Farmwork-Related Injury Among Farmers 50 Years of Age and Older in Kentucky and South Carolina: A Cohort Study, 2002-2005

J. L. Marcum, S. R. Browning, D. B. Reed, R. J. Charnigo

ABSTRACT. *Farmers in the U.S. are becoming more diverse; the average age of the farmer is increasing, as is the number of women and minority farm operators. There is limited research on injury risk factors in these special populations of farmers. It is especially important to study the risk factors for injury in these growing and at-risk groups. A longitudinal survey was conducted of farmers (n = 1,394) age 50 and older who resided in Kentucky and South Carolina. The questionnaire was administered by telephone and mail surveys four times between 2002 and 2005 to the fixed cohort of farmers, obtained by convenience sample. Approximately half of the cohort was female, and the majority of the cohort worked less than 40 hours per week. This cohort reported a crude, non-fatal injury rate of 9.3 injured farmers per 100 per year. Farmers reporting chronic bronchitis/emphysema (estimated odds ratio [EOR] = 1.57), back problems (EOR = 1.37), arthritis (EOR = 1.31), 3 to 4 restless nights in the past week (EOR = 2.02), or 5 to 7 restless nights in the past week (EOR = 1.82) were at significantly higher odds of sustaining a farmwork-related injury as calculated by the generalized estimating equations (GEE) regression method. Farmers operating equipment on highways (EOR = 1.51) or climbing higher than eight feet (EOR = 1.69) were at significantly higher odds of sustaining a farmwork-related injury, and females were at higher risk of injury when performing animal-related tasks (EOR = 3.00) or crop-related tasks (EOR = 2.21). Identified factors associated with farmwork-related injury should better inform agricultural health policies and guidelines for older farmers, such as policies governing the allowable number of hours worked per week and rest breaks, guidelines that advise appropriate types of farm tasks, and ergonomic engineering advances on farming equipment.*

Keywords. *Agricultural injury, Older farmworkers.*

Agriculture continues to be recognized as one of the most hazardous industries in the U.S. Preliminary data from the Bureau of Labor Statistics for 2008 rank the agriculture, forestry, fishing, and hunting industry as having the highest

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fatality rate (29.4 deaths per 100,000 full-time equivalent workers) among all industries in the private sector and report an 11% increase in fatalities from 2007 (BLS, 2009). Additionally, the agriculture, forestry, fishing, and hunting industry ranks fourth in nonfatal illnesses and injuries within the private sector, with an incidence rate of 5.0 illnesses and injuries per 100 full-time workers (BLS, 2008).

Numerous studies have examined why this industry is so hazardous (Brison and Pickett, 1992; Gerberich et al., 1993; Zhou and Roseman, 1994; Nordstrom et al., 1995; Browning et al., 1998; Lewis et al., 1998; Hwang et al., 2001). The risk factors identified may be categorized as either individual-level factors or farm environment level factors. Previously reported individual-level risk factors associated with increased nonfatal farmwork-related injury include demographics such as younger age and male gender, number of hours doing farmwork per week, role on farm, prescription drug use, and hearing or vision impairments (Brison and Pickett, 1992; Gerberich et al., 1993; Zhou and Roseman, 1994; Nordstrom et al., 1995; Browning et al., 1998; Lewis et al., 1998; Hwang et al., 2001; Voaklander et al., 2006). Insufficient sleep has also been reported to increase injuries among farmers (Choi et al., 2006; Heaton et al., 2010). Risk factors identified at the environmental level include type of commodities produced and gross annual farm income (Brison and Pickett, 1992; Browning et al., 1998; Hwang et al., 2001).

The majority of studies identifying risk factors for injury among farmers have focused on youths and on younger to middle-aged adults. Less is known about older farmers' risk of injury. The USDA Census of Agriculture reports an increasingly diverse workforce of farmers. According to the USDA National Agricultural Statistics Service (NASS), the average age of the principal operator has increased from 50 years in 1978 to 54 years in 1997 and, most recently, 57 years in 2007, with 30% of the nation's principal operators over the age of 65 (NASS, 2009). The aging of the farmer can be attributed to younger people seeking higher-paying positions, older people beginning a career in farming after retirement from other fields, and a unique strong emotional tie to the work and land itself (Garkovich et al., 1995; Marotz-Baden et al., 1995). There were also reported increases between 2002 and 2007 in the numbers of women and minority operators (NASS, 2009).

