Working in swine-confinement buildings causes an accelerated decline in FEV1: a 7-yr follow-up of Danish farmers

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Working in swine-confinement buildings causes an accelerated decline in FEV1: a seven-year follow-up of Danish farmers. M. Iversen, R. Dahl. ©ERS Journals Ltd 2000.
ABSTRACT: Work in swine confinement units causes exposure to high levels of organic dust and is associated with a high prevalence of work-related respiratory symptoms and probably with accelerated decline in forced expiratory volume in one second (FEV1).

A 7-yr follow-up on FEV1, forced vital capacity (FVC), bronchial reactivity, and respiratory symptoms was performed on 181 Danish farmers. The participation rate was 76.3% and nonparticipants had more symptoms, were more likely to be current-smokers and had lower lung function in the first survey than participants in both surveys.

Farmers who worked exclusively with pigs in the follow-up had an accelerated decline in FEV1 but not in FVC compared with dairy farmers, where the observed decline in FEV1 was close to the expected. For a nonsmoking pig farmer compared to a nonsmoking dairy farmer the mean additional decline in FEV1 was 17 mL·yr^{-1} (53.0 mL·yr^{-1} *versus* 36.1 mL·yr^{-1}).

The authors conclude that working in swine confinement units causes an accelerated decline in forced expiratory volume in one second but not in forced vital capacity. The mean decline is ~0.5 L during a working life and some farmers will develop clinically significant airway obstruction due to work in swine confinement units.
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Working in closed swine-confinement buildings is always associated with exposure to high concentrations of organic dust [1] and high prevalence of work-related respiratory symptoms in cross-sectional studies. This has been confirmed in several studies from northern Europe, Canada, and the USA [2–8]. The dust from confinement buildings has strong biological properties and causes severe bronchial inflammation [9, 10] and work in confinement buildings is associated with a cross-shift decline in forced expiratory volume in one second (FEV1) [7, 11, 12]. Several cross-sectional studies have suggested that pig farmers develop bronchial hyperresponsiveness and that this is related to symptoms and airway obstruction [8, 13–16]. Results from cross-sectional studies [8, 13] have suggested that work in swine confinement buildings is associated with and accelerated decline in FEV1 and this seems to be confirmed from longitudinal studies [14–17].

The purpose of this longitudinal study was to investigate whether farmers with exclusively swine farming (high dust exposure) had an accelerated decline in FEV1 compared to farmers with exclusively dairy farming (low dust exposure) a longitudinal study. Secondary endpoints were development in respiratory work-related symptoms and bronchial reactivity and its relation to decline in FEV1.

Methods

From a previous cross-sectional study [8] all 181 male farmers were invited to a 7-yr follow-up. Measurement of FEV1/forced vital capacity (FVC) and bronchial reactivity by histamine challenge was performed with the same equipment and with the same procedure as in the first survey [8]. The group of farmers consisted of full-time farmers with medium to large farms who were exclusively pig or dairy farmers at the first survey.

Questionnaire

Farmers were asked about their farming practices and smoking habits in the follow-up period so that they could be classified according to exposure. Furthermore, they were asked about the presence of work-related respiratory symptoms like shortness of breath, wheezing and dry cough when working in the confinement building. The questions on respiratory symptoms were the same as in the first survey.

Lung function measurements

A dry bellow spirometer, Vitalograph S-20600 (Vitalograph Ltd., Buckingham, UK) was used for measurement of FEV1 and FVC. Before the study period the spirometer was calibrated by a certified technician to an accuracy of within 1%. The spirometer was checked each study day for leaks by a calibrated syringe. Persons were in the standing position and no nose clip was used. FEV1 and FVC was determined according to the same guidelines as in the first

survey. After two or more practice blows FEV1 and FVC was determined as the highest value from the results of measurements.

Histamine challenge

Bronchial reactivity to histamine was performed in accordance with a method described by COCKROFT *et al.* [18]. The aerosol was generated by a Wright nebulizer, calibrated to give a constant output of 0.13–0.15 mL·min^{-1}. The aerosol was inhaled during 2 min of tidal breathing through a mouthpiece. A nose clip was used. FEV1 was measured before start of the procedure and 90 s after each inhalation (Vitalograph, Model S; Vitalograph Ltd.). FEV1 after isotonic saline inhalation was used as baseline. Histamine dihydrochloride was inhaled in doubling concentrations from 0.03–32 mg·mL^{-1}. The results were expressed as the provocative concentration of histamine causing a 20% fall in FEV1 (PC20) histamine obtained from the log dose-response curve by linear interpolation of the two last points or the slope calculated as the maximal fall in per cent of FEV1 divided by the cumulative doses of histamine in mg. Bronchial hyperreactivity in this study means a PC20 histamine of ≤32 mg·mL^{-1}.

