

# Final Progress Report

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## List of Terms and Abbreviations

### Claim number

Consecutive number of insurance claims for each insured person.

### Cost-of-living and wage index

Official index used for adjusting payments and benefits in Finnish social insurance programs, known as the TEL Index. The index is updated annually by the Finnish Social Insurance Institution.

### Personal claim rate

Personal injury/illness claim rate based on past claims experience. Calculated in this study as follows:  $\text{Personal claim rate} = (\text{Claim number} / \text{Years insured}) * 10$ . Euro Common European currency; abbreviation: EUR, character: €. All costs in this study were in Euros. As of 10/30/08, €1 EUR = \$1.27 USD.

### Impairment allowance

An impairment allowance can be paid if the injury/illness causes a permanent impairment and help is required to cope with daily activities. The impairment allowance can be paid after one year from the incident. The allowance is 1-60% of the annual income depending on the severity of the impairment. The payment is usually paid in one installment.

### Injury

An injury is described in MATA as a sudden unexpected forceful event with an external cause, which results in bodily damage or an ailment, and which occurs in the course of agricultural work.

### Insured farm income

A specific income determined by Mela for each farm and each insured person. Arable land, forestland, animal production, taxable income, and personal adjustments are considered when determining the income for the farm. The farm income is usually divided evenly between the spouses or owners. The insured farm income reflects the value of work on the farm. The premiums and certain benefits are based on the insured farm income.

### Long-term disability

Disability lasting longer than one calendar year from the incident. An accident pension is paid for the disability time starting one year from the incident. The pension can be permanent or temporary, and full or partial. In this study, three categories of long-term disability were used: 1) cases with any disability time (pension) beyond one year from the incident, 2) cases with disability time (pension) beyond the data extraction date, August 1, 2000, and 3) permanent disability (pension) cases.

### Lost-time per diem

A daily compensation for lost work time and productivity. Physicians assign the disability time. The per diem is paid for all days of the week, up to one year from the incident. Per diem is paid only if the disability lasts at least three days after the incident day. One per diem payment is 1/360 of the annual insured income.

### No-claims bonus

Insured persons who have no compensated claims during the previous year receive a 10% reduction in their premiums. Each claim-free year thereafter adds 10% to this bonus up to the 50% level in five consecutive claim-free years. Each compensated claim reduces the bonus by 10%, but the 0% level is never exceeded. The no-claims bonus was implemented on July 1, 1997.

### MATA insurance

Abbreviation used in the Finnish language for the farmers' employment accident (workers' compensation) insurance system. MATA has been mandatory for all farmers since July 1, 1982, and provides compensation for agricultural injuries and occupational diseases. Farmers Social Insurance Institution (Mela) administers the MATA insurance.

**Mela**

Abbreviation used in the Finnish language for the Farmers Social Insurance Institution, Finland. Mela is a semi-private insurance company, which was established by legislation to administer the farmers' work-related pension system in 1970. Mela currently administers a broad range of social security programs for the Finnish agricultural populations, including the MATA insurance.

**Occupational disease**

Specific illnesses defined by legislation, which are probably predominantly due to specific physical, chemical, or biological factors associated with work.

**Short-term disability**

Disability lasting up to one year. A daily per diem compensation is paid for each disability day up to one year. Per diem is paid only if the disability lasts at least three days after the incident day. Physicians assign the length of disability.

**Years insured**

Number of years the person has been insured by MATA.

## Abstract

**Background.** Agriculture remains one of the most hazardous industries in the US and effective interventions are needed. We conducted a systematic review of interventions in agriculture, and we evaluated a well-established agricultural occupational health service (OHS) intervention in Finland. This study addressed three NORA priority areas: asthma and chronic obstructive pulmonary disease, traumatic injuries, and intervention effectiveness research. This K01 research career award also enhanced the Principal Investigator's research career through mentored research and training. The University of Iowa provided the research environment and mentors (Drs. Craig Zwerling, Kelley Donham, Johannes Ledolter, Robert Ohsfeldt).

**Methods.** This research had two hypotheses: 1) Farmers who are members of the Occupational Health Service (OHS) have lower injury rates, respiratory disease rates, and claim costs compared to non-members, and 2) Serious injuries are associated with demographic, income, and farm characteristics. 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 Euros). Hypothesis 1 was tested in a retrospective cohort study, measuring if 2002 claim rates and costs differed between OHS members and non-members. Hypothesis 2 was tested in a multiple logistic regression analysis identifying risk factors for injury and serious injury. Serious claims (>€2000 Euros) represent about 20% of the cases and 80% of the insurance costs. Both analyses were based on a large, well-defined cohort (N=93,550) and data on injuries (N=5507) and occupational diseases (N=302) in 2002. Comprehensive claims data (N=222,848 claim cases) from 1982 to 2008 for this population were acquired in 2008. Analyses of those data continue, and new proposals are under preparation, expanding this research utilizing the new data.

**Results.** A total of 5507 compensated injuries occurred in 2002 (rate 5.9/100 person-years); 1167(21%) of them were serious (rate 1.25/100 person-years). The causes/sources resulting in most costly claims 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), and animal production were risk factors for injury. Unexpectedly, OHS membership was also a risk factor 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 on the farm, farm ownership status, and OHS membership were not risk factors for serious injury, indicating potential biases in claims reporting between different demographic groups. OHS members (vs. non-members) reported more minor injuries, while there were no differences between members and non-members in serious claims. Average claim costs were €1717 Euros for OHS members and €1875 Euros for non-members (p=0.005).

**Conclusions.** Cost-effective prevention efforts should address: older age, male gender, larger income and operation size, livestock production, motor vehicle incidents, falls from elevation, and slips, trips and falls. OHS membership increased claims (particularly minor claims), but decreased claim costs. These findings initiated changes in the OHS system in Finland, emphasizing the importance of hazard identification and removal on farms. Research continues, examining the effect of the intervention and the potential biases in claims reporting between OHS members and non members.

