgent need for further investigation. In areas with a considerable proportion of subjects working in agriculture,

special prevention strategies will be needed and COPD should be regarded as an occupational disease of farmers.

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