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Agricultural Injuries Among Older Kentucky Farmers: The Farm Family Health and Hazard Surveillance Study

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This population-based study reports the cumulative incidence of agricultural injuries during a 1-year period in a sample of 998 farmers aged 55 years and older living in Kentucky. A total of 98 farm-related injuries were reported among 88 older farmers for a crude injury rate of 9.03 injured farmers per 100 farmers (95% confidence interval (CI) = 7.03–11.03) over a 1-year period. The leading external causes of farm injury were falls (24.9%), machinery (22.5%), wood-cutting (14.6%), and animal-related events (14.3%). Farmers working on farms with beef cattle (alone) (odds ratio = 1.90; 95% CI = 1.02–3.55) or farms with beef cattle and tobacco (odds ratio = 2.15; 95% CI = 1.00–4.59) had a statistically significant increased risk for a farm-related injury. Farmers reporting a prior injury that limited their ability to farm were at increased risk for a farm-related injury. Approaches to using farm injury surveillance data for injury control programs in the state are discussed. Am. J. Ind. Med. 33:341–353, 1998. *© 1998 Wiley-Liss, Inc.*

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For both fatal and nonfatal injuries, agriculture has been recognized as one of the most hazardous occupations in the United States [Myers, 1990; Murphy, 1992; National Safety Council, 1995]. Whereas fatality rate data for agricultural workers are available, data on nonfatal agricultural injuries have been limited [Purschwitz and Field, 1990; Gunderson et al, 1990; Layde, 1990], and few population-based epidemiologic studies assessing potential risk factors for agricultural injuries have been conducted [Elkington, 1990;Brison and Pickett, 1992; Zhou and Roseman, 1994; Pickett et al., 1995; Nordstrom et al., 1995].

Risk factors associated with nonfatal farm injuries can be categorized into two levels: (1) characteristics of the farm environment, and (2) characteristics of the farmer. Studies examining farm environment factors have reported that larger farms, farms with more workers, and farms with higher annual production were associated with higher injury risks for the farmer [Zhou and Roseman, 1994; Pickett et al., 1995]. Studies have demonstrated that nonfatal injury risk is elevated on farms with animals, especially on beef and dairy farms [Pratt et al., 1992; Brison and Pickett, 1992; Zhou and Roseman, 1994; Nordstrom et al., 1995]. The patterns of injury have been fairly consistently reported across these studies, with farm machinery, accidental falls, and animal-related injuries being the three major external causes of injury [Brison and Pickett, 1992; Zhou and Roseman, 1994; Nordstrom et al., 1995].

With respect to individual risk factors for the farmer, greater number of hours spent farming, full-time farm work, greater cumulative years of farm work experience, and male gender have shown positive associations with higher injury rates [Stallones, 1990; Brison and Pickett, 1992; Zhou and Roseman, 1994; Layde et al., 1996]. Whereas several studies

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have suggested that farmers holding off-the-farm employment may be at greater risk for injury [Zhou and Roseman, 1994, 1995; Nordstrom et al., 1995], other studies have not confirmed the finding [Brison and Pickett, 1992]. Although other personal risk factors for injuries, including alcohol consumption, prior traumatic injury, lower levels of education and training, and the use of prescription medications have been investigated, the evidence associating these risk factors with farm injuries remains inconclusive [Elkington, 1990; Zwerling et al., 1995; Zhou and Roseman, 1995].

This manuscript presents data on the magnitude of and the potential risk factors for injury among older, male Kentucky farmers. There are several reasons for investigating injuries among an older-farmer population. Older farmers may have lost some of their ability to perform tasks that were once easier for them to accomplish or for which they have little experience or training, such as the operation of new equipment. Because no mandatory retirement age exists for older farmers, many may continue to perform some tasks beyond their ability to safely accomplish the work. Second, certain chronic health conditions (impaired vision, hearing loss, arthritis) or use of medications may place older farmers at risk of injury and may impair their ability to safely perform certain farm tasks [Elkington, 1990].

The specific objectives of this study were (1) to determine the 1-year incidence of nonfatal farm-related injuries, (2) to determine the distribution of these injuries by external cause, severity, and other injury characteristics, and (3) to determine the potential risk factors for injuries among older Kentucky farmers. Specific recommendations regarding preventive interventions are made based on a consideration of the data from this study.

METHODS

This manuscript reports the 1-year incidence of nonfatal farm-related injuries occurring among farmers aged 55 years and older from a two-stage cluster sample of farms from 60 counties in Kentucky. Nationally, Kentucky ranks fourth in total number of farms (90,281), 85% of which are single-proprietor, family-owned and operated [Census, 1992]. Kentucky's agricultural commodities include beef cattle, tobacco, cash grain, and general crops [Williamson and Brannen, 1995]. Agricultural work injury data have been limited for most of these family-operated farms because there are no legal requirements for reporting injuries on farms with fewer than 11 employees [Purschwitz and Field, 1990; Murphy, 1992]. Farms were defined as any place from which $1,000 or more of agricultural products from livestock, crop, or specialty operations were produced and sold or normally would have been sold during the census year [Census, 1992]. The study used data from the National Institute for Occupational Safety and Health-sponsored Kentucky Farm Family Health and Hazard Surveillance Project, a multi-mode effort to determine agricultural risks and injuries among farm families.

Sampling

To construct the sampling frame for the study, two-stage cluster sampling was used. At the first stage, a sample of 60 counties was selected from the 120 Kentucky counties using probability proportional to size sampling, of which size was the number of farms in each of the counties based on the 1987 Census of Agriculture for Kentucky. Several counties in the eastern portion of the state were excluded from the study before sampling based on logistical considerations including the likelihood of cooperation from farmers, availability of telephones, and the relatively few farms per county.

