Healthy Worker Effect in Swine Farmers

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Abstract

We conducted a long term follow-up of pulmonary function in swine farmers in 2003/04 that was preceded by previous studies in 1990/91 and 1994/95. Those still swine farming showed better pulmonary function than did those who quit swine farming over the interval. Predictors of 2003/04 continuing as a swine farmer were 1990/91 values for younger age, higher values for pulmonary function tests, and larger herd size. We conclude that there is a significant healthy worker effect among farmers who continue to work in swine confinement facilities, as compared to those who drop out.

Key words: lung function, swine farmers, survival, healthy worker effect

Introduction

The respiratory health effects of exposure to swine farming using intensive animal confinement facilities have been studied in recent years.[1-19] People working in swine confinement facilities are exposed to a number of contaminants associated with respiratory manifestations, including ammonia, hydrogen sulphide, dust and endotoxin.[1,2,20] The Iowa study showed that decrements in lung function were associated with endotoxin levels.[19] Similarly, our study from Saskatchewan showed that endotoxin exposures correlated with mean values of pulmonary function test variables in exposed farmers.[7]

One consideration in occupational epidemiological studies is a "healthy-worker survivor" effect.[21] It has been suggested that when exposed to various contaminants, susceptible individuals will develop symptoms and or dysfunction that may result in them leaving the industry, resulting in a working population that appears to be healthier than the general population. This health based selection process has been suggested to occur in swine farmers.[22] However, we do know that some people may develop an asthma-like picture within a short time of commencing work in the facilities, necessitating withdrawal from work.[23]

As a follow-up to our earlier study of swine farmers,[17,18] we attempted to contact previously tested swine farmers and previously tested non-farming rural dwelling non-exposed control subjects. The objective of the study that we here-in report was to examine pulmonary function changes between three testing periods over a 13 year span and to investigate the possibility of a potential health worker effect.

Materials and methods

Figure 1 shows the numbers of farmers and non-farming rural dwelling control subjects studies in each of 1990-91, 1994-95 and 2003-04. Methods for pulmonary function tests in the third study were as described for the first and second studies.[5,7,17,18] using testing techniques followed American Thoracic Society recommendations.[24] The following parameters were recorded: forced expiratory volume in one second (FEV_1, L); forced vital capacity (FVC, L); FEV_1/FVC ratio (%); and forced expiratory flow between 25 and 75 percent of FVC ($FEF_{25-75\%}$, L/s). Percent predicted values for FEV_1, FVC, FEV_1/FVC ratio, and $FEF_{25-75\%}$ were obtained from equations developed by Crapo et al.[25]

In the third study, conducted in 2003/2004, we obtained data on 163 farmers and 118 control subjects, all of whom had been studied in both 1990/91 and 1994/95 (Figure 1). Of the 163 farmers studied in 2003/04, 52 were "still swine farming" as they continued to work in swine production and 111 had "quit swine farming" as they had discontinued raising swine between 1994/95 and 2003/04. Of 388 persons (217 farmers and 171 control subjects) evaluated in the second study, 107 persons (54 farmers and 53 control subjects) were not evaluated in the third study for reasons of lack of interest (36%), inability to locate (26%), lack of availability (24%) and, death or illness (14%), resulting in 163 swine farmers and 118 control subjects participating in the third study (Figure 1).

Smoking definitions were as previously described[17] for the 2003/2004 follow-up. Those reporting smoking in 2003/2004 were defined as current smokers. Those who reported smoking either in 1990/91 or in 1994/95 but who denied smoking in 2003/2004 were defined as ex-smokers. Those who denied smoking on all three occasions were defined as non-smokers.

Continuous variables were expressed as mean ± Standard Deviation (SD) and categorical variables by frequency and percentages with differences described by two independent sample t-tests and χ^2 tests with 2 degrees of freedom respectively. Logistic regression was used to investigate the relationship between independent variables and the outcome of quit swine farming vs. still swine farming.

