Human Health Effects of Dust Exposure in Animal Confinement Buildings

M. Iversen, S. Kirychuk, H. Drost, L. Jacobson

Abstract

Work in swine and poultry units is associated with exposure to significant levels of organic dust and endotoxins with the highest concentrations found in poultry houses, whereas values found in dairy and in cattle farming are much lower. Corresponding to this is an excess of work-related respiratory symptoms in swine farmers. A dose-response relationship exists between symptoms and number of working hours. Longitudinal studies have demonstrated an accelerated decline of lung function in swine farmers large enough to cause clinically significant disease in some farmers. Because of the large number of people needed in swine farming and the long working hours, swine farming has emerged as the major respiratory problem in farming. Experimental studies indicate that exposure has to be lowered substantially to avoid acute effects and longitudinal studies demonstrate that loss of lung function occurs in non-smoking swine farmers without respiratory symptoms and that accelerated decline in lung function occurs below endotoxin concentrations in dust (100 ng/m³) proposed as a safe threshold.

Keywords: Dust, Animal housing, Human exposure, Lung disease.

Possible adverse human health effects due to dust exposure have received growing attention in the last decade and are today an area of major concern. This is reflected at international agricultural conferences where the topic has appeared and at international medical and occupational conferences where the topic now is regularly represented with a substantial number of abstracts and oral presentations.

The human health effects due to dust exposure are primarily respiratory because it is in the lungs that the dust interacts with the body. Researchers who are trying to evaluate (and in recent years solve) this problem have involved agricultural engineers and scientists, veterinarians, respiratory physicians, occupational physicians, epidemiologists, and immunologists. All these professions were represented at the International Symposium on Dust Control in Animal Production Facilities held in Aarhus, Denmark, in June 1999. This type of research has developed into and requires a truly multidisciplinary area of research.
Exposure

The respiratory problems are concerned mainly with the high levels of dust exposure in poultry and pig farming. In a European study in England, the Netherlands, Germany, and Denmark with stationary measurements in 256 animal buildings mean values for inhalable dust in cattle, pig, and poultry buildings were 0.38, 2.19, and 3.60 mg/m³, respectively, and endotoxin in inhalable dust was 14, 67, and 200 ng/m³, respectively (Takai, 1998, 1999; Seedorf, 1998).

Much has been learned about dust concentrations, generation and transport of dust, and the biological properties of dust in the last decade and the present state of knowledge is summarized in recent reports (Pedersen, 2000; Ellen, 2000). From a human health perspective dust exposure in pig farming is the most important because of the large number of workers needed in pig production and the increasing number of working hours inside enclosed buildings. Socioeconomic changes have resulted in fewer small family based farms and the development of pig farms with most of the working hours spent inside confinement buildings. This structural change has increased worker exposure and will continue to do so in the future and could have a major impact on the respiratory health of the agricultural workers.

The Problem from the Human Health Perspective

Several studies have demonstrated that working in pig confinement buildings is associated with symptoms of chronic bronchitis (cough and phlegm), asthma-like symptoms such as wheezing and shortness of breath during work, and with evidence of mild airways obstruction in cross-sectional studies. Some studies also show increased bronchial reactivity to irritants (Iversen, 1990; Zhou, 1991; Bessette, 1993). Most important, dust exposure does not seem to be associated with the development of emphysema as in smokers. Most studies have shown that work inside pig confinement buildings double or triple respiratory symptoms, and that there is a clear dose-response relationship with the number of working hours inside buildings (Radon et al., 2000). Also, it has been determined from several studies that the many respiratory symptoms are not caused by sensitization to pig proteins (Iversen, 1999) in spite of animal proteins being present in the airborne dust (Donham, 1986). This is fundamentally different from the problems encountered by workers in laboratories with rodents like mice and rats where persons frequently become sensitized and develop allergic asthma. The reason for the lack of sensitization to pig proteins is not known. The problem is mostly irritation of the airways with other possible disease mechanisms (allergic alveolitis, allergic asthma, Organic Dust Toxic Syndrome, emphysema, lung fibrosis) being either rare or of no significance. A general overview is given in (Iversen, 1999).

