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PREVALENCE AND RISK FACTORS FOR AIRWAY DISEASES IN FARMERS - SUMMARY OF RESULTS OF THE EUROPEAN FARMERS' PROJECT

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Abstract: The aim of the European Farmers' Project was to determine prevalence and risk factors of respiratory diseases in farmers across Europe. A cross-sectional study in 7 centres was carried out. In the first stage of the study, nearly 8,000 farmers in Denmark, Germany, Switzerland, the UK, and Spain answered a standardised questionnaire on farming characteristics and respiratory symptoms. The second stage of the study included exposure assessment and lung function measurements in 4 of the centres. Within the group of farmers, pig farmers were at high risk of asthma-like syndrome as compared to farmers keeping other kinds of animals. Among plant farmers, greenhouse workers were at higher risk for symptoms of asthma. The prevalence of symptoms of allergies were significantly lower among animal farmers as compared to the population of the European Community Respiratory Health Survey. In contrast, animal farmers had a significantly higher prevalence of symptoms of chronic bronchitis. The major risk factor for respiratory symptoms was shown to be ventilation of the animal houses and greenhouses. Intervention studies are now warranted to test the effectiveness of improved ventilation on respiratory health. The reasons for the low prevalence of allergic diseases among farmers are currently under study.

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Key words: farmer's lung, occupational asthma, allergies, chronic bronchitis, endotoxins, cross-sectional study, crop farmer, animal farmer.

INTRODUCTION

Across the European Union, a wide variety of agriculture can be found. While in Northern Europe production of animals (pigs, cattle, poultry) and grain farming are most common, in the south of Europe plant crop cultivated primarily in greenhouses (flowers and fruits) is predominant. Limited data on the prevalence of respiratory diseases among greenhouse workers are available. Up to now, work-related risk factors for

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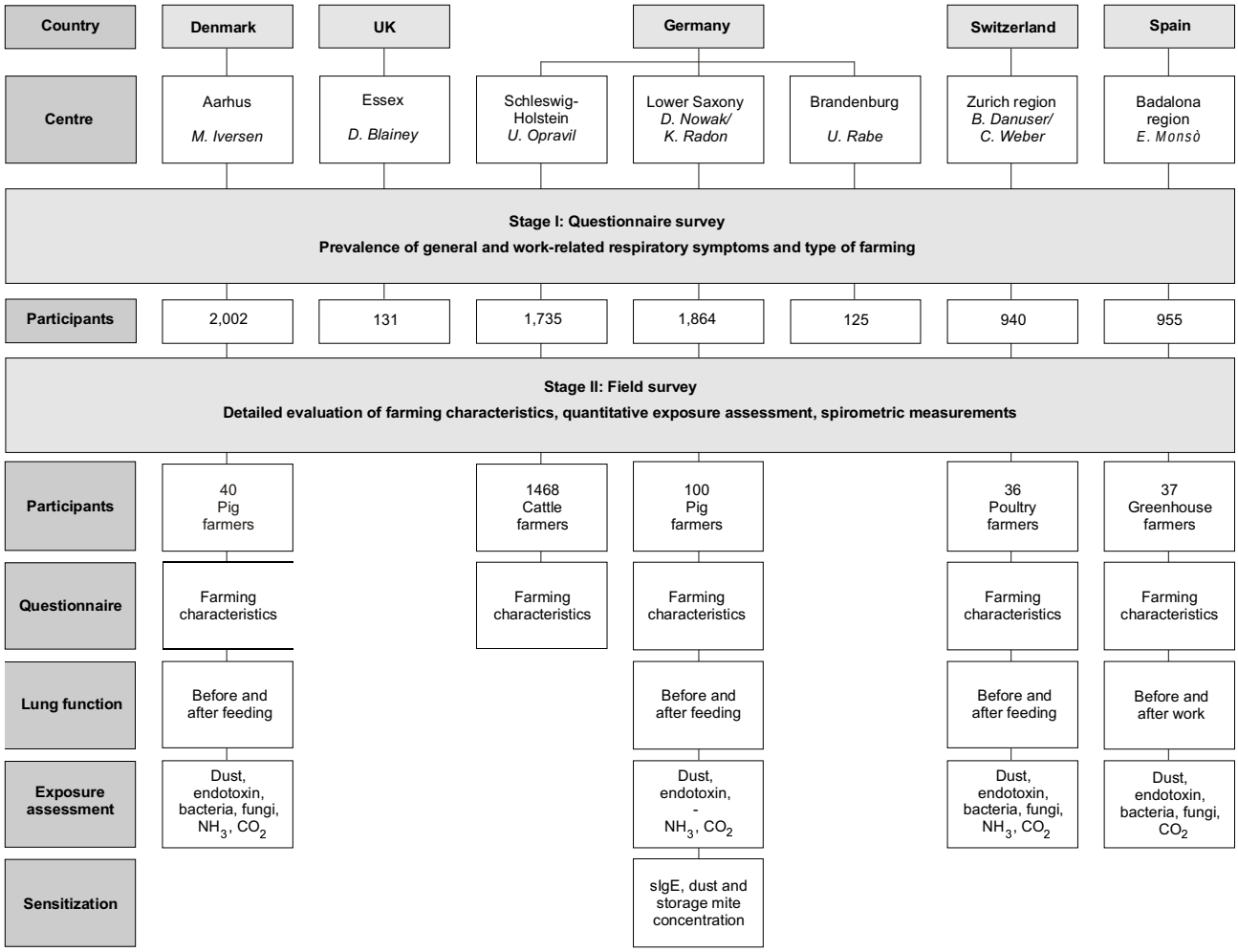


