AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 52:419–428 (2009)

Risk Factors for Serious Injury in Finnish Agriculture

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Background *Previous studies indicate 20% of injuries represent 80% of injury costs in agriculture. To help prevent the most costly injuries, we aimed to identify characteristics and risk factors associated with serious injuries.*

Methods *We analyzed insurance records of 93,550 self-employed Finnish farmers. We ranked injury causes by claim cost and used multiple logistic regressions to identify risk factors for (any) injury and serious injury (injuries exceeding claim costs of €2000).*

Results *A total of 5,507 compensated injuries occurred in 2002 (rate 5.9/100 person-years), and 1,167 or 21% of them (rate 1.25/100 person-years) were serious. The causes/sources resulting in highest average claim costs were motor vehicles; stairs, scaffoldings, and ladders; trailers and wagons; floors, walkways, and steps; other structures and obstacles; augers, mills, and grain handling equipment; horses; combines and harvesting equipment; tractor steps; and uneven and slippery terrain. Older age, male gender, higher income level, greater field size, residing on the farm, Finnish language (vs. Swedish), occupational health service (OHS) membership, and animal production were risk factors for injury. The risk factors for serious injury were similar; however, the effects of age, income level, and the raising of horses were more prominent. Language, residence, ownership status, and OHS membership were not risk factors for serious injury.*

Conclusions *Cost-effective prevention efforts should address the following risk factors: older age, male gender, larger income and operation size, livestock production (particularly dairy, swine, and horses), motor vehicle incidents, falls from elevation, and slips, trips and falls.* Am. J. Ind. Med. 52:419–428, 2009. © *2009 Wiley-Liss, Inc.*

KEY WORDS: agriculture; injury; accident; insurance; workers' compensation

INTRODUCTION

Agriculture is a hazardous industry. In Finland, the occupational fatality rate in 2002 was 11/100,000 among self-employed farmers and 2/100,000 for all industries combined. The non-fatal injury rate was 5.8/100 among self-employed farmers and 2.8/100 in all industries [Eskola et al., 2003; Ministry of Social Affairs and Health, 2006]. The US agricultural fatality rate was three times higher (32/100,000) and the all-industry rate was twice as high (4/100,000) compared to Finland [CFOI, 2007]. The US OSHA recordable injury rates were 6.1/100 full-time employee years (FTE) among hired agricultural workers and 4.3/100 FTE among all workers in private industries [Bureau of Labor Statistics, 2007]. In 1996 the direct insurance cost of agricultural injuries

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Contract grant sponsor: National Institute for Occupational Safety and Health (NIOSH); Contract grant number: K01 OH008300.

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Accepted 5 January 2009
DOI 10.1002/ajim.20688. Published online in Wiley InterScience (www.interscience.wiley.com)

in Finland was 0.7% of the gross farm income and 2.2% of the net farm income [Rautiainen et al., 2005a]. In 1992 the US agricultural injury costs (direct and indirect costs) were estimated at $4.573 billion, which was 2.8% of the value of agricultural products sold, and 15.0% of the net cash returns [Leigh et al., 2001; USDA, 1992].

While preventive efforts have been initiated to reduce the high rates and costs of agricultural injuries, there is little evidence that these efforts have been effective [DeRoo and Rautiainen, 2000; Rautiainen et al., 2008]. Some progress has been made in reducing tractor overturn fatalities. Many countries (including Finland in 1969) have established legislation to mandate the use of Rollover Protective Structures (ROPS) on tractors [Springfeldt, 1993]. In the US, manufacturers have equipped new tractors with ROPS voluntarily since 1986. While the magnitude and trends of agricultural fatalities are fairly well understood, less information is available on non-fatal injuries [McCurdy and Carroll, 2000; Rautiainen and Reynolds, 2002].

A recent study showed that 20% of the most serious injury claims represented 79.5% of all workers' compensation costs among Finnish farmers [Rautiainen et al., 2005a]. This finding suggests that preventive efforts should be targeted at the most serious injuries as such a strategy would improve the cost-effectiveness of the efforts. Using comprehensive national insurance and agricultural statistics data for Finnish farmers, our current study aims to identify characteristics and risk factors that are associated with serious injuries. We expect that serious injuries have specific characteristics and risk factors, which are different from those of other (minor) injuries. The resulting information allows for improved targeting of preventive efforts and for improving their cost-effectiveness.