## Highlights/Significant Findings

Our findings in response to the specific aims are stated below.

Hypothesis 1: Finnish farmers who are members of the Occupational Health Service (OHS) have lower injury rates, occupational respiratory disease rates, and claim costs compared to non-members. We found that injury and occupational disease rates among members were actually higher, but the costs were slightly lower.

Specific Aim 1: Measure whether the injury rates differ between OHS members and matched non-members while adjusting for demographic, income, and farm characteristics. We found a difference in injury rates favoring non-members, but we also found that there was a potential reporting bias against the members, where members had a tendency to file more small claims, while there was no difference in serious claims.

Specific Aim 2: Measure whether the occupational respiratory disease rates differ between OHS members and matched non-members while adjusting for demographic, income, and farm characteristics. There was a clear difference in occupational respiratory disease rates, favoring non-members. Research continues, examining if this difference could be influenced by 1) reporting bias, 2) those with respiratory conditions seeking care and becoming members while dealing with their illness, and/or 3) members being screened and diagnosed more effectively while non-members may have similar disease rates, but their diseases are not diagnosed.

Specific Aim 3: Measure whether the total claim costs differ between OHS members and matched non-members while adjusting for demographic, income, and farm characteristics. The average claim costs were €1717 Euros for OHS members and €1875 Euros for non-members. Claim costs have a distribution that is skewed to the right. Therefore the means were compared after log transformation and the differences were significant ( $p=0.14$  without log-transformation;  $p=0.005$  after log transformation). In a multi-variable logistic regression analysis, evaluating risk factors for over 2000 Euro claims, we found no difference between OHS members and nonmembers.

Specific Aim 4: Measure whether the injury and occupational respiratory disease rates differ between OHS members and matched non-members, before and after members join OHS. New data were acquired in the summer of 2008, covering the farming career of the insured population ( $N=222,848$  claim cases) from 1982 to 2008. Analysis of these new data continues and will be reported later, including longitudinal observations of respiratory disease.

Specific Aim 5: Measure whether the injury and occupational respiratory disease rate trends differ between members and matched non-members, before and after members join OHS. New data were acquired in the summer of 2008, covering the farming career of the insured population. Analysis of these new data continues and will be reported in future publications.

Hypothesis 2: Serious injuries are associated with selected demographic and farm characteristics. We constructed a multi variable analysis which identified risk factors for injury. Based on our literature searches, our set of risk factors is the most complete and most precise (narrow confidence intervals) produced in the agriculture industry to date. The risk factors are listed in Table 4 in this report.

Specific Aim 6: Identify and measure the association of serious injuries and selected demographic, income, and farm production characteristics. Older age, male gender, higher income level, greater field size, residing on the farm, Finnish language (vs. Swedish), occupational health service 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.

In a systematic review of the literature, we identified over 8000 references which were potentially reporting results of intervention studies in agriculture. Only 8 of those studies met the selection criteria and had a rigorous research design (randomized controlled trial, cluster randomized controlled trial, or interrupted time series study). Only three studies reported positive effects on injuries. Five studies showed no difference or negative findings. Therefore, our results appear similar to other intervention studies in agriculture. This finding raises important questions about the quality of the interventions and the quality of research measuring the effect of interventions. Clearly, the high rates of injury in agriculture would require effective interventions, but based on current research, such interventions have not been found effective. Based on our findings, we recommend increased efforts in designing and testing interventions that could reduce the high rates of injury and illness in the agriculture industry.

**Translation of Findings.** The main findings of this study are in press and data analyses continue investigating in greater detail the effects of the OHS intervention and the claim reporting biases that might distort the reporting of injuries in this population. The findings have been reported in two major scientific conferences in the agricultural health and safety field, and there results have raised much discussion. The officials in Finland who are responsible for the OHS program have been informed of the results, and they have initiated strong efforts enhancing the OHS intervention. Particularly the importance of the farm visits has been emphasized, aiming to detect hazards and remove them more effectively. This study indicates that although a broad-based public health approach has been used to address injuries, occupational diseases, and wellness issues, this major effort has not resulted in a clear reduction of injury and occupational disease claims. The results of this study present a strong signal to the OHS intervention system, encouraging efforts that could make the intervention more effective. The findings of this study have universal importance for re-evaluating if a broad based public health effort aiming to address health and safety in a comprehensive way can address specific agents of injury effectively. A more rigorous identification and removal of hazards, and motivation to work safely appears to be needed. Development of prevention programs that effectively remove hazards on the farm appears a high priority.

### **Outcomes/Relevance/Impact.**

In response to the question: "How did this project lead to improvements in occupational safety and health?" we suggest the following:

- This study identified numerous risk factors for injury. This information can be used for targeting prevention programs for population groups with highest risk of injury.
- This study identified injury causes that result in high cost claims. This information can be used for targeting specific injury causes, aiming to remove them from the farm.
- This study can be used by those designing research and prevention policy measures. This study makes a major contribution to the knowledge of risk factors and causes which need to be addressed in prevention.
- In a systematic review of the literature we found little evidence of interventions being effective in reducing injuries. Considering the high rate of injuries in agriculture, this finding challenges those working in the agricultural safety and health field to re-focus their efforts and find more effective strategies.

- This project initiated changes in the farm safety assessment system in the Finnish OHS. There is a greater emphasis on completing the farm safety assessments in a timely manner, and emphasizing effective hazard identification and removal on farms. Similar programs, such as the Iowa Certified Safe Farm, can use this experience in developing their procedures.

