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Health Effects From Work in Swine Confinement Buildings

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A total of 14 epidemiologic studies from four countries, involving 2,786 workers is reviewed for respiratory symptoms, pulmonary function, antibodies to swine house allergens, and exposure-response variables. Cough and phlegm were the most common symptoms (ranging from 12 to 55%). Tightness of chest and wheezing were frequently reported (12 to 33%) as well as episodes of organic dust toxic syndrome. Acute symptoms, directly associated with work, were from 1.5 to 2 times more prevalent than chronic symptoms. Baseline pulmonary function generally revealed decrements in flow rates, but not volumes; over-shift changes showed small decrements in both flows and volumes. IgG antibodies to swine house antigens were common; no relation to symptoms could be found. Exposure response studies were limited, but relationships were seen between endotoxin and pulmonary function decrements, or respiratory symptoms.

Key words: swine confinement buildings, chronic bronchitis, pulmonary function, agricultural dusts, ODTS

INTRODUCTION AND BACKGROUND

During recent years, research reports from several countries have described health problems for persons working in swine buildings. This paper will review and summarize the data from these reports, focusing on symptoms and pulmonary function studies and comparing these parameters to those of workers exposed to agricultural dusts in various processes.

Agents

The agents within the air of swine confinement buildings include gases [Attwood et al., 1987] as well as aerosols [Donham et al., 1985; Donham et al., 1986]. The most dramatic effect of any agent within livestock confinement buildings is that of the acute poisoning from hydrogen sulfide gas [Donham et al., 1985; Donham et al., 1982]. For buildings with liquid manure stored under the building, occasional sudden exposures to high levels of hydrogen sulfide may result in fatal acute poisonings or pulmonary edema when the manure is agitated. The storage of liquid

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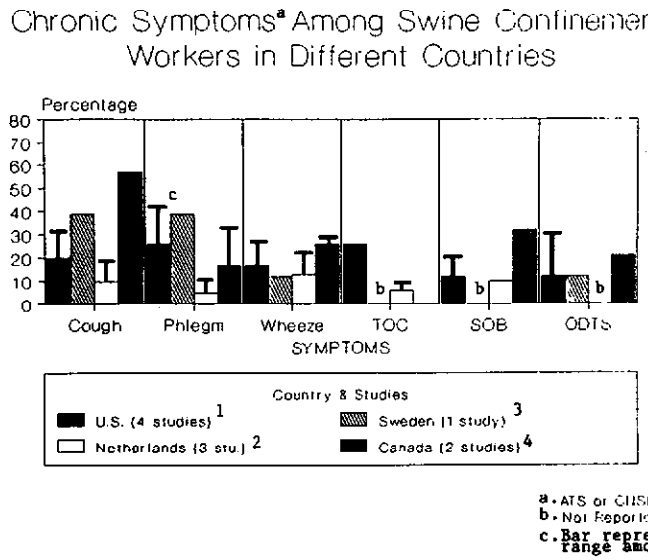

Fig. 1. Chronic symptoms among swine confinement workers in different countries. TOC, tightness of chest; SOB, shortness of breath; ODTS, organic dust toxic syndrome.

manure under the building is being phased out on farms in Western Europe but is still fairly common in North America.

In comparison to hydrogen sulfide, chronic exposure to aerosols is much more prevalent, occurring in almost all types of swine buildings around the world [Donham et al., 1986]. This aerosol is a very complex mixture of substances, containing components of both plant and animal origin, as well as microbial constituents and microbial metabolites [Donham, 1986].

Symptoms

This review is based on 14 different epidemiological studies of swine confinement workers. Ten of these studies also included pulmonary function testing. Approximately 2,786 people were studied in these 14 reports. Most of the questionnaires used to assess symptoms were based either on the British Medical Research Council questionnaire, the American Thoracic Society questionnaire, or similar questionnaires. Most of the studies assessed chronic symptoms. Only a few of the studies assessed acute symptoms related to the workplace exposure.

Figure 1 compares the major chronic respiratory symptoms among swine confinement workers in different countries. The countries compared included the U.S. [Donham et al., 1977; Donham et al., 1982; Donham et al., 1984a; Donham et al., 1986], the Netherlands [Brouwer et al., 1986; Bongers et al., 1987; Heederik et al., 1988], Sweden [Donham et al., 1986; Donham, 1986, Haglind and Rylander 1987], and Canada [Holness et al., 1987; Dosman et al., 1988].

