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RESEARCH ARTICLE

Modifiable risk factors for depressed mood among farmers

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BACKGROUND: Risk for depression among farmers is not fully understood. DSM-IV considers sadness or depressed mood a critical symptom of depression. The aim of this study was to examine risk factors for depressed mood among farmers using a longitudinal study design.

METHODS: Participants were principal farm operators in the Iowa Certified Safe Farm study. We identified risk factors for depressed mood by calculating relative risks (RR) using the generalized estimating equations method.

RESULTS: In the multivariate model, pesticide exposure (RR = 1.26; 95% CI: 1.04 to 1.53), having an additional job off the farm (RR = 1.32; 95% CI: 1.08 to 1.62), stress (RR = 3.09; 95% CI: 2.55 to 3.75), and previous injury (RR = 1.41; 95% CI: 1.05 to 1.89) prospectively increased the risk of depressed mood.

CONCLUSIONS: Consistent with earlier non-longitudinal studies, the results of this study suggest that reducing pesticide exposure, stress, and injury may reduce the risk of depression in the farm setting.

KEYWORDS: depression, pesticides, orthophosphates, farming, stress, serotonin

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INTRODUCTION

Farming is associated with increased risk of depression.[1,2] The consequences of depression among farmers are far reaching. Although depression affects a farmer's personal life and his or her family's well-being,[3] lost work days due to depression among farmers have a significant impact on the economy of urban and rural communities.[4] In a study conducted between 1997 and 1999 that examined 29,400 individuals born between

1953 and 1957 in Hordaland County, Norway, agricultural workers showed the highest Hospital Anxiety and Depression Scale scores[5] relative to all other occupational groups.[6] In the United States, farming—together with unskilled labor and technical work—is among the occupations associated with greater depression.[7] Estimated prevalence in the Midwest ranges from 7.4% to 35%, varying by study and state.[8-10] Among male farmers, the prevalence of depression was 35% in Ohio,[8] 26.1% in Missouri,[9] 12.2% in Iowa,[10] and 7.4% in Colorado.[10] Rate variation may be due to approach—including assessment and definition of depression—recruitment criteria, and intrinsic characteristics of the farmers by state.

Elevated rates of depression among farmers predictably are associated with elevated suicide risk.[11-18] Suicide among farmers and agricultural workers greatly contributes to higher suicide rates seen in rural vs urban populations.[15] The suicide rate among Kentucky farmers is estimated at 42.2/100,000/year, compared with 19.2/100,000/year among the general US population.[11] High suicide rates among farmers are not limited to the United States; in Scotland, suicide among farmers is estimated at 31.4/100,000/year compared with 27.5/100,000/year among the general Scottish population.[17]

Assessment of depression in farm studies has varied greatly. Widely used methods have ranged from participant-administered questionnaires including the Center for Epidemiologic Studies-Depression Scale,[10,19-21] the Hospital Anxiety and Depression Scale,[1] the general mental health subscale of the short form (36) health survey,[7,22] to a single anamnestic question—eg, "Has a doctor ever diagnosed you with depression requiring medication?"[23] or "Have you experienced feelings of sadness or depression within the last year?"[24]

There is considerable interest in the presence of sadness among farmers. Inability to resolve negative mood has been shown to increase vulnerability of developing clinical depression.[24,25] Furthermore, sadness or low mood is a criterion, together with loss of pleasure, that is required for a depression diagnosis (and it will not change in DSM-5).[26] Based on satisfactory sensitivity and specificity against depression severity measured with assessment scales (>65.0% and >87.0% relative to the Beck Depression Inventory[27,28] and 86% and 78% relative to the Montgomery-Åsberg Depression Rating Scale[29,30]), assessment of sad mood is a widely used method to track changes in personal emotional status in longitudinal epidemiological studies.[24,27,30,31]

Previous cross-sectional studies have identified several psychosocial risk factors for depression among farmers including substantial income decline, being single, having poor general health, and loss of something of sentimental value.[10] Farming exposes individuals to high stress and injuries,[24,32] factors known to elevate depression risk.[24] Biologic risk factors also have been identified, such as younger age, which also may be considered a psychosocial risk factor.[33] Alcohol use has been linked to depression. Patten and Charney[34] found that consuming 5 to 10 alcoholic drinks per week increased the risk of depression among farmers. Several cross-sectional surveys[20,21,23,35,36] and 1 longitudinal study[19] have reported the association between pesticide application and depression. Beseler et al[19] reported that depression was associated with cumulative and chronic—but not acute—pesticide exposure.

