RISK FACTORS FOR FARM-RELATED ADVERSE HEALTH OUTCOMES

by

Obiora Edward Onwuameze

A thesis submitted in partial fulfillment
of the requirements for the Doctor of
Philosophy degree in Occupational and Environmental Health
in the Graduate College of
The University of Iowa

May 2009

Thesis Supervisors: Assistant Professor Risto H. Rautiainen
Professor Corrine Peek-Asa

To my loving wife, Nkechi, my kids Kosi, Muna, Lota and my dear parents Dr. Chinwuba Onwuameze and Late Mrs. Ukamaka Onwuameze

ACKNOWLEDGMENTS

I would like to thank all those that made the completion of this PhD thesis possible.

The support for this research came from NIOSH (Grant No. UO6/CCU712193), the Iowa Wellmark Foundation, Pioneer Hi-Bred International Inc., Iowa Pork Producers Association, National Pork Producers Council, Iowa Injury Prevention Research Center and the Heartland Education and Research Center (Grant No. T42OH008491). My acknowledgement also goes to those who designed and conducted the study at the University of Iowa including Kelley Donham (Principal Investigator), Kendall Thu, Natalie Roy, Risto Rautiainen, Carol Hodne, LaMar Grafft, Sara Schneiders, Aaron Kline, and Paul Whitten who initiated the program, obtained the funding, provided coordination of research efforts and trained healthcare providers and farm safety consultants. The Spencer Agrisafe Clinic (Spencer, Iowa) conducted the clinical components of the study.

My sincere gratitude to the members of my dissertation committee: Risto Rautiainen (chair) Corrine Peek-Asa (co-chair), Gideon Zamba (member), Nancy Sprince (member), Kelley Donham (member) and Dan Anton (member).

My appreciation to my brother Emeka for his financial support during my course work, to Chinwe and Nnamdi for their moral support, Patrick O'Shaughnessy for his encouragement, Chika, Nkechi and Ikenna.

I also want to thank Sergio Paradiso for his encouragement, the Akamigbo's, the Goshit's, the Alamu's, the Okons' Gregory Gray, the Enekwechi's, Adaugo, the Plates', Agnes Deraad and Bode.

ABSTRACT

This study aimed to evaluate the prevalence, incidence and risk factors for farm-related disease symptoms (musculoskeletal disorders, skin diseases and depression) in a cohort of Iowa farmers using data from the Certified Safe Farm study.

The prevalence of MSD at baseline was 41.1% and during the three-year follow-up period, the cumulative period prevalence (proportion of persons with symptoms) for all MSD symptoms was 70.2%. The cumulative prevalence was 68.0% for low-back pain and 14.2% for neck/shoulder pain. The incidence (cases per 100 person-years) was 8.1 for low back pain and 3.0 for neck/shoulder pain. Working ≥ 42 hours weekly (OR=1.81; 95% CI: 1.40 – 2.35), heavy lifting (OR=1.45; 95% CI: 1.08 – 1.94), and exposure to loud noise (OR=1.51; 95% CI: 1.17 – 1.95) were risk factors for MSD even in multivariable models, while farming crop acres was protective (OR= 0.34; 95% CI: 0.19 – 0.59).

The three-year cumulative prevalence of skin disorders was 16.3% and the incidence was 4.8 cases per 100 person-years during the follow-up consisting of 758 person-years. Exposure to pesticides (OR=1.92; 95% CI: 1.14 – 3.23) was a risk factor for skin disorders. Conversely, the use of hat with wide brim (OR=0.38; 95% CI: 0.18 – 0.77), wearing long sleeve clothing when working outside (OR=0.41; 95% CI: 0.20 – 0.83) and a history of allergy (OR=0.39; 95% CI: 0.24 – 0.65) were protective. Previous skin ulcer (OR=11.35; 95% CI: 5.82 – 22.14) was a risk factor for skin cancer while sunscreen use (OR=0.34; 95% CI: 0.25 – 0.46) decreased the risk.

Pesticide application (OR=1.83; 95% CI: 1.38 – 2.43) was a risk factor for high depression, while education (≤ high school) (OR=0.58; 95% CI: 0.37 – 0.92) was protective.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This study aimed to evaluate the prevalence, incidence and risk factors for three common farm-related disease symptoms in a cohort of 316 Iowa farmers. The study had three main components. The first component evaluated the prevalence, incidence and risk factors of musculoskeletal disorder symptoms (MSDs); the second component evaluated the prevalence, incidence and risk factors of skin disease symptoms and the third component evaluated the risk factors for depression symptoms among farmers.

