CLUSTERING OF OCCUPATIONAL INJURIES, DISEASES, AND DISABILITY IN FINNISH FARMERS – an opportunity for targeted prevention

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DOCTORAL THESIS IN AGROTECHNOLOGY

To be presented, with the permission of the Faculty of Agriculture and Forestry of the University of Helsinki, for public examination in Auditorium B2, Latokartanonkaari 7, Helsinki, on January 24, 2014, at 12 o'clock noon.

Helsinki 2014
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ISBN 978-952-10-8880-3 (Print)
ISBN 978-952-10-8881-0 (Online)
ISSN 1798-7407 (Print)
ISSN 1798-744X (Online)
ISSN-L 1798-7407

Electronic publication available at: http://ethesis.helsinki.fi
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Unigrafia
Helsinki 2014
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References
LIST OF ORIGINAL ARTICLES

This doctoral thesis is based on the following articles, which are referred to in the text by their Roman numerals:


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EE = Mr. Erkki Eskola (Farmers' Social Insurance Institution, Finland)
ABSTRACT

The objective of this doctoral thesis was to generate knowledge that can be used to enhance the prevention of occupational injuries, diseases, and declined work ability among self-employed Finnish farmers.

This research was based on four separate studies: a postal survey addressing work ability among dairy farmers, two longitudinal analyses of occupational injury and disease claims data of farmers, and a combined postal/telephone survey among case and control dairy farm couples. These data were augmented with national insurance and agricultural statistic data. The results were reported in five peer-reviewed articles.

Prior injuries and diseases diagnosed by a physician were strongly associated with declined work ability of dairy farmers measured either by the standard Work Ability Index, or a single question addressing the self-assessed current work ability. However, the temporal order of the above-mentioned health conditions requires further study.

Analyses of claims data indicated both occupational injuries and diseases were clearly clustered among farmers. Livestock farmers in particular were at risk of recurrent injury and disease. Both minor and serious claims frequently resulted from work activities and causes related to animal husbandry. Recurrent injuries and diseases of the musculoskeletal system in particular were caused by strenuous working motions and postures in animal husbandry. However, the relative frequency of serious injury was highest among cereal crop farmers, and in work activities related to seasonal crop farming regardless of the claimants' main type of production.

Risk of occupational injuries, diseases, and disability was particularly high among aging livestock farmers in general and dairy farmers in particular. These full-time farmers or farm couples typically had a long work history of mixed livestock and crop farming. Dairy farmers with small and middle-sized farms with arduous working conditions were at the highest risk. In contrast, expanding the production and improving the working environments and methods protected against adverse health outcomes.

Supplemental data indicated a downward trend in the annual number and rate of both occupational injuries and diseases after insurance policy changes in 2005. Simultaneously, the proportion of serious injuries has grown significantly. Based on the current structural changes including the aging of farmers and transition from full-time mixed livestock and crop farming to seasonal crop farming, these trends may prevail in the future.

The identified risk and protective factors could be used for selecting high-risk target populations among farmers to increase the cost-effectiveness of preventive efforts in Finland and elsewhere. Finally, various measures are suggested to prevent hazardous working conditions, adverse health outcomes, and premature retirement from farming among Finnish farmers.
Tämän väitöstiteliksen tavoitteena oli tuottaa tietoa, jonka avulla kyetään tehostamaan työtapaturmien, ammattitautien ja työkyvyttömyyden torjuntatoimia suomalaisen maatalousyrittäjien keskuudessa.


PREFACE AND ACKNOWLEDGEMENTS

This decade-long project was carried out at the TTS - Work Efficiency Institute for the Department of Agricultural Sciences in the University of Helsinki. For the first five years or so, this project progressed slowly alongside my full-time job as a researcher and a few commissions of trust. Looking back now, that time was well spent in developing my professional networks and experience. In the case of the doctoral thesis, the other half of the decade has obviously been more fruitful.

First of all, I am thankful to my supervisors, Professor Jukka Ahokas and Professor Risto Rautiainen. Jukka Ahokas navigated me smoothly through the pitfalls of my PhD studies. Always so industrious Risto Rautiainen was the co-author of all my articles as well. His expertise, advice, and encouragement were absolutely vital for my thesis.