Results

Table 1 demonstrates that in the third follow up, conducted in 2003/04, the non-farming control subjects were significantly older than the still swine farming subjects. There were significantly more non-smokers among still swine farming subjects. Among the farmers studied in 2003/04, mean observed values for FEV_1/FVC and $FEF_{25-75\%}$, percent predicted FEV_1/FVC and $FEF_{25-75\%}$ were significantly lower in those subjects who had quit swine farming compared to those who continued to be swine farmers (still swine farming).

Figure 2 shows that 1990/91 baseline value for FEV_1/FVC was significantly greater (p=0.0089) for those still swine farming in 2003/04 compared to those who had quit swine farming by the time of the 2003/04 study. Figure 3 shows that 1994/95 values for FEV_1/FVC (p=0.009) and $FEF_{25-75\%}$ (p=0.017) were significantly greater for those still swine farming in 2003/04 compared to those who quit swine farming by the time of the 2003/2004 study.

Table 2 shows the odds ratios for the association between quitting swine farming and other factors from univariate and multivariate logistic regression analyses. In multivariate analysis age was a significant predictor of farmers remaining working in the swine barns. In both univariate and multivariate analyses, lower values for FEV_1/FVC measured at baseline in 1990/91 were significantly

associated with quitting swine farming. Lower values for FEV_1/FVC measured in 1994/95 were also significantly associated with quitting swine farming.

Discussion

This is the first study, of which we are aware, where long-term evaluation of lung function in swine farmers has taken place and in which long-term catchments have included both farmers who continue to work in the swine barns (still swine farming) and those who have ceased to do so (quit swine farming). The subjects who stayed in the study for the third study in 2003/04 had higher pulmonary function values in 1990/91 and in 1994/95 than did the ones unavailable for follow up in 2003/04, regardless of them being swine farmers or non farming control subjects. Among those swine farmers who were available for follow-up in 2003/04, those who were still swine farming had better lung function than did those who quit swine farming in the interval between 1994/95 and 2003/04. In addition, lung function in both 1990/91 and 1994/95 was a significant predictor of continuing to work in the swine confinement facilities in 2003/04.

Previous studies on livestock and grain workers support the findings we have obtained with the 2003/04 follow up. The longitudinal study conducted by Holness et al[26] in Ontario did not find differences between swine farmers and dairy farmers in cross-sectional observations, but the longitudinal follow-up on these farmers reported by Holness and Nethercott[27] reported increases in work-related symptoms on swine barn exposures and what appeared to be an increased occurrence of asthma cases. In essentially the same group of swine farmers on whom Senthilselvan et al reported convincing decline in lung function test variables over a 4 year period,[17] cross-sectional observations reported by Zejda et al four years earlier showed differences in lung function tests that were most pronounced in

younger workers[5] and pulmonary function test values that related to endotoxin exposure.[7] We have recently reported on 4 cases of what appeared to be occupational asthma in newly employed "8 hours/day" workers in the swine confinement industry that developed within weeks or months of work commencement and that necessitated withdrawal from the industry. [23] The common feature among these workers was absence of previous asthma or previous swine barn exposure.[23] The case of what would appear to be Reactive Airways Disease Syndrome (RADS) reported by Cormier et al[28] as a result of acute exposure to H_2S gas in a swine barn would appear different from the cases of early onset asthma or asthma-like syndrome that we reported[23] because the syndrome is different and because elevated H_2S levels were not observed in facilities that we have studied,[7,9,10] although, periodic exposures to H_2S as a cause of gradual reductions in lung function in exposed farmers cannot be ruled out.

Based on the current study and previous literature, it appears that working in swine confinement facilities may result in several different potential outcomes with regard to lung function. (1) Early onset of asthma following commencement of employment[23] may be a characteristic of the recent shift towards the 8 hour working day in large commercial confinement facilities. This manifestation may be more prominent in persons commencing employment who have had no previous swine barn exposure. (2) Gradual reduction in lung function in the long-term farmer may occur[17] leading to quitting being a swine farmer. This is suggested by the data from the study that we report here. The fact that baseline lung function in 1990/91 and also in 1994/95 in the study that we here-in report can predict continuing working or quitting working is also compatible with the fact that farmers entering the study in 1990/91 already had variable lengths of exposures. The observation by Kirychuk et