Figure 1. Course of survey.

respiratory disorders have not been studied in greenhouse farmers. For animal farmers, no data on the geographic variation in allergic diseases have so far been available using the same instruments and definitions in all centers. In animal houses little attention has been paid to the relationship between construction characteristics of the animal houses, such as bedding, feeding or ventilation systems on one hand, and exposure data on the other hand. No comparable data on exposure patterns, temperature, humidity and respiratory symptoms and diseases were available in different countries of Europe.

Therefore, the overall aim of this joint project was to advance scientific understanding of prevalence and risk factors of airways obstruction in farmers across Europe. The prevalence of respiratory symptoms was compared to the EC Respiratory Health Survey (ECRHS) [1]. The influence of inherent and occupational risk factors for the development of obstructive airway diseases in farmers was assessed. As a result, a European rationale for the development of control measurements to reduce the risk of obstructive airway diseases in farmers has been worked out. This, in turn, will lead to improvements in the health of farmers through a reduction in the burden of aerial pollutants in farming environments.

The project had 2 main stages with the following objectives to determine:

Stage I
- Prevalence of work-related respiratory symptoms among European farmers in Denmark, UK, West and East Germany, Switzerland, Spain;
- Main types of farming in different European regions;
- Associations between type of farming and prevalence of work-related respiratory symptoms.

Stage II
- Details of farming characteristics;
- Exposure patterns in different types of farming (pig farming, poultry farming, greenhouses) in Denmark, West Germany, Switzerland and Spain;
- Baseline lung function values and lung function changes during the working day in the respective farmers.

The study was conducted under standardised conditions in all participating countries. This paper summarises the main results of this study. Further details have been published elsewhere [8, 9, 10, 11, 12, 13, 14, 15, 16].

