Scand J Work Environ Health 1991;17:269—75

Respiratory health of workers exposed to swine confinement buildings only or to both swine confinement buildings and dairy barns

by Yvon Cormier, MD, Louis-Philippe Boulet, MD, Gaetane Bedard, Guy Tremblay, MSc[1]

CORMIER Y, BOULET L-P, BEDARD G, TREMBLAY G. Respiratory health of workers exposed to swine confinement buildings only or to both swine confinement buildings and dairy barns. *Scand J Work Environ Health* 1991;17:269—75. Swine building workers (N = 488) and nonfarming neighborhood referents (N = 216) were enrolled in this study. There was a slight but significant increase in the prevalence of chronic bronchitis (17.49 versus 11.57 %) and more evidence of airflow obstruction (forced expiratory volume in 1 s/forced vital capacity 0.75 versus 0.78) among the swine workers when they were compared with the referents. The subjects who spent more than 3 h/d in the swine buildings had a higher prevalence of chronic bronchitis (21.94 versus 13.25 %) and airflow obstruction (forced expiratory volume in 1 s/forced vital capacity 0.75 versus 0.76) than those with shorter daily contact. Swine building only workers had no precipitins to antigens found in their environment and no clinical evidence of extrinsic allergic alveolitis. The number of years on the farm, dual exposure with dairy cattle, positive skin prick tests, type of piggery, and type of feeding did not add to the respiratory health impact of swine buildings.

Key terms: agricultural workers' diseases, alveolitis, bronchitis, extrinsic allergic, lung, occupational diseases, precipitins, respiratory function tests, skin tests.

Although numerous studies have been reported on the subject, the respiratory health impact of working in a swine confinement building remains controversial (1). There are large differences in the reported incidence of respiratory ailments, such as chronic bronchitis, and in the functional impairment observed. Some studies have reported a very high prevalence of cough and sputum production for these workers (2—4), while others found fewer symptomatic subjects (5, 6). Similar differences can be found for the number of subjects with abnormal pulmonary functions (5, 7). Some of these differences can be explained by differences in study populations and differences in the swine building environments. While one study reported on workers of small hog raising units (7), another involved workers of industrial-scale swine production (8). Climatic conditions in the different countries where the studies were done could also have influenced the results. In colder climate swine buildings tend to be less well ventilated, while microbial growth may be more important in warmer environments. Other confounding variables, such as the small size of the study population and the absence or inadequacy of references, make the interpretation of published results sometimes difficult (2, 3, 5, 6, 8, 9).

Many farmers in Canada and other countries have mixed swine-dairy cattle exposure. Both swine confinement buildings and dairy barns contain potentially hazardous airborne contaminants. Previous reports show an increased prevalence of respiratory ailments for both of these environments (10, 11). Data from one study suggest that dairy barns have significantly less negative impact on respiratory health than swine buildings (11), while no differences were found regarding the prevalence of chronic bronchitis and lung function impairments between swinery workers and cattle workers in another study (12).

Swine confinement buildings are known to contain large numbers of microorganisms (13, 14), some of which induce precipitating antibodies and extrinsic allergic alveolitis (13). The prevalence of hog producers with serum precipitins to these specific antigens is currently unknown. Previous studies have reported variable prevalences of immunoglobulin G (IgG) to hog and feed antigens and to swine building dust (5, 11, 15). Interstitial changes in the lungs of guinea pigs and rabbits raised in swine confinement buildings have been described (16), and possible interstitial abnormalities have been suggested for swine building workers (7). Bronchoalveolar lavage of asymptomatic swine show an increase in alveolar lymphocyte counts (17) when compared with the counts of asymptomatic dairy farmers (18).

Antigens present in swine buildings include animal danders and urine, grain dusts, and a variety of microorganisms. The possible role of immediate type hypersensitivity to airborne antigens on respiratory symptoms and functional abnormalities remains to be elucidated. Atopy has been reported to increase the risk of respiratory symptoms in farmers (19).

This study reports the results obtained from 488 Quebec swine confinement building workers (164 swine

[1] Unité de Recherche, Centre de Pneumologie de l'Hôpital Laval et Université Laval, Québec, Canada.