al that across-shift reductions in lung function on the initial observation[18] predict longitudinal decline in exposed farmers is compatible with the idea that some of these farmers have greater susceptibility to exposures. This concept is indirectly supported by the report of Zejda et al[5] who demonstrated apparent increased effects of exposure on lung function in younger farmers, with the possibility of the older group being selected out or acclimatizing to the working environment. (3) The third outcome in the swine farmers would appear to be selection to keep working in the barns based on a healthy worker effect in which those farmers who remain employed represent a group with superior lung function and or superior ability to withstand exposure.[21] The healthy worker or survivor effect is well recognized in occupational medicine.[21, 29,30] One possibility in explaining the apparent "healthy worker" survivorship that continued exposure to endotoxin and other substances in the swine confinement facilities results in "acclimatization," with the potential for reversal of atopy and reduction in sensitivity resulting from endotoxin exposures,[31] possibly influenced by genetics,[32,33] resulting in a survivor population.

Potential limitations have been discussed with the previously published report of the four year follow-up of these swine farmers.[17] In our study, the swine farmers were some 4 years younger than the control subjects at baseline. As with any longitudinal study of lung function measures, reproducibility of measures across time is a consideration. However, we used the same type of volume displacement equipment on all 3 study occasions, and technician training and supervision (TSH) was constant.

Taken together these studies add additional support to a mounting body of evidence that among long term workers in this industry, workers may be divided into those who seem less effected by the ambient air environment in the swine barns,

and continue to work in the industry, and those who are more effected and quit working in the swine barns.

However, these observations point to the need for health surveillance programs aimed at identifying those who might be more susceptible to lung dysfunction, and of introducing good occupational hygiene and environmental controls for all workers. There is also a need for increased awareness among physicians who practice in rural areas where these farmers live and work.

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Table 1 - ***Characteristics of Swine farmers (still farming and quit farming) and non-farming control subjects in 2003/04****

Variables	Still swine farming (n=52) Mean ± SD	Quit swine farming (n=111) Mean ± SD	Non-farming control subjects (n=118) Mean ± SD
Age, yr	48.4±10.0	51.5±11.0	54.1±9.9‡
Height, cm	175.9±6.5	177.3±5.5	177.7±6.4
Weight, kg	91.7±16.2	90.5±16.6	90.6±16.1
FEV_1, L	3.82±0.68	3.69±0.75	3.67±0.67
[%predicted]	[97.67±15.25]	[94.48±15.21]	[95.27±14.05]
FVC, L	4.97±0.87	5.02±0.89	4.93±0.81
[%predicted]	[102.23±15.86]	[102.47±14.39]	[101.57±13.57]
FEV_1/FVC, %	76.9±5.6	73.5±7.4‡	74.5±7.2
[%predicted]	[95.9±6.9]	[92.3±9.1] ‡	[94.0±8.4]
$FEF_{25-75\%}$, L/s	3.52±1.13	3.01±1.28†	3.06±1.23
[%predicted]	[90.79±28.22]	[78.73±31.23]†	[82.02±30.60]
Smoking§	No. %	No. %	No. %
Nonsmoker	34 (65.0)	57 (51.4)	47 (39.8)
Ex-smoker	15 (29.0)	45 (40.5)	54 (45.8)
Current	3 (6.0)	9 (8.1)	17 (14.4)

* Comparisons were made between still swine farming vs. quit swine farming and still swine farming vs. non-farming control subjects. Differences in means were tested by two independent sample t-tests.

†$p< 0.05$, ‡$p<0.01$

§ Differences in smoking status between three groups were tested using χ^2 statistics with 4 degrees of freedom.