In response to the question: "How can the findings of this study guide future investigations and research?" we suggest the following:

- Workers compensation data, linked with agricultural statistics data provide an excellent resource for cost-effective agricultural injury research. This type of research makes a unique contribution and it should be expanded.
- Large sample size, complete data entry, and accurate coding of injury characteristics enable analyses with high statistical power.
- The Finnish OHS program is likely the largest comprehensive public health oriented agricultural OHS program in the world. We found increased reporting of minor claims, no difference in serious claims, and slight reduction in claim costs among OHS members. These findings are a challenge for the agricultural safety and health field. The findings raise the question if a broad based public health program is too generic, and not specific enough to address specific injury hazards on the farm. Future research should address how such programs could be made more effective.
- Changes are being made in the Finnish OHS model, including merging OHS provider districts and making larger, more focused agricultural OHS service units. Farm safety assessments are also concentrated to fewer well trained consultants who may gain better expertise compared to those who only conduct few farm visits per year. These changes should be evaluated in further research, identifying if they can improve program effectiveness.

## Scientific Report

In this section we include abstracts of selected papers stemming from this research. The main findings so far are presented in a manuscript which is pending final approval by the American Journal of Industrial Medicine. Research continues using the new large dataset, and further publications will be added to this report as they are published.

### Abstracts

Scand J Work Environ Health. 2008 Oct;34(5):327-36. Epub 2008 Oct 14.

Links

## **Effectiveness of interventions in preventing injuries in agriculture-a systematic review and meta-analysis.**

**Lehtola MM, Rautiainen RH, Day LM, Schonstein E, Suutarinen J, Salminen S, Verbeek JH.**

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**OBJECTIVES:** This study reviewed the effectiveness of interventions in preventing occupational injuries among workers in agriculture. **METHODS:** Randomized controlled trials, controlled before-after studies, and interrupted time-series studies assessing interventions aimed at preventing injuries among workers in agriculture were considered. MEDLINE and five other databases were searched up to June 2006. Two authors independently assessed the eligibility of studies and the methodological quality of the ones included. Randomized controlled trials were combined in a meta-analysis. Interrupted time-series studies were reanalyzed to assess the immediate and progressive effect on injuries. **RESULTS:** Five randomized controlled trials and three interrupted time-series studies met the inclusion criteria. Six studies evaluated educational interventions and financial incentives, and two studies evaluated the effect of legislation. Three randomized controlled trials on educational interventions with 4670 adult participants did not indicate any injury-reducing effect, with a rate ratio of 1.02 (95% confidence interval 0.87-1.20), nor did two randomized controlled trials among children (6895 participants). Financial incentives decreased the injury level immediately after the intervention in one interrupted time-series study. Banning endosulfan pesticide in Sri Lanka led to a significant decrease in the trend of poisonings over time. Legislation requiring rollover protective structures on all tractors in Sweden did not produce a reduction in injuries, but the same requirement for new tractors was associated with a decrease in fatal injuries. **CONCLUSIONS:** The reviewed studies provided no evidence that educational interventions are effective in decreasing injury rates among agricultural workers. Financial incentives may be a better means of reducing injury rates. Banning highly toxic pesticides may be effective. Legislation on safety devices on tractors yielded contradictory results.

## **Interventions for preventing injuries in the agricultural industry.**

**Rautiainen RH, Lehtola MM, Day LM, Schonstein E, Suutarinen J, Salminen S, Verbeek J.**

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**BACKGROUND:** Agriculture is more hazardous than most other industries. Many strategies have been introduced to reduce injuries in the field, yet the effectiveness of different interventions on occupational injuries still remains unclear. **OBJECTIVES:** This review aims to determine the effectiveness of interventions to prevent occupational injuries among workers in the agricultural industry compared to no interventions or to alternative interventions. **SEARCH STRATEGY:** Cochrane Central Register of Controlled Trials, Cochrane Injuries Group's specialised register, MEDLINE, EMBASE, PsychINFO, OSH-ROM (including NIOSHTIC and HSELINE) databases were searched up to June 2006. Reference lists of selected articles, relevant reviews and additional topic related databases and web sites were also searched. The searches were not restricted by language or publication status. **SELECTION CRITERIA:** Randomised controlled trials, cluster-randomised controlled trials, prospective cohort studies with a concurrent control group, and interrupted time series studies assessing any type of intervention aiming to prevent fatal or non-fatal injuries among workers in agriculture. **DATA COLLECTION AND ANALYSIS:** Two reviewers conducted data extraction and study quality assessment independently. Rate ratios of randomised controlled trials were calculated and the effect sizes were combined in a meta-analysis. Interrupted time series studies were reanalysed and each of them studied for having an immediate and a progressive effect. **MAIN RESULTS:** Five randomised controlled trials (RCTs) with 11,565 participants and three interrupted time series studies (ITSs) with 26.3 data points on average met the criteria. For educational interventions aiming at reducing injury rates among adults the pooled rate ratio after recalculation from effect sizes in three RCTs was 1.02 (95% CI 0.87 to 1.20). For educational interventions aiming at children the pooled rate ratio for injury rates in two RCTs was 1.27 (95% CI 0.51 to 3.16). One ITS that evaluated the effect of an intervention that included financial incentives decreased the injury level immediately after the intervention with an effect size of -2.68 (95% CI -3.80 to -1.56) but did not have a significant effect on the injury trend over time with an effect size of -0.22 (95% CI -0.47 to 0.03). One ITS study that evaluated the effect of legislation to ban Endosulfan pesticide on fatal pesticide poisonings increased the level of poisonings immediately after the introduction with an effect size of 2.20 (95% CI 0.97 to 3.43) but led to decrease in the trend of poisonings over time with an effect size of -2.15 (95% CI -

2.64 to -1.66). One ITS study documented four different regulations aiming to increase the use of rollover protective structures (ROPS) on tractors and their effect on injuries and fatal injuries. The introduction of two different pieces of legislation requiring ROPS on new tractors sold after a certain date was associated with a decrease of fatal injuries over the long term (effect size -0.93 95% CI -1.02 to -0.03) but they were also associated with an increase of injuries in general (fatal and non-fatal injuries combined). Introduction of legislation requiring ROPS on all tractors, old tractors included, was not associated with a decrease but with an increase of injuries and fatal injuries over the long term. AUTHORS' CONCLUSIONS: The selected studies provided no evidence that educational interventions are effective in decreasing injury rates among agricultural workers. Financial incentives could reduce injury rates. Legislation to ban pesticides could be effective. Legislation expanding the use of safety devices (ROPS) on new tractors was associated with a decrease in fatal injuries.

