Journal of Occupational and Environmental Hygiene, 4: 10–16
ISSN: 1545-9624 print / 1545-9632 online
DOI: 10.1080/15459620601067266

Risk Factors for Low Back Injury Among Farmers in Iowa: A Case-Control Study Nested in the Agricultural Health Study

Nancy Sprince,[1] Hyesook Park,[2] Craig Zwerling,[1] Paul Whitten,[1] Charles Lynch,[3] Leon Burmeister,[4] Kendall Thu, [5] Patricia Gillette,[3] and Michael Alavanja[6]

[1]The University of Iowa – Occupational & Environmental Health, University of Iowa, Iowa City, Iowa
[2]Ewha Womans University – Preventive Medicine, Seoul, South Korea
[3]The University of Iowa – Epidemiology, Iowa City, Iowa
[4]The University of Iowa – Biostatistics, Iowa City, Iowa
[5]Northern Illinois University – Anthropology, Dekalb, Illinois
[6]National Cancer Institute, Bethesda, Maryland

The aim of this study was to assess risk factors for low back injury requiring medical advice or treatment among Iowa farmers. Although farmers are at risk for low back injury, few studies have addressed risk factors for farm work-related low back injury. We screened 6999 participants in the Iowa portion of the Agricultural Health Study to identify 49 male farmers who reported farm work-related low back injury requiring medical advice or treatment in the previous year. We compared them with 465 uninjured male farmer controls. Multivariable modeling identified four risk factors significantly associated with low back injury: age less than 45 years (OR = 3.32; 95% CI 1.75–6.20), doctor-diagnosed asthma (OR = 4.26; 95% CI 1.49–12.10), education beyond high school (OR = 2.12; 95% CI 1.13–3.90), and difficulty hearing normal conversation (even with a hearing aid, in the case of those using one) (OR = 1.98; 95% CI 1.02–3.80). Although hearing difficulty may be a general risk factor for occupational injury, asthma may be a more specific risk factor for low back injury. Future research to assess the risk factors, asthma and difficulty hearing, may be particularly important, since farmers are at increased risk for hearing loss, and farmers come into contact with many inhaled agents that can cause asthma.

Keywords agricultural work, farmer, low back injury, risk factors

Address correspondence to: Nancy Sprince, University of Iowa – Occupational & Environmental Health, 100 Oakdale Campus, # 108 IREH, Iowa City, IA 52242-5000; e-mail: nancy-sprince@uiowa.edu.

INTRODUCTION

Risk factors for low back injury and low back pain have been studied in several high risk occupational groups. Farming is one occupational group at increased risk for low back injury and low back pain. Studies from two states have shown that about 30% of farmers report having daily back pain for at least a week in the previous year.[1,2] Limited information is available about risk factors for low back injury or pain in farmers. A study of Iowa farmers[1] found that having an off-farm job and being in the age group 45 to 59 were associated with back pain. A study of Colorado farmers[2] found that depression, work duration of 10 to 29 years, and major occupation in farming or ranching were associated with back pain. Those studies did not differentiate work-related from non-work-related back pain. In the current study, we had the opportunity to assess risk factors for work-related low back injury requiring medical advice or treatment in a case-control study nested in the Agricultural Health Study.[3]

METHODS

The overall methods for the large case-control study from which the present study was drawn have been described in detail.[3–6] From the 30,009 eligible Iowa pesticide applicators enrolled in the large prospective Agricultural Health Study[7] we mailed a screener questionnaire with mail and telephone follow-up to 6999 applicators to identify Iowa farmers who had a farm work-related injury in the past year. Farmers were those who reported that the farm they worked on in the last year had gross annual sales of agricultural goods of $1,000 or more in the past 12 months. Injured farmers were classified as those who answered "yes" to both of the following questions: (1) During the past 12 months, were you injured seriously enough that you got medical advice or treatment?[8] (2) Were any of these injuries or accidents in any way related to your farm operation? (This includes activities such as farm-related transportation on roadways, or any other aspect of your farm, such as raising animals for recreation or home use).[9]

Of the 6115 farmers who completed the screener questionnaire (response rate of 87.4%), 521 farmers reported a farm work-related injury in the past year. A total of 431 injured