The risk of nonfatal injury attributed to farmwork has been shown to decrease with age (Hoskin et al., 1988; Lewis et al., 1998; Hwang et al., 2001). While more nonfatal injuries may occur among younger farmers overall, older farmers are more likely to sustain more severe injuries. Research has revealed that older farmers are more likely to be hospitalized for their injuries and are more likely to sustain permanently disabling or fatal injuries than younger farmers (Zhou and Roseman, 1994; Layne and Landen, 1997; Lewis et al., 1998; Hard et al., 1999; Pickett et al., 1999; Hwang et al., 2001; Pickett et al., 2001; Hard et al., 2002; Mitchell et al., 2002; Myers et al., 2009). It is important to consider this unique population of workers, as chronic health conditions may impair their ability to perform certain tasks and operate machinery safely. This article describes the factors associated with nonfatal, farmwork-related injuries in a cohort of older farmers over the age of 50.

Materials and Methods

Sample

A fixed cohort of farmers over age 50 from Kentucky and South Carolina was followed between 2002 and 2005. The sample was selected from three different sources: the Kentucky Farm Family Health and Hazard Surveillance Project (KFFHHSP) listing for 1994-1996 (Browning et al., 1998) and listings of African-American farmers from the Kentucky and South Carolina Agricultural Statistics Services. The overall response rate for the telephone and mail surveys at baseline (2002) was 43%, with 1,422 usable surveys. Observations were excluded from analyses only if the subject's age was unknown or less than 50 years; this resulted in 1,394 subjects available for the analyses. A few participants (n = 13) did not become 50 years old until after wave 1 (wave 1 = 2002, wave 2 = 2003, wave 3 = 2004, and wave 4 = 2005). Only data collected during waves at which the farmers were 50 years or older were analyzed. As a result, the number of participants at baseline is lower than the total number of participants included in the analyses (n = 1,381 and 1,394, respectively).

Data Collection

Data were collected between 2002 and 2005 using two different methods to increase response rates. A mailed survey was used in addition to a computer-assisted telephone survey (CATI). Approval was obtained from the University of Kentucky Institutional Review Board prior to each wave of data collection.

Time-independent variables (e.g., gender, education, race, participation in farmwork before age 18) were collected only once, and variables that were time-dependent were collected at each wave of data collection with the following exceptions: data on health conditions were not collected at wave 2, and farm tasks were not recorded at waves 2 and 4. Conservative assumptions were made so that waves 2 and 4 could be included in the analyses. A health condition was assumed present at wave 2 if the condition was reported at both waves 1 and 3. Similarly, a farm task was assumed to have been performed at waves 2 and 4 if it was reported at both waves 1 and 3. Finally, data on height and weight were collected only at the last wave but were used to represent height and weight at each wave.

Variable Definitions

Injuries

The questionnaire specifically asked participants to report any of the following injuries that resulted in their not being able to perform usual activities for at least half a day or an injury for which they saw a doctor: cuts requiring stitches, chemical reactions, burns, broken bones, loss of fingers/extremities, or injuries classified as other. An open field allowed description of the other injury. Participants were also asked to specify if the injury resulted from farmwork. The outcome studied was any nonfatal injury occurring while doing farmwork and was coded as a binary variable. An event was defined as a report of at least one farmwork-related, nonfatal injury in the previous year or since the last survey was administered.

Health Conditions

Height and weight data were used to calculate body mass index: BMI = weight (kg) / height^2 (m). BMI was categorized as underweight if below 18.49, normal if between

18.50 and 24.99, overweight if between 25.00 and 29.99, and obese if above 30.00 (WHO, 2006). Participants were also asked if they currently had the following health conditions confirmed by a doctor: heart attack/heart condition, stroke, high blood pressure, diabetes, hearing problems, cataracts/vision problems, arthritis/joint problems, back problems, osteoporosis, carpal tunnel syndrome, skin cancer, other cancers, chronic bronchitis/emphysema, incontinence, or prostate problems. The lay terms for injury types and health conditions were used on the survey instrument to aid in the respondents' understanding of terms. Sleep quality was assessed by asking how many days in the past week sleep was restless.

Work Practice Factors

Farm tasks were categorized as a crop task, animal task, highway task, or climbing task. A crop task involved any of the following: mowing fields, tilling ground, applying pesticides or herbicides, baling hay or straw, chopping silage, planting crops, operating a combine or cotton picker, hand-harvesting crops, or transporting crops. An animal task entailed any of the following: feeding animals, milking animals, castrating animals, herding animals, transporting animals, or other veterinary work. A climbing task was defined as performing any task that required climbing higher than eight feet, and a highway task was defined as operating equipment on highways. At baseline, farmers were asked if they performed any of the above tasks in the past five years; at subsequent waves, they were asked if they performed any of the tasks in the past year.

