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Differences in lung health of Alberta farmers and the effect of atopy.

by

Thomas Matheson Lawley 

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

in

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Abstract

Objectives - The purpose of this study was to determine differences in the respiratory health of various types of farmers in east-central Alberta and the effect of atopy on these differences.

Design - This was a cross-sectional study of 781 farmers who grew grain crops and raised livestock.

Results - Respiratory symptoms were not associated with farm size. Livestock farmers had more respiratory symptoms than grain farmers. Atopic farmers did not report more symptoms than non-atopic farmers. Turkey farmers were the only group of farmers significantly more likely to report a diagnosed respiratory illness - asthma (OR 2.69; 95%CI 1.29-5.61). Lung function results for pig farmers and canola farmers showed statistically significant differences, but clinically the differences were small.

Conclusion - Farm size was not a surrogate for exposure. Grain farmers reported fewer symptoms than livestock farmers, and atopic farmers did not have more respiratory symptoms than non-atopic farmers. Lung function tests from different types of farmers did not differ clinically.

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I want to thank Dr Pat Hessel for his supervision, constructive criticism, and patience during the preparation of this thesis. I want to thank Dr Jim Cheng and Dr Alex Herbert for their help on the supervisory committee. I also appreciate the statistical help given to me by Mr Gian Jhangri.

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OR	Odds ratio
CI	Confidence interval
FEV_1	Forced expiratory volume in 1 second
FVC	Forced vital capacity
$FEF_{25-75\%}$	Maximal midexpiratory flow rate
SCB	Swine confinement building
WBC	White blood cell
IL	Interleukin
IgE	Immunoglobulin E
IgG	Immunoglobulin G
RAST	Radioallergosorbent test
COPD	Chronic obstructive pulmonary disease
HP	Hypersensitivity pneumonitis
FLD	Farmers lung disease
MF	*Micropolyspora faeni*
TV	*Thermoactinomyces vulgaris*
ODTS	Organic dust toxic syndrome
n	Number
SPSS	Statistical Package for Social Sciences
BTPS	Body temperature pressure saturated
IBM	International Business Machines
HWE	Healthy worker effect

INTRODUCTION

Farming is an important and historical occupation in Alberta. There are many different types of farming operations that occur in Alberta including both grain and livestock farms. Some of the more important grains include wheat, oats, and barley. Oil-seed grains such as canola have become more important in recent years. The major livestock animals are beef cattle, dairy cattle, hogs, chickens and turkeys. Horses are also common on many farms.

Since there is so much variety in the grains and livestock, farmers are exposed to several different types of dust and antigens that can cause respiratory symptoms (Zejda, 1993; Dosman, 1987). Certain animals and grains have become associated more often with respiratory symptoms than others.

Farmers with respiratory problems associated with their work may be interested in knowing which grains or animals may be causing their problems or which types of farming are more or less likely to trigger respiratory problems.

Atopy is a common condition with a prevalence of 15-50 percent in the general population (Frew, 1989). Atopic individuals are more likely to have respiratory symptoms when exposed to certain antigens than those who are not atopic. Most farms contain a number of antigens capable of triggering symptoms in some atopic individuals. However, the role of atopy in potentially modifying

relationships between respiratory symptoms and individual exposures on the farm is not well understood. Clarification of these relationships would be helpful in counseling farmers with respiratory problems and susceptible individuals intending to take up the occupation.

Since atopy is common in the population, many of these farmers will be atopic. Atopic individuals who want to become farmers or atopic farmers who are experiencing respiratory symptoms may want to know what type of farming will give them fewer symptoms.

In a previous cross-sectional study, (Melenka et al., 1999) farmers growing grain crops and raising livestock in east central Alberta completed questionnaires that inquired about past respiratory history, smoking, allergies, type of farm and farm practice. They also underwent spirometry. Skin prick testing for immediate skin reactivity to common allergens was done and of the 781 full time farmers less than 65 years old, 154 farmers (19.7%) had a positive skin prick test indicating atopy.

The previous analysis compared the respiratory health of the farmers to that of other workers. However the impact of the type of farming on respiratory health was not examined, nor was the potential role of atopy in modifying relationships between farming exposures and respiratory health.

The present analysis examined the respiratory health of these farmers in relation to the type of farming. It also investigated the role of atopy as a potential modifier of these relationships.

LITERATURE REVIEW

There are numerous articles in the literature describing respiratory health effects in the agriculture industry. The following literature review covered the respiratory health effects of grain and livestock farming, and the role of atopy.

Health effects of grain farming

Much of the information on the respiratory health effects of grain dust has come from studies of grain elevator workers (Broder et al., 1979; Huy et al., 1991; Chan-Yeung et al., 1992). These studies showed an increase in cough, sputum production, and shortness of breath. They also showed a small decrease in forced vital capacity (FVC) and forced expired volume in one second (FEV_1). There was a dose-response relation between cumulative exposure to grain dust and lung function (Chan-Yeung et al., 1992). The Chan-Yeung study was composed of five cross-sectional studies of grain elevator workers in British Columbia. They showed that exposure to grain was significantly associated with lower FEV_1 and FVC. The effect of grain dust on FVC was greater than on FEV_1. Grain dust exposure had no effect on the maximal midexpiratory flow

rate ($FEF_{25-75\%}$) or FEV_1/FVC. Smoking was a strong determinant of $FEF_{25-75\%}$ and FEV_1/FVC but not of FVC.

A dose-response relationship between grain dust and lung function has been shown (Huy et al.,1991). Four hundred and fifty-four grain elevator workers were compared to 55 civic workers and a dose-response relationship was seen for chronic phlegm production, breathlessness on exertion, FEV_1 and FVC. Other studies have shown this longitudinal decline in lung spirometry among grain handlers (Tabona et al., 1984; Enarson et al.,1985).

A study by Broder et al. (1985) did not show this rate of decline in lung function when workers were exposed to grain dust. In the Broder study many grain handlers having an excess of various symptoms left the study and this probably led to an underestimate of the adverse health effects explaining the lack of rate of decline in lung function.

The pathogenesis of grain induced respiratory disease is unknown but it is postulated to be an interstitial inflammatory response in the bronchioles (Stepner et al., 1989). Grain dust contains tannins that may cause a non-immunologic activation of the complement system leading to inflammation of the bronchioles (Skea et al., 1988).

In a prevalence study looking at grain farmers in Ohio, the prevalence of respiratory symptoms (with 95% confidence intervals (CIs)) are as follows: chronic cough 9.4% (7.6-11.1), chronic phlegm 10.8% (9.0-12.6), dyspnea 16.2% (14.1-18.3) and 8.1% (6.4-9.8) for wheeze in the absence of a cold (Wilkins et al., 1999). Smoking status was found to be the strongest predictor of symptom prevalence.

A study investigating the combined effect of grain farming and smoking on lung function and the prevalence of chronic bronchitis was examined in 1633 residents aged 20-65 in Saskatchewan (Chen et al.,1991). They found that women grain farming and smoking had a synergistic effect. The combined effect for grain farming and smoking was not significant in men. Their data suggested that there was a positive interaction between grain farming exposure and smoking in lung function and the prevalence of chronic bronchitis in women.

In a survey of chronic respiratory symptoms and airflow obstruction in a rural Manitoba population, aged 20-65 years, the effects of farming and exposure to grain dust was examined (Manfreda et al., 1989). The study included current farmers, former farmers, and those who had never farmed. Almost all the current farmers were exposed to grain, on average, for 2 months of the year. There was a strong association between smoking and symptoms, but there was no association between respiratory symptoms and exposure to grain and

farming once age and smoking were controlled. The authors suggested that the farmers do not have chronic respiratory symptoms from exposure to grain dust. They felt that lung function was reflective of exposures to livestock in the past.

Health effects of livestock farming

Livestock farmers are exposed to a wide variety of potentially hazardous agents and bioaerosols that come from animals, feces, and feed. These include dried livestock or poultry proteins such as urine and dander, feces, ammonia dried to particles, bacteria, grain mites and infectious agents (Donham, 1995). Reviews of individual types of livestock farming follow.

Pig farming

Health hazards to farmers working with pigs were reported in 1977 (Donham et al., 1977). The prevalence of chronic respiratory symptoms is known to be high in pig farmers, but the etiology is not fully known.

Fifty-three pig confinement farmers and 43 control farmers were studied in Ontario in 1987 (Holness et al., 1987). Pulmonary function, and total and respirable personal dust levels were obtained. Dust levels were higher in the pig farms compared to the control farms, and the pig farmers reported more symptoms than the control farmers, but no relationships between dust levels

and symptoms were evident. Pig confinement farmers had no difference in lung function compared to the control farmers.

A study investigating chronic respiratory symptoms and lung function in pig farmers found that exposure to dust, endotoxins, and ammonia were not related to chronic respiratory symptoms (Preller et al., 1995). The authors found that the duration of the disinfection procedure, and the pressure at which the disinfectant was applied from the apparatus at the time of disinfection were positively associated with chronic respiratory symptoms. They stated that a longitudinal study with exposure data was necessary to fully investigate the respiratory health effects of endotoxins and ammonia in pig farmers.

A recent study investigated whether clean pig confinement buildings were less harmful than older and dirtier facilities (Cormier et al., 2000). Eight volunteers were exposed for 4 hours, at 1 week intervals, to 8 swine confinement buildings (SCBs) Parameters measured were FEV_1, FVC, nasal white blood cells (WBCs) and IL-8, and serum IL-6. Mean airborne levels for dust, bacteria, endotoxins, molds and ammonia were measured. FEV_1 decreased after exposure, nasal WBCs and IL-8 increased, and serum IL-6 increased. They concluded that the modern techniques for pig farming did not decrease the exposures of the subjects in the study.

Factors, in addition to the pigs, such as the use of quaternary ammonium for disinfection and the use of an automated dry feeding system may accelerate the decline in lung function over time (Vogelzang et al., 1997,1998).

A cross-sectional study was done to define the asthma like syndrome in pig confinement workers in rural Nebraska (Von Essen et al., 1998). Hypertonic saline challenges were used to induce sputum. The pig workers reported more symptoms of wheezing, cough, and sinusitis than controls ($p=0.003$). Macrophages were elevated in the pig workers, but not neutrophils. No eosinophils were observed. Spirometry values did not differ significantly between the pig group and the control group, even though there was evidence of lower respiratory tract inflammation determined by an increased number of macrophages in the induced sputum. The findings in pig confinement workers were noted to be different than people with asthma or chronic bronchitis.

A longitudinal study from 1989 to 1991 and 1994 to 1995 tried to determine the predictors of changes in pulmonary function in swine confinement workers in Saskatchewan (Kirychuk et al., 1998). Of the 98 original workers in 1989/91, 42 workers were studied again in 1994/95. Preshift FEV_1 and FVC were measured and repeated every 2 hours. After adjusting for age, height, smoking and hours spent in the barn, lung function changes across the work shift were good predictors of the annual rate of change in FEV_1 and FVC. They also looked at

the effect of indoor air quality and found that endotoxin level was a significant predictor of longitudinal changes in lung function in swine confinement workers.

Determinants of longitudinal changes in spirometric function were compared between swine confinement operators (n=168) and neighborhood farmers (n=127) in Iowa (Schwartz et al., 1995). The control population was matched for age, sex and geographic location. The average follow-up time was 2 years. The swine confinement operators had less farming experience than the neighborhood farmer control group. The swine confinement group was exposed to higher environmental dust concentrations than the control group. The swine confinement group had slightly lower measures of airflow and greater work shift declines in FEV_1, FVC and FEF_{25-75} . The authors found that higher concentrations of endotoxins were important determinants of accelerated decrements in airflow in agriculture workers.

In another longitudinal study in Iowa, 207 swine workers representing 108 swine farms were selected using a stratified random sample from 2,000 swine farms in Iowa (Reynolds et al.,1995). Pulmonary function testing, assessment of respiratory symptoms, and personal breathing zone and area measurements of environmental exposures were completed on all subjects. Measurements were done at the start of the study and again at approximately 48 months. The second measurements showed a mean cross-shift decrease in FEV_1 of 2%.

Cross-shift changes were significantly correlated with personal exposures to total dust, total endotoxin, respirable endotoxin, and ammonia.

Donham et al. (1995) investigated the respiratory dysfunction in swine production facility workers, and determined a dose-response relationship of environmental exposures and pulmonary function. Positive correlations were seen between changes in pulmonary function over a work period, and exposure to total dust, respirable dust, ammonia, and respirable endotoxins. These relationships did not become manifest until exposed for more than 6 years. Total dust and ammonia were the strongest predictors of lung function decrements.

Most pig farming is done indoors. The above studies compare indoor pig farming with outdoor farmers. The indoor environment may contribute to decreased lung function.

The literature shows that pig farmers have increased respiratory health problems by comparison with a variety of groups. The exact causative agents are not fully known. There is good evidence implicating endotoxin; however there are many other agents and factors that may contribute to the respiratory health problems of pig farmers.

Dairy farming

The prevalence of respiratory problems in dairy farmers is not as well studied as in pig farmers or grain workers. Cross-sectional studies with control groups have suggested that dairy farmers have changes in their expiratory flow rates (Daulphin et al., 1998; Heller et al., 1986). Other authors have not found this to be conclusive (Malmberg et al., 1985; Rautalahti et al., 1987).

A prevalence study was done in 1998 to determine whether dairy farming was associated with an excess of asthma and respiratory symptoms (Daulphin et al., 1998). The respiratory status of 265 dairy farmers and 149 non exposed workers were compared. There was a questionnaire, spirometry, bronchiodilation test, IgE levels and skin prick testing. There was no difference in the reports of asthma in the two groups. The prevalence of all respiratory symptoms was higher in the farming group. There was a statistically significant difference after adjusting for age, sex, and smoking status, for cough, morning phlegm, and chronic bronchitis. The study suggested that the combined effect of farming and smoking were additive for chronic cough.

In a six-year longitudinal study of respiratory function in dairy farmers in France, dairy farmers had more respiratory symptoms and lower levels of lung function than did control subjects (Dalphin et al., 1998). The study suggested that dairy farming is associated with a moderate loss of respiratory function that increases with exposure and is significant in older males.

The type of drying procedure that was used for fodder was investigated in a longitudinal study in dairy farmers in France (Mauny et al., 1997). The authors compared barn-drying to traditional-drying of the fodder. The hypothesis was that barn-drying reduced the exposure to fungal and bacterial micro-organisms, especially thermophilic actinomycetes. After controlling for age, smoking status and cumulative exposure, the farmers who dried fodder in the barns had less chronic bronchitis and slightly better respiratory function than those farmers who used the traditional-drying methods. The type of drying procedure did not significantly reduce the annual rate of decline in respiratory function.

The literature suggests that dairy farmers, like other farmers, have work related respiratory symptoms and an increased annual decline in lung function, but the mechanism of action has not been determined.

Poultry

Poultry workers have been shown to have a high prevalence of exposure related respiratory symptoms. A study conducted in South Africa examined workers at three poultry farms (n=134) and unexposed blue-collar workers (n=122) in 1993 (Rees et al., 1998). The outcome measures were respiratory symptoms, allergy and hypersensitivity to poultry antigens identified by skin-prick tests, and the presence of IgE and IgG antibodies. The results showed that the smoking habits and atopic status were similar in the poultry workers and the controls. Symptoms such as cough and wheeze were common in the poultry workers. Significantly more poultry workers complained of chest

symptoms, and had more symptoms of asthma. There was no association between immunological status and respiratory symptoms in the poultry workers.

In a cross-sectional study of turkey farmers in Minnesota, the farmers had worse respiratory symptoms in the winter months, when exposure to environmental agents was the highest (Reynolds et al., 1993). Prevalence of symptoms was highest in smokers, people who worked in the hen barns, and people who had worked for more than 10 years in the turkey growing industry. Pulmonary function also decreased through the day.

Respiratory symptoms and immunological status were investigated in poultry workers in Yugoslavia (Zuskin et al., 1994). A group of 57 female poultry workers in a processing plant were compared to 51 non-exposed workers. Compared to the non-exposed workers, the poultry workers had higher prevalence of cough, dyspnea, rhinitis, chronic phlegm and bronchitis. Exposed workers with a positive skin test to poultry food extract had a higher prevalence of all chronic respiratory symptoms compared to those workers with a negative skin test.

A dose-response relationship was determined between occupational exposures and cross-shift declines in lung function in poultry workers (Donham et al.,2000). A total of 257 poultry workers were studied for respiratory symptoms, pulmonary function, exposure to dust, endotoxin, and ammonia. Significant dose-response relationships were observed between exposures and pulmonary

function decline decrements over a work shift. Exposure concentrations associated with significant pulmonary function decrements were as follows:2.4 mg/m^3 total dust, 0.16 mg/m^3 respirable dust, 614 EU/m^3 endotoxin, and 12 ppm ammonia.

In a cross sectional study of 95 turkey farmers in Minnesota, pulmonary function was found to decrease through the day. Prevalence of symptoms was higher in smokers, personnel who worked in hen barns, and persons who had worked in the turkey growing industry for more than 10 years (Reynolds et al.,1993). Their data supported the association between respiratory disease and exposure to the environment in confinement buildings.

Horses

The prevalence of asthma and allergy symptoms was examined in New Zealand farmers (Kimbell-Dunn et al., 1999). They found that asthma was higher in horse breeders/groomers (16.5%), pig farmers (18.2%), poultry farmers (17.4%) and oat farmers (17.4%). Horse allergy can cause a wide range of clinical symptoms from urticaria to respiratory distress (Roberts and Lack, 2000).

This study found that exposure to horses was associated with multiple respiratory symptoms. Farmers with horses were the only group of farmers to demonstrate an excess of wheezing. Wheeze without a cold, attacks of

wheeze, and chest tightness were additional symptoms associated with horse farming.

Atopy and allergy

Atopy is derived from the Greek word meaning "out of place" or "strange disease". The term atopy was proposed by Coca and Cooke in 1923 to identify a subgroup of clinical allergies that invoked skin sensitizing antibodies and are subject to hereditary influence (Blumenthal, 1998). The term atopy is used by investigators and clinicians and has different meanings depending on who is using the term. Some use the term to mean any allergic phenomena regardless whether an antibody is found or not. Others believe it is due to an allergen-specific skin-sensitizing immunoglobulin E (IgE) antibody. IgE was a major advance in the field of allergy and was discovered by Ishizaka in 1966.

Owenby defined the term atopy to refer to the predisposition of certain individuals to inappropriately synthesize IgE specific for certain protein components of antigens or "allergens" encountered on mucosal surfaces (Owenby, 1998). This is frequently, but not always, accompanied by elevated synthesis of non-specific total serum IgE.

The relationship between respiratory disorders and allergy skin-test reactions has been established for many years. Burrows et al. (1976) showed that atopic individuals appeared to have increased bronchoconstriction and recurrent chest

infections, and that atopy may be a risk factor for development of chronic obstructive pulmonary disease (COPD).

Atopy in farmers and grain handlers

A study of maize workers, in South Africa in 1989, investigated respiratory symptoms and IgE levels (Van Niekerk and Weich, 1989). The authors found that symptoms suggestive of allergy were found in 90% of the farm workers compared to 4% of the control workers. However, the total IgE levels were not raised, and only 40% had positive radioallergosorbent (RAST) test against specific allergens. The mechanism for the symptoms was not determined.

The effect of atopy on longitudinal decline in lung function was analyzed, adjusting for smoking and age by Tabona et al. (1984). There was no difference in longitudinal decline in lung function between those with and those without immediate skin reactivity to any of the common allergens tested. The presence of chest symptoms was also analyzed. No correlation between chest symptoms and longitudinal decline in lung function was found.

Lung Disease in Farmers

Hypersensitivity pneumonitis

Hypersensitivity pneumonitis (HP) or extrinsic allergic alveolitis, is an immunologically induced inflammation of the lung parenchyma, involving alveolar walls and terminal airways, secondary to repeated inhalation of organic

dusts and other agents by a susceptible host (Hunninghake, 1998). HP usually results from exposure to "moldy" hay, silage, grain, birds or humidification systems.

The clinical picture differs from patient to patient and is related to the frequency and level of exposure to the causative antigen, and the individual. The presentation can be acute, sub-acute, or chronic. In the acute form the symptoms are fever, chills, cough, malaise and dyspnea. These symptoms can occur 6 to 8 hours after exposure to the antigen and clear when there is no further exposure to the antigen. The sub-acute form appears insidiously over a period of weeks and cough and dyspnea can be severe. The chronic form of the disease can present as a gradual progressive interstitial disease with cough and exertional dyspnea without a prior history of the acute or sub-acute forms. Farmer's lung disease (FLD) is a type of hypersensitivity pneumonitis caused by exposure to moldy forage. Patients with FLD can have non-specific hyperresponsiveness. A study done in Japan looked at FLD in 3 groups of farmers (Amishima et al., 1995). The first group had episodes of FLD, the second group had antibodies to *Micropolyspora faeni* (MF) or *Thermoactinomyces vugaris* (TV), and the third group had no antibodies to MF or TV and had no FLD. There was no difference in bronchial hyperresponsiveness among the groups, and no difference in the IgE levels. The authors suggested that the bronchial hyperresponsiveness was not due to past episodes of FLD or sensitization to *Micropolyspora faeni* or

Thermoactinomyces vugaris, but due to the occupational environment of dairy farming.

Organic Dust Toxic Syndrome

Organic toxic dust syndrome (ODTS) is a hazard in which inhalation of mold dust is associated with a febrile condition distinct from allergic alveolitis (Rask-Anderson, 1995). ODTS is a flu-like, short term, acute febrile illness that occurs within hours of the dust exposure. It is a nonimmunological, noninfective condition that is self-limited. Exposures to high concentrations of grain dust may cause influenza-like symptoms, with or without respiratory symptoms (do Pico, 1994). Symptoms include cough, fever and myalgias occurring within a few hours of exposure to fungal spores.