MATERIALS AND METHODS

Stage I: Prevalence of respiratory symptoms in European farmers and associations with the main type of farming

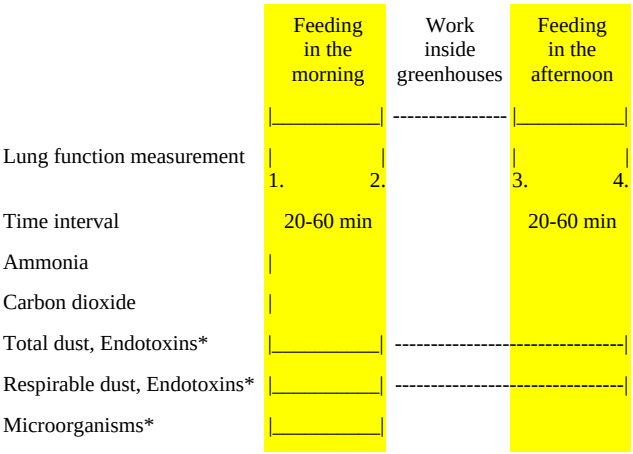
Subjects. In order to estimate the prevalence of respiratory symptoms in European farmers a cross-sectional questionnaire survey was carried out in the participating centres. Farmers were selected randomly on the basis of the register of local farming associations (Denmark, Germany, Spain) or national census records (Switzerland). In the UK, all farmers enrolled in the "Longitudinal study of the respiratory, inflammatory and immunological effects to grain dust in the UK" were asked to participate. To increase the response rate, all farmers in Germany were visited at the farm. In the other countries farmers were contacted up to 4 times by mail, phone, and ultimately by home visits. As a result, 7,752 farmers participated in the first part of the study achieving to our knowledge the largest epidemiological study on farmers' respiratory health. The number of farmers in each participating centre is shown in Figure 1. The lower response rate in the centre in Brandenburg was a result of re-organisation of the farms in this part of Germany after reunification.

Questionnaire. The questionnaire was developed in the coordinating centre, where possible, from pre-existing questionnaires and was sent out in 5 languages (Danish, English, German, Spanish, Catalan). The medical part of the questionnaire contained 5 questions on chronic respiratory symptoms within the preceding year taken from the questionnaire of the European Community Respiratory Health Survey (ECRHS) [1]. Five questions focused on work-related respiratory symptoms and one question on organic dust toxic syndrome (ODTS). This latter question was taken from the Questionnaire Evaluating Organic Dust Exposure proposed by Rylander *et al.* [18]. Additionally, questions on farming characteristics and the duration of exposure in each type of animal house and greenhouse were asked. These questions were also taken from a standardized questionnaire [4], and have been used to assess the potential association between type of farming and the prevalence of respiratory symptoms.

Stage II: Quantitative exposure assessment, detailed evaluation of farming characteristics and lung function measurements

Stage II of the study was carried out in the centres in Denmark, Lower Saxony/Germany, Switzerland, and Spain (Fig. 1). Additionally, in Schleswig-Holstein/Germany detailed questions on farming characteristics were answered by 1,468 cattle farmers and related to the prevalence of symptoms.

The second part of the survey was focused in each centre on the group of farmers that emerged to be at highest risk for respiratory diseases in this area in the first part of the study. As a result, 100 pig farmers in Germany, 40 pig farmers in Denmark, 36 poultry farmers in Switzerland, and 37 greenhouse farmers in Spain participated in the second part of the investigation. While in Lower Saxony farmers claiming for compensation due to occupational obstructive airway disease were studied, in the other centres the farmers were chosen randomly on the basis of the data of the first part of the study. In these groups of farmers, quantitative exposure assessment as well as detailed evaluation of farming characteristics and lung function measurements were performed. The course of the field work over the sampling day is given in Figure 2.



*personal measurements, --- work inside greenhouses

Figure 2. Course of field work.

Qualitative exposure assessment. All farmers answered a detailed interview-based questionnaire on farming characteristics and typical working tasks. The questionnaire was adapted to each kind of farming (cattle, pig, poultry, greenhouse).

Quantitative exposure assessment. In this stage of the study, exposure parameters (dust, endotoxins, micro-organisms, ammonia, carbon dioxide) as well as microclimatic parameters (temperature, air velocity, air humidity) were determined during 1 feeding/working period inside the animal buildings or greenhouses using the same methods in the 4 centres [11]. As personal measurements have been shown to reflect the exposure better than taking samples at an area base [3], dust, endotoxin and microorganism samples were taken at a personal base (Fig. 2). In each centre a maximum of 2 persons performed the measurements after thorough control training. All air quality measurements were evaluated by the same laboratories.