This study used data from the Certified Safe Farm (CSF) program that was designed to assess the effectiveness of a multi-faceted farm safety intervention. The CSF study was funded by the NIOSH Community Partners for Health Farming Initiative (Grant No. U06/CCU712193) and this dissertation research was funded by the NIOSH-funded Heartland Education and Research Center (Grant No. T420H008491).

Farm environments have many exposures which may lead to adverse health effects. However, work-related illnesses are not well documented in US agriculture. A review of the literature revealed that MSDs, certain cancers, respiratory diseases, noise-induced hearing loss, skin conditions and zoonoses are common in agriculture (Rautiainen and Reynolds, 2002). Musculoskeletal disorders (MSDs) are diseases or ailments of the muscles, ligaments, tendons, bones, joints, cartilages, or peripheral nerves. They may also be called ergonomic injuries and illnesses. Common symptoms include pain and limitation of movement. The pathophysiology of MSDs in lay terms is strain due to wear and tear, usually from overuse or misuse. Skin disorders include a variety of medical problems associated with the skin such as dermatitis, psoriasis, vitiligo, moles as well as benign and neoplastic growths. Depression is a mental condition characterized by a sense of inadequacy and sometimes significant inactivity. Some factors unique to farming that may be associated with increased stress and depression include weather conditions, interpersonal relationship problems, financial worries, sole proprietorship and government interference in one's business enterprise (Walker and Walker, 1987).

Significance

MSDs

MSDs are common and they place a significant burden on the economy. The estimated lifetime prevalence of MSDs is between 60-90% (Kelsey and Golden, 1988). A reported 22.4 million cases of back pain among workers in the United States in 1988 resulted in a loss of 149.1 million workdays (Guo et al., 1995; 1998). MSD is the leading occupational injury in the United States and accounted for a third of occupational injuries between 1992 and 2001 (BLS, 2005). In the period from 2002 to 2005, it accounted for over 30.0% of total days off work due to injuries or illnesses in the US (BLS, 2006). The rate of MSD cases involving days away from work in 2001 for Iowa private industry was 67.2% (BLS, 2003). This is similar to European experience, for instance in Belgium, where Goubert at al. (2004) reported that LBP was the second most frequently reported pain complaint (Goubert et al., 2004). Also, Picavet and Schouten (2003) reported LBP as the most important cause of professional disability and sick leave.

Skin disorders

Dermatoses or skin disorders represent almost 15% of adverse health outcomes in the workplace (BLS, 2005). The incidence rate of occupational skin disorders in the US private industry was 4.5 per 10,000 full time workers in 2006 (BLS, 2008).

The prevalence of skin disorders among self-employed farmers is not well known. For hired farm workers, the prevalence varies based on crop type. The one-year prevalence for skin rash among a population of Californian tomato, grape and citrus workers was 12% (Gamsky et al., 1992). The same study reported 52% prevalence for grape workers and 19% for tomato workers. In Iowa, [a]Park et al. (2001) reported 9.6% dermatitis prevalence for male farmers and 14.4% prevalence for their wives.

Depression

The rate of diagnosed depressive illnesses and the use of antidepressants has continued to rise in the US and has increased among each race and ethnic group: from 10.9 to 15.4 per 100 for whites, from 4.2 to 7.6 for blacks and from 4.8 to 7.0 for Hispanics (Sclar et al., 2008). Farming is associated with increased levels of stress, anxiety and depression (Sanne et al., 2004; Simkin et al., 1998). Roberts and Lee (1993) reported that farmers had a higher prevalence of depression when compared to other occupations. The weighted frequencies of symptoms of depression were 12.2% for Iowa farmers and 7.4% for Colorado farmers (Scarth et al., 2000).

Costs

The cost of MSDs in the US has been estimated at $50-$100 billion in 1990 of which 75% or more can be attributed to the 5% of people who become permanently disabled from back pain (Frymoyer and Cats-Baril, 1991). In 1998, the National Research Council estimated direct workers' compensation expenditure for MSDs at $20 billion. Praemer et al. (1999) reported the total cost for MSD to be $215 billion in 1995. The costs of MSDs in agriculture are not well known, because self-employed farmers are generally not covered by workers' compensation and few studies have addressed injury and illness costs in agriculture.