At the second stage, a systematic sample of farms in the 60 counties was selected from a listing maintained by the Kentucky Agricultural Statistics Service. This listing of farms is updated periodically by on-site enumeration, reinterviews, and telephone calls. Kentucky Agricultural Statistics Service provides coverage for approximately 83% of Kentucky's farms (75,836 farms); 84% of those listed (63,702) have valid and current telephone numbers [Williamson and Brannen, 1995]. The result was a sample of approximately 125 farm households per county within each of the 60 selected counties. In six counties, an oversample was taken to obtain the requisite sample size. A short telephone survey (Farm Hazard and Demographic Enumeration Survey, or FHADES) was conducted with these selected farm households to enumerate male farmers aged 55 years and older (hereafter ''older farmers'') who had actively engaged in farm work within the past year. Enumeration of these older farmers produced a sample frame of 3,858 individuals. This sampling frame was stratified by county and within each county, a simple random sample of farmers was selected, which yielded a total sample of 1,416 older farmers to be contacted for the 30-minute telephone survey.

Data Collection

A 30-minute telephone survey (Farm Health Interview Survey, or FHIS) was designed, including questions on injury incidence, risk factors relating to injury, as well as characteristics of the farm and demographics of the farmer. Standard questions from the National Health Interview Survey were used extensively in the development of the FHIS survey [Massey et al., 1989]. Data were collected by the Survey Research Center at the University of Kentucky using a computer-assisted telephone interviewing system between June of 1994 and September of 1995, resulting in 998 completed interviews. Telephone interviewers were trained in the administration of the survey with specific emphasis given to their understanding the agricultural terms

and questions in the survey. Interviewers were monitored by Survey Research Center personnel for quality control over the course of the study, and respondent farmers were assured during the telephone interview of the confidentiality of their responses. All telephone interviews were completed by male farmers aged 55 years and older who were engaged in farm work; proxy respondents were not used in this study. Data from these 30-minute interviews form the basis for this study.

Definition of Study Variables

Farm-related injuries were defined as injuries occurring while doing farm work or farm chores over the 12 months preceding the telephone interview. This definition extended to farm-related injuries that occurred in off-farm locations, such as in the woods or at another person's farm. Injuries sustained while working in other occupations, from recreational activities, in the home environment, or while traveling unrelated to farm work or farm chores were excluded. The 1-year cumulative incidence rate of injury among the older farmers was calculated with the number of injury cases (farmers) as the numerator and the total number of surveyed, older farmers as the denominator. For farmers who had multiple injuries within a 1-year period, the analyses were based on the most severe injury, as defined below.

Categories for classification of external cause of injury were created by considering responses to questions addressing how the injury occurred and the activity that the farmer was participating in at the time of the injury. The primary categories of external causes of injury include machinery, falls, animals, wood-cutting, and a category for other injuries. Severe injuries included amputations, fractures, and cuts, whereas moderate injuries included scrapes, contusions, and strains. Burns, stabs, and other injuries were grouped in an ''other'' category. Each farm was classified by primary commodity according to how the older farmer described the farm. Primary classifications included beef cattle (alone), tobacco, beef cattle and tobacco, and a combined category (''general'') of other farms (vegetable, hog, dairy, grain, horses, etc.). Current work status for these older farmers was defined by a question that asked whether they considered themselves completely retired, partially retired, or not retired at all from farming. Those who considered themselves completely or partially retired from farming were classified as part-time, whereas those who answered ''not retired'' were considered full-time. A prior injury was defined as an old injury that limited the type or amount of work that the farmer could do.

Data Management and Analysis

For analysis, the population of interest was restricted to older working farmers living within the 60 counties selected in the first stage of the sampling. This analytic approach was chosen because of the necessity of excluding certain counties from the sample in the first stage of the sample design (see Sampling section). Given this restriction, the analysis was performed using a single-stage, stratified design with the 60 counties composing the strata and a simple random sample without replacement selected within each stratum. Consequently, parameter estimates are calculated and apply to the 60-county population of this target group of older farmers. Weighted analyses were performed, based on the single-stage design, in accordance with traditional survey analysis procedures [Snedecor and Cochran, 1980; Levy and Lemeshow, 1991]. Data management and analysis were performed using the SAS and SUDAAN software systems [SAS Institute, 1990; Shah et al., 1995].

The number of farmers (n) in the sample and the number of farmers in the 60 counties (N) are given in the analysis tables. The subscript ''$_i$'' references injured farmers, and the subscript ''$_p$'' represents the total number of farmers. The notation N_i, therefore, would denote the total number of injured farmers in the 60-county population. Each observation is assigned a sampling weight that is equal to the inverse of its probability for inclusion in the sample. The weights differ from county to county but are the same for observations within a particular county. The weights are computed as a ratio of the number of older farmers within the county (county population size) to the number of older farmers sampled in the county (county sample size). Because the number of older farmers within a county was not known, it was estimated using the results from the FHADES survey. To obtain this estimate, the average number of older farmers per farm was computed for a county and then multiplied by the number of farms in the county [Williamson and Brannen, 1995].

The representativeness of the sample that responded to the FHADES survey was assessed by comparing the demographics of the study population with demographic data of the Kentucky farm population that participated in the 1992 Kentucky Census of Agriculture [Census, 1992]. Descriptive statistics, as well as the multivariable logistic regression estimates, used the sampling weights and the appropriate design statements for the correct computation of the standard errors of the estimates [Shah et al., 1995].

Crude and specific injury rates were calculated for all farm-related injuries for demographic, behavioral, and farm environment variables. Descriptive and categorical data analysis methods were used to examine the associations between self-reported farm injury and potential risk factors for the injury. The association between farm-related injuries and potential risk factors was assessed by calculating unadjusted prevalence odds ratios using logistic regression [Kleinbaum et al., 1982; Hosmer and Lemeshow, 1989]. Variables found to be important in analyses of the association of the injury with the potential risk factors, and also

logically and biologically plausible, based on a review of the epidemiologic literature, were included in the multivariable logistic regression modeling [Kleinbaum et al., 1982; Rothman, 1986].