Reprint requests to: Dr Y Cormier, Hôpital Laval, 2725, chemin Sainte-Foy, Sainte-Foy, Québec, Canada G1V 4G5.

only and 324 both swine and cattle) and 216 nonfarming neighborhood referents. We found some increase both in respiratory symptoms and in the number of subjects with abnormal pulmonary functions, but the prevalence of these abnormalities was less than previously reported. Dual building exposure did not increase the health risk. The swine workers had not developed precipitating antibodies to microorganisms present in their work environment. And the presence of immediate skin prick test reaction was not associated with the respiratory symptoms of these workers.

Subjects and methods

In the winter months of 1988 and 1989 (between 15 January and 15 April) 704 subjects were enrolled into this study. Of these persons, 488 were swine confinement building workers (164 swine only and 324 swine and dairy) and 216 were referents. The swine worker were taken from a membership list of the Quebec "Union des producteurs agricoles, section porc" (Swine worker's union). We contacted 526 subjects identified on the list provided by the union. Of these, 117 were no longer involved in swine production and 45 refused participation. A total of 364 farms were therefore retained. An additional 15 farms were subsequently identified by the visited farmers. The 488 swine workers were enrolled from these 379 farms. Each enrolled worker identified his or her first nonfarming and not retired neighbor, who was then asked to serve as a referent. Three hundred and twenty referents were identified and solicited. Of these, 104 refused. Each swine worker was visited at home, while the nonfarmer referents were seen at a local social club. The swine farmers were visited in the daytime, while the referents were seen in the evening. After having signed an informed consent form, the subjects were asked to (i) answer a standard questionnaire, (ii) do a forced expiratory maneuver, (iii) have venous blood drawn for precipitin analysis, and (iv) submit to a battery of skin prick tests with 23 airborne allergens.

The questionnaire was based on the standard suggested by the American Thoracic Society (ATS) (20) with questions on the work environment added. These questions included the number of pigs, the number of hours spent daily in the confinement buildings, the number of years worked in this environment, type of piggeries, type of feedings used (eg, dry versus wet), type of farm (hog only, mixed hog-dairy cattle, etc). Questions related to a history of extrinsic allergic alveolitis (diagnosis confirmed by a qualified physician) or to symptoms suggestive of this disease were also added. All the questionnaires were filled out by the same trained nurse (GB). Chronic bronchitis was defined as the presence of cough and sputum production for three months per year for a minimum of two consecutive years. Forced expiratory flows were performed according to a standardized procedure (21) using a compact Vitalograph® spirometer (Roxon, Buckingham, England). From the best forced expiratory maneuver we obtained the forced vital capacity (FVC), the forced expiratory volume in 1 s ($FEV_{1.0}$), and the maximal midexpiratory flow rate (MMFR). The study was approved by our ethics committee. The

Table 1. Allergens used for the prick tests and their concentration. (wt/vol = weight per volume, PNU = protein nitrogen unit)

Allergens[a]	Concentration
Control (glycerine 50 %)	
Histamine	1 mg/ml
Cat hair-epithelium	1:50 wt/vol[b]
Dog hair-dander	1:50 wt/vol[b]
Horse epithelium	1:10 wt/vol
Cattle epithelium	1:10 wt/vol
Feather mix	1:10 wt/vol
Hog hair-dander	1:10 wt/vol
House dust	20 000 PNU/ml[b]
Dermatophagoides farinae	5000 PNU/ml
Tree mix (6)	1:20 wt/vol
Birch	1:20 wt/vol
Maple	1:20 wt/vol
Grasses (5)	1:20 wt/vol
Ragweed	1:20 wt/vol
Weeds (6)	1:20 wt/vol
Alternaria	1:10 wt/vol
Hormodendrum	1:10 wt/vol
Mucor	1:10 wt/vol
Helminthosporium	1:10 wt/vol
Hog hair-dander	1:10 wt/vol
Penicillium (4)	1:10 wt/vol
Pork (meat)	1:10 wt/vol
Cereal dust	1:10 wt/vol
Aspergillus fumigatus	1:10 wt/vol

[a] In a 50 % glycerine solution.
[b] Antigens from Hollister-Stier (Miles Laboratories, Inc, Elkhart, Indiana, United States). Histamine and all other antigens were from Omega, Montreal, Canada.

Table 2. Characteristics of the study populations.