The Major Concern from the Human Health Perspective

The present concern are development of asthma in young people entering farming and the development of chronic airways obstruction in long-term workers in pig confinement buildings. The close association between asthma-like symptoms and dust exposure was reinforced in the largest study to date which includes 7,988 farmers in Denmark, United Kingdom, Germany, Switzerland, and Spain (Radon et al., 1999). From a large Danish prospective study on "Respiratory Health..."
in Young Danish Rurals" that consisted of 1.691 farming students and 407 controls (Omland, 1999) it was found that farming students at an early stage had slightly reduced lung function measured by FEV$_1$ (Forced Expiratory Volume in 1 s) and FVC (Forced Vital Capacity) and that this condition was associated with increased bronchial responsiveness to irritants. From the same study (Sigsgaard, 1999), the results from the first two years of follow-up examinations demonstrated that the development of asthma was related to the total dust exposure with a relative risk of 1.0 in the lowest quartile rising to 5.5 in the quartile with the highest dust exposure. Because of this dose-response relationship much effort has been put into studies which try to lower the dust exposure under a certain threshold so that symptoms will not appear. A study with respiratory protection by a two-strap disposable respirator (with a metal nose strap) in a pig confinement facility (Senthilselvan, 1999) demonstrated substantial worker protection against acute effects on lung function as measured by FEV$_1$/FVC, bronchial reactivity measured by metacholine test, and inflammatory reactions measured by neutrophile counts in peripheral blood. Mean shift changes in FEV$_1$ was 8.1% decline on non intervention days and 0.32% increase on intervention days. Similar results were obtained from the same group (Barber et al., 1999) where wearing a respirator was compared with the effects of lowering dust exposure by a canola oil spaying method. In accordance with previous results the oil spraying method was highly effective (90%) in reducing dust levels and the mean percent change in FEV$_1$ over the workday was significantly reduced by either wearing a mask or by the oil treatment dust control method.

**The Major Human Health Perspective in the Future**

It has been well documented that the major respiratory health problems of workers in animal confinement buildings with heavy dust exposure, especially for pig and poultry production, is airway inflammation caused by a non-allergic mechanism. This inflammation is associated with asthma-like work-related respiratory symptoms. The endotoxin content of the dust is probably the most important part of the dust for the inflammatory process (Rylander, 1989).

It has also been demonstrated that dust exposure is associated with an accelerated decline in FEV$_1$ in pig farmers (Iversen, 1994, 2000; Senthilselvan, 1997a; Vogelzang, 1998). The loss in FEV$_1$ approximately doubles in most farmers and will cause clinically significant disease in some farmers.

The acute reaction to dust exposures by animal production workers with its immediate development of symptoms and signs of inflammation, seems to be related to the long-term outcome (Schwartz, 1995; Kirychuk, 1998), a concept that was developed several years ago (Becklake, 1995) and which has also been found in the cotton industry (Glindmeyer, 1994; Christiani, 1994). The efficacy of acute reaction approach in showing the effects of intervention is best demonstrated by (Senthilselvan, 1997b). This study also indicates that dust and endotoxin concentrations must be very substantially lowered to abolish or significantly diminish acute inflammatory reactions in the airways.
Aims for the Future

The exposure to airborne dust in modern animal confinement buildings is still substantial (Takai, 1999) and in many cases above the levels of endotoxin where long-term deleterious effects have been demonstrated in longitudinal studies in swine farmers (Vogelzang, 1998). We know from longitudinal studies of dairy and swine farmers that swine farmers do have an accelerated decline in FEV₁, whereas dairy farmers do not (Iversen, 2000). We also know that exposure in present European dairy farmers is 10 to 15% of the exposure in swine farmers (Takai, 1999). The dust and endotoxin concentrations reported in these studies are below the values previously put forward as potential threshold values for workers in swine confinement units (2.5 mg/m³ total dust, 0.23 respirable dust, 100 ng/m³ Endotoxin, and 7 ppm ammonia, Reynolds, 1996; Donham, 1995) and recently proposed values as threshold g/m values in poultry houses (total dust 2.4 mg/m³, respirable dust 0.16 mg/m³, endotoxin 61 ng/m³) (Donham, 1999). The discrepancy between results from acute exposure studies and results from long term studies is still unresolved. One reason for these differences is the use of different populations of persons for the studies. Populations in some studies are selected after years of exposure in farming and others, mainly the persons used in acute experiments, are so-called naive subjects to this environment. It is important to note that the studies of Donham were done on farmers with years of experience. Another possible explanation is that the use of subjects naive to the working environment in acute exposure experiments is not appropriate because the reaction to long-term exposure might be different. Bronchoscopy studies of chronically exposed swine farmers show some but much lower level of inflammation in the airways than found in acute experiments with naive subjects (Pedersen, 1996). Long-term follow-up studies have shown that accelerated decline in lung function will occur at considerably lower endotoxin concentrations than 100 ng/m (Vogelzang, 1998) and that asymptomatic swine farmers will experience decline in lung function due to work (Iversen, 2000). The establishment of dust and endotoxin thresholds for exposure in animal confinement buildings should be the short-term goal for the good of the animal production industry.

Conclusion

Work in swine confinement units is associated with high dust exposure and the development of work-related respiratory symptoms and long-term decline in lung function, whereas work in cattle and dairy farming is associated with much lower dust exposure and is not associated with an accelerated decline in lung function.

Work in poultry houses causes even higher exposure to dust than work in swine houses, but because of the large number of persons in swine farming and the long working hours inside buildings this exposure has received most interest.

Safe Threshold Limit Values for dust and endotoxin in animal houses have yet to be established, because accelerated decline in lung function has been observed below values proposed as safe limits.

References


