

## Respiratory symptoms and ventilatory capacity in swine confinement workers

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### Abstract

**A group of 59 workers (41 men and 18 women) employed in swine confinement areas was studied to assess the presence of acute and chronic respiratory symptoms and the prevalence of abnormalities in ventilatory function. A control group of 46 (31 men and 15 women) unexposed workers was studied for the prevalence of chronic respiratory symptoms. For both male and female swine confinement workers complaints of chronic cough, dyspnoea, and chest tightness were significantly more frequent than among control workers. Male workers also complained more of chronic phlegm. Male swine confinement workers who were smokers had significantly higher prevalences of chronic cough, chronic phlegm, and chronic bronchitis than male non-smoking swine confinement workers. The frequency of acute symptoms associated with the workshift was high among the swine confinement workers with more than half of the workers complaining of cough and dyspnoea associated with work. Significant acute across shift reductions in lung function occurred in swine confinement workers, being largest for FEF<sub>25</sub>. All Monday preshift ventilatory capacity measurements in male confinement workers were significantly lower than predicted values; FVC and FEV<sub>1</sub> were found to be lower than predicted values for women. The data indicate that exposure in swine confinement buildings is associated with the development of acute and chronic respiratory symptoms and impairment of lung function. Smoking appears to aggravate these changes.**

Organic dusts and their biologically active constituents are recognised as important factors in the

development of respiratory diseases in swine confinement buildings. In The Netherlands, pig farmers have far more health complaints than do other farmers.<sup>1</sup> Among Dutch pig farmers a relation has been found between exposure in swine confinement buildings and effects on the respiratory system.<sup>2</sup> Donham and Gustafsson<sup>3</sup> reported that swine confinement workers developed high prevalences of acute respiratory symptoms as well as fever after exposure. The same authors divided respiratory symptoms into three major classifications—namely, acute respiratory symptoms, delayed symptoms, and acute toxic reactions. Donham *et al*<sup>4</sup> found that swine confinement workers experienced a significantly higher prevalence of chronic bronchitis and wheezing than other farm workers. No significant abnormality in baseline pulmonary function was, however, documented. A high prevalence of chronic cough (60%) and chronic phlegm (40%) as well as changes in lung function were reported by Donham *et al*.<sup>5</sup> Brouwer *et al*<sup>6</sup> stated that average values of lung function for pig farmers were low when compared with normal values. Hog confinement farmers reported respiratory symptoms significantly more often than did controls,<sup>7</sup> but lung function in that study did not differ between exposed and control farmers. Bongers *et al*<sup>2</sup> found that all measured pulmonary function values, except for FVC, were on average lower than expected for swine workers. The authors, however, did not find an association between duration of exposure and abnormalities of pulmonary function. Haglund and Rylander<sup>8</sup> suggested that exposure to dust in swine confinement buildings may lead to respiratory impairment. These authors found, however, that characteristic changes in FEV<sub>1</sub> over the work shift were generally absent. Dosman *et al*<sup>9</sup> reported that swine producers had lower values for both forced vital capacity (FVC) and forced expiratory volume in one second (FEV<sub>1</sub>) than did control subjects. This finding suggests a mixed restrictive and obstructive pattern of impairment among workers.

In the current investigation we studied the prevalence of respiratory symptoms and abnormalities of ventilatory function in a group of swine confinement workers employed on swine farms near Zagreb, Yugoslavia.

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## Subjects and methods

### SUBJECTS

Fifty nine workers (41 men and 18 women) employed in swine confinement areas were studied. They represented 80% of all workers employed in these areas. The mean ages were 32 (range 19–54) for the men and 38 (range 22–57) for the women. The mean exposure in the swine confinement buildings for the men was eight (range 1–22) years; women were exposed on average for 10 (range 1–21) years. Among the men 26 (63.4%) were smokers (mean 20 cigarettes daily). Among the women only five (27.7%) smoked and they were light smokers. A control group of 31 men and 15 women employed in a fruit juice bottling company were also included in this study. These were matched by sex, age, and smoking habits but were not exposed to noxious agents in their workplace.

Swine confinement workers in this survey were employed in preparing animal food, feeding animals, cleaning confinement buildings, and breeding animals.

