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Cattle-Related Injuries and Farm Management Practices on Kentucky Beef Cattle Farms

S. R. Browning, S. C. Westneat, W. T. Sanderson, D. B. Reed

ABSTRACT. *While working on farms with livestock increases the risk of injury among farm workers in comparison to other commodity farms, few studies have examined the role of farm management practices in association with the risk of cattle-related injury. We examined the farm management practices of Kentucky beef cattle farms in association with self-reported rates of cattle-related injuries among workers. We conducted a mail survey of a random sample of 2,500 members of the Kentucky Cattlemen's Association. Results from 1,149 farm operators who were currently raising beef cattle and provided complete survey response are reported. During the busy season, the principal operator worked 20 hours per week on the beef operation, and among all farm employees, the beef operation required 35 hours per week (median cumulative hours). There were 157 farms that reported a cattle-related injury in the past year among the principal operator or a family member, yielding an annual cattle-related injury rate of 13.7 beef cattle farms per 100 reporting at least one cattle-related injury. The majority of these injuries were associated with transporting cattle, using cattle-related equipment (head gates, chutes, etc.), and performing medical or herd health tasks on the animal. A multivariable logistic regression analysis of cattle-related injuries indicated that the risk of injury increased with increasing herd size, increasing hours devoted to the cattle operation per week by all workers, and the number of different medical tasks or treatments performed on cattle without the presence of a veterinarian. Farms that performed 9 to 13 tasks/treatments without a veterinarian had a two-fold increased risk of a cattle-related injury (OR = 1.98; 95% CI: 1.08-3.62) in comparison to farms that performed 0 to 4 tasks without a veterinarian. In adjusted analyses, the use of an ATV or Gator for cattle herding was associated with a significantly reduced risk of cattle-related injury (OR = 0.51; 95% CI: 0.30-0.86) in comparison to other herding methods. This study indicates that a substantial proportion of cattle-related injuries are associated with work activities related to handling practices and cattle restraining equipment.*

Keywords. *Agricultural injury, Beef cattle farms.*

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Epidemiologic studies have documented that farm animals and livestock are a significant source of injury among farm workers (Cleary et al., 1961; Hoskin and Miller, 1979; Brison and Pickett, 1992; Pratt et al., 1992; Hendricks and Adekoya, 2001; Day et al., 2009; Myers et al., 2009). Living on farms with beef or dairy cattle, in comparison to farms without livestock, has been associated with an increased injury risk in several studies (Pratt et al., 1992; Waller, 1992; Nordstrom et al., 1995; Layde et al., 1996; Browning et al., 1998). Nordstrom et al. (1995) reported the injury risk to be 2.5 times greater among dairy farm residents than nondairy farm residents in Wisconsin. In Kentucky, Browning et al. (1998) reported that older farmers with beef cattle (OR = 1.90) or beef cattle and tobacco (OR = 2.15) were at a significantly increased risk of a farm-related injury compared to farmers without cattle. Animals were the third most common external cause of fatality among older farmers in the study conducted by Myers et al. (2009).

Two case-control investigations have addressed the issue of animal-related injuries among adult farm residents. Layde et al. (1996) investigated animal-related injuries, primarily due to cattle, as part of a population-based, case-control study of injuries in farm residents in central Wisconsin. A rate of 11 animal-related injuries requiring medical attention per 1,000 person-years was reported. The use of all-terrain vehicles for chores was found to be protective of an animal-related injury (OR = 0.47; 95% CI: 0.22-1.04) in this study. Boyle et al. (1997) reported results from a case-control study of animal-related injuries to farm household members resulting from dairy cattle activities. Milking had the greatest risk of injury, with odds ratios increasing with increasing hours per week devoted to milking. Additionally, trimming or treating hooves was associated with an increased risk of injury (OR = 4.2; 95% CI: 1.2-15.4).