RESULTS

Response and Representativeness of the Study Population

The response rate for the brief telephone survey (FHADES), which enumerated the farm household members and obtained descriptive information regarding the farm, was 86%. The response rate for the 30-minute telephone interview of the older farmers (FHIS) was 71%. The response rates for the telephone interview varied by county; however, on a regional level, the rates were comparable across different regions of the state.

Table I provides a comparison of the Kentucky farm population from the 1992 Kentucky Census of Agriculture with the farm population enumerated in the FHADES survey. The farm population enumerated in the FHADES survey consisted of farm members of all ages and both genders. Generally, the results of the comparison indicated that the sample selected for our survey was representative of the farms in the state. Our sample contained a slightly greater percentage of male principal operators, a smaller percentage of principal operators holding an off-farm job, and farm operators who were older than those surveyed in the 1992 Census. Whereas the distribution of farms by acreage was similar between the Census and the FHADES surveys, the Census contained a larger proportion of the smaller-acreage farms. Data were not available for a comparison of the demographic characteristics of respondent and nonrespondent farms in the FHADES enumeration survey.

TABLE I. Characteristics of Kentucky Farm Population: 1992 Census of Agriculture[a] vs. 1994 FHADES Sample

	Census of Agriculture		FHADES
Characteristic	Percent in state	Percent in 60 sampled counties	Percent in sample (weighted)
Gender of principal operator			
Female	8.5	8.0	4.8
Male	91.6	92.0	94.7
Missing	—	—	0.5
Employment of principal operator			
Off-farm	56.6	56.4	51.3
Farm only	36.0	36.1	48.1
Missing	7.4	7.5	0.6
Age of principal operator (years)			
<25	1.6	1.6	0.2
25–34	9.7	9.8	5.6
35–44	19.6	19.8	18.3
45–54	23.1	22.8	25.5
55–59	10.6	10.5	13.1
60–64	10.2	10.3	11.2
65–69	9.3	9.4	10.6
≥70	15.9	15.8	14.4
Missing	—	—	1.0
Size of farm (acres)			
1–9	11.5	11.4	2.5
10–49	24.3	24.1	16.8
50–179	40.5	41.0	46.9
180–499	18.3	18.3	24.2
500–999	3.8	3.8	5.6
1000–1999	1.2	1.0	1.4
≥2000	0.4	0.3	0.2
Missing	—	—	2.4

[a]1992 Census of Agriculture, Geographic Series 1B. U.S. summary and county-level data.

Demographics and Health Conditions of Older, Male Farmers

Table II presents the demographics for the 998 male farmers aged 55 years and older who were engaged in farm work in the year preceding the FHIS. Of the 998 farmers in the sample, the majority were married (91%), white (98%) males, with approximately half of the population having a twelfth-grade education or higher. The average age was 68 years (SE = 0.24), and the mean number of years of experience in the agricultural industry was 43 years (SE = 0.47). In the year before the interview, these farmers spent an average of 152 days (SE = 4.3) on their tractors. The mean acreage of the farms on which these older farmers worked was 181 acres (range, 3 acres to 2,000 acres) with the major commodities being beef cattle and tobacco. Nearly two thirds of the older farmers (61%) worked less than full-time on their farms at the time of the interview.

Approximately 36% of the older farmers reported their health status to be fair or poor, and 56% of the farmers indicated that they currently used prescription medications. The self-reported prevalence of chronic health conditions that may influence injury events was examined among the 998 farmers in the study. The self-reported prevalence of hearing difficulty (other than deafness) was 34.2% (95% confidence interval (CI) = 30.8–37.6), vision difficulty was 11.4% (95% CI = 9.3–13.4), and arthritis was 50.4% (95% CI = 46.8–53.8).

Farm-Related Injuries

A total of 98 farm-related injuries were reported among 88 older farmers. Of the 88 injured farmers, 80 were injured

TABLE II. Demographic Characteristics of Older Kentucky Farmers: Farm Family Health and Hazard Surveillance Project (n = 998)

Characteristic	Farmers in sample (n_p)	Farmers in population (N_p)[a]	Weighted percent
Age			
55–59	115	2170	12.3
60–69	462	8037	45.6
≥70	421	7400	42.0
Race			
White	977	17,272	98.1
Other	21	335	1.9
Education			
≤8th grade	364	6314	35.9
9th–11th grade	133	2271	12.9
12th grade	331	5787	32.9
College	170	3234	18.4
Marital status			
Married	893	15,982	90.8
Other	105	1625	9.2
Farm work status			
Full time	392	6846	38.9
Part time	606	10,762	61.1
Type of farm			
Beef cattle	396	7399	42.0
Beef and tobacco	177	3281	18.6
Tobacco	116	1901	10.8
General	309	5027	28.6
Health of farmer			
Excellent/very good	321	5637	32.0
Good	319	5660	32.1
Fair/poor	358	6310	35.8
Current use of medication			
Yes	560	9833	55.8
No	438	7774	44.2

[a]N_p = estimated number of farmers aged 55 years and older in the 60-county population.

once, 6 were injured twice, and 2 had three or more injuries. An overall rate of 9.03 injured farmers (95% CI = 7.03–11.03) per 100 farmers per year was calculated using the number of injury cases as the numerator. Extrapolation of the estimated number of injured farmers in the 60 counties included in the survey to a state-level estimate projects that approximately 3,600 active, male farmers 55 years of age or older will be injured as a result of performing farm work on family-owned farms in Kentucky. This estimate, however, is not based on the expansion from the two-stage design but rather uses the 1992 Census of Agriculture estimate of the number of noncommercial farms in the state and allows for regional variation in injury rates and the mean number of older farmers residing in farm households within regions of the state.

