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ASHCA/NIOSH CONFERENCE: PANEL PRESENTATION

Respiratory Issues in Beef and Pork Production: Recommendations From an Expert Panel

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ABSTRACT. This paper summarizes "Respiratory Issues in Confined Feeding Operations," a panel discussion at the Agricultural Safety and Health Council of America/National Institute for Occupational Safety and Health conference, "Be Safe, Be Profitable: Protecting Workers in Agriculture," Dallas/Fort Worth, Texas, January 27–28, 2010. Occupational exposure to confined animal feeding operations is associated with cough, wheezing, and shortness of breath. Published data shows that 20% to 40% of hog confinement workers experience such symptoms, although most are able to continue working in this industry. Endotoxin is one component of hog barn dust that is associated with respiratory disease in workers. Endotoxin levels on cattle feedlots can also be in the range linked with occupational lung disease. The cattle industry has not yet prepared guidance documents for producers, in part because much less is known about the prevalence of lung disease in its workers. However, the pork industry provides information for pork producers on reducing their respiratory health risks through a multifaceted approach, including the use of respirators. Some jobs cannot be done safely without respiratory protection, such as entering manure pits. It is less clear for other jobs when respirators should be worn. Use of respiratory protection should be considered but not mandated for all persons working in close proximity to livestock in dusty conditions. A respiratory protection program may also serve as a cost effective biosecurity measure to protect animals from human pathogens such as influenza virus. Proper design and management of barn ventilation systems is critical for maintaining temperature and humidity levels for optimal animal growth; as well as decreasing the level of gases and respirable dusts. The pork and the cattle industries support occupational health and safety; however, the governmental guidance and recommendations for such programs are limited for the agricultural industries as a whole. The industries should lead the way in the effort to improve respiratory protection for workers. Overall, a team approach that includes input from managers, workers, and veterinarians is important for the reduction of respiratory hazards on livestock farms.

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PURPOSE OF THIS REVIEW

The purpose of this review is to summarize occupational respiratory issues associated with beef and pork production and to express expert opinions about future needs for research and education. Panel members speak from the perspective of their research in this topic area as well as work experience in occupational health and safety in these industries. Publications discussed were chosen by the panel for their relevance. The panel members acknowledge that respiratory issues have also been associated with the dairy and poultry industry, but a review of that topic is beyond the scope of this discussion.

TRENDS AMONG EXPOSED POPULATIONS

Raising livestock in confined animal feeding operations has proven to be economically advantageous. The majority of hogs raised in the United States are housed in confinement barns. Also, almost all beef cattle slaughtered in the United States are fed to market weight in commercial feedlots. Concerns about respiratory health of agricultural workers raising hogs in confinement barns were initially voiced in the 1970s by Donham and colleagues.[1] Numerous studies have been published since that time looking at respiratory symptoms and lung function in persons who work in swine confinement barns providing the daily care of the animals.[2–7] It has been demonstrated that hog confinement barn workers are more likely to have respiratory symptoms than do nonfarming control subjects. Specifically, cough with or without production of phlegm, chest tightness, and wheeze are described as being more common in workers exposed to this environment. According to published studies, anywhere from 20% to 40% of workers report these respiratory disease symptoms. It has also been shown that veterinarians who work in hog confinement barns still commonly have respiratory symptoms and airway obstruction on pulmonary function testing.[8] Although many of these papers were published in the decades before modern barn ventilation design was implemented, investigators continue to describe the presence of lung disease symptoms in swine barn workers.[4,5,9] It is of note that most published studies available to this panel of authors that describe respiratory disease symptoms in swine confinement barn workers were done in colder regions of the world such as the Midwestern region of the United States, the prairie provinces of Canada, and Central Europe. In these locations, barn ventilation is different from that in climates where there is less need to conserve heat in winter for the comfort and well-being of the animals. However, no comparative studies have been done to date for the purpose of determining if hog barns in warmer climates have significantly different air quality than do those in colder climates.