METHODS

This study used administrative insurance data from the Finnish Farmers Social Insurance Institution (Mela) and the Finnish national agricultural statistics service. All farmers with at least five hectares of farmland are covered by mandatory workers' compensation insurance. Their farm, production, insurance, and claims records were extracted and merged into research datasets where social security number was replaced with random number, and name and address information was removed. The data are maintained in Finnish or Swedish, based on the insured person's native language. The lead author was previously employed by Mela and is familiar with the languages and data resources. Mela accepted his formal request to use specified data for this research (KO1 OH008300). The University of Iowa's Institutional Review Board and the Centers for Disease Control and Prevention (NIOSH Research Grants Program Office) determined that this study was not considered human subjects research, because it used existing data collected for insurance purposes, made no contact with study subjects, and used data without personal identifiers. This decision was based on an interpretation of the August 10, 2004 document (Guidance on Research Involving Coded Private Information or Biological Specimens), issued by the Office for Human Research Protections (OHRP) of the Department of Health and Human Services (HHS) [OHRP, 2004].

Subjects

The study population consisted of 93,550 farmers who were insured during the entire calendar year 2002. Those farmers filed 5,977 compensated claims, 5,507 of them for injuries, 302 for occupational diseases and 168 for specific illnesses which are defined by statute (not injury and not occupational disease; resulting from relatively short [1 day to few days] exposure, including specific low back pain and cumulative trauma). Some farmers (n = 493) were injured more than once during 2002 and filed multiple claims. The numbers of records used in this study are summarized in Table I.

Injury Characteristics

The data included several coded variables for characterizing the injury including the work activity while experiencing the incident, cause, nature of incident, and ICD10 health outcome. Most of these variables had detailed coding systems (some had more than hundred categories). We ranked the causes by mean claim cost and used a Chi-square test to assess

TABLE I. Number of Insured Farms, Farmers, Claims, and Records in Dataset (2002)

Type of record	Frequency
Farms	63,886
Farmers (incl. spouses and salaried family members)	93,550
Farmers filing no compensated claims	88,138
Farmers filing one or more compensated claims	5,412
1 claim	4,919
2 claims	433
3 claims	51
4 claims	8
7 claims	1
Number of compensated claims	5,977
Injuries	5,507
Occupational diseases	302
Specific illnesses defined by statute (incl. certain low back pain)	168
Records added for farmers who had multiple injury claims (new lines for second, third, etc., additional injury claim)	565
Records (lines in the final dataset): includes all farmers, plus repeat entries for those farmers with multiple injury claims	94,115

the differences in the proportions of the various cause categories for serious and non-serious injuries.

Outcome

Compensated claims were used as outcome. A total of 5,507 occupational injuries which occurred in 2002 were compensated. Occupational diseases, specific illnesses defined by statute, and leisure injuries were excluded. A compensable injury is described as a sudden unexpected forceful event due to an external cause in the course of agricultural work, resulting in bodily damage or an ailment. Disability duration and claim cost were available for measuring injury severity. These measures were correlated ($r = 0.42$, $P < 0.001$). We constructed two "serious injury" outcome variables which identified about 20% of the most serious cases: (1) claims with at least €2000 cost and (2) claims with at least 30-day disability duration. Cost-effective injury prevention was the primary focus of this paper. Hence the definition of a serious injury in terms of claim costs in excess of €2000 was used as the outcome variable.

Potential Risk Factors

The potential risk factor variables available in our data included: age, sex, language, years insured (farmed), farm income, municipality, residence (farm/off-farm), status (owner/operator, salaried family member, other), field hectares, forest hectares, occupational health service (OHS) membership, main farm production type, and presence of bovines, pigs, poultry, sheep, and horses on the farm. Some of these variables are unique to Finnish agriculture. Language is an indicator of culture and farming practices which differ somewhat among Finnish and Swedish speaking farmers. Insurance years indicate the duration of pension and workers' compensation insurance coverage—typically years as farm owner/operator. Farm income is the individual's share of the total farm income; Mela uses the size of the operation in its calculation. OHS membership indicates whether the farmer has joined the voluntary health and safety program which has been available since the 1980s [Husman et al., 1990]. Most farms own some forest, and the associated forestry work carries specific health and safety hazards. The main production type indicates where the farm receives most of its income, but farms typically raise other commodities and/or animal species as well. Municipality was not used in the regression analyses because of the large number of municipality codes (n = 428).