PMID: 18254102 [PubMed - indexed for MEDLINE]

Ergonomics. 2008 Oct 17:1-16. [Epub ahead ofprint]<sup>inf0rma</sup>

[Links](#)

## **Slip, trip and fall injuries in potato, sugar beet and open field vegetable production in Finland.**

**Mattila TE, Kaustell KO, Rautiainen RH, Pitkanen TJ, Lotjonen T, Suutarinen J.**

MTT Agrifood Research Finland, Vihti, Finland.

STF injuries are common in agriculture. The purposes of this study were to assess the magnitude of STF injuries, to identify contributing factors and to propose preventive actions to reduce injuries in potato, sugar beet and open field vegetable production in Finland. The material consisted of 1648 injury claim records and 22 interviews. The analysis showed 45% (n = 740) of the non-fatal injuries were STFs or jumps. Phrase analysis of injury descriptions provided further insight into the characteristics of STF injuries. The current findings suggest interventions should focus on making access paths (e.g. stairs, ladders, platforms) safer, minimising the need for mounting and dismounting equipment, decreasing manual material handling, improving contamination control and housekeeping in working areas and improving the safety of traffic areas and farmyards.

PMID: 18937092 [PubMed - as supplied by publisher]

J Agric Saf Health. 2007 Nov;13(4):395-406. [Links](#)

## **Safety performance of animal confinement floors: slip, trip, and fall injuries in Finland.**

**Kaustell KO, Mattila TE, Rautiainen RH.**

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Slip, trip, and fall (STF) injuries are common in agriculture. The aims of this study were to characterize STF injuries and to identify floor-related safety problems that can be reduced or eliminated through building design. Our material consisted of Finnish agricultural injury claim records for the period 1992-2002. The material included 6,414 slip, trip, and fall injuries that occurred in dairy, beef and swine production and were caused by floor structures. We examined coded information and injury descriptions to identify causes and contributing factors. The performance approach (PA) was used as a framework for discussing findings and their application to building design. PA provides a logic model for building design that considers the needs of workers, animals, and production processes. Nearly half (42%) of agricultural injuries occurred in dairy, beef, and swine production work. Fourteen percent of these injuries were slips, trips, and falls (STF) related to floor structures. More than 450 work years were lost due to disability resulting from these injuries. Many STF injuries occurred in milking (n = 1135), moving feeds (n = 962), and animal transport and care (n = 880). More than half (59%) of STF injuries occurred while carrying or moving a load. STF injury causes included floors, door sills, gutters, curbs, steps, ramps, grates, and contaminants like water, ice, snow, manure, detergent, forage, and hay. Men had a lower STF injury risk compared to women (RR = 0.63, 95% CI: 0.61-0.67). The magnitude and nature of STF injuries suggest that there is a need for improving the safety performance of floors and related structures. Key areas include slip-resistant floorings, effective contamination control, macro structures (elevations, entrances, access ways), and logistics for materials handling and storage spaces.

PMID: 18075015 [PubMed - indexed for MEDLINE]

### **Farm Building Construction-related Injuries and Diseases**

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#### **Abstract**

*Both agriculture and construction sectors have high rates of occupational injuries and certain types of occupational diseases. However, little attention has been given to hazards associated with the construction of farm buildings and other farm structures such as fences and corrals. The Finnish Farmers Social Insurance Institution has collected data within their claims records that include occupational injuries and diseases related to farm*

*building construction. The objective of this study is to describe the injuries and diseases related to farm building construction in Finland based upon these data during the years, 2000 through 2006. This data analysis excludes farm dwelling construction. For this period, 117 diseases—one of which was respiratory—and 2,747 injury claims including four fatalities represent 6.7% of all injury and disease claims among 85,000 farmers over the 7-year period. Results of the study indicate that 6.6% and 93.4% claims were made for females and males, respectively. As to the type of activity, building maintenance represented the highest incidence (1,119), followed by new construction (777), renovation (525), demolition (133), and making other structures such as fences and corrals (130). The principle causes of injuries were scaffolds or temporary ladders (478); circular saws and woodworking machines (225); uneven or slippery terrain (168); structural members such as windows, doors, stalls, walls, or ceilings (158); and hand tools (137). The principle injury-causing events were falls (341), struck by machines (253), falling objects (141), slips and trips with a load (102) and without a load (106), and hit against objects (186). Struck by or bit by animals (12) was small but unique. The principle parts of body injured included the leg (492), fingers (446), back and spine (288), foot (255), body excluding back (236), and eyes (194).*

### **Lost Time from Injuries and Occupational Diseases in Agriculture in Finland**

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Submitted to the Journal of Safety Science in March 2008

#### **Abstract**

We aimed to quantify lost time from agricultural injuries and occupational diseases and to identify risk factors for long disability. Compensated injury and occupational disease claims in 1996 (N=10,922) from the Finnish farmers' workers' compensation were included in this study. Statistical methods were used for examining lost time characteristics and potential risk factors. The total lost time was 1431 person-years, which was 1.04% of the 137,002 person-years in agriculture in 1996. About 51% of the lost time was from short-term disabilities compensated within one year from the incident, 21% was from temporary long-term disabilities, and 28% was from permanent disabilities. Occupational diseases comprised 8% of claims and 29% of lost time.