I am sincerely thankful for the support I received from my superiors and colleagues, both past and present, at TTS. Without your positive attitude, and the extensive support provided by TTS, my project surely would have failed. I also thank my counterparts in MTT Agrifood Research Finland, Finnish Institute of Occupational Health, and University of Helsinki for your contributions and intellectual sparring during this project. In particular, I owe warm thanks to Docent, University Lecturer Hanna-Riitta Kymäläinen for her most valuable comments with the manuscript of the thesis.

The Farmers’ Social Insurance Institution (Mela) funded the original studies included in this thesis, provided parts of the data, and offered staff support, which is gratefully acknowledged. From Mela, I owe special thanks to the Mr. Erkki Eskola and Mr. Pentti Saarimäki for their generous help.

The Finnish Cultural Foundation and The Scientific Agricultural Society of Finland financially supported my work. I want to express my gratitude for this support.

Docent Markus Pyykkönen from the University of Helsinki and Professor John Rosecrance from the Colorado State University, the reviewers of my thesis, are gratefully acknowledged for their valuable work.

Thanks to my wife Nora for your love and patience, and bearing my absent-mindedness. I owe thanks also to my siblings and their families, as well as to my relatives, friends, and acquaintances for your encouragement during my studies.

Finally, my warmest thanks go to my mother and late father. A quarter of a century ago you allowed me the opportunity to study as far as I wanted. Well, I think finishing the thesis is a pretty good milestone.

Veikkola, December 6, 2013

Janne Karttunen
ABBREVIATIONS AND DEFINITIONS

Abbreviations, acronyms, and definitions are used as follows in this thesis:

CI
Confidence Interval
CWA
Current Work Ability
farming population
self-employed farmers, spouses, and other salaried family members, referred to as "farmers"
FIOH
Finnish Institute of Occupational Health
FOHS
Farmers' occupational health services
ICD-10
The International Statistical Classification of Diseases and Related Health Problems, 10th Revision (WHO 2013)
incidence
The number of new cases of an outcome that develop in a particular population in a given period of time (Greenland and Rothman 2008)
longitudinal study
Involving the repeated observation of a set of subjects over time with respect to one or more study variables (Merriam-Webster 2013)
Mela
Finnish acronym for the Farmers' Social Insurance Institution
occupational disease
A disease that is probably predominantly due to physical, chemical, or biological factors associated with work (TVL 2012, Occupational Safety and Health Administration 2013)
occupational injury
A sudden, unexpected and unwanted forceful event due to an external cause in the course of work, resulting in bodily damage (TVL 2012, Occupational Safety and Health Administration 2013)
OR
Odds Ratio: the odds of an outcome in one group divided by the odds of an outcome in another group (Cochrane Collaboration 2013)
prevalence
The number of cases of an outcome that are present in a particular population at a given time (Greenland and Rothman 2008)
RR
Risk Ratio/Relative Risk: risk of an outcome in one group divided by the risk of an outcome in another group (Cochrane Collaboration 2013)
Tike
Finnish acronym for the Information Centre of the Ministry of Agriculture and Forestry
WAI
The Work Ability Index (Tuomi et al. 2006)

Keywords: agriculture, claim, dairy, disease, disability, farm, gender, injury, insurance, livestock, occupational health, risk, Work Ability Index
1 INTRODUCTION

This chapter will firstly introduce the main features of Finnish agriculture including the structural changes of farming in general and of dairy farming in particular. The social insurance system, occupational health services, and farm relief worker services of the self-employed farming population will be briefly introduced as well. Secondly, annual rates and distribution of occupational injury and disease as well as the measurement of work ability among farmers both in Finland and elsewhere will be briefly reviewed.

1.1 MAIN FEATURES OF FINNISH AGRICULTURE

Finnish agriculture is mostly based on traditional family farming. In 2010, private individuals owned 88%, farming syndicates formed by, e.g., two generations of the farming family owned 7%, and heirs owned 4% of the Finnish farms. Other forms of ownership such as limited companies, or registered or limited partnerships were rare. (Tike 2011a).

Self-employed farming population includes farmers, spouses, and other salaried family members. They composed approximately 90%, and hired nonfamily workers with regular work, and municipal or private farm relief workers with permanent contracts composed the rest of the workforce in Finnish agriculture in 2010. These figures do not include the seasonal workforce on farms. (Tike 2011b, Mela 2012).

Meanwhile, approximately one-third of the Finnish farms (31%) were diversified, and this was more common in crop farms than livestock farms. Diversified farms are engaged in other gainful activities besides agriculture. Nearly half (46%) of the diversified farms provided machinery contracting, such as farm or forest machinery contracting, snow ploughing and other road maintenance, or excavation work. (Tike 2011c, Tike 2011d).