The original coding in the source data was used for most of the categorical variables, with the exception of a few main production type categories with very low frequencies which were grouped into "other production." Continuous variables were categorized for logistic regression analyses as shown in Table II. The unit of analysis was person/record (n = 94,115).

TABLE II. Potential Risk Factor Variables (n = 94,115 Records)

Variable	Category	Count	Percentage
Age	19–29	4,049	4
	30–39	19,032	20
	40–49	31,603	34
	50–59	33,116	35
	60-	6,315	7
Sex	Male	59,392	63
	Female	34,723	37
Language	Finnish	86,202	92
	Swedish	7,913	8
Insurance years	0–9	19,473	21
	>10	74,642	79
Income in Euros	0–4,999	12,658	13
	5,000–9,999	22,738	24
	10,000–14,999	30,934	33
	15,000-	27,785	30
Residence	Farm	88,675	94
	Off-farm or not known	4,244	5
Status	Farmer	92,409	98
	Family member	1,706	2
Field hectares	0–9	15,382	16
	10–19	23,369	25
	20–29	19,553	21
	30–39	12,586	13
	>40	23,225	25
Forest hectares	0–49	35,962	38
	>50	58,153	62
OHS member	Yes	29,779	32
	No	64,336	68
Main production	Special crops	5,354	5.7
	Vegetables	2,083	2.2
	Greenhouse	417	0.4
	Other crops	3,587	3.8
	Dairy	30,332	32.2
	Beef	5,520	5.9
	Other bovines	630	0.7
	Feeder pigs	2,254	2.4
	Finishing pigs	1,536	1.6
	Other pigs	1,928	2.0
	Poultry	346	0.4
	Eggs	938	1.0
	Other poultry	185	0.2
	Sheep	590	0.6
	Goats	49	0.05
	Horses	969	1.0
	Other production	322	0.3
	Unknown	10,947	11.6
	Cereal crops	26,128	27.8
Presence of animals	Bovines	36,883	39
	Pigs	5,721	6
	Poultry	3,007	3
	Sheep	2,166	2
	Horses	4,749	5

TABLE III. Number and Percentage of Injuries by Severity

Injury severity class	Number of injuries	Percentage of injuries	Number of injuries per one fatality	Injury rate per 1,000 person-years
Fatality	11	0.2	1	0.1
Disability duration				
≥360 days	96	1.7	9	1.0
240–359 days	63	1.1	6	0.7
120–239 days	194	3.5	18	2.1
60–119 days	369	6.7	34	3.9
30–59 days	723	13.1	66	7.7
14–29 days	1301	23.6	118	13.9
7–13 days	1529	27.7	139	16.3
1–6 days	666	12.1	61	7.1
0 days	566	10.3	51	6.0
Total	5518	100.0	502	59.1
Compensation amount				
≥€10,000	179	3.3	17	1.9
≥€5000	451	8.3	42	4.9
≥€2000	1167	21.7	109	12.8

Statistical Methods

Multiple logistic regression was used as the primary method for identifying the risk factors for injury. Risk factors were examined at two outcome severity levels: (1) any injury vs. no injuries and (2) serious injury (at least €2000 claim compensation) versus no injuries. We employed the stepwise (forward) procedure for initial model selection for the any injury data, including and keeping variables at the $P < 0.05$ level. We then used this model with its included factors for the analysis of the serious injury data. Using the Chi-square test, we examined whether there was an association between the cause and the severity of injury. For each injury cause, we calculated the average claim amount and its standard error. Injury causes were ranked on the basis of their average claim compensation amount. Statistical analyses were performed using SAS Version 9.1 software [SAS Institute Inc, 2007].

RESULTS

Subjects

Farmers (93,550) were insured during 2002 (63% male, 37% female). The data set included 94,115 records, after adding 565 records for farmers who filed more than one injury claim. These repeated entries were necessary to maintain information on all compensated claims. Means (with standard deviation in brackets) for selected demographic characteristics were: age 46 (9) years, years farmed/insured 18 (9), farm income €12,135 (€6,067), field size 30 (26) hectares, and forest size 53 (61) hectares.

Outcomes

A total of 5,507 injury claims were compensated (rate 5.9/100 person-years). The great majority of insured farmers 88,138 (94%) filed no injury claims for the year 2002. Out of those who did file, most filed only one injury claim. Some filed multiple claims, up to seven cases. This distribution is presented in Table I.