The prevalence of symptoms in the swine worker populations was from two to four times that in the comparison populations. Cough and phlegm were the two most prevalent symptoms with cough ranging from 15 to about 55% and phlegm from 12

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TABLE I. Differences Between Prevalence (%) of Acute and Chronic Symptoms in Swine Confinement Buildings as Reported in 14 Epidemiologic Studies

Symptoms	Chronic	Acute
Cough		
U.S. and Sweden	20–39	38–74
The Netherlands	10–16	18
Phlegm		
U.S. and Sweden	16–58	24–64
The Netherlands	5–12	6
Wheeze		
Tightness of chest		
U.S. and Sweden	12–38	20–55
The Netherlands	10–22	8

to about 55% in the population. The extent of symptoms cough and phlegm were comparable in the U.S., Sweden, and Canada. In the Netherlands, they were about 50% less prevalent compared to other countries. However, the prevalence of wheezing and tightness of chest in the Netherlands was more similar to the other three countries, ranging between 12 and 33%. Distribution of the shortness of breath symptom was similar to that of tightness of chest. Organic dust toxic syndrome (ODTS) was studied in the U.S., Canada, and Sweden and the figures were reasonably comparable, ranging from 10 to 30%.

Acute symptoms, defined as those which the worker directly associated with the working environment, were studied in the U.S., Sweden, and the Netherlands. Table I compares the prevalence of chronic and acute symptoms in these studies.

Workers in the U.S. and Sweden had a similar prevalence of acute cough (38–75%), which was about twice as prevalent as chronic cough. Workers in the Netherlands reported little difference between acute cough (18%) and chronic cough (10–16%).

The prevalence of the acute symptoms of wheeze and tightness of chest was 20–55%, or approximately one and one-half to two times that seen for the chronic symptoms. However, in the Netherlands, the prevalence of these acute symptoms was comparable to the chronic symptoms.

In evaluating the symptomatology, it can be postulated that the symptoms described are a result of airways inflammation, manifesting itself in bronchitis. Bronchitic symptoms are a very common finding among swine workers, particularly in the U.S. and Sweden. Acute bronchitis is more prevalent than chronic bronchitis. The symptoms of wheeze and tightness of chest are suggestive of an occupational asthma. This seems to be a more proportionally important condition among the swine workers in the Netherlands rather than bronchitis.

Pulmonary Function Testing

Pulmonary function testing has been reported in ten studies of swine confinement workers. Nine of these studies included baseline pulmonary function testing (Table II). The mean forced vital capacity (FVC) for these swine workers in all countries studied were within normal limits when compared to standard nonfarm urban control populations. Studies in the Netherlands revealed apparent decrements in

TABLE II. Baseline Pulmonary Function Test Among Swine Confinement Workers: Percent Predicted Values*

	n	FVC	FEV	FEV/FVC × 100	Flows
U.S.					
Donham et al., 1984	24	102	109	79	112
Donham et al., 1988	198	108	108	81	80
controls (unpublished)					
Sweden					
Haglind et al., 1987		95	92	—	—
Donham et al., 1989		92	100	78	60
Canada					
Holness et al., 1987	5	98	95	97	64
controls	?	95	94	99	72
Dosman et al., 1988	50	97	96	98	87
controls	?	107	104	97	90

*n, number of persons; —, measurements not done.

the forced expiratory volume in 1 second (FEV_1), the FEV_1 to FVC ratio, and flow rates. There were also apparent decrements in FEV_1/FVC and flow rates in studies from Sweden and the U.S., although the FEV_1 was not decreased. This picture of decrements in the ratios and in the flow rates suggest a pattern of obstructive disease.

In three studies, work period shifts in pulmonary function were examined [Donham et al., 1984b, 1989; Haglind et al., 1987]. In all of these studies, 318 farmers were investigated. The decrements in FVC ranged from 1.2 to 3.3% while those in FEV_1 ranged up to 6%. The FEV_1/FVC showed a decrement of 3%. However, the greatest change over the work shift was in the flow rates, such as FEF25-75 (4–12%). Statistically significant work shift changes in FEV_1 and flow rates were present in both Swedish and U.S. studies.

Two studies, one in Canada and one in the Netherlands [Dosman et al., 1988; Brouwer et al., 1986], calculated prevalence of lung dysfunction (defined as less than 80% of predicted value, or at least 1 standard deviation from the mean). The Canadian study showed that 14% of the swine workers had decrements in FVC.

Significant decrements in FEV_1 were also seen but were less notable. Twelve percent of the swine farmers in the Netherlands had significant decrements in FEV_1 and 20% had decrements in flow rates.