Statistics

Parametric statistics were used with the Statistical Package for the Social Sciences (SPSS) [19]. Analysis of variance with covariate analysis was used to compare means and multiple linear regression analysis to study explanatory variables for decline in FEV1 and FVC. Test for normal distribution of variables was performed with the Lilliefors test. A significance level of 0.05 was used throughout. Because of a very skewed distribution of bronchial reactivity, measurements were compared with nonparametric statistics, Wilcoxon matched pairs test for paired comparison and Mann-Whitney Wilcoxon test for unpaired comparisons.

Results

Participants versus nonparticipants

Of the 181 farmers, four died in the follow-up period. Death certificates were obtained from the national death certificate register. None of the deaths were caused by respiratory disease and the four deceased farmers had lung function values in the normal range at the survey in 1989. Of 177 farmers, 135 (76.3%) participated in the survey. Participants and nonparticipants were of the same age and height and had the same number of working hours in confinement buildings (table 1) but nonparticipants had significantly lower FEV1 (96.0% *versus* 105.3%), FVC, FEV1/FVC ratio and more respiratory symptoms during work (39.1% *versus* 24.4%) and more were smokers 20.7% *versus* 34.8%) than participants (table 1). The daily number of working hours in the confinement buildings were nearly the same in participants and nonparticipants (5.0 and 5.3 h). Three farmers had changed their farming practices so that they could not be classified as

Table 1. – Personal characteristics of participants and nonparticipants in follow-up study

Variable	Participants n=135	Nonparticipants n=46	p-value
Mean age yrs	43	44	0.553
Mean height m	1.76	1.76	0.964
FEV1 % pred	105.3	96.0	0.004
FVC % pred	104.0	97.5	0.017
FEV1/FVC %	82.8	79.1	0.020
FEV1/FVC <70%	8.1	21.7	0.013
Work-related respiratory symptoms %	24	39	0.056
Current smoking %	21	35	0.056
Positive skin prick test %	37	50	0.122
Daily working hours in confinement building	5.0	5.3	0.367

FEV1: forced expiratory volume in one second; FVC: forced vital capacity; % pred: percentage of the predicted value.

exclusively pig or dairy farmers in the follow-up period, therefore 132 farmers were included in the analysis.

Decline of forced expiratory volume in one second and forced vital capacity

The decline of FEV1 (fig. 1), and FVC (fig. 2), showed a continuous distribution not significantly different from a normal distribution (p>0.20). This also applied to the subgroups of dairy farmers/swine farmers and smokers/ nonsmokers with a normal distribution (Lilliefors test, p>0.05).

Because the first cross-sectional survey had demonstrated an interaction between smoking and pig farming, the decline in FEV1 and FVC were analysed separately in farmers who were nonsmokers in the study period and in the whole group of farmers.

Corrected for age, height and pack-yrs in the study period the annual decline in FEV1 of pig farmers was significantly higher than dairy farmers (53.8 *versus* 41.8 mL, p=0.045), whereas there was no significant difference for FVC (33.7 *versus* 39.1 mL, p=0.608) (table 2). With the analysis restricted to farmers who were nonsmokers in the
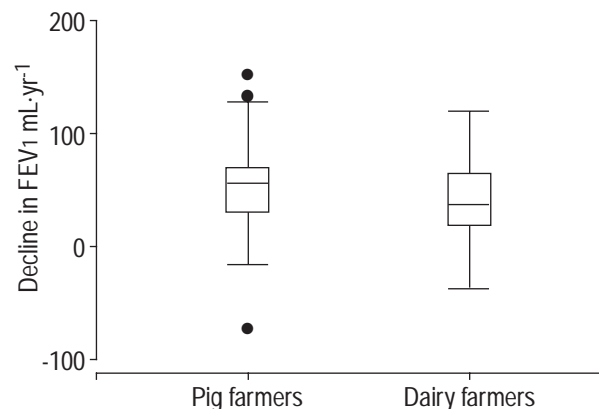

Fig. 1. – Box-plot of decline in forced expiratory volume in one second (FEV1) (mL·yr^{-1}) in pig and dairy farmers. Fifty per cent of observations are within the closed boxes, median values are indicated by the solid lines. ●: outliers.