The mean lost time was 37 days for injuries and 185 days for occupational diseases. Women had more occupational diseases and longer disability times compared to men. Disability duration increased with age. Work with dairy and beef animals and horses, commuting, transportation, grain and feed handling, and cutting trees were work activities associated with long disabilities. Circular saws, sawmills, wood chippers and splitters; biological causes; motorcycles, snowmobiles, and fishing vessels; power take-off shafts; stairs; ladders; scaffoldings; and slippery terrain were causes associated with long disabilities. Injuries and occupational diseases decrease productive work time in agriculture. Prevention of lung disease from organic dusts, falls from elevation, injuries from large animals, and certain machinery-related injuries should be prioritized.

### Manuscript

Submitted to the American Journal of Industrial Medicine, November 2007

### Risk Factors for Serious Injury in Finnish Agriculture

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**KEY WORDS:** agriculture, injury, accident, insurance, workers' compensation, disability, injury cost

### Abstract

**Background.** Previous studies indicate twenty percent of injuries represent eighty percent 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 Euros).

**Results. A** total of 5507 compensated injuries occurred in 2002 (rate 5.9/100 person-years), and 1167 or 21 percent 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 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 occupational health service system 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.

### 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 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]. 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 5 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 5977 compensated claims, 5507 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 [one 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 1.

Table 1. Number of insured farms, farmers, claims, and records in dataset (2002).

<u>Type of record</u>	<u>Frequency</u>
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

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 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 5507 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 Euro 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 indicates 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. Occupational health service (OHS) membership indicates whether the farmer has joined the voluntary health and safety program which has been available since the 1980's [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 2. The unit of analysis was person/record (n=94,115).

Table 2. 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
Pigs		5,721	6
Poultry		3,007	3
Sheep		2,166	2
Horses		4,749	5

Statistical methods: Multiple logistic regression was used as the primary method for identifying the risk factors for injury. We used the stepwise (forward) procedure for model selection, including and keeping variables at  $p < 0.05$  level. Risk factors were examined at two outcome severity levels: 1) any injury vs. no injuries and 2) serious injury (at least €2000 Euro claim compensation) vs. no injuries. 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: 93,550 farmers 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) Euros, field size 30 (26) hectares, and forest size 53 (61) hectares.

Outcomes: A total of 5507 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 7 cases. This distribution is presented in Table 1.

The severity distribution of the injury outcomes is presented in Table 3. Fatality cases (n = 11) were added to this table, increasing the total injury count to 5518. 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 3. The same information in fewer categories is drawn in Figure 1.

Table 3. Number and Dercentagee of injuries b<sup>y</sup> severity.

Injury severity class	Number of injuries	Percentage of injuries	Number of injuries per one fatality	Injury rate per 1000 person-years
Fatality	11	0.2	1	0.1
Disability duration	96	1.7	9	1.0
>=360 days				
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 Euros	179	3.3	17	1.9
>=€5000 Euros	451	8.3	42	4.9
>=€2000 Euros	1167	21.7	109	12.8

## Figure 1. Injury Pyramid.

Number of non-fatal injuries per one fatality.

Disability duration	
/1	H Fatality
9	H $\geq 360$ days
<hr/> 23	H 120-359 days
<hr/> 99	H 30-119 days
<hr/> 369	H 0-29 days

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, occupational health service (OHS) membership, main type of production, and the presence of bovines, poultry, sheep, and horses. Most of the same risk factors were also selected when using serious injury as outcome; a few factors became insignificant and were omitted from the final model. Table 4 gives estimates of the odds ratios (OR), together with their 95% 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 when compared to women. Higher income level and greater field size were risk factors for injury and serious injury. Finnish language (compared to Swedish), residence on the farm, owner status, and occupational health service membership were significant risk factors for injury, but not for serious injury. 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 increased the injury risk; the raising of horses increased the risk of serious injury. 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.

Table 4. Risk factors for all injuries and serious injuries (n = 94,115 records).

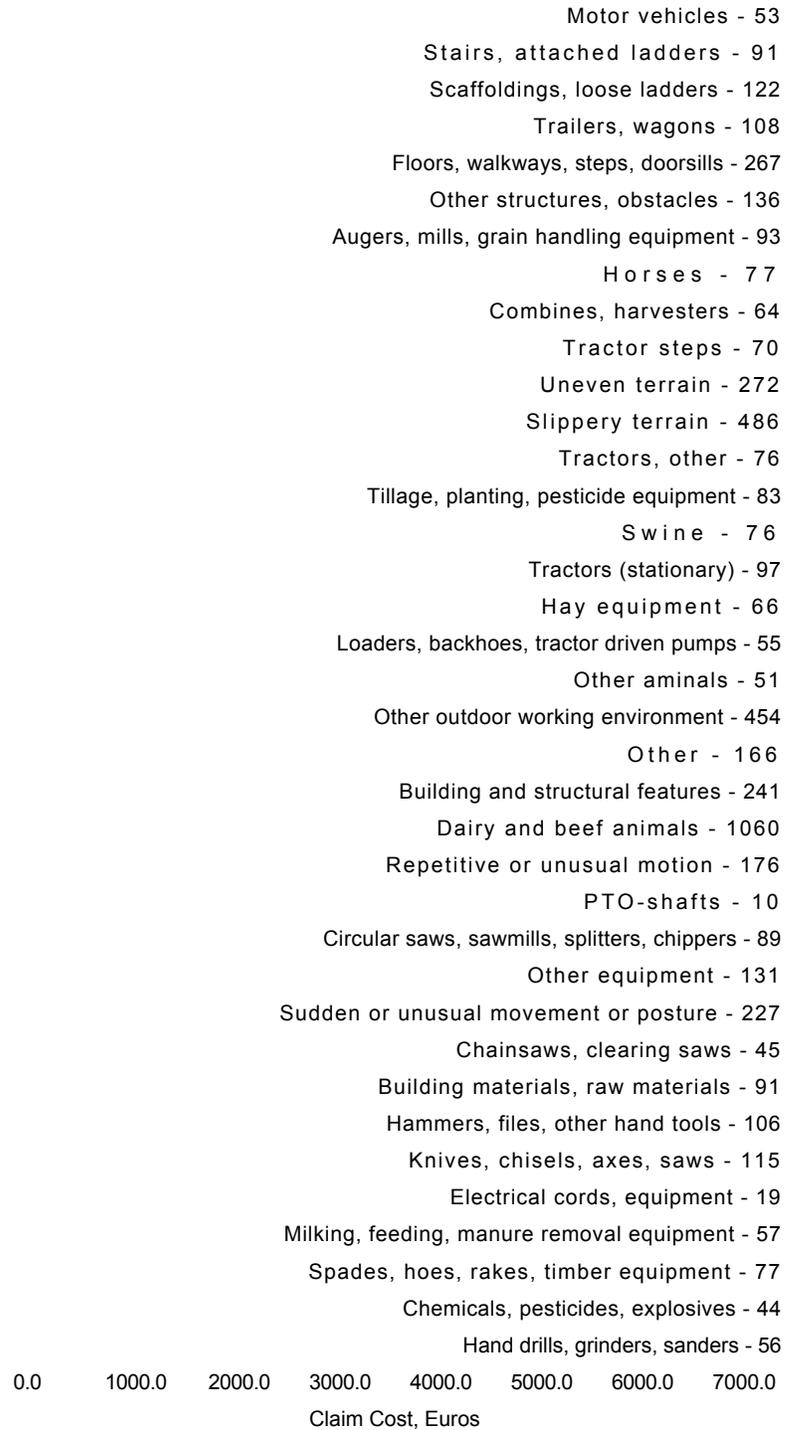
Variable	Category	Frequency	All injuries (n=5507)		$\geq$ €2000 Euro injuries (n=1195)			
			Odds Ratio	95% Confidence limits	Odds Ratio	95% Confidence Limits		
				Lower	Upper	Lower	Upper	
Age	19-29	4,049	<b>0.77</b>	<b>0.64</b>	<b>0.92</b>	<b>0.64</b>	<b>0.42</b>	<b>0.98</b>