TABLE I. Characteristics of the 69 Low Back Injuries Among 49 Male Farmers with Low Back Injury in the Past 12 Months in Iowa, 1997

Heading	No. of Injuries	Total Injuries (%)
Nature of Injury		
Sprains, strains, tears	32	46.4
Dislocations	26	37.7
Bruises, contusions	5	7.2
Fractures	2	2.9
Other or unspecified	4	5.8
Source of Injury		
Tractor	9	13.0
Combine	4	5.8
Conveyors	3	4.3
Other machinery	11	15.9
Cattle	10	14.5
Hogs	5	7.2
Other large livestock	4	5.8
Gates	2	2.9
Other or unclassifiable	21	30.4
Event Related to Injury		
Overexertion in lifting	28	40.6
Falls	20	28.9
Assault by animal	4	5.8
Jump from nonmoving vehicle	4	5.8
Overexertion in holding, pulling, or throwing	3	4.3
Other or unclassified	10	14.5

cases (response rate = 82.7%) and 473 uninjured controls (response rate = 78.4%) completed a detailed, computer assisted telephone interview. For the present study, we considered as cases those injured farmers who noted that their injury affected the low back. Investigators used the Bureau of Labor Statistics *Occupational Injury and Illness Classification Manual*[10] to classify the nature, source, and event related to the injury (Table I). Because of small numbers of injured females (one case and 8 controls), we considered only male farmers in this study, for a total of 49 male farmers with low back injury (cases) and 465 uninjured male farmers (controls).

The same questionnaire was used simultaneously to assess both risk factors for injury and the injury outcome. Injury outcome was characterized for major type of injury, major body part affected, event leading to injury, source of injury, and severity as measured by need for hospitalization. Risk factors for injury were divided into six categories of independent variables (shown in Table II): (1) demographics; (2) personal habits of smoking and drinking; (3) farming factors including size of farm, presence of large livestock, debt/asset ratio, and self-reported financial condition of the farm; (4) work factors; (5) medical conditions; and (6) risk acceptance and stress.

We used standardized scales to characterize depression,[11] stress,[12] sleepiness,[13] and alcoholism.[14] The medical condition questions were derived from the Health and Retirement Survey questionnaire [15] and the National Health Interview Survey on Disability. [16] Risk acceptance was assessed with a set of five questions concerning attitudes about the riskiness of farming. [17]

Statistical Methods

For the first step in the analysis, we calculated the bivariate associations for each potential risk factor with farm work-related low back injury using the PROC FREQ/CMH procedure (SAS 8.0, SAS Institute), which resulted in odds ratios and 95% confidence intervals. Next, we used the method described by Higgins and Koch[18] for variable selection for the multivariable model. After controlling for the known risk factor, age, we calculated the Mantel-Haenszel $\chi^{2(19)}$ divided by the degrees of freedom for each variable and then stratified by the variable with the highest χ^2/df at $p \leq 0.10$. We then recalculated the Mantel-Haenszel χ^2/df, stratified by the previously identified significant variables along with the variable with the next highest χ^2/df until no further variables were significant at $p \leq 0.10$. We then entered all the selected variables into a multivariable logistic regression model, which we called the base or final model. Next, we added each independent variable for which the temporal relationship with low back injury was uncertain (depression, stress, and risk acceptance) to the base model to assess its association with low back injury.

We assessed the goodness-of-fit of the final model using the method described by Hosmer and Lemeshow.[20] These statistical analyses were performed using SAS 8.0. Because of the small sample size, follow-up analyses were performed for the final logistic regression model using LogXact4 (CYTEL Software Corporation), logistic regression software designed for exact estimation with small or highly unbalanced sample sizes. The unit of analysis was the individual farmer, regardless of the number of low back injuries the farmer sustained. The study procedures were reviewed and approved by the University of Iowa Institutional Review Board that considers human subjects research.