Occupational injury research among veterinarians is relevant to the issue of animal-related injuries, especially among smaller, rural farms in Kentucky where some veterinary procedures are performed by family members (Meade, 1992; Billings, 1997). A study by Billings (1997) examined injuries among large-animal veterinarians in Kentucky. Cattle were the animals most often involved in injury events. One-fourth of the injuries occurred while the veterinarian was working alone, with bites and kicks being the prominent causes of animal-related injury. Dehorning and castration were tasks commonly associated with veterinarian injuries. These tasks are often done by farmers, particularly on smaller farms.

The trend toward larger farming operations precludes the ability of workers to know the temperament of individual animals (Steele-Bodger, 1969). Additionally, trends toward more intensive animal husbandry, including more confined feeding systems, use of artificial insemination, and enclosed housing systems that crowd animals, have increased direct contact with animals and the risk of injury to workers (Boissy and Bouissou, 1988; Lundqvist, 1995). However, Meade (1992) suggested that although artificial insemination increases direct contact with cows, it reduces the injury risk associated with maintaining bulls for breeding purposes. Injuries resulting from the use of head gates have been documented in several studies (Billings, 1997; Huhnke et al., 1997). Huhnke et al. (1997) reported on injuries sustained among a small sample of cattle producers in Oklahoma. Pens (permanent, temporary, and mobile) (40%), alleyways (17%), and squeeze chutes (16%) were identified as the most common locations for cattle-related injuries. The authors suggested that approximately 25% of the injuries sustained in working with cattle could be associated with problems related to cattle-handling equipment and the design of facilities.

Several authors have noted the high impact with respect to lost work days and medical costs of livestock, especially cattle, related injuries to workers and have highlighted the need for increased understanding of the relationship between animal husbandry tasks, the design of facilities, and their relationship to the risk of injury (Huhnke et al., 1997; Sprince et al., 2003; Douphrate et al., 2009). Douphrate et al. (2009) reported that livestock-handling injuries are among the most severe of agricultural injuries. This article reports results from a cross-sectional study to assess work practices on Kentucky beef cattle farms and to determine whether specific practices are associated with an increased risk of cattle-related injuries to the principal operator and farm family members on beef cattle operations.

Materials and Methods

We conducted a cross-sectional study of farm management practices specific to beef cattle operations and of the annual reported cattle-related injuries among farm operators and family workers who were members of the Kentucky Cattlemen's Association (KCA). A complete list of KCA members was obtained from KCA officials at their state office and comprised the sampling frame of the survey. The list was reviewed, and members with addresses outside of Kentucky or that were businesses were removed, yielding 4,126 distinct mailing addresses. A random sample of 2,500 members was selected for contact to participate in the study.

The farm management practices questionnaire was developed and designed to be completed by the principal operator of the farm. Our definition of an eligible participant was the "principal farm operator or the individual most knowledgeable about the beef cattle operation" and who was a member of the KCA. The minimum age of a participant in our study was 19 years. In addition to measures generated by the investigators, questions from the National Animal Health Monitoring System and a questionnaire employed by researchers examining occupational injury among individuals in cow-calf operations in Oklahoma were used for selecting survey questions (Huhnke et al., 1997; USDA-APHIS, 1998). A committee comprised of faculty and staff, a USDA veterinarian, a state public health veterinarian, two rural health specialists, and two academic injury prevention specialists developed the survey. The survey was modified after initial pilot testing on a convenience sample of ten farms.

The questionnaire focused on the farm management practices of the beef cattle operation. Questions included the demographic characteristics of the operator (age, gender, hours worked per week during the busy season, and years of beef cattle operation on the farm). Characteristics of the beef cattle operation were defined by the type of operation, reason for raising cattle, calving season, use of bulls maintained for breeding, growing hay or grain, facilities and equipment maintained on the farm, and the use of an ATV or Gator for cattle herding tasks. Information was also collected on the breeds maintained on the farm, number and type of cattle-related tasks performed by children on the farm, type of feeding operation, herding methods, medical treatments performed by the operator and/or veterinarian, castration and dehorning procedures, and occurrences of cattle-related injury on the farm in the past 12 months. Cattle-related injuries were defined as the respondent (typically owner/operator) or a member of his/her family having had at least one injury directly from cattle or when performing tasks directly related to the beef cattle operation on the farm within the past year.