### RESPIRATORY SYMPTOMS

Chronic respiratory symptoms were recorded using the British Medical Research Council Committee questionnaire on respiratory symptoms<sup>10</sup> with additional questions on occupational asthma.<sup>11</sup> In all workers a detailed occupational history and questions about their smoking habits were recorded. The following definitions were used:

*Chronic cough or phlegm*—cough, or phlegm production, or both for at least three months a year.

*Chronic bronchitis*—cough and phlegm for a minimum of three months a year and for not less than two successive years.

*Dyspnoea grades*—grade 3: shortness of breath when walking with other people at an ordinary pace on level ground; grade 4: shortness of breath when walking at their own pace on level ground.

*Occupational asthma*—recurring attacks of dyspnoea, chest tightness, and impairment of pulmonary function of the obstructive type diagnosed by physical examination and spirometric measurements during exposure to dust at or after work.

In all swine confinement workers, the presence of acute symptoms during a shift, such as cough, dyspnoea, chest tightness, irritation or dryness of the throat, secretion, dryness or bleeding of the nose, headache, and fever, were specifically recorded.

### VENTILATORY CAPACITY

Ventilatory capacity was measured by recording maximum expiratory flow volume (MEFV) curves using a portable flow volume spirometer (Pneumoscreen, Jaeger, Germany). Measurements were performed on the first working day of the week (Monday) before (6.00 am) and after (2.00 pm) the

workshift. The FVC, FEV<sub>1</sub>, and maximum expiratory flow rates at 50% (FEF<sub>50</sub>) and 25% (FEF<sub>25</sub>) of the control vital capacity were measured on these curves. At least three MEFV curves were recorded and the best value was used as the result of the test. The measured Monday preshift values of ventilatory capacity were compared with the expected normal values of the Commission des Communautés Europeennes<sup>12</sup> for FVC and FEV<sub>1</sub> and of Cherniack and Raber<sup>13</sup> for FEF<sub>50</sub> and FEF<sub>25</sub>.

### ENVIRONMENTAL MEASUREMENTS

Airborne dust was sampled during an eight hour shift at the worksites of the examined workers. Casella personal samplers with Millipore field monitors and Millipore AA membrane filters were used to estimate total dust exposure.

Also, the concentrations of ammonia, hydrogen sulphide, carbon dioxide, and carbon monoxide were measured using Drager indicator tubes. These tubes were read immediately after sampling in the same locations in which dust and microbiological samples were taken.

The temperature and humidity were continuously registered in the stalls over an eight hour sampling period with a graphic thermohygrometer type 252 (Lambrecht Gottingen, Germany). Air flow was determined using a thermal anemometer (Wilh, Lambrecht KG, Gottingen, Germany).

Measurements of airborne bacteria were made in the breathing zone of the workers. Samples were collected with a bacteria sampler Mk2 (Casella, London). The air was sampled by vacuum pump with an intake flow of 30 l/min. Total bacterial counts were measured on the surface of the blood nutrient agar and gram negative bacteria on the McConkey medium. The pH of the medium was 7.0. Samples were incubated for 24–48 hours at 37°C. Bacteria were counted as colony forming units in 1000 ml of air. Total numbers of bacteria and gram negative bacteria were expressed as the numbers of colonies/m<sup>3</sup>.

## Results

### RESPIRATORY SYMPTOMS

Table 1 presents the prevalence of chronic respiratory symptoms in swine confinement and control workers. Among the men, we found a statistically significant difference in the prevalence of all chronic respiratory symptoms except for chronic bronchitis. For the women we found significant differences in the prevalence of chronic cough, dyspnoea, and chest tightness between exposed and control workers. No cases of asthma were reported among exposed or control workers.

Table 2 indicates the prevalence of chronic respiratory symptoms in male swine confinement workers separately for smokers and non-smokers.

Table 1 Prevalence of chronic respiratory symptoms in swine confinement workers and control workers

Group	No	Mean age (y)	Mean exposure (y)	No with					
				Chronic cough	Chronic phlegm	Chronic bronchitis	Asthma	Dyspnoea	Chest tightness
<b>Men:</b>									
Exposed	41	32	8	17 (41.5) p < 0.05	15 (36.6) p < 0.05	13 (31.7) NS	0 (0) NS	9 (21.9) p < 0.01	9 (21.9) p < 0.01
Control	31	36	7	6 (19.4)	5 (16.1)	5 (16.1)	0 (0)	2 (6.5)	0 (0)
<b>Women:</b>									
Exposed	18	38	10	9 (50.0) p < 0.01	5 (27.8) NS	3 (16.7) NS	0 (0) NS	9 (50.0) p < 0.01	4 (22.2) p < 0.05
Control	15	35	8	1 (6.7)	1 (6.7)	0 (0)	0 (0)	1 (6.7)	0 (0)

Non-significant (p > 0.05). Percentages in parentheses.