ODTS or grain fever is common condition affecting up to 32 percent of grain elevator workers (do Pico et al., 1996). The incidence of allergic alveolitis is much lower, ranging from 0.2 to 0.4 per thousand in the farming population (Malmberg et al., 1990).

The mechanism of action is thought to be a systemic and pulmonary inflammatory reaction with the induction of peripheral blood leukocytosis and and airway neutrophilia (Rask-Anderson, 1989). Clinically, in the early stages, it is difficult to distinguish between OTDS and hypersensitivity pneumonitis.

Symptoms begin 4-8 hours post exposure, and consist of fever, chills, headache, myalgias, dyspnea and/ or nausea.

Asthma

Asthma is characterized by increased responsiveness of the tracheobronchial tree to multiple stimuli (McFadden, 1998). There is widespread narrowing of the air passages that may be relieved spontaneously or as a result of therapy. Clinically it is characterized by paroxysms of dyspnea, cough and wheezing. The common denominator is nonspecific hyperirritability of the tracheobronchial tree. The stimuli that increase airway responsiveness can be grouped into seven major categories: allergic, pharmacologic, environmental, occupational, infectious, exercise-elated, and emotional.

Allergic asthma is dependent upon an IgE response that is controlled by T and B lymphocytes and an interaction with the IgE and mast cells. Occupational asthma can result from over 200 agents (Banks, 2000), and there are many of these agents on a farm including, wood and vegetable dusts, animal and insect dusts, secretions, and fertilizers. The prevalence of asthma in the farming environment is from 3.0-7.7% (Bessot et al., 1996).

Predictors of asthma were investigated in rural Saskatchewan by Sentilselvan et al. (1993). They found that age, level of education, and physical activity at work were significant predictors of asthma or wheezing. When stratified by sex,

grain farming was a significant predictor of asthma in men but not women. Smoking and grain farming were significant predictors of wheezing in both sexes.

In another study determinants of asthma were investigated in a farming population in Norway (Melbostad et al.,1998). They determined that the combination of animal farming, smoking, and a positive family history gave an OR of 8.1 (95%CI 4.0-16.2) for current asthma. They concluded that there was an interaction between genetic factors and exposure factors involved in the causation of asthma.

Bronchitis

Chronic bronchitis is a condition associated with excessive tracheobronchial mucus production sufficient to cause cough with expectoration for at least 3 months of the year for more than 2 consecutive years (Honig and Ingram, 1998). Smoking is the single most important etiologic factor for chronic bronchitis, however occupational and environmental factors are also important.

Chronic bronchitis in farming was studied in relation to work time and years of exposure to farming (Melbostad et al., 1997). The exposure factors were full time farming versus part time farming, livestock production, and occupational dust exposure outside agriculture. The combination of these work exposure

factors showed a 2-to-3 fold increase for bronchitis. Combinations with smoking showed a 6-fold increase.

Chronic obstructive pulmonary disease

Chronic obstructive pulmonary disease (COPD) is a generalized airways obstruction particularly of the small airways, associated with varying combinations of chronic bronchitis and emphysema (West,1987). The term COPD was introduced because these conditions often coexist, and it may be difficult in an individual case to decide which is the major cause of the obstruction. Airway obstruction is defined as an increased resistance to airflow during forced expiration. It may result from narrowing of airways secondary to intrinsic airway disease, from excessive collapse from emphysema, from bronchospasm from asthma or a combination of these factors.

OBJECTIVES AND HYPOTHESIS

Objective

The objective of the study was to determine differences in the respiratory health of various types of farmers in east-central Alberta and the effect of atopy on these differences.

Hypothesis

Differences in lung health of various types of farmers are more marked among atopic farmers than non-atopic farmers.

STUDY POPULATION AND METHODS

Two counties in east-central Alberta (Camrose and Wetaskiwin) were used for study because most farms included both livestock and grain crops. They were far enough from a major urban center so that few farmers would be commuting to urban centers for other jobs, and they were close enough to the investigators to make the study feasible.

A list of all farmers in these two counties who enrolled in the Federal Fertilizer Rebate Program was obtained from the district agriculturists. This was felt to be the most complete listing of farmers in the area, since virtually all farmers applied artificial fertilizers and were eligible for rebates. All farmers were contacted by telephone and were questioned regarding their eligibility. Eligible farmers included males between the ages of 18 and 65 who spent at least 80 percent of their time farming. Of those who were eligible, 76 percent (n=781) agreed to participate in the study. White males were studied as there were few non-white male farmers in the area and although many women were involved in farming, relatively few had full-time exposures throughout the year.

A questionnaire was administered under the supervision of trained staff. It incorporated the American Thoracic Society Adult Questionnaire (Ferris, 1978). Questions on attacks of wheeze and chest tightness were added. Detailed inquiry was made about occupational history. Nonsmokers were defined as

those who had never smoked tobacco products regularly. Ex-smokers were those who had given up smoking at least one month prior to the study.

Allergy skin tests

Testing of immediate skin reactivity to aeroallergens was performed by the skin prick method. A drop of antigen was placed on the skin and a small prick was made with a sterile needle. The largest diameter of the skin wheal was measured after 15 minutes and a measurement of 3 mm or greater than the control saline injection on any one of the tests was interpreted as positive. These farmers were considered to be atopic. The antigens were commercially prepared and included rye, wheat, house dust, *Alternaria* species, cat dander and birch tree. These were chosen because of the anticipated high frequency response, based on previous experience in this region (Herbert, et al., 1982).

Farm Classification

Statistics Canada classifies farms according to the predominant commodity grown or produced (Statistics Canada, 1996). The commodity that accounts for 51 percent or more of the total value of sales for a farm determines the farm operation. For example, a farm with total sales of 53% from beef cattle, 27% from hogs, and 20% from barley would be classified as a beef cattle farm.

This classification scheme was not feasible in this study for two reasons. First, data were not available on farm income. Second, using this definition, the type

of farm could change with commodity prices, even though exposures stayed the same.

The farms were classified according to the types of livestock and grains that were raised or grown on that farm. If a farm had multiple types of livestock or grain, then the farm had multiple classifications. Many of the farms were mixed and had multiple classifications. If a farmer had hogs, beef cattle, and turkeys, the symptoms and conditions of interest were analyzed using the three different types of livestock. The same farmer was included in the analysis as a hog farmer, beef cattle farmer, and a turkey farmer.

The types of livestock farming included in the study were dairy cattle, hogs, chickens, beef cattle, turkeys and horses. The types of grain farming included wheat, oats, canola and barley.

The farms ranged from a few animals to thousands of animals or a few acres of grain to hundreds of acres of grain, depending on the type of farm. To get a better exposure assessment the farm operations such as dairy, hogs, or wheat were grouped into or tertiles of low, medium and high farm sizes. The farm operations and farm practices are listed in Group I.

Group I: The farm operations, and farm practices included:

A) Livestock

1) Dairy cattle

2) Hogs

3) Chickens

4) Beef cattle

5) Turkeys

6) Horses

B) Grain

1) Wheat

2) Oats

3) Barley

4) Canola

C) Farm practice

1) Make silage

2) Grind grain

Data Analysis

The farmers were stratified by age and smoking status (nonsmokers, ex-smokers and current smokers). A nonsmoker was someone who never smoked as much as one cigarette a day for as much as a year, an ex-smoker was

someone who stopped smoking one month before filling out the questionnaire, and a smoker was someone who was smoking at the time of the study. Age was stratified as less than 35 years, 35-49 years and 50-64 years.

The respiratory parameters of interest included signs and symptoms, diagnosed illnesses, and lung function. These are listed below.

Group II: The respiratory conditions of interest included:

A) Signs and symptoms:

1) Usual cough
2) Phlegm
3) Shortness of breath
4) Wheeze without cold
5) Attacks of wheeze with shortness of breath
6) Chest tightness
7) Attacks of chest tightness
8) Chest tightness with shortness of breath
9) Fever, chills, flu-like symptoms

B) Diagnosed illnesses:

1) Asthma
2) Bronchitis
3) Pneumonia

C) Lung function studies:

1) FEV_1

2) FVC

3) FEV_1/FVC

The analysis of data was done on an IBM compatible computer and SPSS was used as the statistical package. Standard statistical methods used included chi-squared analysis, logistic regression, and analysis of variance.

The farm operation was stratified by size into tertiles. This was done to test the association between the size of the farm, (numbers of livestock, or acres of grain) and the respiratory condition of interest. This method allowed for an exposure-response curve to be formulated. A chi-square test for trend was done to see if the size of the farm was related to the conditions.

Logistic regression analysis was used to study the effect of respiratory condition by farm operation. Smoking and age were the two confounders controlled in the logistic regression model. For each type of farming and each respiratory condition, a sub-group analysis was done to see if the relationship between respiratory conditions and farming exposures differed between atopic and non-atopic farmers.

Spirometry was preformed in a standardized manner using a 13.5 litre Collins water-sealed spirometer (Warren E Collins, Bainttree, MA, USA). At least five forced expiratory maneuvers were completed. Analysis was performed on the largest FVC and FEV_1. Measurements were converted to body temperature and pressure saturated (BTPS).

The relationship between lung function and farming type was assessed using analysis of variance. Farmers were categorized by smoking category and each type of farmer was compared to those not farming that animal or grain. The lung functions parameters measured were FEV_1, FVC and FEV_1/FVC. Lung function results were expressed as percent of predicted using the prediction equation of Crapo et al. (1981).

RESULTS

The distribution of the 781 participating farmers and the atopic sub-group of farmers, by type of farming is presented in Table 1a. The total of the percentages exceeds 100 because many farmers raised multiple animals and/or crops. The mean age was 45.6 years and the standard deviation was 11.6 years.

The prevalence of symptoms for non-atopic farmers and atopic farmers is listed in Table 1b. The prevalence of atopy was similar to that reported in the general population (Frew, 1989). Attacks of wheeze with SOB and asthma were more prevalent among the atopic farmers.

For all farm operations with the exception of canola, the greatest number of farmers was in the age group of 50-64 years (Table 2). The canola farmers were younger on average.

Across all types of farming approximately half of the farmers were lifelong nonsmokers while less than 20 percent were current smokers (except turkey farmers) (Table 3).

The cut points used to establish tertiles of farm size for each farm operation are listed in Table 4. In most instances it was possible to divide the distribution equally into thirds.

Since many farmers raised multiple types of livestock and/or crops, it was necessary to assess the extent to which the same farmers raised individual animals/crops. This was done by calculating the ORs resulting from a series of 2-by-2 tables of one type of farming (yes/no) by the other (yes/no). These ORs are presented in Table 5. The high ORs indicate that the farmers who raised one type of animal/crop were more likely to also raise the other. The converse

is true for ORs less than one. These results were helpful in assessing similar results for different farm operations. For example, the odds of a beef farmer being a hog farmer were 2.10, the odds of a beef farmer being a chicken farmer were 2.27 and the odds of a chicken farmer being a hog farmer were 2.42.

Tables 6-15 have three parts: a, b, and c. The 'a' tables compare respiratory symptoms and diagnosed illnesses by farm size. The 'b' tables include the crude ORs and CIs for respiratory symptoms and diagnosed illnesses by the number animals or acres of grain on the farm. The 'c' tables are the adjusted ORs and CIs for respiratory symptoms and diagnosed illnesses by the number animals or acres of grain on the farm.

Tables 6a to 15a present comparisons of the respiratory symptoms or diagnosed illnesses by the type of farming stratified by farm size. The columns list the number and percent of farmers with symptoms in each category of farm size, including those who are not involved in the particular type of farming. For example in Table 6a, 48 of the farmers (13.4%), who did not raise dairy cows had a usual cough. Twenty (14.4%) of the farmers in the lowest tertile of farm size among dairy farmers had a usual cough, etc. The percentages do not add up to 100 but rather reflect the percent of farmers within the category of farm size who reported the symptom or illness.

Tables 6b to 15b are a continuation of Tables 6a to 15a. Tables 6b to 15b list the crude ORs and CIs for respiratory conditions by farm size. The low, medium and high farm sizes, in the 'b' tables, correspond to the low, medium and high farm sizes in the 'a' tables. Those who did not farm the animal or crop were used as the reference category for calculating the odds ratios. The odds of having a cough if you were a dairy farmer in a farm with a low number of animals was 1.01 (95% CI 0.61-1.88). The odds of having a cough if you were a dairy farmer on a farm with a medium number of animals was 1.26 (95% CI 0.75-2.13). The odds of having a cough if you were a dairy farmer on a farm with a high number of animals was 1.27 (95% CI 0.74-2.18).

Tables 6c to 15c are a continuation of Tables 6a and 6b to 15a and 15b. Tables 6c to 15 c list the adjusted ORs and CIs for respiratory symptoms or diagnosed illnesses by farm size. The low, medium and high farm sizes, in the 'c' tables, correspond the low, medium and high farm sizes in the 'a' and 'b' tables. As in the 'b' tables, those who did not farm the animal or crop were used as the reference category for calculating the odds ratios. The odds of having a cough if you were a dairy farmer in a farm with a low number of animals, controlling for age and smoking, was 0.91 (95% CI 0.54-1.75). The odds of having a cough if you were a dairy farmer on a farm with a medium number of animals was 1.27 (95% CI 0.74-2.20). The odds of having a cough if you were a dairy farmer in a farm with a high number of animals was 1.27 (95% CI 0.73-2.21).

A summary of the statistically significant findings from Tables 6b to 15b is given in Tables 16a and 16b for the crude data, and a summary of the statistically significant findings from Tables 6c to 15c is given in Tables 17a and 17b. Tables 17a and 17b are similar to Tables 16a and 16b, except the data were controlled for smoking and age. After controlling for smoking and age there were fewer statistically significant results but the general trend was the same for conditions and the farm operations.

Since there were 10 farm operations and 12 symptoms or diagnosed illnesses, there were numerous statistically significant findings. The odds ratios were included in the summary table as well, but not the confidence intervals because of space limitations. This was done to facilitate examination of exposure-response trends.

For livestock farmers the significant findings were mainly in the low or medium size farms with the exception of beef farming. Shortness of breath, chest tightness, and chest tightness with shortness of breath, were significantly elevated among hog, beef, and chicken farmers. The groups of farmers with the highest ORs were the chicken and beef farmers. In general the livestock farmers with low to medium numbers of animals had higher ORs than the larger farms. For turkey farmers, asthma was more common in the low and medium size farms.

The farmers who predominately farmed grain had fewer respiratory findings than the farmers who predominately farmed livestock. The wheat farmers with medium size farms had significantly less cough, phlegm and asthma than those with the low or high farm sizes. The canola farmers in the medium size farms had less cough and more flu-like symptoms than the low or high farm sizes. The oat farmers had wheeze without a cold and attacks of chest tightness in the medium size farms and chest tightness and attacks of wheeze with shortness of breath in the farms with high number of acres of oats.

Using the chi-square test for trend, each respiratory symptom/condition with individually significant findings was tested by farm size not controlled for age or smoking. Generally there was no significant trend for farm size and respiratory conditions with the exception of chicken farmers and chest tightness with shortness of breath ($p=0.008$) and this association showed a negative trend. That is, farmers were more likely to report symptoms in the smaller farms.

Tables 18 to 29 present comparisons of all farmers, regardless of farm size, who were involved in a specific type of farming compared to those farmers who were not involved in that type of farming. Tables 18a to 29a include both the crude and adjusted data. Tables 18b to 29b include the atopic farmers and the non-atopic farmers.

In Table 18a it is the farmers who raised dairy cows and had those symptoms or diagnosed illnesses listed compared to those farmers who did not raise dairy cows. Using the crude data, if you were a farmer, the odds of having a cough if you raised dairy cows was 1.20 (95%CI 0.80-1.81) compared to those farmers who did not raise dairy cows. The table also includes ORs and CIs for the same farmers but adjusted for smoking and age. Tables 18b-29b are related to Tables 18a-29a, respectively, and include separate analysis for atopic and non-atopic farmers. This presentation allows the reader to look at the crude data, adjusted data, atopic data and non-atopic data altogether for comparison.

Table 30 is a summary of the significant findings from the crude analysis (i.e., Tables 18a to 29a). The significantly elevated symptoms for chicken farmers were shortness of breath, chest tightness and chest tightness with shortness of breath. Hog farmers had the same significant symptoms as the chicken farmers. For beef farmers shortness of breath, chest tightness, and chest tightness with shortness of breath were also elevated in addition to attacks of chest tightness. Turkey farmers were significantly more likely to have asthma. Farmers with horses had the most statistically significant symptoms including shortness of breath, wheeze without a cold, attacks of wheeze with shortness of breath, chest tightness, attacks of chest tightness, chest tightness with shortness of breath, and pneumonia.

The odds ratio for usual cough for canola farmers was significantly less than 1. When the canola farmers were investigated on an age specific basis, the younger group of farmers had ORs significantly less than 1 for usual cough; the older two groups did not. Oat farmers were significantly more likely to report chest tightness and attacks of chest tightness. Grinding grain was significantly related to pneumonia and shortness of breath.

Table 31 is a summary of the significant findings using the same data adjusted for smoking and age (also from Tables 18a to 29a). The significant findings for hog and chicken farmers were shortness of breath, chest tightness, and chest tightness with shortness of breath. Beef farmers had significant findings for chest tightness and chest tightness with shortness of breath. Farmers with horses had significant findings for wheeze without a cold, attacks of wheeze with shortness of breath, chest tightness. Turkey farmers had a positive association with asthma.

The odds ratio for usual cough for wheat farmers and canola farmers were significantly less than 1. Oat farmers were significantly more likely to report chest tightness and attacks of chest tightness. Grinding grain was significantly related to pneumonia. Fewer significant associations with respiratory symptoms/conditions were found for grain farmers, compared to the livestock farmers.

Table 32 is a summary table for the atopic farmers showing the statistically significant findings. Atopic dairy farmers were more likely to report chest tightness with shortness of breath than atopic farmers who did not raise dairy cows (OR 2.88; 95%CI: 1.20-6.95). Atopic beef farmers had higher prevalence of chest tightness (OR 4.90; 95%CI: 1.30-18.50) than atopic non-beef farmers. The only illness associated with livestock farming in the atopic farmers was asthma, which was associated with turkey farming (OR 4.83; 95%CI: 1.36-17.18). This relationship between the total group of turkey farmers and asthma was also present (Table 34b).

The other positive findings were that atopic dairy farmers were significantly less likely to report shortness of breath, and atopic chicken farmers less often reported wheeze without a cold. Atopic grain farmers who farmed wheat, oats and canola had significantly less cough than atopic farmers who did not raise these crops.

Table 33 is a summary of the significant findings for the non-atopic farmers. The findings were similar to Table 31 for hogs, chickens, beef, horses and oats. The relationship between asthma and turkey farming was not significant in this group. In the non-atopic group canola farming had an OR greater than 1 for flu-like symptoms. Wheat farming had an OR less than 1 for asthma, and grinding grain had a positive association with flu-like symptoms.

Tables 34a and 34b allow for an easy comparison of the associations between symptoms/conditions and farming type for all the farmers, the atopic farmers and the non-atopic farmers. It is a condensed version of Tables 30, 31, and 32.

The data in Tables 35 to 47 compare the percent of predicted lung function for farmers who did and did not raise a particular animal/crop by smoking category. Table 48 is a summary of the statistically significant findings. In the livestock group the only significant findings were for the hog farmers. Even though there were statistically significant findings for the mean percent of predicted FEV_1 ($p=0.007$) and the mean percent of predicted FVC ($p=0.001$), the mean percent of predicted values for both the FEV_1 and FVC were close to 100 percent.

In the grain group the only statistically significant finding was in the canola farmers. The mean percent of predicted FEV_1 for canola farmers was higher than mean percent of predicted FEV_1 for the non-canola farmers ($p=0.033$). Again in the non-canola farmers the mean percent of predicted FEV_1 was close to 100 percent.

DISCUSSION

Approach

The objective of this study was to determine differences in the respiratory health of various types of farmers and the effect of atopy on these differences. Since farm sizes varied greatly, from a few animals to thousands of animals, the approach was to divide the farms into tertiles of low, medium and high numbers of animals or acres of grain farmed to see if farm size had an effect. The next step was to investigate the respiratory health of all the farmers in different farming environments, to see what the respiratory problems were, and then to see if the respiratory health of atopic farmers differed. The respiratory health was determined by symptoms, diagnosed illnesses, and lung function.

When reviewing these findings several factors have to be considered. A single significant excess of a respiratory symptom is not necessarily clinically significant. To assess a clinical significance, groups of symptoms were considered.

In addition biological plausibility and support in the literature were taken into account. If, for example, livestock farming was shown to have a protective association with wheezing, this might not have been given a lot of weight, especially if it was an isolated finding. Antigens from animals can initiate an IgE response and allergic asthma. This has been well documented in the literature

(Burrows et al., 1989). Therefore, the isolated finding that exposure to a type animal was protective for wheezing would not be viewed as important.

Symptoms that were not statistically significant or had CIs that contained 1, were reviewed to see how the ORs and CIs changed going from the crude data, to the adjusted data, and to the stratified data. Again, symptoms that could be grouped were considered more informative.

Limitations

This study had several limitations. One limitation was the internal comparison of farmers. The respiratory symptoms and diagnosed illnesses that were found in the farmers, were not compared to a non-exposed group, but compared to other farmers in different types of farming. This overlap in exposure has to taken into consideration, and may have made it more difficult to find a positive or negative association between the type of farming and the respiratory conditions of interest.

There were numerous variables and therefore many calculations in this study, so by chance alone it was possible to have a number of statistically significant results. Statistically significant findings were viewed, knowing that they could have occurred by chance alone. Emphasis was placed on significant findings that were recurrent and findings that could be grouped together. These

significant findings had to make biological sense and had to be consistent with similar findings in the literature.

This was a cross-sectional study and farmers with respiratory symptoms or atopy may have stopped farming because of these symptoms, and would not have been included in the survey. This would have reduced the percent of farmers with symptoms.

Years of farming could have been used as a surrogate measure of exposure. The farm owners were the people surveyed, but not the farm laborers. The laborers may have had different exposures than the owners.