Respiratory symptoms. Structured interviews were performed in all centres with questions on respiratory symptoms, current medication, use of respiratory protective measures during work, working conditions,

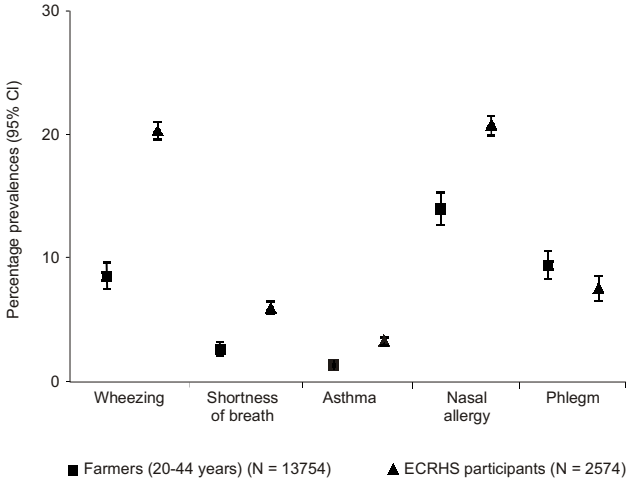


Figure 3. Percentage prevalences of respiratory symptoms with 95% confidence intervals (95% CI) standardised by age and gender. The data were restricted to farmers in the age range of 20–44 years because the European Community Respiratory Health Survey (ECRHS) only included participants in this age range. The data are taken from the centres in Denmark, West-Germany, Switzerland (ECRHS: Basel) and Spain (ECRHS: Barcelona).

smoking habits, family history and standardised questions on chronic bronchitis (Medical Research Council Criteria).

Lung function measurements. Lung function tests were performed immediately before and after the working period. In each centre a maximum of 2 persons performed the lung function measurements after thorough control training. All results were analyzed by 1 technician according to the American Thoracic Society (ATS) standardization criteria.

Statistical analysis. The data were analysed using the statistical software packages Statistica© (Tulsa, USA), SPSS Inc., (City, USA) and SAS (Cary, USA). After univariate analyses, multivariate models were conducted using multiple linear regression models for continuous variables and multiple logistic regression models for dichotomous variables.

RESULTS

Stage I: Prevalence of respiratory symptoms in European farmers and associations with the main type of farming

The prevalence of work-related respiratory symptoms varied largely over the centres under study (Tab. 1). Due to different exposure patterns the prevalence of respiratory symptoms was separately analysed for animal and crop farmers.

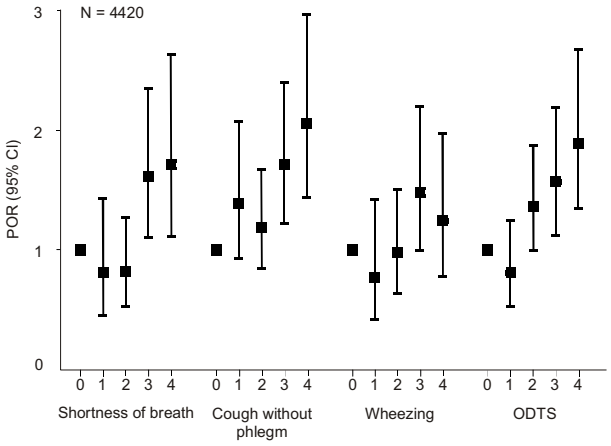
Animal farmers. In order to compare the prevalence of respiratory symptoms among animal farmers to the participants of the European Community Respiratory Health Survey-I, the data had to be restricted to the age group 20–44 years because the latter survey included only young adults in this age group. After standardisation for age and gender, the prevalence of symptoms related to asthma and other airway allergies was significantly lower among farmers compared to the general population. In contrast, farmers were more likely to complain about symptoms of chronic bronchitis (Fig. 3).