Table 2 Prevalence of chronic respiratory symptoms according to smoking habit in male swine confinement workers

Group	No	Chronic cough	Chronic phlegm	Chronic bronchitis	Asthma	Dyspnoea	Chest tightness
Smokers	26	16 (61.5) p < 0.01	15 (57.7) p < 0.01	13 (50.0) p < 0.01	0 (0) NS	8 (30.8) NS	7 (26.9) NS
Non-smokers	15	1 (6.7)	0 (0)	0 (0)	0 (0)	1 (6.7)	2 (13.3)

NS = Non-significant (p > 0.05). Percentages in parentheses.

Smokers had a significantly higher prevalence of chronic cough, chronic phlegm, and chronic bronchitis than non-smokers (p < 0.01).

Table 3 presents the prevalence of acute symptoms during the workshift in swine confinement workers separately for male and female workers. The highest prevalence in both groups was found for cough, dry throat, throat irritation, and eye irritation. Among the women, many complained of headache. None of the studied workers complained of fever during or after the workshift.

#### VENTILATORY CAPACITY

Table 4 examines acute and chronic changes in ventilatory capacity. Data are presented as measured values and as a percentage change for FVC, FEV<sub>1</sub>, FEF<sub>503</sub>, and FEF<sub>25</sub>. The largest across shift reductions in the men were recorded for FEF<sub>25</sub> (-12.8%) with similar reductions for FEF<sub>25</sub> (-9.4%) among the women. Comparison with predicted normal values showed significantly lower values for all preshift

parameters in male workers and for FVC and FEV<sub>1</sub> in female workers.

Table 5 presents the changes in ventilatory capacity in male swine confinement workers by smoking habit. Among smokers all ventilatory capacity tests were significantly lower than predicted normal values. Among non-smokers, the values were significantly lower for FVC and FEV<sub>1</sub>.

#### ENVIRONMENTAL MEASUREMENTS

Table 6 presents data on environmental measurements. All values were below the maximum allowed by Yugoslav standards except for relative humidity, which was somewhat higher.

#### Discussion

Our study confirms previous investigations that showed an increased prevalence of acute and chronic respiratory symptoms and abnormalities of lung function in workers employed in swine confinement buildings. Increased rates of chronic cough, dys-

Table 3 Prevalence of acute symptoms during work shift in swine confinement workers

Sex	No	Cough	Dyspnoea	Throat		Eye irritation	Nose			Headache
				Irritation	Dryness		Secretion	Dryness	Bleeding	
Men	41	29 (70.7)	23 (56.1)	19 (46.3)	27 (65.9)	19 (46.3)	6 (14.6)	12 (29.3)	3 (7.3)	4 (9.8)
Women	18	13 (72.2)	11 (61.1)	14 (77.8)	13 (72.2)	14 (77.8)	6 (33.3)	6 (33.3)	2 (11.1)	9 (50.0)

Percentages in parentheses.

Table 4 Acute and chronic changes of ventilatory capacity in swine confinement workers by sex

Sex	FVC			FEV <sub>1</sub>			FEF <sub>50</sub>			FEF <sub>25</sub>		
	Before shift l	Difference before-after shift		Before shift l	Difference before-after shift		Before shift l/s	Difference before-after shift		Before shift l/s	Difference before-after shift	
		%	p		%	p		%	p		%	p
Men: (n=41)	4.44 (0.72) p<0.001 5.33* (0.76)	-5.2	p<0.001	3.70 (0.65) p<0.001 4.23* (0.63)	-3.8	p<0.001	5.55 (1.36) p<0.05 5.96* (0.52)	-4.1	p<0.001	2.89 (0.88) p<0.05 3.12* (0.59)	-12.8	p<0.001
Women: (n=18)	3.32 (0.61) p<0.001 4.02* (0.49)	-4.8	p<0.001	2.86 (0.52) p<0.01 3.09* (0.46)	-4.5	p<0.001	4.57 (0.79) NS 4.71* (0.40)	-10.1	p<0.001	2.44 (0.59) NS 2.53* (0.53)	-9.4	p<0.001

\*Predicted normal values. The data are presented as mean (SD). NS = Non-significant (p > 0.05).