Data Analysis

All analyses were performed using SAS 9.2 (SAS Institute, Inc., Cary, N.C.). Descriptive statistics, including means, frequencies, percentages, and rates were calculated to provide information about the distribution of injuries and potential risk factors in the cohort. The relationship between farmwork-related injury and potential risk factors was assessed using a logistic regression model fitted by the generalized estimating equations (GEE) method to account for the non-independence of repeated measures on the same subjects. A longitudinal logistic approach was preferred over a survival approach to the analyses due to a lack of exact injury times and the potential for repeat injuries within one wave of data collection (Twisk et al., 2005).

Unadjusted odds ratios and 95% confidence intervals (CI) were estimated for each factor, including demographic characteristics, health status and medical conditions, and work practices. A factor's inclusion in the multivariable model was based on a backward elimination algorithm with the modification that a factor without a significant main effect could be retained if it was involved in a significant interaction or if it was significant within one gender stratum. Analyses were performed using observations with complete data on all factors presently under consideration; 85% of the observations were included in the multivariable model. The observations not included in the final model due to missing values did not differ significantly from the other 85% of observations on age, gender, race, state of residence, education, number of hours worked in the past week, or farmwork-related injury. This suggests that the data were missing at random and their exclusion from the model did not bias the resulting estimates.

Table 1. Demographic characteristics of farmers by wave (2002-2005).[a]

Demographic Factor		Wave 1 (2002), No. (%)	Wave 2 (2003), No. (%)	Wave 3 (2004), No. (%)	Wave 4 (2005), No. (%)
Age (years)	50-59	405 (29)	287 (26)	221 (23)	179 (19)
	60-69	569 (41)	469 (43)	414 (42)	390 (41)
	70-79	362 (26)	309 (28)	301 (31)	321 (34)
	80+	45 (3)	32 (3)	40 (4)	55 (6)
Gender	Female	670 (49)	536 (49)	477 (49)	454 (48)
	Male	711 (51)	561 (51)	499 (51)	491 (52)
Education (years)	0-12	967 (70)	760 (69)	671 (69)	649 (69)
	13+	414 (30)	337 (31)	305 (31)	296 (31)
Race	White	1089 (79)	874 (80)	780 (80)	763 (81)
	African-American	268 (20)	202 (19)	176 (18)	167 (18)
	Other[b]	17 (1)	15 (1)	14 (1)	9 (1)
Marital status	Not married	123 (9)	111 (10)	98 (10)	95 (10)
	Married	1254 (91)	986 (90)	877 (90)	848 (90)
Percent of income from farming	<50%	939 (75)	748 (71)	677 (73)	646 (73)
	≥50%	318 (25)	304 (29)	249 (27)	244 (27)
Residence	Kentucky	1188 (86)	954 (87)	850 (87)	830 (88)
	South Carolina	193 (14)	143 (13)	126 (13)	115 (12)

[a] Thirteen participants were not 50 years old until after wave 1 and were only included in analyses for waves at which they reached this age. Percentages may not add to 100 due to rounding.

[b] The "other" race category consisted of 15 Native Americans and two of unspecified race.

Results

Demographics

Table 1 contains the demographic characteristics of the 1,394 farmers in the study sample by wave of data collection. At baseline, the mean age of the cohort was 65 years (standard deviation = 8 years), with 29% of the cohort between 50 and 59 years old, 41% between 60 and 69 years old, 26% between 70 and 79 years old, and 3% over the age of 80. The cohort contained a similar proportion of males and females upon entry (51% and 49%, respectively). At baseline, three-quarters supplemented more than half of their income from sources other than farming. The majority of the farmers in the cohort had a twelfth-grade education or lower (70%), were married (91%), and resided in Kentucky (86%) at wave 1. The overall attrition rate for the study was 32%; 945 farmers participated in the last wave of data collection. Reasons for attrition included: refusal to participate (52%), unable to contact (42%), and death (5%). Table 1 also shows that the cohort characteristics changed very little across waves of data collection, indicating that attrition had little effect on cohort demographics.

