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INTRODUCTION

Agriculture dates back to the first recorded civilizations in Mesopotamia (currently known as Iraq) in 8000 B.C. and is defined as "the science, art, or practice of cultivating the soil, producing crops, and raising livestock and in varying degrees the preparation and marketing of the resulting products." (1) It is a worldwide craft and agriculture is thought to be one of the three most hazardous occupations in the United States. There has been data collection regarding farm size, crops or animals produced and income generated for more than 150 years. A farm includes any place that sells or produces, or normally would have sold, $1,000 worth of agricultural products during the census year. The last available data from the Census of Agriculture in 1997 estimated that there were 1.9 million farms in our country. (2) On these farms, it is estimated there are between 1.24 and 3.35 million hired agricultural workers. (3)

Agriculture as an occupation presents a wide variety of hazards to workers, including noise, organic dusts and physical and mechanical exposures that can result in traumatic injury and even death. While the data accuracy has been questioned, there has been some level of farm-related surveillance since 1930. (4) Fatality information has been collected nationwide since the 1940s, whereas nonfatal injuries are monitored more on a state level and only since the 1970s. The agriculture fatality rate in 1999 was 22.5 per 100,000 workers, which is higher than all other industries except mining. Tractors remain the leading cause of death with approximately 300 per year. (3) The nonfatal injury data is much harder to access and farms are not required to report to the Bureau of Labor Statistics until they employ 11 or more people. The most commonly reported problem involves musculoskeletal disorders. (5) Other common diseases or outcomes associated with agricultural workers involve respiratory illness due to organic dust exposure, chemicals or hydrogen sulfide gases, certain cancers, noise induced hearing loss and skin disorders. The purpose of this study is to review literature on the epidemiologic relationship between being an agricultural worker and the increased risk of respiratory illness, musculoskeletal disorders and noise-induced hearing loss.

REVIEW OF STUDIES

A variety of respiratory illnesses occur in agricultural workers and are one of the oldest researched areas in the occupational field. The focus in this review is that of farmer's lung disease (FLD) and its sequelae. It is caused by inhalation of organic dusts and fungus from moldy hay, specifically, exposure to Thermophilic actinomycetes. These

are found to grow under conditions of high temperature and high humidity. When farmers handle the hay and straw for animal feeding, these are released and inhaled. Exposures to these organisms over time and in areas that are not well ventilated predispose agricultural workers to FLD. In a Finland study conducted in 1999, researchers looked at 87 cases of FLD and compared them to 81 controls to evaluate IgG antibody level, chronic bronchitis and pulmonary function values in farmer's lung patients. Cases were matched for age, sex, smoking status, height and occupation, which minimized the risk of confounders. Farm size, measured in cultivation acres, and number of dairy cattle were also very similar so exposure time to the inhaled antigens was also controlled. The bias that existed was the lack of antibody status at the beginning of the follow up study. To avoid misclassification, all study subjects underwent clinical examinations. The researchers were interested in four "traditional" types of antigens as well as four "new" microbes and their relationship to antibody levels and chronic bronchitis or pulmonary function. (6)

It was discovered that FLD patients had higher serum IgG levels against all microbes than the control farmers. Antibody levels were also higher in the FLD patients with chronic bronchitis than controls with chronic bronchitis, and cases also had a lowered pulmonary capacity. Other important aspects of this study were the fact that the researchers recognized that development of farmer's lung might be due to individual sensitivity. This may also explain some of the antibody responses and predisposition to chronic bronchitis. It was also stated initially that the microbes that were examined were specific to their local area, so generalizing this study cannot occur in areas where the microbes varied. The study subjects were heavily weighted with women participants; so again, generalizing it to male subjects is not as applicable. Height and individual sensitivities are a concern. The researchers used an abbreviation in the discussion area regarding the pulmonary tests that was never explained, so it leaves doubt in my mind as to what it represents. Overall, the amount of matching the researchers did in this study was impressive. They recognized the importance of good control selection to minimize bias, starting with a pool of four times the number of cases, and selected the most qualified to participate in a clinical examination. It was a well-done study and demonstrated that FLD patients had significantly higher antibodies than controls. (6)