The majority of Finnish farms (93% in 2010) owned forestland, i.e., forests, afforested land and arable land prepared for afforestation. In 2010, the average forestland area per farm was 53 hectares (1 hectare = 2.47 acres). (Tike 2011e).

1.1.1 Structural change of farming

Registered owner-operators of the farms are accustomed to indicating their primary subsector for various information sources. Mixed farming, i.e., combination of livestock and various crops typically augmented with forestry, has traditionally been common on farms, but the structural change of farming is altering this situation.

The total number of farms reached its peak during the late 1950’s when there were approximately 330,000 farms with over one hectare of
arable land (Tike 2000a). Ever since that the number of farms has declined relatively steadily (Tike 2000a, Tike 2000b, Tike 2011f). In 1995, when Finland became the member of the European Union, there were 99,964 active farms left, and over half (54%) of these were livestock farms (Tike 2011g).

While the total number of active farms continued to decline during the first decade of the 2000’s, the remaining farms enlarged their average field area (Figure 1). In 2001, there were 77,320 farms with the average field area of 29 hectares, while in 2010 there were 62,767 farms left with the average field area of 37 hectares (Tike 2011a, Tike 2011h).

The total number and proportion of livestock farms continued to decline during the late 1990’s and the first decade of the 2000’s. In 2001, there were 34,825 livestock farms representing less than half (45%) of all active farms. In 2010, there were 20,829 livestock farms left, which represented one-third (33%) of all active farms. Only the horse husbandry farms showed an increasing trend both in absolute and relative terms. (Tike 2013).

Simultaneously, the total number of crop farms has remained unchanged, but their proportion has grown. In 2001, there were 41,448 crop farms representing over half (54%) of all active farms, while in 2010 there were 41,251 crop farms representing two-thirds (66%) of all active farms. Cereal crop farms represented two-thirds (66%) of the crop farms. (Tike 2013). The rest were growing special crops such as reed canary grass, caraway, broad bean, and flax, or other crops such as oilseed rape, root vegetables such as carrots and sugar beet, potatoes, and peas.

Along with all the other livestock farms except for the horse husbandry farms, the number of dairy farms has declined, and the remaining dairy farms have enlarged their operations (Figure 2). In 2001, there were

![Figure 1 Number of farms by production type (columns) and average field area (line) from 2001 to 2010 in Finland (Tike 2013).](image)
21,922 dairy farms with the average of 16 dairy cows and 34 hectares of arable land (Tike 2002a, 2002b, 2011i). In 2010, there were 11,907 dairy farms left with the average of 24 dairy cows and 51 hectares of arable land (Tike 2011j, Tike 2011k).

During the first decade of the 2000’s, the proportion of dairy farms in the smaller herd sizes (<30 dairy cows) has steadily declined (Figure 2). As for the larger herd sizes (≥30 dairy cows), their proportion has steadily increased. Despite of that, nearly 2000 dairy farms had less than ten dairy cows in 2010, and half of all had less than 20 dairy cows. (Tike 2011k).

![Figure 2](image)

Figure 2 Number of dairy farms by herd size (columns) and average number of dairy cows per dairy farm (line) from 2001 to 2010 in Finland (Tike 2002a, Tike 2010–2003, Tike 2011k).

Along with the structural change, the average age of the owner-operators has increased. In 2001, their average age was 47.7 years, while in 2010 it was 50.6 years (Tike 2011i). Livestock farmers are younger, on average, than those at operating crop farms (Tike 2011m). However, these statistics do not include spouses and other salaried family members.

### 1.1.2 Farmers’ social insurance system

In Finland, the self-employed farming population between the age of 18 to 67, from a farm with at least five hectares of owned or rented farmland, and with at least the defined farm income (≥3,553 Euros in 2012) must take a statutory pension insurance, a group life insurance, and an accident insurance against occupational injuries and diseases. Forestland is also considered and one hectare of cultivated farmland equals 10–20 hectares of forestland depending on the geographical location of the farm. Smaller farms may obtain these insurances voluntarily. (Mela 2013a, Mela 2013b).
This workers’ compensation scheme, administered by the Farmers’ Social Insurance Institution (hereafter referred by its Finnish acronym: Mela), covers both full-time and part-time farmers. Insured persons have a financial incentive to claim their occupational injuries and diseases, and the insurance practices are well established.

