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Relation between respiratory symptoms, type of farming, and lung function disorders in farmers

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Abstract

Respiratory symptoms and function were examined in a random sample of 181 farmers (124 pig farmers and 57 dairy farmers) with a mean age of 43 years. Wheezing and shortness of breath during work in the animal house were significantly associated with pig farming (odds ratio 11·4), current smoking (odds ratio 2·2), bronchial hyperreactivity (odds ratio 3·8), and low FEV_1 (odds ratio 3·4). Pig farmers had a slightly lower FEV_1 than dairy farmers (101% versus 104% predicted, NS). Symptomatic farmers had significantly lower FEV_1 than symptomless farmers (93% versus 106% predicted). A multiple linear regression analysis of the cross sectional values of FEV_1 showed that there was a decline in FEV_1 associated with pig farming (−12 ml/year of pig farming) and smoking (−23 ml/pack year) in addition to the age related decline of 32 ml/year. A multiple linear regression analysis of PC_{20} histamine showed that bronchial reactivity increased with age, number of pack years, and number of years in pig farming. Work in closed pig rearing units is a pulmonary health hazard and causes decline in lung function.

Farmers have a high prevalence of respiratory symptoms[1–3] and airways obstruction.[2 3] Pig farming appears to be a special risk factor for the development of respiratory symptoms[4–7] and a high percentage of farmers with asthma and respiratory symptoms have severe airways obstruction irrespective of the type of farming.[8] In our previous study the group of farmers was obtained by stratified sampling. The aim in this study was to study these relations in more detail in a well defined group of farmers obtained by random sampling.

Methods

STUDY POPULATION

The Farmers Association in three municipalities was asked to supply a list of all pig and dairy farmers with medium sized and large farms. Arbitrary lower limits were set at 30 cows and 300 pigs. The study population was intended to be a random sample of farmers with large modern farms who are likely to be in farming for many years. Their personal characteristics are given in table 1. A letter explaining the purpose of the study and asking the farmers to participate was sent to 175 randomly selected farmers. Two refused to participate and seven were excluded because of various diseases (recent treatment for cancer 2, recent myocardial infarction 2, Parkinson's disease 1, sarcoidosis 2). Five farmers had been misclassified (they combined pig and dairy farming) and were thus not eligible for study. Three symptomless farmers were excluded because they could not perform lung function tests in a reproducible manner. They appeared to have normal lung function. In addition to the 158 farmers recruited through the Farmers Association, 29 pig farmers volunteered for lung function tests and fibreoptic bronchoscopy with lavage. There was no significant difference between the four groups of pig farmers (three districts and one volunteer group) with respect to age (up to and over 40 years), smoking, and frequency of respiratory symptoms during work (χ^2 test, $p > 0·05$). Six farmers were female and were not included in the study. Thus the total study population consisted of 181 farmers, of whom 124 were pig farmers and 57 dairy farmers.

QUESTIONNAIRE

All farmers had a structured interview with questions on respiratory symptoms, working conditions, smoking habits, and family history and standardised questions on chronic bronchitis (Medical Research Council criteria). Special emphasis was given to respiratory symptoms during work that suggested airways narrowing or irritation (shortness of breath, wheezing, and dry cough).

LUNG FUNCTION TESTS

Lung function was measured with the Jaeger Transferscreen II (Eric Jaeger GMBH, Würzburg, Germany). A nose clip was used during all measurements. Inspiratory vital capacity (VC), single breath transfer factor for carbon monoxide (TLCO), TLCO per litre alveolar volume (TLCO/VA), residual volume (RV), and functional residual capacity (FRC) were measured with the subject seated. The forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were measured with the subject standing. Tests were performed according to accepted guidelines[9]; the predicted values were the European values of Quanjer *et al.*[9] Histamine challenge was performed by the method of Cockcroft *et al.*[10] A Wright's nebuliser calibrated to an output of 0·13–0·14 ml/min was used with

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Table 1 Characteristics of the 181 farmers

	Pig farmers (n = 124)	Dairy farmers (n = 57)	p
Mean age (y)	42·8	43·4	0·75
% with work related symptoms			
Shortness of breath	30	6	<0·01
Wheezing	21	2	<0·01
Dry cough	32	4	<0·01
Any symptom	39	5	<0·01
% with aggravation of respiratory symptoms by:			
Physical exercise	18	7	0·08
Cold air	13	0	0·01
Tobacco smoke	19	4	0·01
Coryza*	22	11	0·08
% who were current smokers	20	33	0·19
% with chronic bronchitis	24	19	0·46
% with PC_{20} histamine $\leqslant$ 32 mg/ml	50	42	0·36
Mean FEV_1% predicted	101	104	0·36
Geometric mean PC_{20} histamine (mg/ml)	11·7	16·8	0·11

*Symptoms suggesting upper respiratory tract infection.