To examine issues that may predispose farmers to the occurrence of FLD, a Japanese study conducted in 2002 was reviewed that looked at the effects of meteorological conditions over a 20-year period. This prospective cohort study started in 1978 with researchers reviewing surveys from 265 farmers that asked about systemic and respiratory symptoms, smoking habits, farming conditions, farm size, numbers of animals, working inside a barn and hay handling time. Since it was based on farmer recall, some of the data was quantifiable; others were qualitative and thus subject to bias. Since it occurred over 20 years, farm size and the number of cattle increased, the operations for hay making became more mechanized and there was no matching, making these confounding variables. It was discovered that the number of days below freezing prior to harvest and the smaller amount of sunlight hours were closely associated with the occurrence of FLD. Rainfall had no association and humidity was not analyzed, which was unfortunate as it correlates with the "curing" of hay. (7)

Other important aspects of this study included the identification of only "new" cases of FLD so as to assess incidence, not prevalence. It was stated in the results section that the five cases in 1978 could not have been considered "new" so was excluded. However, when the final numbers were tabulated, these five were counted in the total of 34 cases, confusing the final interpretation. Their diagnostic criteria was excellent in that five pulmonary specialists examining radiographs were blinded and all had to concur with the diagnosis before a patient would be considered positive for FLD. Considering the changes that have occurred in farming operations in the last 20 years and the technology regarding cattle rearing, it was a fairly well done study. The diagnostic criteria were superb, and the qualitative measurements are not subject to large errors, making the internal validity of the study strong. It was a good comparison group for the non-FLD cases and generalizable for similar farming communities. There was a comment at the end of the discussion section that described decreasing the chances of FLD by hiring temporary workers that was an unnecessary suggestion. The reader should be left with the thought of exposing temporary employees as a control mechanism for decreasing the threat to the farm owner. Wearing protective masks, decreasing exposure time and increasing ventilation were all mentioned, which are excellent prevention strategies. All individuals working in those conditions deserve to be educated about prevention techniques. (7)

Besides the risks associated with respiratory illness, farmers also have a higher prevalence of musculoskeletal symptoms than other occupations. In order to illustrate this, a cohort study conducted in Iowa was reviewed regarding the risk factors for back pain among male farmers. The subjects for this study came from data collected about back pain risk factors during the 1992-1994 Iowa Farm Family Heath and Hazard Survey (IFFHHS) and included 287 males. Follow-up questionnaires were sent 18 months later to assess the occurrence of back pain. Cohorts were selected from the National Health Interview Survey (NHIS) and the U.S. farmer comparison group consisted of 408 males 19 years of age or older that were currently working under the farming classification code and had answered questions regarding back pain. To control for farming, an additional comparison group was used and consisted of the general male U.S. working population. The same criteria applied to the NHIS survey excluding the occupation code of farming and 2,812 males were in this group. (8)

The variables that were evaluated in this study included height and weight, education, personal risk factors (smoking, alcohol, depression), economic status and occupational exposure (primary occupation, number of years worked as a farmer, major farming activities). Initial data was presented and then the researchers adjusted for age, marital status and education, so as to limit these confounders. Back pain was significantly higher (31 percent) in Iowa farmers compared to the general population (18.5 percent) over the previous 12 months. Farmers aged 45-59 had a statistically significant risk of back pain, and farmers with a second job were found to be at an increased risk, but not statistically significant. Selection bias was addressed in that there was a low response rate in regards to the initial surveys, but the researchers felt that it was still generalizable data since the demographics of the respondents closely matched that of Iowa Agricultural Census data. The selection bias based on the presence or absence of back pain could not

be eliminated. Finally, the recall of back pain over a 12-month period could result in underestimating the actual prevalence, and the researchers recognized this in their analysis. An important aspect of this study includes the clear statement of the purpose in the beginning of this article. Also, it was a population based study initially so findings should be representative of male Iowa farmers, and the 18-month prospective cohort study allowed a good indication of back pain factors. This was a well-done study in that it explained all the variables, utilized odds ratios and confidence intervals regarding those variables, there were very good explanations for all factors and results and they addressed the confounders and biases. (8)