RESULTS

Forty-nine male farmers reported 69 low back injuries. The farmers with low back injury were slightly but not significantly younger than the uninjured farmers (36.6 ± 20.3 vs. 42.6 ± 23.5; $p = 0.09$) and had fewer years of farming experience (23.2 ± 8.9 vs. 29.2 ± 11.9; $p = 0.0001$). Six of the 49 farmers (12%) were hospitalized for low back injury. Thirty-seven farmers had a single episode of low back injury in the previous year, eight farmers had two low back injuries, and four farmers had four low back injuries. We could not distinguish whether these repeated injuries were new or a recurrence of a previous low back injury. There was no minimum time period required between repeat injuries. Table I shows the

TABLE II. Bivariate Associations of Risk Factors with Low Back Injury on the Farm in the Past 12 Months in Iowa, 1997

Variable[A]	Characteristic Present		Characteristic Absent		Odds Ratio[B]	95% CI[B]
	Cases	Controls	Cases	Controls		
Demographic Features						
Education more than high school	30	200	19	265	1.98	(1.07–3.65)
Not married	6	46	43	419	1.18	(0.47–2.95)
Principal operator	43	406	6	59	1.34	(0.54–3.29)
Lives on farm	46	420	3	45	1.42	(0.42–4.84)
Had safety training prior to any injury	19	174	30	290	0.93	(0.50–1.75)
Farmwork experience ≤25 years	36	199	13	266	2.82	(1.04–7.65)
Personal Habits						
Current smoker	9	47	40	418	1.87	(0.85–4.09)
Ex-smoker	13	125	36	340	1.18	(0.59–2.34)
Drinks alcohol currently	41	350	8	115	1.35	(0.61–3.01)
Has 2 or more drinks per day	11	86	30	264	1.01	(0.47–2.14)
CAGE score high	0	10	49	407	0.00	—
Farming Factors						
Farm size small (≤500 acres)	24	225	24	228	1.17	(0.64–2.15)
Large livestock on farm	41	338	7	119	1.70	(0.73–3.94)
Debt/asset ratio ≥10%	38	266	10	180	1.99	(0.95–4.13)
Self-reported financial condition poor/fair	12	91	36	365	1.38	(0.68–2.78)
Work Factors						
Farmer worked 50 or more weeks on farm in past year	42	351	7	113	1.65	(0.71–3.83)
Farmer worked 50 or more hours/week on farm in past year	33	250	16	208	1.53	(0.81–2.88)
Spouse helped 8 or more weeks on farm in past year	24	226	25	239	1.05	(0.58–1.90)
Spouse helped 2 or more hours/week on farm in past year	22	223	27	237	0.92	(0.50–1.68)
Others helped 12 or more weeks on farm in past year	28	207	21	255	1.56	(0.86–2.85)
Others helped 24 or more hours/week on farm in past year	23	229	26	229	0.87	(0.48–1.57)
Farmer worked part-time on farm past year	3	50	46	415	0.58	(0.17–1.93)
Farmer had job off farm past year	20	153	29	310	1.29	(0.70–2.37)
Farmer worked 12 or more weeks off farm past year	10	112	39	350	0.77	(0.37–1.60)
Medical Conditions						
Wears eyeglasses	28	311	21	154	1.07	(0.55–2.08)
Self-reported vision poor/fair	1	31	48	434	0.35	(0.05–2.59)
Wears hearing aid	1	11	48	454	1.51	(0.18–12.42)
Self-reported hearing poor/fair	8	95	41	369	0.97	(0.43–2.19)
Difficulty hearing normal conversation (even with a hearing aid, in the case of those using one)	17	106	32	357	2.07	(1.09–3.94)
Doctor-diagnosed arthritis/rheumatism	10	72	39	389	2.3	(1.02–5.16)
Doctor-diagnosed depression	8	21	41	442	3.99	(1.61–9.87)
Depression score high	10	37	39	423	2.92	(1.33–6.41)
Doctor-diagnosed heart disease	4	49	45	415	1.30	(0.42–4.01)
Doctor-diagnosed asthma	6	19	43	445	4.18	(1.53–11.47)
Pre-existing disability	11	80	34	384	1.87	(0.89–3.92)
Sleepiness score high	20	210	29	255	0.87	(0.47–1.59)
Takes medication regularly	17	154	32	311	1.63	(0.85–3.11)
Risk Acceptance and Stress						
Risk acceptance score high	10	71	31	306	1.32	(0.61–2.86)
Stress score high	16	77	33	388	2.11	(1.10–4.05)

[A] For variables in bold, their age-adjusted confidence interval does not include 1.00.
[B] Age-adjusted odds ratio and 95% confidence interval.