Fig. 2. – Box-plot of decline in forced vital capacity (FVC) (mL·yr⁻¹) in pig and dairy farmers. Fifty per cent of observations are within the closed boxes, median values are indicated by the solid lines. ●: outliers.
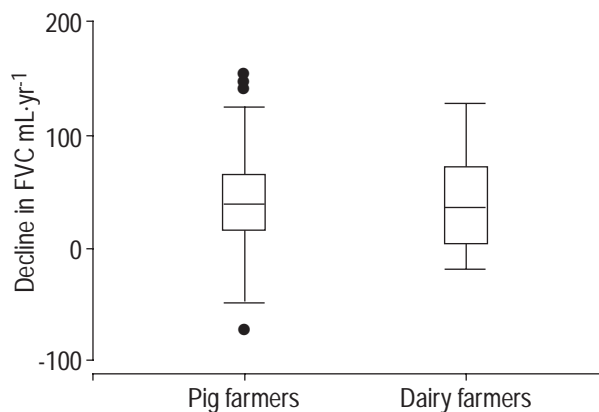
study period, the difference was more pronounced for FEV_1 (53.0 mL·yr⁻¹ for pig farmers and 36.1 mL·yr⁻¹ for dairy farmers (p=0.018)) whereas FVC was essentially unchanged (38.2 mL·yr⁻¹ *versus* 36.8 mL·yr⁻¹, p=0.920) (table 3).

Multiple linear regression analysis showed that the level of bronchial reactivity expressed by the histamine slope at the initial survey was not a significant predictor for decline in FEV_1 in the total group (p=0.536) (table 4), or in the group of nonsmokers (p=0.340) (table 5).

Bronchial reactivity

In the first survey bronchial reactivity was not significantly different between pig and dairy farmers (p=0.715) nor was it in the second survey (p=0.969). With linear correction for FEV_1 with respect to PC_{20} histamine a significant, although small, decrease in bronchial hyperreactivity was seen (p>0.001 for pig and dairy farmers). The difference in both groups was caused by a number of persons going from light bronchial hyperreponsiveness to a non-respondent status (fig. 3).

Work-related respiratory symptoms

The number of persons with asthma-like respiratory symptoms like wheezing, shortness of breath or dry cough during work in the animal house was similar in the two surveys (n=11) and they were all found among the pig farmers.

Table 2. – Values of decline in forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) for pig and dairy farmers. Analysis of variance with correction for age, height, and pack-yrs in the follow-up period

Variable	Pig farmers n=94	Dairy farmers n=38	p-value
Decline in FEV_1	53.8	41.8	0.045
Decline in FVC	33.7	39.1	0.608

Data presented as mL·yr⁻¹.

Table 3. – Values of decline in forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) for pig and dairy farmers who did not smoke in the follow-up period. Analysis of variance with correction for age and height

Variable	Pig farmers n=76	Dairy farmers n=26	p-value
Decline in FEV_1	53.0	36.1	0.018
Decline in FVC	38.2	36.8	0.920

Data presented as mL·yr⁻¹.

Pig farmers with symptoms had more airways obstruction than nonsymptomatic pig farmers (FEV_1/FVC ratio 0.76 *versus* 0.84, p=0.316) larger annual decline in FEV_1 (72.7 *versus* 51.7 mL, p=0.066), larger annual decline in FVC (58.2 *versus* 30.34 mL) and there were more current smokers (36% *versus* 13%, p=0.123) but none of the differences were significant.

Discussion

This 7-yr follow-up study had a bias in the participation as nonparticipants had significantly more work-related respiratory symptoms, airways obstruction and number of current-smokers. However there was no bias with respect to pig/dairy farmer, age, height or number of working hours in confinement building. The bias is substantial and probably means that this study will underestimate the harmful effects of pig farming with respect to decline in FEV_1.