2 ml of test solution in the nebuliser. For the inhalation the subject performed two minutes' tidal breathing wearing a nose clip. FEV_1 was measured 30 and 90 seconds after each inhalation (Vitalograph S-26000, Buckingham). The test started with inhalation of isotonic saline and the FEV_1 90 seconds later was used as the baseline value in further calculations. Histamine chloride was then inhaled in increasing concentrations until a maximum concentration of 32 mg/ml had been reached or the FEV_1 had fallen more than 20% from baseline. Challenge in symptomless subjects was usually performed with 2, 8 and 32 mg/ml histamine, whereas in subjects with asthma or severe symptoms of wheezing the first concentration used was 0·03 mg/ml histamine. The provocative concentration of histamine causing a 20% fall in FEV_1 (PC_{20} histamine) was determined by linear interpolation on a logarithmic concentration-response plot between the concentration that caused a greater than 20% fall in FEV_1 and the preceding concentration. Bronchial hyperreactivity in this study means a PC_{20} histamine of 32 mg/ml or less. When PC_{20} was over 32 mg/ml a value of 33 mg/ml was assigned. PC_{20} values were log transformed for analysis.

ANALYSIS

Statistical evaluation was performed with the Statistical Package for the Social Sciences (SPSS).[11] Comparison of means for parametric values was done by analysis of variance. Association between discrete variables was examined by the χ^2 test and the odds ratio[12] was used to indicate the degree of association between two dichotomous variables. Confidence limits for odds ratios were calculated according to the method of Miettinen,[13] and this was also used to give an approximation for odds ratios from the Mantel-Haenszel test[14] when this was used to examine dichotomous variables in stratified analysis. Multiple linear regression analysis was used to evaluate which factors influenced FEV_1 and PC_{20}. When no other values are given, the limit of significance is 5% and confidence limits are 95% limits. To avoid age and height bias for FEV_1 and other lung function measurements the standardised deviations were used (that is, the observed value minus the predicted value divided by the residual standard variation[9 15]) and denoted by the prefix S (for example, $SFEV_1$).

Results

Personal characteristics

There was no significant difference between pig and dairy farmers in mean age (42·8 and 43·4 years), percentage of current smokers (20% and 33%), percentage with Medical Research Council criteria of chronic bronchitis (24% and 19%), and FEV_1 as a percentage of the predicted value (101% and 104%). Geometric mean PC_{20} histamine did not differ significantly between pig farmers (11·7 mg/ml) and dairy farmers (16·8 mg/ml). The proportion of subjects with a PC_{20} histamine value below 32 mg/ml was higher in pig farmers (62, 50%) than in dairy farmers (24, 42%) but this difference was not significant. A pronounced difference between groups was found for the symptoms shortness of breath, wheezing, and dry cough during work; one or more of these symptoms occurred in 48 (39%) of the pig farmers and 3 (5%) of the dairy farmers ($p < 0·01$). Pig farmers had significantly more exacerbations of respiratory symptoms during exercise, when exposed to tobacco smoke or cold air, or during a coryzal illness than dairy farmers (table 1). All farmers had worked in farming since their youth. For pig farmers the median number of years exclusively in pig farming was 12 years and the median number of years with lung symptoms was five years.

When farmers were divided into those with shortness of breath, wheezing, or dry cough during work in the animal house and those without such symptoms the mean age did not differ, being 42·2 years in symptomless farmers and 45·1 years in symptomatic farmers (table 2). Symptomatic farmers included more smokers (18, 35% *v* 26, 20%) and had a lower FEV_1 % predicted (93% *v* 106%) and a lower PC_{20} histamine (5·6 mg/ml *v* 18·1 mg/ml) than symptomless farmers; all these differences were significant ($p < 0·01$).