In summary, these pulmonary function studies showed minor decrements in flow volumes, as well as FEV_1/FVC and (in the Netherlands) FEV_1. The major change was in decrements in flow rates over the workshift. Although it is generally recognized that there is a problem with variability in measurement of flow rates, these parameters were consistently low in all workshift and baseline studies. Clinically significant decrements in individual workers were primarily seen in flow rates. These pulmonary function studies suggest that obstructive conditions were present.

Allergy Studies of Swine Confinement Workers

There have been seven different studies (summarized in Table III) that assess allergic conditions in swine confinement workers. Five of these studies showed evidence of increased IgG antibodies to antigens that were isolated from the environment including both animal allergens and mold spores. Two of the studies showed

TABLE III. Allergy

Katila et al., 1981
Harries and Cromwel
Matson et al., 1983
Donham et al., 1985
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TABLE III. Allergy Studies of Swine Confinement Workers: Skin Prick Test (SPT)*

	IgG	IgE	SPT	Other	Controls	Disease relation
Katila et al., 1981	+	neg	NR	NR	+	None
Harries and Cromwell, 1982				challenge	NR	Asthma
Matson et al., 1983	+	+	+	NR	+	None
Donham et al., 1985	+	NR	NR	NR	+	None
Brouwer et al., 1986	+	+	NR	NR	NR	Hrs/week
Heederik and Brouwer 1988 (unpublished)	+	NR	NR	NR	NR	None
Donham, 1988 (unpublished)	NR	NR	+	NR	+	None

*+, increased levels; NR, not reported.

an IgE response. Skin prick testing was done in two studies, and in one study a challenge test was done. However, only four of these studies included a control population.

The results of these immunologic studies showed that IgG antibodies to environmental allergens were frequently seen. IgE antibodies responses were less common than IgG. In the studies with controls, no difference in antibody levels between swine workers and controls were found. No relationship was found in the one study that examined the relationship between the presence of antibodies to environmental allergens and symptoms. However, in one of the Dutch studies [Brouwer et al., 1986], a relationship was seen between IgE antibodies and hours worked per week in the swine building. In the studies where skin prick testing was done, there was no relationship to a disease condition. One case study in the United States showed that a challenge of pig urine resulted in development of asthma in one patient. No other challenge studies could be found in the literature.

In summary, a relationship between antibody or skin test response to disease was not seen in any of these studies. The antibody appears to be more indicative of exposure but not related to disease or symptoms.

It is apparent that classical Type I or Type 3 mediated illnesses are only a minor part of the disease picture in the healthy working population of swine confinement workers.

Exposure Response Studies in Swine Confinement Buildings

Five studies have attempted to investigate relationships between environmental exposures and symptoms or pulmonary function in swine confinement workers. Three of these studies were done in United States, one in Sweden, and two in the Netherlands. Smoking and total exposure time showed the most consistent relationship to symptomatology, as well as pulmonary dysfunction.

Regarding the relation of symptoms to smoking, studies by Matson [1983] and Donham et al., [1982; 1986] point out that there is a relative risk of from 1.5 to 2 for coughing and wheezing for those confinement workers who smoke. However, no increased risk for workers who smoke could be found regarding phlegm, shortness of breath, and work absence.

Table IV summarizes the effects of smoking on pulmonary function testing. Regarding baseline pulmonary function, smokers generally have lower values for

TABLE IV. Effects of Smoking on Pulmonary Function Test (PFT) in Studies of Swine Confinement Workers a,b*

Baseline	Nonsmokers compared to smokers %
FVC	0 to 7% lower
FEV_1	4% to 20% lower
Flows	5% lower
Workshift decline	**Relative risk**
FVC	1–2
FEV_1	1–2
Flows	1.5–2

*a, Matson, 1983; b, Donham and Gustafsson, 1982; Donham, 1986.

FVC (0–7%). FEV_1 was 4% to 20% lower compared to nonsmokers. The decrements in flow rates were approximately 5% lower in smokers as compared to nonsmokers.

In examining workshift decline in pulmonary function to smoking, workers who smoke had from one to two times greater workshift decrement in FVC compared to nonsmokers. This same decrement was seen also in FEV_1, as well as in the flow rates. Exposure-response studies also included endotoxin, dust, ammonia, and microbes.