	30-39	19,032	<b>0.77</b>	<b>0.68</b>	<b>0.88</b>	0.82	0.62	1.09
	40-49	31,603	<b>0.83</b>	<b>0.74</b>	<b>0.94</b>	1.01	0.77	1.32
	50-59	33,116	0.99	0.87	1.11	1.20	0.92	1.57
	>=60-Reference	6,315	-	-	-	-	-	-
Sex	Male	59,392	<b>1.77</b>	<b>1.66</b>	<b>1.89</b>	<b>1.40</b>	<b>1.23</b>	<b>1.60</b>
	Female - Reference	34,723	-	-	-	-	-	-
Language	Finnish	86,202	<b>1.30</b>	<b>1.15</b>	<b>1.46</b>	<b>N/S</b>	<b>N/S</b>	<b>N/S</b>
	Swedish -Reference	7,913	-	-	-	-	-	-
Income, Euros	0-4,999	12,658	<b>0.31</b>	<b>0.26</b>	<b>0.37</b>	<b>0.20</b>	<b>0.13</b>	<b>0.30</b>
	5,000-9,999	22,738	<b>0.63</b>	<b>0.57</b>	<b>0.69</b>	<b>0.44</b>	<b>0.36</b>	<b>0.54</b>
	10,000-14,999	30,934	<b>0.83</b>	<b>0.78</b>	<b>0.87</b>	<b>0.68</b>	<b>0.59</b>	<b>0.77</b>
	>=15,000-Reference	27,785	-	-	-	-	-	-
Residence	Farm	88,675	<b>1.47</b>	<b>1.19</b>	<b>1.81</b>	<b>N/S</b>	<b>N/S</b>	<b>N/S</b>
	Not known	4,244	1.21	0.84	1.76	N/S	N/S	N/S
	Off-Farm - Reference	1,196	-	-	-	-	-	-
Status	Owner operator	92,409	<b>0.67</b>	<b>0.53</b>	<b>0.86</b>	<b>N/S</b>	<b>N/S</b>	<b>N/S</b>
	Other - Reference	1,706	-	-	-	-	-	-
Field size, ha	0-9	15,382	<b>0.73</b>	<b>0.64</b>	<b>0.84</b>	<b>0.63</b>	<b>0.46</b>	<b>0.86</b>
	10-19	23,369	<b>0.74</b>	<b>0.68</b>	<b>0.80</b>	<b>0.69</b>	<b>0.57</b>	<b>0.83</b>
	20-29	19,553	<b>0.85</b>	<b>0.78</b>	<b>0.91</b>	0.86	0.73	1.01
	30-39	12,586	<b>0.87</b>	<b>0.80</b>	<b>0.94</b>	0.92	0.77	1.09
	>=40 - Reference	23,225	-	-	-	-	-	-
OHS member	Yes	29,779	<b>1.28</b>	<b>1.20</b>	<b>1.36</b>	<b>N/S</b>	<b>N/S</b>	<b>N/S</b>
	<b>No</b> - Reference	64,336	-	-	-	-	-	-
Production	Special crops	5,354	<b>1.30</b>	<b>1.12</b>	<b>1.49</b>	1.08	0.81	1.45
	Vegetables	2,083	<b>1.47</b>	<b>1.17</b>	<b>1.84</b>	0.85	0.47	1.52
	Greenhouse	417	<b>1.90</b>	<b>1.20</b>	<b>3.01</b>	1.09	0.34	3.43
	Other crops	3,587	<b>1.28</b>	<b>1.05</b>	<b>1.56</b>	1.28	0.85	1.93
	Dairy	30,332	<b>2.07</b>	<b>1.71</b>	<b>2.51</b>	<b>1.57</b>	<b>1.06</b>	<b>2.32</b>
	<b>Beef</b>	5,520	<b>1.54</b>	<b>1.25</b>	<b>1.90</b>	0.99	0.63	1.54
	Other bovine	630	<b>1.88</b>	<b>1.34</b>	<b>2.63</b>	1.69	0.86	3.32
	Feeder pigs	2,254	<b>2.04</b>	<b>1.72</b>	<b>2.42</b>	<b>1.51</b>	<b>1.05</b>	<b>2.17</b>
	Finishing pigs	1,536	<b>1.42</b>	<b>1.14</b>	<b>1.77</b>	<b>1.73</b>	<b>1.17</b>	<b>2.55</b>
	Other pigs	1,928	<b>1.82</b>	<b>1.51</b>	<b>2.18</b>	<b>1.52</b>	<b>1.04</b>	<b>2.21</b>
	Poultry	346	1.09	0.67	1.77	0.53	0.13	2.14
	<b>Eggs</b>	938	<b>1.60</b>	<b>1.19</b>	<b>2.16</b>	1.50	0.87	2.59
	Other poultry	185	1.20	0.64	2.26	0.51	0.07	3.64
	Sheep	590	<b>1.56</b>	<b>1.03</b>	<b>2.37</b>	1.14	0.42	3.09
	Goats	<b>49</b>	<b>4.77</b>	<b>1.96</b>	<b>11.60</b>	4.32	0.59	31.78
	Horses	969	<b>2.76</b>	<b>2.10</b>	<b>3.62</b>	<b>3.66</b>	<b>2.27</b>	<b>5.92</b>
	Other production	322	1.66	0.98	2.81	2.05	0.75	5.59
	Unknown	10,947	1.08	0.92	1.27	1.01	0.72	1.41
	Cereals - Reference	26,128	-	-	-	-	-	-
Bovines	Yes	36,883	<b>1.27</b>	<b>1.06</b>	<b>1.52</b>	1.40	0.96	2.04
	No - Reference	57,232	-	-	-	-	-	-
Poultry	Yes	3,007	<b>1.28</b>	<b>1.08</b>	<b>1.53</b>	<b>N/S</b>	<b>N/S</b>	<b>N/S</b>
	<b>No</b> - Reference	91,108	-	-	-	-	-	-
Sheep	Yes	2,166	<b>1.24</b>	<b>1.02</b>	<b>1.50</b>	<b>N/S</b>	<b>N/S</b>	<b>N/S</b>
	<b>No</b> - Reference	91,949	-	-	-	-	-	-
Horses	Yes	4,749	<b>1.22</b>	<b>1.08</b>	<b>1.37</b>	<b>N/S</b>	<b>N/S</b>	<b>N/S</b>
	<b>No</b> - Reference	89,366	-	-	-	-	-	-