Table 2 – F*actors associated with quitting swine farming using logistic regression*[*]

	Univariate analysis		Multivariate analysis	
Factors	OR (95% CI)	p-value	OR (95% CI)	p-value
Age (in 1990/91), yrs	1.03 (0.99, 1.06)	0.08	1.02 (1.00, 1.04)	0.047
Smoking				
Nonsmoking	1.00	-		
Current	1.79 (0.45, 7.07)	0.67		
Former	1.79 (0.87, 3.69)	0.53		
Years worked until quit or 2003/04	0.97 (0.93, 1.00)	0.049		
FEV_1, L (1990/91)	0.84 (0.51, 1.37)	0.49		
FVC, L (1990/91)	1.09 (0.73, 1.65)	0.67		
FEV_1/FVC, % (1990/91)	0.53 (0.30, 0.92)[†]	0.03	0.03 (0.002, 0.54)	0.018
$FEF_{25-75\%}$, L/s (1990/91)	0.81 (0.62, 1.05)	0.11		

[*] OR = odds ratio, CI = confidence interval

[†] for 10 units change in FEV_1/FVC

Figure 1– Description of numbers tested at each of the three studies

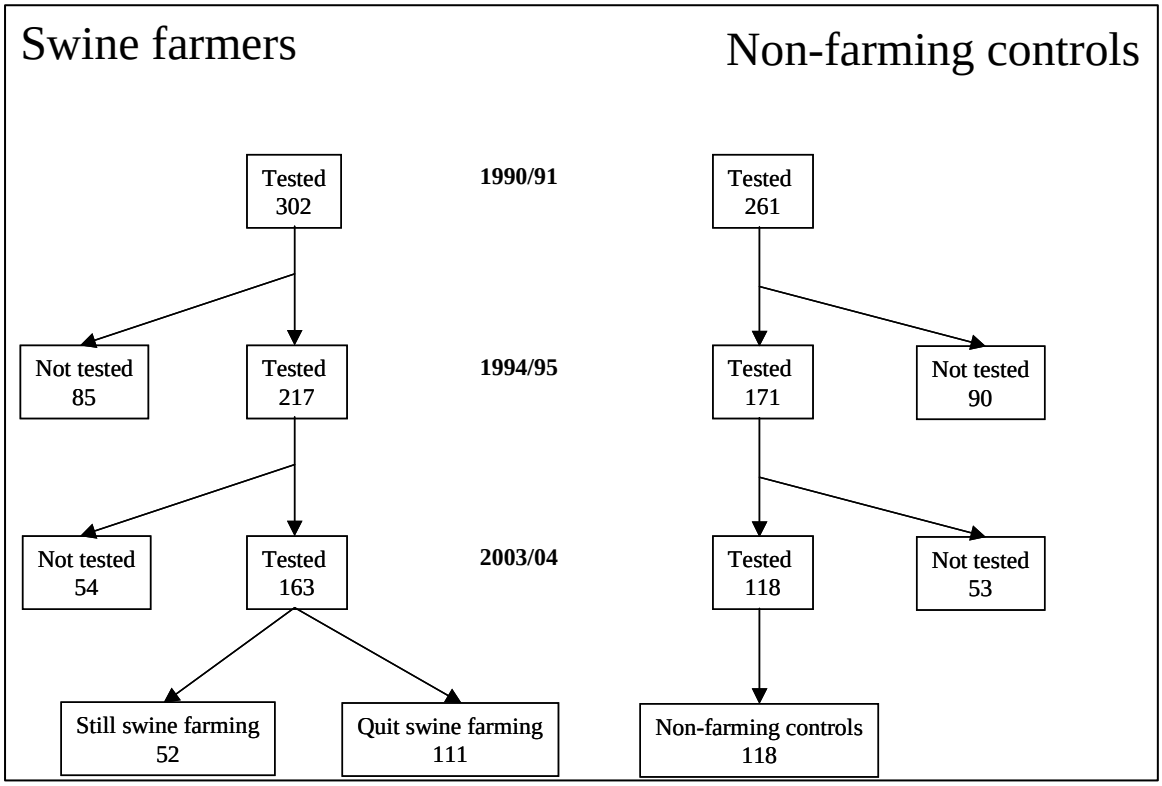
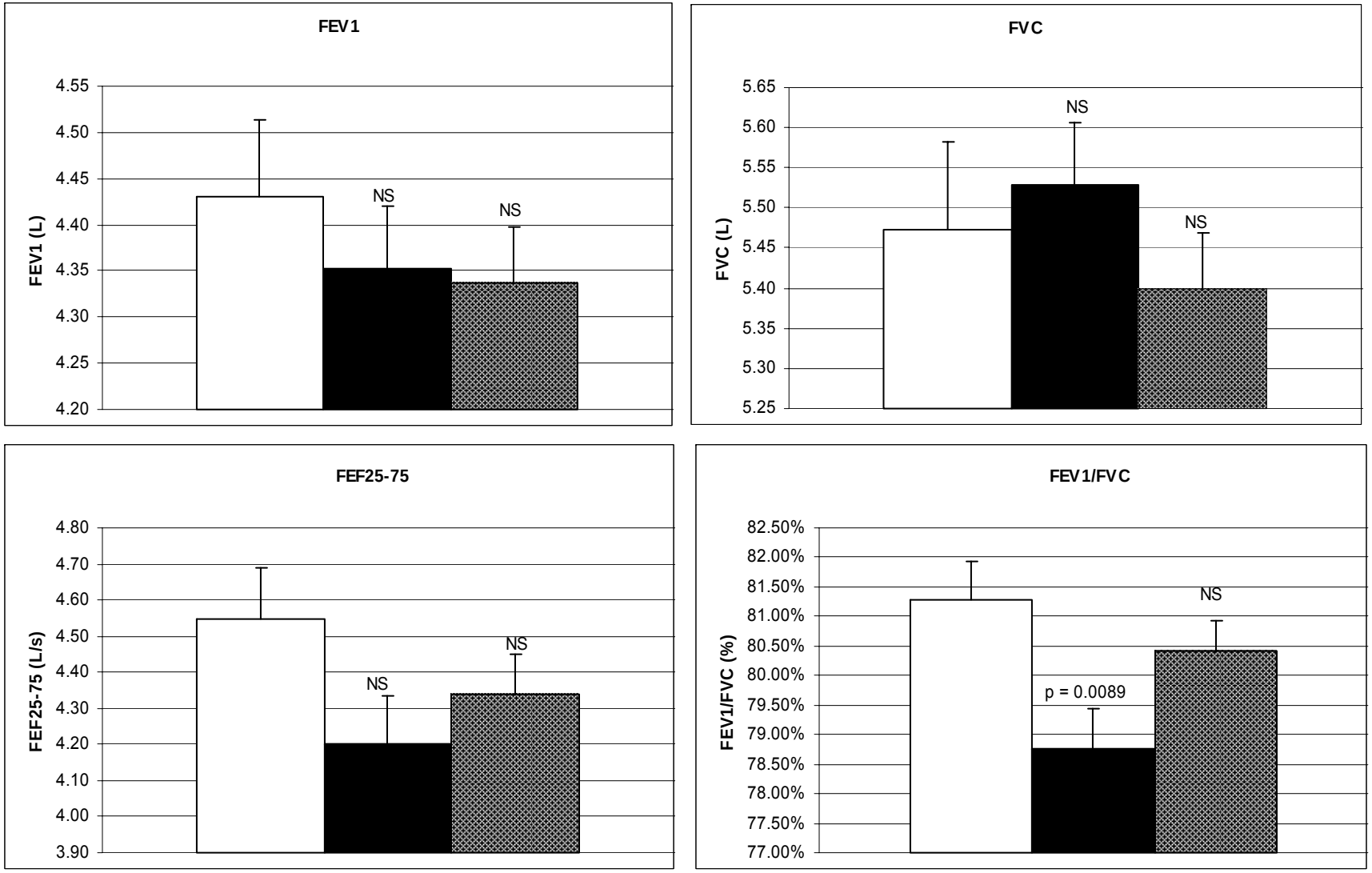


