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Effects of exposure to dust in swine confinement buildings—
a working group report

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Pulmonary and other symptoms among workers in swine confinement buildings were evaluated by an
international working group. In several studies in five different countries a total of about 2000 workers
has been studied in clinical and epidemiologic investigations. Symptoms indicative of acute and chronic
airway inflammation were widespread, as were systemic reactions of organic dust toxic syndrome. The
base-line, and across work shift, pulmonary function changes were moderate. There was no evidence that
antigen–antibody reactions are important in the pathogenesis. Longitudinal studies are recommended to
establish the relationship between acute and chronic symptoms and end stage disease.

Key terms: bronchitis, inflammation, organic dust, pulmonary function.

Recent research has shown that pulmonary disease and
certain systemic symptoms caused by organic dusts are
far more common among exposed workers than previ­
siously suspected (1). To the well-studied exposure
sources of cotton dust and moldy hay have been added
other environments (animal confinement buildings,
sewage treatment stations, wood processing, and in­
dustrial fermentation) in which symptoms are preva­

In occupational medicine, it is a common practice
to relate a disease to the occupation in which the clin­
cical symptoms were first observed, eg, farmer’s lung,
welder’s fever, and stone cutter’s disease. As the num­
ber of studies on occupational disease grows, this con­
ccept becomes more complex and, indeed, cumbersome.
When a farmer reports symptoms not typical of farm­
er’s lung as originally described, new terms such as
‘atypical’ or ‘acute’ farmer’s lung are invented. The
presence of similar symptoms in relation to other work
environments may be disregarded and not considered
appropriate for compensation, as they do not adhere
to the traditional textbook description and disease title.

A systematic evaluation of all the symptoms and
clinical findings related to a specific environment is
thus necessary to establish a rationale for diagnosis,
treatment, and compensation. This approach has previ­
ously been used to summarize information on the ex­
posure effects of cotton dust (2).

Organic dust exposure is also present in swine con­
finement buildings. The first studies on the health of
persons working in swine confinement buildings were
published in the United States (3) and Finland (4), fol­
lowed by several reports from the United States, The
Netherlands, Canada, and Sweden (5–17). A work­
ing group was assembled to summarize the symptom­
tology, clinical findings, and pathogenesis of the ex­
posure. A distinction was made between changes ap­
ppearing after acute exposure and those present after
prolonged exposure. Dose-response relationships for
different specific agents in the environment were dis­
cussed. Effects of toxic gases which also might be
present in this environment (eg, hydrogen sulfide and
ammonia) were not discussed. This paper presents a
summation of the working group’s findings.

Symptomatology

Respiratory symptoms

Airway symptoms are frequently reported by work­
ers in swine confinement buildings (5–17). Work­
related cough and phlegm are the two most prevalent
symptoms, the prevalence ranging from 15 to 55 %
and from 12 to 55 % of the exposed populations.
Wheezeing and chest tightness are also common, in 12
to 35 % of the exposed populations. In several of the
studies, symptoms were more than twice as common
as in the reference group (8, 13, 16, 18). In addition
shortness of breath was present in up to 20 % of the
workers (13, 16–18). Longer exposure periods were
related to the feeling of chest tightness.
Data from some studies suggest that younger workers with a short history in pig farming report only symptoms of irritation in the airways, whereas workers with a longer history report cough with phlegm (chronic bronchitis) and occupational asthma-like symptoms (11). This finding has been supported by the results of other studies (5, 6, 10, 16).

The respiratory symptoms may occur with varying exposure patterns. Some recent data suggest that in many persons cough, phlegm, and chest tightness appear during the first day after time off work. This finding is similar to the symptoms of cotton workers, and the finding may be relevant to an understanding of the pathogenesis of the illness. However, among swine workers, the periods off work are very irregular, and a systematic evaluation of these “Monday” symptoms is difficult.

Systemic and other symptoms
Episodes of a febrile illness with influenza-like symptoms, including malaise, muscle aches, joint pain, and fatigue, are experienced by 5 to 20% of swine confinement workers (5, 8, 13, 16—18). These symptoms are consistent with what has been described as the organic dust toxic syndrome (1). This syndrome is often reported 2 to 6 h after an unusually heavy exposure to a variety of organic dusts.

In addition, more persistent symptoms, including fatigue, muscle aches, and joint pain, are seen (8, 16). Clinical evidence of classical hypersensitivity pneumonitis has not yet been reported (3—17). This lack should not, however, be interpreted as an absence of risk. As the incidence of strictly defined allergic alveolitis is less than 1% in populations at risk (19), the chances of finding such cases in cohorts of the sizes studied are very small.

Irritation of the eyes, nose, and throat and a dry cough are commonly reported (5, 8). These symptoms suggest that this work environment causes a general inflammation of the mucous membrane. Another group of symptoms often reported includes stuffy nose, “popping” ears, continuous cold, headaches, and dizziness (8). These symptoms are also consistent with an inflammation in and swelling of the epithelium in the nasopharyngeal area.