ASSOCIATION BETWEEN VARIABLES

The reporting of any work related respiratory symptom (shortness of breath, wheezing, or dry cough) was significantly associated with current smoking (odds ratio 2·2, 95% confidence limits 1·1–4·4), pig farming (odds ratio 11·4, 4·1–31·7), PC_{20} histamine $\leqslant$32 mg/ml (odds ratio 3·8, 2·0–7·6), and low FEV_1 defined as an $SFEV_1$ of less than -1 (odds ratio 3·4, 1·5–7·7) but not with age ($\leqslant$40, >40 years) (odds ratio 1·1, 0·9–1·2). Current smoking, low FEV_1, and a PC_{20} histamine value of 32 mg/ml or less were all significantly associated with each other ($p < 0·05$).

Because of the interrelation between variables some of the associations between symptoms and pig farming, smoking, and bronchial

Table 2 Characteristics of the 51 farmers with shortness of breath, wheezing, or dry cough during work in the animal house and of the 130 farmers without such symptoms

	No symptoms (n = 130)	*Symptoms (n = 51)*	*p*
Mean age (years)	42·2	45·1	0·12
% who were current smokers	20	35	<0·01
% with PC_{20} histamine $\leqslant$32 mg/ml	39	71	<0·01
% with $SFEV_1$*< −1	10	28	<0·01
Mean FEV_1 % predicted	106	93	<0·01
Mean FVC % predicted	105	95	<0·01
Geometric mean PC_{20} histamine (mg/ml)	18·1	5·6	<0·01

*$SFEV_1$ is the standardised deviation of FEV_1.

hyperreactivity were analysed with stratification for relevant variables. The strong association between pig farming and respiratory symptoms during work was even stronger after stratification for smoking (odds ratio 16·5, 5·5–49·2). The association between respiratory symptoms during work and smoking (odds ratio 2·2) was stronger after stratification for pig versus dairy farming (odds ratio 3·8, 2·0–7·5). The association between respiratory symptoms during work and a PC_{20} histamine value of 32 mg/ml or less (odds ratio 3·8) was unchanged after stratification for pig versus dairy farming (odds ratio 4·0, 2·0–8·3), but the number of dairy farmers with respiratory symptoms during work was small. The stratified analysis showed that pig farming, current smoking, and a PC_{20} value of 32 mg/ml or less were independent risk factors for shortness of breath, wheezing, or dry cough during work in the animal house.

LUNG FUNCTION MEASUREMENTS

Mean values of FEV_1, FVC, and VC were significantly higher than predicted values in dairy farmers, whereas this was only true for VC in pig farmers. The standardised deviations of lung function measurements were slightly lower in pig farmers than in dairy farmers but not significantly so (table 3). There was no significant difference between pig farmers and dairy farmers for TLCO (13·2 and 15·5 mmol min^{-1} kPa^{-1}) and TLCO/VA (1·8 and 1·7 mmol min^{-1} kPa^{-1} l^{-1}). Farmers with shortness of breath, wheezing, or dry cough had significantly lower values for FEV_1, FVC, and VC than symptomless farmers, and this also applied to standardised values ($p < 0·05$). There was, however, no significant difference between symptomatic farmers and symptomless farmers with respect to TLCO (13·5 *v* 14·5 mmol min^{-1} kPa^{-1}), TLCO/VA (1·76 *v* 1·80 mmol min^{-1} kPa^{-1} l^{-1}), RV, FRC, and TLC ($p < 0·05$ in each case). Thus pig farmers tended to have lower lung function measurements than dairy farmers but not significantly so; symptomatic farmers had evidence of airways narrowing with low FEV_1, FVC, and VC; but TLCO was preserved and there was no increase in RV.

Table 3 Lung function measurements in pig farmers and dairy farmers (means of observed (predicted) values and 95% confidence intervals (CI) for observed means)

	Pig farmers (n = 124)	*Dairy farmers (n = 57)*	*p*
FEV_1 (l)	3·98 (3·98)	3·89 (3·71)	
95% CI	3·82–4·15	3·64–4·15	
SR*	0·12	0·35	0·29
FVC (l)	4·85 (4·79)	4·76 (4·53)	
95% CI	4·68–5·01	4·52–5·00	
SR*	0·10	0·38	0·10
VC (l)	5·31 (5·00)	5·25 (4·72)	
95% CI	5·15–5·47	5·02–5·48	
SR*	0·55	0·93	0·05

*Mean standardised residual—that is, observed−predicted/residual standard deviation.