Group	Gender				Age (years)		Smoking history					
	Males		Females				Smokers		Ex-smokers		Nonsmokers	
	N	%	N	%	N	%	N	%	N	%	N	%
Dual environment farmers (N = 324)	258	79.6	66	20.4	42.4	[illegible]	83	19.4	134	56.3	77	23.8
Swine only farmers (N = 164)	132	80.5	32	19.5	36.3	[illegible]	36	22.0	83	50.6	45	27.4
Referents (N = 216)	154	71.3	62	28.7	38.7	[illegible]	75	34.7	78	36.1	63	29.2

consent form explained in detail all of the four aspects of the study and the study goals.

Ten milliliters of venous blood was drawn and kept at 4°C until the following morning when it was centrifuged. The sera were frozen at −70°C until analyzed for serum precipitins. The sera were tested for the presence of precipitating antibodies to *Saccharopolyspora rectivirgula*, formerly *Micropolyspora faeni* (22), and to five other antigens produced from microorganisms identified in the air of four Quebec swine buildings (13). These microorganisms were *Aspergillus* spp, *Enterobacter agglomerans*, *Mucor* spp, *Penicillium* spp, and *Scopulariopsis* spp. The analysis for precipitins was done by a modified double diffusion technique based on the method of Ouchterlony (23). The antigens were prepared from live cultures of the aforementioned microorganisms by the method described by Schuyler et al (24). Skin prick tests to 20 common aeroallergens and three hog antigens (table 1) were performed as previously described (25) all by the same nurse (GB). A test was considered valid if the histamine positive control reacted to a minimum of 2 mm and the glycerol negative control produced no measurable induration. A mean wheal diameter of ≥3 mm to any antigen was read as positive for that antigen.

The characteristics of our study population are presented in table 2. Significant differences between the groups included a higher prevalence of smokers and more females in the reference group. The occupations of the referents were varied, 170 were considered as having no significant environmental exposure (eg, health personnel, teachers, office workers, housewives). The other 46 subjects (including woodworkers, general mechanics, grain mill workers, etc) had some potential work-related exposure to different pollutants.

The number of subjects reported under each variable differs. The questionnaires were answered by all the subjects, reproducible forced expiratory maneuvers could not be obtained from 25 workers and seven referents, serum for precipitin analysis was not available from two swine workers, while skin prick tests were either not obtained or invalid for 58 workers and four referents. A large number of workers did not have the skin prick test because we had enrolled 55 of the subjects before we decided to include the skin tests.

A description of the exposure of the swine workers is provided in table 3. Most of these workers spent more than 1 h/d in the swine buildings. These subjects were long-term swine confinement building workers (71 % >10 years) and almost half had more than 500 pigs. As expected, the swine only workers spent more time in the swine buildings than those with dual work environments ($P<0.001$). The swine only workers also had more pigs, more often had both types of piggeries (farrowing and fattening), and had been in the business of raising pigs for a shorter period of time than the dual environment farmers.

The chi-square test was used to verify any association between gender or smoking status and group of subjects. The significance between the means of the pulmonary function tests was assessed by an analysis of covariance, adjustment being made for age, smoking status, gender, and height, while the significance of differences in the prevalence of chronic bronchitis was assessed by logistic regression, adjustment being made for gender and smoking status (26). All the treatment of the data was performed with an SAS (statistical analysis system) package (27).

Results

The results of the symptoms of chronic bronchitis and pulmonary functions in relation to a variety of variables are presented in tables 4, 5, 6, and 7. The swine building workers had a higher prevalence of chronic bronchitis and more evidence of airflow obstruction (lower $FEV_{1.0}$/FVC and MMFR) than the referents (table 4). Time spent daily in the swine confinement buildings significantly influenced symptoms and pulmonary functions; workers exposed for more than 3 h daily had more chronic bronchitis and airflow obstruction (table 5). The number of years spent in the swine raising industry did not influence these variables (table 5).

The skin prick tests revealed a higher prevalence of immediate type allergy to hog antigens, while positive reactions to other antigens were similar in all the groups (table 8). A positive skin prick test to common aeroallergen and parameters of airflow obstruction ($FEV_{1.0}$/FVC and MMFR) were not associated with a significantly lower $FEV_{1.0}$ (table 6). The prevalence

Table 3. Description of the exposure in of swine workers.