The estimated cost for occupational dermatitis in 1985 was between $222 million and $1 billion (Mathias, 1985). In 2001 the incidence rate for occupational skin diseases in the private industry was 4.3 per 10,000 full time workers (BLS, 2001). Agriculture had consistently higher incidence rates than other industries during 1992 - 2001 and they involve a median of about 3 days away from work (BLS, 2003). There was no specific information reported about the costs for agriculture. In the CSF study, the average annual cost for skin conditions was $49 (Donham et al., 2007).

Only limited information is available with regards to the costs for psychosomatic disorders in the workplace. Thompson and Richardson (1999) reported that depression can result in productivity losses via increased rates of absenteeism and short-term disability as well as via impaired on-the-job performance. Also, depression is a common disease that has more impacts on employers' health care costs and workplace productivity than many other chronic medical conditions (Riotto, 2001).

The overall cost burden for the three health outcomes (MSDs, skin disorders and depression) is not well known in US agriculture, but is likely high. The three-year cost burden for MSD was $539 per farmer in the CSF study. This was 60.8% of the total self-reported work-related health outcome costs (Donham et al., 2007). In an earlier study in Finland, Rautiainen et al. (2005) reported the total injury and occupational disease cost burden at 215 Euros per Finnish farmer for 1999, based on workers' compensation data. The gaps in knowledge on the direct and indirect costs as well as the factors that increase the risk of these outcomes impedes the ability to identify how changes might be made to improve working conditions in the farm environment.

This study aims to address the gaps in our current understanding of MSDs, skin disorders and depression in agriculture and contribute to the body of knowledge in this area.

CHAPTER 2

RISK FACTORS FOR WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG FARMERS

Abstract

Background: Agriculture is a physically demanding industry that exposes workers to high risk of musculoskeletal disorders (MSDs). However, the prevalence, incidence and risk factors for MSD in agriculture are not well known.

Methods: We analyzed data on 316 principal farm operators in the Iowa Certified Safe Farm study. Participants were followed up quarterly and annually in 1999-2002 to document exposures and outcomes. We calculated the cumulative prevalence and incidence rates of MSD symptoms during this three-year period. Risk factors for MSD symptoms (including low back pain and muscle/joint pain) were assessed using univariable and multivariable regression analyses methods (Generalized Estimating Equations). We matched each quarterly exposure measurement with the outcome from the following quarter to establish temporal relationships.

Result: The three-year cumulative period prevalence (proportion of persons with symptoms) for all MSD symptoms was 70.2% with baseline prevalence at 41.1%. The incidence (new cases per 100 person-years) was 8.1 for low back pain and 3.0 for neck/shoulder pain. Loud noise exposure (OR=1.51; 95% CI: 1.17 – 1.95), heavy lifting (OR=1.45; 95% CI: 1.08 – 1.94) and > 42 average weekly hours (OR=1.81; 95% CI: 1.40 – 2.35) were risk factors for MSD.

Conclusions: The prevalence and incidence of MSD symptoms (particularly low back pain) were high among farmers. The results of the study provide further evidence that controlling modifiable risk factors like heavy lifting and working hours is important in preventing MSD. Noise was also a risk factor but it may be surrogate for vibration and other exposures in machinery operation which we did not measure.

Introduction

Agriculture is a physically demanding industry that exposes workers to a high risk for musculoskeletal disorders (MSDs) (Bobick and Myers, 1995; Hwang et al., 2001). Previous MSD prevalences have ranged between 28 - 64% for farmers (Xiang et al., 1999; [b]Park et al., 2001; Gomez et al., 2003; Deyo et al., 2006; Buranatrevedh and Sweatstrikul, 2005; Barrero et al., 2006; Rosecrance et al., 2006). Different research methods and variation in agricultural practices may contribute to the wide range in prevalences.

Risk factors for MSD can be categorized into occupational risk factors and worker characteristics (Xiang et al., 1999). Occupational risk factors include awkward postures and repetitive movements (Morse et al., 2007). The association of heavy lifting and low back pain (LBP) has been described in the literature for both farming and the general industry (Kelsey and Golden, 1988; Bernard, 1997; Cameron et al., 2006; Rosecrance et al., 2006). Individual and lifestyle risk factors include older age, male gender, higher weight, taller height, smoking and previous pain (Deyo and Bass, 1989; Garzillo and Garzillo, 1994).