Additionally, it was shown that pig farmers were at highest risk for the development of work-related respiratory symptoms related to asthma-like syndrome. Poultry farmers showed an increased risk of wheezing. This was the first study including a sufficient number of sheep farmers. The latter group reported excess work-related cough with phlegm. Additionally, a significant dose-response relationship between daily hours worked inside animal houses and symptoms was established for pig farmers (Fig. 4). Similar associations were seen for poultry farmers.

Crop farmers. Among crop farmers the highest prevalence of asthma was found in farmers producing flowers. Farmers cultivating oil plants also showed an excess in risk for ODTS as compared to other crop farmers. Working inside greenhouses was a secondary risk factor for asthma among farmers cultivating vegetables, tomatoes, fruits or flowers.

Table 1. Prevalence of work-related respiratory symptoms (WRS: wheezing, breathlessness, and/or cough without phlegm during work) in different groups of farmers. Numbers do not add up to 7,752 because most farmers keep more than one type of animals and produce animals and crops.

	N_{total}	WRS (%)
Denmark, Aarhus	2,002	20.2
United Kingdom, Essex	131	32.8
Germany, Schleswig-Holstein	1,735	25.8
Germany, Lower Saxony	1,864	18.3
Germany, Brandenburg	125	31.7
Switzerland, Zürich	940	22.3
Spain, Badalona	955	23.7
Overall	7,752	22.1
Cattle farmers	4,666	21.8
Pig farmers	2,278	24.3
Poultry farmers	696	23.7
Sheep farmers	522	24.7
Animal farmers	5,993	22.7
Grain farmers	3,706	23.0
Rootcrop farmers	1,770	24.2
Oilplant farmers	1,270	27.2
Vegetable farmers	928	23.6
Fruit farmers	559	25.4
Tomatoe farmers	501	26.6
Flower farmers	298	27.5
Crop farmers	4,621	23.0



0 - not working inside swine confinement buildings (either because of not keeping pigs or not keeping pigs indoors),
1 - 0–1 hours/day work inside swine confinement houses,
2 - 1–2 hours/day work inside swine confinement houses,
3 - 2–4 hours/day work inside swine confinement houses,
4 - >4 hours/day work inside swine confinement houses.

Figure 4. Prevalence Odds Ratio (POR) (95% CI) of work-related respiratory symptoms per quartile of daily duration of work in swine confinement houses. Data presented for animal farmers. Data not available for the centre in Lower Saxony. Adjusted for centre, age, gender, and smoking.

Stage II: Quantitative exposure assessment, detailed evaluation of farming characteristics and lung function measurements

Exposure assessment. In the second stage of the study we found the highest median total dust (7.01 mg/m^3), endotoxin (257.58 ng/m^3), total bacteria (4.7×10^9 cells/m^3), total fungi (28.8×10^6 cells/m^3), ammonia (12 ppm), and carbon dioxide (2100 ppm) concentrations in poultry houses in Switzerland. In these buildings the median climatic conditions, such as air velocity (0.01 m/s) and temperature (16.2°C), were lowest in comparison to the other buildings. The pig houses in Germany had worse environmental conditions compared to the concentrations found in Danish pig confinement buildings. The lowest median amounts of total dust (< detection limit), endotoxins (0.36 ng/m^3), and microorganisms (total bacteria: 15.5×10^6 cells/m^3; total fungi: 2.8×10^6 cells/m^3) were shown inside Spanish greenhouses. Detailed results of exposure assessment have been reported earlier [11].

Respiratory health, farming characteristics and exposure assessment. Due to the not directly comparable conditions inside animal buildings and greenhouses the data on respiratory health in relation to environmental conditions were analysed separately. Additionally, the data for German pig farmers had to be analysed on an individual base because of the differences in the recruiting system. A summary of the results is given in Table 2.