Since it is recognized that low back pain occurs more often in farmers than the general population, a search was conducted with respect to what other musculoskeletal problems exist. In a 1997 study conducted in Sweden, researchers looked at the relationship between osteoarthritis of the hip and farm work. This study included 269 cases of radiologically verified coxarthrosis (degenerative joint disease of the hip) and 538 controls from a local population registry that were matched on age, sex and place of residence. Cases were identified based on radiologic examinations of the pelvis and hip joint from 1986 to 1988 in three different hospitals in Sweden. Then cases and controls were sent a questionnaire that was previously tested on a limited group before dispatching. There was some recall bias in association with a question pertaining to self-reporting of heavy work before age 16. While no median age of the group was revealed, older individuals may have trouble recalling accurate data. Also, the potential for selection bias existed in that occupations that develop coxarthrosis at an early age may have been over represented. (9)

In diagnosing coxarthrosis, researchers only identified one aspect, the radiologic evidence of a narrowed articular distance, as the sole criteria. No degree of severity was assessed which is an important aspect of this study. Another important aspect was their evaluation of different occupations, so as to limit confounders, as well as looking at sports, injuries sustained to lower extremities from accidents and smoking. After evaluation of these different aspects they found no correlation, giving it more truth, or internal validity. Farmers and agricultural workers did have an increased risk of coxarthrosis as their number of years farming increased. Driving a tractor and milking cows also was associated with coxarthrosis, but the researchers felt that agriculture work is so diverse more research needs to be done to identify specific exposures and the risk of osteoarthritis. This study accomplished its goal in a well-done manner, but left more questions unanswered. The statement of heavy work before age 16 associated with coxarthrosis was not supported in that the recall of the subjects may have been biased. Finally, there was no median age of cases or controls given, nor was median age worked for any kind of farm job, farming as a farmer or farming as a laborer listed. It would have helped add to the generalizability of the study. As it stands, it is applicable, but could have been more so. (9)

The previous review stated that driving a tractor was associated with coxarthrosis so a further search was conducted for studies relating to the risks of tractor driving. As stated in the introduction, tractors are responsible for 300 fatalities a year in the United States, but overall they expose the driver to long hours of sitting, whole-body vibrations

and often with a twisted posture. These could predispose a farmer to musculoskeletal disorders, so I chose to review a study that looked at the relationship of tractor-driving hours and self-reported low back and hip symptoms. This article further explained the previous Swedish study. This study, published in 2002, looked at a cross-section of 1,075 Swedish farmers and asked questions regarding gender, age, farm and tractor-driving data and health-related factors. One concern was with one of the questions regarding the recall of average annual tractor-driving time in the previous 10 years. This is a large time frame to have accurate recall and it may have been biased. There was a health question that also concerned me that asked them to record any aches, pains or discomfort in various body parts in the last 12 months. With a 12-month time-span, this area was also subject to recall. They also had a category of the last seven days, which helped to add internal validity to the study. Since crop production is so seasonal, farmers who worked less than 30 hours a week were still considered in the study but this may have been a misclassification bias, depending on their other type of occupation. The multivariate analysis accounted for many confounders, such as age, gender, smoking and employment other than farming. They did not account for any previous history of accidents that involved the lower back and hip, nor did they account for farmer height and weight, which can be related to hip symptoms. (10)