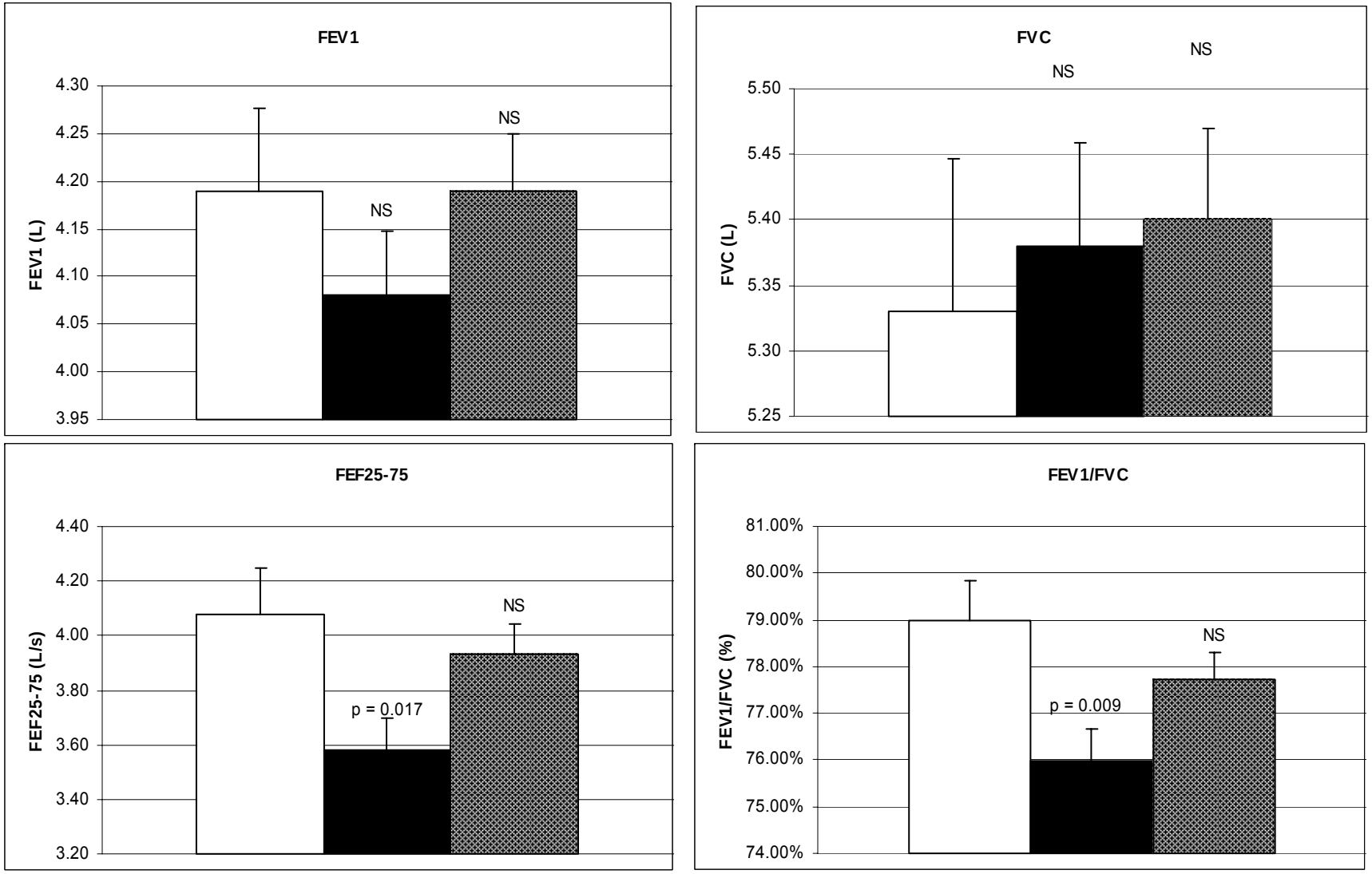
Figure 2 – ***Baseline (1990/91) lung function of study subjects considering their occupation status in 2003/04 (± SE)****



* Comparisons are between still swine farming vs. quit swine farming and still swine farming and non-farming control subjects.

☐Still swine farming ☐Quit swine farming ☐Non farming control

Figure 3 - L*ung function (1994/95) of study subjects considering their occupation status in 2003/04 (± SE)* [*]



[*] Comparisons are between still swine farming vs. quit swine farming and still swine farming and non-farming control subjects.

☐Still swine farming ☐Quit swine farming ☐Non farming control