Injury rates by the age of the older farmer and farm commodity are presented in Table III. Injury rates vary markedly by principal farm commodity, with the highest rates among farmers of beef cattle (alone) and beef cattle and tobacco farms. Table IV presents the distribution of farm-related injuries by selected injury characteristics. Falls (24.9% of all farm-related injuries) and machinery (22.5%) constituted the largest categories for external cause of injury, followed by injuries from wood cutting (14.6%) and animals (14.3%). Falls from machinery (e.g., tractors) composed 35% of all falls, and falls sustained while the farmer was hanging or taking down tobacco in the barn (17%) and falls from slipping on ice (17%) were the three most prevalent types of falls.

Most of the machine injuries involved tractor runovers and overturns (23% of all machine injuries) and power take-off entanglements and hydraulic-hose injuries (27%). Several of the machinery-related injuries were due to clothing entanglements in the picker, the power take-off, and the combine. Eighteen percent of the machine-related injuries involved mowers; these injuries were most often to the hand or eyes. Injuries related to cutting wood were typically of two types: (1) injuries to the extremities from splitting wood with an axe or hatchet, and (2) injuries from fractures and cuts resulting from trees falling on the farmers while they were cutting limbs or felling trees. Nearly all of the animal-related injuries (83%) were the result of being kicked by cattle.

The upper and lower extremities were the body parts most frequently injured, followed by injury to the torso and the head and neck. Cuts, strains, and fractures were the most frequent types of injuries reported. Nearly two thirds of all injuries were reported to have occurred in the spring and summer. Most of the farmers consulted with a physician after the injury, and 56% of the injured farmers missed more than 4 hours of work as a result of the injury. Eighty-five percent of all wood-cutting injuries, 59% of all lifting injuries, and 56% of all falls resulted in the farmer's missing more than 4 hours of work. With respect to the entire population of older farmers, injuries due to falls accounted for the largest number of farmers missing more than 4 hours of work as a result of the injury.

Table V presents the number and percentage of injuries by external cause and other characteristics of the injury. Approximately 75% of all injuries reported in this study occurred on farms with beef cattle (alone) or beef cattle and tobacco, although all farms with any cattle constituted 57% of the farms in the study. Beef cattle farms accounted for 85% of the animal-related injuries, 60% of the machine-related injuries, and 58% of the lifting injuries. For machine- and animal-related injuries, the upper extremities were the body parts most often injured. For falls, the most common injuries were to the lower extremities followed by the upper

TABLE III. Estimated Injury Rates for Older Farmers in 60 Kentucky Counties, by Age and Farm Commodity

Farm commodity	Age 55–59			Age 60–69			Age ≥70			Total		
	N_i[a]	Rate[b]	95% CI[c]	N_i	Rate	95% CI	N_i	Rate	95% CI	N_i	Rate	95% CI
Beef cattle	127	17.1	—[d]	448	13.0	7.7–18.3	206	6.4	2.8–10.3	781	10.6	7.3–13.9
Beef and tobacco	12	2.9	—	213	15.2	6.0–24.4	174	11.9	2.0–21.1	399	12.1	6.6–17.7
Tobacco	0	0.0	—	69	7.0	—	30	5.4	—	99	5.2	0.6–9.8
General	60	9.1	—	140	6.3	1.5–11.1	111	5.1	1.6–8.6	311	6.2	3.3–9.0
Total	199	9.2	2.9–15.5	870	10.8	7.6–14.1	521	7.0	4.4–9.7	1590	9.0	7.0–11.0

[a]Estimated total number of injured farmers in 60 counties within stratum.
[b]Estimated number of injured farmers per 100 older male farmers per year.
[c]95% confidence interval for estimated rate, with adjustment for sampling design.
[d]Too few observations within stratum to calculate valid interval.

extremities. Wood-cutting injuries occurred most commonly to the upper extremities, whereas lifting injuries most frequently injured the torso. Of the 88 injured older farmers, 15 farmers (22%) made permanent changes in the manner in which they undertook their farm work as a result of their injuries. Most injuries (72%) were sustained while the farmer was performing a work activity that was part of his usual job. However, for 36% of the injuries sustained while the farmer was engaged in wood-cutting activities, the wood-cutting task was not considered a usual task by the injured farmer. The majority (76%) of the injuries occurred on the individual's farm with the remainder occurring in the street, field, woods, or on another farm (16.5%) or in an area around the home (7.5%).

Injury rates and the unadjusted prevalence odds ratios (risk) of farm-related injuries by potential risk factors are given in Table VI. In univariate logistic regression analyses, farmers residing on beef cattle (odds ratio (OR) = 1.8) or beef cattle and tobacco farms (OR = 2.1) were at twice the risk of injury when compared with farmers on ''general'' farms. A 30% elevation in risk of injury was seen for farmers working full-time compared with part-time farmers. In univariate logistic analyses, a significant OR of 3.05 (95% CI = 1.25–7.44) was found between a prior injury and a farm-related injury reported in the past year. Older farmers who took prescription medications had a 24% higher risk of injury than those who did not take prescription medications. Farmers reporting excellent to very good health had a higher risk of injuries compared with those reporting good, fair, or poor health. Analyses of data from the subgroup of older farmers who had hearing trouble but did not wear a hearing aid found a significantly elevated risk for a farm-related injury (OR = 4.43; 95% CI = 1.04–18.93).

Table VII presents adjusted odds ratios and confidence limits from the multivariable logistic regression analyses of farm-related injuries and potential risk factors. The best predictive model for the group of 998 older farmers, controlling for known and potential risk factors from the univariate logistic analyses, included years in agriculture, farm type, gross farm income, prior injury, full- or part-time work status, difficulty hearing, and vision difficulty. Farmers working on farms with beef cattle (alone) (OR = 1.90; 95% CI = 1.02–3.55) or farms with beef cattle and tobacco (OR = 2.15; 95% CI = 1.00–4.59) had a statistically significant increased risk for a farm-related injury. Prior injury was significantly associated with risk of farm injury in the model. Risk of farm-related injuries increased with increasing years of experience in the agricultural industry—until the category of 52 or more years of experience—and with increasing farm income. Farmers with self-reported hearing trouble were at a 60% increased risk for injury, whereas farmers who reported vision trouble were at a 42% increased risk.

