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Safety Practices, Neurological Symptoms, and Pesticide Poisoning

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Depression, anxiety, inability to concentrate, and spatial disorientation associated with pesticide poisoning may influence farmers' ability to comply with established safety procedures. The purpose of this article is to describe the relationship between safety practices, neurological symptoms, and pesticide poisoning. A survey of farm residents was conducted in an eight-county area in Colorado. Multivariate logistic regression models were used to determine associations between safety practices, neurological symptoms, and previous pesticide poisoning. A number of safety practices were associated with the following neurological symptoms: difficulty concentrating; feeling irritable; relatives noticing memory difficulties; and difficulty understanding reading materials. The associations between safety practices and neurological symptoms were increased in the presence of pesticide poisoning. Factors associated with failure to engage in established safety practices in this study were neurological symptoms.

Introduction

Agriculture has one of the highest injury rates of all industries in North America. Both fatal and nonfatal injury rates are high among workers in agriculture. The type of farm [1] [2] [3] [4] [5] [6] and exposure to specific agents of injury [1] [2] [7] among agricultural workers have been well documented, but less has been reported related to specific safety practices and factors that influence those practices on farms. [8] [9] [10] [11]

Pesticide intoxications occur in some parts of the world at rates that surpass or rival those of infectious disease traditionally viewed as the most frequent health problems. [12] In six Central American countries, active surveillance of pesticide poisonings yielded a regional estimate of 400,000 cases a year, representing 1.9% of the total population, 76% of which were work-related. [13] Impairments resulting from pesticide poisoning may include both cognitive and physical sequelae. [14] [15] [16] Acute effects reported include nausea, vomiting, abdominal pain, numbness and/or tremors in the extremities, fatigue, headaches, excessive salivation, diarrhea, generalized weakness, respiratory problems, and blurred vision. [14] [15] Acute psychological effects reported include anxiety, depression, irritability and restlessness. [14] [15] [16] Additionally, neuropsychological effects such as difficulty concentrating, word finding problems, memory impairments, decreased alertness may result after an acute exposure. [14] [15]

Exposure to organophosphates may have chronic, long-term effects and has been linked to delayed-onset peripheral neuropathies, primarily affecting the extremities and producing neuropsychological [17] [18] and neurobehavioral changes. [17] [18] [19] In a 1992 study of migrant **farmworkers**, 21 workers who had experienced two documented acute exposures were evaluated with a neuropsychological battery, medical history questionnaire, and an anxiety and depression scale. [17] The investigators found the exposed group to be significantly more impaired on measures of motor speed and coordination, visuospatial memory, anxiety, depression, and physical symptoms. Savage et al [18] also found individuals with a history of organophosphate poisoning to perform worse on tests of intellectual functioning, academic skills, flexibility of thinking, abstraction, and motor speed and coordination than a group of nonpoisoned individuals. Rosenstock et al [19] studied a group of 36 agricultural workers with a history of hospitalization for acute organophosphate poisoning and found that their performance on the neurological and neuropsychological batteries was significantly inferior to controls. The workers

were evaluated an average of 2 years postpoisoning, and exposure during the 3 months prior to testing was uncommon. The poisoned group had poorer performance scores on five of six subtests evaluating verbal attention, visual memory, visuomotor, and motor functions. In addition, the exposed group performed significantly worse on neuropsychological tests of visuomotor sequencing, problem-solving, and visual attention. [19] Steenland et al [20] reported results of evaluating 128 individuals with suspected and confirmed organophosphate poisoning in California. These individuals differed significantly from controls on tests of sustained visual attention and two mood scale tests. Those individuals with confirmed poisoning also differed significantly from controls on a test of vibrotactile sensitivity and the symbol digit test. [20]

Depression, anxiety, inability to concentrate, and spatial disorientation associated with a previous acute poisoning from organophosphates may lead to high risk of injuries through reducing the frequency with which an individual uses established safety procedures. Ability to comply with safety practices may be linked to specific neurological symptoms, thereby increasing the risk of injury occurrence. The purpose of this article is to describe the relationship between safety practices, neurological symptoms, and pesticide poisoning in a population of farm residents.