The temporal relationship of risk factors for farm-related MSDs is not well known. Most previous studies on risk factors for MSDs (low back pain, neck/shoulder pain, muscle pain etc.) have been cross-sectional and they have relied on subjects to recall past events, sometimes longer than one year ago ([b]Park et al., 2001; Rosecrance et al., 2006). We found no studies that evaluated risk factors for MSD prospectively among farmers. This study aims to calculate the prevalence and incidence of MSD symptoms among farmers and to identify risk factors for MSD symptoms from a three-year prospective study.

Methods

This study analyzed data from the Certified Safe Farm (CSF) study, which was designed to evaluate the effectiveness of a multi-faceted farm safety intervention. The participants were pair-matched by farm characteristics and randomly assigned into the intervention and control cohorts. Participants were followed up quarterly and annually in 1999-2002 to document exposures and outcomes. The CSF study design has been described by Rautiainen et al. (2004). That paper summarized injury outcomes and risk factors for injury. Choi et al. (2005) reported on hearing loss as a risk factor for injury among CSF study participants. Donham et al. (2007) reported on costs of farm-related outcomes. The current study focuses on the prevalence, incidence, and risk factors associated with MSD symptoms among CSF study participants.

Subjects

The CSF study was conducted in a nine-county area in northwestern Iowa. All principal farm operators who met the USDA farm criteria (at least $1000 in agricultural product sales per year) were eligible. Donham et al. (2007) described the recruiting process. Subjects were invited to participate through mailings and the media. Those who returned a card indicating willingness were contacted by telephone. After verifying eligibility and future farming plans and obtaining informed consent forms, 300 farms (one principal operator per farm) were recruited. The farms were pair matched on corn and soybean acres, number of cattle and hogs and previous injury experience. The pairs were randomly assigned into the intervention and control cohorts. Nineteen intervention farms and 30 control farms were added by additional recruitment in 2000 to maintain at least 125 subjects in both cohorts. The total number of subjects (initial and additional) that responded to at least one quarterly call was 316.

Data Collection

Four primary data collection systems were used in this study: quarterly phone calls, annual occupational history forms, annual on-farm safety reviews and annual clinic screenings. The quarterly phone call data were collected by computer-aided telephone interviews (CATI) from September 1999 to August 2002. Ten rounds of quarterly phone call data covering work exposures, injuries and illnesses were collected. This follow-up covered 390 person-years among intervention farmers and 368 person-years among control farmers (total 758 person-years). Participants were asked to recall their agricultural work-related exposures, injuries and illnesses during each follow-up period. CSF calendars were distributed each year, helping farmers to record their health outcomes. The occupational history forms, clinic screenings and on-farm safety reviews were completed annually from 1998 to 2003. Occupational history forms and quarterly calls were completed for all participants but the clinic screenings and on-farm safety reviews were only completed for intervention farms as these procedures were major components of the intervention. The occupational history forms included demographic and farm production variables as well as questions about health outcomes, safety behaviors and use of personal protective equipment. The current study used the quarterly call data as the primary data set, augmented with data from the other data collection instruments. The primary dataset had quarterly and occupational history data that were available for both intervention and control subjects. The second dataset had only variables that were available for intervention farmers and was a combination of the four datasets.

Outcome Variables

The first primary outcome variable for this analysis, back pain, was derived from question 1: "Did you have any farm work related back pain between [first month of quarter] and [last month of quarter]?" For those who answered yes, question 2 was asked:

"Is this an old back pain, or one that has surfaced for the first time between [first month of quarter] and [last month of quarter]?" Further questions for those reporting symptoms addressed the location of the pain, duration of symptoms, duration of restricted work ability, type of care received and cost of care.

Similar questions addressed muscle/joint problems: question 1 was "Did you have any farm work related muscle/joint problems between [first month of quarter] and [last month of quarter]?" Question 2 for those answering yes was: "Is this an old muscle/joint problem, or one that has surfaced for the first time between [first month of quarter] and [last month of quarter]?" The case definitions for prevalent and incident cases of back pain and muscle/joint pain were as follows:

Prevalent case = first "Yes" response to question 1. Repeated "Yes" responses in subsequent quarters were considered continuation of the same case.

Incident case = "Yes" response to question 1 and "New" response to question 2.