Table 5 Acute and chronic changes in ventilatory capacity in male swine confinement workers by smoking habit

Group	FVC			FEV <sub>1</sub>			FEF <sub>50</sub>			FEF <sub>25</sub>		
	Before shift l	Difference before-after shift		Before shift l	Difference before-after shift		Before shift l/s	Difference before-after shift		Before shift l/s	Difference before-after shift	
		%	p		%	p		%	p		%	p
Smokers: (n=26)	4.47 (0.76) p<0.001 5.26* (0.77)	-5.1	p<0.001	3.65 (0.65) p<0.001 4.22* (0.61)	-3.6	p<0.001	5.29 (1.39) p<0.05 5.83* (0.79)	-10.2	p<0.001	2.63 (0.84) p<0.005 3.11* (0.55)	-11.0	p<0.001
Non-smokers: (n=15)	4.39 (0.68) p<0.001 5.46* (0.75)	-5.5	p<0.005	3.79 (0.67) p<0.01 4.26* (0.69)	-3.7	p<0.02	6.01 (1.22) NS 5.99* (0.57)	-7.2	p<0.001	3.28 (0.84) NS 3.13* (0.66)	-15.5	p<0.001

\*Predicted values. The data are presented as mean (SD). NS = Non-significant (p > 0.05).

pnoea, and chest tightness were noted in our male and our female swine confinement workers. The prevalence of dyspnoea among women was particularly high (50.0%). These data are similar to our findings on animal food processing workers exposed to different components of animal food dust.<sup>14</sup> Donham *et al*<sup>15</sup> described an association between work in confinement areas and an increased rate of symptoms of bronchitis and respiratory diseases such as colds, chest illnesses, and pneumonia resulting in a significant loss of worktime. Previous clinical studies in the United States<sup>3-4, 15-17</sup> as well as the study by doPico<sup>18</sup> document febrile episodes suggestive of hypersensitivity syndrome occurring in swine workers.

In our study we did not find any workers with occupational asthma. The mean exposure of our workers varied from 8-10 years and the absence of occupational asthma might reflect a healthy worker effect. Harries and Cromwell<sup>19</sup> have reported a case of

occupational asthma in a 21 year old woman due to exposure to pig's urine. Recently Iversen *et al*<sup>20</sup> found, in an epidemiological study of Danish farmers, that pig farming represented a significant risk for occupational asthma and chronic bronchitis (prevalence 10.9%-32.0%). The authors found a strong association between age and most respiratory symptoms. The age of their workers varied from 30-70 and reflected the number of years of exposure in this occupation. Recently Donham *et al*,<sup>21</sup> in a five year prospective study, reported that swine confinement workers experience significant insult to the respiratory tract, manifest as inflammation typified by bronchitis and reactive airways. The mean exposure of their workers varied from 10-17 years. The same authors reported for the first time "Monday symptoms" similar to those seen with byssinosis. Donham *et al*<sup>22</sup> also reported significantly higher frequencies of respiratory symptoms, more frequent colds and absence from work due to chest

Table 6 Environmental variables in swine confinement buildings

Variable	Measured values	Maximum allowable values*
Ammonia	< 5 ppm	50 ppm
Carbon monoxide	< 5 ppm	50 ppm
Carbon dioxide	< 2000 ppm	5000 ppm
Hydrogen sulphide	< 0.1 ppm	7 ppm
Total dust	< 8 mg/m <sup>3</sup>	10 mg/m <sup>3</sup>
Respirable dust	< 0.5 mg/m <sup>3</sup>	3 mg/m <sup>3</sup>
Temperature	18.4–25.8°C	10–25°C
Relative humidity	73–86%	40–70%
Air flow (ventilation)	0.06–0.18 m/s	0.5 m/s
Total bacteria	0.9–1.5 × 10 <sup>5</sup> †	
Gram negative bacteria	0.9 × 10 <sup>3</sup> –4.7 × 10 <sup>4</sup> †	

\*Yugoslav Standards: National Commission on Environmental Health.

