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Occupational Injury and Disease Incidence and Risk Factors in Finnish Agriculture Based on 5-Year Insurance Records

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ABSTRACT. The aim of this retrospective cohort study was to evaluate the incidence of and risk factors for compensated occupational injuries and diseases in agriculture. The study population consisted of 78,679 Finnish farmers, spouses, and salaried family members covered by mandatory workers' compensation insurance. This population had a total of 24,424 occupational injuries and 1684 diseases from 2000 to 2004. In the 5-year period, 20.2% of the population had (one or more) injuries and 2.0% had occupational diseases. Multiple claims were common particularly among livestock producers. Using Poisson regression analyses, we identified several personal and farm-related risk factors, with relative risk estimates ranging from 1.07 to 3.08 for injuries and from 1.45 to 3.01 for diseases. Cattle-intensive geographic regions, occupational health service membership, large farm size, and farming alone were identified as risk factors for both outcomes. Further, male gender, higher number of insurance years, and residing on the farm were among risk factors for injury. These risk factors identified from a large longitudinal data set can be considered for developing and targeting interventions for farmers at highest risk of occupational injury and disease.

KEYWORDS. Agriculture, cohort study, compensated claim, disease, farmer, gender, injury, insurance, livestock, occupational, Poisson regression, risk factor

INTRODUCTION

Although farmers are a relatively small proportion of the total labor force in many countries, agriculture ranks among the most hazardous industries globally based on occupational injury rates.[1] In addition to injuries, occupational and other work-related diseases constitute a major threat to the health of farmers.[2] Previous studies have reported high occupational injury and disease rates among both male and female farmers.[3–5] Some studies have reported high injury rates among children, adolescents, elderly persons, and salaried workers on farms as well.[6–8] A growing body of literature has identified individual and work-related risk factors for occupational injuries and diseases.[9–11]

According to a meta-analysis of Visser et al.,[12] occupational injuries and diseases are not distributed evenly in the working population;

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some individuals have frequent injuries and diseases, whereas others have few or none. However, there is little information on this phenomenon in the agricultural sector. In the study of Rautiainen et al.,[13] the majority of self-employed farmers had no compensated injury claims in a given year, and out of those who did, most had one claim, but some had up to seven claims. According to a another study focusing on full-time Finnish farmers,[14] one fifth of all compensated injuries occurred to those who had previous injuries in a 2-year observation period. Visser et al.[12] suggests that persons with frequent compensated injury claims may be described injury-prone individuals, and they could be considered a specific target group for prevention. It has been suggested that injury-prone individuals are also more likely to suffer from illnesses.[15]

Occupational injuries and diseases differ in regard to their probability, severity, and risk factors. Zhao et al.[16] and Sinisalo[17] examined these three dimensions regarding injuries in agriculture. Injury risk factor studies often define injury without consideration for the severity of injury. In one study conducted among Finnish farmers,[13] risk factors were identified for all injuries and serious injuries (at least €2000 claim compensation) separately. The comparison of identified risk factors for serious injuries and all injuries showed similar risk factor profiles but some risk factors were more prominent for serious injuries.[13] According to Rautiainen et al.,[18] occupational diseases are about 5 times as costly as injuries on average. Furthermore, one fifth of the most serious claims represented four fifths of all accident insurance costs.[18]

A range of preventive efforts have been implemented to reduce the high rates and costs of occupational injuries and diseases in agriculture, but to date, there is little evidence that these efforts have been effective.[19] We suggest that better understanding of the risk and protective factors for both occupational injuries and diseases is an important step in targeting prevention and improving the efficiency of preventive programs.

Our retrospective study aimed to evaluate the incidence of and risk factors for compensated occupational injuries and diseases requiring medical care in agriculture based on 5-year insurance claim records. Using longitudinal national insurance and agricultural statistic data for self-employed Finnish farmers, we aimed to identify segments of the farming population with either increased or decreased risk of occupational injuries and diseases. This information can be used for selecting target groups for interventions.

MATERIALS AND METHODS

This study builds on an earlier study of Rautiainen et al.[13] We used similar administrative insurance data from the Farmers' Social Insurance Institution (Finnish acronym: Mela) and the national agricultural statistics service (Finnish acronym: Tike). These data are routinely generated and used in the administration of pension and accident insurance programs at Mela. No additional data collection was carried out for this study. The research data sets included no personal identifiers. A randomly generated personal identifier was used in separate data elements, which enabled us to merge and generate research data sets. Data on occupational fatalities (about 10 cases per year) were also excluded. Confidentiality was described in a signed agreement between Mela and the authors in accordance with Finnish laws governing use of insurance data for research.

Subjects

Finnish agriculture is based on traditional family farming. Farmers, spouses, and salaried family members with at least 5 hectares (12.4 acres) of farmland are required to carry insurance (workers' compensation) against occupational injuries and diseases. Their insurance coverage and benefits are based on the size of the farm operation, which is calculated from owned and rented arable land, forestland, and nonfarm business activity on the farm. The premiums and benefits of each insured person are based on his/her share of the calculated farm income, reflecting his/her contribution to farm

work. Mela is the sole carrier of this mandatory accident insurance scheme for farmers, known as Mata insurance.