The prevalence and incidence rates were calculated as follows:

Prevalence = prevalent cases / number of subjects * 100

Incidence rate = incident cases / total person-years of follow-up

Cumulative three-year period prevalence was constructed by counting cases during the first quarter and adding new cases from each subsequent quarter and dividing the total case count by the number of subjects.

The responses for back pain and muscle/joint problems were combined to form musculoskeletal disorder symptoms (MSD) which was our second primary outcome variable.

Explanatory Variables

Explanatory variables (and their cut points) included age (≥ 56 years), education (≤ high school), height (≥ 1.81 m), weight (≥ 93 kg) and body mass index (BMI) (≥ 30 kg/m^2). Occupational risk factors included heavy lifting, off farm work, raising livestock, acreage (> 628 acres vs ≤ 628 acres), weekly farm hours (> 42 hours), high farm safety score (> 98 points) and high hazard correction number (> 28 corrections). The next set of variables that were dichotomous (yes or no) included: previous injury, stroke, arthritis, high blood pressure, as well as general health status (poor vs. good). Stress and depression were derived from questions in quarterly data that asked subjects to rate their stress (depression) level (very low, low, average, high or very high). Both stress and depression variables were dichotomized into high (high and very high) versus low (very low, low and average) for analyses.

The anthropometric variables (BMI, height and weight) were only available for the intervention farmers as were the farm safety scores and hazard correction scores that were derived from the on-farm safety reviews. The farm safety score variable indicated the level of safety of a farm. It was derived from the farm safety review score (range 0-100%). The hazard correction number was the number of identified hazards that were removed or corrected on the farm. These five variables were categorized and examined separately using a dataset consisting of the intervention group alone.

Data Analysis

Variables were obtained from four data sources: quarterly calls, occupational history forms, farm reviews and clinical screenings. These data were merged by the unique farm identifier to examine the association of potential risk factors (exposures) and MSD symptoms. The quarterly call dataset consisted of up to ten repeated records of exposures and outcomes for each study subject. Variables from the other data collection instruments were selected and merged into the quarterly dataset. This combined dataset covered three years from September 1999 to August 2002. We compared the frequency distribution of independent and outcome variables between the intervention and control groups using the chi square test in SAS version 9.1. The Generalized Estimating

Equations (GEE) method was used to evaluate the associations of exposures and outcomes in these repeated measures data. GEE analyses were performed using generalized logit as the link function, the number of months of observation as the offset factor, independent as the correlation matrix and the farm identification number as the clustering factor (Zeger et al., 1988; SAS Institute Inc., 2004; Flynn, 2003].

The temporal association of MSD symptoms and preceding exposures was an important feature of this study. The following methods were used to establish that the exposure occurred before the outcome, reported in the quarterly call data:

1) exposures from each quarter were matched with outcomes from the following quarter (outcome observations were pushed back one quarter in the dataset) and

2) most recent available annual occupational history, clinic screening and farm review observations prior to the quarterly call outcome observation were added to the dataset.

Odds ratios were calculated using GEE regression methods. The model building included the following steps. The association of MSDs and potential risk factor variables was first assessed in univariable analyses. Those risk factors that were significant at a p-value <0.10 level were selected for multivariable analysis. The stepwise forward selection was used to select the final model using p<0.05 to keep variables in the model.

Results

The main demographic and farm characteristics of our study population and Iowa farmers are presented in Table 1. CSF farms were larger than Iowa farms on the average. CSF farmers were younger (in the beginning of the prospective study) and had a higher proportion of males compared to Iowa farmers. Further baseline characteristics of the study population are presented in Table 2, including height, weight, BMI and work hours on and off the farm.

MSD Rates

The average proportion of persons reporting MSD symptoms was 26.3% during the ten quarterly observation periods, ranging from 16.5% in quarter 7 to 41.4% in quarter 1. In many cases, the same MSD condition lasted longer than one quarter and after eliminating repeated reporting of one MSD condition over several quarterly observation periods, the number of separate MSD cases was 604. The cumulative three year period prevalence of MSD symptoms is presented in Figure 1. The baseline prevalence in quarter 1 was 41.1%. Each quarter added new subjects with MSD symptoms and at the end of the three year follow-up, 224 out of 316 persons had MSD symptoms, resulting in a three year cumulative period prevalence of 70.2%.