There were no data on medications. Some asthmatics may have been well controlled, and therefore did not have respiratory symptoms.

Farm size

No significant relationship has been shown between respiratory symptoms and farm size or amount of livestock (Choma et al., 1998). Farm size in this study was not a factor that determined the respiratory health of farmers. The statistically significant respiratory symptoms, as shown in Tables 17a and 17b, occurred in all farm sizes. Dairy farmers reported symptoms in the medium size farms, but hog, chicken, horse, and turkey farmers reported most symptoms in

low and medium farms. Beef farmers had more symptoms in the high farm size.

A chi-square test for trend was done to see if there was a trend for respiratory symptoms in the larger or smaller operations. Farm size, in this study, was not related to the respiratory symptoms, therefore farm size was not useful as a surrogate for exposure.

The significant findings in the low or medium sized dairy, hog, chicken, and turkey farms may have arisen if the farmers in the smaller farms did not have the finances to install a good ventilation system. These systems are often found in the larger operations, and should improve the air quality. This may have caused increased respiratory effects among farmers in the smaller operations. Because beef farmers do a lot of outside farming, the air quality inside the barns may not be as important a factor.

Livestock Farming

Livestock farmers are exposed to animals, feed, feces, bacteria, grain mites and ammonia (Crook et al., 1991). Since the livestock farmer can be exposed to such a wide variety of substances, and since different livestock environments have potentially different exposures, the findings in this study will be discussed by farm operation.

Pig farming

Health hazards to swine confinement buildings have been documented since 1977 (Donahu et al., 1977). When pig farmers were compared to a control group of farmers they reported a significantly higher frequency of cough, sputum production, chronic bronchitis and nasal complaints. They reported higher frequencies of wheezing and flu-like symptoms (Holness et al., 1987).

This study found that pig farmers had symptoms of shortness of breath, chest tightness, and chest tightness with shortness of breath, which is compatible with the literature.

Lung function has been shown to be affected by pig farming (Donham et al., 1977, Kirychuk et al., 1998) but some studies have not seen such a decline (Holness et al., 1987, Von Essen et al., 1998).

This study also showed a statistically significant difference in percent of predicted FEV_1 for pig farmers compared to non-pig farmers. The average lung function values were close to normal, so the clinical significance of the result can be questioned. Although the lung function changes were not clinically significant, the long-term effect on these farmers is not known.

Dairy farmers

The literature is not conclusive on the effects of dairy farming on lung function and respiratory symptoms. The prevalence of symptoms in dairy farmers was significantly lower than in pig farmers (Choudat et al., 1994). Cross-sectional studies have suggested that dairy farmers have changes in their expiratory flow rates (Daulphin et al., 1989, Heller et al., 1986), while other authors have not found this to be conclusive (Malberg et al., 1985; Rautalahti et al., 1987).

The results showed that lung function tests for the dairy farmers did not differ from the non-dairy farmers. The dairy farmers did not demonstrate excess prevalence of respiratory symptoms. The dairy farmers were less likely to report shortness of breath than other farmers. This finding does not make sense biologically and the finding was rejected.

Poultry

Poultry workers have been shown to have a high prevalence of exposure related problems. Rees et al., (1993) showed that poultry workers had significantly more respiratory symptoms and asthma, but there was no association between immunological status and respiratory symptoms in poultry workers.

Zuskin et al. (1994), however, found that exposed workers with a positive skin test to poultry food extract had a higher prevalence of all respiratory symptoms

compared to those workers with a negative skin test. Reynolds (1993) found that workers who worked for more than 10 years in the turkey industry had more respiratory symptoms.

This study found that turkey farmers had an increased prevalence of asthma, OR 2.67 (95%CI, 1.29-5.61), but the turkey farmers did not report increased symptoms of asthma or airway hyperresponsiveness. It may be that the turkey farmers with asthma were well controlled on medication, or managed to reduce their exposure because they knew they would develop symptoms.

When the total group of turkey farmers was stratified into atopic and non-atopic farmers, the association between turkey farming and asthma appeared stronger among the atopic turkey farmers (Table 23b) OR 4.83 (95%CI 1.36-17.18). However, the sample size was small (n=23), and this gave a wide 95%CI (1.36-17.18). If the sample size were larger the CI would narrow so the true value may or may not be significantly different. This association is interesting and may be worth further investigation.

Horses

The prevalence of asthma has been shown to be high in horse breeders/groomers (Kimbell-Dunn et al., 1999), and horse allergy can cause a wide range of clinical symptoms including respiratory distress (Roberts and Lack, 2000).

This study found that horses were associated with multiple respiratory symptoms. Farmers with horses were the only group of farmers to have wheezing positively associated with farm operation. Wheeze without a cold, attacks of wheeze, and chest tightness were the symptoms associated with horse farming.

Grain farming

Grain dust

The high prevalence of respiratory symptoms among grain workers when compared to referent groups has been well documented in the literature (Chan-Yeung et al., 1992; Broder et al., 1979; Dosman et al., 1980; Herbert, 1981). The increase in symptoms include cough, phlegm, wheeze, and dyspnea (Chan-Yeung et al., 1992; Broder et al., 1979). Most of this work was done in grain elevator workers. Manfreda et al. (1989) studied farmers who were exposed to grain dust for 2 months of the year. They found no association between symptoms and exposure to grain. A study of New Zealand farmers found that the prevalence of asthma symptoms was greater in livestock farmers and oat farmers (Kimbell-Dunn et al., 1999)

In the present study grain farmers did not have as many symptoms as livestock farmers. The oat farmers were the exception. They had symptoms of chest tightness and attacks of chest tightness, but no changes in lung function.

Grain farmers are not exposed to the high concentration of grain dust nor are the farmers exposed to grain dust year round like the grain elevator workers. This may explain the reduced symptoms seen in the grain farmers compared to the grain elevator workers. Also, livestock farmers are exposed to dust, mites, dander and chemicals year round in the indoor barn environment. This difference in environment may explain some of the increased symptoms seen in livestock farmers.

Oil for dust suppression

Canola oil has been used for dust suppression in pig barns (Senthilselvan, 1997). Inhalation dust concentrations and endotoxin levels were lower in the barns after the canola oil was sprayed. The FEV_1 was measured before and after a 5-hour shift, and the workers in the barn where the canola oil was sprayed had a smaller decline in lung function at the end of the shift.

In this study canola was not actively sprayed for dust suppression but farmed as a crop. Farmers who grew canola were less likely to report cough OR 0.62 (95% CI 0.41-0.94). The reasons for this finding are not apparent at this time. When the canola farmers were investigated on an age-specific basis, the younger farmers reported significantly less cough, but the middle age group and the older farmers did not. This relationship was seen in the crude data, and adjusting for smoking.

Wheat farmers also reported fewer symptoms of usual cough compared to those who did not raise wheat OR 0.59 (95%CI 0.37-0.93). This finding may be explained by the looking at the odds of canola farming and wheat farming. The odds of farming wheat and canola were 15.84 (Table 5). The wheat farmers, who reported fewer symptoms of usual cough, may have done so because they also farmed canola, and it was the effect of canola oil on dust suppression.

Effect of atopy

The study by Van Niekerk and Weich, (1989) found symptoms suggestive of allergy in 90% of the farm workers, however, the IgE levels were not raised, and the authors thought that mechanisms other than allergy were responsible for the farm workers' symptoms.

In a study of the effect of atopy on longitudinal decline in lung function (Tabona et al., 1984) there was no difference in longitudinal decline in lung function between those with and those without immediate skin reactivity to any of the common allergens tested. No correlation between chest symptoms and atopy or longitudinal decline in lung function was found.

In this study, when all the farmers were grouped together and then stratified according to atopy, the main symptoms were chest tightness, chest tightness with shortness of breath, or shortness of breath in the total group and the non-

atopic group. Table 33a and 33b are summary tables of all the farmers plus atopic farmers and non-atopic farmers for all farm sizes.

The atopic group had odds ratios less than one for shortness of breath and wheeze without a cold. These findings may have occurred by chance as there is no biological reason to explain why dairy farming would decrease shortness of breath or chicken farming would decrease wheeze without a cold.

The exception was chest tightness and beef farmers. Chest tightness can be a respiratory or cardiac symptom. Since it was only a symptom and not a grouping of symptoms, chest tightness alone in atopic farmers does not support our hypothesis.

The hypothesis that atopy can modify the respiratory health of farmers was not supported by the data.

Symptoms and disease process

Cardiac disease, pulmonary disease, hematological disease or general unwellness can present with many of the chest symptoms found in this study. Angina pectoris can present with chest discomfort described as heaviness, squeezing, tightness (Selwyn and Braunwald, 1998). It can occur with exertion, at rest, or at night with chest discomfort and dyspnea. Hematological problems such as anemia often represent cardiovascular and pulmonary adjustments,

and the symptoms can include chest tightness or shortness of breath (Hillman, 1998).

The symptoms seen in this study such as chest tightness and chest tightness with shortness of breath, were suggestive respiratory or cardiac problems. These symptoms could be early signs that a farmer may develop respiratory problems in the future, but they were not diagnostic for a respiratory disease at that time.

The hog farmers, the beef farmers, and the chicken farmers had symptoms of chest tightness, chest tightness with shortness of breath, or shortness of breath. These symptoms are not diagnostic for any disease although they are consistent with bronchial responsiveness. However, from these symptoms alone, it is not possible to suggest which disease process was most likely to be responsible or if it was a combination of disease processes.

Healthy worker effect

The healthy worker effect (HWE) has to be considered in most occupational studies. The HWE is not a new concept and was described by Ogle in 1885 (Arrighi and Hertz-Picciotto, 1993). The term HWE was first used by McMichael (1975). The HWE refers to a continuing selection process such that those who remain in the workforce or employed at a particular job will tend to be healthier than those who leave employment. In many industries approximately half the

individuals that are hired quit or are terminated within a year (Choi, 1993). Grain workers have stopped farming because of respiratory symptoms (Dosman et al., 1991). The ability to detect adverse effects in grain handlers was diminished by the selective loss of more severely affected workers from the grain handler population (Broder et al, 1985). It is possible that farmers stopped farming because of increased respiratory symptoms while farming. The healthy worker effect has been considered a source for selection bias (Li and Sung, 1999), and the results from this study could have been affected. The result would have been to see less respiratory symptoms in this group of farmers.

Patient advice

When giving information to a patient, all the information gathered from a study has to be considered in light of the patients' present condition, past medical history, family history, financial status, and the patients' willingness to be monitored and followed.

The odds of developing asthma if the farmer was a turkey farmer is greater than for other farmers, so it may be worthwhile to try to monitor these individuals. Monitoring would depend on the individual patient and their circumstances. Monitoring programs may be a worthwhile effort for the symptomatic farmers Hopefully the monitoring would allow for an earlier diagnosis of asthma, and earlier intervention to prevent further progression of the disease.

Conclusions

The size of the farming operation did not have an impact on respiratory health of farmers. If a farmer has experienced respiratory symptoms, downsizing will not help his symptoms. Conversely, if a farmer is having respiratory symptoms, enlarging his farm will not make his symptoms worse.

The livestock farmers reported more symptoms than the grain farmers did. If a farmer is having respiratory symptoms, then changing to grain farming from livestock farming may be beneficial.

Atopy did not have an effect on the respiratory symptoms of farmers and this hypothesis was rejected. Based on the findings in this study, atopic farmers would not benefit from changing their farming practices because of their atopy.

Turkey farmers reported having more asthma. The total number of turkey farmers and atopic turkey farmers was small. These findings justify further investigations to see if the association between turkey farmers and asthma is present in other turkey farmers. Symptomatic turkey farmers may benefit from a monitoring program.

Canola farmers reported less usual cough and had statistically better lung function. There was a statistically significant decrease in the lung function of pig farmers.

Table 1a Number and percent of all farmers and atopic farmers in each type of farming

Farm type	All Farmers		Atopic Farmers	
	n	Percent	n	Percent
Dairy	432	55.3	82	19.0
Hogs	547	70.0	104	19.0
Chickens	431	55.2	83	19.3
Beef cattle	650	83.2	126	19.4
Horses	306	39.2	66	21.6
Turkeys	123	15.7	23	18.7
Wheat	603	77.2	121	20.1
Oats	509	65.2	97	19.1
Canola	460	58.9	93	20.2
Barley	730	93.2	141	19.3

Table 1b Prevalence of symptoms for atopic and non-atopic farmers

	Farmer status	
	Atopic	Non-atopic
Symptom or diagnosed illness	%	%
Usual cough	18.2	13.9
Phlegm	20.1	21.8
Shortness of breath	21.4	24.2
Wheeze without a cold	55.8	46.2
Attacks of wheeze with SOB	17.5	8.3
Chest tightness	29.9	26.4
Attacks of chest tightness	10.4	14.2
Chest tightness with SOB	20.8	11.2
Fever, chills, flu-like symptoms	15.6	16.0
Asthma	8.4	3.7
Bronchitis	18.8	16.0
Pneumonia	26.0	24.3

TABLE 2 Farming operation and age category with percentage

Farm operation	Age (years) < 35 n (%)	35-49 n (%)	50-64 n (%)	Total n
Dairy	78 (18.1)	134 (31.0)	220 (50.9)	432
Hogs	87 (15.9)	194 (34.5)	266 (48.6)	547
Chickens	70 (16.2)	142 (32.9)	219 (50.8)	431
Beef cattle	128 (19.7)	238 (36.6)	284 (43.7)	650
Horses	49 (16.0)	106 (34.6)	151 (49.3)	306
Turkeys	21 (17.1)	46 (37.4)	56 (45.5)	123
Wheat	131 (21.7)	232 (38.5)	240 (39.8)	603
Oats	113 (22.2)	188 (36.9)	208 (40.9)	509
Canola	112 (24.3)	192 (41.7)	156 (33.9)	460
Barley	161 (22.1)	271 (37.1)	298 (40.8)	730

TABLE 3 Comparison of farming operation by smoking category

Farm operation	Smoking category: Nonsmoker	Ex-smoker	Current smoker	Total
	n (%)	n (%)	n (%)	n
Dairy	226 (52.4)	129 (29.9)	76 (17.7)	431
Hogs	285 (52.2)	167 (30.6)	94 (17.2)	546
Chickens	221 (51.4)	139 (32.3)	70 (16.2)	430
Beef cattle	337 (51.9)	195 (30.1)	117 (18.0)	649
Horses	149 (48.7)	103 (33.7)	54 (17.6)	306
Turkeys	61 (49.6)	36 (29.3)	26 (21.1)	123
Wheat	318 (52.8)	168 (27.9)	116 (19.3)	602
Oats	269 (53.0)	147 (28.9)	92 (18.1)	508
Canola	249 (54.1)	130 (28.3)	81 (17.6)	460
Barley	386 (53.0)	211 (28.9)	132 (18.1)	729

Note that farmer groups were not mutually exclusive

TABLE 5 Odds ratios for cross tabulations of farming operations

	Dairy	Beef	Hogs	Chicks	Horses	Turkeys	Wheat	Oats	Canola	Barley
Dairy										
Beef	1.04									
Hogs	2.06	2.10								
Chicks	1.90	2.27	2.42							
Horses	1.42	3.48	1.50	2.15						
Turkeys	2.13	1.54	1.94	11.59	1.82					
Wheat	0.61	1.59	1.41	1.02	0.71	0.79				
Oats	1.82	2.43	1.11	1.17	1.58	1.00	0.52			
Canola	0.60	0.99	1.09	0.65	0.88	0.60	15.84	0.39		
Barley	1.82	3.38	1.42	2.18	0.76	0.65	3.96	3.77	2.81	

TABLE 6a Comparison of respiratory symptoms and diagnosed illnesses by farm size for **dairy cows**

Symptom or diagnosed illness	Farm size: No cows		Low		Medium		High	
	n	(%)	n	(%)	n	(%)	n	(%)
Usual cough	48	(13.4)	20	(14.4)	25	(16.6)	23	(16.7)
Phlegm	79	(22.4)	27	(19.4)	30	(20.0)	31	(22.5)
Shortness of breath	85	(24.1)	32	(23.0)	45	(29.8)	23	(16.7)
Wheeze without a cold	179	(50.1)	62	(44.6)	76	(49.7)	60	(56.5)
Attacks of wheeze with SOB	32	(9.1)	11	(7.9)	25	(16.6)	12	(8.8)
Chest tightness	95	(26.9)	39	(28.1)	52	(34.4)	27	(19.6)
Attacks of chest tightness	36	(10.2)	12	(8.6)	26	(17.2)	14	(10.1)
Chest tightness with SOB	49	(13.9)	24	(17.3)	37	(24.5)	13	(9.4)
Fever, chills, flu-like symptoms	52	(14.7)	19	(13.7)	35	(23.2)	18	(13.0)
Asthma	15	(4.3)	3	(2.2)	14	(9.3)	5	(3.7)
Bronchitis	58	(16.5)	22	(15.8)	24	(16.1)	25	(18.2)
Pneumonia	83	(23.9)	33	(23.7)	43	(28.9)	33	(24.3)

TABLE 6b Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **dairy cows** on the farm

Symptom or diagnosed illness	Farm size Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.07	(0.61-1.88)	1.26	(0.75-2.13)	1.27	(0.74-2.18)
Phlegm	0.84	(0.51-1.36)	0.87	(0.54-1.39)	1.01	(0.63-1.61)
Shortness of breath	0.94	(0.59-1.50)	1.34	(0.88-2.05)	0.63	(0.38-1.05)
Wheeze without a cold	0.78	(0.53-1.16)	0.99	(0.67-1.44)	0.75	(0.50-1.11)
Attacks of wheeze with SOB	0.85	(0.42-1.75)	1.97	(1.12-3.46)	0.95	(0.48-1.91)
Chest tightness	1.06	(0.68-1.64)	1.43	(0.95-2.15)	0.66	(0.41-1.07)
Attacks of chest tightness	0.83	(0.42-1.65)	1.83	(1.06-3.16)	0.99	(0.52-1.91)
Chest tightness with SOB	1.30	(0.76-2.21)	2.01	(1.25-3.25)	0.65	(0.34-1.23)
Fever, chills, flu-like symptoms	0.92	(0.52-1.62)	1.81	(1.13-2.92)	0.87	(0.49-1.55)
Asthma	0.49	(0.14-1.73)	2.29	(1.07-4.86)	0.86	(0.31-2.42)
Bronchitis	0.95	(0.56-1.63)	0.97	(0.58-1.64)	1.13	(0.68-1.90)
Pneumonia	0.99	(0.63-1.58)	1.34	(0.87-2.06)	1.02	(0.64-1.63)

TABLE 6c Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **dairy cows** on the farm controlling for smoking and age

Symptom or diagnosed illness	Farm size					
	Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	0.91	(0.54-1.75)	1.27	(0.74-2.20)	1.27	(0.73-2.21)
Phlegm	0.84	(0.51-1.44)	0.88	(0.54-1.44)	1.01	(0.62-1.62)
Shortness of breath	0.59	(0.36-0.98)	1.00	(0.64-1.58)	0.56	(0.33-0.96)
Wheeze without a cold	0.67	(0.44-1.02)	0.93	(0.62-1.40)	0.72	(0.48-1.09)
Attacks of wheeze with SOB	0.81	(0.39-1.69)	2.02	(1.14-3.61)	0.95	(0.47-1.91)
Chest tightness	1.00	(0.64-1.58)	1.40	(0.92-2.13)	0.65	(0.40-1.06)
Attacks of chest tightness	0.73	(0.36-1.47)	1.63	(0.93-2.86)	0.98	(0.51-1.88)
Chest tightness with SOB	1.14	(0.65-1.97)	1.86	(1.14-3.06)	0.63	(0.33-1.21)
Fever, chills, flu-like symptoms	0.96	(0.54-1.71)	1.92	(1.18-3.12)	0.87	(0.49-1.55)
Asthma	0.42	(0.17-1.49)	2.13	(0.98-4.62)	0.84	(0.30-2.36)
Bronchitis	0.87	(0.50-1.51)	0.94	(0.55-1.60)	1.13	(0.67-1.89)
Pneumonia	0.80	(0.49-1.29)	1.15	(0.74-1.80)	0.99	(0.62-1.59)

TABLE 7a Comparison of respiratory symptoms and diagnosed illnesses by farm size for **hogs**

Symptom or diagnosed illness	Farm size							
	No Hogs		Low		Medium		High	
	n	(%)	n	(%)	n	(%)	n	(%)
Usual cough	40	(14.1)	31	(19.0)	23	(12.0)	22	(15.5)
Phlegm	61	(21.5)	25	(15.5)	41	(21.2)	40	(28.2)
Shortness of breath	47	(16.5)	52	(31.9)	55	(28.6)	31	(21.8)
Wheeze without a cold	137	(48.2)	80	(49.1)	91	(47.4)	69	(48.6)
Attacks of wheeze with SOB	23	(8.2)	24	(14.7)	19	(9.9)	14	(9.9)
Chest tightness	62	(21.8)	51	(31.3)	62	(32.3)	38	(26.8)
Attacks of chest tightness	26	(9.2)	23	(14.1)	28	(14.6)	11	(7.7)
Chest tightness with SOB	29	(10.2)	35	(21.5)	38	(19.8)	21	(14.8)
Fever, chills, flu-like symptoms	39	(13.7)	26	(16.0)	41	(21.4)	18	(12.7)
Asthma	12	(4.3)	13	(8.0)	8	(4.2)	4	(2.8)
Bronchitis	56	(19.9)	24	(14.7)	29	(15.2)	20	(14.1)
Pneumonia	67	(24.0)	38	(23.3)	50	(26.5)	37	(26.2)

TABLE 7b Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **hogs** on the farm