Studies carried out to examine factors associated with depression among farmers have identified both nonmodifiable (eg, younger age), modifiable (eg, pesticide exposure), psychosocial (eg, income decline), and biologic factors (eg, alcohol use). Most studies have employed cross-sectional designs. The caveat with this design is that association among variables is synchronic, greatly limiting inference of causality. Understanding the temporal associations between risk factors and depression may suggest (albeit not prove) causation and help design appropriate interventions and preventive measures.

This study prospectively evaluated risk factors for depressed mood in a relatively large cohort of farmers. Based on prior literature, it was hypothesized that both psychosocial[1,2,10,16,33] (including modifiable factors as occupational stress) and biologic factors[19-21,23,34-36] (including modifiable factors as pesticide exposure) will be associated with depression.

METHODS

This study examined data from the Iowa Certified Safe Farm (CSF) study, which is designed to evaluate the effectiveness of a multifaceted farm safety intervention. The methods for and a summary of this study have been described in detail.[32,37,38]

Participants

The Iowa CSF study targeted a 9-county area in northwestern Iowa. All principal farm operators who met the

US Department of Agriculture farm criteria (>$1,000 in agricultural product sales per year) were eligible. Initially, participants were invited to participate through mailings and the media. Farmers who returned a card indicating their willingness to take part in the study were contacted by telephone until 300 farmers were recruited. They were pair matched based on farm size (crop acres), whether they raised livestock in general, raised pigs specifically, and previous injury experience. Pairs were randomly assigned to intervention or control groups. The intervention group received an on-farm safety review and educational intervention focusing on farm hazards including use of personal protective equipment (PPE). Other aspects of intervention included an annual health screening and monetary incentive. There was no significant association between the intervention group and depressed mood (RR [95% CI] = 0.94 [0.78 to 1.13], $P > .5$). Further recruiting was conducted to replace dropouts, and data from 257 farmers were available for analyses.

TABLE 1
Baseline characteristics of CSF farmers and the general Iowa farming population

Variables	Iowa CSF farmers (N = 257)	Iowa farmers in general[a] (N = 61,935)
Mean age (years)	56	52
Sex (% male)	98%	92.7%
Ethnicity (% white)	100%	99.9%
Mean total acres farmed	628	350
Mean hog herd[b]	2,798	850
Mean corn acreage	318	187
Mean soybean acreage	302	176

[a]The US Census of Agriculture 2002.
[b]Principal operators were exclusively hog-raising farmers.
CSF: Certified Safe Farm.

Data collection

Outcome and risk factor data were collected through quarterly phone calls, annual occupational history forms, annual on-farm safety review, and annual clinic screenings.[37] Ten rounds of computer-aided, quarterly phone calls covered work exposures, injuries, and illnesses in a 3-year period. Calendars were provided for tracking health-related events including depression, injuries, skin conditions, hearing loss, and joint pain. All participants completed the annual occupational history forms and quarterly calls, and only farmers in the intervention group completed the clinic screenings and on-farm safety reviews because these procedures were major components of the intervention. The occupational history forms included demographic and farm production variables, as well as questions on safety behaviors and PPE use. The clinic screening form included questions about health outcomes.

Study variables

The outcome variable for this analysis was derived from the question asked during each quarterly interview: "How would you rate your level of depression in the last quarter?" Possible responses were: very low, low, average, high, or very high. Responses were combined based on clinical relevance: a dichotomous outcome variable "no depressed mood" and "depressed mood" was created. Responses from very low to average depression were believed to have unclear clinical relevance and represent normal mood fluctuations. Therefore very low, low, and average responses were parsimoniously classified as no depression. "High" and "very high" responses were classified as depression.

The demographic variables in this study included age, sex, and education. The age variable was assessed as a continuous variable, while education was dichotomized into ≤12 or >12 years of education. Occupational risk factors included raising livestock, exposure to pesticides, and exposure to agricultural chemicals, all of which were recorded using dichotomized (ie, "yes" or "no") answers. Other dichotomized occupational variables included off-farm work and weekly farm hours (≤42 hours or >42 hours) as were included in previous studies.[19] Lifestyle variables included drinking >9 alcoholic drinks per week and smoking (presence or absence). The General Health Status variable was recorded as 5 severity levels: very good, good, fair, poor, and very poor, and was dichotomized into poor—very poor and poor—vs good—very good, good, and fair. Presence or absence of a previous injury and stress also were predictor variables.