Farmwork-Related Injuries

A crude injury rate of 9.3 injured farmers per 100 per year was reported in the cohort over a period of four years. Figure 1 displays the total number of farmwork-related injuries by gender and type across all waves of data collection. Eighty percent of all injuries were reported by males. The majority of farmwork-related injuries reported were classified as "other" (66% of all farmwork-related injuries); 26 of the 307 "other" injuries were specified and were mainly muscle sprains or strains (n =18). The second most commonly reported farmwork-related injury among males was cuts

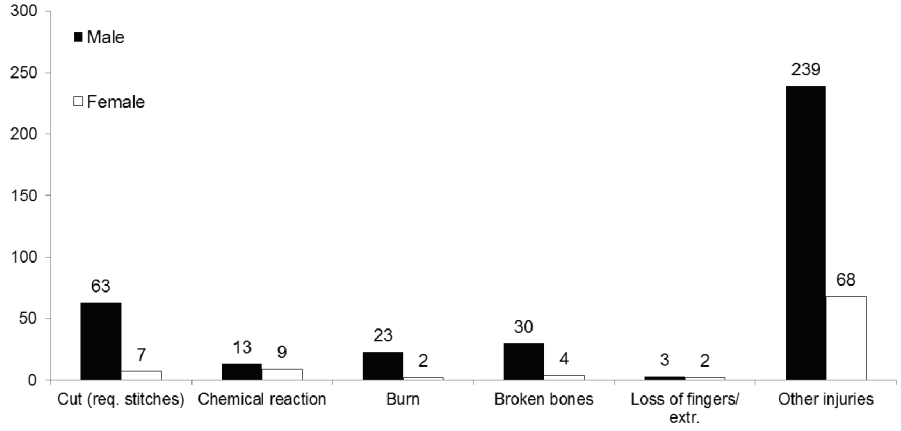

Figure 1. Number of injuries by type and gender (all waves).

Table 2. Rate of injured farmers per year and unadjusted odds ratio estimates from univariate regression analysis of injury by demographic factors.

Demographic Factor		Rate per 100 Observations (*n*)	OR Estimate (95% CI)	p Value
Age (years)	50-59	11.8 (129)	--	
	60-69	8.3 (152)	--	
	70-79	9.0 (116)	--	
	80+	8.1 (14)	--	
	Increase in ten years		0.85 (0.72, 1.00)	0.0560
Gender	Female (ref)	4.1 (87)	--	
	Male	14.3 (324)	3.94 (2.91, 5.33)	<0.0001
Education (years)	0-12	8.6 (262)	--	
	13+	11.0 (149)	--	
	Increase in ten years		1.35 (0.87, 2.10)	0.1802
Race	White (ref)	9.2 (321)	--	
	African-American	10.0 (81)	1.04 (0.75, 1.45)	0.8075
	Other[a]	16.7 (8)	1.64 (0.81, 3.33)	0.1663
Marital status	Not married (ref)	8.2 (35)	--	
	Married	9.4 (374)	1.15 (0.75, 1.76)	0.5141
Percent of income from farming	<50%	9.3 (280)	--	
	≥50%	10.2 (114)	--	
	Increase in 25%		1.12 (1.01, 1.23)	0.0255
Residence	Kentucky (ref)	9.5 (363)	--	
	South Carolina	8.3 (48)	0.82 (0.55, 1.23)	0.3381

[a] The "other" race category consists of 48 Native Americans and seven unspecified observations.

severe enough to require stitches and chemical reaction injuries among females. Males and females reported similar numbers of chemical reactions (n = 13, males; n = 9, females) and loss of fingers and/or extremities (n = 3, males; n = 2, females).

Univariate Regression Analyses

The farmwork-related injury incidence rates for 2002-2005 are displayed in tables 2 through 4 along with the results of the univariate regression analyses by demographic (table 2), health-related (table 3), and work practice factors (table 4).

Table 3. Rate of injured farmers per year and unadjusted odds ratio estimates from univariate regression analysis of injury by health-related factors.