Hired nonfamily workers and municipal farm relief workers compose approximately 15% of the total workforce in agriculture.[20,21] They are covered by other workers' compensation insurance systems. In Finland, the statutory farm relief worker service enables livestock farmers to take an annual vacation (up to 26 days) free of charge. All farmers are entitled to partially subsidized relief worker services temporarily, for example, in the case of disability.

Our base population consisted of those who were covered by Mata insurance on December 31, 2002 (96,858 persons).[22] We excluded those who started farming between January 1, 2000, and December 31, 2002, and those who retired from farming between January 1, 2003, and December 31, 2004. After these exclusions, our study population consisted of 78,679 self-employed Finnish farmers, spouses, and salaried family members who were insured during the entire 5-year period of 2000−2004. The difference (18,179 farmers, 18.8%) is an indication of turnover in the farming population in a 5-year period.

Outcome Variables

Data provided by Mela included occupational injury and disease claim records for the insured population during 2000–2004. An occupational injury is defined as a sudden, unexpected, and unwanted forceful event due to an external cause in the course of agricultural work, resulting in bodily damage. An occupational disease is defined as a disease that is probably predominately due to physical, chemical, or biological factors associated with agricultural work. We used compensated occupational injury and disease claims requiring medical care (i.e., treated and/or diagnosed by a nurse/physician) in our analyses. The claim records consisted of 24,424 compensated occupational injuries and 1684 compensated occupational diseases. Personal counts of occupational injury and disease claims were constructed for each insured person over the 5-year period. These outcome data elements were merged into the data set with demographic and farm variables for the entire study population.

Potential Risk Factors

Potential risk factor variables included demographic, insurance, and occupational health service membership variables from Mela as well as farm production variables from Tike for the year 2002—the middle year of our observation period. The potential risk factor variables available in our data were

- *Sociodemographic data*: age and gender of the insured person, native language (Finnish/Swedish, both official languages), farm income (person's share of the total farm income confirmed by Mela), region (location of the farm, 20 regions), residence of the insured person (farm/off-farm), and status of the insured person (farmer/spouse or salaried family member).
- *Insurance data*: years covered by insurance (work experience as owner/operator of the farm) and number of insured persons on the farm.
- *FOHS data*: farmers' occupational health service (FOHS) membership (Yes/No).
- *Farm data*: field hectares, forest hectares, and main type of production (18 types).

Some of the abovementioned variables are unique to Finnish agriculture. Finland has a Swedish-speaking minority (5.6% of the general population in 2002[23]), which is mostly concentrated to Åland Islands and certain coastal municipalities in southern, southwestern, and western Finland. In comparison with other Finns, Swedish-speaking Finns have cultural differences that have positive effects to their general health.[24] Farmers' occupational health service (FOHS) membership indicates whether the farmer has joined the voluntary health and safety program. FOHS is most commonly utilized by full-time farmers, especially dairy and other livestock producers.[25] The majority of active Finnish farms own forestland: in 2002 94% of the Finnish farms owned forestland, 49 hectares (121 acres) on average.[26]

Forestry work involves specific health and safety hazards.[27,28] In 2002, approximately 700 forestry work–related injuries (about 10% of all injuries) were compensated to farmers in Finland.[29] The main production type indicates from what commodity, livestock, or specialty subsector the farmer receives most of his/her income. Mixed farming is also relatively common on Finnish farms, but farmers are accustomed to indicating their primary subsector for various information sources.

Statistical Methods

The data analysis included examining the means, standard deviations, medians, minimums, and maximums of potential continuous risk factor variables and categorizing them for further analyses. The frequencies of categorical variables were analyzed using the chi-square test. Poisson regression was used as the primary method for identifying risk factors for both compensated occupational injuries and diseases using counts of claims as outcome variables. We assessed each potential risk factor first in univariate analyses, and those that were significant at $p < .05$ level, were entered into multivariate analyses. We employed the GENMOD procedure in SAS for constructing the final models. We used the backward selection process where variables that did not reach the $p < .05$ significance level were removed. Potential two-way interactions and multicollinearity between the explanatory variables were tested by using the VIF (variance inflation factor), TOL (detection tolerance), and COLLIN (collinearity analysis including condition index) procedures. The statistical analyses were conducted using SAS version 9.2 software (SAS Institute, Cary, NC).

RESULTS

Farms and Farmers

Our study cohort consisted of 78,679 insured persons from 54,959 farms. Nearly two thirds of the insured persons were males (Table 1). The distribution of the number of insured persons per farm was as follows: one person (32,149 farms; 58.5%), two persons (22,016 farms; 40.1%), three persons (683 farms; 1.2%), and four or five persons (111 farms; 0.2%). The gender distribution varied as follows: farms with one person (79.8% males), farms with two persons (52.4% males), and farms with three or more insured persons (64.2% males).

Males were slightly younger and had been insured slightly longer on average than females. The insurance coverage began at age 24 among males and at age 26 among females on average. About 21% of the insured persons had started their career as insured farmer at the age of 18 to 22 years; 77% of them were male. Age was positively correlated with the number of years covered by insurance ($r = .68$, $p < .001$).

Farmers and their spouses living on the farm (73,746; 93.7%) or outside the farm (2793; 3.5%) constituted the majority of the insured farming population. The rest were either salaried family members living on the farm in most cases, or the residence of the insured person was unknown.