TABLE III. Logistic Regression Model of Risk Factors Predicting Farm Work-Related Low Back Injuries Among Iowa Male Farmers in the Agricultural Health Study, 1997

Independent Variable	Odds Ratio[A]	95% Confidence Interval
Age less than 45 years	3.32	1.75–6.20
Asthma	4.26	1.49–12.10
Education more than high school	2.12	1.13–3.90
Difficulty hearing normal conversation (even with a hearing aid, in the cases of those using one)	1.98	1.02–3.80

[A]Each odds ratio has been adjusted for all other independent variables in the table.

nature, source, and event related to the low back injuries. The majority of the injuries were sprains/strains/tears or dislocations and most were caused by machinery or livestock. Falls and overexertion in lifting were the events that accounted for the majority of these injuries.

Table II presents the associations between potential risk factors and farm-related low back injuries among farmer cases compared with noninjured controls. Eight risk factors were significantly related to low back injury in bivariate analysis after age adjustment: (1) education more than high school; (2) fewer years of farming experience; (3) difficulty hearing normal conversation (even with a hearing aid, in the case of those using one); (4) doctor-diagnosed arthritis, (5) depression; (6) asthma; (7) high depression score; and (8) high stress score.

Table III shows the results of multivariable modeling. The Higgins-Koch variable selection process led to six variables as possible risk factors for low back injury, which were used in the following multivariable logistic regression model: (1) age less than 45 ($\chi^2 = 13.1, p < 0.01$); (2) asthma ($\chi^2 = 9.9, p < 0.01$); (3) education more than high school ($\chi^2 = 5.4, p = 0.02$); (4) arthritis ($\chi^2 = 5.4, p = 0.02$); (5) difficulty hearing normal conversation (even with a hearing aid, in the case of those using one) ($\chi^2 = 4.4, p = 0.02$); and (6) less than 25 years farming experience ($\chi^2 = 4.0, p = 0.04$). Risk factors that remained significant in the final (base) model were younger age, asthma, education beyond high school, and difficulty hearing normal conversation even with a hearing aid. Follow-up analysis with LogXact4 showed very similar odds ratios and 95% confidence intervals for all four variable in the final (base) model.

Three other risk factors were associated with more than double the odds of low back injury, but the associations were not statistically significant: (1) fewer years of farming experience (OR = 2.47, 95%CI 0.90–6.70); (2) debt to asset ratio greater than 10% (OR = 2.03, 95%CI 0.95–4.30); and (3) doctor-diagnosed arthritis or rheumatism (OR = 2.12, 95%CI 0.90–4.90). The three risk factors (depression, stress, and risk acceptance) were not allowed to enter the final (base) model because of uncertainty about the time sequence of any association between them and low back injury. When these three variables were added to the final (base) model one by one, we found that doctor-diagnosed depression (OR = 3.03, 95%CI 1.18–7.70) and a high depression score (OR = 2.55, 95%CI 1.13–5.70) were both significantly associated with low back injury, whereas stress and risk acceptance were not.

DISCUSSION

This study identified several risk factors for low back injury among farmers, including age less than 45 years, asthma, and difficulty hearing normal conversation even with a hearing aid, in the case of those using one. Although the direction of the relationship cannot be determined from this study, we also found that depression was associated with low back injury. The finding of an increased risk for low back injury among those farmers educated beyond high school should also be noted.

The association between low back injury and age is of interest. Our study, showing increased risk for low back injury in the younger age group, is consistent with results from several studies of nonfarming occupational groups. Studies of material handlers,[21] nursing and elder home workers,[22] transit workers,[23] and manufacturing workers[24] also reported an inverse relationship between age and occurrence of low back disorders. Further analysis from three of those studies[21,22,24] showed that older workers had more serious back disorders, associated with disability[21,22] or more costly back injury claims.[24] Studies in farmers have shown conflicting results. In Colorado farmers, Xiang et al.[2]found two to three times the risk for back pain among farmers in the 20 to 29 year age group, whereas Park et al.[1] found that Iowa farmers in the 45 to 59 year age group had double the risk for back pain compared with younger farmers. Differences between results from those two Farm Family Study states may be due to regional differences in farm tasks or patterns of work activity for the aging farmer. An explanation for the age findings in the present study of low back injury may be that younger farmers are performing more heavy physical work on the farm compared with older farmers. Another possible explanation is that older farmers with low back injury modify their work environment to reduce the risk of future episodes of low back injury.