DISCUSSION

This population-based study represents one of the few large survey initiatives of nonfatal agricultural injuries among actively working older male farmers. Although the data from this study indicate that the population of farms selected in the enumeration stage of the study (FHADES) tended to be larger in acreage and were more likely to have a full-time principal operator on the farm than the population of farms enumerated in the 1992 Census of Agriculture for Kentucky, this finding is similar to that reported in other studies [Pickett et al., 1995] and suggests that the data are broadly generalizable to family-operated farms in Kentucky.

The overall crude, nonfatal farm injury rate reported for older farmers in this study (9.0 injured farmers per 100 farmers per year) is generally comparable to crude farm injury rates reported in other studies [Brison and Pickett, 1991, 1992; Zhou and Roseman, 1994; National Safety Council, 1995; Pickett et al., 1995;]. The crude nonfatal farm injury rate for full-time farm workers reported in the National Safety Council's 31-state survey was 10.9 injured farmers per 100 full-time workers in 1988; a Canadian study

TABLE IV. Distribution of Farm-Related Injuries in Older Kentucky Farmers: Farm Family Health and Hazard Surveillance Project (n = 88)

Characteristics of injuries	Number of injured farmers in sample (n_i)	Est. number of injured farmers in population of 60 counties (N_i)	Weighted percent	95% CI
External cause				
Falls	23	396	24.9	14.9–35.0
Machinery	22	357	22.5	13.2–31.8
Animals	12	228	14.3	6.3–22.3
Splitting wood	11	232	14.6	5.7–23.5
Lifting	8	124	7.8	1.6–14.0
Other	12	252	15.9	6.5–25.3
Part of body injured				
Upper extremities	36	653	41.1	29.5–52.7
Lower extremities	25	471	29.7	19.2–40.2
Torso	15	211	13.3	6.1–20.5
Head/neck	7	161	10.1	2.2–18.0
Multiple body parts	5	93	5.9	—[a]
Type of injury				
Cut	21	417	26.2	10.5–31.6
Strain	13	292	18.3	8.5–28.1
Fracture	13	188	11.8	4.7–18.9
Contusion	9	134	8.4	2.5–14.3
Multiple injury	6	91	5.7	—[a]
Amputation	1	16	1.0	—[a]
Not classified[b]	25	452	28.5	18.0–39.0
Season of injury				
Spring	32	625	39.3	27.5–51.1
Summer	25	405	25.5	15.8–35.2
Fall	14	299	18.8	8.9–28.7
Winter	17	262	16.5	8.5–24.5
Place injury occurred				
Farm	69	1213	76.3	68.3–84.3
Home	5	114	7.2	—[a]
Other	14	263	16.5	8.2–24.8
Consulted with doctor after injury				
Yes	67	1267	79.7	70.7–88.7
No	21	323	20.3	11.3–29.3
Missed more than 4 hours of work				
Yes	47	890	56.0	44.6–67.4
No	41	700	44.0	32.6–55.4

[a]Too few observations to calculate valid interval.
[b]Includes burns, stabs, and other injuries that were not classified.

of farm owners and operators reported a rate of 9.0 injured farmers per 100 full-time farmers, an Alabama survey of farm operators calculated a rate of 7.8 injured farmers per 100 farmers, and a survey from a national database reported an adjusted injury rate of 13.9 injured per 100 farmers [National Safety Council, 1990; Zhou and Roseman, 1994; Pickett et al., 1995; Zwerling et al., 1995]. Whereas these farm injury rates are similar, the rates are not strictly comparable given the differing definitions for farm-related injuries, differing population enumeration and data-collection strategies, and the different population demographics in the studies. It is especially important to note that the present study reports on the injury experience of an older group of farmers, two thirds of whom consider their employment as ''part-time.''

Farm Environment Variables

Like other studies, the findings from this study indicate that a substantial portion of the risk for injury associated with working on the farm can be attributable to the farm environment itself. The highest injury risk was observed for farms for which beef cattle was the principal commodity. Seventy-two percent of all the machinery-related injuries and 98% of all the animal-related injuries reported in this study occurred on farms with beef cattle. The presence of beef cattle elevated the risk of a farm-related injury nearly twofold, with statistically significant adjusted odds ratios of 2.15 for beef cattle and tobacco farms and an adjusted odds ratio of 1.90 for farms with beef cattle (alone) in multivariable logistic regression analyses, which controlled for the influence of other potentially confounding risk factors. The finding of elevated injury rates among farms with large animals has been previously reported by Stallones et al. for Kentucky, and Pickett et al. have described the excess risk associated with beef farms in a Canadian population [Stallones, 1990; Pickett et al., 1995].

There may be several reasons for the elevated risk of injury on farms with beef cattle. Research by Elkington suggests that farms with livestock tended to be the most time-consuming enterprises and that injury risk increased with increasing number of hours worked on the farm [Elkington, 1990]. Brison and Pickett [1992] reported a harvest-related peak for injuries on beef farms. They argued that the excessive fatigue, missed meals, and stress associated with harvest time is particularly felt by beef farmers. They indicated that beef farmers worked larger amounts of land with fewer manpower resources and used older equipment. Whereas the behavior of large animals can be unpredictable, our data demonstrate that 62% of the animal-related injuries occurred in the spring, with most of these injuries from cattle kicks. The data from this study and others suggest that proper animal handling and transportation practices and the exercise of caution around bulls,

TABLE V. Distribution of External Causes of Farm Injury (n = 88) by Circumstances and Characteristics of Injury