The severity distribution of the injury outcomes is presented in Table III. Fatality cases (n = 11) were added to this table, increasing the total injury count to 5,518. The number of compensated injuries increased as the severity decreased. However, in the least serious categories, the number of claims decreased for reasons that are explained in the discussion. The "injury pyramid"—number of less serious injuries per one fatality is also presented in Table III. The same information in fewer categories is drawn in Figure 1.

Injury Risk Factors

Logistic regression with a stepwise (forward) model selection procedure identified the following risk factors for (any) injury: age, sex, language, income, residence, ownership status, field size in hectares, OHS membership, main type of production, and the presence of bovines, poultry, sheep, and horses. Most of these risk factors were also significant when using serious injury as outcome. Table IV gives estimates of the odds ratios (OR), together with their 95%

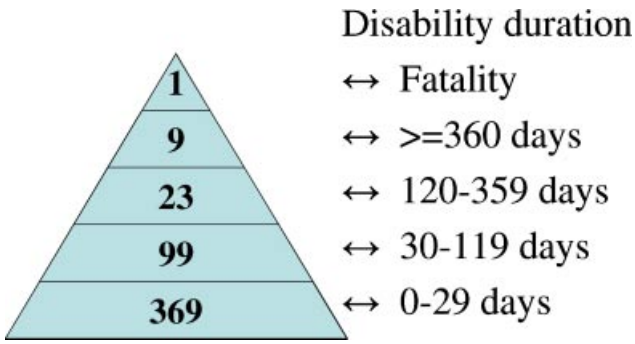

FIGURE 1. Injury pyramid. Number of non-fatal injuries per one fatality.

confidence limits, for the levels of each explanatory variable. The odds ratios need to be interpreted relative to the selected reference group. Significant odds ratios are presented in bold.

The results indicated that older farmers had a higher risk of injury, and an even higher risk of serious injury. Men had a higher risk of injury and serious injury compared to women. Higher income level was a risk factor; the odds of injury 3.26 (2.74–3.88) and serious injury 4.94 (3.27–7.46) were clearly higher in the highest income group compared to the lowest income group. Finnish language (compared to Swedish), residence on the farm, owner status, and OHS membership were significant risk factors for injury, but not for serious injury. Greater field size was a risk factor; the odds of injury 1.37 (1.19–1.56) and serious injury 1.52 (1.11–2.09) were higher in largest field size group compared to the smallest group. Main farm production type was associated with injury and serious injury. In general, animal production and special crops increased the injury risk compared to growing cereal crops. Dairy and swine production and the raising of horses and goats increased the injury risk. Even though the presence of various livestock species duplicated the main type of production, we included both in the analyses, since it is common to raise more than one crop and/or livestock species on a farm.

We examined the severity of injuries as a function of the cause of the incident. We combined the 108 original cause categories into the 37 larger categories shown in Figure 2. We first examined the association of injury severity ($\geq$€2000 claim Y/N) and injury cause and found significant differences (Chi-square test, $P < 0.0001$). We then calculated the average claim costs (for all injuries) and their standard errors and ranked the causes by claim cost. The results are presented in Figure 2. This figure also lists the frequency of injuries for each cause category.

DISCUSSION

The current study reports injury risk factors from a large national insurance system (which started in 1982) that covers practically all farmers in Finland. Farmers have a financial incentive to claim their injuries, and a well established legal framework is in place to guide insurance practices. The farmers in this population were relatively young, 46 years on the average, compared to 55 years in the US [USDA, 2002]. The pension system enables retirement at age 63–68 and in many cases younger [Farmers Social Insurance Institution, 2007]. Farmers were predominantly male; only 37% were female. The average field area was 30 hectares (74 acres) and the average forest area was 53 hectares (130 acres). Finnish farms were smaller than farms in many industrialized countries, but about half of Finnish farms were still full-time operations (>75% of income comes from farming) [Virtanen et al., 2003].

The injury rate during 2002 was 5.89 injuries per 100 person-years, which is similar to the rates found by other studies [McCurdy and Carroll, 2000; Rautiainen and Reynolds, 2002]. While the great majority of farmers had no injuries in 2002, some had as many as seven. Farmers with frequent injury claims may have specific risk factors. This issue is addressed in an ongoing study using longitudinal data with 10-year and career-long injury claim datasets.