In the three years of follow-up there were 604 cases of MSD of which 312 cases were back pain and 194 cases were muscle/joint pain. About 475 cases of the total cases reported were prevalent cases and 129 were incident cases. Of the prevalent cases, 284 (52.2%) were back pain, while 191 (47.8%) were muscle/joint pain. There were 64 cases of new (incident) back pain and 65 cases of new muscle/joint pain. The prevalence and incidence rates for specific MSD outcomes are presented in Table 3. There were no significant differences in prevalence and incidence rates between the intervention and control groups. For the independent variables, only heavy lifting and alcohol use differed significantly between the two groups.

Univariable analysis

Odds ratios (OR) and 95% confidence intervals (CI) for risk factors for back pain are presented in Table 4. In univariable analysis, age (≥56 years old), heavy lifting, loud noise exposure, and exposure to gases/fumes/dusts showed increased odds for back pain.

Odds ratios and 95% confidence intervals for MSD (both back pain and muscle/joint pain combined) in a single variable GEE regressions are described in Table

5. Working > 42 hours weekly, exposure to loud noise, heavy lifting, high stress and exposure to gases/fumes/dusts showed increased odds for MSD.

Multivariable Analysis

The multivariable model results regarding risk factors for back pain are presented in Table 4. Only age ≥ 56 years remained significant when those variables that were significant in univariable regression were included in the model. The final multivariable model of risk factors for MSD is presented in Table 5. Only working > 42 hours weekly, heavy lifting and exposure to loud noise remained significantly associated in multivariable models that included those variables that were significant in univariable regression.

Discussion

Figure 1 demonstrates how the cumulative prevalence of all MSD symptoms increased over time, starting from 41.1% during the baseline quarter and reaching 70.2% at the end of the three-year study period. This is close to lifetime prevalences reported in the literature (Kelsey and Golden, 1988). This figure demonstrates how over time, most people have MSD symptoms and thus the length of the observation period has a great influence on the prevalence.

The three-year cumulative prevalence rate of 70.2% for MSD in our study was high. Our baseline prevalence of 41.1% was higher than the 31% for Iowa farmers as reported by [b]Park et al. (2001), 26.2% for Colorado farmers (Xiang et al., 1999) and about the same as the 41% back pain prevalence rate in New York farmers (Gomez et al., 2003). Our one-year prevalence of about 60% is similar to that reported among Kansas farmers (Rosecrance et al., 2006) and close to the 64% reported among Chinese farmers by (Barrero et al., 2006). The high prevalence in this study may be explained by the design of the CSF study. This was a longitudinal study, participants were paid, they used

CSF calendars for recording health events, and reported periodically using different data collection instruments. They were perhaps more ready to observe and report their illnesses than would have been in a cross-sectional survey. With regards to the variation in rates from one study to the other, one explanation may be the variation in crops and livestock raised and the farm type (size, mechanization) from one region to another.

Our prevalences for neck/shoulder pain 14.2%, knees or lower limbs 14.6%, hands/wrist or upper limbs 15.8% and hip 7.3% were lower than 35%, 29%, 28% and 15% respectively in the New York study (Gomez et al., 2003). The differences in rates from one region to the other may be attributed to the differences in farm characteristics. Dairy farming is more common in New York than in Iowa and dairy farming involves high exposure to repetitive motions to these body sites (Nonnenmann et al., 2008; Pinzke 2003). Differences in the definitions of MSD outcomes across studies may be another explanation for this variation.

The ability to measure incidence rates was a unique feature in this study. It was possible due to the prospective study design. We did not find previous studies reporting incidence rates among farmers. Our study showed an incidence rate of 8.1 per 100 person-years for LBP and the neck/shoulder incidence rate was 3.0 per 100 person-years.

Several risk factors have been elucidated in the literature for back pain and general MSDs. The contributing occupational mechanisms include heavy lifting, twisting, awkward postures, bending and vibration which are common in farm work (Rosecrance et al., 2006). The pathophysiological linkage between age and MSDs (back, muscle/joint pains) through osteoporosis and other degenerative diseases notwithstanding, previous studies have been unable to show a consistent association for age and MSD across reports. The age and LBP association has been demonstrated by Xiang et al. (1999) and

[b]Park et al. (2001). These studies reported increased risk between early thirties to mid fifties (Xiang et al., 1999; [b]Park et al., 2001; Sprince et al., 2007). Rosecrance et al. (2006) reported a protective association for farmers age ≥ 56.9 compared to younger famers < 56.9 years. Our findings showed that subjects ≥ 56 years old had more than one and half fold increase in the odds for back pain (OR=1.79, 95%CI: 1.01 – 3.20) in univariable analyses. The explanation for the difference is not clear, but may be due to some inherent differences in the two populations.