All insured persons and farms owned either field or forest areas or both. The majority of the farms (52,747; 96.0%) had fields. The majority of the farms (51,929; 94.5%) had some forest as well. The mean field area of the insured farms was 31.0 hectares (standard deviation 26.5; median 24.3). The mean forest area was

TABLE 1. Finnish Farming Population With Mandatory Accident Insurance Coverage During the Entire 5-Year Period, 2000–2004

Population	Frequency (%)	Age[a]	Years insured[a]
Total farming population[b]	78,679 (100.0)	46.2 (8.5)	18.1 (8.2)
Males	50,346 (64.0)	46.0 (8.7)	18.4 (8.2)
Females	28,333 (36.0)	46.4 (8.2)	17.6 (8.0)

[a]Mean age and mean number of years insured in 2002—the middle year of the observation period. Standard deviations are presented in parentheses.
[b]Includes self-employed owner-operators of the farm, their spouses, and salaried family members.

53.6 hectares (standard deviation 61.2; median 38.0).

The distribution of the insured persons by main production type (18 different production types) is presented in Table 2. About half of the persons (40,629; 51.6%) and farms (25,911; 47.1%) were engaged in livestock farming, including horse breeding. One third of the total farming population and two thirds (67.2%) of the livestock producers were engaged in dairy farming, which was the largest single main production type.

Over two fifths of the farms (23,946; 43.6%) and two fifths of the persons (32,048; 40.7%) were crop producers, including greenhouse production. A small number of the farms (207; 0.4%) had "other production" such as farm tourism as their main production type. For the rest of the farms (5031; 9.2%), the main production type was unknown. The majority of these farms (4651; 92%) had less than 20 hectares of arable land.

Livestock producers were younger than crop producers on average (45.0 vs. 46.9 years). However, there was little difference between these groups in their average years insured (18.0 vs. 17.9 years).

In general, it was common for livestock farms to have two insured persons, whereas crop farms usually had one. For example, over half (9414; 56.5%) of the dairy farms had two insured persons, and some (338; 0.6%) had three to five insured persons. Over two thirds (11,513; 69.4%) of the farms growing cereal crops had only one insured person, and less than a third (4953; 29.9%) had two insured persons.

FOHS Membership

In our data, over one third (28,046; 35.6%) of the farming population had voluntarily joined the FOHS (active members in 2002). However, membership was significantly associated with production type and farm size. Livestock producers in general (48.9%) and dairy producers in particular (53.1%) had joined the FOHS more often than crop producers (23.9%). Persons with at least 30 hectares of fields had joined the FOHS more often (48.4%) than persons with less field area (27.4%).

Dairy producers with over 40 hectares of fields (7452 persons) and cereal producers with less than 20 hectares (8713 persons) represented the two extremes with their FOHS membership, being 63.9% and 12.5%, respectively. All the above-mentioned differences in proportions were significant (chi-square test, $p < .0001$).

Incidence of Occupational Injuries and Diseases

Majority of the insured persons had neither compensated occupational injuries nor diseases requiring medical care during 2000−2004 (Table 3). The 5-year incidence (percentage of persons with one or more cases) was 20.2% for injury and 2.0% for disease. Among persons with compensated claims, most had only one compensated injury or disease case. However, a total of 4926 (6.3%) persons had 2 or more injuries, and 119 (0.2%) persons had two or more diseases, up to 18 injuries or five diseases for one person. Altogether 626 (0.8%) persons had both (one or more) injuries and diseases in their records. More than half of the injuries (13,442; 55.0%) and over one tenth of the diseases (261; 15.5%) occurred to those with repetitive claims. Males represented three fourths (11,814; 74.3%) of the injuries and nearly two thirds (967; 62.7%) of the diseases.

Although representing half of the farming population, livestock producers were significantly overrepresented regarding compensated claims in many respects. Livestock producers accounted for over two thirds (11,770; 69.9%) of all claimants and nearly three fourths (18,994; 72.8%) of all compensated claims. Furthermore, they represented the majority (3706; 75.2%) of those with two or more injuries, two or more diseases (92; 77.3%), or both (one or more) injuries and diseases (504; 80.5%). All the above-mentioned differences of proportions were significant (chi-square test, $p < .05$).

Risk Factors for Occupational Injuries and Diseases

All potential risk factor variables were associated either with occupational injuries or diseases or both in the univariate Poisson regression

TABLE 2. Risk Factors for Compensated Occupational Injuries and Diseases Requiring Medical Care Among Finnish Farming Population Based on 5-Year Insurance Records