The insurance coverage is based on the size of the farm operation, which is calculated from owned and rented arable land, forestland, and non-farm 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 2013a).

The total number of the self-employed farming population with pension insurance has steadily declined during the first decade of the 2000’s (Figure 3). The number of farms with pension insurance had a declining trend as well. Meanwhile, the proportion of insured males has steadily increased. In 2001, their proportion was 63%, and in 2010 it was 67%. (Mela 2013c, 2013d).

In addition, professional fishermen and reindeer herders are included in the Figures 3–5. They are covered by the same legislation regardless of the possessed farm- and forestland, but they are few in number compared to the regular self-employed farming population. In 2010, they composed 2.3% of the persons insured by Mela (Mela 2013c). Other workers’ compensation insurance carriers cover hired non-family workers and municipal farm relief workers.
1.1.3 Farmers’ occupational health services and farm relief worker services

In Finland, the self-employed farming population with the farmers' pension insurance may voluntarily join the farmers' occupational health services (referred hereafter by its acronym: FOHS). In 2010, almost two-fifths (39%) of this population had joined the FOHS (Mela 2012). FOHS is most commonly utilized by full-time farmers, especially dairy and other livestock farmers (Kinnunen et al. 2009).

FOHS are available from municipal health care centres and private clinics as well. These services include a health examination, a farm walkthrough, survey of working conditions, and health education. Also curative services are arranged. FOHS is administrated by the Finnish Institute of Occupational Health (referred hereafter by its acronym: FIOH).

According to the Good Occupational Health Practice in FOHS (Kinnunen et al. 2007), health examination to assess member's health status is made by an occupational health nurse at least every two years. If work-related health conditions, such as diseases of the musculoskeletal or respiratory system or skin diseases, are suspected, the member is then referred to an occupational physician or physiotherapist or both.

A farm walkthrough including, e.g., hygiene measurements, chemical risk assessments, and guidance regarding health and safety on farms is made by an occupational health nurse and a local farm advisor at least every four years or when the working conditions change substantially. If needed, an occupational physiotherapist or physician or both may take part in the farm walkthrough. Separate survey of working conditions and the farm walkthrough rotate every two years. (Kinnunen et al. 2007).

Curative services are provided by occupational nurses and physicians (general practitioners) if the member chooses to include these in his/her service contract. The Social Insurance Institution of Finland and the state compensate most of the expenses of this system. Members are entitled to a 20% discount on their accident insurance premiums assuming willingness to allow a farm walkthrough. (Kinnunen et al. 2007).

Also farm relief worker services are available to those with the statutory pension insurance. Livestock farmers with a defined number of livestock (e.g., at least 4 dairy cows or 16 suckler cows) are entitled to take an annual vacation (26 days in 2012) free of charge while the relief worker takes care of the animal husbandry (Mela 2011, Mela 2013e). Besides the livestock farmers, all other farmers are entitled to the partially subsidized relief worker services temporarily, e.g., in the case of sickness, disability, child care, adult education, or for the duration of rehabilitation, occupational health activities, and maternity or paternity leave. These services are, however, always discretionary. (Mela 2011).

The Ministry of Social Affairs and Health supervises the provision of the farm relief worker services. Mela is the administrator of this service,
while local units composed of one or more municipalities handle the practical arrangements and employ an adequate number of relief workers.

According to the statistics of Mela, there were over 4,500 municipal relief workers with permanent contracts in 2010 (Mela 2013f). Farmers themselves can also employ a farm relief worker, and the resultant cost is then reimbursed to the farmer. The costs of the services are covered partly by the national budget and partly by the farmers themselves.

1.2 OCCUPATIONAL SAFETY AND HEALTH IN FARMING

While farmers are a relatively small proportion of the total labor force in many western countries including Finland, agriculture ranks among the most hazardous industries based on occupational injury rates (ILO 2013). In addition to financial losses, various adverse health outcomes pose a threat to the farmers' work ability and quality of life. Severe outcomes may also cause major changes in production, premature retirement from farming, or even death.

Characteristics of and risk factors for occupational injuries among farmers in general (Solomon et al. 2007, Goldcamp 2010) and among various subpopulations of farming population have been identified. These sub-populations have included males (Day et al. 2009), older males (Nilsson et al. 2010), females (McCoy et al. 2002), adolescents (Zaloshnja et al. 2011), children (Hartling et al. 2004), and hired workers (McCurdy et al. 2003).