Materials and Methods

The study population was a stratified sample of farmers residing in eight counties in Northeastern Colorado. A total of 479 farms and 761 farm residents were enrolled in the survey between 1993 and 1997. In-person interviews were conducted. Twenty-four neurological symptoms were assessed using the World Health Organization-recommended Neurobehavioral Core Test Battery. Ten safety practices were assessed related to use of protective equipment (hearing protection, respirators, dust masks, machine guards, animal handling equipment), behavior around animals, general maintenance of slippery surfaces, reading instruction manuals for equipment, and chemical storage. Pesticide poisoning was based on self-reported episodes of poisoning and symptoms associated with the event. The question read as follows: "Have you ever become ill from any exposure to pesticides?" Logistic regression was used to the model the relationship among safety behaviors, neurological symptoms, and pesticide poisoning episodes. Neurological symptoms examined here are those that were found significantly associated with having reported a pesticide-related illness in a previous report [21] and those that

occurred frequently enough to be studied in relation to safety practices. These symptoms were difficulty concentrating; trouble remembering things; having to make notes to remember things; finding it hard to understand the meaning of newspapers, magazines, and books; feeling irritable; feeling depressed; and sleeping more than usual. [21]

Statistical Analysis

Analyses of the safety practices questions were performed by first using three categories in univariate, unadjusted proportional odds models, taking advantage of the ordinal nature of the outcome variable. Proportional odds regression is similar to logistic regression but allows the outcome of interest to have multilevel responses rather than binary outcomes. It models the outcome as a function of cumulative log odds using ordered logistic regression as opposed to simply modeling the log odds as a linear function. The safety factor fell naturally into three categories of low, intermediate, and high risk. The low-risk group included people who most of the time or always engaged in the safety practice, the intermediate risk group included individuals who sometimes engaged in the safety practice, and the high-risk group reported rarely or never engaging in the practice. Factors that might account for differences in safety practices between the low-risk and high-risk groups include alcohol use; fatigue; increasing age; a neurological condition resulting in an inability to concentrate; and having experienced a pesticide-related illness. Participants were asked whether they had ever attended a 10- or 20-hour tractor safety-training program through vocational agriculture. This variable was modeled as a risk factor if they responded they had not attended the class. Safety practices and potential risk factors were selected for further analysis in multivariate logistic regression models if they were significant predictors of being in the high-risk safety practices group. Unfortunately, the proportional odds assumption was not met, because of small numbers, when covariates were included in the model, so the safety practices were collapsed into all or most of the time as the group considered at low risk and sometimes, rarely, or never as the group at high risk. The results from unadjusted logistic regression models were compared to the proportional odds models to check for significant differences due to classification of the safety factor. Health status, hours spent working, alcohol use, smoking status, and social support indicators were considered in age- and gender-adjusted logistic regression models. Age, hours of work per day, the number of clubs an individual was active in, the number of close relatives an individual had, and the number of people he or she was close to were used as continuous variables in the models. Current smoking was classified as yes or no. Alcohol consumption was used as a dichotomous variable as whether one drank or not, a continuous variable reflecting the average number of drinks one had when

drinking, coded to reflect a combination of how often one drank and the number of drinks ingested on a usual occasion of drinking. Health status was used as a dichotomous variable with those reporting excellent, very good and good health being the reference group, while those reporting fair or poor health were considered the high-risk group.

Responses to the seven neurological symptoms were not at all; a little; moderately; quite a bit; or extremely often during the past month. Individuals reporting no neurological symptom at all were the reference group and others were grouped as experiencing a neurological symptom. This was done both because of the subjective nature of symptom reporting and because of the low frequency of reports of moderate, quite a bit, and extremely often experiencing the neurological symptoms. Neurological symptoms were compared by gender and tested for significant differences using the chi-square test.

Cross-sectional studies do not permit the establishment of a causal pattern of events. It is possible that being in a high-risk safety category increases the probability of having experienced a pesticide-related illness, rather than the pesticide illness precipitating the poor safety practice. For this reason, χ^2 and Fisher's Exact tests reporting two-sided *P*-values were used on a subgroup of those who reported having no neurological symptoms, examining whether pesticide poisoning was significantly associated with being in the high risk safety category. If being in a high-risk safety group was not significantly associated with having had a pesticide-related illness and an association occurred only in the presence of a neurological effect, this lends support to the pesticide illness being the initiating event, followed by the failure to practice a certain safety factor.

To examine the association of significant neurological symptoms and safety practices with pesticide-related illness, the neurological symptom variable was stratified into whether the individual had reported a pesticide-related illness or not. This resulted in three categories, those having no neurological symptoms, those having neurological symptoms and no pesticide-related illness, and those having neurological symptoms and having reported a pesticide-related illness. Those who did not experience any neurological symptoms were the reference group and indicator variables were used in the models for the groups under study who reported neurological symptoms with or without a pesticide illness.