				Adjusted model, injuries[a] 2000–2004 ($n = 24,424$)			Adjusted model, diseases[a] 2000–2004 ($n = 1684$)		
					95% Confidence limits			95% Confidence limits	
Variable	Category	Frequency ($N = 78,679$)	Percentage	Rate ratio	Lower	Upper	Rate ratio	Lower	Upper
Gender	Male	50,346	64.0	**1.69**	**1.64**	**1.75**	0.94	0.85	1.05
	Female (Ref.)	28,333	36.0	—	—	—	—	—	—
Insurance years	≥30	9487	12.1	**1.22**	**1.16**	**1.28**	**0.58**	**0.47**	**0.71**
	25–29	9718	12.4	**1.21**	**1.15**	**1.27**	**0.69**	**0.58**	**0.84**
	20–24	13,578	17.3	**1.12**	**1.07**	**1.17**	**0.83**	**0.71**	**0.97**
	15–19	18,101	23.0	**1.07**	**1.02**	**1.11**	**0.85**	**0.73**	**0.99**
	10–14	14,770	18.8	**1.07**	**1.02**	**1.12**	0.86	0.74	1.01
	<10 (Ref.)	13,025	16.6	—	—	—	—	—	—
Insured persons on the farm	1	32,149	40.9	**1.23**	**1.14**	**1.33**	**1.93**	**1.33**	**2.80**
	2	44,032	56.0	**1.12**	**1.04**	**1.21**	**1.85**	**1.29**	**2.65**
	3–5 (Ref.)	2498	3.2	—	—	—	—	—	—
Native language	Finnish	72,107	91.6	**1.12**	**1.03**	**1.22**	**1.92**	**1.29**	**2.86**
	Swedish (Ref.)	6572	8.4	—	—	—	—	—	—
FOHS member[b]	Yes	28,046	35.6	**1.34**	**1.30**	**1.37**	**1.60**	**1.43**	**1.77**
	No (Ref.)	50,633	64.4	—	—	—	—	—	—
Income, euros	≥15,000	24,391	31.0	**2.71**	**2.49**	**2.95**	**3.01**	**2.15**	**4.21**
	10,000–14,999	26,649	33.9	**2.27**	**2.09**	**2.46**	**2.81**	**2.03**	**3.89**
	5000–9999	18,304	23.3	**1.78**	**1.64**	**1.93**	**2.10**	**1.51**	**2.91**
	<5000 (Ref.)	9335	11.9	—	—	—	—	—	—
Field size, ha	≥40	20,090	25.5	**1.33**	**1.24**	**1.42**	**1.51**	**1.13**	**2.01**
	30–39	10,716	13.6	**1.17**	**1.09**	**1.26**	**1.60**	**1.20**	**2.14**
	20–29	16,666	21.2	**1.13**	**1.06**	**1.21**	**1.50**	**1.14**	**1.97**
	10–19	19,450	24.7	1.00	0.94	1.06	1.25	0.96	1.63
	<10 (Ref.)	11,757	14.9	—	—	—	—	—	—
Forest size, ha	≥50	30,689	39.0	0.99	0.92	1.06	1.36	0.98	1.89
	1–49	44,308	56.3	1.04	0.97	1.12	**1.45**	**1.05**	**2.01**
	0 (Ref.)	3682	4.7	—	—	—	—	—	—
Residence of the insured person	Farm	74,793	95.1	**1.15**	**1.04**	**1.27**	1.08	0.72	1.62
	Unknown	1006	1.3	1.00	0.84	1.19	0.66	0.28	1.52
	Off farm (Ref.)	2880	3.7	—	—	—	—	—	—
Region of the farm[c]	Varsinais-Suomi	7529	9.6	**1.24**	**1.12**	**1.37**	0.89	0.59	1.35
	Satakunta	4502	5.7	**1.53**	**1.38**	**1.70**	0.77	0.49	1.23
	Kanta-Hame	3035	3.9	**1.20**	**1.07**	**1.34**	1.08	0.68	1.71
	Pirkanmaa	5278	6.7	**1.41**	**1.28**	**1.56**	0.99	0.65	1.51

(*Continued*)

TABLE 2. (Continued)