Health-Related Factor		Rate per 100 Observations (*n*)	OR Estimate (95% CI)	p Value
Hearing problem	No (ref)	8.1 (266)	--	
	Yes	13.9 (114)	1.63 (1.23, 2.16)	0.0035
Vision problem	No (ref)	8.3 (273)	--	
	Yes	13.5 (112)	1.38 (1.07, 1.77)	0.0084
Arthritis, joint problems	No (ref)	7.7 (189)	--	
	Yes	11.7 (194)	1.68 (1.32, 2.14)	0.0137
Carpal tunnel	No (ref)	8.9 (326)	--	
	Yes	12.2 (54)	1.60 (0.97, 2.63)	0.2766
Back problems	No (ref)	8.0 (262)	--	
	Yes	14.6 (118)	1.80 (1.37, 2.37)	0.0007
Heart attack or heart condition	No (ref)	8.9 (313)	--	
	Yes	11.6 (68)	1.19 (0.89, 1.60)	0.2421
Stroke	No (ref)	9.2 (358)	--	
	Yes	12.2 (28)	1.27 (0.86, 1.89)	0.2268
High blood pressure	No (ref)	8.8 (210)	--	
	Yes	10.0 (172)	1.06 (0.85, 1.32)	0.6074
Chronic bronchitis or emphysema	No (ref)	8.7 (340)	--	
	Yes	19.1 (37)	2.36 (1.53, 3.62)	0.0002
Osteoporosis	No (ref)	9.5 (362)	--	
	Yes	6.9 (19)	0.74 (0.48, 1.14)	0.1743
Skin cancer	No (ref)	8.9 (346)	--	
	Yes	15.6 (34)	1.51 (0.98, 2.33)	0.0608
Other cancers	No (ref)	9.3 (371)	--	
	Yes	10.5 (12)	1.24 (0.76, 2.03)	0.3902
Incontinence	No (ref)	9.0 (351)	--	
	Yes	14.8 (31)	1.37 (0.84, 2.21)	0.2033
Prostate problems (males)	No (ref)	14.3 (201)	--	
	Yes	19.1 (36)	1.33 (0.87, 2.02)	0.1822
Daily prescription	No (ref)	9.6 (325)	--	
	Yes	8.6 (86)	1.00 (0.75, 1.32)	0.9843
BMI	Underweight	8.3 (2)		
	Normal	7.5 (72)		
	Overweight	8.1 (124)		
	Obese	14.5 (146)		
	Increase in ten units		1.43 (1.10, 1.86)	0.0081
Restless nights in past week	<1 day (ref)	7.8 (220)	--	
	1-2 days	10.6 (76)	1.30 (0.98, 1.73)	0.0659
	3-4 days	14.2 (54)	1.88 (1.32, 2.66)	0.0004
	5-7 days	14.7 (53)	1.78 (1.25, 2.53)	0.0013

A ten-year increase in age resulted in a significant 15% estimated decrease in odds of injury (estimated odds ratio [EOR] = 0.85). Males had almost four times the odds of injury (EOR = 3.94) as females. A greater reliance on farming for household income also significantly increased injury odds. A 25% increase in the percentage of household income from farming resulted in a 12% increase in odds of injury (EOR = 1.12). Level of education, race, marital status, and state of residence did not significantly influence injury odds.

Several health-related factors were significantly associated with farmwork-related injury (table 3): hearing impairment (EOR = 1.63), vision impairment (EOR = 1.38), arthritis (EOR = 1.68), and back problems (EOR = 1.80). Farmers with chronic bron-

Table 4. Rate of injured farmers per year and unadjusted odds ratio estimates from univariate regression analysis of injury by work practice factors.

Work Practice Factor		Rate per 100 Observations (*n*)	OR Estimate (95% CI)	p Value
Farmwork before age 18	No (ref)	10.6 (363)	--	
	Yes	4.9 (48)	2.29 (1.55, 3.39)	< 0.0001
Crop task	No (ref)	2.7 (28)	--	
	Yes	11.4 (350)	3.43 (2.31, 5.08)	< 0.0001
Animal task	No (ref)	4.8 (71)	--	
	Yes	11.6 (307)	2.32 (1.73, 3.12)	< 0.0001
Operation of equipment on highways	No (ref)	4.8 (117)	--	
	Yes	15.4 (261)	3.12 (2.39, 4.07)	< 0.0001
Any task that involved climbing higher than 8 feet	No (ref)	4.9 (117)	--	
	Yes	15.2 (261)	2.90 (2.22, 3.80)	< 0.0001
Time doing farmwork in past week	0	3.5 (49)	--	
	1-39	10.9 (264)	--	
	40+	18.7 (88)	--	
	Increase in 10 hours		1.27 (1.21, 1.34)	< 0.0001

chitis/emphysema (EOR = 1.57), back problems (EOR = 1.37), and arthritis (EOR = 1.31) were at increased odds of injury as compared to those farmers not reporting these health conditions. Farmers reporting at least three days of restless sleep in the past week were estimated to have about twice the odds of injury as those reporting less than one day of restless sleep in the past week.