Results

Of the 761 farm residents surveyed, 51 did not participate in farm work and were excluded from the analysis and 12 individuals were excluded because of missing information on all neurological symptoms. These exclusions left 708 individuals in the analysis. Only a few respondents refused to answer or did not know. Table 1 describes the 708 farm residents included in the analysis. Greater than 99% were white, and nearly 50% were older than 50 years of age. They were married, high school graduates and in good health. Approximately 25% of them had experienced a substantial income decline. Nearly 10% had experienced a pesticide poisoning. Pesticides used on the farms included herbicides, crop insecticides, and livestock insecticides. Herbicides were applied by 44.8% of the farm workers, primarily 2,4-D (37.1%) and atrazine (17.1%). Crop insecticides, applied by 29.5% of the farm workers, included terbufos (20.8%), chlorpyrifos (7.5%), and other organophosphates and carbamates (11.4%). Livestock insecticides were applied by 48.9% of participants and consisted of dichlorovos (4.4%), phosmet (0.9%), and other organophosphates and carbamates (37.1%).

Table 1. Characteristics and Comparison of Male, Female, and Combined Farm Residents in the Study Population, Colorado, 1993–1997

Characteristic	Males % (n) (*n* = 458)	Females % (n) (*n* = 250)	Population % (n) (*n* = 708)
Age in years			
<30	2.6 (12)	4.8 (12)	3.4 (24)
30–40	19.2 (88)	20.4 (51)	19.6 (139)
41–50	29.9 (137)	27.6 (69)	29.1 (206)
51–60	20.3 (93)	22.4 (56)	21.1 (149)
>60	28.0 (128)	24.8 (62)	26.8 (190)
Married			
Yes	86.9 (398)	96.4 (241)	90.2 (639)
No	13.1 (60)	3.6 (9)	9.8 (69)
Perceived general			

Characteristic	Males % (n) (*n* = 458)	Females % (n) (*n* = 250)	Population % (n) (*n* = 708)
health			
Excellent	27.3 (125)	22.9 (57)	25.8 (182)
Very good	42.7 (195)	44.2 (110)	43.2 (305)
Good	23.9 (109)	29.3 (73)	25.8 (182)
Fair/Poor	6.1 (28)	3.6 (9)	5.2 (37)
High school graduate			
Yes	88.0 (403)	93.6 (233)	90.0 (636)
No	12.0 (55)	6.4 (16)	10.0 (71)
Substantial income decline			
Yes	26.9 (122)	25.3 (63)	26.3 (185)
No	73.1 (332)	74.7 (186)	73.7 (518)
Pesticide-related illness			
Yes	12.4 (56)	5.2 (13)	9.8 (69)
No	87.6 (397)	94.8 (235)	90.2 (632)
Current smoker			
Yes	10.3 (47)	10.4 (26)	10.3 (73)
No	89.7 (411)	89.6 (224)	89.7 (635)

Many of the 708 farm residents who did perform farm work reported certain safety practice questions were not applicable to their farm situation. Table 2 shows the numbers and percentages of farm residents classified into risk categories based on the safety practices questions and the numbers who reported the questions as not applicable to their work. The only gender-related difference in safety practices was that women were less likely to be calm around animals than their male counterparts (χ^2 18.89, $P < 0.0001$).

Table 2. Numbers and Percentages of 708 Farm Residents Categorized by Response to Safety Practice Questions, Colorado, 1993–1997[*]

Safety Practice	All Respondents % (*n*)
Use of a respirator when handling dusty or moldy grain	N/A = 287
Low risk	39.8 (167)
High risk	60.2 (253)
Being calm when around animals in close quarters	N/A = 163
Low risk	92.1 (501)
High risk	7.9 (43)
Replacing protective shields after working on equipment	N/A = 199
Low risk	88.6 (450)
High risk	11.4 (58)
Wearing a dust mask during dusty operations	N/A = 168
Low risk	54.6 (294)
High risk	45.4 (245)
Using restraining or handling facilities for treating animals	N/A = 251
Low risk	87.9 (401)
High risk	12.1 (55)
Wearing ear protection when tending to noisy farm operations	N/A = 149
Low risk	34.5 (192)
High risk	65.5 (365)
Keeping chemicals out of the reach of children	N/A = 102
Low risk	94.0 (568)
High risk	6.0 (36)

Safety Practice	All Respondents % (*n*)
Keeping passage ways clear of slippery substances	N/A = 162
Low risk	91.7 (497)
High risk	8.3 (45)
Reading instruction manuals for farm machinery	N/A = 160
Low risk	85.1 (464)
High risk	14.9 (81)
Keeping moving equipment parts shielded	N/A = 158
Low risk	93.2 (508)
High risk	6.8 (37)

* Low risk are defined as those reporting always or almost always practicing the safety practice and high-risk as those who sometimes, rarely, or never practice the safety practice.