A unique finding in the present study is the association between asthma and low back injury in farmers. In a study assessing associations between asthma and other allergic conditions with low back pain and depression among 6836 U.S. adults aged 20–39 from the Third National Health and Nutrition Examination Survey, Hurwitz and Morgenstern[25] found that the odds of low back pain were about 50% higher in subjects with a history of asthma compared with those with no asthma history. Those authors suggested, in part, that hypersensitivity reactions in asthma and other allergic conditions, acting through their effect on the hypothalamic-pituitary-adrenal axis, may lead to altered reactions to mechanical stressors. In our study population, a possible link between

asthma and low back injury is heavy physical work performed in farm environments that generate respiratory hazards. Our results should be interpreted with caution, since they are based on six subjects with the combination of low back injury and asthma. However, follow-up analysis with LogXact showed that the odds ratio and confidence interval for the association between asthma and low back injury (OR = 4.17, 95% CI 1.19–12.89) was similar to that shown in Table III. Because we examined multiple risk factors, it is possible that the association between asthma and low back injury occurred by chance alone. Further assessment of the asthma/low back injury relationship is needed in other farming populations and other occupational groups.

Our results showing an association between higher education and low back injury are in contrast to several other studies. In a review of articles published between 1966 and 2000 that assessed the relationship between formal education and back pain, Dionne et al.[26] reported that 16 out of 19 studies showed an association between low levels of formal education and frequency of low back pain. Most of these 19 studies were population based and included noninstitutionalized subjects. No specific occupational groups were assessed in these studies, although four limited the population-based subjects to those actively working. In a specific occupational study of machine operators, no association was found between level of education and sciatic pain.[27] Our study is consistent with others that have shown an association between injuries on the farm and higher education.[3,28,29] Our study of risk factors for overall farm injury,[3] from which the present subgroup of low back-injured subjects was drawn, also showed an association between higher education and farm work-related injury. Other studies of injuries among farmers have also reported associations with higher education.[28,29] We do not believe that there is a direct causal connection between higher education and low back injury. It is possible that farmers with more education are more likely to recall and/or report farm work-related injuries, including low back injury.

Farmers, especially those older than 64, have an increased risk for hearing loss compared with other currently employed workers.[30] There are several sources for increased noise levels on the farm, including animals and machinery. Several studies have found significant associations between hearing difficulties and overall agricultural injury[3,31] In our subgroup analyses, wearing a hearing aid was associated with both machinery-related[6] and animal-related injuries.[5] Difficulty hearing may be a general risk factor for farm injury although the reason behind the association is not clear. It is possible that limited hearing may make it more difficult for farmers to react quickly to avoid injury from animals, machinery, and other exposures. An alternative explanation is that hearing difficulties are indicative of increased exposure to noisy animals and machinery, which are themselves risk factors for farm work-related injury.

Our study results showing an association between symptoms of depression and low back injury are consistent with the results of several other studies. Population-based prospective studies have reported that depression is a risk factor for subsequent low back disorder.[32,33] A prospective study of metal industry employees also showed that depressive symptomatology is a risk factor for low back pain.[34] In a cross-sectional study of farmers, Zwerling et al.[35] found that farmers with a high depression score were three times more likely to have an occupational injury compared with farmers with a lower depression score. In another cross-sectional study of farmers, Xiang et al.[2] also found a significant association between a high depression score and back pain. The depression/low back injury association should be explored further in farmers using a prospective study design. It would be important to clarify this association in the occupation of farming given the high prevalence of both back pain[1,2] and depression among farmers.[36,37]

A major strength of this study is that its design allowed us to assess risk factors for several subgroups of injury, including the present study of low back injury and previous studies of high pesticide exposure incidents,[4] machinery-related injury,[6] and animal-related injury.[5] Our design allowed us to examine the effect of multiple risk factors simultaneously. The high response rate helps assure comparability between actual and eligible study participants in this cohort.