Note: N/S = Not significant — excluded in logistic stepwise procedure at  $p < 0.05$  level.

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 ( $\geq \text{€}2000$  Euro 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.

**Figure 2. Average Claim Cost and Standard Error by Cause of Injury**  
**Frequency of injuries indicated for each category**



## Discussion

The current study reports injury risk factors from a large national insurance system (which started in 1982) that covers all farmers. 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 could be addressed using longitudinal data with a longer injury follow-up period, preferably data over the entire working career. While such data could be obtained from Mela, we have not addressed this issue in our present study.

In 2002, 4919 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, 2007]. We have not reported these results as they were similar to the logistic regression results in Table 4.

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 one-year disabilities, hundred one-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 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, occupational health service (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, and horses 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 Euro 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 (Meta) 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, a 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 5507 compensated agricultural injuries occurred in Finland in 2002, and 1167 (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 (versus Swedish), occupational health service 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 raising 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**

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## **Publications.**

This project has produced and contributed to the following publications and presentations.

### Peer-reviewed journal articles

1. Rautiainen R, Lehtola M, Day L, Salminen S, Schonstein E, Suutarinen J. Interventions for preventing injuries in the agriculture industry. The Cochrane Collaboration. Occupational Health Field. Systematic review protocol. The Cochrane Library, Jan 2007, Issue 1.
2. Kaustell KO, Mattila TEA, Rautiainen RH. Safety performance of animal confinement floors – slip, trip and fall injuries in Finland. *J Agric Saf Health* 13(4):395-406. November 2007.
3. Rautiainen R, Lehtola M, Day L, Salminen S, Schonstein E, Suutarinen J. Interventions for preventing injuries in the agriculture industry. The Cochrane Collaboration. Occupational Health Field. Systematic review. The Cochrane Library. February, 2008.
4. Mattila TEA, Kaustell KO, Rautiainen RH, Pitkinen T, Lotjonen T, Suutarinen J. Slip, Trip and fall injuries in potato, sugar beet and open field vegetable production in Finland. *Ergonomics* (Online publication Oct 17, 2008).
5. Lehtola MM, Rautiainen RH, Day LM, Schonstein E, Suutarinen J, Salminen S, Verbeek JH. Effectiveness of interventions in preventing injuries in agriculture – a systematic review and meta-analysis. *Scand J Work Environ Health* (Online publication Oct 22, 2008).

### Peer-reviewed articles in press (submitted):

1. Rautiainen RH, Sprince NL, Donham KJ, Ohsfeldt RL, Burmeister LF, Reynolds SJ, Zwerling C. Lost time from injuries and occupational diseases in agriculture in Finland. *Safety Science*. (Submitted Dec 2007)
2. Rautiainen L, Ledolter J, Ohsfeldt R, Donham K, Zwerling C. Risk Factors for Serious Injury in Finnish Agriculture. *Am J Ind Med*. Submitted Nov 2007.

3. Myers ML, Rautiainen RH, Eskola E. Farm building construction-related injuries and diseases. *Journal of Agromedicine*. Submitted Sept 2008.