A survey packet was mailed to the 2,500 selected KCA members in October 2001. The packet included the questionnaire with instructions, a joint letter of support from the University of Kentucky and the KCA, a raffle ticket as a participation incentive, and a pre-stamped reply envelope. The self-administered survey was seven pages in length and was estimated to take less than ten minutes to complete. The principal operator or individual most knowledgeable about the beef cattle operation was encouraged to answer the survey. If beef cattle were not raised on the farm in the past twelve months, respondents were asked to write “not eligible” and return the survey blank. Approval was obtained from the University of Kentucky Institutional Review Board for the data collection.

Data Analysis

Descriptive statistics, including means, frequencies, percentages, and rates, were calculated from the cross-sectional data collected as part of the KCA survey. Cattle-related injury rates were calculated as a cumulative incidence with the number of farms that currently had cattle and reported at least one cattle-related injury in the past year divided by the total number of active beef cattle farms. An index of medical tasks and treatments performed in the absence of a veterinarian by the farm operator or other workers was created by summing affirmative responses to thirteen specific tasks, including dehorning, castration, administration of antibiotics, treating “down” animals, deworming, pregnancy checks, and artificial insemination. The index was then categorized into tertiles for analysis. Stratified analysis of the cattle-related injury rates on farms was undertaken by various demographic, farm type, and farm management variables. Univariate odds ratios and confidence intervals were calculated using standard procedures. Multivariable logistic regression analysis was undertaken to examine the predictors of farms with cattle-related injuries, following the univariate analysis, generally employing the strategy advocated by Kleinbaum and Greenland (Kleinbaum et al., 1982; Kleinbaum, 2002; Greenland, 1989). Variables initially included in the multivariable model were those determined to increase risk of injury in the univariate analysis, as well as those characteristics of farms that have generally been determined to be risk factors in the literature (e.g., hours of work, number of head of cattle). A backward elimination procedure of the initial main effects model was employed using a change-in-estimate method (10%) in the exposure effect premised on key variables (number of cattle on the farm and total hours per week of work by all workers). Analyses were performed using observations with complete data on all factors under consideration. Adjusted odds ratios (OR) and 95% confidence intervals (CI) were estimated and presented for the final multivariable model. All analyses were performed using SAS statistical software (SAS, 2010).

Results

From the random sample of 2,500 addresses to which we sent surveys, we obtained 1,149 complete surveys from farms that currently were raising beef cattle and that we used for the analysis. Of the total completed surveys returned ($n = 1,226$), we deleted 77 from the analysis, of which 68 farms were not currently raising beef cattle, 6 had not reported data on the herd size, and 3 had insufficient data on the principal operator. In addition, 41 surveys were returned that had been sent to an invalid address or were returned unopened. We conservatively estimate our response rate at 48% after removing the ineligible surveys ($n = 118$) from the denominator. Demographic characteristics of the principal operators and descriptive characteristics of the 1,149 beef cattle farms that were cur-

rently raising cattle, stratified by the median number of cattle, are given in tables 1 and 2. Ninety-five percent of the respondents were male principal operators. These principal operators worked a median of 20 hours per week on tasks directly related to their beef cattle operation. For all of these farms, the median cumulative hours worked per week during the busy season for all employees was 35 hours (interquartile range: 40 hours). Approximately one-quarter of the farms in the survey reported that more than 60 person-hours per week were needed for beef cattle activities during the busy season. The median number of cattle on all farms was 85 head with a wide range from 2 to 3,500 head. The median number of years of experience in beef cattle farming reported by these operators was 25 years, with 33% of the operators having more than 30 years of experience.