Table 3 compares two different methods of categorizing the neurological symptom variable and shows the large gap in the numbers between those with any symptoms and those with a moderate degree of symptoms. With the exception of having to make notes to remember things, very few individuals reported moderate to extreme symptoms. Self-reported neurological symptoms differed between men and women, but the gender effect was reduced when looking at those with more severe symptoms.

Table 3. Numbers and Percentages of Two Different Categorizations of Neurological Symptoms in the Study Population and, in the Broader Category, Stratified by Gender, Colorado Farm Residents, 1993–1997

Neurological Symptom	Population *% (*n*)	Males % (*n*)	Females % (*n*)	χ^2 (*P* value)	Population †% (*n*)
Had difficulty concentrating?	30.5 (216)	26.6 (122)	37.6 (94)	9.17 (0.003)	3.9 (28)
Have your relatives noticed that you have trouble remembering things?	20.7 (145)	22.1 (100)	18.2 (45)	1.45 (0.229)	3.6 (25)
Had to make notes to remember things?	64.1 (453)	57.6 (263)	76.0 (190)	23.9 (<0.0001)	28.0‡ (198)
Found it hard to understand the meaning of reading materials?	13.2 (93)	14.2 (65)	11.2 (28)	1.32 (0.251)	2.8 (20)
Felt irritable?	52.5 (372)	45.4 (208)	65.6 (164)	26.4 (<0.0001)	9.0 (64)
Felt depressed?	25.2 (178)	21.5 (98)	32.0 (80)	9.46 (0.002)	4.4 (31)
Sleeping more than is usual for you?	12.1 (86)	11.8 (54)	12.8 (32)	0.155 (0.694)	2.7 (19)

* Those in the study population reporting experiencing at least a little of the neurological symptom during the past month.

† Those in the study population reporting moderately, quite a bit and extremely experiencing a neurological symptom in the past month.

* Only making notes remained significantly different between men and women in those reporting more frequent neurological symptoms ($\chi^2 = 9.93$, *P* value 0.002).

Table 4 shows the results of unadjusted proportional odds models. Keeping chemicals out of the reach of children was removed from the analysis because it appeared to be selecting for those whose approach to chemicals increased their risk of a pesticide-related illness. Therefore, the direction of the effects could not be determined. Neither increasing age of the respondent nor alcohol consumption was significantly associated with any safety practice. Being a current smoker increased the probability of not wearing a respirator when handling dusty or moldy grain (odds ratio [OR] 2.05; 95% confidence interval [CI] = 1.09, 3.83). Fatigue was not a factor in safe farm practices. In fact, an increasing number of working hours each day decreased the odds of being in the high-risk category for being calm around animals (OR 0.86; 95% CI = 0.79, 0.94), wearing a dust mask (OR 0.93; 95% CI = 0.89, 0.97), and wearing hearing protection (OR 0.92; 95% CI = 0.88, 0.97). Farm residents reporting fair or poor health status were less likely to replace protective shields after working on equipment (OR 3.34; CI = 1.44, 7.73), were less likely to keep moving equipment parts shielded (OR 4.60; CI = 1.83, 11.53), and were less likely to keep passageways clear (OR 3.63, CI = 1.40, 9.40). The only significant social support indicator was the number of clubs and organizations in which the farm resident reported being active. This factor was protective for wearing a respirator (OR 0.87; CI = 0.78, 0.97), wearing hearing protection (OR 0.86; CI = 0.79, 0.95), and keeping passageways clear (OR 0.78; CI = 0.61, 0.95). Having attended a 10- or 20-hour tractor safety program was protective for wearing a respirator ($P < 0.05$), but was not associated with any other safety practice. Difficulty concentrating was shown to be significant in six of 10 safety practices, feeling irritable and sleeping more than is usual were significantly associated with two safety practices, and feeling depressed was associated with one safety practice.