	Dual environment farmers		Swine only farmers		All Swine workers	
	N	%	N	%	N	%
Hours daily						
<1	43	13.3	3	1.8	46	9.4
1—3	157	48.4	47	28.7	204	41.8
>3—6	94	29.0	58	35.4	152	31.1
>6	30	9.3	56	34.1	86	17.6
Duration (years)						
<5	24	7.4	24	14.6	48	9.8
5—10	54	16.7	37	22.6	91	18.6
>10	246	75.9	103	62.8	349	71.5
Number of pigs						
<100	69	21.3	7	4.3	76	15.6
100—199	57	17.6	7	4.3	64	13.1
200—299	40	12.3	8	4.9	48	9.8
300—399	36	11.1	12	7.3	48	9.8
400—499	18	5.6	10	6.1	28	5.7
≥500	104	32.1	120	73.1	224	45.9
Types of piggerie						
Farrowing	127	39.2	54	32.9	181	37.1
Fattening	102	31.5	25	15.3	127	26.0
Both	95	29.3	85	51.8	180	36.9

Table 4. Prevalence of chronic bronchitis and the pulmonary function of the swine workers and the referents. (POR = prevalence odds ratio. FVC = forced vital capacity, $FEV_{1.0}$ = forced expiratory volume in 1 s, MMFR = maximal midexpiratory flow rate)

Group	Chronic bronchitis			Pulmonary function tests											
				FVC (l)			$FEV_{1.0}$ (l)			MMFR (l/s)			$FEV_{1.0}$/FVC		
	Prevalence (%)	POR	Adjusted POR	Mean	SEM	P-value	Mean	SEM	P-value	Mean	SEM	P-value	Mean	SEM	P-value
Referents	11.57	1.00	1.00	433	0.04		3.35	0.04		3.31	0.071		0 78	0.005	
						<0.01			0.78			0.03			<0.001
Swine workers	17.49	1.82	2.03[a]	4.46	0.03		3.36	0.02		3.12	0.05		0.75	0.003	

[a] 95 % confidence interval 1.22—3.38.

Table 5. Influence of exposure in terms of hours per day in the swine buildings and the number of years spent in the industry on the prevalence of chronic bronchitis and pulmonary function. (POR = prevalence odds ratio, FVC = forced vital capacity, $FEV_{1.0}$ = forced expiratory volume in 1 s, MMFR = maximal midexpiratory flow rate)

Exposure	Chronic bronchitis			Pulmonary function tests											
				FVC (l)			$FEV_{1.0}$ (l)			MMFR (l/s)			$FEV_{1.0}$/FVC		
	Prevalence (%)	POR	Adjusted POR	Mean	SEM	P-value	Mean	SEM	P-value	Mean	SEM	P-value	Mean	SEM	P-value
Daily (h/d)															
≤3	13.25	1.00	1.00	4.52	0.04		3.46	0.03		3.29	0.07		0.76	0.005	
						0.49			0.01			<0.01			<0.01
>3	21.94	1.84	1.73[a]	4.48	0.04		3.33	0.04		3.02	0.07		0.74	0.005	
Duration (years)															
<5	12.50	1.00	1.00	4.37	0.10		3.31	0.09		3.20	0.16		0.76	0.012	
5—10	17.58	1.49	1.95[b]	4.42	0.07	0.15	3.31	0.06	0.15	2.97	0.11	0.18	0.75	0.009	0.63
>10	18.16	1.55	1.77[c]	4.53	0.03		3.43	0.03		3.20	0.06		0.75	0.004	

[a] 95 % confidence interval 1.04—2.85.
[b] 95 % confidence interval 0.68—5.66.
[c] 95 % confidence interval 0.69—4.57.