RESEARCH ANALYSIS

The respiratory symptoms described above are consistent with the presence of airway disease. Lung function testing is another means of assessing workers' respiratory health. Evidence of airway obstruction, which is usually mild in nature, has been documented in hog confinement workers using spirometry.[6,10] Others have found restriction, potentially secondary to air trapping.[2] This is also usually mild. Serial spirometric measurements have revealed accelerated loss of lung function.[11] Methacholine challenge tests often reveal bronchial hyperresponsiveness in symptomatic individuals in some but not all studies.[10,12,13] It must be remembered that because persons with respiratory symptoms and abnormal lung function tend to leave industries involving physical labor, they may be lost to follow-up and not included in studies looking at the hog industry. This phenomenon is known as the healthy worker effect. A recently published

prospective study conducted in Canada revealed that those who gave up raising hogs were more likely to do so if they had lower lung function and had smaller herds.[14]

Even though the symptoms and signs of lung disease associated with working in hog confinement barns resemble those of asthma, current evidence suggests that this disorder has a different pathophysiology in most cases. It has been shown that the respiratory symptoms and airway obstruction very rarely occur secondary to allergy to porcine proteins.[15] There is often no response to medications typically prescribed for asthma, further providing evidence that this disorder occurs by different pathophysiologic mechanisms.[16–18] The disease process most likely represents a response of the innate immune system. Research has revealed that there is a partial immunologic tolerance to the exposures in this environment that develops over time.[19,20] The tolerance phenomenon has also been observed in a rat model of airway inflammation and hyperresponsiveness after swine barn exposure for 5 or 20 days.[21]

Investigators have searched for substances in the barn environment that cause the lung disease seen in workers. Hog barns are a complex environment in terms of dust and gases present in the air. Published studies indicate that endotoxin, total dust, respirable dust, and ammonia levels are associated with a cross-shift drop in lung function in swine confinement workers.[22] Several published papers describe use of certain chemical disinfectants (quaternary ammonium compounds and ammonia based compounds) as being a risk factor for respiratory disease in hog confinement workers.[23,24] It is possible that other substances known to be present, such as peptidoglycan, could play an important role in causing airway disease in this setting.[20] It has been suggested that barn cleanliness from a perspective of possible impact on respiratory health can be determined by visual inspection. However, one study suggested that cleanliness of barns as determined by visual inspection did not influence airway inflammation in normal volunteers who were acutely exposed to the hog barn environment and that even the cleanest barns produced measurable evidence of respiratory tract inflammation.[25]

Published information on cattle feedlot workers is limited at this point in time. We do know from a recently published study that mean dust levels on feedlots were 2.4 mg/m^3, a value comparable to levels reported from testing hog confinement barns, even though samples were collected in an open air environment.[26] Mean endotoxin values were 943 EU/m^3, levels that were comparable to values from analysis of samples collected inside some hog barns.

Use of respiratory protective equipment by workers is another approach to limiting exposure to substances in the air that may have a negative effect on respiratory health.[27] It has been demonstrated that use of a respiratory protection device can reduce endotoxin exposure by more than 90% and that it can also attenuate the inflammatory response in normal volunteers acutely exposed to the hog barn environment.[28,29] However, a recent study of the use of personal protective equipment by Midwestern farmers indicated that routine use of respirators in confinement housing is practiced by only 3% of respondents.[30] Similar findings have been reported from Brazil.[23]

RESPIRATORY PROTECTIVE EQUIPMENT

Use of respiratory protective equipment (RPE) by any CAFO workers is a complex matter. A few of the significant issues surrounding the use of RPE by concentrated animal feeding operation (CAFO) workers involve what level of protection is supplied by the varying types of RPE, when RPE should be employed, and what the legal implications of supplying RPE for the employers are. These are all factors that have been expressed to the authors by those who work within the industry as barriers to RPE use. These must be weighed when discussing the best way to provide respiratory protection to those working at a CAFO. However, given the developing body of literature we discussed earlier surrounding the potential health implications of airborne microorganisms and particles in and around the CAFO environment, which have no threshold limit values or permissible exposure

limits, the benefits of a voluntary respiratory protection program should be explored.

Industry- and task-specific regulations are in place to guide when and where respiratory protection is required. However, there are no industry-specific regulations for the agricultural industry; and thus when to provide respiratory protection must be determined on the basis of the job task. Some job tasks cannot be done safely without the proper respiratory protection, such as entering manure pits. It is often less clear for other job tasks when respirators should be worn. Once it is determined that a job requires respiratory protection, then a respirator must be used as defined under Occupational Safety and Health Administration's (OSHA's) Respiratory Protection standard.[31] This requires a comprehensive respiratory protection program that includes the determination of the appropriate level of RPE, fit testing, medical evaluation, and training of the worker on the operation and maintenance of the respirator. A number of daily agricultural activities may not fall into the category of a job task that would require RPE under OSHA guidelines. However, the potential exposures may be such that the employee or employer may wish for RPE to be utilized; one such example may be the particle and bioaerosol exposures associated with working within a hog barn.