Table 4. Odds ratios and 95% Confidence Intervals From Unadjusted Univariate Proportional Odds Regression Analyses, Modeling the Odds of Being in a High-Risk Safety Category and Possible Explanatory Factors, Colorado Farm Residents, 1993–1997

Safety Practice	OR (95% C.I.)
Use of a respirator when handling dusty or moldy grain	

Safety Practice	OR (95% C.I.)
Number of clubs/organizations active in	0.87 (0.78, 0.97)
Current smoker	2.05 (1.09, 3.83)
Being calm when around animals in close quarters	
Hours per day of farm work	0.86 (0.79, 0.94)
Difficulty concentrating	2.17 (1.16, 4.07)
Feeling irritable	3.20 (1.50, 6.79)
Replacing protective shields after working on equipment	
Health status	3.34 (1.44, 7.73)
Wearing a dust mask during dusty operations	
Hours per day of farm work	0.93 (0.89, 0.97)
Using restraining or handling facilities for treating animals	
Difficulty concentrating	1.81 (1.01, 3.22)
Hard to understand the meaning of reading materials	2.09 (1.04, 4.22)
Feeling irritable	1.91 (1.05, 3.47)
Sleeping more than is usual for you	2.92 (1.40, 6.11)
Wearing ear protection when tending to noisy farm operations	
Hours per day of farm work	0.92 (0.88, 0.97)
Number of clubs/organizations active in	0.86 (0.79, 0.95)
Difficulty concentrating	1.47 (1.03, 2.11)
Sleeping more than is usual for you	3.01 (1.68, 5.42)
Keeping chemicals out of the reach of children	
Difficulty concentrating	2.10 (1.06, 4.13)

Safety Practice	OR (95% C.I.)
Keeping passage ways clear of slippery substances	
Number of clubs/organizations active in	0.76 (0.61, 0.95)
Difficulty concentrating	3.17 (1.70, 5.91)
Health status	3.63 (1.40, 9.40)
Reading instruction manuals for farm machinery	
Difficulty concentrating	1.80 (1.11, 2.94)
Keeping moving equipment parts shielded	
Feeling depressed	2.15 (1.07, 4.31)
Health status	4.60 (1.83, 11.5)

Unadjusted logistic regression models using the dichotomized safety outcome showed the same variables to be significant as the proportional odds models with only slight changes in the ORs and 95% CIs. Age- and gender-adjusted logistic regression models using the dichotomized safety variable showed some changes in the significant variables (Table 5). Difficulty concentrating showed a reduced effect in some safety practices, but neurological symptoms such as relatives noticing you had trouble remembering things became significant. The number of hours worked in a day was not as protective in gender adjusted models for being calm around animals as it was in the unadjusted models.

Table 5. Odds Ratios and 95% Confidence Intervals From Age- and Gender-Adjusted Logistic Regression Analyses, Modeling the Probability of Being in a High-Risk Safety Category and Possible Explanatory Factors, Colorado Farm Residents, 1993–1997

Safety Practice	OR (95% CI)
Use of a respirator when handling dusty	

Safety Practice	OR (95% CI)
or moldy grain	
Number of clubs/organizations active in	0.84 (0.75, 0.94)
Current smoker	2.00 (1.00, 4.00)
Being calm when around animals in close quarters	
Hours per day of farm work	0.93 (0.83, 1.04)
Difficulty concentrating	1.76 (0.92, 3.37)
Relatives noticed that you have trouble remembering	2.23 (1.09, 4.59)
Feeling irritable	2.45 (1.13, 5.32)
Replacing protective shields after working on equipment	
Health status	3.13 (1.29, 7.57)
Wearing a dust mask during dusty operations	
Hours per day of farm work	0.92 (0.87, 0.98)
Using restraining or handling facilities for treating animals	
Difficulty concentrating	1.80 (1.01, 3.23)
Relatives noticed that you have trouble remembering	1.99 (1.04, 3.80)
Hard to understand the meaning of reading materials	2.33 (1.13, 4.82)
Feeling irritable	1.88 (1.02, 3.45)
Sleeping more than is usual for you	2.95 (1.38, 6.31)
Wearing ear protection when tending to noisy farm operations	
Hours per day of farm work	0.92 (0.87, 0.97)
Number of clubs/organizations active in	0.84 (0.76, 0.93)