However, the study has several limitations as well. Because we examined multiple risk factors, it is possible that some observed associations occurred by chance alone. The cross-sectional nature of this study did not allow us to assess the temporal relationship between low back injury and associations with variables, such as depression, which may be a risk factor for low back injury or a result of the injury. The small number of cases in our study limited our ability to assess some variables that appeared related to low back injury (odds ratios > 2.0) but were not statistically significant, such as doctor-diagnosed arthritis/rheumatism, debt to asset ratio, and years of farming experience. We did not have access to medical or hospital records to validate the reports of injury. Reporting bias may account for our observed association between higher education and low back injury. Our results may not be generalizable to all farmers or even all Iowa farmers. We have previously reported that the participants in the Agricultural Health study were younger and worked on larger farms compared with Iowa farmers in general.[6]

With regard to the independent variables we assessed, our study addressed several work factors but was not designed to assess specific job tasks or actual workload, which can be quite varied within a farm and between farms. The outcome variable, low back injury, represents a heterogeneous group of underlying diagnoses as shown in Table I. The size and power of our study did not allow us to assess risk factors for specific subgroups. Furthermore, our case definition does not exclude workers with an exacerbation of chronic low back pain. Our definition, restricted to injury requiring medical advice or treatment, allows for control subjects who had low back injury that did not require medical advice or treatment. If the same independent variables are associated with low back injury whether or not medical advice or treatment was

needed, we may have underestimated the strength of these associations.

The current study should be viewed in the context of limitations in the body of literature on risk factors for low back injury or pain. A previous study[38] has pointed out the lack of objective criteria for diagnoses and the inconsistency in case definition for the various diverse outcomes reported in the literature. These diverse outcomes include low back pain, low back injury, back pain, and back sprain. With regard to the studies addressing farmers' back injuries, the studies from the Farm Family Health and Hazard Surveillance Study[1,2] used a case definition of back pain every day for a week or more, whereas the Traumatic Injury Surveillance of Farmers' Study[39] required at least a half day of restricted activity or medical treatment. This variability in definition of the outcome variable makes it very difficult to compare our study with others in the literature. A review of eight cohort studies that assessed associations between work-related exposures and back injury or pain reported further variability in the criteria used to assess whether the pain or injury was work related.[38] Criteria varied and included worker compensation claims, incident reports at work, OSHA recordkeeping reports, company medical records, and company medical department visits for treatment. Because Iowa farmers' injuries are generally unrelated to worker compensation, OSHA, or medical departments, we used the farmers' self-report that the injury was related to his/her farm operation. The studies of risk factors for back pain in farmers did not differentiate between work and non-work-related back pain.[1,2]

Among the farmer studies, our definition from Gerberich et al.[9] may have added increased specificity for work-related vs. non-work-related back disorder. However, the differences in definition of work relatedness make it very difficult to compare results across studies. In addition, the risk factors may vary depending on the stage of the low back disorder. The review by Ferguson and Marras[40] of 57 articles that assessed risk factors for low back disorders found that psychosocial risk factors were more important for the later stages of low back disorder (lost worktime, disability), whereas physical exposure risk factors were more important in the earlier stages, such as discomfort or injury without work limitations. Our cases may include a heterogeneous group at various stages of low back disorder, which would tend to bias our results toward the null.

The risk factors we identified for low back injury of asthma and difficulty hearing may be particularly important for future research and prevention efforts, since farmers are at increased risk for hearing loss[30] (caused by exposure to noisy animals and machinery) and farmers come into contact with many inhaled agents that can cause asthma.[41]