Table 1. Demographic characteristics of Kentucky beef cattle farms, stratified by size (N= 1,149).^[a]

	<85 Head of Cattle			85 to 3,500 Head			Total		
	N	Median	IQR ^[b]	N	Median	IQR ^[b]	N	Median	IQR ^[b]
Age of principal operator (years)	576	54	19	567	53	19	1143	53	19
Work experience of principal operator (years)	578	23	21	568	28	18	1146	25	20
Work per week for principal operator in busy season (h)	567	20	20	558	30	30	1125	20	26
Cumulative work per week for all farm employees (h)	560	25	27	557	50	50	1117	35	40
Number of cattle during a typical year (head)	579	45	35	570	150	160	1149	85	105

^[a] Numbers of farms does not sum to 1,149 for all variables due to small number of missing values.

^[b] IQR = interquartile range.

Table 2. Characteristics of beef cattle operations on Kentucky farms, stratified by size (N= 1,149).

Description	<85 Head of Cattle (N= 579)		85 to 3,500 Head (N= 570)	
	(N)	(%)	(N)	(%)
Main reason for raising beef cattle				
Primary income	190	32.9	321	56.5
Secondary income	199	34.4	174	30.6
Extra money	138	23.9	53	9.3
Other	51	8.8	20	3.5
Type of beef cattle operation				
Commercial cows	397	68.6	431	75.6
Feeders, backgrounders	55	9.5	78	13.7
Purebred, registered	94	16.2	54	9.5
Feedlot	6	1.0	-	-
Other	27	4.7	7	1.2
Calving season				
Spring	383	66.1	348	61.1
Fall	84	14.5	46	8.1
Spring and fall	35	6.0	81	14.2
Winter	26	4.5	29	5.1
Year-round	17	2.9	16	2.8
Other / none	34	5.9	50	8.8
Grow or harvest grain/corn on the farm (% yes)	138	24.0	269	47.6
Grow or harvest hay on the farm (% yes)	541	89.1	540	94.9
Bull(s) on farm for breeding (% yes)	513	88.8	512	90.1
Cattle castration performed on the farm (% yes)	457	79.9	520	92.0
Cattle dehorning performed on farm (% yes)	211	37.0	351	62.1

Raising beef cattle was undertaken as a primary source of income for 57% of the operators with farms having 85 or more cattle. For farms with less than 85 head of cattle, the cattle operation was considered a secondary source of income, with 24% of these farms reporting that they raised a few cattle for “extra money.” Many of these farms tended to be beef cattle and tobacco operations, with the primary income coming from tobacco. The calving season was predominantly in the spring (63% overall) for both the small and large farms. Overall, 89% of all farms maintained a bull for breeding purposes; there was negligible variation between farms with less than 85 head and farms with more than the median number of animals with regard to maintaining a bull. For all farms, castration (86%) and dehorning (49%) were commonly undertaken by the farm operators. Cattle were typically herded using gates and panels (85%) and using sticks (54%) to move the animals. ATVs were used for herding on 18% of the farms. Larger herd farms were significantly more likely to grow their own grain or corn for feed (48%) compared with the smaller herd farms (24%), although growing hay was uniformly high across all farms. Angus (64% of farms), crossbred cattle of two or more breeds (36%), Charolais (29%), and Black Baldie (29%) were the predominant cattle breeds (data not shown).

Cattle-Related Injury Analysis

A total of 157 farms reported at least one cattle-related injury among principal operators or a family member within the 12 months preceding the survey. An estimated 13.7% (95% CI: 11.7 to 15.8) of beef cattle farms reported at least one cattle-related injury to the operator or a family member on an annual basis. Complete information from the open-ended question describing the injury was available for 149 of the 157 reported injury occurrences. The majority (91%) of the cattle-related injuries were to male workers. Bruises (22%), cuts (9.4%), and fractures (8.7%) were the primary types of injuries reported. One-third of the injuries (33.6%) required medical attention or resulted in more than four hours of missed work. Working with cattle (20.8%), the use of cattle-related equipment (16.1%), moving, loading, and unloading cattle (11.4%), and performing medical tasks related to cattle (10.7%) were the primary activities performed at the time of the injury. Direct contact with the animal was associated with 89% of the injuries. Being kicked or run over by cattle (49.6%) were the primary reasons for injuries. In 11% of the cases, the animal caused another object to fall or move, resulting in the injury. The leg, hip, and knee (30.2%), followed by the hand and the wrist (14.7%), were the body parts most often injured. Cows accounted for the majority of the injuries (36%), followed by calves (16.8%), and then bulls and steers (13.4%). Of the injuries reported in this survey, only 5% of all cattle-related injuries occurred to children (<18 years old).