Safety Practice	OR (95% CI)
Difficulty concentrating	1.52 (1.02, 2.28)
Sleeping more than is usual for you	3.31 (1.65, 6.64)
Keeping passage ways clear of slippery substances	
Number of clubs/organizations active in	0.76 (0.61, 0.95)
Health status	3.40 (1.26, 9.15)
Difficulty concentrating	3.48 (1.85, 6.55)
Feeling irritable	2.17 (1.13, 4.20)
Reading instruction manuals for farm machinery	
Difficulty concentrating	1.70 (1.04, 2.80)
Keeping moving equipment parts shielded	
Feeling depressed	2.24 (1.11, 4.52)
Health status	4.96 (1.90, 12.9)

Multivariate models were used to examine whether the protective factors attenuated the significance of the neurological symptoms. The protective effect of working a greater number of hours in a day was not significant in the models for being calm around animals when any neurological effect was also in the model. In the models for wearing hearing protection, both hours per day of work and number of clubs remained protective, with a slight reduction in the odds ratios of the neurological symptoms. Modeling keeping passageways clear showed that number of clubs remained protective. Health status was insignificant for difficulty concentrating and but remained significant in the model with feeling irritable, but showed a slightly reduced odds ratio (OR 3.24; 95% CI = 1.18, 8.90). The odds ratio for feeling depressed remained elevated but was not significant when health status was included in the model for keeping moving equipment parts shielded (OR 2.02, 95% CI = 0.98, 4.13).

Further analysis focused on being calm around animals, using gates when handling animals, wearing hearing protection, and keeping passageways clear of slippery

substances because neurological effects were the strongest predictors of being in a high risk safety group. Table 6 shows the results of analysis using models stratifying the neurological variable by pesticide-related illness. Although the confidence intervals are wide, reflecting the small numbers in these groups, the consistently elevated odds ratios for safety practices shown to have a neurological component suggests an increasing effect in those who had a pesticide-related illness compared with those who did not.

Table 6. Odds Ratios and 95% Confidence Intervals from Gender-Adjusted Logistic Regression Analyses, Modeling the Probability of Being in a High-Risk Safety Category and Categorized Neurological Symptom and Pesticide Poisoning, Colorado Farm Residents, 1993–1997

Safety Practice	OR (95% CI)* No Pesticide Poisoning	OR (95% CI)* Pesticide Poisoning
Being calm when around animals in close quarters		
Difficulty concentrating	1.67 (0.84, 3.31)	3.30 (1.01, 10.8)
Relatives noticed that you have trouble remembering	1.68 (0.75, 3.76)	4.67 (1.38, 15.8)
Feeling irritable	2.28 (1.03, 5.05)	4.60 (1.51, 14.1)
Using restraining facilities for treating animals		
Difficulty concentrating	1.76 (0.95, 3.27)	2.42 (0.76, 7.73)
Relatives noticed that you have trouble remembering	1.51 (0.73, 3.11)	3.88 (1.28, 11.8)
Hard to understand the meaning of reading materials	1.40 (0.59, 3.31)	7.11 (2.06, 24.5)
Feeling irritable	1.77 (0.95, 3.33)	3.30 (1.25, 8.74)
Keeping passage ways clear of slippery		

Safety Practice	OR (95% CI)* No Pesticide Poisoning	OR (95% CI)* Pesticide Poisoning
substances		
Difficulty concentrating	3.42 (1.76, 6.64)	3.70 (1.26, 10.9)
Relatives noticed that you have trouble remembering	1.31 (0.61, 2.87)	3.10 (1.08, 8.92)
Feeling irritable	2.12 (1.08, 4.19)	2.62 (0.89, 7.73)

* Referents are those reporting no symptoms, whether they reported a pesticide poisoning or not.

The subgroup analysis using those who reported not having a certain neurological symptom found only four significant associations using the χ^2 and Fisher's Exact tests, although the numbers of individuals who reported no neurological symptoms and reported a pesticide-related illness were small. Those who reported no problems with concentration were less likely to wear hearing protection if they had a pesticide illness ($\chi^2 = 4.27$, $P = 0.04$). Those who reported not being depressed and not sleeping more than usual were less likely to keep equipment parts shielded if they had a past pesticide illness ($P = 0.04$ and $P = 0.006$). Those reporting not sleeping more than usual also were less likely to keep passageways clear if they had a pesticide illness ($P = 0.04$). None of these associations were observed in the stratified analysis (Table 6) and may indicate symptoms indicative of depression, which might result in unsafe practices, with or without a previous pesticide-poisoning event.