Table 6. Prevalence of chronic bronchitis and the pulmonary function of swine workers who had no allergy or had positive skin prick tests to common aeroallergens or specific hog antigens. (See table 1.) (POR = prevalence odds ratio, FVC = forced vital capacity, $FEV_{1.0}$ = forced expiratory volume in 1 s, MMFR = maximal midexpiratory flow rate)

	Chronic bronchitis			Pulmonary function tests											
				FVC (l)			$FEV_{1.0}$ (l)			MMFR (l/s)			$FEV_{1.0}$/FVC		
	Prevalence (%)	POR	Adjusted POR	Mean	SEM	P-value	Mean	SEM	P-value	Mean	SEM	P-value	Mean	SEM	P-value
Common aeroallergens															
No allergy	18.08	1.00	1.00	4.54	0.04		3.44	0.03		3.18	0.06		0.75	0.004	
						0.07			0.10			0.45			0.91
Positive skin prick test	17.81	0.98	0.95[a]	4.43	0.05		3.35	0.04		3.11	0.08		0.75	0.006	
Hog antigens															
No allergy	19.12	1.00	1.00	4.51	0.03		3.41	0.03		3.14	0.05		0.75	0.004	
						0.75			0.81			0.45			0.33
Positive skin prick test	12.99	0.63	0.73[b]	4.48	0.07		3.42	0.06		3.23	0.11		0.76	0.008	

[a] 95 % confidence interval 0.55—1.65.
[b] 95 % confidence interval 0.35—1.52.

of chronic bronchitis was also not associated with positive skin tests. Allergy to specific swine allergens was not a contributing variable (table 6). The type of piggery (farrowing, fattening, or both) and the type of feeding (dry versus wet) did not influence these results (data not shown).

Comparing for the variable double exposure (dairy cattle-swine), we found no differences between the two

Table 7. Prevalence of chronic bronchitis and the pulmonary function of the swine workers who had contact with swine confinement buildings only (swine only farmers) and those who had exposure to both swine buildings and dairy barns (dual environment farmers). (POR = prevalence odds ratio. FVC = forced vital capacity. $FEV_{1.0}$ = forced expiratory volume in 1 s. MMFR = maximal midexpiratory flow rate)

Group	Chronic bronchitis			Pulmonary function tests											
				FVC (l)			$FEV_{1.0}$ (l)			MMFR (l/s)			$FEV_{1.0}$/FVC		
	Prevalence (%)	POR	Adjusted POR	Mean	SEM	P-value	Mean	SEM	P-value	Mean	SEM	P-value	Mean	SEM	P-value
Swine only farmers	20.25	1.00	1.00	4.48	0.05		3.37	0.04		3.14	0.08		0.75	0.006	
						0.80			0.38			0.81			0.82
Dual environment farmers	16.10	0.76	0.76[a]	4.51	0.03		3.41	0.03		3.17	0.06		0.75	0.004	

[a] 95 % confidence interval 0.46—1.25.

subgroups (table 7). The only clinical difference between these two groups of farmers was that a history of farmer's lung was only reported for five workers exposed to both building environments.

Eight farmers with dual exposure had precipitating antibodies to *S rectivirgula*. Only one of the swine only workers had antibodies to this antigen, while none were determined for the referents. One subject had precipitins to *Aspergillus* sp; he was in the dual environment group. There were eight positive reactions to *E agglomerans* (three dual environment farmers, two swine only workers, and three referents). No precipitins were identified against *Mucor* sp, *Penicillium* sp, or *Scopulariopsis sp*.

Table 8. Results of skin prick tests given as the percentage of the subjects with a positive skin reaction to one or more antigen. There were no differences between the groups for the common aeroallergens (P = 0.56); however, the swine workers had more positive reactions to hog antigens than the referents. (P = 0.007).

Group	Common aeroallergens	Hog antigens
Swine workers	35.0	18.4
Dual environment	35.2	20.2
Swine only	34.4	14.5
Referents	30.7	9.9

Discussion

The present study supports the results of authors who have shown a moderate increase in respiratory abnormalities in swine confinement building workers (5). We found more abnormalities than some researchers (6, 7) but less than what was reported by Donham et al (9). These differences between studies can be explained by the differences in design, differences in contact (ie, types of piggeries, number of hogs, duration of daily contact, etc), and differences in climatic conditions between countries where the studies were performed.

Some of the previous studies had not compared swine workers with referents (5); others used nonhog farmers as referents (2, 8, 9, 12). In view of the potential health problems related to, for example, dairy farming (10), such referents may be questionable.

In this study we did not select a sample of swine confinement building workers, but solicited all workers from a predefined geographic region (three rural counties south of Quebec City). We had an excellent participation rate of 88 %. The number of solicited subjects who participated was higher for the swine workers than for the referents. This difference is understandable since swine workers were the target population and had personal interests in the study. If some of the referents who participated were also influenced by personal interest (ie, subjects who suspected they may have pulmonary disease), it is possible that we underestimated the health impact of swine building exposure. Against this possibility is the fact that the prevalence of respiratory symptoms and functional impairments of our referents were as previously reported for "normal" populations (28). Since there were more smokers among the referents than the farmers, we corrected for this variable in the analysis.