Variable	Category	Frequency ($N = 78,679$)	Percentage	Adjusted model, injuries[a] 2000–2004 ($n = 24,424$)			Adjusted model, diseases[a] 2000–2004 ($n = 1684$)		
				Rate ratio	95% Confidence limits		Rate ratio	95% Confidence limits	
					Lower	Upper		Lower	Upper
	Paijat-Hame	2622	3.3	**1.26**	**1.13**	**1.41**	1.10	0.69	1.76
	Kymenlaakso	2798	3.6	**1.19**	**1.06**	**1.33**	0.66	0.40	1.10
	South Karelia	2387	3.0	**1.13**	**1.01**	**1.27**	1.36	0.87	2.15
	Etela-Savo	4604	5.9	**1.24**	**1.12**	**1.38**	**2.04**	**1.37**	**3.06**
	Pohjois-Savo	6306	8.0	**1.59**	**1.44**	**1.75**	**2.15**	**1.47**	**3.16**
	North Karelia	3946	5.0	**1.41**	**1.27**	**1.56**	**2.18**	**1.46**	**3.24**
	Central Finland	4380	5.6	**1.29**	**1.16**	**1.43**	**1.77**	**1.18**	**2.66**
	South Ostrobothnia	8267	10.5	**1.57**	**1.43**	**1.73**	1.25	0.85	1.85
	Ostrobothnia	4962	6.3	**1.38**	**1.24**	**1.54**	1.32	0.81	2.13
	Central Ostrobothnia	2288	2.9	**1.24**	**1.11**	**1.39**	0.93	0.58	1.49
	North Ostrobothnia	6823	8.7	**1.22**	**1.11**	**1.35**	**1.60**	**1.09**	**2.36**
	Kainuu	1516	1.9	**1.28**	**1.13**	**1.46**	0.92	0.53	1.58
	Lapland	2407	3.1	**1.51**	**1.35**	**1.69**	**1.72**	**1.11**	**2.68**
	Ita-Uusimaa	1651	2.1	1.00	0.87	1.15	0.82	0.44	1.52
	Aland Islands	637	0.8	0.92	0.74	1.16	0.53	0.12	2.33
	Uusimaa (Ref.)	2741	3.5	—	—	—	—	—	—
Main type of production	Dairy	27,313	34.7	**2.25**	**2.16**	**2.34**	**2.21**	**1.88**	**2.61**
	Beef	4988	6.3	**1.77**	**1.67**	**1.88**	**1.49**	**1.17**	**1.88**
	Suckler cows	576	0.7	**2.18**	**1.91**	**2.48**	**2.15**	**1.29**	**3.58**
	Feeder pigs	2034	2.6	**1.92**	**1.78**	**2.07**	**1.92**	**1.40**	**2.62**
	Finishing pigs	1393	1.8	**1.48**	**1.35**	**1.63**	**1.53**	**1.03**	**2.28**
	Other pigs	1745	2.2	**1.82**	**1.68**	**1.97**	1.34	0.93	1.95
	Poultry	315	0.4	1.11	0.89	1.38	0.79	0.25	2.47
	Eggs	851	1.1	**1.37**	**1.20**	**1.56**	**1.78**	**1.08**	**2.93**
	Other poultry	165	0.2	**1.77**	**1.40**	**2.25**	1.53	0.49	4.80
	Sheep/goats	525	0.7	**2.13**	**1.82**	**2.50**	**2.26**	**1.26**	**4.05**
	Horses	724	0.9	**3.08**	**2.74**	**3.46**	0.85	0.38	1.92
	Special crops	4751	6.0	**1.27**	**1.19**	**1.36**	1.18	0.88	1.58
	Vegetables	1830	2.3	**1.28**	**1.14**	**1.42**	1.36	0.91	2.04
	Greenhouse	364	0.5	**1.37**	**1.08**	**1.73**	0.39	0.05	2.76
	Other crops	2942	3.7	**1.14**	**1.04**	**1.25**	0.88	0.59	1.31
	Other production	277	0.4	**1.53**	**1.19**	**1.96**	1.11	0.35	3.48
	Unknown	5725	7.3	**0.74**	**0.66**	**0.82**	1.11	0.76	1.62
	Cereal crops (Ref.)	22,161	28.2	—	—	—	—	—	—

[a]Poisson regression model with full adjustment. Significant estimates of the relative risk (rate ratio) and their confidence limits are presented in bold.
[b]FOHS member = farmer has joined the voluntary farmers' occupational health service program.
[c]Every region consists of several municipalities that were known for each insured person. Several joints of municipalities along the years were taken into account.

TABLE 3. Finnish Farming Population, and Number of Compensated Occupational Injury and Disease Claims Per Person From 2000 to 2004

Population	Frequency	Percentage
Persons in the study[a]	78,679	100.0
Persons with no compensated injury or disease claims	61,852	78.6
Occupational injuries		
Persons with no compensated injuries[b]	62,771	79.8
Persons with one or more compensated injuries	15,908	20.2
1 injury	10,982	14.0
2 injuries	3058	3.9
3 injuries	1058	1.3
4 injuries	389	0.5
5 injuries	207	0.3
6 injuries	102	0.1
7 injuries	50	0.1
8 injuries	26	0.0
9 injuries	15	0.0
10 injuries	6	0.0
11−18 injuries	15	0.0
Total number of compensated injuries	24,424	100.0
Occupational diseases		
Persons with no compensated diseases[c]	77,137	98,0
Persons with one or more diseases	1542	2.0
1 disease	1423	1.8
2 diseases	102	0.1
3 diseases	12	0.0
4 diseases	4	0.0
5 diseases	1	0.0
Total number of compensated diseases	1684	100.0

[a]Includes self-employed owner-operators of the farm, their spouses, and salaried family members.
[b]Some of these persons had compensated occupational diseases.
[c]Some of these persons had compensated occupational injuries.

models. Hence, all variables were entered into the multivariate analyses.

Age of the insured person and years covered by insurance were correlated. Since the latter variable was a novel one and more consistently associated with both outcomes, it was included in the final model instead of the age. Also field size in hectares correlated significantly and positively with the farm income ($r = .48$, $p < .001$). These variables were included in to the final model. The status of the insured person (farmer/spouse or salaried family member) was not associated with either of the outcomes in the multivariate analysis, and it was excluded from the final models.

The final adjusted Poisson regression model identified the following factors associated with occupational injuries: gender, years covered by insurance, number of insured persons on the farm, native language, FOHS membership, income level, field size in hectares, residence type, region of the farm, and main type of production. Forest (vs. no forest) was not associated with the injuries and not included in the final model.

The same statistical procedure identified the following factors associated with occupational diseases: years covered by insurance, number of insured persons on the farm, native language, FOHS membership, income level, field size in hectares, forest size in hectares, region of the farm, and main type of production. Gender and the residence type of the insured person were not associated with the diseases in the final model.

The rate ratios (RRs) for occupational injuries and diseases are presented together with their 95% confidence intervals (CIs) for the levels of the explanatory variables. The rate ratios need

to be interpreted relative to selected reference groups. Significant rate ratios (associations) are presented in bold in Table 2.