Symptom or diagnosed illness	Farm size Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.44	(0.86-2.42)	0.83	(0.48-1.43)	1.12	(0.64-1.97)
Phlegm	0.67	(0.40-1.12)	0.97	(0.63-1.54)	1.43	(0.90-2.23)
Shortness of breath	2.38	(1.51-3.76)	2.01	(1.29-3.13)	1.41	(0.85-2.37)
Wheeze without a cold	1.05	(0.71-1.54)	0.96	(0.67-1.38)	1.01	(0.67-1.52)
Attacks of wheeze with SOB	1.95	(1.06-3.58)	1.23	(0.65-2.33)	1.23	(0.61-2.46)
Chest tightness	1.66	(1.07-2.54)	1.70	(1.12-2.56)	1.31	(0.82-2.09)
Attacks of chest tightness	1.64	(0.90-2.99)	1.68	(0.95-2.97)	0.83	(0.40-1.74)
Chest tightness with SOB	2.42	(1.42-4.14)	2.16	(1.28-3.64)	1.53	(0.84-2.79)
Fever, chills, flu-like symptoms	1.20	(0.70-2.06)	1.75	(1.08-2.83)	0.91	(0.50-1.66)
Asthma	1.94	(0.86-4.36)	0.97	(0.39-2.41)	0.65	(0.20-2.04)
Bronchitis	0.70	(0.41-1.18)	0.72	(0.44-1.17)	0.66	(0.38-1.15)
Pneumonia	0.97	(0.62-1.53)	1.16	(0.76-1.77)	1.13	(0.71-1.79)

TABLE 7c Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **hogs** on the farm controlling for smoking and age

Symptom or diagnosed illness	Farm size					
	Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.27	(0.74-2.18)	0.68	(0.38-1.21)	1.01	(0.99-1.03)
Phlegm	0.65	(0.38-1.10)	0.93	(0.57-1.49)	1.43	(0.89-2.30)
Shortness of breath	1.79	(1.11-2.89)	1.25	(0.78-2.01)	1.10	(0.65-1.86)
Wheeze without a cold	0.90	(0.60-1.36)	0.75	(0.50-1.12)	0.91	(0.59-1.38)
Attacks of wheeze with SOB	1.84	(0.99-3.45)	1.14	(0.59-2.21)	1.18	(0.58-2.39)
Chest tightness	1.58	(1.01-2.47)	1.56	(1.01-2.41)	1.27	(0.79-2.04)
Attacks of chest tightness	1.49	(0.81-2.75)	1.41	(0.78-2.57)	0.77	(0.37-1.62)
Chest tightness with SOB	2.17	(1.25-3.76)	1.78	(1.03-3.08)	1.40	(0.76-2.58)
Fever, chills, flu-like symptoms	1.26	(0.73-2.19)	1.89	(1.14-3.14)	0.95	(0.52-1.74)
Asthma	1.65	(0.72-3.78)	0.77	(0.30-1.99)	0.57	(0.18-1.81)
Bronchitis	0.62	(0.36-1.05)	0.60	(0.36-1.01)	0.60	(0.34-1.05)
Pneumonia	0.79	(0.50-1.27)	0.86	(0.55-1.34)	0.97	(0.60-1.56)

TABLE 8a Comparison of respiratory symptoms and diagnosed illnesses by farm size for **chickens**

Symptom or diagnosed illness	Farm size: No chickens		Low		Medium		High	
	n	(%)	n	(%)	n	(%)	n	(%)
Usual cough	45	(12.9)	31	(18.9)	21	(18.3)	18	(13.7)
Phlegm	77	(22.0)	32	(19.6)	21	(18.3)	34	(30.0)
Shortness of breath	57	(16.3)	51	(31.1)	40	(34.8)	29	(22.1)
Wheeze without a cold	173	(49.4)	82	(50.0)	56	(48.7)	58	(44.3)
Attacks of wheeze with SOB	34	(9.8)	23	(14.0)	13	(11.5)	8	(6.1)
Chest tightness	73	(20.9)	60	(36.6)	38	(33.0)	36	(27.5)
Attacks of chest tightness	34	(9.7)	24	(14.6)	16	(13.9)	12	(9.2)
Chest tightness with SOB	35	(10.0)	42	(25.6)	25	(21.7)	17	(13.0)
Fever, chills, flu-like symptoms	49	(14.0)	28	(17.1)	21	(18.3)	21	(16.0)
Asthma	14	(4.1)	12	(7.4)	8	(7.1)	2	(1.5)
Bronchitis	53	(15.2)	22	(13.6)	25	(21.7)	24	(18.5)
Pneumonia	79	(22.8)	38	(23.9)	31	(27.0)	40	(30.5)

TABLE 8b Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **chickens** on the farm

Symptom or diagnosed illness	Farm size: Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.58	(0.96-2.61)	1.51	(0.86-2.67)	1.08	(0.60-1.94)
Phlegm	0.87	(0.55-1.36)	0.79	(0.46-1.35)	1.24	(0.78-1.98)
Shortness of breath	2.32	(1.50-3.57)	2.74	(1.70-4.42)	1.46	(0.87-2.41)
Wheeze without a cold	1.02	(0.71-1.48)	0.97	(0.64-1.48)	0.81	(0.54-1.22)
Attacks of wheeze with SOB	1.51	(0.86-2.65)	1.20	(0.61-2.36)	0.60	(0.27-1.33)
Chest tightness	2.19	(1.45-3.30)	1.87	(1.18-2.99)	1.44	(0.91-2.28)
Attacks of chest tightness	1.59	(0.91-2.79)	1.50	(0.80-2.84)	0.94	(0.47-1.87)
Chest tightness with SOB	3.10	(1.89-5.08)	2.50	(1.42-4.40)	1.34	(0.72-2.49)
Fever, chills, flu-like symptoms	1.27	(0.76-2.10)	1.37	(0.78-2.41)	1.24	(0.72-2.15)
Asthma	1.87	(0.84-4.14)	1.79	(0.73-4.39)	0.37	(0.08-1.64)
Bronchitis	0.88	(0.51-1.50)	1.55	(0.91-2.64)	1.27	(0.74-2.15)
Pneumonia	1.07	(0.68-1.66)	1.25	(0.77-2.03)	1.55	(0.99-2.42)

TABLE 8c Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **chickens** on the farm controlling for smoking and age

Symptom or diagnosed illness	Farm size: Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.54	(0.91-2.60)	1.44	(0.80-2.61)	1.18	(0.61-2.05)
Phlegm	0.89	(0.55-1.43)	0.80	(0.46-1.38)	1.28	(0.79-2.07)
Shortness of breath	1.80	(1.14-2.85)	2.08	(1.25-3.44)	1.17	(0.69-1.98)
Wheeze without a cold	0.95	(0.64-1.40)	0.87	(0.56-1.36)	0.78	(0.51-1.19)
Attacks of wheeze with SOB	1.48	(0.82-2.64)	1.15	(0.58-2.32)	0.61	(0.27-1.37)
Chest tightness	2.18	(1.43-3.33)	1.84	(1.14-2.97)	1.43	(0.89-2.30)
Attacks of chest tightness	1.44	(0.81-2.26)	1.34	(0.70-2.56)	0.80	(0.39-1.65)
Chest tightness with SOB	2.87	(1.73-4.78)	2.26	(1.27-4.04)	1.21	(0.64-2.30)
Fever, chills, flu-like symptoms	1.34	(0.80-2.25)	1.45	(0.82-2.57)	1.32	(0.76-2.31)
Asthma	1.73	(0.76-3.91)	1.63	(0.65-4.09)	0.36	(0.08-1.61)
Bronchitis	0.82	(0.48-1.43)	1.45	(0.84-2.49)	1.25	(0.73-2.15)
Pneumonia	0.92	(0.58-1.44)	1.06	(0.64-1.74)	1.38	(0.87-2.18)

TABLE 9a Comparison of respiratory symptoms and diagnosed illnesses by farm size for **beef cattle**

Symptom or diagnosed illness	No beef cattle		Farm size Low		Medium		High	
	n	(%)	n	(%)	n	(%)	n	(%)
Usual cough	29	(14.5)	31	(15.7)	26	(14.0)	30	(15.1)
Phlegm	46	(23.0)	46	(23.5)	37	(19.9)	38	(19.2)
Shortness of breath	32	(16.0)	53	(26.9)	47	(25.3)	53	(26.8)
Wheeze without a cold	95	(47.5)	86	(43.7)	90	(48.4)	106	(53.5)
Attacks of wheeze with SOB	16	(8.0)	22	(11.3)	19	(10.2)	23	(11.7)
Chest tightness	32	(16.0)	53	(26.9)	62	(33.3)	66	(33.3)
Attacks of chest tightness	12	(6.0)	25	(12.7)	24	(12.9)	27	(13.6)
Chest tightness with SOB	19	(9.5)	34	(17.3)	33	(17.7)	37	(18.7)
Fever, chills, flu-like symptoms	24	(12.0)	30	(15.2)	33	(17.7)	38	(19.2)
Asthma	5	(2.6)	14	(7.1)	9	(4.9)	9	(4.7)
Bronchitis	38	(19.1)	27	(13.8)	29	(15.7)	35	(17.7)
Pneumonia	42	(21.2)	49	(25.1)	52	(28.4)	49	(25.0)

TABLE 9b Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **beef cattle** on the farm

Symptom or diagnosed illness	Farm size Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.01	(0.64-1.91)	0.97	(0.54-1.70)	1.10	(0.61-1.83)
Phlegm	1.03	(0.64-1.64)	0.83	(0.51-1.35)	0.80	(0.49-1.29)
Shortness of breath	1.93	(1.18-3.16)	1.78	(1.07-2.93)	1.92	(1.17-3.14)
Wheeze without a cold	0.86	(0.58-1.27)	1.04	(0.70-1.55)	1.27	(0.86-1.89)
Attacks of wheeze with SOB	1.46	(0.74-2.88)	1.31	(0.65-2.63)	1.53	(0.78-2.99)
Chest tightness	1.93	(1.18-3.16)	2.62	(1.62-4.27)	2.62	(1.62-4.24)
Attacks of chest tightness	2.28	(1.11-4.67)	2.32	(1.13-4.79)	2.47	(1.22-5.03)
Chest tightness with SOB	1.99	(1.09-3.62)	2.06	(1.12-3.76)	2.19	(1.21-3.96)
Fever, chills, flu-like symptoms	1.32	(0.74-2.35)	1.58	(0.90-2.79)	1.74	(1.00-3.03)
Asthma	2.93	(1.04-8.32)	1.95	(0.64-5.93)	1.87	(0.62-5.68)
Bronchitis	0.68	(0.40-1.16)	0.79	(0.46-1.34)	0.92	(0.55-1.52)
Pneumonia	1.25	(0.78-1.99)	1.51	(0.95-2.42)	1.24	(0.77-1.98)

TABLE 9c Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **beef cattle** on the farm controlling for smoking and age

Symptom or diagnosed illness	Farm size					
	Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.02	(0.58-1.79)	0.88	(0.49-1.58)	0.99	(0.56-1.75)
Phlegm	0.99	(0.61-1.60)	0.82	(0.50-1.35)	0.80	(0.49-1.31)
Shortness of breath	1.59	(0.95-2.66)	1.44	(0.85-2.43)	1.56	(0.93-2.60)
Wheeze without a cold	0.76	(0.50-1.15)	0.95	(0.62-1.44)	1.20	(0.80-1.82)
Attacks of wheeze with SOB	1.41	(0.71-2.80)	1.26	(0.62-2.55)	1.49	(0.75-2.94)
Chest tightness	1.84	(1.12-3.04)	2.58	(1.57-4.22)	2.60	(1.60-4.24)
Attacks of chest tightness	2.06	(0.99-4.26)	2.17	(1.05-4.50)	2.32	(1.13-4.75)
Chest tightness with SOB	1.79	(0.97-3.27)	1.89	(1.02-3.48)	2.03	(1.11-3.70)
Fever, chills, flu-like symptoms	1.35	(0.75-2.41)	1.62	(0.91-2.87)	1.79	(1.02-3.14)
Asthma	2.71	(0.95-7.73)	1.78	(0.58-5.47)	1.70	(0.55-5.22)
Bronchitis	0.64	(0.37-1.10)	0.74	(0.43-1.27)	0.86	(0.51-1.44)
Pneumonia	1.10	(0.68-1.78)	1.35	(0.84-2.18)	1.10	(0.68-1.77)

TABLE 10a Comparison of respiratory symptoms and diagnosed illnesses by farm size for **horses**

Symptom or diagnosed illness	Farm size: No horses		Low		Medium		High	
	n	(%)	n	(%)	n	(%)	n	(%)
Usual cough	68	(14.3)	24	(19.7)	12	(16.0)	12	(11.2)
Phlegm	101	(21.2)	35	(28.7)	18	(24.0)	13	(12.1)
Shortness of breath	98	(20.5)	35	(28.7)	20	(26.7)	32	(29.9)
Wheeze without a cold	210	(44.0)	67	(54.9)	43	(57.3)	57	(53.3)
Attacks of wheeze with SOB	39	(8.2)	17	(14.0)	11	(14.7)	13	(12.3)
Chest tightness	111	(23.3)	44	(36.1)	29	(38.7)	29	(27.1)
Attacks of chest tightness	44	(9.2)	20	(16.4)	12	(16.0)	12	(11.2)
Chest tightness with SOB	64	(13.4)	22	(18.0)	17	(22.7)	20	(18.7)
Fever, chills, flu-like symptoms	70	(14.7)	23	(18.9)	19	(25.3)	13	(12.1)
Asthma	17	(3.6)	7	(5.8)	8	(10.8)	5	(4.7)
Bronchitis	75	(15.8)	23	(18.9)	13	(17.6)	18	(17.0)
Pneumonia	104	(22.2)	37	(30.6)	16	(21.3)	36	(33.6)

TABLE 10b Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **horses** on the farm

Symptom or diagnosed illness	Farm size: Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.47	(0.88-2.47)	1.15	(0.59-2.24)	0.76	(0.40-1.46)
Phlegm	1.49	(0.95-2.34)	1.17	(0.66-2.08)	0.51	(0.28-0.96)
Shortness of breath	1.56	(0.99-2.44)	1.41	(0.81-2.46)	1.65	(1.03-2.64)
Wheeze without a cold	1.55	(1.04-2.31)	1.71	(1.05-2.79)	1.45	(0.95-1.21)
Attacks of wheeze with SOB	1.83	(0.99-3.36)	1.92	(0.94-3.94)	1.56	(0.80-3.04)
Chest tightness	1.86	(1.22-2.85)	2.08	(1.25-3.47)	1.23	(0.76-1.97)
Attacks of chest tightness	1.93	(1.09-3.42)	1.87	(0.94-3.74)	1.24	(0.63-2.44)
Chest tightness with SOB	1.42	(0.83-2.42)	1.89	(1.04-3.45)	1.48	(0.85-2.58)
Fever, chills, flu-like symptoms	1.35	(0.80-2.27)	1.97	(1.11-3.52)	0.80	(0.43-1.51)
Asthma	1.63	(0.66-4.03)	3.22	(1.34-7.76)	1.32	(0.48-3.65)
Bronchitis	1.24	(0.74-2.08)	1.14	(0.60-2.17)	1.09	(0.62-1.92)
Pneumonia	1.55	(0.99-2.41)	0.95	(0.53-1.74)	1.78	(1.13-2.81)

TABLE 10c Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **horses** on the farm controlling for smoking and age

Symptom or diagnosed illness	Farm size: Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.47	(0.86-2.49)	1.07	(0.54-2.12)	0.64	(0.33-1.27)
Phlegm	1.52	(0.96-2.40)	1.13	(0.63-2.03)	0.50	(0.26-0.95)
Shortness of breath	1.58	(0.99-2.54)	1.35	(0.75-2.41)	1.04	(0.63-1.72)
Wheeze without a cold	1.58	(1.05-2.40)	1.65	(0.99-2.76)	1.29	(0.82-2.02)
Attacks of wheeze with SOB	1.81	(0.98-3.35)	1.85	(0.90-3.82)	1.47	(0.74-2.95)
Chest tightness	1.88	(1.22-2.89)	2.04	(1.22-3.43)	1.13	(0.69-1.86)
Attacks of chest tightness	1.95	(1.10-3.47)	1.87	(0.93-3.75)	1.07	(0.53-2.16)
Chest tightness with SOB	1.42	(0.83-2.44)	1.85	(1.01-3.41)	1.25	(0.70-2.22)
Fever, chills, flu-like symptoms	1.35	(0.80-2.27)	1.95	(1.09-3.47)	0.81	(0.42-1.55)
Asthma	1.60	(0.65-3.97)	3.11	(1.28-7.52)	1.07	(0.37-3.05)
Bronchitis	1.22	(0.73-2.06)	1.10	(0.57-2.11)	0.97	(0.54-1.75)
Pneumonia	1.54	(0.98-2.41)	0.92	(0.50-1.67)	1.44	(0.89-2.31)

TABLE 11a Comparison of respiratory symptoms and diagnosed illnesses by farm size for **turkeys**

Symptom or diagnosed illness	Farm size							
	No turkeys		Low		Medium		High	
	n	(%)	n	(%)	n	(%)	n	(%)
Usual cough	95	(14.3)	8	(16.3)	7	(21.2)	6	(17.6)
Phlegm	141	(21.2)	9	(18.4)	9	(28.1)	8	(23.5)
Shortness of breath	154	(23.2)	14	(28.6)	7	(21.2)	10	(29.4)
Wheeze without a cold	316	(47.5)	25	(51.0)	13	(39.4)	23	(32.4)
Attacks of wheeze with SOB	63	(9.5)	9	(18.4)	5	(15.2)	3	(8.8)
Chest tightness	180	(27.1)	11	(22.4)	13	(39.4)	9	(26.5)
Attacks of chest tightness	72	(10.8)	6	(12.2)	5	(15.2)	5	(14.7)
Chest tightness with SOB	101	(15.2)	8	(16.3)	8	(24.2)	6	(17.6)
Fever, chills, flu-like symptoms	110	(16.5)	4	(8.2)	6	(18.2)	5	(14.7)
Asthma	25	(3.8)	6	(12.2)	4	(12.1)	2	(5.9)
Bronchitis	114	(17.2)	6	(12.2)	3	(9.7)	6	(17.6)
Pneumonia	166	(25.3)	10	(20.4)	10	(31.3)	7	(20.6)

TABLE 11b Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **turkeys** on the farm

Symptom or diagnosed illness	Farm size					
	Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.17	(0.53-2.58)	1.62	(0.68-3.83)	1.29	(0.52-3.19)
Phlegm	0.84	(0.40-1.76)	1.45	(0.66-3.21)	1.14	(0.51-2.58)
Shortness of breath	1.33	(0.70-2.53)	0.89	(0.38-2.10)	1.38	(0.65-2.96)
Wheeze without a cold	1.15	(0.64-2.10)	0.72	(0.35-1.47)	2.31	(1.11-4.81)
Attacks of wheeze with SOB	2.14	(0.99-4.60)	1.70	(0.63-4.55)	0.92	(0.27-3.10)
Chest tightness	0.78	(0.39-1.56)	1.75	(0.85-3.59)	0.97	(0.44-2.12)
Attacks of chest tightness	1.15	(0.47-2.79)	1.47	(0.55-3.93)	1.42	(0.53-3.78)
Chest tightness with SOB	1.09	(0.50-2.39)	1.79	(0.78-4.07)	1.20	(0.48-2.96)
Fever, chills, flu-like symptoms	0.45	(0.16-1.27)	1.12	(0.45-2.78)	0.87	(0.33-2.28)
Asthma	3.51	(1.37-9.02)	3.47	(1.13-10.63)	1.57	(0.36-6.93)
Bronchitis	0.67	(0.28-1.62)	0.52	(0.15-1.73)	1.03	(0.42-2.56)
Pneumonia	0.76	(0.37-1.55)	1.34	(0.62-2.90)	0.77	(0.33-1.79)

TABLE 11c Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of **turkeys** on the farm controlling for smoking and age

Symptom or diagnosed illness	Farm size					
	Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.13	(0.50-2.53)	1.64	(0.67-4.00)	0.99	(0.39-2.51)
Phlegm	0.82	(0.38-1.75)	1.56	(0.70-3.50)	1.01	(0.44-2.33)
Shortness of breath	1.28	(0.65-2.53)	0.81	(0.33-1.98)	0.98	(0.44-2.18)
Wheeze without a cold	1.13	(0.62-2.06)	0.70	(0.33-1.48)	1.89	(0.88-4.06)
Attacks of wheeze with SOB	2.11	(0.97-4.58)	1.70	(0.63-4.61)	0.77	(0.23-2.63)
Chest tightness	0.76	(0.38-1.54)	1.78	(0.86-3.69)	0.83	(0.38-1.85)
Attacks of chest tightness	1.15	(0.40-2.79)	1.46	(0.54-3.91)	1.27	(0.47-3.42)
Chest tightness with SOB	1.07	(0.48-2.37)	1.78	(0.77-4.11)	0.99	(0.39-2.46)
Fever, chills, flu-like symptoms	0.44	(0.16-1.26)	1.13	(0.46-2.81)	0.84	(0.32-2.32)
Asthma	3.44	(1.33-8.91)	3.40	(1.10-10.54)	1.27	(0.28-5.70)
Bronchitis	0.66	(0.27-1.58)	0.51	(0.15-1.71)	0.90	(0.36-2.24)
Pneumonia	0.73	(0.36-1.52)	1.33	(0.61-2.91)	0.62	(0.26-1.47)

TABLE 12a Comparison of respiratory symptoms and diagnosed illnesses by farm size for **wheat**

Symptom or diagnosed illness	Farm size							
	No wheat		Low		Medium		High	
	n	(%)	n	(%)	n	(%)	n	(%)
Usual cough	34	(18.8)	35	(17.5)	18	(9.0)	29	(14.4)
Phlegm	46	(25.4)	43	(21.6)	31	(15.5)	47	(23.5)
Shortness of breath	41	(22.7)	49	(24.5)	51	(25.6)	44	(21.9)
Wheeze without a cold	80	(44.1)	95	(47.5)	101	(50.8)	101	(50.2)
Attacks of wheeze with SOB	19	(10.6)	22	(11.1)	18	(9.1)	21	(10.4)
Chest tightness	53	(29.3)	55	(27.5)	60	(30.2)	45	(22.4)
Attacks of chest tightness	23	(12.7)	25	(12.5)	18	(9.0)	22	(10.9)
Chest tightness with SOB	27	(14.9)	35	(17.5)	34	(17.1)	27	(13.4)
Fever, chills, flu-like symptoms	24	(13.3)	29	(14.5)	35	(17.6)	36	(17.9)
Asthma	13	(7.3)	11	(5.6)	4	(2.0)	9	(4.6)
Bronchitis	30	(16.7)	24	(12.1)	39	(19.6)	36	(18.1)
Pneumonia	41	(22.9)	50	(25.4)	49	(24.7)	52	(26.3)