Univariate Logistic Analysis

Cattle-related injury rates were higher on farms with more than the median number of cattle (>85 head); injury risk increased significantly two-fold (OR = 2.30; 95% CI: 1.40-3.73) for farms with >152 head of cattle in comparison to those farms with 45 or fewer head (table 3). Cattle-related injury risk increased with increasing hours worked by the principal operator as well as the total cumulative number of hours from all workers on the farm. Farms that pastured their cattle all year long reported a lower cattle-related injury rate (12.6 farms with a cattle-related injury per 100 farms) in comparison to those farms that did not (15.4 per 100), although the resulting odds ratio was not significant.

Table 3. Univariate logistic regression analysis of risk factors for cattle-related injuries on Kentucky beef cattle farms.

Risk Factor		No. of Farms ^[a] (n = 1,149)	Farms Reporting Cattle-Related Injury ^[b] (n = 157)	Injury Rate per 100 Farms	Odds Ratio	95% CI
Size of cattle herd (head)	2-45	295	29	9.8	1.0	-
	46-85	284	27	9.5	0.96	0.56-1.67
	86-152	286	44	15.4	1.67	1.01-2.75
	>152	284	57	20.1	2.30	1.40-3.73
Total hours per week worked by principal operator	0-14	238	28	11.8	1.0	-
	15-20	330	30	9.1	0.75	0.44-1.29
	21-40	227	29	12.8	1.10	0.63-1.91
	>40	326	69	21.2	2.01	1.30-3.24
Total hours per week of work on farm (all workers)	0-20	325	30	9.2	1.0	-
	21-35	239	29	12.1	1.36	0.79-2.33
	36-60	296	44	14.9	1.72	1.05-2.81
	>60	255	52	20.4	2.52	1.55-4.09
Bull maintained for breeding	No	121	19	15.7	1.0	-
	Yes	1025	138	13.5	0.84	0.50-1.41
Cattle pastured (entire year)	No	415	64	15.4	1.0	-
	Yes	716	90	12.6	0.79	0.56-1.12
Castration performed	No	160	16	10.0	1.0	-
	Yes	977	138	14.1	1.48	0.86-2.56
Dehorning performed	No	574	62	10.8	1.0	-
	Yes	562	92	16.4	1.62	1.14-2.28
No. of medical tasks or treatments without a veterinarian present	0-4	261	22	8.4	1.0	-
	5-8	443	57	12.9	1.60	0.96-2.69
	9-13	437	75	17.2	2.25	1.36-3.72
Location where cattle were usually fed	Pasture	793	100	12.6	1.0	-
	Barn	51	9	17.7	1.49	0.70-3.14
	Slab	43	8	18.6	1.58	0.71-3.51
	Pen	84	14	16.7	1.39	0.75-2.55
	Other	174	26	14.9	1.22	0.76-1.94
Method used for herding cattle	Other	922	135	14.6	1.0	-
	ATV/Gator	218	22	10.1	0.65	0.41-1.05
Cattle restraining equipment used	Manual squeeze chute with head gate					
	No	615	70	11.4	1.0	-
	Yes	524	87	16.6	1.55	1.10-2.18
	Loading chute					
	No	940	125	13.3	1.0	-
	Yes	199	32	16.1	1.25	0.82-1.91
	Working chute or alley					
	No	329	38	11.6	1.0	-
	Yes	810	119	14.7	1.32	0.89-1.95
	Crowding pen					
	No	546	56	10.3	1.0	-
	Yes	593	101	17.0	1.80	1.27-2.55
	Palpation cage					
	No	818	98	12.0	1.0	-
	Yes	321	59	18.4	1.65	1.16-2.35

^[a] The number of farms does not sum to 1149 (total) for each variable due to missing variables in the dataset.