Discussion

Previous reports noted a reduction in verbal and visual attention, visual memory, and mood disorders with changes in motor function in those who experienced acute and/or chronic exposure to organophosphate pesticides. The neurological symptoms examined here, that is, difficulty concentrating, trouble remembering things,

difficulty understanding reading materials, feeling irritable, feeling depressed, and sleeping more than usual address the lack of alertness, attention deficits, memory, and mood disorders addressed in other reports. If symptoms were not associated with safety practices, then, by chance alone, some symptoms would show significance and should appear randomly distributed among the various safety practices and not clustered in particular practices, as they do in this study.

The major causes of farming injuries are the result of animal handling, working with farm machinery, and unintentional falls. In this report, the most predictive factors, and sometimes the only predictive factors, for failing to practice good safety techniques when handling animals, working with equipment, and keeping passageways clear were neurological symptoms. Difficulty concentrating was associated with six of nine safety practices. Feeling irritable and sleeping more than usual were significantly associated with several safety practices. Three of nine safety practices showed significant differences between those who were pesticide poisoned compared with those who were not.

Not wearing a respirator or a dust mask was not associated with any neurological symptoms. Although health status is highly correlated with depression and other neurological effects, it was not a major risk factor for most safety practices. Health status was only associated with replacing shields after working on equipment, and to a lesser extent, keeping passageways clear. Neurological symptoms were clustered around animal handling, as reflected by being calm around animals and using restraining or handling facilities for treating animals, and no other risk or protective factors were associated with these safety practices. Animal handling is probably where being alert is a critical component of being safe. Wearing hearing protection had protective factors, such as the number of hours per day worked and the number of clubs the farm resident was active in and several neurological components, but these neurological components did not appear to be related to a previous pesticide illness. In the animal handling safety practices where neurological effects were strongest, protective factors did not lessen these effects.

The number of hours a farm resident spent working each day was protective, perhaps because busier farmers are more cognizant of the consequences of not using safe practices all the time. Farmers who work more hours may feel less rushed to get the work done and may take the time to put on personal protective equipment. The number of hours worked and number of clubs the individual was active in could act as surrogates identifying those who were not in a depressed state. Being active in clubs may promote discussions among farmers that promote good safety techniques and sharing of ideas to prevent injuries when performing specific tasks.

Health status, which is highly associated with depression, was associated with three safety practices, two of which were related to farm equipment. Health status was the only risk factor associated with failing to replace protective shields after working on equipment. Where the greatest number of neurological symptoms was observed in relation to several safety factors, health status was not a significant variable, indicating that health status is not likely to account for the neurological effects observed in relation to the safety practice behavior.

Because approximately half of this overall healthy population was over 50 years of age, it is not surprising that many individuals reported experiencing mild neurological symptoms. Unfortunately, the number of people reporting more severe symptoms was too small to be analyzed with respect to safety practices. However, people reporting mild symptoms should distribute equally between those who reported a pesticide poisoning and those who did not. If having an acute pesticide poisoning is associated with neurological symptoms, then those with more severe symptoms should cluster in the pesticide-poisoned group. Elevated ORs were observed for those who both reported a pesticide poisoning and reported a neurological symptom. Neurological effects resulting from a pesticide poisoning may decrease concentration and cause irritability, making it difficult to engage in good safety practices, especially when handling animals, where many of the farm injuries occur. This may be especially true for female farm residents, who appear to be more anxious around animals then male farm residents.

A major limitation of this type of cross-sectional study is the temporal sequence of events. It is conceivable that individuals who tend to be careless are more likely to be pesticide poisoned and develop neurological symptoms. There is no definitive way of knowing whether the failure to practice good safety techniques leads to pesticide poisoning and neurological symptoms or whether the pesticide exposure and subsequent neurological symptoms leads to the failure to exercise good safety practices. In this study, it appeared that certain neurological symptoms were much more strongly associated with safety behaviors than the pesticide-related illness was, indicating the neurological symptom was mediating the safety behavior. There were relatively few individuals with neurological symptoms who had not had a pesticide-related illness and when examining certain safety behaviors, the cell counts became small. It is possible that both temporal sequences could exist simultaneously and further research is needed to elucidate the relationships between pesticide poisoning, development of neurological symptoms and engaging in safety practices that prevent injury.

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