Serious occupational injuries including work-related fatalities among farmers in general (Hard et al. 2002, Thelin 2002) and among older male farmers (Meyer 2005), children (Brison et al. 2006), and hired workers (Horsburgh et al. 2001) have been studied. In addition to injuries, occupational and other work-related diseases constitute a major threat to the health of the farmers (ILO 2000). Chronic health outcomes such as musculoskeletal diseases (Rosecrance et al. 2006, Osborne et al. 2012a), skin diseases (Feldman et al. 2009, Stocks et al. 2010), hearing loss (Choi et al. 2005, Humann et al. 2012), respiratory diseases (Kirkhorn and Schenker 2002, Greskevitch et al. 2007), and associated biological, chemical, and physical exposures have been reported.

However, agricultural exposures are difficult to measure due to the seasonal nature and variability of farm work, as well as mixed exposure situations (Kromhout and Heederik 2005). Gender differences in farm work and corresponding claims have also been reported (Dimich-Ward et al. 2004).

1.2.1 Occupational injury and disease rates

Annual injury rate among farming populations in different countries vary widely in the literature: range 4.6–35.0 injuries/100 persons (Suutarinen 2003). According to the following three studies, this variation exists within the same country as well. Rautiainen et al. (2009) reported an occupational injury rate of 5.9/100 person-year and 0.32/100 person-year for occupa-
tional disease among the self-employed Finnish farming population based on insurance records data in 2002.

Virtanen et al. (2003) utilized insurance records data as well, and reported an occupational injury rate of 16.7/100 persons per two-year follow-up period among the self-employed Finnish farming population practicing full-time farming in 1996–1997. Full-time farming was defined as at least 75% of income coming from farming.

Taattola et al. (2012) reported selected results of a survey study conducted among full-time Finnish farmers in 2004. According to that study, 16% of the respondents recalled an occupational injury requiring medical care during the past 12 months.

The above-mentioned studies indicate the definition of an injury and disease, the follow-up period, study cohort, and data collection method influence the observed rates of agricultural injury and disease.

In Finland, Mela keeps detailed statistics on the occupational injury and disease claims of the self-employed farming population. Before compensation, each claim has to meet the definitions based on national legislation,1 interpreted by Occupational Safety and Health Administration (2013) and Federation of Accident Insurance Institutions (TVL 2012). Further, medical care provided by medical professionals has to be involved. An occupational injury is considered as minor if it causes at most 30 compensated disability days, whereas a serious injury causes at least 31 disability days (Lappalainen and Saarela 2009, Statistics Finland 2012). If the disability continues over a year, employment accident pension is available.

A premium discount (no-claims bonus) system was implemented in 1997 in the Finnish farmers’ workers’ compensation scheme. Rautiainen et al. (2005a) described the mechanism and evaluated the effect of this system. They found that the premium discount system decreased the overall claim rate, and suggested that in addition to under-reporting of particularly minor claims, this system may also have some preventive effect.

In the beginning of 2005, Full Compensation Act came into effect in Finland. According to the Act, municipal or private health centers have to report to the insurance company each time they tend an insured patient with work-related injury or disease. After that, insurance companies including Mela pay full compensation directly to the producers of medical care due to medical treatment of work-related injuries and diseases. However, it is still up to the patient, whether he or she will eventually file a claim or not.

The Act increased particularly the number of claimed and, consequently, compensated minor claims in 2005 and after among Finnish employees (TVL 2010). Farmers are not, however, included in these statistics. It is noted that due to this insurance reform, only years before 2005, or the year 2005 and after are fully comparable (TVL 2010).

The annual occupational injury rate among the Finnish self-employed farming population had a downward trend between 2005 and 2010 (Figure 4). The six-year average rate for 2005–2010 was 6.58 per 100 persons. (Mela 2013c, Mela 2013g).

![Figure 4](image)

**Figure 4** Annual number (columns) and rate of occupational injury (lines) compensated to the self-employed Finnish farming population from 2001 to 2010 (Mela 2013c, Mela 2013g, and Erkki Eskola, personal communication, October 16, 2012).

The above-mentioned trend was mostly due to the declining trend in minor injuries, which constituted the majority of all injuries. The six-year average proportion of minor injuries was 74.4%. In 2005, the rate of minor injury was 5.79 per 100 persons, and five years later it was 4.17.