Participation in the first survey and knowing the results of lung function measurements represents another possible bias. Pig farmers especially had increased awareness of the potential harmful effects of their occupation and the harmful effects of smoking and some took measures to reduce exposure. This bias, which would tend to diminish the effects of pig farming found in this study were not evaluated. Nonsmoking dairy farmers had an annual decline in FEV_1 very close to the expected 30 mL·yr⁻¹ found nonsmoking Danish men in a non rural population [20]. The excess decline due to pig farming had a mean value of 17 mL·yr⁻¹ which would correspond to 0.51 L in 30 yrs of work. As the normal physiological loss of FEV_1 from the age of 30 to the age of 60 is ~1 L an additional decline of 0.5 L represents a substantial loss. Farmers with FEV_1 values low in the normal range or higher than average decline in FEV_1 due to pig farming will probably develop clinically significant airways obstruction before the age of

Table 4. – Regression analysis of decline in forced expiratory volume in one second (FEV_1), results from all 132 participants

Predictor variable	Dependent variable: decline in FEV_1 mL·yr⁻¹		
	B	SE of B	p-value
Histamine slope 1989	0.057	0.097	0.536
Pig *versus* dairy farming	-11.010	6.328	0.084
Smoking in follow-up	2.421	6.535	0.711
Constant 61.521			

B: regression coefficient; SE: standard error.

Table 5. – Regression analysis of decline in forced expiratory volume in one second (FEV1), results from the 101 participants who were nonsmokers in the follow-up period

Predictor variable	Dependent variable: decline in FEV1 $mL \cdot yr^{-1}$		
	B	SE of B	p-value
Histamine slope 1989	0.452	0.103	0.340
Pig *versus* dairy farming	-15.205	7.161	0.036
FEV1 in 1989 L	0.009	0.042	0.843
Constant 64.349			

B: regression coefficient; SE: standard error.

sixty. Smoking in pig farmers would aggravate this further.

The excess decline in FEV1 found in this study is comparable, although lower, to the results from studies from Canada [21] and the Netherlands [22] where there was a mean decline of 26 $mL \cdot yr^{-1}$ and 10–70 $mL \cdot yr^{-1}$ depending on endotoxin exposure. In contrast with the Canadian and Dutch studies, an excess decrease in FVC was not found, thus extending the results from previous cross-sectional surveys [8, 13] and longitudinal survey [17] where development of airways obstruction was found. In the first survey [8] there was evidence of airways obstruction in pig farmers compared to dairy farmers but there was no evidence of impairment in diffusion capacity. This is also in accordance with the study with transbronchial biopsies performed by SCHWARTZ *et al.* [23] from Iowa, where no evidence of parenchymal damage was seen and with the longitudinal study from the same centre [24].

Contrary to what was to be expected from previous cross-sectional surveys [8, 13] a general increase in bronchial reactivity in pig farmers during the follow-up period was not seen nor was any increase in the number of persons with work-related respiratory symptoms. This could be due to selection bias in the participation since nonparticipants were more affected than participants and possibly to declining exposure in the follow-up period, because many farmers became aware of the risk and some changed their working practices.

In conclusion, nonsmoking pig farmers experience significant excess decline in forced expiratory volume in one second but not in forced vital capacity over a 7-yr period, whereas nonsmoking dairy farmers have declines in forced expiratory volume in one second and forced vital capacity comparable to the general population.

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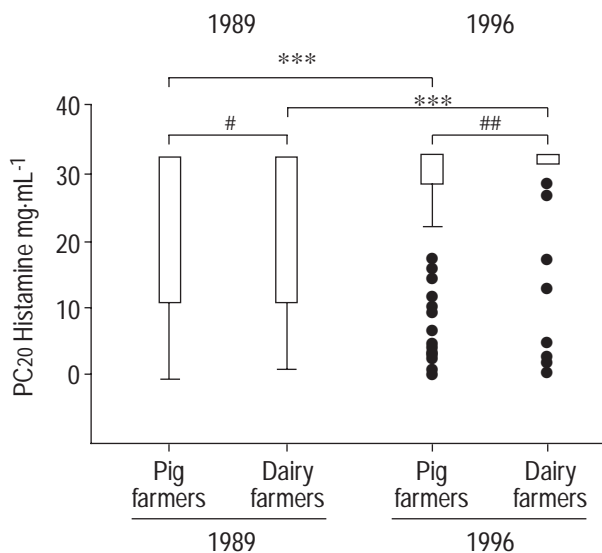
Fig. 3. – Box-plot of decline in provocative concentration of histamine causing a 20% fall in forced expiratory volume in one second (PC20 histamine) in 1989 and 1996 in pig and dairy farmers. Fifty per cent of observations are within the closed boxes, median values are indicated by the solid lines. ●: outliers; ***: p=0.001; #: p=0.715; ##: p=0.969.

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