	Machine		Falls		Wood		Lifting		Animal		Other[a]		Total	
	n_i	Weighted percent	n_i	Weighted percent	n_i	Weighted percent	n_i	Weighted percent	n_i	Weighted percent	n_i	Weighted percent	n_i	Weighted percent
Farm type														
Beef	12	60.1	7	35.4	2	16.3	4	58.0	8	84.8	6	49.0	39	49.2
Beef and tobacco	4	11.6	5	21.0	5	66.1	1	25.5	3	12.7	3	23.8	21	25.1
Tobacco	0	0	3	14.2	2	4.7	0	0	0	0	1	12.5	6	6.2
General	6	28.3	8	29.4	2	12.8	3	16.5	1	2.5	2	14.7	22	19.5
Part injured														
Head/neck	2	9.4	2	17.4	1	3.6	0	0	0	0	2	19.8	7	10.1
Torso	3	8.7	3	8.6	2	10.4	5	62.2	2	19.7	0	0	15	13.3
Upper extremity	11	48.8	7	26.5	5	47.6	1	3.3	6	52.7	6	55.0	36	41.1
Lower extremity	4	18.6	10	44.4	3	38.4	1	25.5	3	19.6	4	25.2	25	29.7
Multiple	2	14.5	1	3.0	0	0	1	9.1	1	8.1	0	0	5	5.9
Severity														
Severe[b]	11	57.6	9	48.3	6	43.7	3	16.1	6	48.7	5	31.0	40	44.5
Moderate	9	35.8	11	43.2	3	28.6	3	52.0	5	44.8	2	20.7	33	36.7
Not classified[c]	2	6.6	3	8.5	2	27.7	2	32.0	1	6.6	5	48.4	15	18.8
Missed work														
≤4 hours	12	54.2	9	43.8	3	15.3	4	41.5	6	59.0	7	56.0	41	44.0
>4 hours	10	45.8	14	56.2	8	84.7	4	58.5	6	41.0	5	43.9	47	56.0
Talked to a physician														
Yes	17	81.6	20	93.2	10	89.0	5	67.6	6	44.9	9	84.4	67	79.7
No	5	18.4	3	6.8	1	11.0	3	32.5	6	55.1	3	15.6	21	20.3
Made permanent change in farm work														
Yes	3	19.0	2	8.8	4	45.4	2	22.8	2	24.3	2	20.7	15	21.6
No	19	81.0	21	91.2	7	54.6	6	77.3	10	75.7	10	79.4	73	78.4
Season														
Spring	5	26.5	6	37.2	7	53.5	4	51.2	7	61.8	3	21.4	32	39.3
Summer	8	31.3	5	21.1	2	18.2	2	22.8	3	17.6	5	39.2	25	25.5
Fall	6	27.3	4	15.7	1	19.0	0	0.0	2	20.6	1	18.8	14	18.8
Winter	3	14.9	8	26.0	1	9.2	2	26.1	0	0.0	3	20.6	17	16.5

[a]Includes injuries from fence or gate repair, water (pond), small machine repair.
[b]Includes amputations, fractures, and cuts; moderate includes scrapes, contusions, and strains.
[c]Includes burns and stabs.

steers, and pregnant cows could reduce some of these injuries [Layde et al., 1996].

Whereas no trend in farm injury risk was observed with increasing farm acreage across all commodity types, there was a positive association between gross annual farm income and farm injury risk in this study. Pickett et al. [1995] reported a relationship between injury rates and both tillable acreage and gross farm income. Additionally, studies in Sweden and New York have reported associations between larger farm size and higher injury rates [Jansson, 1987; Pratt et al., 1992]. Whereas tillable farm acreage may be a proxy for exposure hours or farm activity, gross farm acreage, in general, may not reflect the amount of land in production or farm work activity and, therefore, may not be associated with farm injury rates.

Individual Risk Factors

Given a population of farmers aged 55 years and older in this study, it is not surprising that injuries from falls constituted the largest proportion of the reported farm-related injuries. Nearly half of the falls sustained by these

TABLE VI. Univariate Logistic Analysis of Potential Risk Factors for Farm-Related Injuries in Older Kentucky Farmers (n = 998)

Risk factor	Number of farmers (n_p)	Number of injured farmers (n_i)	Rate[a]	Odds ratio	95% CI
Type of farm					
General	309	22	6.2	1.00	
Beef cattle	396	39	10.6	1.80	0.98–3.28
Beef and tobacco	177	21	12.1	2.10	1.03–4.29
Tobacco	116	6	5.2	0.83	0.29–2.40
Size of farm (acres)					
≤85	248	16	7.8	1.00	
86–144	242	28	11.2	1.51	0.73–3.12
145–230	270	21	6.7	0.85	0.40–1.80
≥231	238	23	11.1	1.48	0.69–3.19
Farm income					
<$5,000	349	25	7.7	1.00	
$5,000–10,000	233	17	7.6	0.99	0.50–1.96
$10,000–40,000	311	35	10.5	1.40	0.77–2.56
>$40,000	105	11	12.4	1.69	0.67–4.22
Number of farm helpers					
None	237	19	8.5	1.00	
1	199	16	7.8	0.81	0.40–1.63
2	157	13	7.6	0.79	0.36–1.70
3 or more	405	40	10.6	1.07	0.58–1.98
Years in agriculture					
≥53	253	17	6.7	1.00	
47–52	235	27	11.1	1.75	0.86–3.53
39–46	256	24	10.8	1.68	0.83–3.42
≤38	254	20	7.8	1.18	0.54–2.55
Days of tractor use in past year					
≤35	251	22	9.6	1.00	
36–150	261	21	9.9	1.03	0.52–2.05
151–250	258	22	7.8	0.79	0.40–1.55
≥251	228	23	9.0	0.92	0.46–1.86
Farm work status					
Full time	392	39	10.2	1.00	
Part time	606	49	8.3	0.79	0.48–1.31
Prior injury					
No	962	81	8.6	1.00	
Yes	36	7	22.2	3.05	1.25–7.44
Current use of prescription medication					
No	438	35	8.1	1.00	
Yes	560	53	9.8	1.24	0.75–2.05
Self-reported health status of farmer					
Excellent/very good	321	30	10.5	1.00	
Good	358	34	9.7	0.63	0.34–1.15
Fair/poor	319	24	6.8	0.92	0.52–1.65
Hearing difficulty (other than deafness)					
Yes	332	36	11.6	1.58	0.96–2.60
No	666	52	7.7	1.0	
Vision difficulty					
Yes	119	15	12.9	1.59	0.85–2.99
No	879	73	8.5	1.0	
Arthritis					
Yes	486	46	10.2	1.34	0.83–2.17
No	512	42	7.8	1.0	