The paucity of precipitins for workers who raised pigs only is somewhat surprising. Only farmers with dual contact, cattle and hogs, had significant levels of precipitins. However, swine only workers are exposed to large quantities of microorganisms that are known to produce extrinsic allergic alveolitis (eg, *Penicillium* sp, *Aspergillus* sp). The antigens that we tested were obtained from the air of local piggeries and were the most predominant (13). Brouwer et al (5) found an increase in the level of IgG_4 against pig antigens, but they did not study antibodies to other environmental antigens. Matson et al (11) did not find IgG antibodies against antigens commonly associated with extrinsic allergic alveolitis. Bronchoalveolar lavages of asymptomatic swine workers do not show an increase in lymphocytes as has been described for dairy farmers (17, 18). These findings, the absence of a history of farmer's lung, and the lack of evidence of symptoms suggestive of extrinsic allergic alveolitis in the swine only workers suggest that such an entity is very

unlikely related to swine building contact. This result is consistent with those of previous reports (2, 17), but different from the results reported by Terho et al (29).

The presence of skin allergy in a swine building worker was not associated with a greater prevalence of respiratory symptoms or lower $FEV_{1.0}/FVC$. This finding is in opposition to the results of Vohlonen et al (19), who found a higher prevalence of chronic bronchitis for atopic subjects. These differences between our two studies could be explained by patient selection and data analysis. Vohlonen et al selected subjects with skin lesions, often eczema; we made no prior selection. Their population was therefore probably more atopic than ours, and it is possible that the increased risk is found only for this subset of subjects. Swine building exposure increases the prevalence of immediate type skin reaction to hog antigens, but not to other common aeroallergens, those with underlying allergies being more susceptible to the swine building environment.

Farmers who had dual exposure (hog and cattle) had a prevalence of chronic bronchitis and respiratory function abnormalities similar to that of the subjects who worked in swine buildings only; there does not seem therefore to be an added risk for this double exposure. We did not study dairy farmers only; previous studies of workers of that environment have however described respiratory abnormalities resembling those of swine confinement building workers (12, 30).

Acknowledgments

The authors are grateful to "L'Union des producteurs agricoles, section porc" for its excellent collaboration, to Ms C Ferland for her technical assistance, and to Ms S Tennina for her statistical support.

This study was financially supported by MRC Canada (MA72-92).