Endotoxin showed the strongest and most consistent relationship to symptoms of organic dust toxic syndrome (ODTS) and work period PFT decrements. A slightly stronger relationship was seen between dust and bronchitic symptoms (cough and phlegm), but a weaker relationship to tightness of chest and febrile syndromes. There was no relationship of dust to pulmonary function changes. Ammonia did show some relationship to baseline pulmonary function decrements in two different studies. In one of the studies, the levels of microbes showed a significant relationship to symptoms of occupational asthma.

GENERAL EVALUATIONS

These studies reviewed have involved different methods, and assessment of symptoms and pulmonary functions are sometimes difficult to compare from one study to another. Of the fourteen studies, only seven included comparison (control) populations, and in one instance the comparison population was extremely small. The following conclusions are made with recognition of the current limitations of the data.

The various symptoms seen in swine confinement workers can be grouped and then classified according to a probable disease condition. Some of the most apparent generalizations that can be made include: 1) symptoms of upper and lower airways inflammation are common, manifesting themselves as bronchitis (cough and phlegm); 2) inflammation of upper airways manifesting itself as rhinitis, pharyngitis, and sinusitis; and 3) symptoms of airway hyperreactivity are less common.

Generalized symptoms were also present in swine workers. Episodes of delayed onset of fever, malaise, muscle aches, and headaches (symptoms of ODTS) were commonly reported [Malmberg et al., 1985]. Other symptoms are fatigue, chronic muscle aches and pains.

Table V summarizes and groups symptoms reported by swine confinement workers. When considered this way, there is suggestive evidence that several con-

TABLE V. Summary of Symptoms Reported by Swine Confinement Workers and Suggested Disease Conditions

Symptoms	Suggested conditions
Cough Phlegm Tightness of chest	Airway inflammation or bronchitis
Tightness of chest Shortness of breath Wheeze	Occupational asthma or hyperreactive airway disease
Acute episodes of fever Malaise, muscle and joint pain, headache, fatique	Organic dust toxic syndrome
Chronic fatique, muscle and joint pains, shortness of breath	Chronic inflammation
Irritation of throat, eyes, and nose	Mucous membrane irritation
Dizziness, "popping" ears, continuous or frequent colds, stuffy nose	Mucous membrane inflammation
Chest tightness on return to work	Byssinosis-like reaction

ditions may be ascribed to swine confinement building exposure. Several of the conditions may occur simultaneously in the same workers.

As pulmonary function testing often demonstrates marginal decreases (in mean values), symptoms may be a better parameter to study populations for respiratory disease relative to their working environment. In future studies it is thus a need to use a standardized questionnaire that assesses the types of symptoms seen after organic dust exposures. It is also necessary that representative control populations be included in future studies.

Perspective to Other Agricultural Dusts

Swine confinement work is but one example of the agricultural processes resulting in agricultural dust exposure. It is apparent that there are similarities in confinement workers' illnesses and illnesses among persons exposed to other agricultural and other vegetable dust exposures [Schlenker et al., 1985; Pratt and May, 1984]. The resulting disease conditions may depend on the type of exposures, i.e., chronic exposure and/or an acute agricultural dust exposure.

In chronic exposure, the workers complain primarily of symptoms suggestive of chronic airways inflammation including bronchitis and reactive airways disease. Commonly reported also are symptoms of chronic muscle aches, fatigue, and dyspnea.

There are processes resulting in acute agricultural dust exposures, characterized by dust levels from 5–20 mg/m^3, endotoxin from 0.3 to 2 μg/m^3, and microbes from 10^7 to 10^{10} per m^3. The effects that results from this exposure are acute attacks of ODTS and/or occasionally perhaps hypersensitivity pneumonitis. The symptoms of airways obstruction and bronchitis are not the primary feature of these types of exposures but possibly result from multiple acute exposures.

The swine confinement environments may be looked on as a model for generic

agricultural dust exposures. The exposure is both of a chronic nature and with episodic acute exposures during certain activities, such as moving and sorting animals, and sweeping and cleaning in dusty and moldy places. A detailed study of swine confinement workers could represent a study of the full range of potential health effects of agricultural dusts.

REFERENCES

Attwood P, Brouwer R, Ruigewaard P, Versloot P, deWit R, Heederik D, Boleij JSM (1987): A study of the relationship between airborne contaminants and environmental factors in Dutch swine confinement buildings. Am Ind Hyg Assoc J 48:745–751.

Bongers P, Houthwijs D, Remijn B, Brouwer R, Biersteker K (1987): Lung function and respiratory symptoms in pig farmers. Br J Ind Med 44:819–823.