In 2002, 4,919 farmers filed one claim and 493 farmers filed two or more claims. We added 565 new records (lines) for those farmers who had more than one claim in order to maintain information on all injury cases. Our logistic regression models ignore the violation of the independence assumption (493 farmers had duplicate records, and one could expect that repeated observations on the same farmer are no longer independent). However, we verified the results of the logistic regression with a Generalized Estimating Equations (GENMOD) analysis, using the person ID as the clustering factor [SAS Institute Inc, 2007]. We have not reported these results as they were similar to the logistic regression results in Table IV.

The study material enabled examination of injury severity using claim cost and disability duration. The "injury pyramid"—distribution of injuries at various severity levels, has been discussed earlier by Heinrich [1941] and others. This study provided an example of "injury pyramid" proportions for self-employed farmers. For each fatality, there were about ten 1-year disabilities, hundred 1-month disabilities, and 400 less serious injuries. In this workers' compensation system, the number of claims increases exponentially when going from most serious to less serious cases, but decreases again towards shortest disability times (similar distribution in claim cost). This is likely due to farmers not finding it worth their time to make small claims. The no-claims bonus system also discourages making small claims [Rautiainen et al., 2005b].

Overall, the analyses identified many risk factors for injuries and a smaller number of risk factors for serious injuries. There was a linear association between age and injury; and an even stronger association for serious injury. Older age groups were at greater risk. Male gender was a clear

TABLE IV. Risk Factors for All Injuries and Serious Injuries (n = 94,115 Records)

			All injuries (n = 5507)			≥€2000 injuries (n = 1195)		
				95% Confidence limits			95% Confidence limits	
Variable	Category	Frequency	Odds ratio	Lower	Upper	Odds ratio	Lower	Upper
Age	19–29—reference	4,049	—	—	—	—	—	—
	30–39	19,032	1.01	0.86	1.17	1.29	0.89	1.88
	40–49	31,603	1.08	0.93	1.26	**1.58**	**1.10**	**2.28**
	50–59	33,116	**1.28**	**1.10**	**1.49**	**1.91**	**1.32**	**2.75**
	≥60	6,315	**1.30**	**1.08**	**1.56**	**1.61**	**1.04**	**2.48**
Sex	Male	59,392	**1.77**	**1.66**	**1.89**	**1.41**	**1.24**	**1.61**
	Female—reference	34,723	—	—	—	—	—	—
Language	Finnish	86,202	**1.30**	**1.15**	**1.46**	1.22	0.96	1.55
	Swedish—reference	7,913	—	—	—	—	—	—
Income, Euros	0–4,999—reference	12,658	—	—	—	—	—	—
	5,000–9,999	22,738	**2.05**	**1.74**	**2.43**	**2.18**	**1.45**	**3.28**
	10,000–14,999	30,934	**2.71**	**2.28**	**3.20**	**3.35**	**2.23**	**5.03**
	≥15,000	27,785	**3.26**	**2.74**	**3.88**	**4.94**	**3.27**	**7.46**
Residence	Farm	88,675	**1.47**	**1.19**	**1.81**	1.41	0.89	2.24
	Not known	4,244	1.21	0.84	1.76	1.52	0.73	3.17
	Off-farm—reference	1,196	—	—	—	—	—	—
Status	Owner operator	92,409	**0.67**	**0.53**	**0.86**	0.71	0.40	1.27
	Other—reference	1,706	—	—	—	—	—	—
Field size, ha	0–9—reference	15,382	—	—	—	—	—	—
	10–19	23,369	1.01	0.89	1.15	1.07	0.79	1.44
	20–29	19,553	**1.16**	**1.01**	**1.33**	1.33	0.96	1.81
	30–39	12,586	**1.19**	**1.03**	**1.37**	**1.40**	**1.01**	**1.94**
	≥40	23,225	**1.37**	**1.19**	**1.57**	**1.52**	**1.11**	**2.09**
OHS member	Yes	29,779	**1.28**	**1.20**	**1.36**	1.12	0.99	1.27
	No—reference	64,336	—	—	—	—	—	—
Production	Special crops	5,354	**1.30**	**1.12**	**1.49**	1.07	0.80	1.44
	Vegetables	2,083	**1.47**	**1.17**	**1.84**	0.83	0.46	1.49
	Greenhouse	417	**1.90**	**1.20**	**3.01**	1.14	0.36	3.60
	Other crops	3,587	**1.28**	**1.05**	**1.56**	1.23	0.82	1.86
	Dairy	30,332	**2.07**	**1.71**	**2.51**	**1.49**	**1.01**	**2.22**
	Beef	5,520	**1.54**	**1.25**	**1.90**	0.95	0.61	1.49
	Other bovine	630	**1.88**	**1.34**	**2.63**	1.59	0.81	3.12
	Feeder pigs	2,254	**2.04**	**1.72**	**2.42**	**1.45**	**1.00**	**2.09**
	Finishing pigs	1,536	**1.42**	**1.14**	**1.77**	**1.69**	**1.14**	**2.48**
	Other pigs	1,928	**1.82**	**1.51**	**2.18**	**1.46**	**1.00**	**2.12**
	Poultry	346	1.09	0.67	1.77	0.64	0.15	2.67
	Eggs	938	**1.60**	**1.19**	**2.16**	1.93	0.99	3.72
	Other poultry	185	1.20	0.64	2.26	0.63	0.08	4.66
	Sheep	590	**1.56**	**1.03**	**2.37**	0.77	0.27	2.23
	Goats	49	**4.77**	**1.96**	**11.60**	2.90	0.38	22.06
	Horses	969	**2.76**	**2.10**	**3.62**	**3.08**	**1.82**	**5.20**
	Other production	322	1.66	0.98	2.81	1.89	0.69	5.17
	Unknown	10,947	1.08	0.92	1.27	0.97	0.69	1.37
	Cereals—reference	26,128	—	—	—	—	—	
Bovines	Yes	36,883	**1.27**	**1.06**	**1.52**	1.38	0.95	2.01