VARIABLES ASSOCIATED WITH FEV_1

Multiple linear regression analysis was used to assess which factors influenced the cross sectional values of FEV_1 and $SFEV_1$. Height and age were included in the analysis of FEV_1 but only age in the analysis of $SFEV_1$ to determine whether $SFEV_1$ decreased with age—that is, whether the decrease in FEV_1 with age was larger than expected from the regression equation for predicted values. Exposure variables were pack years for smoking and number of years spent exclusively in pig farming. The two regression models are shown in table 4. Height, age, number of pack years, and number of years in pig farming were all significantly associated with FEV_1 and explained 58% of the variation in FEV_1. Number of pack years and years of pig farming were significantly associated with $SFEV_1$ whereas age was not. The yearly decrease of FEV_1 estimated from the regression coefficients (model 1) was 32 ml/year of age, 23 ml/pack year, and 12 ml/year of pig farming.

ANALYSIS OF BRONCHIAL REACTIVITY

Eighty seven (48%) of the 181 farmers had a PC_{20} histamine value of 32 mg/ml or less and this was significantly associated with smoking, low FEV_1, and older age ($p < 0·05$). Multiple linear regression analysis using two regression models was performed with log PC_{20} as the dependent variable (table 5). Age, years in pig farming, and number of pack years were all significantly associated with bronchial reactivity (model 1). With lung function ($SFEV_1$) included in the analysis (model 2) age and number of pack years were still significant predictors but not years in pig farming. $SFEV_1$ was by far the most important factor associated with log PC_{20} histamine.

Discussion

The study population was a random sample of a well defined group of farmers. With the criteria used the study population would for socioeconomic reasons consist of younger farmers with medium sized and large farms. This procedure was used instead of random sampling of all farmers as this would include a proportion of elderly farmers, part time farmers or farmers with small farms. Every year a large number of these farmers leave their farms. The results of this study confirm and extend the results of earlier studies. The high

Table 4 Multiple regression analysis of FEV_1 and standardised deviation of FEV_1 ($SFEV_1$) as dependent variables: unstandardised regression coefficients (B) and their standard errors (SE) and significance of B

Model 1: dependent variable FEV_1

Predictor variable	B	SE of B	p	R^2*
Height (m)	3·889	0·774	<0·001	0·22
Pig farming (y)	−0·012	0·006	0·036	0·29
Smoking (pack y)	−0·023	0·004	<0·001	0·49
Age (y)	−0·033	0·005	<0·001	0·58
(Constant = −1·189)				

Model 2: dependent variable $SFEV_1$

Predictor variable	B	SE of B	p	R^2*
Age (y)	−0·005	0·009	0·567	0·09
Pig farming (y)	−0·024	0·011	0·027	0·09
Smoking (pack y)	−0·045	0·008	<0·001	0·47
(Constant = −1·046)				

*Proportion of the variation in the dependent variable explained by successive steps in the regression equation.

Table 5 Multiple regression analysis of log PC_{20} (PC_{20} in units of 0·01 mg/ml histamine): unstandardised regression coefficients (B) and their standard errors (SE) and significance of B

Model 1: dependent variable log PC_{20}

Predictor variable	B	SE of B	p	R^2*
Age (y)	−0·009	0·004	0·031	0·16
Pig farming (y)	−0·014	0·005	0·007	0·18
Smoking (pack y)	−0·020	0·004	<0·001	0·30
(Constant = 3·806)				

Model 2: dependent variable log PC_{20}

Predictor varaible	B	SE of B	p	R^2*
Age (y)	−0·019	0·004	0·012	0·16
$SFEV_1$	0·236	0·031	<0·001	0·44
Pig farming (y)	−0·006	0·005	0·177	0·45
Smoking (pack y)	−0·009	0·004	0·009	0·47
(Constant 3·591)				

*Proportion of the variation in the dependent variable explained by the successive steps in the regression equation.

prevalence of work related respiratory symptoms in pig farmers is in agreement with cross sectional studies of farmers.[4-7] Pig farmers were more likely than dairy farmers to have exacerbations of their symptoms during exercise or when having upper respiratory tract infections, and this suggests an increased bronchial sensitivity towards various irritants and infectious agents.