TABLE 12b Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of acres of **wheat** grown on the farm

Symptom or diagnosed illness	Farm size Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	0.92	(0.54-1.55)	0.43	(0.23-0.79)	0.73	(0.43-1.26)
Phlegm	0.81	(0.50-1.30)	0.54	(0.32-0.90)	0.90	(0.57-1.44)
Shortness of breath	1.11	(0.69-1.78)	1.17	(0.73-1.87)	0.96	(0.59-1.56)
Wheeze without a cold	1.14	(0.76-1.71)	1.29	(0.86-1.93)	1.29	(0.86-1.98)
Attacks of wheeze with SOB	1.05	(0.55-2.02)	0.85	(0.43-1.67)	0.99	(0.52-1.92)
Chest tightness	0.92	(0.59-1.43)	1.04	(0.67-1.61)	0.70	(0.44-1.11)
Attacks of chest tightness	0.98	(0.54-1.80)	0.68	(0.35-1.31)	0.85	(0.46-1.58)
Chest tightness with SOB	1.21	(0.70-2.09)	1.17	(0.67-2.03)	0.89	(0.50-1.58)
Fever, chills, flu-like symptoms	1.11	(0.62-1.99)	1.44	(0.82-2.52)	1.44	(0.82-2.52)
Asthma	0.75	(0.33-1.72)	0.27	(0.09-0.83)	0.62	(0.27-1.48)
Bronchitis	0.69	(0.38-1.22)	1.21	(0.72-2.05)	1.11	(0.65-1.89)
Pneumonia	1.15	(0.71-1.84)	1.13	(0.70-1.81)	1.21	(0.75-1.93)

TABLE 12c Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of acres of **wheat** grown on the farm controlling for smoking and age

Symptom or diagnosed illness	Farm size					
	Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	0.81	(0.47-1.39)	0.38	(0.20-0.72)	0.72	(0.41-1.26)
Phlegm	0.74	(0.45-1.20)	0.51	(0.30-0.85)	0.86	(0.53-1.39)
Shortness of breath	0.92	(0.56-1.52)	1.14	(0.69-1.86)	1.19	(0.72-1.98)
Wheeze without a cold	1.02	(0.67-1.55)	1.26	(0.83-1.92)	1.34	(0.88-2.05)
Attacks of wheeze with SOB	0.99	(0.51-1.90)	0.82	(0.41-1.62)	1.00	(0.51-1.94)
Chest tightness	0.84	(0.54-1.33)	1.01	(0.65-1.57)	0.70	(0.44-1.12)
Attacks of chest tightness	0.89	(0.48-1.65)	0.67	(0.35-1.28)	0.90	(0.48-1.70)
Chest tightness with SOB	1.08	(0.62-1.88)	1.13	(0.65-1.97)	0.94	(0.53-1.69)
Fever, chills, flu-like symptoms	1.10	(0.61-1.97)	1.42	(0.81-2.50)	1.41	(0.80-2.49)
Asthma	0.68	(0.29-1.57)	0.25	(0.08-0.78)	0.65	(0.27-1.57)
Bronchitis	0.65	(0.36-1.16)	1.19	(0.70-2.01)	1.15	(0.67-1.98)
Pneumonia	1.02	(0.63-1.67)	1.10	(0.68-1.79)	1.34	(0.83-2.17)

TABLE 13a Comparison of respiratory symptoms and diagnosed illnesses by farm size for **oats**

Symptom or diagnosed illness	Farm size							
	No oats		Low		Medium		High	
	n	(%)	n	(%)	n	(%)	n	(%)
Usual cough	37	(13.5)	30	(18.6)	26	(14.7)	23	(13.7)
Phlegm	57	(20.7)	35	(21.9)	33	(18.8)	42	(24.9)
Shortness of breath	59	(21.5)	38	(23.6)	42	(23.7)	46	(27.3)
Wheeze without a cold	121	(44.0)	76	(47.2)	95	(53.7)	85	(50.6)
Attacks of wheeze with SOB	21	(7.7)	16	(10.0)	16	(9.1)	27	(16.2)
Chest tightness	63	(22.9)	37	(23.0)	55	(31.1)	58	(34.5)
Attacks of chest tightness	22	(8.0)	20	(12.4)	26	(14.7)	20	(11.9)
Chest tightness with SOB	38	(13.8)	22	(13.7)	32	(18.1)	31	(18.5)
Fever, chills, flu-like symptoms	45	(16.4)	21	(13.0)	25	(14.1)	34	(20.1)
Asthma	13	(4.8)	5	(3.1)	8	(4.5)	11	(6.6)
Bronchitis	53	(19.5)	24	(15.0)	24	(13.6)	28	(16.7)
Pneumonia	65	(24.0)	40	(24.8)	42	(24.0)	45	(27.3)

TABLE 13b Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of acres of **oats** grown on the farm

Symptom or diagnosed illness	Farm size Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.47	(0.87-2.49)	1.12	(0.65-1.92)	1.01	(0.58-1.77)
Phlegm	1.07	(0.67-1.72)	0.88	(0.55-1.42)	1.27	(0.80-1.99)
Shortness of breath	1.13	(0.71-1.80)	1.15	(0.73-1.80)	1.37	(0.88-2.14)
Wheeze without a cold	1.14	(0.77-1.68)	1.49	(1.02-2.18)	1.29	(0.88-1.89)
Attacks of wheeze with SOB	1.34	(0.68-2.65)	1.21	(0.61-2.39)	2.31	(1.26-4.23)
Chest tightness	1.00	(0.63-1.60)	1.53	(1.00-2.34)	1.76	(1.15-2.69)
Attacks of chest tightness	1.63	(0.86-3.09)	1.99	(1.09-3.64)	1.54	(0.82-2.92)
Chest tightness with SOB	0.99	(0.56-1.74)	1.39	(0.83-2.32)	1.40	(0.83-2.35)
Fever, chills, flu-like symptoms	0.77	(0.44-1.34)	0.85	(0.50-1.44)	1.29	(0.79-2.11)
Asthma	0.64	(0.23-1.84)	0.95	(0.38-2.33)	1.40	(0.61-3.21)
Bronchitis	0.73	(0.43-1.24)	0.65	(0.39-1.10)	0.82	(0.50-1.36)
Pneumonia	1.05	(0.67-1.65)	1.01	(0.65-1.57)	1.22	(0.78-1.89)

TABLE 13c Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of acres of **oats** grown on the farm controlling for smoking and age

Symptom or diagnosed illness	Farm size					
	Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.52	(0.89-2.61)	1.13	(0.65-1.96)	0.97	(0.55-1.73)
Phlegm	1.08	(0.67-1.75)	0.84	(0.52-1.37)	1.26	(0.80-2.00)
Shortness of breath	1.17	(0.72-1.89)	1.18	(0.74-1.90)	1.31	(0.82-2.09)
Wheeze without a cold	1.16	(0.77-1.74)	1.54	(1.04-2.29)	1.27	(0.85-1.89)
Attacks of wheeze with SOB	1.35	(0.68-2.69)	1.22	(0.62-2.42)	2.30	(1.25-4.23)
Chest tightness	1.10	(0.63-1.61)	1.52	(0.99-2.34)	1.74	(1.14-2.67)
Attacks of chest tightness	1.65	(0.87-3.13)	1.96	(1.06-3.60)	1.51	(0.80-2.87)
Chest tightness with SOB	1.00	(0.56-1.76)	1.37	(0.81-2.32)	1.36	(0.81-2.30)
Fever, chills, flu-like symptoms	0.77	(0.44-1.34)	0.85	(0.50-1.44)	1.29	(0.79-2.11)
Asthma	0.65	(0.23-1.86)	0.97	(0.39-2.39)	1.36	(0.59-3.13)
Bronchitis	0.73	(0.43-1.24)	0.66	(0.39-1.12)	0.80	(0.48-1.33)
Pneumonia	1.06	(0.67-1.67)	1.00	(0.64-1.58)	1.17	(0.75-1.82)

TABLE 14a Comparison of respiratory symptoms and diagnosed illnesses by farm size for **canola**

Symptom or diagnosed illness	Farm size							
	No canola		Low		Medium		High	
	n	(%)	n	(%)	n	(%)	n	(%)
Usual cough	60	(18.7)	21	(13.3)	16	(10.4)	19	(12.8)
Phlegm	72	(22.5)	31	(19.7)	25	(16.1)	39	(26.4)
Shortness of breath	83	(25.9)	36	(22.8)	30	(19.5)	36	(24.3)
Wheeze without a cold	154	(50.0)	72	(45.6)	82	(53.2)	69	(46.6)
Attacks of wheeze with SOB	37	(11.6)	12	(7.6)	17	(11.1)	14	(9.5)
Chest tightness	93	(29.0)	48	(30.4)	38	(24.7)	34	(23.0)
Attacks of chest tightness	43	(13.4)	16	(10.1)	15	(9.7)	14	(9.5)
Chest tightness with SOB	57	(17.8)	21	(13.3)	25	(16.2)	20	(13.5)
Fever, chills, flu-like symptoms	42	(13.1)	27	(17.1)	35	(22.7)	20	(13.5)
Asthma	17	(5.4)	7	(4.5)	7	(4.6)	6	(4.1)
Bronchitis	48	(15.0)	28	(17.8)	22	(14.3)	31	(21.1)
Pneumonia	77	(24.2)	43	(27.6)	40	(26.0)	32	(22.2)

TABLE 14b Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of acres of **canola** grown on the farm

Symptom or diagnosed illness	Farm size					
	Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	0.67	(0.39-1.15)	0.50	(0.28-0.90)	0.64	(0.37-1.12)
Phlegm	0.85	(0.53-1.36)	0.66	(0.40-1.10)	1.23	(0.79-1.93)
Shortness of breath	0.85	(0.55-1.34)	0.69	(0.43-1.10)	0.92	(0.59-1.45)
Wheeze without a cold	0.92	(0.63-1.35)	1.22	(0.83-1.79)	0.95	(0.64-1.40)
Attacks of wheeze with SOB	0.64	(0.32-1.26)	0.95	(0.51-1.74)	0.80	(0.42-1.52)
Chest tightness	1.08	(0.71-1.64)	0.80	(0.51-1.23)	0.73	(0.47-1.15)
Attacks of chest tightness	0.73	(0.40-1.35)	0.69	(0.37-1.29)	0.68	(0.36-1.28)
Chest tightness with SOB	0.72	(0.42-1.23)	0.89	(0.53-1.49)	0.72	(0.42-1.26)
Fever, chills, flu-like symptoms	1.38	(0.82-2.34)	2.01	(1.23-3.29)	1.04	(0.59-1.84)
Asthma	0.84	(0.34-2.11)	0.86	(0.35-2.11)	0.76	(0.29-1.97)
Bronchitis	1.24	(0.74-2.06)	0.93	(0.54-1.61)	1.51	(0.91-2.49)
Pneumonia	1.20	(0.79-1.86)	1.13	(0.73-1.75)	0.89	(0.56-1.43)

TABLE 14c Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of acres of **canola** grown on the farm controlling for smoking and age

Symptom or diagnosed illness	Farm size					
	Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	0.69	(0.40-1.19)	0.51	(0.28-0.93)	0.68	(0.38-1.21)
Phlegm	0.87	(0.54-1.40)	0.65	(0.39-1.09)	1.25	(0.78-1.99)
Shortness of breath	0.94	(0.59-1.50)	0.91	(0.55-1.50)	1.34	(0.83-2.18)
Wheeze without a cold	0.96	(0.64-1.43)	1.36	(0.91-2.04)	1.06	(0.70-1.60)
Attacks of wheeze with SOB	0.65	(0.33-1.29)	0.99	(0.53-1.83)	0.84	(0.43-1.63)
Chest tightness	1.12	(0.73-1.70)	0.83	(0.53-1.30)	0.77	(0.49-1.23)
Attacks of chest tightness	0.77	(0.42-1.42)	0.77	(0.41-1.45)	0.76	(0.40-1.46)
Chest tightness with SOB	0.76	(0.44-1.31)	1.01	(0.59-1.71)	0.84	(0.48-1.48)
Fever, chills, flu-like symptoms	1.38	(0.82-2.34)	2.00	(1.21-3.30)	1.04	(0.58-1.85)
Asthma	0.88	(0.36-2.17)	0.94	(0.38-2.35)	0.87	(0.33-2.29)
Bronchitis	1.27	(0.76-2.13)	0.99	(0.57-1.73)	1.64	(0.98-2.74)
Pneumonia	1.29	(0.83-2.01)	1.33	(0.84-2.09)	1.08	(0.66-1.75)

TABLE 15a Comparison of respiratory symptoms and diagnosed illnesses by farm size for **barley**

Symptom or diagnosed illness	Farm size							
	No barley		Low		Medium		High	
	n	(%)	n	(%)	n	(%)	n	(%)
Usual cough	7	(13.2)	42	(17.2)	27	(11.3)	40	(16.4)
Phlegm	15	(28.3)	44	(18.1)	49	(20.3)	59	(24.3)
Shortness of breath	11	(20.8)	64	(26.2)	52	(21.7)	58	(23.8)
Wheeze without a cold	29	(54.7)	116	(47.5)	112	(46.7)	120	(49.2)
Attacks of wheeze with SOB	4	(7.7)	26	(10.7)	26	(12.1)	24	(9.9)
Chest tightness	13	(24.5)	71	(29.1)	73	(30.4)	56	(23.0)
Attacks of chest tightness	6	(11.3)	29	(11.9)	28	(11.7)	25	(10.2)
Chest tightness with SOB	6	(11.3)	41	(16.8)	44	(18.3)	32	(13.1)
Fever, chills, flu-like symptoms	6	(11.3)	36	(14.8)	45	(18.7)	38	(15.6)
Asthma	4	(7.8)	13	(5.4)	11	(4.7)	9	(3.7)
Bronchitis	8	(15.4)	39	(16.1)	32	(13.3)	50	(20.6)
Pneumonia	13	(24.5)	60	(25.0)	60	(25.2)	59	(24.5)

TABLE 15b Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of acres of **barley** grown on the farm

Symptom or diagnosed illness	Farm size Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.37	(0.57-3.24)	0.83	(0.34-2.02)	1.30	(0.55-3.07)
Phlegm	0.56	(0.28-1.11)	0.65	(0.33-1.27)	0.81	(0.42-1.58)
Shortness of breath	1.36	(0.66-2.80)	1.05	(0.51-2.18)	1.20	(0.58-2.48)
Wheeze without a cold	0.75	(0.41-1.36)	0.72	(0.40-1.31)	0.81	(0.45-1.47)
Attacks of wheeze with SOB	1.44	(0.48-4.31)	1.45	(0.48-4.35)	1.33	(0.44-4.00)
Chest tightness	1.26	(0.64-2.50)	1.34	(0.68-2.65)	0.92	(0.46-1.84)
Attacks of chest tightness	1.06	(0.42-2.69)	1.03	(0.40-2.63)	0.90	(0.35-2.31)
Chest tightness with SOB	1.58	(0.64-3.94)	1.75	(0.70-4.35)	1.19	(0.47-3.00)
Fever, chills, flu-like symptoms	1.36	(0.54-3.40)	1.80	(0.72-4.47)	1.45	(0.58-3.63)
Asthma	0.67	(0.21-2.14)	0.57	(0.18-1.88)	0.46	(0.14-1.54)
Bronchitis	1.06	(0.46-2.42)	0.84	(0.36-1.95)	1.43	(0.63-3.24)
Pneumonia	1.03	(0.51-2.05)	1.05	(0.53-2.10)	1.00	(0.50-2.00)

TABLE 15c Odds ratios (OR) and 95% confidence intervals (CI) for respiratory symptoms by the number of acres of **barley** grown on the farm controlling for smoking and age

Symptom or diagnosed illness	Farm size					
	Low		Medium		High	
	OR	95% CI	OR	95% CI	OR	95% CI
Usual cough	1.35	(0.56-3.27)	0.80	(0.32-2.00)	1.29	(0.53-3.13)
Phlegm	0.54	(0.27-1.09)	0.60	(0.30-1.20)	0.77	(0.39-1.52)
Shortness of breath	1.31	(0.62-2.78)	1.06	(0.50-2.27)	1.34	(0.63-2.86)
Wheeze without a cold	0.72	(0.39-1.33)	0.67	(0.36-1.25)	0.78	(0.42-1.46)
Attacks of wheeze with SOB	1.44	(0.48-4.33)	1.45	(0.48-4.37)	1.33	(0.44-4.03)
Chest tightness	1.25	(0.63-2.50)	1.31	(0.66-2.61)	0.92	(0.46-1.85)
Attacks of chest tightness	1.05	(0.41-2.67)	1.00	(0.39-2.58)	0.93	(0.36-2.40)
Chest tightness with SOB	1.56	(0.62-3.93)	1.73	(0.69-4.33)	1.23	(0.48-3.12)
Fever, chills, flu-like symptoms	1.35	(0.54-3.39)	1.78	(0.72-4.43)	1.43	(0.57-3.57)
Asthma	0.64	(0.20-2.05)	0.56	(0.17-1.84)	0.45	(0.13-1.55)
Bronchitis	1.04	(0.45-2.39)	0.84	(0.36-1.94)	1.44	(0.64-3.28)
Pneumonia	1.01	(0.50-2.03)	1.06	(0.52-2.12)	1.06	(0.54-2.13)

TABLE 16a Summary of statistically significant results from Tables 6-15 for crude data

	Farm Size					
	Low		Medium		High	
	Condition	OR	Condition	OR	Condition	OR
Dairy	~		Attacks of wheeze with SOB	1.97	~	
			Attacks of chest tightness	1.83		
			Chest tightness with SOB	2.01		
			Asthma	2.29		
Hogs	Shortness of breath	2.38	Shortness of breath	2.01	~	
	Attacks of wheeze with SOB	1.95	Flu-like symptoms	1.23		
	Chest tightness	1.66	Chest tightness	1.70		
	Chest tightness with SOB	2.42	Chest tightness with SOB	2.16		
Chicks	Shortness of breath	2.32	Shortness of breath	2.74	~	
	Chest tightness	2.19	Chest tightness	1.87		
	Chest tightness with SOB	3.10	Chest tightness with SOB	2.50		
Beef	Shortness of breath	1.93	Shortness of breath	1.78	Shortness of breath	1.92
	Chest tightness	1.93	Chest tightness	2.62	Chest tightness	2.62
	Attacks of chest tightness	2.28	Attacks of chest tightness	2.32	Attacks of chest tightness	2.47
	Chest tightness with SOB	1.99	Chest tightness with SOB	2.06	Chest tightness with SOB	2.19

~ no significant findings for that type of farming

TABLE 16b Summary of statistically significant results from Tables 6-15 for crude data

	Farm Size					
	Low		Medium		High	
	Condition	OR	Condition	OR	Condition	OR
Horses	Wheeze without a cold	1.55	Wheeze without a cold	1.71	Shortness of breath	1.65
	Chest tightness	1.86	Chest tightness	2.08	Pneumonia	1.78
	Attacks of chest tightness	1.93	Chest tightness with SOB	1.89		
			Flu-like symptoms	1.97		
			Asthma	3.22		
Turkeys	Asthma	3.51	Asthma	3.47	Wheeze without a cold	2.31
Wheat	~		Cough	0.43	~	
			Phlegm	0.54		
Oats	~		Wheeze without a cold	1.49	Attacks of wheeze with SOB	2.31
			Attacks of chest tightness	1.99	Chest tightness	1.76
Canola	~		Cough	0.50	~	
			Flu-like	2.01		
Barley	~		~		~	

~ no significant findings for that type of farming

TABLE 17a Summary of statistically significant results from Tables 6-15, values adjusted for smoking and age

	Farm Size					
	Low		Medium		High	
	Condition	OR	Condition	OR	Condition	OR
Dairy	Shortness of breath	0.59	Attacks of wheeze with SOB	2.02	Shortness of breath	0.56
			Chest tightness with SOB	1.86		
			Flu-like symptoms	1.92		
Hogs	Shortness of breath	1.79	Flu-like symptoms	1.89	~	
	Chest tightness	1.58	Chest tightness	1.56		
	Chest tightness with SOB	2.17	Chest tightness with SOB	1.78		
Chicks	Shortness of breath	1.80	Shortness of breath	2.08	~	
	Chest tightness	2.18	Chest tightness	1.84		
	Chest tightness with SOB	2.87	Chest tightness with SOB	2.26		
Beef	Chest tightness	1.84	Chest tightness	2.58	Chest tightness	2.60
			Attacks of chest tightness	2.17	Attacks of chest tightness	2.32
			Chest tightness with SOB	1.89	Chest tightness with SOB	2.03
					Flu-like symptoms	1.79
Horses	Wheeze without a cold	1.58	Chest tightness	2.04	Phlegm	0.50
	Chest tightness	1.88	Chest tightness with SOB	1.85	~	
	Attacks of chest tightness	1.95	Flu-like symptoms	1.95		
			Asthma	3.11		

~ no significant findings for that type and size of farm

TABLE 17b Summary of statistically significant results from Tables 6-15, values adjusted for smoking and age

	Farm Size					
	Low		Medium		High	
	Condition	OR	Condition	OR	Condition	OR
Turkeys	Asthma	3.44	Asthma	3.40	~	
Wheat	~		Cough	0.81	~	
			Phlegm	0.74		
			Asthma	0.68		
Oats	~		Wheeze without a cold	1.54	Chest tightness	1.74
			Attacks of chest tightness	1.96	Attacks of wheeze - SOB	2.30
Canola	~		Cough	0.51	~	
			Flu-like symptoms	2.00		
Barley	~		~		~	