^[b] The number of farms reporting at least one cattle-related injury among the principal operator or a family member in the past year may not sum to 157 for each variable given missing values in the dataset. Missing values were less than 5% for any of the variables in the table.

The use of an ATV or Gator for herding cattle was associated with the lowest rate of cattle-related injuries among the herding methods examined; the odds ratio for the use of an ATV for herding (OR = 0.65; 95% CI: 0.41-1.05) was suggestive of a protective effect in the crude analysis. A variety of different types of cattle-restraining equipment were used on these farms. Manual squeeze chutes with head gates were used on 46% of the farms, and the risk of a cattle-related injury was significantly increased 50% (OR 1.55; 95% CI: 1.10-2.18) on farms with this equipment. Similarly, the use of palpation cages and crowding pens increased risk of injury a similar magnitude on farms with this equipment in comparison to those without.

Multivariable Logistic Regression Analysis

Variables that were statistically significant in the univariate logistic regression or that have been documented as known risk factors for animal-related injuries (e.g., total hours of work during the week) were entered into the an initial logistic regression model and fit using a backward elimination method conditioned on a change-in-estimate approach (table 4). The final multivariable logistic regression analysis of the farms that reported a cattle-related injury indicated that the risk of injury increased with increasing herd size, although the linear test for trend was not significant ($p = 0.46$). A marginally significant increased risk of injury with an increasing number of different medical tasks/treatments performed on cattle without the presence of a veterinarian was obtained ($p = 0.051$). Farms that performed 9 to 13 tasks/treatments without a veterinarian were at twice the risk of a cattle-related injury (OR = 1.98; 95% CI: 1.08-3.62) compared to farms that performed 0 to 4 tasks without a veterinarian, controlling for head of cattle, method of herding, location where cattle were fed, and cumulative hours of work per week for all workers, simultaneously. Using an ATV or Gator was significantly associated with a reduced risk of injury (OR = 0.51; 95% CI: 0.30-0.86) in comparison to farms that employed other cattle herding methods, after control for the previous listing of variables.

Table 4. Multivariable logistic regression analysis of risk factors for cattle-related injuries on Kentucky beef cattle farms.^[a]

Risk Factor		Adjusted OR	95% CI	p-Value
Size of cattle herd (head)	2-45	1.0	-	-
	46-85	0.92	0.51-1.68	0.79
	86-152	1.19	0.66-2.13	0.57
	>152	1.89	1.05-3.40	0.03
	Test for linear trend: $\chi^2 = 0.56$, $p = 0.46$			
Number of medical tasks/treatments without a veterinarian present	0-4	1.0	-	-
	5-8	1.81	0.99-3.29	0.05
	9-13	1.98	1.08-3.62	0.03
	Test for linear trend: $\chi^2 = 3.79$, $p = 0.051$			
Method for herding cattle	Other	1.0	-	-
	ATV or Gator	0.51	0.30-0.86	0.01
Location where cattle were usually fed	Bar, slab, pen, other	1.0	-	-
	Pasture	0.82	0.53-1.29	0.40
Total hours per week of work on farm (all workers, increase per 100 hours per week).		1.52	1.00-2.31	0.05

^[a] Multivariable logistic model is premised on 983 observations and 130 injury events for which complete data were available. The main effects model controls for head of cattle, number of veterinary medical tasks, method of herding, location where cattle were fed, and total hours of work on the farm, simultaneously. The Hosmer-Lemeshow goodness of fit $\chi^2 = 3.89$, 8 df, and $p = 0.87$ indicate an adequate fit.