All work practice factors considered significantly influenced the cohort's odds of sustaining a farmwork-related injury (table 4). Engaging in farmwork before the age of 18 (EOR = 2.29), performing a crop-related task (EOR = 3.43), performing an animal-related task (EOR = 2.32), operating equipment on highways (EOR = 3.12), and engaging in any task involving climbing higher than eight feet (EOR = 2.90) significantly increased odds of injury. Finally, each 10-hour increase in time spent doing farmwork in the past week resulted in a 27% increase in odds of injury.

Multivariable Regression Analyses

The results from the multivariable GEE regression analysis of demographic, health-related, and work practice factors and farmwork-related injury are detailed in table 5. Increased age was found to be significantly associated with decreased odds of farmwork-related injury overall; an increase in 10 years of age corresponded to 19% decreased odds. Each 10-hour increase in farmwork per week, operation of equipment on highways, and climbing tasks increased the odds of injury by an estimated 29%, 51%, and 70%, respectively. The relationship between injury and performing crop- and animal-related tasks was modified by gender (table 5). A significant interaction was observed between gender and crop-related tasks ($p = 0.0191$) and animal-related tasks ($p = 0.0171$). Interactions between gender and operation of equipment on highways and climbing tasks were tested but were not statistically significant at $\alpha = 0.05$. Among females, performing a crop-related task multiplied the odds of injury by an estimated 2.20, performing an animal-related task by an estimated 3.01, and performing both tasks by an estimated 6.63 as compared to females performing neither task. Comparable odds ratio estimates were not observed among males.

Finally, gender itself had a significant relationship with farmwork-related injury. An injury rate of 7.7 injured farmers per 100 observations was reported among males

Table 5. Adjusted parameter estimates, odds ratios, and 95% confidence intervals from multivariable GEE regression analysis.

Main Effects			OR Estimate (95% CI)	p Value
Age	Increase in ten years		0.81 (0.67, 0.98)	0.0333
	Chronic bronchitis/emphysema (yes vs. no)		1.57 (1.00, 2.46)	0.0495
	Back problems (yes vs. no)		1.37 (1.00, 1.87)	0.0480
	Arthritis (yes vs. no)		1.31 (1.02, 1.71)	0.0374
Restless nights in past week	<1 day (ref)		--	
	1-2 days		1.32 (0.96, 1.81)	0.0883
	3-4 days		2.02 (1.32, 3.09)	0.0011
	5-7 days		1.89 (1.28, 2.80)	0.0012
Time doing farmwork in past week	Increase in ten hours		1.29 (1.13, 1.47)	0.0001
	Operating equipment on highways		1.51 (1.08, 2.10)	0.151
	Climbing higher than eight feet		1.69 (1.22, 2.35)	0.0013
Gender × task interactions	Females	Neither task (ref)	--	
		Crop task only	2.21 (1.04, 4.70)	0.0401
		Animal task only	3.00 (1.39, 6.48)	0.0049
		Animal and crop task	6.62 (2.67, 16.44)	<0.0001
	Males	Neither task (ref)	--	
		Crop task only	0.64 (0.30, 1.36)	0.2421
		Animal task only	1.05 (0.69, 1.58)	0.8214
		Animal and crop task	0.67 (0.33, 1.37)	0.2730
	Females, neither task (ref)		--	
	Males, neither task		15.63 (5.70, 42.83)	< 0.0001

not performing crop- or animal-related tasks, while the analogous figure for females was 0.7 injured farmers per 100 observations. In the multivariable model that controlled for other factors, males who did not perform crop- or animal-related tasks were at significantly increased odds of injury (EOR = 15.56) as compared to females who performed neither crop- nor animal-related tasks.

Discussion

This study demonstrates that chronic health conditions and certain farm tasks put older farmers at increased risk for farmwork-related injuries. This study also reveals interesting relationships among gender, type of task performed, and injury. Translation of specific findings is discussed below.

Demographic Factors

Several previous studies reported a decreased overall risk of nonfatal injury while performing farmwork-related activities (Hoskin et al., 1988; Lewis et al., 1998; Hwang et al., 2001). Older farmers may sustain fewer nonfatal injuries because they work fewer hours than their younger counterparts (Browning et al., 1998; Lewis et al., 1998). As farmers age, their chronic health conditions may limit not only the amount of work but also the type of tasks performed. Therefore, older farmers could be at decreased risk because they work fewer hours and perform less risky tasks. Farmers most at risk may have sustained fatal or severe injuries at a younger age and are, therefore, not working at an older age. This does not fully explain the significant relationship between age and injury in the multivariable regression model controlling for number of hours worked and type of task performed. Other possible explanations include that older farmers may be more experienced in performing dangerous tasks and

working with complex equipment. The present data set does not allow these hypotheses to be formally tested.