Meanwhile, the annual rate of serious injury declined more moderately: in 2005 it was 1.78 and in 2010 it was 1.57. (Mela 2013c, Mela 2013g, and Erkki Eskola, personal communication, October 16, 2012). In comparison to year 2005, the proportion of serious injuries was significantly larger in 2010: 23.5% vs. 27.3%, respectively (chi-square test, p<0.0001).  

The annual occupational disease rate fluctuated between 2005 and 2010 (Figure 5). All in all, it had a declining trend. The six-year average rate for 2005–2010 was 0.38 per 100 persons. (Mela 2013c, Mela 2013g).

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2 The number of fatal occupational injuries and diseases of the insured self-employed farming population is included but cannot be extracted from the publicly available statistics of Mela. According to Mr. Erkki Eskola from Mela (personal communication, October 16, 2012), the number of fatal occupational injuries fluctuated between 5–10 cases per year during 2001–2010 (annual rate 6–11/100,000 persons). The corresponding number for fatal occupational diseases was 1–4 cases per year. These figures do not include uninsured persons.
Similar to injuries, the above-mentioned trend was mostly due to minor claims: the six-year average proportion of minor diseases for 2005–2010 was 78.9%. In 2005, the rate of minor disease was 0.40, and five years later it was 0.18. Meanwhile, the annual rate of serious disease had a downward trend as well: in 2005 this rate was 0.09, and in 2010 it was 0.06. (Mela 2013c, Mela 2013g, and Erkki Eskola, personal communication, October 16, 2012). The proportions of serious diseases did not, however, differ significantly between 2005 and 2010 (chi-square test, p=0.11).

1.2.2 Distribution and costs of occupational injuries and diseases

Nearly a century ago, Greenwood and Woods (1919) found that less than a tenth (8.2%) of British munitions factory workers had recurrent injuries accounting for almost two-fifths (39.0%) of the reported injuries. Ever since, numerous studies have reported similar results in various industries. The meta-analysis by Visser et al. (2007) confirmed that injuries were not distributed evenly in the general western population; some individuals have recurrent injuries while others have few or none. Engel (1991) suggested that individuals with recurrent injuries are also more likely to suffer from diseases. Galizzi (2012) emphasized "the need to address the phenomenon of recurrent multiple occupational injuries". However, there is little information on this in the agricultural sector.

Rautiainen et al. (2009) reported that the majority of the Finnish farmers had no compensated occupational injury or disease claims in a given year, and out of those who did, most had one claim, but some had up to seven claims. Another study among full-time Finnish farmers reported that almost one-fifth of
all compensated occupational injuries occurred to those who had previous injuries in a two-year observation period (Virtanen et al. 2003).

According to Rasmussen et al. (2000), over half of the occupational injuries, reported by a sample of Danish farmers and farm workers, were repetitive with a range of 2 to 8 injuries per person in one-year observation period. Ruseckaite and Collie (2011) compared groups of hired workers with single and multiple (two or more) compensated claims. Nearly one-third (28.5%) of the claimants working in agriculture, forestry, or fishing had multiple injury or disease claims in a five-year observation period (Ruseckaite and Collie 2011).

Visser et al. (2007) suggested that persons with recurrent claims could be considered a specific target group for prevention. It was also concluded that future studies looking into recurrence of claims would benefit from focusing on injuries requiring medical care, using a case-control design, and categorization of these injuries concerning, e.g., traffic or work (Visser et al. 2007).

Recurrent injuries and diseases cause not only human suffering but disproportionate costs as well. According to Jansson et al. (2004), adult Swedes with three or more injuries requiring hospital care in a 12-year observation period accounted for 19% of the injuries but 63% of all medical costs. Ruseckaite and Collie (2011) reported that the recurrent claims of repeat claimants among hired workers resulted in substantially higher costs and longer disability than their initial claims. As stated earlier, this study included farm workers as well. Sinisalo (2012) presented an exemplary list and estimates of various direct and indirect costs of injuries in Finnish agriculture.

Rautiainen et al. (2005b) determined the cost burden from compensated injuries and occupational diseases in Finnish agriculture using workers compensation records. According to these results, injuries represented 92% of the claims and 71% of the total costs, and occupational diseases represented 8% of the claims and 29% of the costs. Occupational diseases were about five times as costly as injuries on average. Furthermore, one-fifth of the most serious claims represent four-fifths of the total costs. (Rautiainen et al. 2005b).