One epidemiologic study suggests that the swine confinement environment might lower the resistance of the respiratory tract to infections (16). This study reported that 16% of the Swedish swine farmers studied had a previous history of pneumonia confirmed by a physician as compared to 6% of the reference group. In addition, frequent chest cold was reported by 53% of the workers as compared with 20% of the referents. This finding is consistent with 30% of the workers reporting that they have had to take time off from work as a result of respiratory illness, compared to 18% of the referents.

In support of this finding, one animal study has demonstrated that the swine environment can severely damage the respiratory epithelium (7).

Clinical and epidemiologic studies
Lung function — base-line changes
Pulmonary function studies have so far been performed on a total population of approximately 1000 farmers and pig farm workers in eleven independent studies in five countries (6, 8, 10, 11, 13—18, 20). Several of these population studies reported small mean decreases in the base-line lung function when compared with reference values; these differences remained after standardization for smoking (13, 15, 16, 18). Clinically significant lung function decrements have been found in 15—20% of the working population (11, 18). Most of these studies refer to measurements of forced vital capacity and the forced expiratory volume in 1 s. Flow-volume parameters were decreased in some studies (8, 16).

Dose-response relationships between lung function changes and exposure have been suggested in three studies (6, 10, 16). There is information suggesting a relation between base-line lung function and several exposure variables, like duration of exposure during the day or the years of employment (10). Such relations have also been found for certain exposure agents, eg, dust, ammonia and endotoxin (3).

Lung function — across shift changes
Changes in lung function across a workshift or workday have been reported in several studies (6, 15, 16). In all these studies the average decrease was small and seldom exceeded 5% of the base-line value (6, 8). As compared with base-line values, 15—20% of the population have clinically significant work-period decrements (16). There were indications of relationships between the workday change in lung function and exposure to endotoxin and ammonia. In one study (7), the work-period decrements were significantly related to endotoxin exposure.

No clear relations to total dust or respirable dust fractions have been reported.

Serology
Only a few studies have evaluated the relation of atopy to the development of symptoms and lung function changes (4, 16, 20, 21). The number of workers studied has usually been small, and appropriate reference groups have sometimes been lacking.

In a Dutch study (21), 13% of 130 pig farmers had elevated levels of immunoglobulin (Ig) E antibodies against storage mites, detected by the radioallergosorbent test. However, 70% of these farmers also had
an elevated IgE level against house dust mite (Dermatophagoides) allergens. No IgE antibodies were found against swine antigens; this finding is consistent with the results of a Finnish study (4). Another study showed no difference in precipitating antibodies to agents related to hypersensitivity and swine antigens and molds isolated from the swine environment (16).

In an unpublished Dutch study (Brouwer et al, personal communication) elevated levels of IgG4 antibodies were seen among subgroups of swine confinement workers involved in intensive forms of pig farming. Relationships were seen between respiratory complaints during, or shortly after work and the IgG4 levels in serum after adjustment for age, smoking, and endotoxin exposure. Another study reported elevated levels of IgG antibodies against swine antigens (4) in comparison with the levels of reference groups, but there were no correlations with respiratory symptoms. Matson et al (22) studied the occurrence of IgG and IgE antibodies. Some farmers had elevated levels of antibodies to swine antigens, but in none of the cases could the presence of elevated levels of antibodies be correlated with symptoms.

Pathogenesis
The question concerning a causative agent(s) for the symptoms and clinical findings presented in the preceding discussion has not been resolved. Several of the symptoms and pulmonary function deficits are closely related to bacterial endotoxins, but associations also exist between dust levels, ammonia, and other agents. Several potential toxic agents are present in the swine confinement environment (3), and it is at present impossible to exclude a possible role for these in addition to the ones presented in the preceding discussion.

In view of the imprecise documentation on causative agents, conclusions concerning the pathogenesis behind the observed symptoms and clinical changes remain uncertain. Several of the effects described can, however, be caused by acute or chronic inflammation of the airways. Many agents in the swine confinement environment, such as endotoxins, ammonia, and hydrogen sulfide, may induce inflammation causing swelling and edema of the epithelium or induce contraction of bronchial smooth muscle. Both events cause narrowing of the airway lumen. Experience also indicates that this inflammation may cause an increased bronchial reactivity to other inhaled agents, such as tobacco smoke. The combined effects of organic dust and tobacco smoke may occur in a synergistic manner and decrease defense mechanisms to inhaled microorganisms. This may be the reason for the increased frequency of upper respiratory infections observed in some studies. Inflammation may also develop in other contact surfaces, such as the epithelium in the nasal passages or in the eye, and cause subjective irritation.