Cattle farming in Schleswig-Holstein. The questionnaire study on farming characteristics in 1,468 cattle farmers in Schleswig-Holstein has shown a significant relationship between ventilation of the cattle house and work-related respiratory symptoms. Additionally, climatic factors and the size of the animal house were shown to significantly influence the development of work-related respiratory symptoms. Especially wall ventilation (no walls but draught-excluders/porch nets around the stable, 3 walls and 1 open side, or gaps between the planks) was shown to be significantly associated with a lower prevalence of breathlessness, cough, wheezing and/or nasal irritation during work. Likewise, a larger area of the cattle barn was associated with a lower prevalence of these symptoms.

Pig farming in Denmark and poultry farming in Switzerland. Mean baseline lung function results in pig farmers were significantly higher than in poultry farmers. In pig farmers, ventilation control via humidity sensors was significantly associated with higher baseline FEV_1 values.

No significant decrease in spirometric results was shown over the feeding period for the whole group of farmers. In contrast, symptomatic farmers had a tendency for lung function decline over the feeding period.

Table 2. Associations between farming characteristics and respiratory health.

Region	Denmark	Schleswig-Holstein	Lower Saxony	Switzerland	Spain
Type of farming	Pigs	Cattle	Pigs	Poultry	Greenhouses
Health indicator	FEV_1 % Predicted	WRS	FEV_1 % Predicted	FEV_1 % Predicted	Wheezing
N	40	1,468	100	36	39
Ventilation	+†	–†	+†	+†	–†
Temperature	–‡	+‡	0	0	0
Area	0	+‡	0	0	+‡
Number of animals	0	0	–‡	0	Ø

+: positive association; –: negative association; 0: no statistical association; Ø: Parameter not relevant, †: protective factors; ‡: risk factors. WRS: work-related respiratory symptoms.

Pig farming in Lower Saxony. A significant decline in FVC (3.25%), FEV_1 (4.44%) and $MMEF_{25/75}$ (5.25%) was seen over the feeding period in 100 symptomatic farmers. In a multivariate model the decrease over the feeding period in FVC and FEV_1 % predicted was significantly negatively correlated with air velocity. Higher respirable dust concentrations were shown to be significant predictors for $MMEF_{25/75}$ decline. Baseline lung function results were shown to be significantly negatively associated with an air outlet in the wall, manual feeding, duration of employment and number of pigs on the farm.

In these farmers, the median concentrations of Der p 1 and Der 2 in the mattress dust were significantly higher than in samples of mattress dust of 22 urban dwellers (53.4 µg/g dust *vs* 1.05 µg/g dust, $p = 0.001$; 19.6 µg/g dust *vs* 2.2 µg/g dust; $p < 0.0001$, respectively). The mite concentrations in the transit areas were strongly related to bedroom exposures. Additionally, a dose-response relationship was seen between Der p1 concentrations in farmers' beds and sensitisation to *D. pteronyssinus*. Despite high Der p 1 concentrations in dust samples taken from farming and home environments, farmers did not show a higher prevalence of sensitisation to this allergen compared to the general population in Germany (16% *vs* 18%, respectively).

Greenhouses in Spain. Of the 38 growers participating in the second part of the study in Spain, 13 were sensitised to flowers or moulds (34.2%). No association was seen between greenhouse characteristics and sensitisation. However, as in the animal houses, the ventilation rate inside the buildings was associated with the prevalence of wheezing in greenhouse workers (OR 0.11, 95%CI 0.01-1.04).

DISCUSSION

This study on prevalence and risk factors of respiratory morbidity among European farmers is among the most comprehensive studies of its kind. Apart from its size, its main advantage was the use of standardised questionnaires, same sampling methods, and standardised spirometric measurements in all participating centres. This allowed, for the first time, comparisons between countries and different types of farming.