(*Continued*)

TABLE IV. (*Continued*)

			All injuries (n = 5507)			≥€2000 injuries (n = 1195)		
				95% Confidence limits			95% Confidence limits	
Variable	**Category**	**Frequency**	**Odds ratio**	**Lower**	**Upper**	**Odds ratio**	**Lower**	**Upper**
	No—reference	57,232	—	—	—	—	—	
Poultry	Yes	3,007	**1.28**	**1.08**	**1.53**	0.73	0.47	1.13
	No—reference	91,108	—	—	—	—	—	
Sheep	Yes	2,166	**1.24**	**1.02**	**1.50**	**1.50**	**1.01**	**2.22**
	No—reference	91,949	—	—	—	—	—	—
Horses	Yes	4,749	**1.22**	**1.08**	**1.37**	1.17	0.91	1.51
	No—reference	89,366	—	—	—	—	—	—

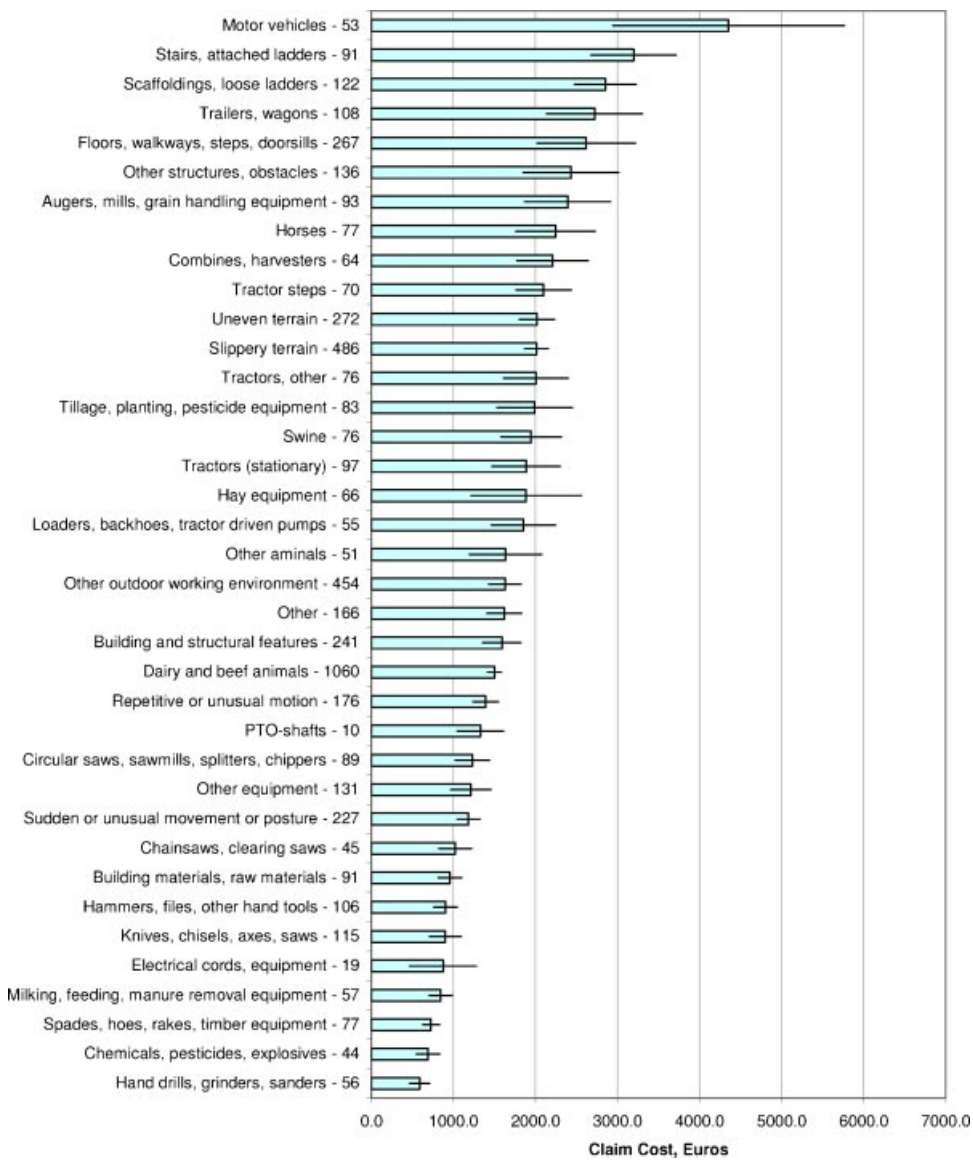

FIGURE 2. Average claim cost and standard error by cause of injury. Frequency of injuries indicated for each category.

risk factor for injury and slightly less for serious injury. Finnish language was a risk factor for injury, but not for serious injury. It is likely that language is an indicator for differences in culture, farming practices, and the utilization of the insurance system. Since no language effect was found for serious injury, it is likely that Swedish speaking farmers do not make small claims quite as readily as Finnish speaking farmers, although insurance services and claims forms are provided in both languages. This phenomenon is not well understood and would require further study. There was a strong linear association with income and injury risk; greater income level was a risk factor, particularly for serious injury. This is not surprising as the income level reflects the size of the operation and exposure time to farm hazards. Farmers with high farm (and off-farm) incomes suffer greater financial losses and their claims are a greater burden for the insurance system. Farm (vs. off-farm) residence was a risk factor for injury but not for serious injury. Owner/operator status (vs. salaried family member) was protective for injury but not for serious injury. The numbers of persons residing off the farm and non-owner-operators were small. There was a linear association with field size and injury risk. Larger field size was a risk factor for both injury and serious injury. Forest size was not significant. Interestingly, OHS aims to prevent injuries and illnesses but OHS membership was a risk factor for injury. There was no significant association with serious injury. These results could be due to reporting bias where OHS members are more active in making claims, particularly for less serious injuries. Most farm production types or commodities had an elevated injury risk compared to growing cereal crops. Particularly raising dairy, pigs, horses, and goats had high odds ratios.