The role of traditional immunologic mechanisms, particularly the type-III reaction (antigen-antibody reactions) remains obscure. In spite of efforts to characterize the immunologic responsiveness of the host (atopy) and the determination of antibodies against various antigens in the swine confinement building air, no clearcut relationships have been demonstrated. An increase in a specific subclass of antibodies may indicate the involvement of antibody-antigen reactions, but it may also simply reflect the exposure. General increases in antibody levels are also found after a general stimulation of the immune system through inflammatory and adjuvant agents, such as endotoxins.

Comments
Information on reported symptoms is important for attending physicians, occupational hygienists, engineers, managers, and the employees themselves. They must recognize that a series of local and general symptoms may be caused by exposure to the swine confinement environment. These symptoms are common in exposed groups, and the individual may suffer considerable discomfort and be forced to leave work. Although the symptomatology and clinical findings reported do not adhere to the criteria of traditional occupational lung diseases (asthma, hypersensitivity pneumonitis, pneumoconiosis), they should, nevertheless, be recognized as posing a health hazard, and action should be taken to decrease the risk of the workers.

The information on dose-response relationships and different agents for the development of symptoms and clinical findings is as yet limited. The most complete information available refers to endotoxin, for which dose-response relationships have been demonstrated for an acute decrease in the forced expiratory volume in 1 s over the workshift, and for cough, phlegm, wheezing, chest tightness, and fever as well. The importance of other agents, such as ammonia and other irritating gases, other microbial products (such as glucans and mycotoxins), and the particles themselves, needs to be investigated further.

For the purposes of long-term prevention, the relation between acute effects over the workshift and the risk for long-term effects needs to be evaluated. The only means with which to obtain such information is to perform longitudinal studies, in which persons starting work in swine confinement buildings are screened for airway reactivity, atopy, the presence of symptoms after an exposure period, and pulmonary function. These workers need to be followed on a regular basis. For those who leave their work in swine confinement buildings, the reasons, particularly if related to adverse pulmonary reaction, should be documented. Furthermore, dose-response relationships between irritating gases, other microbial products such as glucans, and the particles themselves need to be investigated further.
I. Rylander R, Peterson Y, Donham KJ, ed. Health effects of organic dusts in the farm environment: proceedings from an international workshop. Skokloster (Sweden): April, 1986. Am J Ind Med 1986;10:1-340.

2. Rylander R, Schilling RSF, Pickering CAC, Rooke GB, Dempsey AN, Jacobs RR. Effects of acute and chronic exposure to cotton dust: the Manchester criteria [Editorial]. Br J Ind Med 1987;44:577-9.

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. Donham KJ, Gustafsson KE. Human occupational hazards from swine confinement. Ann Am Conf Gov Ind Hyg 1982;2:137-42.

6. Donham KJ, Zavala DC, Merchant JA. Acute effects of the work environment on pulmonary functions of swine confinement workers. Am J Ind Med 1984;5:367-76.

7. Donham KJ, Leininger J. The use of laboratory animals to study potential chronic lung diseases in swine confinement workers. Am J Vet Res 1984;45:926-31.

8. 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;39:96-100.

9. Biersteker K, Willems H, Smid T. A postal survey of health and working conditions. In: Proceedings of the 9th international congress in agricultural medicine and rural health; vol 1. Christchurch (New Zealand): 10—14 September, 1984:1-7.

10. Bongers P, Houtheijns D, Remijn B, Brouwer R, Biersteker K. Lung function and respiratory symptoms in pig farmers. Br J Ind Med 1987;44:819-23.

11. Brouwer R. Prevalence, control and prevention of non-specific lung disorders among pig farmers in the Netherlands. In: Bruce JM, Sommer M, ed. Agriculture, environmental aspects of respiratory disease in intensive pig and poultry houses including the implication for human health. Bucksbum, Aberdeen (United Kingdom): Scottish Farm Building Investigation, 1987:133—42.

12. Willems H, Verlinden F, Biersteker K. Work and health of Dutch farmers [in Dutch]. Tijdschr Soc Gezondheid 1984;62:21—7. (English abstract.)

13. 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.

14. Haglind P, Rylander R, Clark CS. Respiratory function among workers in swine confinement buildings. In: Bernhard J, Gee L., Morgan KC, Stuart M, ed. Occupational lung disease. New York, NY: Brooks, Raven Press, 1984:228.

15. Haglind P, Rylander R. Occupational exposure and lung function measurements among workers in swine confinement buildings. J Occup Med 1987;29:904—7.

16. Donham KJ, 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.

17. Wilhelmsson J, Bryngelsson I-L, Ohlson C-G. Respiratory symptoms among Swedish swine producers. Am J Ind Med 1989;15:311—8.

18. 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. Am J Occup Med 1988;30:715—20.

19. Terho EO, Heinonen OP, Lammi S. Incidence of clinically confirmed farmer's lung disease in Finland. Am J Ind Med 1986;10:330.

20. Brouwer R, Biersteker K, Bongers P, Remijn B, Houtheijns 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.

21. Brouwer R, Heederik D, v Swieten P. IgG4 antibodies against pig-derived antigens. Am J Ind Med (in press).

22. 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.

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