The results indicate that males had higher risk of injury compared with females (RR: 1.69; 95% CI: 1.64−1.75), but there was no significant difference between the genders regarding diseases.

Persons with higher number of insurance years had elevated risk of injury. In contrast, the risk of disease declined with longer insured career. Those with the longest insured career had 72% lower risk of diseases than the reference group ($1/0.58 = 1.72$).

Those who were either the only insured person or had another insured person on the farm had higher risk of both injury and disease than their peers having two to four insured persons sharing the farm work.

Finnish-speaking persons had slightly higher risk of injury but clearly higher risk of disease than their Swedish-speaking peers; RR 1.12 (95% CI: 1.03−1.22) and 1.92 (95% CI: 1.29−2.86), respectively. FOHS membership was associated with increased risk of both injury and disease as well. However, the increase of risk was more prominent regarding diseases.

Persons in the higher income and higher field size groups had elevated risk of both injury and disease. Forest size in hectares was associated with disease but not with injury; persons with some forest (1–50 hectares) had higher risk of disease than those with no forest.

Persons living on the farm had slightly higher risk of injury than persons living outside the farm. However, residence of the insured person was not associated with diseases.

Seventeen regions out of 19 had significantly higher risk of injury than the reference region Uusimaa, which is the southernmost region of Finland, including the Helsinki metropolitan area. Six regions had higher risk of disease than Uusimaa.

Main type of farm production was associated with the risk of both injury and disease. All other types of crop and livestock farming except poultry farming increased the injury risk compared with growing cereal crops. Several forms of livestock farming were associated with increased risk of disease as well. All three types of cattle farming stand out as both injury and disease prone.

All risk factor variables included in the final multivariate model had significant association with some of the other factors. For example, those farming alone were more often males than females, and Finnish-speaking farmers were members of FOHS more often than their Swedish-speaking peers. However, we did not detect multicollinearity (instability of the model due to extreme correlations) using the VIF, TOL, and COLLIN procedures in SAS.

We evaluated potential interactions regarding the risk of both outcomes. Interaction between two or more explanatory variables (independent by default) may complicate multiple regression models; instead of "normal" additive effect, interactive variables may have synergistic or antagonistic effect. We detected some significant ($p < .05$) two-way interactions in univariate Poisson regression models regarding particularly the risk of injuries. For example, gender had significant interaction with language, residence type, and field area; Swedish-speaking males had higher risk of injuries than Swedish-speaking females, females residing on the farm had higher risk of injuries than those residing off the farm, and females with higher field area had elevated risk of injuries compared with females with less than 10 hectares of field. However, we did not detect any meaningful interactions in the multivariate model.

DISCUSSION

This study evaluated risk factors for compensated occupational injuries and diseases requiring medical care from a large national insurance system that covers practically the entire self-employed farming population in Finland. These data are relatively complete because farmers have a financial incentive to claim their injuries and diseases, and a well-established legal framework is in place to guide insurance practices. Potential risk factor variables included all sociodemographic, insurance, FOHS membership, and farm production variables that were available in the administrative insurance data.

Earlier studies based on data from the same insurance system reported injury risk factors using 1-year injury records.[13,18] In the current study, we used a 5-year follow-up. Another study evaluated the effect of an insurance premium discount (bonus) program and found a reduction in the claim rate of minor injuries in Finland.[30] However, it is suggested that in addition to underreporting, the premium discount may also have some preventive effect.[30]

Our study cohort included all owner-operators, spouses, and salaried family members who had mandatory insurance coverage during the calendar years 2000–2004. It is likely many farm only part-time, but we were not able to address this issue due to no access to total household income or working hours on and off the farm.

The majority of the farming population had no compensated claims during our study period. The 5-year incidence of occupational injury and disease was 20.2% and 2.0%, respectively. According to the insurance records of Mela, annual occupational injury and disease rates among Finnish farmers have varied between 6.2 and 7.5 injuries and between 0.34 and 0.57 diseases per 100 persons per year during the past decade.[22,31] Our current study shows that both rates increase notably when using a 5-year versus 1-year follow-up period.

An earlier study shows that 17.7% of the compensated claims (injuries and diseases combined) occur to those with previous claims in 1 year.[13] Our longitudinal study shows a substantial increase regarding the relative proportion of the repetitive claims: 55.0% of the injuries and 15.5% of the diseases occurred to those with previous claims.

A relatively large number of farmers had multiple (up to 18) injuries and multiple (up to 5) diseases. Several hundred persons had both (one or more) compensated injuries and diseases. Livestock producers in general and dairy or other cattle producers in particular were overrepresented among those with multiple claims. Taattola et al.[32] showed similar results among full-time Finnish farmers. Persons with multiple injury and/or disease claims may have specific individual and farm work-related risk factors in addition to those identified in this study.

Our study indicated a large portion of Finnish farms is operated by one insured male farmer. Our finding that males had an elevated risk of injury is in accordance with previous studies.[13,14] One earlier study[18] found that males had a lower risk of occupational disease; however, we found no significant difference. There is no current and comprehensive information on the division of farm work between the genders in Finland, or elsewhere to our knowledge. In the absence of data on working hours and tasks, risk differences cannot be addressed directly. In our data, it was more likely on livestock farms to have insured females along with males. Livestock production involves higher risks of occupational injury and disease, and it is likely that the work roles between genders differ. We agree with Dimich-Ward et al.[33] who stated that gender may be an indicator of different exposures rather than being a risk factor in itself.