Overall, the risk factors for injury and serious injury were quite similar. Moderate differences were found in some variables. Partly due to smaller number of serious injury outcomes, fewer odds ratios for serious injury were significant. The risk of serious injury was prominent for older age, larger income, larger field size, and raising horses.

A literature search from PubMed (at: http://www.ncbi.nlm.nih.gov/pubmed/) produced eight agricultural injury risk factor studies. These studies found that the following factors were associated with an increased risk of injury: age less than 45 years, doctor-diagnosed asthma, education beyond high school, and difficulty hearing normal conversation (even with a hearing aid, in the case of those using one) [Sprince et al., 2007]; livestock, poor general health, and exposures to dust and gas, noise, chemicals, pesticides, and lifting [Rautiainen et al., 2004]; hearing loss in the better ear, hearing asymmetry, and fair/poor self-reported hearing [Choi et al., 2005]; number of machines, musculoskeletal disorders, and management quality (significant work delays) [Suutarinen, 2004]; male gender [Dimich-Ward et al., 2004]; child's sex and parental education [Bancej and Arbuckle, 2000]; moving animals within the farm, veterinary procedures, repair of field machinery, and stable equipment [Rasmussen et al., 2000]; and age (and/or experience), previous injury status, body mass index, hours of sleep, a daytime drowsiness and perceived stress [Low et al., 1996]. Most of these studies were from relatively small populations, used cross-sectional samples, and relied on self-reported data. A larger study using 1996–1997 data from the same sources as the current study reported on injury characteristics and risk factors, including gender, language, farm type, cultivated area, and number of dairy cows [Virtanen et al., 2003]. For gender, language, and cultivated area, our results are very similar. The current study includes several new variables and expanded the farm type into more specific categories. Our focus was to examine if risk factors for serious injuries (over €2000 compensation) differ from the risk factors found for all injuries combined.