Symptoms of chronic bronchitis are not sufficient to explain work related respiratory symptoms in farmers because shortness of breath, wheezing, and dry cough were associated more closely with pig farming than were symptoms of chronic bronchitis, though both groups of symptoms were associated with smoking and low FEV_1. The reason for the increase in respiratory symptoms in pig farmers is not known but dust, which is characteristic of pig rearing buildings, has been suggested as the most probable cause.[6 16]

In a cross sectional study[8] pig farming was significantly associated with a low FEV_1 but a stratified sampling technique was used and the association could only be seen in farmers with symptoms. Furthermore, the mean age of the farmers was high (58 years) and many had worked under conditions not representative of modern farming. The rate of decline in FEV_1 (as assessed from the cross sectional data) due to age in this study (32 ml/year) was very similar to the rate of decline indicated by the regression equation for the European predicted values (29 ml/year)[9] and similar to the age dependent decline (40 ml/year) found in a study of 428 English farmers.[17] The additional rate of decline associated with smoking (23 ml/pack year) was also close to that found in other studies.[18] The additional rate of decline in FEV_1 associated with pig farming (12 ml/year) was similar to that found in a longitudinal study of 556 industrial workers, in whom dust exposure caused a 10–20 ml/year decline in addition to the age and smoking related decline.[19] In grain workers, whose exposure conditions may be more like those of farming than of industry, exposure to grain dust was associated with a decline in FEV_1 similar to or somewhat smaller than that caused by smoking, and this effect seemed to be additive to that of smoking.[20]

Pig farmers[21] and grain workers[22] have a decline in FEV_1 during a work shift and a six year follow up study[23] showed that 10% of grain workers had an annual decline in FEV_1 of over 100 ml/year. This severe decline was associated with bronchial hyperreactivity and exposure to dust concentrations above 5 mg/m^3.

In this study PC_{20} histamine values of 32 mg/ml and below defined bronchial hyperreactivity. This definition is arbitrary but the concentration of 32 mg/ml histamine represents the highest concentration that can be used with this method without intolerable side effects from histamine (hoarseness, cough, and flushing). Population studies[24 25] have shown that only 10–20% of a random population sample have a 20% fall in FEV_1 with acceptable doses of histamine and that the percentage of the population with a positive response to histamine challenge increases with age and smoking. The lowest prevalence of subjects with a positive response was found in non-smoking individuals aged 35–54 years.[25] Given the mean age and the low prevalence of smoking, our study strongly suggests that farmers have increased levels of bronchial reactivity. The close association between bronchial hyperreactivity and respiratory symptoms has been found in population studies[26] and in workers exposed to dust[27] and the association of a positive response in the histamine test with older age and smoking agrees with the results from population studies.[26] Bronchial reactivity was strongly influenced by $SFEV_1$, and when correction was made for this age and pack years were significant predictors of log PC_{20} whereas number of years in pig farming was not. Bronchial reactivity has been reported to be an independent predictor of decline in FEV_1,[28] but because it was considered a response variable like FEV_1 itself it was not included in the regression analysis of FEV_1.

The mean decline in FEV_1 of 12 ml per year of pig farming may seem low. Thirty years of exposure would amount to a decline of 360 ml, compared with an age related decline in FEV_1 of about 1000 ml in the same time. The crucial questions about these findings are whether they would be confirmed in a longitudinal study and whether some farmers will show a much steeper decline in FEV_1 than most as a result of work in dusty pig rearing units. In a previous study only farmers with symptoms had evidence of impaired lung function.[8] A group of symptomless farmers (mean age 52 years) still had a normal mean FEV_1 and no one was below the lower 95% confidence limit for predicted values, whereas symptomatic farmers (mean age 58 years) had severe airways obstruction. This has implications for diagnosis and control of respiratory disease in farmers. Work in pig rearing units should be considered a pulmonary health hazard and some farmers will probably develop appreciable airways obstruction. Symptoms of chronic bronchitis and work related symptoms of shortness of breath, wheezing, and persistent dry cough should lead to clinical assessment and measurement of lung function so that airways obstruction is detected at an early stage.

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