The voluntary use of respiratory protection devices also fall under OSHA regulations.[31] The only exception is for dust masks, which should not be confused with disposable NIOSH-certified N95 filtering facepiece respirators as they appear similar.[31] Employers who allow the voluntary use of RPE then fall under Appendix D regulations for voluntary use.[31] The requirements for voluntary use are similar to those for required use, but not as restrictive.[32] These additional requirements coupled with concerns regarding opening themselves to both additional regulation and potential litigation may dissuade employers from offering this voluntary option.

Additionally, employers may consider the implementation of RPE for a dual purpose to also include maintaining the biosecurity of the facility and the health of the animals. If an employee were to come to work while ill with a zoonotic disease and this went undetected, that employee could serve as a vector for passing a respiratory borne infection to the animals that the employee is maintaining. RPE are intended to protect the wearer from airborne contaminants; however, they also reduce the amount of potentially infectious organisms released by the wearer in the same way that a surgical mask protects an operating field.[33] So, an approach to increase the use of RPE within the industry could be to advocate a voluntary respiratory protection program as an additional biosecurity feature to maintain the health of the herd. This could serve to further make a voluntary respiratory protection program more cost effective as it could serve to protect both human and animal health.

The level of protection supplied by commonly used RPE has been the cause of much discussion in recent years. Although the filtration capabilities of most RPE have not been questioned, the various measures for the amount of protection received by the worker have not been as consistent. Lee et al.[34] examined the workplace protection factor (WPF) afforded to farm workers. The WPF is the level of protection that a properly used, functioning, and worn RPE provides during work activities, while the assigned protection factor (APF) is the expected level of protection from a properly used, functioning, and worn RPE. The N95 filtering facepiece respirator has an APF of 10, so if a WPF is at or above 10 then the RPE is providing the expected or greater level of protection. Utilizing personal sampling systems Lee et al.[34] collected particle and bioaerosol samples from both inside and outside of N95 respirators. Their results showed great variability between the WPF and the APF. When exposed to culturable bacteria and fungal organisms the WPF was found to be lower than the APF (less than APF of 10) for several of the N95 filtering facepiece respirators evaluated. The WPF were influenced by particle size with N95 filtering facepiece respirators exposed to particles between 0.7 and 1 μm having a geometric mean WPF of 21 and particles between 5 and 10 μm having a geometric mean WPF of 270. Additionally, the WPF for exposure to microorganisms was found to be lower than and not as

protective as those for exposures to particles with over half of the calculated WPFs for microorganism exposures below the APF. This study concluded that the N95 filtering facepiece respirator with an APF of 10 may not be adequate to protect against microorganisms. In a number of laboratory studies, Coffey et al.[35–40] evaluated multiple types and brands of RPE utilizing the 5th percentile simulated workplace protection factor (SWPF) value, which is a protection measurement that utilizes filter penetration and face seal leakage on human subjects in a laboratory.[36] These studies have found a wide variability in the SWPF or estimated protection between the various types of RPE and within the various models of the same type of RPE.[35–40]. Although these and other studies do indicate that some RPE do not provide a consistent level of protection to the worker, all agree that the level of protection provided is far greater than that of no RPE.

Although the use of proper respiratory protection by workers is exposure and situation based, this should be considered for all employees working in proximity to animals, particularly in hog barns. Use of respirators is one way of reducing exposure to substances present in the air in the hog barn environment. It is the authors' opinion that a respiratory protection program, in addition to reducing human health effects, has the potential to serve as a cost-effective biosecurity measure to protect animals from microorganisms exhaled by workers, such as influenza virus.

THE PORK INDUSTRY RESPONSE TO RESPIRATORY HAZARDS

Research has identified occupational health and safety as an important issue for the pork industry. Through a legislative national Pork Checkoff, pork producers invest $0.40 for each $100 value of hogs sold. The National Pork Board has responsibility for Checkoff-funded research, promotion, and consumer information projects and for communicating with pork producers and the public. The Pork Checkoff funds national and state programs in advertising, consumer information, retail and foodservice marketing, export market promotion, production improvement, technology, swine health, pork safety, and environmental management.