~ no significant findings for that type and size of farm

TABLE 18a Comparison of farmers who did and did not raise **dairy cows** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.371	1.20	0.80-1.81	0.484	1.16	0.76-1.78
Phlegm	0.623	0.92	0.65-1.30	0.673	0.92	0.64-1.33
Shortness of breath	0.638	0.92	0.66-1.29	0.044	0.69	0.48-0.99
Wheeze without a cold	0.214	0.83	0.63-1.11	0.070	0.75	0.55-1.02
Attacks of wheeze with SOB	0.460	1.20	0.74-1.93	0.502	1.18	0.73-1.92
Chest tightness	0.951	1.01	0.73-1.39	0.868	0.97	0.70-1.35
Attacks of chest tightness	0.283	1.29	0.81-2.04	0.481	1.18	0.74-1.90
Chest tightness with SOB	0.214	1.29	0.86-1.91	0.418	1.18	0.79-1.78
Fever, chills, flu-like symptoms	0.464	1.16	0.78-1.71	0.449	1.17	0.78-1.74
Asthma	0.580	1.21	0.61-2.41	0.720	1.14	0.56-2.30
Bronchitis	0.783	1.06	0.72-1.56	0.769	0.95	0.67-1.34
Pneumonia	0.632	1.09	0.78-1.51	0.979	1.01	0.67-1.50

TABLE 18b Comparison of farmers who did and did not raise **dairy cows** by respiratory symptoms or diagnosed illness in atopic and non-atopic controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.909	0.95	0.39-2.30	0.270	1.32	0.81-2.18
Phlegm	0.659	0.83	0.36-1.90	0.840	0.96	0.64-1.44
Shortness of breath	0.045	0.42	0.18-0.98	0.222	0.78	0.52-1.17
Wheeze without a cold	0.269	0.68	0.34-1.35	0.155	0.78	0.55-1.10
Attacks of wheeze with SOB	0.782	1.13	0.48-2.67	0.523	1.22	0.66-2.24
Chest tightness	0.551	1.25	0.60-2.59	0.710	0.93	0.64-1.36
Attacks of chest tightness	0.183	2.17	0.70-6.76	0.929	1.03	0.60-1.74
Chest tightness with SOB	0.018	2.88	1.20-6.95	0.689	0.91	0.56-1.46
Fever, chills, flu-like symptoms	0.771	1.19	0.48-2.93	0.350	1.24	0.79-1.95
Asthma	0.635	1.33	0.41-4.33	0.821	0.90	0.37-2.22
Bronchitis	0.524	0.76	0.33-1.75	0.654	1.11	0.70-1.77
Pneumonia	0.706	1.16	0.54-2.47	0.781	0.95	0.64-1.40

TABLE19a Comparison of farmers who did and did not raise **hogs** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.476	1.18	0.75-1.86	0.576	1.15	0.71-1.85
Phlegm	0.393	1.19	0.80-1.75	0.227	1.29	0.85-1.95
Shortness of breath	<0.001	2.26	1.49-3.44	0.025	1.66	1.06-2.59
Wheeze without a cold	0.712	0.94	0.69-1.29	0.385	0.86	0.61-1.21
Attacks of wheeze with SOB	0.476	1.21	0.71-2.07	0.540	1.19	0.68-2.08
Chest tightness	0.025	1.53	1.06-2.21	0.039	1.50	1.02-2.21
Attacks of chest tightness	0.225	1.39	0.82-2.35	0.469	1.23	0.71-2.12
Chest tightness with SOB	<0.001	2.51	1.50-4.20	0.002	2.30	1.35-3.92
Fever, chills, flu-like symptoms	0.300	1.26	0.81-1.96	0.255	1.31	0.83-2.07
Asthma	0.936	1.03	0.49-2.18	0.734	0.87	0.40-1.91
Bronchitis	0.751	0.94	0.62-1.42	0.531	0.87	0.56-1.35
Pneumonia	0.247	1.25	0.86-1.81	0.873	1.03	0.70-1.53

TABLE 19b Comparison of farmers who did and did not raise **hogs** by respiratory symptoms or diagnosed illness in atopic and non-atopic controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.599	1.31	0.48-3.62	0.738	1.10	0.63-1.90
Phlegm	0.715	1.19	0.46-3.06	0.259	1.31	0.82-2.07
Shortness of breath	0.463	1.45	0.54-3.92	0.037	1.70	1.03-2.80
Wheeze without a cold	0.746	1.14	0.53-2.44	0.224	0.79	0.54-1.16
Attacks of wheeze with SOB	0.810	1.13	0.43-2.99	0.562	1.23	0.61-2.47
Chest tightness	0.829	0.92	0.41-2.06	0.020	1.70	1.09-2.66
Attacks of chest tightness	0.422	0.63	0.20-1.96	0.255	1.46	0.76-2.81
Chest tightness with SOB	0.167	2.00	0.75-5.31	0.009	2.41	1.25-4.64
Fever, chills, flu-like symptoms	0.062	3.48	0.94-12.99	0.820	1.06	0.65-1.74
Asthma	0.900	1.09	0.29-4.06	0.524	0.72	0.26-1.97
Bronchitis	0.306	0.62	0.25-1.55	0.900	0.97	0.59-1.60
Pneumonia	0.751	0.87	0.37-2.06	0.708	1.09	0.70-1.70

TABLE 20a Comparison of farmers who did and did not raise **chickens** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.173	1.33	0.88-1.99	0.160	1.36	0.89-2.09
Phlegm	0.840	0.97	0.68-1.36	0.970	0.99	0.69-1.43
Shortness of breath	<0.001	2.19	1.54-3.12	0.003	1.75	1.20-2.55
Wheeze without a cold	0.502	0.91	0.68-1.21	0.298	0.85	0.63-1.15
Attacks of wheeze with SOB	0.664	1.11	0.69-1.78	0.713	1.10	0.67-1.78
Chest tightness	<0.001	1.82	1.31-2.54	0.001	1.82	1.29-2.56
Attacks of chest tightness	0.220	1.33	0.84-2.11	0.487	1.18	0.74-1.90
Chest tightness with SOB	<0.001	2.24	1.47-3.41	0.001	2.07	1.34-3.19
Fever, chills, flu-like symptoms	0.188	1.30	0.88-1.93	0.163	1.33	0.89-2.00
Asthma	0.342	1.40	0.70-2.81	0.563	1.24	0.60-2.54
Bronchitis	0.373	1.19	0.81-1.75	0.507	1.14	0.77-1.70
Pneumonia	0.246	1.12	0.87-1.70	0.825	1.04	0.74-1.47

TABLE 20b Comparison of farmers who did and did not raise **chickens** by respiratory symptoms or diagnosed illness in atopic and non-atopic controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.734	1.17	0.47-2.94	0.234	1.35	0.82-2.21
Phlegm	0.800	0.90	0.39-2.09	0.835	1.04	0.70-1.57
Shortness of breath	0.616	0.80	0.34-1.89	0.001	2.10	1.38-3.22
Wheeze without a cold	0.004	0.34	0.16-0.70	0.753	1.06	0.75-1.49
Attacks of wheeze with SOB	0.551	0.77	0.32-1.84	0.345	1.34	0.73-2.47
Chest tightness	0.751	1.13	0.54-2.37	0.000	2.04	1.38-3.02
Attacks of chest tightness	0.205	2.11	0.66-6.80	0.901	1.03	0.61-1.80
Chest tightness with SOB	0.212	1.71	0.74-3.98	0.002	2.25	1.34-3.79
Fever, chills, flu-like symptoms	0.734	0.85	0.34-2.13	0.090	1.48	0.94-2.34
Asthma	0.548	1.45	0.43-4.84	0.533	1.35	0.52-3.50
Bronchitis	0.904	0.95	0.40-2.23	0.431	1.20	0.76-1.89
Pneumonia	0.731	1.15	0.53-2.49	0.959	1.01	0.69-1.49

TABLE 21a Comparison of farmers who did and did not raise **beef cattle** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.570	1.18	0.67-2.08	0.691	1.13	0.63-2.03
Phlegm	0.459	0.84	0.53-1.33	0.480	0.84	0.53-1.35
Shortness of breath	0.007	2.10	1.22-3.61	0.068	1.69	0.96-2.97
Wheeze without a cold	0.412	0.85	0.57-1.25	0.194	0.76	0.51-1.15
Attacks of wheeze with SOB	0.151	1.74	0.82-3.72	0.180	1.69	0.78-3.64
Chest tightness	<0.001	3.61	1.98-6.58	<0.001	3.52	1.92-6.45
Attacks of chest tightness	0.046	2.25	1.01-5.00	0.087	2.02	0.90-4.53
Chest tightness with SOB	0.001	4.16	1.79-9.67	0.002	3.77	1.61-8.82
Fever, chills, flu-like symptoms	0.085	1.71	0.93-3.15	0.082	1.73	0.93-3.20
Asthma	0.107	3.27	0.78-13.76	0.155	2.86	0.67-12.14
Bronchitis	0.752	1.09	0.64-1.85	0.931	1.02	0.60-1.76
Pneumonia	0.235	1.33	0.83-2.14	0.543	1.16	0.72-1.89

TABLE 21b Comparison of farmers who did and did not raise **beef cattle** by respiratory symptoms or diagnosed illness in atopic and non-atopic controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.453	1.62	0.46-5.77	0.917	1.04	0.53-2.03
Phlegm	0.193	0.50	0.18-1.41	0.835	0.94	0.55-1.62
Shortness of breath **	~	~	~	0.430	1.27	0.71-2.27
Wheeze without a cold	0.788	1.14	0.45-2.87	0.101	0.68	0.43-1.08
Attacks of wheeze with SOB	0.834	0.89	0.28-2.77	0.075	2.96	0.90-9.76
Chest tightness	0.019	4.90	1.30-18.50	0.001	3.31	1.67-6.59
Attacks of chest tightness	0.937	0.94	0.23-3.89	0.049	2.84	1.00-8.05
Chest tightness with SOB	0.064	4.28	0.92-19.99	0.010	3.88	1.38-10.91
Fever, chills, flu-like symptoms	0.574	1.49	0.39-5.58	0.111	1.77	0.88-3.55
Asthma	0.362	2.72	0.32-23.43	0.248	3.32	0.43-25.37
Bronchitis	0.637	1.34	0.40-4.45	0.901	0.96	0.53-1.76
Pneumonia	0.637	1.31	0.43-3.95	0.669	1.13	0.66-1.93

** unable to use

TABLE 22a Comparison of farmers who did and did not raise **horses** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.480	1.16	0.77-1.72	0.634	1.11	0.73-1.68
Phlegm	0.786	1.05	0.74-1.49	0.680	1.08	0.75-1.55
Shortness of breath	0.008	1.58	1.13-2.20	0.153	1.29	0.91-1.84
Wheeze without a cold	0.004	1.52	1.14-2.04	0.014	1.47	1.08-1.99
Attacks of wheeze with SOB	0.019	1.75	1.10-2.79	0.030	1.70	1.05-2.73
Chest tightness	0.003	1.64	1.18-2.57	0.005	1.60	1.15-2.22
Attacks of chest tightness	0.028	1.65	1.06-2.59	0.060	1.55	0.98-2.46
Chest tightness with SOB	0.040	1.50	1.02-2.21	0.115	1.38	0.93-2.05
Fever, chills, flu-like symptoms	0.242	1.26	0.86-1.86	0.198	1.30	0.87-1.93
Asthma	0.050	1.96	1.00-3.85	0.114	1.74	0.88-3.47
Bronchitis	0.510	1.14	0.77-1.67	0.740	1.33	0.72-1.58
Pneumonia	0.024	1.46	1.05-2.03	0.096	1.07	0.95-1.88

TABLE 22b Comparison of farmers who did and did not raise **horses** by respiratory symptoms or diagnosed illness in atopic and non-atopic controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.774	0.88	0.36-2.14	0.649	1.12	0.69-1.81
Phlegm	0.940	1.03	0.45-2.35	0.614	1.11	0.74-1.67
Shortness of breath	0.940	1.03	0.45-2.35	0.135	1.35	0.91-2.00
Wheeze without a cold	0.659	0.86	0.43-1.70	0.003	1.67	1.18-2.36
Attacks of wheeze with SOB	0.969	0.98	0.42-2.32	0.009	2.20	1.22-3.98
Chest tightness	0.377	1.39	0.67-2.85	0.009	1.64	1.13-2.38
Attacks of chest tightness	0.635	1.29	0.45-3.75	0.074	1.60	0.96-2.69
Chest tightness with SOB	0.451	1.36	0.61-3.02	0.206	1.35	0.85-2.16
Fever, chills, flu-like symptoms	0.490	1.37	0.56-3.34	0.333	1.25	0.80-1.94
Asthma	0.399	1.65	0.52-5.23	0.144	1.95	0.80-4.74
Bronchitis	0.380	0.68	0.29-1.60	0.412	1.21	0.77-1.88
Pneumonia	0.103	1.87	0.88-3.99	0.406	1.18	0.80-1.73

TABLE 23a Comparison of farmers who did and did not raise **turkeys** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.460	1.13	0.72-2.04	0.683	1.12	0.65-1.91
Phlegm	0.830	1.05	0.66-1.68	0.910	1.03	0.64-1.66
Shortness of breath	0.511	1.16	0.75-1.80	0.854	1.04	0.66-1.66
Wheeze without a cold	0.219	1.27	0.87-1.88	0.353	1.21	0.81-1.81
Attacks of wheeze with SOB	0.162	1.51	0.85-2.68	0.214	1.45	0.81-2.59
Chest tightness	0.933	1.02	0.66-1.57	0.942	0.98	0.64-1.52
Attacks of chest tightness	0.507	1.22	0.68-2.18	0.549	1.20	0.67-2.15
Chest tightness with SOB	0.519	1.18	0.70-1.96	0.634	1.13	0.68-1.90
Fever, chills, flu-like symptoms	0.638	0.88	0.51-1.51	0.634	0.88	0.51-1.51
Asthma	0.006	2.77	1.34-5.69	0.008	2.69	1.29-5.61
Bronchitis	0.402	0.79	0.46-1.37	0.325	0.92	0.43-1.32
Pneumonia	0.873	0.96	0.62-1.51	0.732	0.76	0.58-1.46

TABLE 23b Comparison of farmers who did and did not raise **turkeys** by respiratory symptoms or diagnosed illness in atopic and non-atopic controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.891	1.09	0.34-3.49	0.685	1.14	0.62-2.09
Phlegm	0.919	1.06	0.35-3.25	0.959	1.01	0.60-1.72
Shortness of breath	0.532	1.41	0.48-4.20	0.973	0.99	0.59-1.66
Wheeze without a cold	0.822	1.12	0.43-2.90	0.338	1.24	0.80-1.95
Attacks of wheeze with SOB	0.302	1.75	0.60-5.07	0.363	1.39	0.68-2.84
Chest tightness	0.180	1.91	0.74-4.91	0.458	0.83	0.50-1.37
Attacks of chest tightness	0.225	2.20	0.62-7.86	0.865	1.06	0.54-2.07
Chest tightness with SOB	0.106	2.25	0.84-6.01	0.706	0.89	0.47-1.66
Fever, chills, flu-like symptoms	0.587	0.69	0.19-2.59	0.750	0.91	0.50-1.65
Asthma	0.015	4.83	1.36-17.18	0.112	2.16	0.84-5.60
Bronchitis	0.837	0.88	0.27-2.89	0.313	0.72	0.38-1.36
Pneumonia	0.957	0.97	0.34-2.75	0.738	0.92	0.55-1.53

TABLE 24a Comparison of farmers who did and did not grow **wheat** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.071	0.67	0.43-1.04	0.024	0.59	0.37-0.93
Phlegm	0.153	0.75	0.51-1.11	0.060	0.68	0.46-1.02
Shortness of breath	0.815	1.05	0.71-1.56	0.732	1.08	0.71-1.63
Wheeze without a cold	0.177	1.26	0.90-1.77	0.275	1.22	0.86-1.72
Attacks of wheeze with SOB	0.850	0.95	0.55-1.64	0.750	0.91	0.53-1.58
Chest tightness	0.508	0.88	0.61-1.28	0.419	0.86	0.59-1.25
Attacks of chest tightness	0.600	0.87	0.52-1.46	0.620	0.88	0.52-1.47
Chest tightness with SOB	0.809	1.06	0.67-1.68	0.827	1.05	0.66-1.69
Fever, chills, flu-like symptoms	0.133	1.46	0.89-2.39	0.167	1.42	0.86-2.33
Asthma	0.720	0.53	0.26-1.06	0.084	0.54	0.26-1.09
Bronchitis	0.750	1.08	0.68-1.70	0.764	1.07	0.68-1.70
Pneumonia	0.322	1.22	0.82-1.83	0.321	1.23	0.82-1.85

TABLE 24b Comparison of farmers who did and did not grow **wheat** by respiratory symptoms or diagnosed illness in atopic and non-atopic controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.024	0.32	0.12-0.86	0.160	0.69	0.40-1.16
Phlegm	0.794	0.88	0.33-2.33	0.054	0.65	0.42-1.01
Shortness of breath	0.668	1.25	0.46-3.39	0.863	1.04	0.66-1.64
Wheeze without a cold	0.062	2.19	0.96-4.98	0.823	1.05	0.71-1.54
Attacks of wheeze with SOB	0.909	0.94	0.34-2.61	0.677	0.87	0.45-1.69
Chest tightness	0.340	0.66	0.28-1.54	0.614	0.90	0.59-1.37
Attacks of chest tightness	0.789	0.85	0.25-2.88	0.608	0.86	0.48-1.53
Chest tightness with SOB	0.694	1.22	0.45-3.31	0.875	0.96	0.56-1.64
Fever, chills, flu-like symptoms	0.598	0.76	0.27-2.13	0.079	1.67	0.94-2.96
Asthma	0.933	0.94	0.24-3.68	0.018	0.35	0.15-0.84
Bronchitis	0.517	1.42	0.49-4.14	0.983	1.01	0.60-1.68
Pneumonia	0.596	1.28	0.51-3.24	0.369	1.23	0.78-1.94

TABLE 25a Comparison of farmers who did and did not grow **oats** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.473	1.17	0.77-1.78	0.477	1.17	0.76-1.81
Phlegm	0.682	1.08	0.75-1.55	0.730	1.07	0.74-1.54
Shortness of breath	0.338	1.19	0.84-1.69	0.315	1.21	0.84-1.75
Wheeze without a cold	0.090	1.29	0.96-1.74	0.086	1.31	0.96-1.78
Attacks of wheeze with SOB	0.089	1.57	0.93-2.65	0.088	1.58	0.93-2.67
Chest tightness	0.040	1.43	1.02-2.01	0.044	1.43	1.01-2.01
Attacks of chest tightness	0.023	1.81	1.08-3.03	0.030	1.80	1.07-3.02
Chest tightness with SOB	0.319	1.23	0.82-1.87	0.343	1.23	0.81-1.87
Fever, chills, flu-like symptoms	0.924	0.98	0.66-1.46	0.864	0.97	0.65-1.44
Asthma	0.952	0.98	0.49-1.96	0.965	0.98	0.49-1.98
Bronchitis	0.138	0.75	0.51-1.10	0.139	1.08	0.50-1.10
Pneumonia	0.601	1.10	0.78-1.55	0.684	0.74	0.76-1.53

TABLE 25b Comparison of farmers who did and did not grow **oats** by respiratory symptoms or diagnosed illness in atopic and non-atopic controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.024	0.32	0.12-0.86	0.437	1.22	0.74-2.01
Phlegm	0.794	0.88	0.33-2.33	0.764	1.07	0.71-1.61
Shortness of breath	0.668	1.25	0.46-3.39	0.811	1.05	0.70-1.58
Wheeze without a cold	0.062	2.19	0.96-4.98	0.048	1.42	1.00-2.01
Attacks of wheeze with SOB	0.909	0.94	0.34-2.61	0.071	1.85	0.95-3.63
Chest tightness	0.340	0.66	0.28-1.54	0.028	1.56	1.05-2.31
Attacks of chest tightness	0.789	0.85	0.25-2.88	0.036	1.88	1.04-3.39
Chest tightness with SOB	0.694	1.22	0.40-3.31	0.193	1.40	0.84-2.31
Fever, chills, flu-like symptoms	0.598	0.76	0.27-2.13	0.946	1.02	0.65-1.60
Asthma	0.933	0.94	0.20-3.68	0.679	1.21	0.49-3.04
Bronchitis	0.517	1.42	0.49-4.14	0.270	0.78	0.50-1.21
Pneumonia	0.596	1.28	0.51-3.24	0.428	1.17	0.79-1.75

TABLE 26a Comparison of farmers who did and did not grow **canola** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.012	0.60	0.41-0.90	0.024	0.62	0.41-0.94
Phlegm	0.659	0.93	0.65-1.31	0.720	0.94	0.65-1.34
Shortness of breath	0.234	0.82	0.59-1.14	0.892	1.02	0.72-1.46
Wheeze without a cold	0.776	1.04	0.78-1.39	0.425	1.13	0.84-1.53
Attacks of wheeze with SOB	0.320	0.79	0.50-1.26	0.392	0.81	0.51-1.31
Chest tightness	0.467	0.89	0.65-1.22	0.658	0.93	0.67-1.29
Attacks of chest tightness	0.181	0.74	0.47-1.15	0.331	0.80	0.51-1.26
Chest tightness with SOB	0.199	0.78	0.53-1.14	0.417	0.85	0.57-1.26
Fever, chills, flu-like symptoms	0.064	1.46	0.99-2.19	1.440	1.44	0.96-2.17
Asthma	0.557	0.82	0.42-1.59	0.691	0.87	0.44-1.72
Bronchitis	0.244	1.26	0.85-1.87	0.166	1.25	0.89-1.98
Pneumonia	0.555	1.11	0.79-1.54	0.206	1.33	0.88-1.77