Race has previously been shown to influence farmwork-related injury. African-American farmers were reported to have age-adjusted fatal injury rates 2.5 times as high as white farmers in North Carolina between 1977 and 1991 (Richardson et al., 1997) and different risk factors for nonfatal injuries (Lyman et al., 1999). African-American farmers were oversampled in this study to provide enough power to detect important differences between white and African-American farmers, had such differences been present. Yet despite the large number of African-American farmers in this study, race did not significantly influence the odds of sustaining a farmwork-related injury. The role of the farmer has been shown to affect the relationship between race and injury. McGwin et al. (2000) reported that African-American farm owners were at similar risk of injury as white farm owners, while African-American workers were at increased injury risk as compared to white owners. The race effect found by Richardson et al. (1997) would likely disappear if white owner/operators were compared to African-American owner/operators or white workers were compared to African-American workers. The overwhelming majority of farmers in this cohort are farm owners (95%); thus, the comparison is essentially between white and African-American farm owners.

One demographic factor significantly predicting injury in this older cohort was gender. Males have been repeatedly found to be at increased risk for farmwork-related injury (Pratt et al., 1992; Gerberich et al., 1993; Pickett et al., 1995; Myers et al., 1999; Pickett et al., 1999). Female farmers may be at decreased risk because they may work fewer hours and perform different farming tasks than males. However, such explanations are not completely satisfactory, since the multivariable regression model demonstrated highly increased odds of farmwork-related injury for males compared to females of the same animal and crop stratum even when controlling for hours worked per week. The relationship between gender and injury is further complicated by the interaction between gender and animal-related and crop-related tasks, as discussed below.

Health-Related Factors

Chronic health conditions may interfere with a farmer's ability to perform certain farm tasks safely. Compared to other U.S. workers, farmers have significantly elevated prevalence rates of cardiovascular disease, arthritis, skin cancer, hearing loss, and chronic respiratory illnesses (Brackbill et al., 1994; Mariger et al., 2008). This burden may be partly attributed to chronic exposures to sun, allergens and various pesticides, loud equipment, and repetitive movements.

Arthritis or joint and back problems significantly increased the odds of injury in this cohort, confirming results reported previously (Sprince et al., 2003; Voaklander et al., 2006). Such health conditions can considerably impair mobility, creating hazards for working with animals and machinery. Mobility impairments may also affect farmers' balance, leading to falls. Engineering advances could reduce injuries due to these chronic conditions. For example, driving a tractor that requires the operator to frequently look in different directions for long periods of time could exacerbate neck and back pain. Ergonomic enhancements for equipment, such as swivel seating, could make such a tractor easier and safer to operate.

Chronic respiratory illnesses (bronchitis or emphysema) also significantly increased the odds of injury in this cohort. Respiratory illnesses are typically studied as an adverse outcome in farmers rather than an injury risk factor. However, chronic conditions that limit or interfere with breathing could lead to increased fatigue, putting the farmer at greater risk of injury. Because smoking status was not included in the survey, the relationship between chronic bronchitis or emphysema and injury detected in this study could be confounded by smoking. Smoking could be even more risky if performed while working; smoking could be distracting to the farmer, and it only leaves one hand free to perform a task that may require two.

In addition to chronic health conditions, quality of sleep was found to influence the odds of injury among older farmers. Poor sleep quality, as measured by three or more days of restless sleep in the past week in this study, was estimated to approximately double the adjusted odds of injury. The association between sleep deprivation and farm injury has been reported previously (Spengler et al., 2004; Choi et al., 2006). Chronic inadequate sleep is hypothesized to increase the risk for injury by leading to daytime fatigue, reduced attentiveness, and increased reaction time (Findley et al., 1992; Dinges, 1995).

Attempting to prevent injuries by treating the sleep disorder may not be as successful as preventing the disorder itself. A common treatment is medication, which actually increases farmwork-related injuries (Spengler et al., 2004). Avoidance of caffeine, alcohol, and certain anxiety-inducing activities such as financial tasks before sleeping are approaches that have been proposed to improve quality of sleep for farmers, as well as carefully constructing work schedules during peak planting and harvesting times to ensure adequate sleep opportunities (Spengler et al., 2004; Choi et al., 2006). Encouraging frequent rest breaks, especially during the busiest seasons, may also reduce injuries among older farmers with inadequate sleep.