[a]Rate = number of injured farmers per 100 older male farmers per year, weighted to account for the sampling design.

older farmers were categorized as severe injuries in this study, with 56% of the farmers who reported a fall missing more than 4 hours of farm work and 93% requiring the services of a physician. An examination of individual survey responses indicated that most of these injuries were falls from farm machinery and falls from heights in the barns. Machinery-related injuries were proportionately the second largest external cause of injury among these older farmers.

The data from the present study did not show marked variation in overall farm injury rates by age, except for a diminution of the injury rate in the category of farmers aged 70 years and older, who had an injury rate of 7.0 injured farmers per 100 farmers per year. Age by itself can be a proxy for many types of factors, including health status, cumulative work experience, risk-taking behavior, and usual number of hours worked per week. Farming is unlike many other occupations in that many farmers never completely retire. The older farmers in this study who claimed to work ''part-time'' still averaged 119 days on the tractor per year.

The finding of 2.5-fold elevation in risk (OR = 2.4, 95% CI = 1.01–5.71) of farm injury for farmers reporting a prior injury is noteworthy. The prevalence of prior injuries among the older farmers was 3.5% (95% CI = 2.3–4.7). Whereas Zhou and Roseman [1995] reported a significant association between traumatic disabilities and incident farm injuries, Brison and Pickett [1992] did not find that past farm injury experience was associated with current injury risk.

TABLE VII. Multivariable Logistic Regression Analysis of Potential Risk Factors for Farm Injuries

Risk factor	Odds ratio	95% CI	*P* value
Type of farm			
General	1.00		
Beef cattle	1.90	1.02–3.55	0.04
Beef and tobacco	2.15	1.00–4.59	0.05
Tobacco	0.85	0.29–2.55	0.77
Gross annual farm income			
<$5,000	1.00		
$5,000–10,000	0.91	0.45–1.83	0.78
$10,000–40,000	1.16	0.62–2.17	0.63
>$40,000	1.52	0.60–3.84	0.38
Years in agriculture			
≥53	1.00		
47–52	1.78	0.88–3.62	0.11
39–46	1.55	0.73–3.26	0.25
≤38	1.17	0.53–2.56	0.69
Farm work status			
Full time	1.00		
Part time	0.77	0.46–1.29	0.33
Prior injury			
No	1.00		
Yes	2.40	1.01–5.71	0.04
Hearing difficulty			
No	1.00		
Yes	1.59	0.95–2.67	0.08
Vision difficulty			
No	1.00		
Yes	1.42	0.76–2.63	0.27

Cleary et al. [1961] reported that farm injury cases were nearly twice as likely as controls to report a prior farm injury, and in a case-control study by Elkington [1990], 16% of the cases (compared with 9% of the controls) reported having ever incurred a serious injury with an OR = 2.35 ($P = 0.054$).

The association of prior injury with current injury risk may be attributable to several factors. Prior injuries that lead to permanent disabilities for a farmer, such as a permanent limp or the loss of a limb, may predispose the individual to new injuries. Prior injuries may also reflect hazardous work environments, risk-taking behaviors, a tendency to overwork, improper work tasks, or the use of older or unsafe equipment. Although the understanding of the association between prior injury and incident injuries remains incomplete, the demonstration of this association may be important for intervention efforts.

With the exception of the 36% of wood-cutting injuries that occurred while the farmer was performing a new or unfamiliar task, our general finding that most of the farm-related injuries occurred while the farmer was performing usual job activities has been documented in other studies [Brison and Pickett, 1992; Zhou and Roseman, 1995]. This finding, however, does not diminish the predictable pattern of injury occurrence and the identification of those activities (falls from heights in barn, clothing entanglements in machinery) that warrant engineering and behavioral solutions for injury prevention and control [Murphy, 1992].

Chronic Conditions and Medication Status

Disorders or conditions that impair mobility, reduce alertness, or decrease sensory acuity have been shown to affect the risk of injury [Robertson, 1992]. Whereas few studies in the agricultural injury literature address this issue, other research on injuries, particularly concerning automobile crashes, has demonstrated that use of prescription medications, alcohol use, and certain preexisting medical conditions are associated with risk of injury [Robertson, 1992; Elkington, 1990]. Data from this study suggest that hearing and vision impairment, the use of prescription medications, and arthritis may increase the risk of farm-related injury. Especially relevant is the finding that a subgroup of farmers who reported difficulty with hearing but who did not wear hearing aids were at four times the risk for a farm-related injury.

Although several investigators have suggested that medical conditions may be contributing causes of farm injury, few have demonstrated positive associations between medical conditions and the increased risk of injury. Of note, however, Brison and Pickett [1992] found that the use of prescription drugs by farm owners was the only variable correlated with an increased risk for injury, and Elkington [1990] reported that injury cases were significantly more likely than noninjured controls to report preexisting arthritis and the use of prescription pain medication. Further research directed toward examining the potential impact of chronic adverse health conditions and other health impairments on injury risk appears warranted in light of findings from this study.