Checkoff dollars are invested to address worker health and safety in a variety of ways, including support of academic research and industry outreach programs. Recent examples include documentation of Methicillin-resistant *Staphylococcus aureus* (MRSA) in U.S. swine and herdspersons[42] as well as prevalence of MRSA in retail meat (data not published) from the Universities of Iowa and Minnesota. Education-oriented projects have included an online health and safety program administered by the University of Iowa[43] (archived sessions are available to view) and a safety course for manure system management developed by North Carolina State University.[44] Specific to respiratory health and safety, Checkoff-funded projects have included a remote sensor system for gases emitted during manure agitation and a study of barriers to use of personal protective equipment (PPE) in swine barns (data not published). The Pork Checkoff also facilitates producer enrollment in occupational health and safety related studies.

The Pork Checkoff does not have specific recommendations on respirator use for pork producers because production conditions and worker exposures can vary greatly. Instead, focus has been on providing self-directed training resources, which enable pork producers to develop a respiratory health and safety program as they see fit. In most cases, pork producers are not required to comply with the Occupational Health and Safety Administration (OSHA) standards concerning respirator use. In general, the Pork Checkoff's safety resources consist of a well-rounded approach to safety; however, many producers choose to focus on the hazards that are thought to cause most pork industry injuries, including livestock handling. The Pork Checkoff encourages pork producers to implement a team approach to health and safety; input from farm managers, veterinarians, and workers is key to the reduction of respiratory hazards.

In 2005, the National Pork Board launched its Pork Production Safety System (PPSS), a comprehensive safety program developed

through a collaborative effort between the industry and academia, with a special focus on input from actively working safety directors.[45] The program includes materials designed to raise producers' and employees' awareness to workplace hazards and suggests ways to manage the risks. The PPSS includes a respiratory health and safety-training module. The complete program is available from the Pork Store and includes a template for the development of a pork production safety plan and resources for training employees on safety, including PowerPoint presentations, videos, and handbooks that are available in both Spanish and English.[45] The PPSS is also available as part of the Checkoff's Production Series DVD collection; the most recent version contains information on raising swine from farrow to finish, as well as ventilation management, biosecurity, worker health and safety, and other industry topics.[46] Ventilation management is especially important for respiratory health of both pigs and workers. Modern swine production facilities use ventilation systems to control the interior thermal environment, control interior humidity, and to manage air quality through the distribution of fresh air. Ventilation systems should be monitored and serviced frequently to ensure that they are in optimal working condition.

The pork industry employs several additional methods to disseminate worker health and safety-related information. In the past, national meetings have been held for industry safety directors. Meetings have consisted of topic-based presentations and Occupational Safety and Health Administration (OSHA) training sessions. In 2007, the Pork Checkoff collaborated with the AgriSafe Network to provide respiratory health and safety training. Archived presentations from the 2005, 2006, and 2007 national meetings can be accessed online.[47] The recent trend has been towards smaller, regional safety meetings, which help conserve Checkoff dollars. The Pork Checkoff also funds several Web-based resources for information sharing. Included are a Checkoff managed listserve for occupational health and safety issues in the pork industry, and a worker safety Web site.[48]

The pork industry recognizes that worker health and safety should not be viewed as an independent part of pork production. Rather, healthy and safe practices should be incorporated into daily tasks and procedures, as well as an integrated worker training process. The We Care initiative, which is also endorsed by the National Pork Producers Council and many packers, includes a statement of ethical principles as well as an action plan to help producers follow the industry's best practices. Occupational health and safety is emphasized, and according to We Care, producers are required to provide a work environment that is safe and consistent with other ethical principles by providing a work environment that promotes the health and safety of employees, educating employees on the Ethical Principles for U.S. Pork Producers and preparing them to meet their obligations consistent with these principles, and providing a work environment where employees are treated fairly and with respect.[49]

THE CATTLE INDUSTRY RESPONSE TO RESPIRATORY HAZARDS

Over the years the cattle industry has had a growing concern for it employees. Fortunately, initiatives to protect its workers have been developed, although they are generally not as specific as in the pork industry. In the cattle industry, initiatives have been developed with regulatory compliance in mind. A safe work environment is important in all aspects of the cattle industry; however, the industry focus appears to be animal handling and low stress management.