The findings of this survey have advanced our understanding of the respiratory health of farmers as there is now a solid database on respiratory symptoms, exposure parameters, and lung function results of animal and crop farmers in different European countries. This is important for farmers' health. Secondly, the European Union and national legislation will be better informed to control exposure inside animal confinement buildings and greenhouses since dose-response relationships can be deduced from our findings.

Pig farmers were shown to be at highest risk for the development of respiratory symptoms. Poultry and flower farmers had an increased risk for the development of symptoms of asthma. Thus, especially in these farming environments, protective measures should be recommended. This was confirmed in the second part of our study. In this part of the survey, median exposure levels for endotoxins and microorganisms were shown to exceed recommended exposure standards not only in randomly chosen animal buildings but also in greenhouses [11]. We have learned that ventilation of the animal houses and greenhouses is an important factor in improving prevention measures in animal buildings [12, 13, 15]. Thus, in regions with warm winters ventilation via the wall (no walls but draught-excluder/porch nets around the stable, 3 walls and 1 open side, or gaps between the planks) might be recommended for new cattle houses [13]. In pig and poultry confinement buildings a better control of ventilation could also improve workplace exposure and thereby, diminish the occupational risk of airway diseases in farmers [12, 15]. Intervention studies are now warranted to test the effect of such measures.

We have shown that farmers are exposed to a higher concentration of house dust mites and storage mites than urban citizens [14]. On the other hand, farmers have shown a lower prevalence of nasal allergies than the general population [10]. This is an important point in understanding the mechanisms of sensitisation. Some might suggest that the lower prevalence of sensitisation among farming populations may be due to health selection processes. On the other hand, farm owners are less likely to change their occupation than workers in other occupations [22]. Additionally, children living on a farm had a significantly lower sensitization rate compared to children living in rural environment but not on a farm [5, 7, 17, 23]. Therefore, another possible explanation for the lack of an association between sensitization and exposure in our study might be a protective effect of, e.g., dietary or environmental factors, which seem to be relevant in farming environments, e.g. endotoxin [24].

Animal farmers complained significantly more often about symptoms of chronic bronchitis than the general population. A high prevalence of chronic phlegm and other symptoms of chronic bronchitis among farmers compared to controls has been reported by several authors [6, 19, 21]. However, the higher prevalence compared to the general population found in our study is remarkable because of the low percentage of smokers among farmers. Dalphin *et al.* [2] even reported an especially elevated risk for the development of chronic bronchitis in non-smokers. As shown in our survey, other studies confirmed high dust concentrations even inside modern animal confinement buildings [20]. This might imply changes in workers compensation practice, e.g., in Germany. Up to now, only asthma can be compensated among farmers. Therefore, one has to consider assimilating chronic bronchitis into the list of work-related respiratory disease.

This survey also supported the presumption that pig farmers mainly suffer from asthma-like syndrome and not from allergic asthma [19]. Asthma-like syndrome is distinguished from asthma as a self-limited inflammatory event that does not involve persistent airway hyper-

responsiveness [19]. Another hint for the occurrence of asthma-like syndrome was the significant lung function decline observed over the feeding period in symptomatic swine confinement farmers [12].

This is the first report on respiratory symptoms in a relatively large number of sheep farmers. Risk factors for this special group of farmers working only in enclosed buildings for a limited time of the year are currently being studied in further detail [16].

CONCLUSIONS

This project has provided valuable information on the prevalence and risk factors of airway obstruction in farmers working in different types of farming in 5 European countries. The strength of the findings are the common methods of measurement which allow comparison between countries, species, and housing types. Evidence has been collected for correlation between farming characteristics as well as occupational exposures and respiratory health of the respective farmers. Ventilation of the livestock buildings and greenhouses, as well as endotoxins, microorganisms, and allergens were shown to be important factors influencing the development of respiratory disease in farmers. Further studies are necessary to improve the understanding of lower sensitization to common allergens among farmers compared to other occupational groups. Additionally, intervention studies are warranted to test the effect of changes in exposure parameters on respiratory health.

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