Trinkoff et al. (2003) and Guo (2002) showed that increased duration of job tasks could increase the risk of LBP and other MSDs in the general industry as well as among farmers (Kar and Dhara, 2007; Holmberg at al., 2003), which is similar to the findings in this study. However, two previous studies in Iowa did not show any association (Sprince et al., 2007; [b]Park et al., 2001). The possible explanation behind this is that working more hours may increase the number and duration of tasks a subject performs within a day. The effect is increased exposure to awkward postures, repetitive motion, high arm vibration and others. On the other hand, extended working hours did not show any association with back pain alone in our study consistent with previous studies (Sprince et al., 2007; [b]Park et al., 2001; Xiang et al., 1999). It is not clear why there was no association even with the scientific and intuitive plausibility, however, it may be related to power and sample size available.

Previous studies that assessed heavy lifting as a potential risk factor for MSDs have demonstrated positive association (Morse et al., 2008; Trinkoff., 2003; Holmberg et al., 2003; Bernard, 1997). This is consistent with our study which also showed a positive association between heavy lifting an MSD. The increased odds for MSD may be explained by the strain placed on the hip joint and other joints when handling and lifting loads. Also, other factors like awkward postures and the awkward forms of objects lifted during farming activities may contribute to increasing the risk of MSD.

Loud noise exposure is a common occupational exposure in the farm environment. It has been assessed in previous studies using its effects, which include hearing difficulties or noise induced hearing loss. Two previous studies that evaluated hearing difficulties demonstrated increased risk for back pain and injuries (Sprince et al., 2007; Hwang et al., 2001). This is consistent with our findings that demonstrated increased odds for MSD for subjects with loud noise exposure. In our study, the explanation for this finding may be related to the sources of noise (tractor operation, machinery and animals). These noisy work environments may also expose farmers to whole body vibration; particularly in tractor and farm machinery operation. Similar findings have been reported in other studies among farmers (Holmberg et al., 2003; Xiang et al., 1999). Sprince et al. (2007) suggested an alternative explanation that loud noise exposure from machinery and animals cause hearing difficulties that may make it hard for farmers to react quickly to avoid MSD type injuries. Further studies are needed to help assess the association between loud noise exposure and MSD.

This is the first study to report incidence rates for MSDs in agriculture. Due to the short recall time (2 – 5 months), our study subjects should be less likely to under-report, a potential weakness in previous studies where the recall times were longer. Another unique strength of this study is that it is the first study evaluating MSD among farmers prospectively, which made the assessment of temporal association possible. The weaknesses in this study include self-selection and low recruitment rate (6%) already described by Rautiainen et al. (2004), which may limit the generalizeability of the results. The study farms had more acres and more livestock than Iowa farms on the average. The independent and outcome variables were all self-reported, which is common in public health studies. We were unable to directly evaluate the association of vibration, high hand force, awkward postures and repetition (all important MSD exposure variables) because this information was not available. Farmers knew that this study (if assigned to the intervention group) included a farm safety assessment. This may have eliminated farmers that felt that they could not score well and therefore farms in this study may be "safer" than farms in Iowa on the average. The evaluation of BMI, height, weight, farm safety scores and hazard correction scores was only possible for the intervention group. This reduced the sample size for analyzing these variables. Due to randomization we did not expect differences between the study groups in height. The intervention addressed wellness and weight managements, so there could be differences in weight.

Conclusions

This study showed high prevalence of MSD symptoms among farmers. The prospective study design enabled reporting incidence rates and establishing temporal relationships where exposures existed before outcomes; both unique features in this study. We found that $\geq$ 56 years of age, working > 42 hours weekly, loud noise exposure and heavy lifting were risk factors for MSD. On the other hand, farming crop acres was protective. The effects of loud noise exposure on MSD ought to be studied further to ascertain the mechanisms of association and help identify areas that may be targeted to reduce MSD among farmers. Reduction or modification of occupational exposures such as heavy lifting, twisting, awkward postures, bending and vibration which are common in farm work can reduce the burden of MSD in agriculture.