The assessment of injury causes revealed clear differences in the severity of injuries from different causes/sources. The most serious injuries were caused by cars, trucks, vans, motorcycles, snowmobiles, and other motor vehicles. These injuries are typically from roadway incidents when commuting or conducting farm business. Next serious injuries were caused by stairs, ladders, and scaffoldings. These injuries typically result in serious fall injuries. Floors, walkways, obstacles, trailers, wagons, tractor steps, uneven terrain, and slippery terrain formed another group of causes/sources resulting in slip, trip, and fall injuries. Perhaps contrary to common beliefs, these injuries were also more serious than most other injury types. Horses and swine were also among causes resulting in serious injuries.

The *strengths* of our study include large population size, outstanding power, and the availability of unique variables. The material in this study consisted of the entire self-employed farmer population in Finland. The Farmers Social Insurance Institution (Mela) administers the mandatory pension and workers' compensation insurance systems and maintains records for each insured person. Additional farm information (field and forest hectares, numbers of animals, and main production type) was added from national agricultural statistics. These detailed records enable an analysis of injury characteristics and risk factors. Similar total population-based agricultural injury data resources may not be available for research in other jurisdictions (countries). We found only a limited number of studies reporting on injury risk factors, all from smaller samples using self-reported survey data.

The *limitations* in using administrative data include limited number of useful variables. The potential risk factor variables in this study were fairly few and general in nature; mostly basic personal characteristics (age, sex, etc.) and farm production (field size, main production, etc.) characteristics. The analysis of injury causes provided further detail. However, a study which generates knowledge of injury characteristics, risk factors, and causes can only be used to point out

what should be prevented—not *how*. Some risk factors are modifiable, while others are not. Both types of factors can be considered in resource allocation and preventive work. Modifiable risk factors, such as production of certain crops, can be addressed directly. A non-modifiable risk factor, such as male gender, may be an indicator for different exposures rather than risk in itself. Non-modifiable risk factors are also useful for allocating prevention resources to those demographic and farm production categories with high risks. Based on the current level of scientific knowledge, direct evidence-based advice on how to prevent specific types of injuries is not possible. Various combinations of engineering, education, enforcement, incentives, and other measures may be needed to prevent specific types of injuries in specific populations. Further intervention effectiveness studies are badly needed as two systematic reviews have found no clear evidence that agricultural interventions have been effective in reducing injuries [DeRoo and Rautiainen, 2000; Rautiainen et al., 2008].

CONCLUSIONS

A total of 5,507 compensated agricultural injuries occurred in Finland in 2002, and 1,167 (21%) of them were serious according to our definition. The causes resulting in highest average claim costs included motor vehicles; stairs, scaffoldings, and ladders; trailers and wagons; floors, walkways, and steps. Older age, male gender, higher income level, greater field size, residing on the farm, Finnish language (vs. Swedish), OHS membership, and animal production were risk factors for injury in general. The risk factors for serious injury were similar to (any) injury. However, the effects of age, income level, and the raising of horses were more prominent. Language, residence, ownership status, and OHS membership were not risk factors for serious injury. Cost-effective prevention efforts should address the following factors: older age, male gender, larger income and operation size, livestock production (particularly dairy, swine, and horses), motor vehicle incidents, falls from elevation, and slips, trips and falls.

ACKNOWLEDGMENTS

This study was funded by the National Institute for Occupational Safety and Health (NIOSH) (KO1 OH008300). The NIOSH-funded Great Plains Center for Agricultural Health (U50 OH07548) provided in-kind support, and The Finnish Farmers Social Insurance Institution (Mela) provided data and staff support.

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