Brouwer R, Biersteker K, Bongers P, Remijn B, Houthuijs D (1986): Respiratory symptoms, lung function and IgG_4 levels against pig antigens in a sample of Dutch pig farmers. Am J Ind Med 10;283–285.

Brouwer R, Heederik D, Baleij J, Brunekneff B, Biersteker K (1988): Determinants of airborne contaminant levels in pig farms (unpublished).

Donham KJ, Rubino MJ, Thedell TD, Kammermeyer J (1977): Potential health hazards of workers in swine confinement buildings. J Occup Med 19:383–387.

Donham KJ, Gustafsson KE (1982): Human health hazards in livestock confinement. Ann Am Conf Governmental Ind Hygienists 2:137–142.

Donham KJ, Knapp LW, Monson R (1982): Acute toxic exposures to gases from liquid manure. J Occup Med 24:142–145.

Donham KJ, Zavala D, Merchant J (1984a): Acute effects of the work environment on pulmonary functions of swine confinement workers. Am J Ind Med 5:367–375.

Donham KJ, Zavala D, Merchant J (1984a): Respiratory symptoms and lung function among workers in swine confinement buildings: A cross-sectional epidemiological study. Arch Environ Health 39: 96–100.

Donham KJ, Popendorf WJ (1985): Ambient levels of selected gases inside swine confinement buildings. Am Ind Hyg Assoc J 46:658–660.

Donham KJ, Yeggy J, Dague R (1985): Chemical and physical parameters of liquid manure from swine confinement facilities: Health implications for workers, swine and environment. Agricultural Wastes 14:97–113.

Donham KJ (1986): Hazardous agents in agricultural dusts and methods of evaluation. Am J Ind Med 10:205–220.

Donham KJ, Haglind P, Peterson Y, Rylander R, Belin L (1986): Environmental and health studies in swine confinement buildings. Am J Ind Med 10:289–294.

Donham KJ, Haglind P, Peterson Y, Rylander R, Belin L (1989): Environmental and health studies of farm workers in Swedish confinement buildings. Br J Ind Med 46:31–37.

Dosman JA, Grahm BL, Hall D, Pahwa P, McDuffice H, Lucewicz M, To T (1988): Respiratory symptoms and alterations in pulmonary function tests in swine producers in Saskatchewan: Results of a survey of farmers. J Occup Med 30:715–720.

Haglind P, Rylander R (1987): Occupational exposure and lung function measurements among workers in swine confinement buildings. J Occup Med 29:904–907.

Harries MG, Cromwell O (1982): Occupational allergy caused by allergy to pig's urine. Br Med J 284:867.

Heederik D, Brouwer R (1988): Symptoms 1988 (unpublished)

Holness DL, O'Glenis EL, Sass-Kortsak A, Pilger C, Nethercott J (1987): Respiratory effects and dust exposures in hog confinement farming. Am J Ind Med 11:571–580.

Katila M, Mäntyjärvi RA, Ojanen T (1981): Sensitization against environmental antigens and respiratory symptoms in swine workers. Br J Ind Med 38:334–338.

Malmberg P, Rask-Anderson A, Palmgren U, Höglund S (1985): Exposure to microorganism, febrile: airway obstructive symptoms, immune status and lung function of Swedish farmers. Scand J Work Env Health 11:287–293.

Matson SC, Swanson
mediate occu
Immunol 72:2
Pratt D, May JJ (198
Preuschen G (1974):
Symposium A
Agricultural E
Schlenker H, Leonar
symptoms amo
Wilhelmsson J, Bryn
producers. An

Matson SC, Swanson MC, Reed CE, Yunginger JW (1983): IgE and IgG-immune mechanisms do not mediate occupation-related respiratory or systemic symptoms in hog farmers. J Allergy Clin Immunol 72:299–304.

Pratt D, May JJ (1984): Feed-associated respiratory illness in farmers. Arch Env Hlth 39:43–48.

Preuschen G (1974): Air pollution and human work capacity. Proceedings of the International Livestock Symposium April 17–19, 1977, University of Nebraska, Lincoln, Nebraska, American Society of Agricultural Engineers, St. Joseph, Michigan, pp 195–198.

Schlenker H, Leonardson G, McClain C, Barnes E, Parry R (1985): The prevalence of respiratory symptoms among farmers and ranchers in southeastern South Dakota. S Dak J Med, July, pp 5–9.

Wilhelmsson J, Bryngelsson I-L, Ohlson C-G (1989): Respiratory symptoms among Swedish swine producers. Am J Ind Med 15:311–318.