The National Cattlemen's Beef Association is an organization that is working to address cattle industry handling hazards through development of training aids and tools.[50] There are also organizations within the industry, such as the Texas Cattle Feeder's Association (TCFA) and Kansas Livestock Association (KLA), which have made concerted efforts within their respective memberships to address many safety hazards including respiratory health.[51,52] As in any industry, the cattle industry has hazards specific to their business and through cooperative membership involvement, measures have been taken to address these hazards according to

FIGURE 1. A typical feedyard. (Photograph provided by Gordon Moore.)

need. Obvious programs of priority are things such as hazardous energy isolation, confined spaces (grain handling facilities), hazardous communication, animal movement, etc. Much like the National Pork Board, both KLA and TCFA have paid staff to aid in program development for OSHA compliance. Written policies and programs are available along with the use of video libraries, worker's compensation pools, and seminars to aid in training. Development and use of training equipment is encouraged with tools such as a simulation trailer to train in the specific needs for safety.

Historically, industrial hygiene has not been a common component of the cattle industry. Most employees within the cattle industry work outside in the elements and weather is a factor that is dealt with daily. This may contribute to the lack of understanding among feedlot workers of the hazards of respiratory health in feedyards because of the "open air" confinement. The Texas Commission on Environmental Quality (TCEQ) has an ongoing litigation process regarding respiratory health issues of surrounding neighbors to feedyards.[53] Although state and federal regulatory agencies such as the Environmental Protection Agency (EPA) and the TCEQ are the compliance motivators when dealing with dusts, manure, gases, and/or chemicals, these agencies tend to create a sense that safety is the byproduct of compliance when just the opposite is true: compliance is the result of operating safely.[54] In order to fully understand the concept of respiratory dangers, they first must be identified as hazards and then best practices must be formed to eliminate them. Although the initiative for respiratory health of humans is not foremost among feedyard concerns, the cattle industry is sensitive to the need to address newly recognized health risks. Until the benchmark of insurance statistics forces an issue of priority in the cattle industry to look at respiratory health of humans, the need will not be aggressively dealt with. More research is needed in order to effectively cope with respiratory health concerns.

GAPS IN KNOWLEDGE AND PRACTICE

Published studies contain extensive information on respiratory symptoms and pulmonary function test results in swine confinement barn workers. Much of that data were collected in the early years of raising pigs in confinement

barns. Barn design has evolved and it is time to redefine the scope of the problem using exposure data and human health effects data collected in modern structures.

Also, the hog industry has moved into areas of the United States where the winters are not as severe as in the Midwest, where many of the original studies were done. These regions of the United States have yet to be included in published studies of worker respiratory health. It is known that climate affects air quality inside the barns, because large seasonal differences have been described in barns in a temperate climate.[55] Swine barn designs, including types of ventilation systems used, may be different between very cold, northern climates versus warmer, southern climates. There are also large differences in relative humidity between various regions where both cattle and hogs are raised, which can impact outdoor dust levels on feedyards and the type of ventilation system chosen for hog barns. Thus, there is a need to better understand the effect of climate and weather conditions on air quality in the livestock industry in general so that recommendations for offering respiratory protection to workers or changing barn ventilation can be based on scientific data.

A number of topic areas relevant to this industry have not yet received a great deal of attention. For example, relatively little is known about the reasons why workers in the livestock industry do not wear respirators or dust masks in greater numbers, and what could be done to increase their appeal. It is also not known how to best identify workers who could potentially benefit most from their use. It is possible that task-specific use of respiratory protective devices is preferable to requiring their use at all times. Exposure to dust has been shown to vary by task, with moving pigs having been shown to be associated with the highest dust exposure.[55] It is not known if dust masks are considered by workers to be more acceptable than N95 respirators and whether their use offers health benefits despite the fact that they are known to be less effective in terms of protecting workers.[31]

It is well known to people employed in the cattle industry that workers will voluntarily wear dust masks, and sometimes respirators, when exposed to dusty conditions in feedyards. However, it is not known if use of these respiratory protective devices conveys measurable health benefits or whether comfort is the only end point. It is also not known if this practice should be recommended to all workers if dust in the air exceeds certain levels, what those levels might be, and how the worker is to recognize when that level has been reached.

RECOMMENDATIONS FOR THE FUTURE

Future recommendations include devising practical recommendations for use of respiratory protective devices on both feedyards and in swine confinement barns using conclusions drawn from information collected on modern livestock farms in a variety of climates and during each of the four seasons of the year. These recommendations should be science-based. Consideration should be given to performing studies designed to assess for the presence of measurable benefit in workers using relatively noninvasive assessment techniques such as nasal lavage for measuring respiratory tract inflammation and spirometry for testing lung function. Any recommendations developed should include task-specific suggestions for use of respiratory protection and for optimizing ventilation when exposures are expected that could cause respiratory symptoms.

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