†Bacteria are presented as number of colonies per m<sup>3</sup> air.

illness, and pneumonia in swine workers than in controls. In this study symptoms were related to the number of years and per cent of the day spent working with swine, to the level of respirable and total dust as well as the endotoxin content in total dust, and to the number of microbes in the air of the work environment.

In the present study small but statistically significant changes in ventilatory capacity in swine confinement workers over the workshift were seen. These were particularly pronounced for FEF<sub>25</sub>, suggesting that such changes in ventilatory capacity occur mostly in smaller airways. These changes are probably due to an interaction between the working environment and smoking.

Previous studies with workers exposed to the dust of coffee, soy bean, spices, or animal food showed similar significant acute reductions in FEF<sub>50</sub> and FEF<sub>25</sub> over workshifts; the changes in those groups were similar in non-smokers and smokers.<sup>14, 23–25</sup> Acute decreases in flow rates among swine confinement workers were also found by Donham *et al.*<sup>4</sup> Their data suggest a dose-response association between environmental exposure to carbon dioxide and hydrogen sulphide. Donham *et al.*<sup>5</sup> found correlations between across shift changes in pulmonary function and endotoxin concentrations and fermentative bacteria in swine confinement areas. Similar findings for dusts containing endotoxin, particularly cotton dust, have been reported.<sup>26–29</sup> This dose response relation suggests that the biological composition of swine confinement area dust rather than the total amount of the dust itself may be important in causing airway diseases.

Preshift (baseline) tests of lung function have been used to characterise chronic effects of occupational exposure on lung function. Baseline FVC, FEV<sub>1</sub>, FEF<sub>50</sub>, and FEF<sub>25</sub> in our male workers were significantly decreased with respect to predicted values.

Among female workers these differences were statistically significant only for FVC and FEV<sub>1</sub>. Significantly lower measured values for flow rates in men are probably the result of concurrent smoking effects. Donham *et al.*<sup>30</sup> suggested such an additive relation between smoking and exposure in the work environment on decline in lung function.

Airborne concentrations of contaminants in our confinement buildings were all within Yugoslav recommended values (table 6). Microclimatic conditions were normal except for relative humidity, which was higher than recommended. Donham and Papendorf<sup>31</sup> found that carbon dioxide, hydrogen sulphide, carbon monoxide, and ammonia concentrations exceeded the respective threshold limit values in one or more of their units. Holness *et al.*<sup>7</sup> found that high total and respirable dust concentrations were associated with the use of floor (scatter) feeding, indoor feed grinding, and the use of high moisture corn feed. In our study the swine confinement areas had similar risk factors. Donham *et al.*<sup>15</sup> found that the two major constituents in the aerosols in swine confinement buildings were grain particles and dried swine fecal matter. Donham and Papendorf<sup>31</sup> reported that buildings housing younger animals were more likely to have hazardous gas concentrations than buildings holding older animals. Clark *et al.*<sup>32</sup> found that airborne concentrations of total and gram negative bacteria in swine confinement units were as high or higher than those found in other environments, such as waste water treatment and cotton card rooms where microbiologically contaminated organic dusts were present. Altwood *et al.*<sup>33</sup> reported that airborne dusts, endotoxin, bacteria, and ammonia are commonly found in high concentrations within swine confinement buildings and that these are present in concentrations at which health effects have been seen in other studies.

Donham *et al.*<sup>34</sup> estimated that about 500 000 people in the United States work in livestock confinement systems that use liquid manure storage. Hydrogen sulphide is a major toxic gas generated and agitation of the liquid manure is an important process in this work environment.

The prevalences of respiratory symptoms and abnormalities of lung function documented in this and other studies support the need for control programmes to protect workers in this industry. Current Yugoslav standards would appear to be inadequate for protecting workers. As indicated in related studies the complex air pollutants generated in this indoor environment need to be characterised and reduced. Also, workers need to be protected. Pre-employment medical examinations and medical surveillance should be considered, to protect susceptible workers from developing progressive disease. Tests of lung function should be performed before

and after the workshift by recording FEV<sub>1</sub> or MEFV curves. Such examinations would allow a better assessment of worker risk in swine confinement buildings and the identification of sensitive persons. In the case of progressive impairment of lung function or the development of respiratory symptoms, workers should be moved out of high risk areas. Persons with pre-existing lung disease should probably be advised to avoid working in swine confinement buildings that carry a risk of inducing acute or chronic respiratory disease.

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