Analysis

Data from quarterly calls, occupational history forms, farm reviews, and clinical screenings were merged to examine the associations between potential risk factors (exposures) and the presence of depression. The quarterly call dataset consisted of 10 repeated records of exposures and outcomes for each study patient. Variables from the other data collection instruments were merged into the quarterly dataset.

TABLE 2
Rates of depressed mood by severity

	High or very high depressed mood	Very low, low, or average depressed mood
Frequency	62/257	195/257
Percentage (%)	24.1%	75.9%

The generalized estimating equations (GEE) method was used to evaluate the associations between exposures and outcomes as well as to calculate relative risks (RR). This analytic procedure is able to handle repeated measure data where responses are correlated. GEE analyses were performed using generalized logit as the link factor, the number of months of observation as the offset factor, and the farm identification number (ie, the unique identification number for each participant) as the clustering factor.[39] The temporal association between occurrence of depression and risk exposure was an essential feature of the present study. The following 2 methods were used to establish that the exposure occurred before the outcome, reported in the quarterly call data:

1) Exposure from each quarter was matched with outcomes from the following quarter

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.

This procedure allowed the independent variables (exposures) to be measured before the outcome measure (depressed mood) from the first to last quarter; depression in the first quarter was excluded. Model building included the following steps: 1) the association of depression with potential risk factors was first assessed in univariate analyses; 2) risk factors that had a P value of ≤.10 in the univariate analysis were selected for multivariate analyses; and 3) all risk factors that met the criteria were included in the multivariate model.

RESULTS

TABLE 1 describes the demographic characteristics of Iowa CSF farmers in comparison with Iowa farmers in general. On average, CSF cohort was slightly older than Iowa farmers in general and had more male farmers. Also, CSF farmers had larger crop acreages and larger hog operations compared with Iowa farmers.

The average percentage of patients reporting "high" or "very high" depressed mood during the 10 examined quarters was 24.1% (TABLE 2). Nine of the 62 patients reported depressed mood in 2 different quarters and the remaining participants reported depression during 1 interview. This signifies that 96.5% of depressed farmers had depressed mood for an estimated duration of ≤4 months. There were no statistically significant differences between farmers with longer and shorter duration of depressed mood for demographic variables as well as pesticide exposure, previous injury, hearing loss, alcohol use, working longer hours (>42 hours per week), livestock farming, and poor general health.

TABLE 3 presents RR, 95% CI, and P values for the univariate regression of potential risk factors and depression. Farmers with pesticide exposure had 1.27 times risk of depression than nonexposed farmers (95% CI = 1.06 to 1.53). Three other variables significantly increased the risk for depressed mood: previous injury increased the risk by 1.53 (95% CI = 1.15 to 2.04); stress increased the risk by 3-fold (95% CI = 2.55 to 3.72); and having an additional job off the farm increased the risk by 1.22 (95% CI = 1.01 to 1.48). Hearing loss also met criteria to be included in the final model. Sex, age, education, smoking, hearing loss, alcohol use, working longer hours weekly (>42 hours per week), livestock farming, and poor general health did not predict depressed mood. To determine the extent to which mood changed with the season, effect of quarter was examined, but did not show association with depressed mood (TABLE 3). Marital status was expected to play a role in depression; however, the data did not allow this computation, because the percentage of single farm operators among the entire data set was <5%.

TABLE 4 describes the RR, 95% CI, and P values for the multivariate regression analysis. The risk for depressed mood after pesticide exposure remained essentially unchanged (RR = 1.26; 95% CI: 1.04 to 1.53). Having an off-farm job, stress, and previous injury remained significant predictors for depressed mood.

DISCUSSION

Negative or depressed mood among vulnerable individuals may initiate a cascade of psychological events leading to clinical depression.[25] Our main focus was to identify modifiable and nonmodifiable, psychosocial, and biologic factors antecedent to depressed mood using data from the Iowa