Work Practice Factors

Work practice factors significantly affected odds of injury in this cohort. As expected, an increase in time doing farmwork increased the odds of injury. Yet even when controlling for number of hours worked per week, the multivariable model linked specific tasks to increased odds of injury. Climbing may be especially hazardous for older farmers because of the high risk of fall injuries in the general elderly population. As many as one-third of all adults 65 and older fall each year in the U.S. (Hornbrook et al., 1994; Hausdorff et al., 2001), and falls were the leading cause of injury-related deaths among older adults in 2009 (CDC, 2005). Development of guidelines for older farmers could be used to suggest appropriate tasks for this population, as has already been done for children working in agriculture (Lee and Marlenga, 1999).

The relationship between crop- and animal-related tasks and injury is modified by gender. The gender × task interaction has not been previously reported. Crop- and animal-related tasks increased the odds of farmwork-related injury among females but, unexpectedly, had no such impact among males. Numerous studies have reported an increased risk of injury for farmers working with animals, especially beef cattle (Hoskin et al., 1988; Brison and Pickett, 1992; Pickett et al., 1995; Crandall et al., 1997; Browning et al., 1998; Myers et al., 2009). While most subjects in previous studies were male, this study did not find a significant relationship between animal-

related tasks and injury among older males. These inconsistent results could be due to different definitions of injury or age differences.

Strengths and Limitations

Few studies have examined injury risk factors among older farmers longitudinally (Xiang et al., 1999). This repeated-measures study related injury during each wave to the values of the covariates during that same wave, leading to a more thorough assessment of risk factors than would be possible with a single set of covariate values. In particular, health conditions and task assignments change over time. Additionally, the large proportions of women (49%) and African-American farmers (20%) permitted conclusions for special populations not often considered in agricultural health studies. Studying injury in these populations is important as the average age of the farmer increases and demographic profiles become more diverse in order to create focused, effective prevention strategies (NASS, 2009).

The injury data used for this study were relatively limited in that all injuries were based on self-report and no specific guidelines standardized what constituted an injury. Most injuries were classified as "other" and, therefore, information on severity was limited. To investigate the potential bias caused by the large proportion of "other" injuries, regression analyses were performed excluding unspecified injuries, and the associations with covariates did not qualitatively change. Specific circumstances surrounding injuries were not requested in the survey and could have potentially given a more complete picture of farmwork-related injury risk. The task variables in the survey may not have captured all hazardous tasks performed and did not necessarily specify the type of equipment being used or the amount of farmwork time devoted to the task. The elevated risk observed in males may reflect males more frequently performing hazardous tasks not included in the crop- and animal-related task definitions. Finally, not collecting health condition information, height, and weight at each wave may have introduced some bias into the results measuring these relationships with injury.

Generalizability

This sample of older farmers reports a crude, nonfatal injury rate of 9.3 per 100 per year, similar to that reported in the KFFHHSP sample of farmers 55 years and older from Kentucky (9.0 injured farmers per 100 farmers per year) (Browning et al., 1998). The nonfatal injury rate for 2001 and 2004 combined for persons 55 and older in agricultural production from a sample using data from the 2001 and 2004 NIOSH Occupational Injury Surveillance of Production Agriculture survey was somewhat lower: 4.5 per 100 per year (Myers et al., 2009). However, these rates may not be strictly comparable because of sampling differences and the diversity of the farmers based on type of commodity produced, socioeconomic status, experience farming, and other factors.

Although the cohort was obtained from a convenience sample, the distribution of commodities produced by the sample was similar to that reported by the USDA for the U.S. in the recent Census of Agriculture. The top two commodities reported by both were cattle and grain, with less than 5% of the sample and farmers 45 years and older in the census reporting production of fruits and vegetables, dairy products, sheep and goats, poultry, and pigs (NASS, 2009). The sample also had a similar proportion of farmers who worked an off-farm job (35%) to what was reported in the census for a

similar age group (40%) (NASS, 2009). Finally, farmers in the sample were as experienced as those reported for farmers over 45 years of age in the U.S. overall. The majority of farmers had ten or more years of experience (86% in the Census of Agriculture; 94% in the sample) (NASS, 2009).

Conclusions

This study identified demographic factors, chronic health conditions, and specific farm tasks that influence the risk of farmwork-related farmers over age 50. These factors associated with farmwork-related injury should better inform agricultural health policies and guidelines to create a safe environment for older farmers to continue to work in. The results reported here suggest that policies governing the allowable number of hours worked per week and rest breaks, guidelines that advise appropriate types of farm tasks, and ergonomic engineering advances for farming equipment would reduce injury risk among older farmers.

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