This study did state the purpose of the study clearly at the beginning, and they addressed the main points, which is an important aspect of any study. Another excellent point they made was the fact that exposure does not automatically imply the risk for symptoms. Another strong point was that they followed up the non-responders to compare some variables and this made it more generalizable. Overall, it was a well-done study in that it answered the proposed question of mean driving time (472 hours annually) and that the operators who were responsible for meat (cattle) and crop production spent the most time driving. The chore associated with the most low back pain was silage chopping, but overall tractor driving time contributed to hip symptoms more so than low-back pain. There were very few women in the study so the data are not generalizable to this group but only to male farmers. It answered some of the questions the previous study proposed. (10)

While not researched as long as respiratory disease, or as commonly reported as musculoskeletal disorders, noise-induced hearing loss is a factor that many farmers have to deal with as a part of their life. The Occupational Safety and Health Administration (OSHA) recommends hearing protection devices be worn for exposure to noise that reach 85 dB for more than eight hours. As a reference point, normal conversation occurs at 60dB. Machinery on farms including tractors, grain dryers and milking machines, greatly exceed those levels, and farmers are exposed to those every day, and often do not wear hearing protection. A 1991 study conducted by Marvel evaluated a cohort of 49 exposed and 49 unexposed farmers looking for the extent occupational hearing loss occurred in New York dairy farmers. Each farmer was matched for age and sex with a rural living, non-farmer so as to minimize confounders. During the evaluation, the researchers also separated the age groups by median age of 43 to help eliminate the risk of presbycusis (progressive, bilaterally symmetrical perceptive hearing loss that occurs with age). (11) To prevent selection bias, the researchers posted announcements seeking

volunteers for the non-farming group. They also excluded anyone who grew up or worked for more than one summer on a farm. (12)

They utilized a questionnaire that was administered by a registered nurse and included directed questions. It was identical for both groups, thus eliminating observation bias. Dairy farmers suffered 65 percent hearing loss in the high frequency range compared to 37 percent of the non-farmers, and interesting to note, the left ear was more severely affected among farmers. This is often the result of monitoring equipment behind a tractor, and the farmer turns to look over their right shoulder, thus exposing their left ear to the noise of the motor. This study was unique in that it was the first of its kind to examine a random sample of farmers selected from a large cohort. It is also important to note that it was the only study at the time to test an age and sex matched comparison of non-farmers. Overall, this was a very well done study in that it had great sample selection and exclusion criteria. The testing methods were well explained and the questionnaire limited selection and observer bias. It is very generalizable to dairy farmers, and because they often have the highest exposure to noise, other farmers will benefit by seeing the worse case scenario. It really set the standard for future studies. (12)

To examine hearing loss among a younger group, a study conducted from 1985 through 1988 involved 872 high school farm students in Wisconsin. This cohort study looked at a variety of subjects and classified them based on who lived and worked on a farm, those who worked on a farm but didn't live on one, individuals who lived on a farm but didn't participate in chores and those who neither worked nor lived on a farm. There was some misclassification bias based on the use of noisy equipment being a dichotomous variable. Rare or occasional use of noisy equipment was given the same weight as very frequent use. Recall bias may have existed because the students needed to report operating certain pieces of equipment. If they did not operate it, but rode on it, they would not have replied the same. Some of the confounders in this study involved use of amplified music, snowmobile, motorcycle or a family history of hearing loss, but they utilized a multivariate analysis to account for these. (13)

The data indicated that teenage children (15-16 years old) that are actively involved in farm work have an increased prevalence of mild hearing loss in the high frequencies. It also revealed a greater left ear hearing loss among the farm students, which is in agreement with other studies. Due to the length of the study, they did evaluate the students a second year, but only reported preliminary data here. An important aspect during this study was the education they provided to the students on wearing hearing protection devices before the initial testing, as well as long term. It would have been interesting to have that data included. The study was well done, with clearly stated objectives and well explained methods. The researchers recognized and addressed the misclassification bias and recognized that some of the recall information was unreliable. The study subjects in farming were heavily weighted with males, which matches census data, so the information is generalizable, adding strength to the study. (13)