Greater number of insured persons on the farm reduced the risk of both outcomes. Having two to four insured family members sharing the farm work was rare but protective against occupational diseases in particular. Our finding is in accordance with two previous studies that reported that working alone is a risk factor for fatal farm injuries.[34,35]

Interestingly, FOHS aims to prevent occupational injuries and diseases but FOHS membership increased the risk of compensated claims for both outcomes even when controlling for production type, size of the farm, and other factors.

In a survey among Finnish full-time farmers ($N = 1182$), over half (54.4%) of the participants had joined FOHS.[25] In that study, the following variables were positively associated with the FOHS membership in the multivariate model (in descending order of importance): animal husbandry as main production type, adopting the quality management system, opinion that FOHS membership should be obligatory, incidence of chronic diseases/illnesses, having vocational education, larger farm size, and high personal physical activity (only among female farmers). Many of these variables were not available in our study.

We agree with Kinnunen et al.[25] who state that physician-diagnosed chronic illnesses (prevalence 39.4% in their study) may encourage farmers to join FOHS. Nearly two thirds (63%) of the Finnish dairy producers have one or more current (occupational or other) diseases diagnosed by a physician.[36] We recognize that our result could be influenced by detection and reporting biases where FOHS members are more effectively diagnosed, more aware of their state of health, and better informed about the insurance benefits they are entitled to. Future studies are needed to examine these potential biases, but based on our results, measures are needed to improve the effectiveness of the FOHS.

Insurance years and the age of the farmer were correlated, but the coefficient (r = .68) indicates that there is variation at what age farmers start operation as insured farmer. Older age was a significant risk factor for injury and disease in the univariate models, and it has been identified earlier as a risk factor for injury.[9,13,17] Occupational injuries and particularly diseases contribute to deterioration of work ability, and the prevalence of declined work ability among livestock farmers starts to rise already at the age of 40.[36]

We used the length of career as insured farmer in multivariate models, as it may better represent the true exposure history (time as farm owner/operator) than the age of the farmer. Persons with greater number of insurance years had elevated risk of injury. In contrast, the risk of disease declined consistently along with insurance years.

According to Viluksela,[37] younger full-time farmers have vocational agricultural education and they have joined the FOHS more often than their older peers in Finland. Since thorough medical examination is part of the FOHS, various conditions may become detected more extensively among members.

Farm income is calculated from the size of the farm, and farm income clearly correlated with field size but not with forest size. Farm income and field area were significantly associated with both injury and disease in the final multivariable models. Persons in the higher income and field size groups had a greater risk of both outcomes, which may simply result from greater work exposure time. Furthermore, higher farm income increases the lost-time compensation payments, creating a greater financial incentive to claim the injuries and diseases.

Forest area was associated with both outcomes in the univariate models. In the final model, those with 1 to 49 hectares of forest had elevated risk of occupational diseases. In Finland, winter is the high season for forestry work, which contains specific injury risks and strenuous work despite the growing use of modern machinery. According to Perkiö-Mäkelä and Penttinen,[38] chronic diseases diagnosed by a physician are relatively common (29%) among Finnish professional forestry workers. Large-scale timber felling and transportation are currently usually left to the professionals. However, for the majority of Finnish farmers, forestry work is an elemental part of the annual spectrum of work.[39] Based on our results, those with larger forest areas differ from those with smaller forest areas regarding exposure to injuries and diseases on forestry work.

Earlier studies have clearly shown the association between livestock farming and higher risk of occupational injuries.[9,10,11,32] Livestock farming also comprises a large variety of physical, chemical, and biological exposures commonly associated with work-related diseases.[3,8,40–42] Our study concurs with previous findings that livestock farming, and dairy farming in particular, increases the risk of injury and disease claims. In addition, we found a higher frequency of repetitive claims among livestock producers as well.

Data on the main type of production were missing for about 10% of the farms in our study. The majority of these farms were small, and few had joined the FOHS (459; 8.0%), or had compensated injuries (293; 5.1%) or diseases (25; 0.4%). The findings among those with no production data are more consistent with crop farmers than livestock farmers.

We found that Finnish-speaking farmers had slightly higher risk of occupational injuries and nearly twice as high risk of occupational diseases than their Swedish-speaking peers. The latter is a novel finding in this study. Similar results regarding injuries among full-time farmers in Finland have been reported.[14] According

to Rautiainen et al.,[13] Finnish-speaking farmers have higher risk of occupational injuries in general but not of serious injuries. Similar results regarding both farmers and workers of other industries as well have been reported.[43]

Since government and other services are offered in both official languages, language should not hinder the utilization of the insurance system. Our result regarding particularly the occupational diseases may reflect differences in culture, behavior, or farming practices (including working environment and methods), as suggested by previous studies.[13,14] Salminen and Johansson[43] state that due to differences in the origins of the languages, Finnish (Ural-Altaic language)-speaking people may think of possible hazards in advance less often than their Swedish (Indo-European language)-speaking peers. We agree with Virtanen et al.[14] who framed the question "Can other groups in Finland and beyond learn something from the Swedish speaking Finns?" and recommend that future studies should examine this matter more closely.