Non-peer-reviewed articles:

34. Mattila T, Rautiainen R, Kaustell KO, Suutarinen J. Safety as criteria for animal housing floor surface design (in Finnish). Conference proceedings of the Finnish agricultural science days, 11-12.1.2006, Viikki, Helsinki. Available at: <http://www.smts.fi/pos06/0805.pdf>. Accessed 3/6/2006.
35. Kaustell KO, Mattila T, Rautiainen R. Safety as criteria for animal housing floor surface design. 6<sup>th</sup> World Congress of the International Ergonomics Association. July 10-14, 2006. Maastricht, the Netherlands.
36. Mattila T, Rautiainen R, Kaustell KO. Slip, Trip and Fall Injuries Related to Floor Structures in Animal Confinements. Paper # 06-05. 2006 Summer Conference of the National Institute for Farm Safety, Sheboygan, Wisconsin. June 28, 2006.
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40. Suutarinen J, Rikkinen P, Karttunen J, Tuure V-M, Rautiainen R, Louhelainen K, Mattila T, Pehkonen A. Strategy for sustainable development in agricultural safety, health, and wellness 2007-2015 (in Finnish). Conference proceedings of the Finnish agricultural science days, 10-11.1.2008, Viikki, Helsinki.
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44. Rautiainen RH, Lehtola M, Day L, Salminen S, Schonstein E, Suutarinen J. Interventions for preventing injuries in the agricultural industry. Paper No 08-13. National Institute for Farm Safety. 2008 Annual Conference. Lancaster, PA. June 22-26, 2008.

**Presentations:**

June 28, 2006	Slip, Trip and Fall Injuries Related to Floor Structures in Animal Confinements	2006 Summer Conference of the National Institute of Farm Safety, Sheboygan, Wisconsin
July 10-14, 2006	Safety as criteria for animal housing floor surface design	6 <sup>th</sup> World Congress of the International Ergonomics Association, Maastricht, the Netherlands
Aug 22, 2006	Trends in agriculture – implications for agricultural safety and health professionals	Nordic Meeting on Agricultural Occupational Health. August 21-23, 2006. Kuopio, Finland
Aug 23, 2006	Cost of compensated injuries and occupational diseases in agriculture in Finland	Nordic Meeting on Agricultural Occupational Health. August 21-23, 2006. Kuopio, Finland
Aug 22, 2006	Impact of changes in operational environment of agriculture to the working environment	Nordic Meeting on Agricultural Occupational Health. August 21-23, 2006. Kuopio, Finland
June 26, 2007	Hearing loss as a risk factor for agricultural injuries	National Institute for Farm Safety, 2007 Summer Conference. Penticton, BC, Canada. June 24-28, 2007.
June 27, 2007	Risk factors for serious injury in agriculture	National Institute for Farm Safety, 2007 Summer Conference. Penticton, BC, Canada. June 24-28, 2007.
Aug 10, 2007	Work, health, and social insurance systems among US agricultural workers	Farmers Social insurance Institution (Mela), Espoo, Finland.
Jan 10-11, 2008	Sustainable strategy for safety, health and wellness in agriculture 2007-2015	Finnish agricultural science days. University of Helsinki, Viikki, Finland
Jan 23, 2008	Iowa Pork Congress. Occupational health and safety for pork producers and employees.	Iowa Pork Producers Council, Des Moines, IA

Jun 24, 2008	Effectiveness of the Certified Safe Farm program on-farm safety review process in identifying and removing injury and illness hazards.	NIFS Annual Meeting, June 22-25, 2008, Pennsylvania.
Jun 24, 2008	Interventions for preventing injuries in the agriculture Industry.	NIFS Annual Meeting, June 22-25, 2008, Pennsylvania.
Jun 24, 2008	Lost time from injuries and occupational diseases in agriculture in Finland.	NIFS Annual Meeting, June 22-25, 2008, Pennsylvania.
Jun 24, 2008	Work ability index among Finnish dairy farmers	NIFS Annual Meeting, June 22-25, 2008, Pennsylvania.
Sep 2, 2008	Does farmers occupational health service reduce injuries – Evaluation of the Finnish farmers' occupational health service system	Nordic meeting on agricultural safety and health. September 1-3, 2008. Aarhus, Denmark.
Oct 21, 2008	Interventions for preventing injuries in the agriculture Industry.	Public health and the ecosystem. 6th International Symposium. Saskatoon, SK, Canada Oct 18-22, 2008.
Oct 22, 2008	Farm building construction-related injuries and diseases	Public health and the ecosystem. 6th International Symposium. Saskatoon, SK, Canada Oct 18-22, 2008.
Oct 22, 2008	Does farmers occupational health service reduce injuries? - Evaluation of the Finnish farmers occupational health service system	Public health and the ecosystem. 6th International Symposium. Saskatoon, SK, Canada Oct 18-22, 2008.

### **Inclusion of gender and minority study subjects.**

The study subjects were Finnish farmers who were insured by the mandatory agricultural workers' compensation insurance. The breakdown of subjects by age, sex, and domestic language is provided below. Information on race or ethnicity are not collected.

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

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**Inclusion of Children.**

The subjects were active farmers or salaried family members. Children younger than 19 years of age were not included in this insurance data system.

**Materials available for other investigators**

This study has initiated collaboration with investigators at The University of Iowa, University of Kentucky, TTS Institute Finland, and MTT Agrifood Research Finland. The Finnish Farmers Social Insurance Institution has provided datasets to Dr. Rautiainen with permission to use them for completing this research project. Further research projects are under preparation and several investigators will be able to utilize this data resource, after presenting a research plan to the Finnish Farmers Social Insurance Institution, and signing a data use agreement which defines the confidentiality rules for using the data for research. The University of Iowa in consultation with CDC/NIOSH determined that research from these data is not considered human subjects research based on using existing data that was collected for insurance and not research purposes, no contacts were made with subjects for collect further data, and no personal identifiers were included in the data.

**b) Final Financial Status Report Forms.**

Financial status report has been submitted by the University of Iowa separately.

**c) Final Invention Statement and Certification Form.**

Financial invention report has been submitted by the University of Iowa separately.

**CONTACTS:**

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