TABLE 3
Univariate analysis for depression risk factors

Variables	Present (N = 257)	RR (95% CI)	P
Education (≤12 years)	82	0.88 (0.72 to 1.07)	.20
Sex (male)	251	0.87 (0.55 to 1.38)	.55
Average weekly farm hours (>42)	108	1.09 (0.81 to 1.32)	.29
Off-farm job	95	1.22 (1.01 to 1.48)	.04
Pesticide exposure	94	1.27 (1.06 to 1.53)	<.01
Agricultural chemical exposure	90	0.95 (0.78 to 1.17)	.63
General health (poor)	5	1.29 (0.64 to 2.56)	.48
Previous injury	28	1.53 (1.15 to 2.04)	<.01
Stress	59	3.08 (2.55 to 3.72)	<.01
Hearing loss	78	1.30 (0.96 to 1.77)	.10
Alcohol (>9 drinks per week)	126	0.94 (0.79 to 1.13)	.51
Smoking (current)	10	1.29 (0.84 to 1.98)	.24
Livestock	158	0.97 (0.81 to 1.16)	.76
Age (mean 56 years)	257	0.83 (0.68 to 1.02)	08

RR: relative risk.

CSF study[32,37,38] as a means to guide further secondary prevention studies. Hypotheses were based on several cross-sectional reports[1,2,10,16,20,21,23,32-36] and a prospective study.[19]

We found several interesting results. Within the 3-year study period, approximately one-fourth of farmers admitted to depressed mood of potential clinical relevance. Risk factors for depressed mood were psychosocial—eg, stress, injury on the farm, holding an additional job off the farm—and biological—eg, exposure to pesticides. Most participants had an estimated duration of depressed mood of ≤4 months. Although some factors, including exposure to pesticides and injury, may be modifiable through improved injury prevention and farming practices, others, including need for a job off the farm to increment income, may be harder to modify in the current financial climate. Factors in cross-sectional studies previously reported to be associated with depression—eg, poor general health, younger age, and alcohol use—were not found to significantly predict depressed mood in the present study. Other factors that have shown association in previous studies—eg, income decline, being single, and loss of "something of sentimental value"—were not assessed.

Before discussing these findings, some specific issues need to be acknowledged. The present study outcome variable was based on a single question and on the conservative opinion that responses of "very low," "low," and "average" level of depression may represent normal mood variations while "high" and "very high" depressed mood may constitute relevant change. Although others have used a similar approach (eg, "Have you experienced feelings of sadness or depression within the last year?"),[24] assessment type should be kept in mind when comparing the present study findings with studies of farmers using other methods to assess depression.[1,19] Related to this issue is the transient nature of depression that might not meet clinical diagnostic threshold. Further studies should attempt to attain data on mental health service use during the longitudinal period to clarify the clinical significance of reported depressed mood. Remarkably, the 24.1% rate of depressed mood found in this study is comparable to the 24.0% reported in a previous study using a similar approach.[24] As expected, this method yielded depression rates higher than a previous Iowa farmers study that assessed depression using the Center for Epidemiologic Studies Depression Scale (CES-D).[10] However, 2 studies conducted in Ohio[8] and Missouri[9] using the CES-D yielded higher rates relative to Iowa, suggesting that rate variation is not exclusively based on depression assessment. Variation among depression rates may be related to the sample characteristics by study and state. Responses on mood changes were attained from phone interviews. In-person interviews may have resulted in different findings.

TABLE 4
Multivariate analysis of potential risk factors for depressed mood

Variables	N	RR (95% CI)	P
Pesticide exposure	257	1.26 (1.04 to 1.53)	.01
Off-farm job	257	1.32 (1.08 to 1.62)	<.01
Stress	257	3.09 (2.55 to 3.75)	<.01
Previous injury	257	1.41 (1.05 to 1.89)	.02

RR: relative risk.

In addition, personal or family history of depression was not recorded to evaluate potential vulnerability to pesticide-induced depression. Farmers participating in the study operated larger farms than Iowa farmers in general, therefore results should be generalized with this caveat. Stress was found to be a predictor of depressed mood in the present study. Responses to the survey (eg, the need for working off the farm) may help to understand the types of stress farmers endure; future studies should more precisely characterize the types of stress affecting farmers (including variables such as farm income and total household income). Pesticide exposure in the present study was self-reported. This assessment is similar to previous studies[20,21,23,35,36] but cannot objectively assess the severity and suddenness of exposure. There is a debate in the literature concerning the extent to which low-dose chronic or high-dose rapid (eg, poisoning) exposure can lead to depression. Future research should aim to improve the assessment method, because self-report has proven unable to distinguish the effects between cumulative high[19] or low[20,21,23,35,36] pesticide exposure on depression.