Generalizability

This study reports on the farm injury experience of a target group of male farmers aged 55 years and older, living within 60 of the 120 counties in Kentucky, and who actively worked on the farm. The study population was predominantly married, white, male farm operators. There were insufficient numbers to allow examination of differences in injury rate by race or marital status. The results of this report should not be extended to all farmers, younger farmers, migrant farm workers, or other persons who are not farm

residents but who may have been injured on farms. Whereas the extension of the results of this study to the population of all older, white male farmers in Kentucky cannot be based on strict statistical methods, we believe that the sample of older farmers in this study is generally representative of the population in the state. Some potential for selection bias exists, however, because the farms of the sample of older farmers in this study were typically larger and were represented by a greater number of farmers not holding off-the-farm jobs compared with the demographics of farms from the 1992 Census of Agriculture [Census, 1992]. The magnitude of these demographic differences, however, is not substantial. The telephone-interview methodology used in this study may account for some of this difference because larger farms may be more likely to have phones and farmers who are available to complete the survey. The results are relevant only to those farm households that had telephones with working phone numbers.

Limitations

Several factors could potentially cause underestimation of the injury rates reported in this study. Failure of the respondent to recall minor injuries over the 1-year period would lead to an underestimation of the injury rate. The data suggest that recall of injuries was focused primarily on injuries requiring medical attention; 80% of all the injured farmers in this study sought medical treatment for their injuries. Recall may also be dependent on the time frame from which the injuries are reported; some studies suggest a higher prevalence of recalled injuries when the time frame is 3 months compared with the 1-year recall used in this study [Peterson and Harbeck, 1993; Harel et al., 1994]. However, because the issue is of greater concern for proxy recall of injury events than self-reported injuries, the statistical adjustment for differential recall was not undertaken in our study.

If some of the farmers screened in the initial survey and categorized as nonactive had quit farming because of a work-related injury, rates of nonfatal injury could be underestimated. The self-reported injuries in this study were not validated by medical record review; however, one study by Pratt et al. documented excellent agreement between telephone-reported cases of injury and cases found in the medical records [Pratt et al., 1992]. The outcome of all farm-related injuries is a heterogeneous outcome, which includes fractures, cuts, and strains from external causes such as falls, machinery, and animals. Potential risk factors for one type of outcome (e.g., a fracture from a fall) may not be associated with a different outcome (e.g., hand injury from a mower). For example, poor vision or hearing may be more likely to elevate the risk of machinery-related injuries than the risk of injuries from animals. The data collected for this study were not extensive nor detailed enough to calculate adjusted odds ratios for specific external causes of injury.

There were several limitations in this study with respect to the collection of exposure data. Classification of the number of hours usually worked per week or the amount of time spent farming was not undertaken. Whereas characterization of person-hours of exposure may be a preferable method for the calculation of rates, the classification by work hours can be problematic, given that workloads and schedules for farmers vary enormously by season and that even the classification of full-time and part-time status may have little relationship with actual hours worked. Finally, the usual limitations of using prevalence data to assess the relationship between a putative risk factor and self-reported farm injuries are applicable to this surveillance study; the temporal relationships between the factors is not clear, and potential changes in the risk factor before or after the injury is not known.

Future Directions

This study provides baseline data from which the efficacy of future initiatives to reduce farm injuries among older farmers can be assessed. This study highlights that aged workers are a significant portion of agriculture's traumatic-injury problem and reports a total statewide burden of 3,600 injured older farmers on an annual basis. Whereas our data collection approach to farm injury surveillance is inherently more difficult, labor-intensive, and expensive than other active and passive data collection mechanisms that rely on hospital or emergency room data, this active surveillance approach should provide a more comprehensive picture of farm injuries in this Kentucky population.

There are two primary strategies for directing intervention programs in public health: the high-risk strategy and the population strategy [Rose, 1992]. Within the context of the high-risk strategy, data from this study can be used to justify interventions at the level of the farm type (beef cattle, tobacco, general) and at the level of the individual farmer. Given that the data indicate that older farmers working on beef cattle farms are at twice the risk of a farm-related injury, especially from machine- and animal-related causes, efforts to disseminate these data to this group of farmers should be encouraged.

This study also suggests several risk factors that allow for personal intervention by health care providers who can deliver educational interventions to individual farmers regarding injury risks. The finding from this study and others that injured farmers are more likely to sustain another injury seems to be an effective point for intervention on the part of the health care provider. A ''teachable moment'' is presented in which the farmer is attuned to acquiring information for the prevention of further injuries. Health care providers should use the entry of the injured farmer into the health care

system as an opportunity for education and instruction of injury prevention.

This study provides data that support the idea that comprehensive hearing and vision screening and assessment of medication use is an important component of the physical examination of older farmers. Hearing protection, use of hearing aids, and corrective lenses can be recommended if necessary. Prior injury also provides a point for improving the health status of afflicted persons (through disability management or vocational rehabilitation, for example) and may prevent future injuries. Counseling regarding the greater likelihood of falls by older farmers, especially while mounting or dismounting machinery or while taking down tobacco in the barn, would be warranted. General safety programs oriented toward ladder safety, the use of safety harnesses, and proper footwear should be encouraged for this group.

The population strategy can also be approached using these data. Policy makers can use the state-level estimates of farm-related injuries to this worker group to justify the necessity and expense of educational, regulatory, or agricultural engineering programs for reducing the farm-related injury toll in the state. This strategy recognizes that the primary determinants of farm-related injury are economic and social and are amenable to prevention. Results from this and other farm injury surveillance studies suggest that social and engineering mechanisms that alleviate long hours of farm work, provide extra labor during peak work periods (harvest), upgrade the machinery and equipment used by farmers, provide an economic incentive for the purchase of safer equipment (ROPs-equipped tractors or axes with longer handles), and provide training on safe operating procedures can have an impact on reducing the risk of injury while performing farm work.

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