In Finland, both livestock and crop farms are found from every region. However, due to logistical, geographical, and climatic reasons, both farm types are heavily centered into certain regions. Livestock farms are located particularly in western and eastern (cattle), and southwestern (pigs and poultry) Finland.[44] Crop farms are mostly found from southern, southwestern, and western Finland.[44] A map of the agricultural regions of Finland is available from the Internet.[44]

We found that several regions had elevated risk of occupational injuries, diseases, or both, even when the main type of production and field size among other variables were controlled. Sinisalo[17] had similar findings regarding injuries. This may reflect differences between regions, for example, in the utilization of the insurance system or in the working methods and environment, including local climate and soil. There may be other personal and farm-related factors involved that we could not control in this study. This matter should be studied more thoroughly in the future studies.

We found that persons living on the farm had a higher risk of injury than persons living outside the farm, which may reflect differences in the exposure time or work tasks performed by these two groups. However, the majority (97.0%) of persons living outside the farm still had the owner-operator status. In 2002, approximately every 10th (10.8%) active farm in Finland was owned by heirs of estates or various farming corporation types (two-generation farms, multifamily farms, etc.). They also have mandatory workers' compensation insurance.[44] Hence, it is not unusual to live off the farm or to have two or more residences but still run one common farm with other operators.

To summarize, those with highest occupational injury and disease risk included Finnish-speaking persons who resided in the cattle-intensive geographic regions of eastern, middle, or northern Finland, who were FOHS members, and who run a dairy or beef cattle farm with higher than average field size and higher farm income level. In practice, these persons were most likely full-time farmers or farm couples.

In contrast, those with the lowest occupational injury and disease risk included Swedish-speaking persons who resided in the crop-intensive geographic regions of southern Finland, were not FOHS members, and run a cereal crop farm with no greater than average field size and farm income level. These persons were most likely part-time farmers having additional income sources and working but not necessary living alone on the farm.

Strengths and Weaknesses

The material in this study consisted of workers' compensation records for an exceptionally large cohort of self-employed Finnish farmers. All compensated occupational injury and disease claims requiring medical care were available for this cohort, which is a strength in this study. Similar data resources are not typically available in the agricultural sector.

We had a complete simultaneous 5-year follow-up period for each person in our study cohort. This design reduces biases from changes in insurance policy, agriculture policy, and society that are complex and difficult to control. With our study approach, the effects of such changes were the same for all participants.

The identified risk factors for injuries are fairly similar to the results of earlier studies with Finnish farming population.[13,14] However, instead of customary logistic regression, our primary method was Poisson regression, which used the number of compensated claims per person as outcome. This method provided total-population-based rate ratios for risk factors that may be more generalizable to national statistics in other countries. We were also able to utilize data from a longitudinal 5-year observation period, which is a more accurate measure of an individual's record compared with 1 year[13] or 2 years[14] in previous studies. This increased statistical power of our study.

We included some new risk factor variables and identified risk factors for occupational diseases in addition to injuries. Occupational disease data are typically not available for self-employed farmers in most countries. Furthermore, occupational diseases are relatively rare, and a longer follow-up period, such as our 5-year period, is needed to have adequate power for statistical analyses. Compared with self-reported data from mail surveys or interviews, insurance record–based data have less bias from recall. When each case is verified from claims and records from health providers, there is less confusion about the date, time, and place of the incident, consequences in terms of lost work time and paid medical expenses and benefits, and the type of incident, which is coded in this insurance system with extensive coding systems.

The limitations in our study include being confined by those potential risk factor variables that are available in the administrative insurance data. These variables are typically defined for insurance, rather than research, purpose. We only had basic personal and farm characteristic variables, and data on work time, tasks, specific exposures, and personal knowledge, attitudes, and behaviors, among other variables of potential interest were not available. The farm variables on characteristics were from the middle year of our 5-year observation period. These characteristics may have changed during the study period, which could reduce the accuracy of the risk factor estimation.

The combination of exceptionally large cohort and longitudinal outcome data provided power to detect risk factors with great accuracy. However, it is important to interpret and judge these results in terms of their practical significance. It is important to note that in large populations, even small differences in risk result in numerous occupational injuries or diseases annually, and such differences, when detected, should not be ignored.

CONCLUSIONS

This study showed that the 5-year incidence of occupational injury and disease requiring medical care was 20.2% and 2.0%, respectively. Clustering of claims was observed; 78.6% of the population had no claims, whereas others had 1 or more, up to 18 claims in one case. Livestock producers in particular had multiple occupational injury and disease claims.

Using the personal count of claims over a long period of time as outcome improves the estimation of risk and protective factors. Our longitudinal claim analyses identified several risk factors for injuries that have been identified in earlier studies with shorter observation periods. In addition, our current findings include new risk factors and more exact risk estimates with narrower confidence intervals. As new findings we found clear differences in risk estimates by geographic region for both occupational injuries and diseases. Greater number of insured persons on the farm reduced the risk of both outcomes. Interestingly, longer career as insured farmer elevated the risk of injury but reduced the risk of occupational disease.

To increase the cost-effectiveness of preventive efforts, the identified risk and protective factors can be used for targeting interventions to high-risk populations, similar to traditional marketing of products and services. Various combinations of engineering, education, enforcement, incentives, and other measures may be needed to prevent specific types of occupational injuries and diseases in specific populations and their subgroups.

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