The prevalent duration of self-reported sad mood in the present study (≤4 months) was consistent with the lower end of the spectrum of duration of episodes of depressive illness (lasting from 2 months to several years, with an average of approximately 5 to 6 months)[40] and with duration of depression among the general population (ie, 3 months).[41] Interestingly, there were no differences reaching statistical significance between farmers with longer and shorter duration of depressed mood on demographic variables, as well as on pesticide exposure, previous injury, hearing loss, alcohol use, working longer hours (>42 hours per week), livestock farming, and poor general health.

Consistent with the findings in the present study, pesticide and chemical exposure have been reported as risk factors for depression in several cross-sectional surveys.[20,21,23,35,36] Our study confirms the temporal antecedence of exposure to pesticide with respect to depression as reported in a study of Colorado farmers.[19] Animal research suggests possible mechanisms explaining the relationship between depressed mood and pesticide exposure. One of the most used pesticides, chlorpyrifos organophosphate,[42] has been shown to disrupt serotonin neurotransmission and lead to neurobehavioral changes.[43-46] For example, exposure of newborn rats (postnatal days 1 to 4) to organophosphate pesticides caused rats grown into adulthood to spend more time in the open arms of the elevated plus maze and to show lower preference for chocolate milk relative to water, similar to behavioral alterations observed in animal models of depression.[43] Other biologic mechanisms of depression among farmers may be stress mediated. A biologic link between stress and depression also has been posited. Stress-related decreased expression of brain-derived neurotrophic factor has been shown to contribute to limbic system atrophy including the hippocampus.[47] In rodents, stress-induced reduction of hippocampal neurogenesis has been suggested as a potential mechanism of depression.[48,49] Notably, the relationship between pesticide exposure and depression may be mediated by paraoxonase gene polymorphism.[50] Human paraoxonase (especially paraoxonase-1) are serum enzymes protecting against exposure to organophosphorus pesticides by hydrolyzing their toxic oxon metabolites.[51] The R allele has been shown the increase the risk of depression among patients with long-term exposure to organophosphate pesticides.[52,53]

It is known that stress is synchronically associated with depression,[1,10,16,54-58] and this study is consistent with previous reports showing that farming is associated with increased stress.[1,2] The present study adds the notion of temporal antecedence of stress relative to depressed mood to the existing literature of depression among farmers. Stress is known to induce interpersonal vulnerability, impaired self-worth, and reduced social connectedness.[55] Farming may lead to depression because of farmers' limited social network, which may be relevant to coping with stress.[59] Several factors contributing to psychosocial stress—including loss of property with sentimental or vocational value, income decline, or financial strain (which may lead to the need to find an additional job besides farming)—have been considered as risk factors.[10,59] In addition, farm work can be physically strenuous and most of it takes place outdoors, often during inclem-

ent weather, especially during planting and harvesting seasons.[60] The emotional demands attached to meeting deadlines for planting and harvesting may contribute to high stress levels.[10] Stress alters the perception of environmental and emotional demands potentially exceeding the farmers' adaptive capacity[58] and generating feelings that may be akin to hopelessness and helplessness.

Income decline or variability of farm income have been identified as primary motivations for working an additional job off the farm.[61] The study's finding is consistent with previous cross-sectional surveys that identified financial difficulties as a risk factor for depression among farmers.[10,58] It should be noted that opportunity to access health benefits may be another reason for having an additional job off the farm, but consider that this also may be tied indirectly to poor finances. Our study showed that farm injury increased the risk of depressed mood, a finding consistent with the current literature.[26] Further studies will need to examine the nature and severity of injury in the farm environment.

In the study, several factors previously shown to be independently associated with depressive illness among the general population including poor general health,[20,33] alcohol use, and smoking[34] did not show significant association with depressive mood. Not associating depression with general health may be an artifact of most participants' good health (98%). Failure to show association with known risk factors for depression in the general population (eg, alcohol) suggests that depressive mood among farmers has an etiology that differs partially from that of depression among the general population.

CONCLUSIONS

This study found that pesticide exposure, stress, and injury were independent risk factors for depressed mood among farmers. Prior studies suggest that suicide is a significant concern among farmers[11,17] and depression has far reaching economic consequences.[4] Together with research showing the importance of negative mood in the mechanisms of clinical depression,[25] the present study suggests potential modifiable factors including pesticide exposure, stress, and injury on the farm that can be targeted in secondary prevention studies. Conceivably, better farming practices aimed at reducing pesticide exposure, stress, and injury may have considerable effects on reducing the risk of depression among farmers. ■

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