Discussion

The cattle-related injury rates for beef cattle farms (13.7% of farms reported at least one cattle-related injury annually) calculated from the farm management survey were slightly higher than, although generally comparable to, the farm injury rates calculated at a person-level among beef farmers in a previous study using a telephone survey methodology in Kentucky. Among all beef cattle farmers who were males age 55 years and older, we estimated the injury rate to be 10.6 (95% CI: 7.3-13.9) injured farmers per 100 farmers per year (Browning et al., 1998). In their large study of farms from a five-state region in the upper Midwest, Erkal et al. (2008) estimated the animal-related injury rate at 3.2 events per 100 persons at risk per year for events attributed directly to animals. If one includes injuries attributed directly to animals as well as injuries associated with the animal operation, then the rate estimated by Erkal et al. (2008) (5.8 injured per 100 per year) approaches what we have estimated in our study. Virtanen et al. (2003) reported a rate of 8.7 injured farmers per 100 per year among fulltime farmers on cattle farms in Finland. In their national survey, Hendricks and Adekoya (2001) estimated that one out of five injuries among farm youth was animal-related, with the majority due to horses and cattle. While it is difficult to make direct comparisons due to differences in the methods employed in the several studies, it is clear that commodity-specific studies have reported increased rates of farm work injuries on farms with livestock and thus highlight the need to report commodity-specific injury rates (Layde et al., 1996; Sprince et al., 2003; Saar et al., 2006).

A majority of the family-owned and operated farms in this study performed herd maintenance tasks without a veterinarian. Cattle dehorning and castration are tasks that may be associated with an increased risk of injury. In the unadjusted analyses, farms that performed castration (OR = 1.48; 95% CI: 0.86-2.56) or dehorning (OR = 1.62; 95% CI: 1.14-2.28) were at increased risk of a cattle-related injury in comparison to farms where the operators did not undertake these tasks. While many farms in this study used veterinarians for some services (treating down cows, medical testing, and pregnancy checks), many of the routine herd management tasks, including castration, dehorning, calving, administration of growth stimulants, administration of vaccinations, deworming, antibiotic treatments, and artificial insemination, were undertaken by the principal operator or another farm family member. The logistic regression analysis confirmed that the risk of injury increased with the number of herd health tasks that were performed by operators or family members on the farm. The number of tasks or treatments performed on cattle without a veterinarian present increased the risk of cattle-related injury with the increasing number of tasks performed (linear test for trend, $p = 0.051$) and was statistically significant for the third tertile of the number of medical tasks in comparison to the first tertile. There exists a substantial literature on the animal-related injury rates among veterinarians that confirms the increased injury risk with many of these tasks (Billings, 1997; Fritschi et al., 2006; Lucas et al., 2009; Gabel and Gerberich, 2002; Kabuusu et al., 2010). Providing livestock farmers with professional veterinary support for some of the more hazardous animal handling tasks may reduce the occurrence of cattle-related injuries.

In addition to injuries associated with performing medical or herd health tasks on the animal, injuries were associated with transporting cattle and using cattle-related equipment (head gates, chutes, etc.). The risk of cattle-related injuries increased with the size of the herd, even after controlling for the increase in exposure time associated with herd

size, possibly indicating that there are factors associated with handling large numbers of animals above and beyond the increased hours required to manage the herd. Virtanen et al. (2003) also documented the increase in the reported injury rates with increasing herd size among dairy cattle. Animals in relatively large herds may pose an increase in risk to handlers, as one agitated animal may influence the behavior of the rest of the herd. In addition, the extent and design of cattle handling facilities will vary with the number of cattle on the farm, often with small producers having relatively minimal facilities. Among the farms in our survey, only 18% reported using a loading chute, 27% using a palpation cage, and 46% using a manual squeeze chute.

The results of the analyses provide suggestions for cattle handling procedures that may decrease the risk of injury. For example, herding techniques that used horses or dogs to move cattle appeared to increase the risk of injury. Hendricks and Adekoya (2001) reported that herding or moving cattle was responsible for most of the cattle-related injuries among farm youth. As a general approach to raising cattle, having the animals in pasture year round reduces the hours spent feeding the herd and the consequent risk of injury. Our study suggests that the use of ATVs for performing herding tasks may be associated with a decreased risk of a cattle-related injury in comparison to other herding techniques. A similar finding was noted in the study by Layde et al. (1996), in which the use of an ATV for chores was associated with a reduced risk of injury among adult farm residents. Obviously, the risks and benefits of ATV use need to be balanced in the context of who is operating the vehicles and for which tasks they are used.