References

1. Donham KJ. Health effects from work in swine confinement buildings. Am J Ind Med 1990;17:17—25.
2. Donham K, Haglind P, Peterson Y, Rylander R, Belin L. Environmental and health studies of farm workers in Swedish swine confinement buildings. Br J Ind Med 1989;46:31—7.
3. Donham KJ, Rubino M, Thedell TD, Kammermeyer J. Potential health hazards to agricultural workers in swine confinement buildings. J Occup Med 1977;19:383—7.
4. Katila M-L, Mäntyjärvi RA, Ojanen TH. Sensitisation against environmental antigens and respiratory symptoms in swine workers. Br J Ind Med 1981;38:334—8.
5. Brouwer R, Biersteker K, Bongers P, Remijn B, Houthuijs D. Respiratory symptoms, lung function, and IgG4 levels against pig antigens in a sample of Dutch pig farmers. Am J Ind Med 1986;10:283—5.
6. Bongers P, Houthuijs D, Remijn B, Brouwer R, Biersteker K. Lung function and respiratory symptoms in pig farmers. Br J Ind Med 1987;44:819—23.
7. Dosman JA, Graham BL, Hall D, et al. Respiratory symptoms and alterations in pulmonary function tests in swine producers in Saskatchewan: results of a survey of farmers. J Occup Med 1988;30:715—20.
8. Holness DL, O'Blenis EL, Sass-Kortsak A, Pilger C, Nethercott JR. Respiratory effects and dust exposures in hog confinement farming. Am J Ind Med 1987;11: 571—80.
9. Donham KJ, Zavala DC, Merchant JA. Respiratory symptoms and lung function among workers in swine confinement buildings: a cross-sectional epidemiological study. Arch Environ Health 1984;39:96—101.
10. Malmberg P. Health effects of organic dust exposures in dairy farmers. Am J Ind Med 1990;17:7—15.
11. Matson SC, Swanson MC, Reed CE, Yunginger JW. IgE and IgG-immune mechanisms do not mediate occupation-related respiratory or systemic symptoms in hog farmers. J Allergy Clin Immunol 1983;72:299—304.
12. Barthel E, Krecklow K. Epidemiologische Querschnittsstudie zur Prävalenz von chronischer Bronchitis und Lungenfunktionsstörungen bei Schweinezüchtern und Melkern. Z Erkr Atmungsorgane 1989;172:143—9.
13. Cormier Y, Tremblay G, Mériaux A, Brochu G, Lavoie J. Airborne microbial contents in two types of swine confinement buildings in Quebec. Am Ind Hyg Assoc J 1990;51:304—9.
14. Clark S, Rylander R, Larsson L. Airborne bacteria, endotoxin and fungi in dust in poultry and swine confinement buildings. Am Ind Hyg Assoc J 1983;44:537—41.
15. Brouwer R, Heederik D, van Swieten P. IgG4 antibodies against pig-derived antigens. Am J Ind Med 1990;17: 96—8.
16. Donham KJ, Leininger JR. Animal studies of potential chronic lung disease of workers in swine confinement buildings. Am J Vet Res 1984; 45:926—31.
17. Pedersen B, Iversen M, Dahl R. Bronchoalveolar lavage of pig farmers. Am J Ind Med 1990;17:118—9.
18. Cormier Y, Bélanger J, Laviolette M. Persistent bronchoalveolar lymphocytosis in asymptomatic farmers. Am Rev Respir Dis 1986;133:843—7.
19. Vohlonen I, Terho EO, Horsmanheimo M, Heinonen OP, Husman K. Prevalence of chronic bronchitis in farmers according to smoking and atopic skin sensitization. Eur J Respir Dis 1987;71(suppl 152):175—80.
20. Ferris BG. Epidemiology standardization project: II. recommended respiratory disease questionnaires for use with adults and children in epidemiological research. Am Rev Respir Dis 1978;118:7—53.
21. Gardner RM, Baker CD, Broennle AM Jr, et al. ATS statement: Snowbird workshop on standardization of spirometry. Am Rev Respir Dis 1979; 119:831—8.
22. Korn-Wendisch F, Kempf A, Grund E, Kroppenstedt RM, Kutzner HJ. Transfer of *Faenia rectivirgula* Kurup and Agre 1983 to the genus *Saccharopolyspora* Lacey and Goodfellow 1975, elevation of *Saccharopolyspora hirsuta* subsp *taberi* Labeda 1987 to species level, and emended description of the genus *Saccharopolyspora*. Int J Syst Bacteriol 1989;39:430—41.
23. Ouchterlony O. Antigen-antibody reactions in gels. Acta Pathol Microbiol Scand 1953;32:231.
24. Schuyler M, Schmitt D, Steinberg D. Hypersensitivity pneumonitis in strain II guinea pigs: I. histologic features. Int Arch Allergy Appl Immunol 1982;68:108—11.
25. Pepys J. Skin testing. Br J Hosp Med 1975;14:412—7.
26. Kleinbaum DG, Kupper LL. Applied regression analysis and other multivariable methods. North Scituate, MA: Duxbury Press, 1978.
27. SAS Institute Inc. SAS® user's guide: statistics, version 5 edition. Cary, NC: SAS Institute Inc. 1985.
28. Manfreda J, Nelson N, Cherniack RM. Prevalence of respiratory abnormalities in a rural and an urban community. Am Rev Respir Dis 1978;117:215—26.
29. Terho EO, Tupi K, Vohlonen I, Husman K. Serum precipitins against microbes in mouldy hay with respect to the geographical location of the farm and to the work

of farmers. Eur J Respir Dis 1987;71(suppl 152):128—38.
30. Vohlonen I, Tupi K, Terho EO, Husman K. Prevalence and incidence of chronic bronchitis and farmer's lung with respect to the geographical location of the farm and to the work of farmers. Eur J Respir Dis 1987;71(suppl 152):37—46.

Received for publication: 29 October 1990