REFERENCES

1. **Park, H., N.L. Sprince, P.S. Whitten, L.F. Burmeister, and C. Zwerling:** Risk factors for back pain among male farmers: Analysis of Iowa Farm Family Health and Hazard Surveillance Study. *Am. J. Ind. Med. 40*:646–654 (2001).
2. **Xiang, H., L. Stallones, and T.J. Keefe:** Back pain and agricultural work among farmers: An analysis of the Colorado Farm Family Health and Hazard Surveillance Survey. *Am. J. Ind. Med. 35*:310–316 (1999).
3. **Sprince, N.L., C. Zwerling, C.F. Lynch, et al.:** Risk factors for agricultural injury: A case-control analysis of Iowa farmers in the Agricultural Health Study. *J. Agric. Safety Health 9(1)*:5–18 (2003).
4. **Alavanja, M.C.R., N.L. Sprince, E. Oliver, et al.:** Nested case-control analysis of high pesticide exposure events from the Agricultural Health Study. *Am. J. Ind. Med. 39*:557–563 (2001).
5. **Sprince, N.L., H. Park, C. Zwerling, et al.:** Risk factors for animal-related injury among Iowa livestock farmers: A case-control study nested in the Agricultural Health Study. *J. Rural Health 19(2)*:65–173 (2003).
6. **Sprince, N.L., H. Park, C. Zwerling, et al.:** Risk factors for machinery-related injury among Iowa farmers: A case-control study nested in the Agricultural Health Study. *Int. J. Occup. Environ. Health 8*:328–334 (2002).
7. **Alavanja, M.C.R., D.P. Sandler, S.B. McMaster, et al.:** The Agricultural Health Study. *Environ. Health Perspect. 104*:362–369 (1996).
8. **U.S. Department of Health and Human Services (DHHS), Centers for Disease Control and Prevention (CDC):** *National Health Interview Survey, Section II, Injuries*. Hyattsville, Md.: National Center for Health Statistics, DHHS, CDC, 1996.
9. **Gerberich, S.G., R.W. Gibson, L.R. French, et al.:** The Regional Rural Injury Study-I (RRIS-I): A population-based effort. Report to the Centers for Disease Control. Minneapolis, Minn.: University of Minnesota, 1993.
10. **U.S. Department of Labor (DOL):** *Occupational Injury and Illness Classification Manual*. Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. Available at: http://stats.bls.gov/oshtc.htm Accessed July 20, 2001.
11. **Kohout, F.J., L.F. Berkman, D.A. Evans, and J. Cornoni-Huntley:** Two shorter forms of the CES-D Depression Symptoms Index. *J. Aging Health 5(2)*:179–193 (1993).
12. **Cohen, S., T. Kamarck, and R. Mermelstein:** A global measure of perceived stress. *J. Health Soc. Behav. 24(4)*:385–396 (1983).
13. **Johns, M.W.:** A new method for measuring daytime sleepiness: The Epworth Sleepiness Scale. *Sleep 14*:540–545 (1991).
14. **Ewing, J.A.:** Detecting alcoholism. *JAMA 252*(14):1905–1907 (1984).
15. **National Insitute on Aging:** "Health and Retirement Study (HRS) Wave 1 (1992) Public Release Codebook and Questionnaire." Available at: http://www.umich.edu/~hrswww/center/qnaires/online.html (Accessed July 27, 2001).
16. **U.S. Department of Health and Human Services (DHHS), Centers for Disease Control and Prevention (CDC):** *National Health Interview Survey on Disability, Phase I Questionnaire*. Hyattsville, Md.: National Center for Health Statistics, DHHS, CDC, 1994.
17. **Harrell, W.:** Factors influencing involvement in farm accidents. *Percept. Mot. Skills 81*(2):592–594 (1995).
18. **Higgins, J., and G. Koch:** Variable selection and generalized chi-square analysis of categorical data applied to a large cross-sectional occupational health survey. *Int. Stat. Rev.* 45:51–62 (1977).
19. **Mantel, N., and W. Haenszel:** Statistical aspects of the analysis of data from retrospective studies. *J. Natl. Cancer Inst. 22*:719–748 (1959).
20. **Hosmer, D.W., and S. Lemeshow:** *Applied Logistic Regression*. New York, N.Y.: John Wiley & Sons, 1989. pp. 135–145.
21. **Peek-Asa, C., D.L. McArthur, and J.F. Kraus:** Incidence of acute low-back injury among older workers in a cohort of material handlers. *J. Occup. Environ. Hyg. 1*:551–557 (2004).
22. **Jansen, J.P., H. Morgenstern, and A. Burdorf:** Dose-response relations between occupational exposures to physical and psychological factors and the risk of low back pain. *Occup. Environ. Med. 61*:972–979 (2004).
23. **Krause, N., R. Rugulies, D.R. Ragland, and S.L. Syme:** Physical workload, ergonomic problems, and incidence of low back injury: A 7.5 year prospective study of San Francisco transit operators. *Am. J. Ind. Med. 46*:570–585 (2004)..
24. **Bigos, S.J., D.M. Spengler, N.A. Martin, J. Zeh, L. Fisher, and A. Nachemson:** Back injuries in industry: A retrospective study. III. Employee-related factors. *Spine 11(3)*:252–256 (1986).