TABLE 26b Comparison of farmers who did and did not grow **canola** by respiratory symptoms or diagnosed illness in atopic and non-atopic controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.006	0.27	0.11-0.70	0.307	0.78	0.49-1.25
Phlegm	0.832	1.10	0.47-2.57	0.656	0.91	0.61-1.36
Shortness of breath	0.552	0.78	0.34-1.79	0.736	1.07	0.72-1.59
Wheeze without a cold	0.626	1.19	0.59-2.42	0.552	1.11	0.79-1.55
Attacks of wheeze with SOB	0.273	0.62	0.26-1.47	0.736	0.90	0.50-1.62
Chest tightness	0.947	0.98	0.46-2.05	0.677	0.93	0.64-1.34
Attacks of chest tightness	0.390	0.62	0.21-1.84	0.446	0.82	0.49-1.37
Chest tightness with SOB	0.845	0.92	0.41-2.10	0.386	0.81	0.51-1.30
Fever, chills, flu-like symptoms	0.743	0.86	0.34-2.15	0.031	1.67	1.05-2.65
Asthma	0.531	0.69	0.21-2.24	0.780	0.88	0.37-2.09
Bronchitis	0.198	1.82	0.73-4.50	0.341	1.24	0.80-1.95
Pneumonia	0.389	1.42	0.64-3.14	0.289	1.23	0.84-1.81

TABLE 27a Comparison of farmers who did and did not grow **barley** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.815	1.10	0.48-2.51	0.847	1.09	0.47-2.54
Phlegm	0.279	0.70	0.37-1.33	0.220	0.66	0.35-1.28
Shortness of breath	0.713	1.14	0.57-2.27	0.652	1.18	0.58-2.41
Wheeze without a cold	0.491	0.82	0.46-1.45	0.409	0.78	0.43-1.41
Attacks of wheeze with SOB	0.553	1.37	0.48-3.92	0.574	1.35	0.47-3.88
Chest tightness	0.535	1.24	0.63-2.41	0.572	1.21	0.62-2.38
Attacks of chest tightness	0.733	1.18	0.46-3.05	0.743	1.17	0.45-3.05
Chest tightness with SOB	0.421	1.43	0.60-3.43	0.432	1.43	0.59-3.45
Fever, chills, flu-like symptoms	0.110	2.33	0.83-6.60	0.120	2.28	0.81-6.47
Asthma	0.263	0.54	0.18-1.59	0.248	0.52	0.18-1.57
Bronchitis	0.370	1.49	0.62-3.57	0.382	1.23	0.61-3.56
Pneumonia	0.559	1.23	0.62-2.44	0.554	1.48	0.61-2.48

TABLE 27b Comparison of farmers who did and did not grow **barley** by respiratory symptoms or diagnosed illness in atopic and non-atopic controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.853	1.00	0.98-1.02	0.009	1.01	1.00-1.02
Phlegm	0.710	1.00	0.98-1.01	0.150	1.01	1.00-1.01
Shortness of breath	0.595	1.01	0.99-1.02	0.257	1.00	0.99-1.00
Wheeze without a cold	0.604	1.00	0.98-1.01	0.521	1.00	0.99-1.01
Attacks of wheeze with SOB	0.040	1.02	1.00 -1.04	0.309	0.99	0.98-1.01
Chest tightness	0.715	1.00	0.99-1.02	0.401	1.00	0.99-1.00
Attacks of chest tightness	0.196	1.02	0.99-1.04	0.331	1.00	0.98-1.01
Chest tightness with SOB	0.863	1.00	0.99-1.02	0.837	1.00	0.99-1.01
Fever, chills, flu-like symptoms	0.442	1.01	0.99-1.03	0.674	1.00	0.99-1.01
Asthma	0.270	1.01	0.99-1.04	0.073	0.98	0.96-1.00
Bronchitis	0.649	1.00	0.99-1.02	0.480	1.00	0.99-1.01
Pneumonia	0.709	1.00	0.99-1.02	0.992	1.00	0.99-1.01

TABLE 28a Comparison of farmers who did and did not make **silage** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.272	1.26	0.84-1.90	0.248	1.29	0.84-1.97
Phlegm	0.169	1.29	0.90-1.84	0.210	1.27	0.88-1.83
Shortness of breath	0.132	0.76	0.53-1.09	0.600	0.90	0.62-1.32
Wheeze without a cold	0.437	0.89	0.66-1.20	0.607	0.92	0.67-1.26
Attacks of wheeze with SOB	0.428	0.81	0.49-1.35	0.475	0.83	0.49-1.39
Chest tightness	0.674	1.07	0.77-1.50	0.495	1.13	0.80-1.58
Attacks of chest tightness	0.205	1.35	0.85-2.13	0.086	1.51	0.94-2.41
Chest tightness with SOB	0.808	0.95	0.63-1.44	0.802	1.06	0.69-1.61
Fever, chills, flu-like symptoms	0.136	1.35	0.91-2.01	0.184	1.31	0.88-1.96
Asthma	0.460	0.76	0.36-1.59	0.671	0.85	0.40-1.81
Bronchitis	0.392	1.19	0.80-1.77	0.279	1.18	0.84-1.87
Pneumonia	0.657	1.08	0.77-1.53	0.367	1.25	0.83-1.68

TABLE 28b Comparison of farmers who did and did not make **silage** by respiratory symptoms or diagnosed illness in controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.941	0.97	0.37-2.51	0.192	1.38	0.85-2.24
Phlegm	0.128	1.94	0.83-4.54	0.505	1.15	0.76-1.74
Shortness of breath	0.637	1.23	0.52-2.95	0.312	0.80	0.52-1.23
Wheeze without a cold	0.421	1.34	0.66-2.75	0.284	0.82	0.58-1.18
Attacks of wheeze with SOB	0.743	1.16	0.47-2.86	0.367	0.74	0.39-1.42
Chest tightness	0.251	1.56	0.73-3.33	0.820	1.05	0.71-1.54
Attacks of chest tightness	0.086	2.58	0.88-7.56	0.268	1.35	0.79-2.31
Chest tightness with SOB	0.382	1.45	0.63-3.32	0.864	0.96	0.58-1.59
Fever, chills, flu-like symptoms	0.932	1.04	0.41-2.68	0.189	1.35	0.68-2.11
Asthma	0.827	0.87	0.25-3.01	0.854	0.91	0.34-2.43
Bronchitis	0.963	1.02	0.42-2.48	0.223	1.36	0.84-2.09
Pneumonia	0.538	1.28	0.58-2.82	0.491	1.15	0.77-1.72

TABLE 29a Comparison of farmers who did and did not **grind grain** by respiratory symptoms or diagnosed illness in both crude and adjusted for smoking and age

	Crude			Adjusted		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.781	1.08	0.61-1.92	0.833	1.07	0.59-1.93
Phlegm	0.179	1.43	0.85-2.43	0.117	1.55	0.90-2.66
Shortness of breath	0.018	1.93	1.12-3.32	0.159	1.50	0.85-2.65
Wheeze without a cold	0.546	0.89	0.60-1.32	0.387	0.83	0.55-1.27
Attacks of wheeze with SOB	0.556	1.23	0.62-2.47	0.590	1.21	0.60-2.46
Chest tightness	0.105	1.49	0.92-2.41	0.138	1.45	0.89-2.37
Attacks of chest tightness	0.779	1.10	0.58-2.09	0.943	0.98	0.51-1.89
Chest tightness with SOB	0.268	1.40	0.77-2.54	0.468	1.25	0.68-2.30
Fever, chills, flu-like symptoms	0.086	1.74	0.93-3.27	0.068	1.81	0.96-3.43
Asthma	0.431	0.71	0.30-1.66	0.268	0.61	0.26-1.46
Bronchitis	0.927	0.98	0.57-1.66	0.778	0.93	0.54-1.59
Pneumonia	0.014	1.98	1.15-3.42	0.046	1.76	1.01-3.06

TABLE 29b Comparison of farmers who did and did not **grind grain** by respiratory symptoms or diagnosed illness in atopic and non-atopic controlling for smoking and age

	Atopic			Non-atopic		
Symptom or diagnosed illness	p-value	OR	95% CI	p-value	OR	95% CI
Usual cough	0.360	0.58	0.19-1.85	0.482	1.30	0.63-2.68
Phlegm	0.984	1.10	0.32-3.17	0.105	1.68	0.90-3.15
Shortness of breath	0.706	1.27	0.37-4.38	0.178	1.56	0.82-2.98
Wheeze without a cold	0.220	1.75	0.71-4.31	0.088	0.66	0.41-1.07
Attacks of wheeze with SOB	0.733	1.24	0.37-4.16	0.660	1.22	0.50-3.00
Chest tightness	0.706	1.21	0.44-3.30	0.190	1.47	0.83-2.60
Attacks of chest tightness	0.223	0.46	0.13-1.60	0.568	1.27	0.56-2.91
Chest tightness with SOB	0.747	0.84	0.29-2.44	0.351	1.45	0.66-3.17
Fever, chills, flu-like symptoms	0.336	0.56	0.17-1.82	0.026	2.52	1.12-5.67
Asthma	0.630	0.70	0.17-2.98	0.315	0.56	0.18-1.75
Bronchitis	0.894	0.93	0.30-2.88	0.792	0.92	0.49-1.72
Pneumonia	0.585	1.37	0.45-4.18	0.049	1.92	1.00-3.68

TABLE 30 Summary table from tables 18a-29a of significant findings from logistic regression and farm operation for the **crude data**

Farm Operation	Symptom or diagnosed illness	p-value	OR	95% CI
Hogs	Shortness of breath	<0.001	2.26	1.49-3.44
Hogs	Chest tightness	0.030	1.53	1.06-2.21
Hogs	Chest tightness with SOB	<0.001	2.51	1.50-4.20
Chicken	Shortness of breath	<0.001	2.19	1.54-3.12
Chicken	Chest tightness	<0.001	1.82	1.31-2.54
Chicken	Chest tightness with SOB	<0.001	2.24	1.47-3.41
Beef	Shortness of breath	0.007	2.10	1.22-3.61
Beef	Chest tightness	<0.001	3.61	1.98-6.58
Beef	Attacks of chest tightness	0.046	2.25	1.01-5.00
Beef	Chest tightness with SOB	0.001	4.16	1.79-9.67
Horses	Shortness of breath	0.008	1.58	1.13-2.20
Horses	Wheeze without a cold	0.004	1.52	1.14-2.04
Horses	Attacks of wheeze with SOB	0.019	1.75	1.10-2.79
Horses	Chest tightness	0.003	1.64	1.18-2.57
Horses	Attacks of chest tightness	0.028	1.65	1.06-2.59
Horses	Chest tightness with SOB	0.040	1.50	1.02-2.21
Horses	Pneumonia	0.024	1.46	1.05-2.03
Turkeys	Asthma	0.006	2.77	1.34-5.69
Oats	Chest tightness	0.040	1.43	1.02-2.01
Oats	Attacks of chest tightness	0.023	1.81	1.08-3.03
Canola	Usual cough	0.012	0.60	0.41-0.90
Grind grain	Shortness of breath	0.018	1.93	1.12-3.32
Grind grain	Pneumonia	0.014	1.98	1.15-3.42

TABLE 31 Summary table from tables 18a-29a of significant findings from logistic regression and farm operation for **all the farmers** adjusted for smoking and age

Farm Operation	Symptom or diagnosed illness	p-value	OR	95% CI
Dairy	Shortness of breath	0.044	0.69	0.47-0.99
Hogs	Shortness of breath	0.025	1.66	1.06-2.58
Hogs	Chest tightness	0.039	1.50	1.02-2.21
Hogs	Chest tightness with SOB	0.002	2.30	1.35-3.92
Chicken	Shortness of breath	0.003	1.75	1.20-2.55
Chicken	Chest tightness	0.001	1.82	1.29-2.56
Chicken	Chest tightness with SOB	0.001	2.07	1.34-3.19
Beef	Chest tightness	<0.001	3.52	1.92-6.45
Beef	Chest tightness with SOB	0.002	3.77	1.61-8.82
Horses	Wheeze without a cold	0.014	1.47	1.08-1.99
Horses	Attacks of wheeze with SOB	0.030	1.70	1.05-2.73
Horses	Chest tightness	0.005	1.60	1.15-2.22
Turkeys	Asthma	0.008	2.69	1.29-5.61
Wheat	Usual cough	0.024	0.59	0.37-0.93
Oats	Chest tightness	0.044	1.43	1.01-2.01
Oats	Attacks of chest tightness	0.026	1.80	1.07-3.02
Canola	Usual cough	0.024	0.62	0.41-0.94
Grind grain	Pneumonia	0.046	1.76	1.01-3.06

TABLE 32 Summary table from tables 18b-29b of significant findings from logistic regression and farm operation for **atopic** farmers

Farm Operation	Symptom or Diagnosed illness	p-value	OR	95% CI
Dairy	Shortness of breath	0.040	0.42	0.18-0.98
Dairy	Chest tightness with SOB	0.018	2.88	1.20-6.95
Chicken	Wheeze without a cold	<0.001	0.34	0.16-0.70
Beef	Chest tightness	0.019	4.90	1.30-18.50
Turkeys	Asthma	0.020	4.83	1.36-17.18
Wheat	Usual cough	0.020	0.32	0.12-0.82
Oats	Usual cough	0.020	0.32	0.12-0.86
Canola	Usual cough	0.010	0.27	0.11-0.70

TABLE 33 Summary table from tables 18b-29b of significant findings from logistic regression and farm operation for **non-atopic** farmers

Farm Operation	Symptom or Diagnosed illness	p-value	OR	95% CI
Hogs	Shortness of breath	0.037	1.70	1.03-2.80
Hogs	Chest tightness	0.020	1.70	1.09-2.66
Hogs	Chest tightness with SOB	0.009	2.41	1.25-4.64
Chicken	Shortness of breath	0.001	2.10	1.38-3.22
Chicken	Chest tightness	<0.001	2.04	1.38-3.02
Chicken	Chest tightness with SOB	0.002	2.25	1.34-3.79
Beef	Chest tightness	0.001	3.31	1.67-6.59
Beef	Chest tightness with SOB	0.010	3.88	1.38-10.91
Horses	Wheeze without a cold	0.003	1.67	1.18-2.36
Horses	Attacks of wheeze with SOB	0.009	2.20	1.22-3.98
Horses	Chest tightness	0.009	1.64	1.13-2.38
Wheat	Asthma	0.018	0.35	0.15-0.84
Oats	Chest tightness	0.030	1.56	1.05-2.31
Oats	Attacks of chest tightness	0.044	1.88	1.04-3.39
Canola	Flu-like	0.031	1.67	1.05-2.65
Grind grain	Flu-like	0.026	2.52	1.12-5.67

TABLE 34a Summary table of all farmers, atopic farmers and non-atopic farmers

	All	OR	Atopic	OR	Non-atopic	OR
Dairy	Shortness of breath	0.69	Shortness of breath	0.42	~	
			Chest tightness with SOB	2.88		
Hogs	Shortness of breath	1.66			Shortness of breath	1.70
	Chest tightness	1.50	~		Chest tightness	1.70
	Chest tightness with SOB	2.30	~		Chest tightness with SOB	2.41
Chicks	Shortness of breath	1.75	Wheeze without a cold	0.34	Shortness of breath	2.10
	Chest tightness	1.82			Chest tightness	2.04
	Chest tightness with SOB	2.07			Chest tightness with SOB	2.25
Beef	Chest tightness	3.52	Chest tightness	4.90	Chest tightness	3.31
	Chest tightness with SOB	3.77			Chest tightness with SOB	3.88
Horses	Wheeze without a cold	1.47	~		Wheeze without a cold	1.64
	Attacks of wheeze w SOB	1.70	~		Attacks of wheeze w SOB	1.67
	Chest tightness	1.60	~		Chest tightness	2.20

~ no significant findings for that farm type

TABLE 34b Summary table of all farmers, atopic farmers and non-atopic farmers

	All	OR	Atopic	OR	Non atopic	OR
Turkeys	Asthma	2.69	Asthma	4.83	~	
Wheat	Cough	0.59	Cough	0.32	Asthma	0.35
Oats	Chest tightness	1.43	Cough	0.32	Chest tightness	1.56
	Attacks of chest tightness	1.80			Attacks of chest tightness	1.88
Canola	Cough	0.62	Cough	0.27	Flu-like symptoms	1.67
Barley	~		~		~	
Silage	~		~		~	
GrGrain	Pneumonia	1.76	~		Flu-like symptoms	2.52

~ no significant findings for that farm type

TABLE 35 Comparison of mean lung function for farmers who did and did not raise **dairy cows** by smoking category

		Dairy		No Dairy		
		Mean	Std deviation	Mean	Std deviation	p-value
	Nonsmoker	103.36	14.39	102.96	12.83	
$PCTFEV_1$*	Ex-Smoker	100.35	14.81	97.38	15.45	0.962
	Current smoker	97.36	13.95	103.10	14.40	
	Nonsmoker	101.59	12.72	101.60	12.21	
PCTFVC*	Ex-Smoker	101.45	13.28	97.81	13.21	0.956
	Current smoker	101.48	13.15	106.48	13.12	
	Nonsmoker	78.88	6.17	80.27	6.03	
FEV_1/FVC	Ex-Smoker	75.52	7.07	76.85	7.13	0.270
	Current smoker	74.94	8.16	76.16	6.76	

*percent of predicted

TABLE 36 Comparison of mean lung function for farmers who did and did not raise **hogs** by smoking category

		Hogs		No Hogs		
		Mean	Std deviation	Mean	Std deviation	p-value
	Nonsmoker	102.32	13.88	105.19	13.26	
$PCTFEV_1$*	Ex-Smoker	98.01	16.03	103.01	11.52	0.007
	Current smoker	99.63	15.23	100.55	12.15	
	Nonsmoker	100.44	12.35	103.96	12.26	
PCTFVC*	Ex-Smoker	99.01	14.31	103.60	9.43	0.001
	Current smoker	103.38	13.98	104.12	12.11	
	Nonsmoker	79.03	6.11	80.79	5.92	
FEV_1/FVC	Ex-Smoker	75.61	7.43	77.41	5.74	0.530
	Current smoker	75.10	7.44	76.59	7.94	

*percent of predicted

TABLE 37 Comparison of mean lung function for farmers who did and did not raise **chickens** by smoking category

		Chickens		No Chickens		
		Mean	Std deviation	Mean	Std deviation	p-value
	Nonsmoker	103.21	14.79	103.16	12.43	
$PCTFEV_1$*	Ex-Smoker	98.45	14.72	100.54	15.77	0.435
	Current smoker	99.40	15.26	100.45	13.30	
	Nonsmoker	101.31	13.32	101.94	11.42	
PCTFVC*	Ex-Smoker	99.72	13.11	100.56	13.89	0.477
	Current smoker	103.53	13.86	103.70	12.95	
	Nonsmoker	79.20	6.38	79.88	5.81	
FEV_1/FVC	Ex-Smoker	75.38	7.51	77.30	6.14	0.361
	Current smoker	74.42	7.32	76.74	7.16	

*percent of predicted

TABLE 38 Comparison of mean lung function for farmers who did and did not raise **beef cattle** by smoking category

		Beef		No Beef		
		Mean	Std deviation	Mean	Std deviation	p-value
$PCTFEV_1$*	Nonsmoker	103.66	13.96	100.99	12.48	0.363
	Ex-Smoker	99.52	15.13	97.23	15.18	
	Current smoker	99.83	15.03	100.40	9.59	
PCTFVC*	Nonsmoker	101.72	12.44	100.61	12.40	0.248
	Ex-Smoker	100.46	13.33	97.04	13.66	
	Current smoker	103.70	14.00	103.19	9.63	
FEV_1/FVC	Nonsmoker	79.57	6.26	79.56	5.30	0.948
	Ex-Smoker	75.89	7.10	77.56	6.85	
	Current smoker	75.27	7.70	77.19	7.07	

*percent of predicted

TABLE 39 Comparison of mean lung function for farmers who did and did not raise **horses** by smoking category

		Horses		No Horses		
		Mean	Std deviation	Mean	Std deviation	p-value
$PCTFEV_1$*	Nonsmoker	103.41	14.07	103.06	13.54	0.984
	Ex-Smoker	100.29	13.70	98.35	16.22	
	Current smoker	97.01	14.07	101.73	14.51	
PCTFVC*	Nonsmoker	101.72	12.81	101.50	12.27	0.738
	Ex-Smoker	101.45	11.56	98.84	14.69	
	Current smoker	101.41	13.64	104.98	13.09	
FEV_1/FVC	Nonsmoker	78.95	6.28	79.88	6.03	0.378
	Ex-Smoker	75.43	7.91	76.65	6.28	
	Current smoker	74.63	8.08	76.17	7.28	

*percent of predicted

TABLE 40 Comparison of mean lung function for farmers who did and did not raise **turkeys** by smoking category

		Turkeys		No Turkeys		
		Mean	Std deviation	Mean	Std deviation	p-value
$PCTFEV_1$*	Nonsmoker	103.18	15.27	103.20	13.45	0.135
	Ex-Smoker	94.25	13.47	100.19	15.27	
	Current smoker	98.19	16.29	100.30	13.85	
PCTFVC*	Nonsmoker	102.74	14.15	101.37	12.14	0.385
	Ex-Smoker	96.08	12.69	100.79	13.41	
	Current smoker	101.64	11.83	104.04	13.68	
FEV_1/FVC	Nonsmoker	78.50	6.18	79.72	6.01	0.127
	Ex-Smoker	74.92	7.43	76.32	7.01	
	Current smoker	74.66	8.94	75.78	7.32	

*percent of predicted

TABLE 41 Comparison of mean lung function for farmers who did and did not grow **wheat** by smoking category