Several investigators have documented the farm injuries associated specifically with bulls, and Sheldon et al. (2009) provide a thorough review of factors associated with bull-related incidents (Casey et al., 1997; Dogan et al., 2008). In our study, 89% of the farms reported maintaining a bull for breeding purposes. The literature indicates that the risk of injury among workers is greater, given equivalent exposure hours, with bulls than cows (Dogan et al., 2008; Sheldon et al., 2009). We did not, however, note an increased rate of cattle-related injuries among the farms with bulls.

There exists a large body of literature concerning recommendations for cattle handling, especially as they relate to the design of cattle handling facilities and appropriate behavioral techniques to employ with cattle (Grandin, 1987, 1996, 1998, 1999). Research in the design of animal handling facilities offers ideas that can affect human safety, as well as the safety and well-being of the animals. Our data suggest that there is substantial variation across the beef cattle farms in the state regarding how the cattle are fed, the usual herding tasks, the degree to which farmers perform their own medical tasks or treatments, and the extent to which different types of cattle restraining equipment are used on the farms. Interdisciplinary collaborations that focus on evaluation of alternative animal handling facilities and handling procedures on injury outcomes are needed. Indeed, facilities and procedures that minimize the harm to the animal are also (generally) likely to reduce the risk of injury to the farm workers.

Strengths and Limitations

The study provides detailed data on farm management practices on beef cattle farms among 1,149 farm operators in Kentucky. Our sample was obtained from the membership of the KCA and thus represents a convenience sample of a commodity group of farmers. A conservative estimate of the overall response rate in this study using a mail survey was 48%, after adjustment for farms that were not currently raising cattle and elimination of ineligible farms. While response bias remains a possibility, the demographic characteris-

tics of those who responded to our survey were comprised of farmers from across the state with a wide range of age and years of experience. The demographics of the respondents (e.g., age) and characteristics of their farms (e.g., head of cattle) in our survey were comparable to those for beef cattle farmers reported by the Kentucky Agricultural Statistics Service. Due to the relatively brief questionnaire used in this study, limitations include the lack of detailed information on the circumstances of the injury, the severity of the injury, and the costs associated with the injury. The proportion of injuries that required medical attention or resulted in more than four hours lost from work was 34%. Consequently, our injury rates may be higher than those of other studies due to the inclusion of less severe injuries.

All cattle-related injuries in this study were based on the self-reports of the farm operators. Given the potential for recall bias, especially the under-reporting of injuries, the estimates in this study are subject to the typical limitations of self-reports. Given the manner in which the data were collected, our analysis provides for associations between the presence of certain equipment and usual work practices on the farm with cattle-related injuries but is not based on the use of a given farm tasks or piece of equipment (such as a squeeze chute, head gate, or ATV) at the time of the specific injury event. The data provide associations between the farms that have this equipment or usually conduct certain animal handling practices and the risk of these types of injuries. In addition, residual confounding from both a failure to account for other risk factors (socioeconomic or safety factors related to the farm) and within the categories of variables used in our models may influence our reported estimates.

Conclusions

In one of the few commodity-specific farm injury studies undertaken, the Traumatic Injury Surveillance of Farmers (TISF), Myers (1997) estimated that the largest numbers of work injuries to farmers occurred in beef, hog, or sheep operations. In addition to horse and fur farms, these farms had the highest rates of injuries (8.2 injuries per 200,000 hours worked). Livestock was the leading cause of lost time injuries on these farms, accounting for 18.1% of the total number of injuries (Myers, 1997). Our study confirms the relatively higher injury rates on cattle farms in comparison to other commodity farms and highlights the diversity of approaches to accomplishing the daily tasks related to raising cattle. Continued research is needed on the prevention of work-related injuries in the context of specific commodities, focused on the strategies and management approaches that reduce the risk of injury to humans and enhance animal welfare.

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