Research has proven that noise-induced hearing loss does exist at a higher level in farmers than other occupations, but do farmers realize the problem exists? A 2001 cohort study was reviewed that looked at 376 New York farmers who self-reported hearing loss and compared it to audiometry testing. Classification bias was limited because the sub-

jects had to be 18 years or older and reside or work year-round on a farm. They compared sensitivity, specificity, false negative and false positive data for the self-reports compared to the audiometric tests. Audiometric testing agreed between 70-79 percent of the time, and the most misclassification came from false-positives. Researchers wanted random selection of participants but the farm owner/operators wanted the health screenings themselves and did not always allow employees to participate, thus resulting in some selection bias. This could affect the generalizability of results. Important to note was their clear statement of their purpose to quantify self-reported hearing loss in relation to audiometry and they succeeded. There was also great explanation of the difference between a hearing impairment versus a handicap included in this study. Of the participants, 85 percent were male with a median age of 48 years old; 73 percent of them worked more than eight hours a day on a farm and of the group, 59 percent were dairy producers. The results were explained rather well, but the researchers were concerned with the generalizability of information. In the census data accessed, this is very indicative of the general farming population, within five years of age. They did not discuss the types of exposure these subjects faced on a daily basis, but other studies, as in the ones above, have reviewed this and this is in agreement. (14)

SUMMARY AND CONCLUSIONS

After reviewing the above articles, it can be concluded that agricultural workers are at an increased risk of respiratory illness, specifically Farmer's Lung Disease, musculoskeletal disorders of the hip and noise-induced hearing loss. These conditions are a result of exposure to allergens, ergonomic stressors and loud noise, but most importantly, they are preventable. Agricultural work is very physically demanding, involves long hours and is often the only occupation some individuals ever know. Public health officials need to focus their attention on practical recommendations that are going to be utilized by agricultural workers when it comes to preventing some of these problems. Education must be made available regarding the risk factors to employers and employees through extension agencies, medical professionals and public health campaigns.

Technology has advanced to provide agricultural workers with respiratory masks that will filter many allergens. Through proper education this alone could help alleviate Farmer's Lung Disease. Wearing a mask is not always convenient for farmers, but if they are educated to how it will decrease their chance of exposure, they may be more willing to comply. We learned through the Japanese study that meteorological conditions play a role. There is information recorded on temperature and growing conditions of hay in the Midwestern states. Combining that information with risk factor data would reveal a target audience of those to be educated. The allergens are locale specific, according to the Finland research, so more studies need to be done in those at-risk areas to identify specific risk factors.

Musculoskeletal disorders arose from tractor driving and milking cows. Again, technology has helped advance this area by making tractors more comfortable with swivel seats that support the hip and lower back while farmers are turned to look behind them. However, the economy in the agriculture industry does not always allow for the purchase of the latest equipment. Agricultural workers need to be aware of the risks

involved with tractor driving and practical recommendations for preventing these disorders is needed. Intervention studies are really needed in this area. Milking cows was also a risk factor for musculoskeletal disorders. As farms get larger, milking equipment is also becoming more sophisticated. The days of constant bending down to milk a cow are fading. More cows are milked in parlor situations, but this is introducing repetitive motion stressors that the public health community needs to be prepared to deal with. Again, additional studies are needed in this area.

Milking cows also brings with it the risk of noise induced hearing loss, as the Marvel study demonstrated. Many people begin to lose their hearing as they age, regardless of exposure, but this study separated groups based on age as well. This study then prompted to Broste et al to look at a younger group of people who were exposed to the same noise levels, but for fewer years. This is where future intervention studies need to focus. There are recommendations established for preventing hearing loss, but it does not always reach the at risk population. Young people who are involved in farming operations need to be aware of the risks so that proper prevention can take place. Older people on farms serve as mentors for these young individuals, so they too need to be educated on the risk factors.

Many countries rely heavily on the agriculture industry. We need to do everything we can as public health professionals to protect those individuals that give 110 percent every day to put food on our tables. There are prevention strategies out there that need to be widely proclaimed to the target groups. For areas that are newly emerging as risk areas, studies need to be done to determine the best prevention protocols.

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