25. **Hurwitz, E.L., and H. Morgenstern:** Cross-sectional associations of asthma, hay fever, and other allergies with major depression and low-back pain among adults aged 20–39 years in the United States. *Am. J. Epidemiol. 150(10)*:1107–1116 (1999).
26. **Dionne, C.E., M. Von Korff, T.D. Koepsell, R.A. Deyo, W.E. Barlow, and H. Checkoway:** Formal education and back pain: A review. *J. Epidemiol. Comm. Health 55*:455–468 (2001).
27. **Riihimaki, H., E. Viikari-Junura, G. Moneta, J. Kuha, T. Videman, and S. Tola:** Incidence of sciatic pain among men in machine operating, dynamic physical work, and sedentary work. *Spine 19(2)*:138–142 (1994).
28. **Zhou, C., and J.M. Roseman:** Agricultural injuries among a population-based sample of farm operators in Alabama. *Am. J. Ind. Med. 25*:385–402 (1994).
29. **Lyman, S., G. McGwin, R. Enochs, and J. Roseman:** History of agricultural injury among farmers in Alabama and Mississippi: Prevalence, characteristics, and associated factors. *Am. J. Ind. Med. 35*:499–510 (1999).
30. **Brackbill, R.M., L.L. Cameron, and V. Behrens:** Prevalence of chronic diseases and impairments among US farmers, 1986–1990. *Am. J. Epidemiol. 139(11)*:1055–1065 (1994).
31. **Hwang, S.A., M.I. Gomez, A.D. Stark, St. John T. Lowery, J.J. May, and E.M. Hallman:** Severe farm injuries among New York farmers. *Am. J. Ind. Med. 40*:32–41 (2001).
32. **Magni, G., C. Moreschi, S. Rigatti-Luchini, and H. Merskey:** Prospective study on the relationship between depressive symptoms and chronic musculoskeletal pain. *Pain 56*:289–297 (1994).
33. **Carroll, L.J., J.D. Cassiday, and P. Cote:** Depression as a risk factor for onset of an episode of troublesome neck and low back pain. *Pain 107*:134–139 (2004).
34. **Leino, P., and G. Magni:** Depressive symptoms and distress symptoms as predictors of low back pain, neck-shoulder pain, and other musculoskeletal morbidity: A 10-year follow-up of metal industry employees. *Pain 53*:89–94 (1993).
35. **Zwerling, C., N.L. Sprince, R.B. Wallace, et al.:** Occupational injuries among agricultural workers 51 to 61 years old: A national study. *J. Agric. Saf. Health 1(4)*:273–281 (1995).
36. **Stallones, L., M. Leff, C. Garrett, et al.:** Depressive symptoms among Colorado farmers. *J Agric. Saf. Health 1(1)*:37–43 (1995).
37. **Scarth, R.D., C. Zwerling, M.Q. Lewis, and L.F. Burmeister:** Depression and risk factors among Iowa farmers. *J. Agromed. 4(3/4)*:207–216 (1997).
38. **Kraus, J.F., L. Gardner, J. Collins, G. Sorock, and E. Volinn:** Design factors in epidemiologic cohort studies of work-related low back injury or pain. *Am. J. Ind. Med. 32*:153–163 (1997).
39. **National Institute for Occupational Health and Safety (NIOSH):** *Injuries Among Farm Workers in the United States, 1995*. NIOSH Pub. No. 2001-153. Cincinnati, Ohio: NIOSH, 2001.
40. **Ferguson, S.A., and W.S. Marras:** A literature review of low back disorder surveillance measures and risk factors. *Clin. Biomech. 12(4)*:211–226 (1997).
41. **Merchant, J., and S.R. Reynolds:** Work in agriculture. In *Epidemiology of Work-Related Diseases,* 2nd Edition, C.J. McDonald (ed.). London: BMJ Books, 2000. pp. 309–329.