		Wheat		No Wheat		
		Mean	Std deviation	Mean	Std deviation	p-value
	Nonsmoker	103.03	13.61	103.69	14.32	
$PCTFEV_1$*	Ex-Smoker	100.00	14.08	97.43	17.65	0.831
	Current smoker	99.14	14.34	103.58	13.60	
	Nonsmoker	101.14	12.78	103.24	11.76	
PCTFVC*	Ex-Smoker	100.57	12.98	99.20	14.66	0.322
	Current smoker	103.20	13.79	105.58	11.21	
	Nonsmoker	79.95	5.58	78.16	7.58	
FEV_1/FVC	Ex-Smoker	76.34	6.98	75.20	7.48	0.112
	Current smoker	75.19	7.80	77.41	6.48	

*percent of predicted

TABLE 42 Comparison of mean lung function for farmers who did and did not grow **oats** by smoking category

		Oats		No Oats		
		Mean	Std deviation	Mean	Std deviation	p-value
	Nonsmoker	102.95	14.18	103.63	12.96	
$PCTFEV_1$*	Ex-Smoker	98.31	15.01	101.23	15.08	0.561
	Current smoker	101.13	15.10	97.48	12.20	
	Nonsmoker	101.75	13.02	101.39	11.69	
PCTFVC*	Ex-Smoker	99.45	13.68	101.63	12.86	0.966
	Current smoker	104.65	13.76	101.53	12.40	
	Nonsmoker	79.38	6.43	79.82	5.58	
FEV_1/FVC	Ex-Smoker	75.95	6.99	76.22	7.37	0.269
	Current smoker	75.52	7.38	75.70	8.13	

*percent of predicted

TABLE 43 Comparison of mean lung function for farmers who did and did not grow **canola** by smoking category

		Canola		No Canola		
		Mean	Std deviation	Mean	Std deviation	p-value
	Nonsmoker	103.60	13.25	102.57	14.51	
$PCTFEV_1$*	Ex-Smoker	101.70	13.43	96.12	16.59	0.033
	Current smoker	100.24	13.87	99.51	14.87	
	Nonsmoker	102.48	12.99	101.02	11.92	
PCTFVC*	Ex-Smoker	101.78	11.34	98.09	15.61	0.056
	Current smoker	104.26	13.08	102.78	13.79	
	Nonsmoker	80.07	5.55	78.73	6.87	
FEV_1/FVC	Ex-Smoker	77.05	6.59	74.68	7.60	0.199
	Current smoker	75.65	7.16	75.49	8.21	

*percent of predicted

TABLE 44 Comparison of mean lung function for farmers who did and did not grow **barley** by smoking category

		Barley		No Barley		
		Mean	Std deviation	Mean	Std deviation	p-value
	Nonsmoker	102.99	13.74	105.65	14.12	
$PCTFEV_1$*	Ex-Smoker	99.44	14.96	97.90	17.13	0.492
	Current smoker	99.83	14.36	102.04	13.09	
	Nonsmoker	101.48	12.38	103.53	14.76	
PCTFVC*	Ex-Smoker	100.48	13.30	96.37	14.82	0.915
	Current smoker	103.72	13.48	101.51	11.39	
	Nonsmoker	79.50	6.09	79.82	7.00	
FEV_1/FVC	Ex-Smoker	75.94	7.17	77.58	6.22	0.166
	Current smoker	75.53	7.70	76.71	5.60	

*percent of predicted

TABLE 45 Comparison of mean lung function for farmers who did and did not make **silage** by smoking category

		Silage		No Silage		
		Mean	Std deviation	Mean	Std deviation	p-value
	Nonsmoker	102.00	14.26	103.81	13.48	
$PCTFEV_1$*	Ex-Smoker	104.41	11.82	97.35	15.76	0.442
	Current smoker	99.62	12.08	100.09	15.39	
	Nonsmoker	101.14	13.54	101.89	12.03	
PCTFVC*	Ex-Smoker	103.42	10.50	98.96	14.22	0.696
	Current smoker	102.11	13.25	104.44	13.43	
	Nonsmoker	78.99	6.35	79.81	6.03	
FEV_1/FVC	Ex-Smoker	78.97	5.71	74.90	7.29	0.284
	Current smoker	76.68	6.40	74.98	8.16	

*percent of predicted

TABLE 46 Comparison of mean lung function for farmers who did and did not **grind grain** by smoking category

		Grind grain		Did not grind grain		
		Mean	Std deviation	Mean	Std deviation	p-value
$PCTFEV_1$*	Nonsmoker	102.95	13.82	104.00	13.19	0.526
	Ex-Smoker	99.27	15.22	100.03	14.47	
	Current smoker	99.95	14.90	100.76	10.07	
PCTFVC*	Nonsmoker	101.31	12.56	102.90	12.15	0.199
	Ex-Smoker	99.94	13.47	102.58	13.15	
	Current smoker	103.61	13.49	104.55	12.60	
FEV_1/FVC	Nonsmoker	79.34	5.98	80.57	6.96	0.836
	Ex-Smoker	76.10	7.11	75.56	7.33	
	Current smoker	77.67	7.67	76.96	7.25	

TABLE 47 Summary table of significant findings from lung function studies from Tables 35-46

		Hogs		No Hogs		
		Mean	Std deviation	Mean	Std deviation	p-value
	Nonsmoker	102.32	13.88	105.19	13.26	
$PCTFEV_1$*	Ex-Smoker	98.01	16.03	103.01	11.52	0.007
	Current smoker	99.63	15.23	100.55	12.15	
	Nonsmoker	100.44	12.35	103.96	12.26	
PCTFVC*	Ex-Smoker	99.01	14.31	103.60	9.43	0.001
	Current smoker	103.38	13.98	104.12	12.11	

		Canola		No Canola		
		Mean	Std deviation	Mean	Std deviation	p-value
	Nonsmoker	103.60	13.25	102.57	14.51	
$PCTFEV_1$*	Ex-Smoker	101.70	13.43	96.12	16.59	0.033
	Current smoker	100.24	13.87	99.51	14.87	

* percent of predicted

TABLE 48 Comparison of mean percent of predicted lung function for farmers who were and were not **atopic** by smoking category

		Atopic		Non- atopic		
		Mean	Std deviation	Mean	Std deviation	p-value
$PCTFEV_1$	Nonsmoker	102.98	13.74	10.18	13.72	
	Ex-Smoker	101.31	15.82	98.77	14.88	
	Current smoker	101.15	14.44	99.56	14.27	0.345
PCTFVC	Nonsmoker	101.71	11.98	101.55	12.63	
	Ex-Smoker	102.72	14.17	99.54	13.14	0.458
	Current smoker	103.41	14.00	103.67	13.24	
FEV_1/FVC	Nonsmoker	79.35	6.87	79.56	6.01	
	Ex-Smoker	76.34	6.83	75.89	7.19	0.368
	Current smoker	76.77	5.22	75.23	8.17	

REFERENCES

Amishima M, Munakatam, Ohtsuka Y, Satoh A, Takahashi T, Taguchi H, Nasuhara Y, Ohe M, Doi I, Homma Y, Kawakami Y. Dairy farmers have increased methacholine bronchial responsiveness independent of sensitization to mold antigens. *American Journal of Critical Care Medicine* 1995;151:1794-1798.

Arrighi HM, Hertz-Picciotto. The evolving concept of the evolving healthy worker survivor effect. *Epidemiology* 1994;5:189-196.

Banks DE, Wang ML. Occupational asthma: "the big picture". *Occupational Medicine* 2000;15:335-358.

Bessot JC, Blaumeiser M, Kopferschmitt MC, Pauli G. Occupational asthma in agriculture. *Revue des maladies Respiratoires* 1996;13:205-215.

Broder I, Corey P, Davies G, Hutcheon M, Mintz S, Inouye T, Hyland R, Lenzoff, Thomas P. Longitudinal study of grain elevator and control workers with demonstration of healthy worker effect. *Journal of Occupational Medicine.* 1985;27:873-880.

Broder I, Mintz S, Hutcheon M, Corey P, Silverman F, Davies G, Leznoff A, Peress L, Thomas P. Comparison of respiratory variables in grain elevator workers and civic outside workers of Thunder Bay , Canada. *American Review of Respiratory Disease* 1979;119:193-203.

Blumenthal M. Epidemiology and genetics of asthma and allergy. In: Kaplan AP ed. *Allergy* 2nd ed. Toronto: WB Saunders; 1998:407-420.

Burrows B, Lebowitz MD, Barbee RA. Respiratory disorders and allergy skin-test reactions. *Annals of Internal Medicine* 1976;84:134-139.

Burrows B, Martinez F, Halonen M, Barbee RA, Cline MG. Association of asthma with serum IgE levels and skin-test reactivity to allergens. *New England Journal of Medicine* 1989;320:271-276.

Chan-Yeung M, Dimich-Ward H, Enarson DA, Kennedy S. Five cross-sectional studies of grain elevator workers. *American Journal of Epidemiology* 1992;136:1269-1279.

Chen Y, Horne SL, McDuffie H, Dosman JA. Combined effect of grain farming and smoking on lung function and the prevalence of chronic bronchitis. *International Journal of Epidemiology* 1991;20:416-423.

Chodat D, Goehen M, Korobaeff M, Boulet A, Dewitte JD, Martin MH. Respiratory symptoms and bronchial activity among pig and dairy farmers. *Scandinavian Journal of Work, Environment and Health* 1994;20:48-54.

Choi BCK. Definition, sources, magnitude, effect modifiers, and strategies of reduction of the healthy worker effect. *Journal of Occupational Medicine* 1992;34:979-988.

Choma D, Westeel V, Dubiez A,Gora D, Meyer V, Pernet D, Polio JC, Madroszyk A, Gibey R, Laplante JJ, Depierre A, Dalphin JC. Respective influence of occupational and personal factors on respiratory fu;nction in dairy farmers. *Revue Maladie Respiratorie* 1998;15:765-772.

Cormier Y, Israel-Assayag E, Racine G, Duchaine C. Farming practices and the health risks of swine confinement buildings. *European Respiratory Journal* 2000;15:560-565.

Crapo R, Morris AH, Gardner RM. Reference spirometric values using techniques and equipment that meets ATS recommendations. *American Review of Respiratory Disease* 1981;123:5659-5664.

Crook B, Robertson JF, Glass SAT, Botheroyd EM, Lacey J, Topping MD. Airborne dust, ammonia, microorganisms and antigens in pig confinement houses and the respiratory health of the exposed farm. *American Industrial Hygiene Association Journal* 1991;52:271-279.

Dalphin JC, Maheu MF, Dussaucy A, Pernet D, Polio JC, Dubiez A, Laplante JJ, Depierre A. Six year longitudinal study of respiratory function in dairy farmers in the Doubs province. *European Respiratory Journal* 1998;11:1287-1293.

Dalphin JC, Dubiez A, Monnet E, Gora D, Westeel V, Pernet D, Polio JC, Gibley R, Laplante JJ, Depierre A. Prevalence of asthma and respiratory symptoms in dairy farmers in the French province of the Doubs. *American Journal of Critical Care Medicine* 1998;158:1493-1498.

Donham KJ, Comro D, Reynolds SJ, Merchant JA. Dose-response elationships betweenn occupational aerosol exposures and cross-shift declines of lung function in poultry workers: recommendations for exposure limits. *Journal of Occupational and Environmental Medicine* 2000;43:260-269.

Donham KJ, Reynolds SJ, Whitten P, Merchant JA, Burmeister L, Popendorf WJ. Respiratory dysfunction in swine production facility workers: dose-response relationships of environment exposures and pulmonary function. *American Journal of Industrial Medicine* 1995; 27:405-418.

Donham KJ, Rubino M, Thedell TD, Kammermeyer J. Potential health hazards to agriculture workers in swine confinement buildings. *Journal of Occupational Medicine* 1987;19:383-387.

do Pico G. Lung (agriculture/rural). *Otolaryngology-Head and Neck Surgery* 1996;114:212-216.

Dosman JA, McDuffie H, Pahwa P. Atopic status as a factor in job decision making in grain workers. *Journal of Occupational Medicine* 1991;33:1007-1010.

Dosman JA, Graham BL, Hall D, Van Loon P, Bhasin P, Froh F. Respiratory symptoms and pulmonary function in farmers. *Journal of Occupational Medicine* 1987;29:38-43.

Dosman JA, Graham BL, Hall D, Pahwa P, McDuffie H, Lucewicz, To T. Respiratory symptoms and alterations in pulmonary function tests in swine producers in Saskatchewan: results of a survey of farmers. *Journal of Occupational Medicine* 1988;30:715-720.

Dreborg S. Skin tests for epidemiological studies. *Allergy* 1989;suppl.10;52-59.

Dubiez A, Meyer V, Gora D, Pernet D, Polio JC, Lagarde D, Gibey R, Laplante JJ, Depierre A, Dalphin JC. Prevalence of IgE allergy to respiratory allergens in dairy farmers in the Doubs (France). *Revue d'Epidemiologie et de Sante Publique* 1995;43:470-476.

Enarson DA, Vendal S, Chan-Yeung M. Fate of grain handlers with bronchial activity. *Clinical and Investigative Medicine* 1988;11:193-197.

Ferris BG. Epidemiology Standardization Project:II. Recommended respiratory diseases questionnaire for use with adults and children in epidemiological research. *American Review of Respiratory Diseases* 1978;118:7-53.

Frew AJ. Skin tests used for epidemiological studies. *Allergy* 1989;44(suppl.):52-59.

Heller RF, Hayward DM, Farebrother MT. Lung function of farmers in England and Whales. *Thorax* 1986;41:117-21.

Herbert FA, Weimer N, Salkie ML. Rast and skin test screening in the investigation of asthma. *Annals of Allergy* 1982;49:311.

Hillman RS. Anemia. In:Fauci et al. eds. *Harrison's Principles of Internal Medicine* 14 ed, Toronto: McGraw-Hill; 1998:334-339.

Holness DL, O'Blenis FL, Sass-Kortsak A, Pilger C, Nethercott JR. Respiratory effects of dust exposures in hog confinement farming. *American Journal of Industrial Medicine* 1987;11:571-580.

Hunninghake GW, Richerson HB. Hypersensitivity pneumonitis and eosinophilic pneumonias. In:Fauci et al. eds. *Harrison's Principles of Internal Medicine* 14 ed, Toronto: McGraw-Hill; 1998:1426-1429.

Huy T, De Schipper K, Chan-Yeung M, Kennedy S. Grain dust and lung function. *American Review of Respiratory Disease* 1991;144:1314-1321.

Honig EG, Ingram, RH. Chronic bronchitis, emphysema,and airways obstruction. In:Fauci et al. eds. *Harrison's Principles of Internal Medicine* 14 ed, Toronto: McGraw-Hill; 1998:1451-1460.

James AI, Zimmerman MJ, Ee H, Ryan G, Musk AW. Exposure to grain dust and changes in lung function. *British Journal of Industrial Medicine* 1990;47:466-472.

Kirychuk SP, Sentilselvan A, Dosman JA, Zhou C, Barber EM, Rhodes CS. Predictors of longitudinal changes in pulmonary function among swine confinement workers. *Canadian Respiratory Journal* 1998;5:472-478.

Kimbell-Dunn M, Bradshaw L, Slater T, Erkinjuntti-Pekkanen R, Fishwick D, Pearce N. Asthma and allergy in New Zealand farmers. *American Journal of Industrial Medicine* 1999;35:51-57.

Li C-Y, Sung F-C. A review of the healthy worker effect in occupational epidemiology. *Occupational Medicine* 1999;49:225-229.

Malmberg P. Health effects of organic dust exposure in dairy farmers. *American Journal of Industrial Medicine* 1990;17:7-15.

Manfreda J, Cheang M, Warren CPW. Chronic respiratory disorders related to farming and exposure to grain dust in a rural adult community. *American Journal of Industrial Medicine* 1989;15:7-19.

Mauny F, Polio JC, Monnet E, Pernet D, Laplante JJ, Depierre A, Dalphin JC. Longitudinal study of respiratory health in dairy farmers: influence of artificial barn fodder drying. *European Respiratory Journal* 1997;10:2522-2528.

Melbostad E, Eduard W, Magnus P. Chronic bronchitis in farmers. *Scandinavian Journal of Work, Environment & Health* 1997;23:271-280.

Melbostad E, Eduard W, Magnus P. Determinants of asthma in a farming population. *Scandinavian Journal of Work, Environment & Health* 198;24:262-269.

Melenka LS, Hessel PA, Yoshida K, Enarson DA. Lung health in Alberta farmers. *The International Journal Tuberculosis and Lung Disease* 1999;3:913-919.

McFadden, ER. Asthma. In:Braunwald et al. eds. *Harrison's Principles of Internal Medicine* 14 ed, McGraw-Hill; 1998:1060-1058

Ownby DR. Clinical significance of Immunoglobulin E. In: Middleton et al. eds. *Allergy, Principles and Practices*. St Louis: Mosby; 1995:770-782.

Pederson B, Iversen M, Bundgaard Larsen B, Dahl R. Pig farmers have signs of bronchial inflammation and increased numbers of lymphocytes and neutrophils in BAL fluid. *European Respiratory Journal* 1996;9:524-530.

Preller L, Heederik D, Boleij JSM, Vogelzang PFJ, Tielen MJM. Lung function and chronic respiratory symptoms of pig farmers: Focus on exposure to endotoxins and ammonia and the use of disinfectants. *Occupational and Environmental Medicine* 1995;52:654-660.

Rask-Anderson A. The organic dust toxic syndrome-a review. In. In:McDuffie H et al., eds *Agriculture health and safety*. Flordia: CRC Press; 1995:101-103.

Rautalahti M, Terho EO, Vohlonen I, Nuutinen J, Husman K, Korhonen O. effect of indoor feeding season for cattle on lung function of dairy farmers. European Journal of Respiratory Diseases 1987;152(suppl):188-196.

Rees D, Nelson G, Kielkowski D, Wasserfall C, da Costa A. Respiratory health and immunological profile of poultry. *South African Medical Journal* 1998;88:1110-1117.

Reynolds SJ, Donham KJ, Whitten P, merchant JA, Burmeister LF, Popendorf WJ. Longitudinal evaluation of dose-response relationships for environmental exposures and pulmonary function in swine production workers. *American Journal of Industrial Medicine* 1996;29:33-40.

Reynolds SJ, Parker D, Vesley D, Smith D, Woellner R. Cross-sectional epidemiological study of respiratory disease in turkey farmers. *American Journal of Industrial Medicine* 1993;24:713-722.

Roberts G, Lack G. Horse allergy in children. *British Medical Journal* 2000;321:286-287.

Schwartz DA, Donham KJ, Olenchock SA, Popendorf WJ, Van Fossen SD, Brumeister LF, Merchant JA. Determinants of longitudinal changes in spirometric function among swine confinement operators and farmers. *American Journal of Critical Care Medicine* 1995;151:47-53.

Selwyn AP, Braunwald E. In:Fauci et al. eds. *Harrison's Principles of Internal Medicine* 14 ed, McGraw-Hill; 1998:1365-1375.

Senthilselvan A, Dosman JA, Kirychuk SP, Barber EM, Rhodes C, Zhang Y, Hurst TS. Accelerated lung function decline in swine confinement workers. *Chest* 1997;111:1733-1741.

Senthilselvan A, Chen Y, Dosman JA. Predictors of asthma and wheezing in adults. Grain farming, sex, and smoking. *American Review of Respiratory Disease* 1993;148:667-670.

Skea D, McAvoy D, Broder I. Phenol amplfies complement-fixing activity and induces IgG-precipitating activity in grain-dust extract. *Journal of Allergy and Clinical Immunology* 1988;81:557-563.

Statistics Canada, 1996. *Agriculture profile of Alberta*. Catalogue number 95-180-XPB, page 31.

Stepner N, Broder I, Baumal R. A study of the pulmonary histopathologic effects of chronic grain dust exposure in rabbits. In: Dosman JA and Crockcroft DW eds. *Principles of health and safety in agriculture*. Boca Raton: CRC Press, Inc.;1989:104-109.

Tabona M, Chan-Yeung M, Enarson D, MacLean L, Dorken E, Schulzer M. Host factors affecting longitudinal decline in lung spirometry among grain elevator workers. *Chest* 85;1984:782-786.

Van Niekerk LS, Weich DJV. Respiratory smptoms and IgE levels in workers on a maize farm. *South African Medical Journal* 1989;76:562-569.

Vogelzang PF, van der Gulden JW, Folgering H, van Schayck CP. Longitudinal changes in lung function with aspects of swine-confinement exposure. *Journal of Occupational and Environmental Medicine* 1998 40:1048-1052.

Vogelzang PF, van der Gulden JW, Preller L, Tielen MJ, van Schayck CP, Folgering H. Bronchial hyperresponsiveness and exposure in pig farmers. *International Archives of Occupational and Environmental Health* 1997;70:327-333.

Von Essen SG, Scheppers LA, Robbins RA, Donham KJ. Respiratory tract inflammation in swine confinement workers studied using induced sputum and exhaled nitric oxide. *Clinical Toxicology* 1998;36:557-565.

Von Essen SG, Fryzek J, Nowakowski B, Wampler M. Respiratory symptoms and farming practices associated with an acute febrile illness after organic dust exposure. *Chest* 1999;116:1452-1458.

West JB. Obstructive Diseases. In:Gardner J, 3rd ed, *Pulmonary pathophysiology*. Baltimore: Williams and Wilkins; 1987:59-61.

Wilkins JR, Engelhardt HL, Rublaitus SM, Crawford JM, Fisher JL. Prevalence of chronic respiratory symptoms among Ohio cash grain farmers. *American Journal of Industrial Medicine* 1999;35:150-163.

Zejda JE, Dosman JA. Respiratory disorders in agriculture. *Tubercle and Lung Diseases* 1993;74:74-86.

Zuskin E, Kanceljak B, Schachtner EN, Mustjbegovic J, Goswami S, MaayaniS, Marom Z, Rienzi N. Immunologic and respiratory findings in swine farmers. *Environmental Research* 1991;56:120-130.