Preventive efforts have been implemented to reduce the high rates and costs of occupational injuries and diseases in agriculture, but according to a meta-analysis of Lehtola et al. (2008), there is little worldwide scientific evidence that these efforts have made a statistically significant impact. Multifaceted interventions with educational components and the use of financial incentives are, however, recommended by Lehtola et al. (2008).

### 1.2.3 Work ability and Work Ability Index

According to Ilmarinen (2006a), work ability is the most important asset for employees in their working life. Work ability is based on a balance model, where individual resources match the work demands in a safe and healthy way (Ilmarinen and Tuomi 2004). Good work ability predicts the ability to function well and remain in good health at the time of retirement and after
In turn, declined work ability predicts disability pension (Liira et al. 1997, Tuomi et al. 1997) or earlier retirement (Feldt et al. 2009). High physical demands of work, hazardous work environments, and poorly organized work substantially deteriorate the work ability of people as they age (Ilmarinen and Tuomi 2004). According to a growing body of literature (e.g., McCurdy and Carroll 2000, Pinzke 2003, Perkiö-Mäkelä and Hentilä 2005, Kolstrup et al. 2006) these factors are present in agricultural work. Furthermore, experiences of work-related stress and other mental symptoms are frequent among farmers (e.g., Thomas et al. 2003, Saarni et al. 2008, Kallioniemi et al. 2011).

However, work ability is not separated from life outside work. According to Ilmarinen (2006b, 2009), microenvironment consisting of family, relatives, friends, and acquaintances, as well as the macro environment consisting of infrastructure, services, and other societal dimensions are connected and contribute to work ability.

The standard Work Ability Index questionnaire, developed by FIOH, has emerged as a useful tool to assess an individual’s work ability. The Work Ability Index (hereafter referred to as the "WAI") has multiple questions under seven main themes or items. Most questions are multiple-choice consisting of both physical and mental dimensions.

The WAI score uses a scale from 7 (worst) to 49 (best) to indicate overall work ability. The self-administrated WAI-questionnaire and instructions are available from a booklet of FIOH (Tuomi et al. 2006). The instructions include interpretation of results and the objectives of measures based on scores.

The WAI has been translated into 26 languages (Ilmarinen 2009), has good test-retest reliability (De Zwart et al., 2002), and is widely used in occupational health services and research in various industries and countries worldwide (Van den Berg et al. 2009, Ilmarinen 2009). The WAI can be used as a screening tool, referring those individuals or groups of people with reduced work ability to appropriate medical care and to activities promoting work ability. In Finland, the WAI is applied commonly in the public healthcare system including the health examinations of the FOHS (Ilmarinen and Tuomi 2004, Kallioniemi et al. 2011).

There are few peer-reviewed studies addressing the WAI within agricultural sector, and none identifying the risk factors for declined WAI among farmers. Nevala-Puranen (1996), Peltoniemi (2005), and Saarni et al. (2008) have used the complete WAI-questionnaire and included a group of Finnish farmers.

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3 Seven Items of the WAI (range of scores): 1: Current work ability (0–10); 2: Work ability in relation to the demands of the job (2–10); 3: Number of current diseases or injuries diagnosed by a physician (1–7); 4: Estimated work impairment due to diseases or injuries (1–6); 5: Sick leave during the past 12 months (1–5); 6: Own prognosis of work ability two years from now (1, 4 or 7); and 7: Mental resources (1–4). (Tuomi et al. 2006).
1.3 Summary of the introductory chapter

Finnish agriculture is based mostly on privately owned family farms operated by the self-employed farming population. This population consists of the owner-operators of the farms, their spouses, and other salaried family members. During the ongoing structural changes, especially small-sized livestock farms have discontinued their operation. At the same time, many farms have continued to expand their field area or livestock operation or both. Transition from mixed livestock-crop farming to cereal crop farming is in progress as well.

The mandatory workers' compensation scheme, administered by the Farmers' Social Insurance Institution, covers practically the entire self-employed farming population in Finland. This population has a financial incentive to claim their occupational injuries and diseases, and a well-established legal framework is in place to guide insurance practices.

Agriculture ranks among the most hazardous industries based on occupational injury rates. In addition to injuries, occupational or other work-related diseases pose a threat to farmers' well-being. In addition to high financial costs, severe outcomes may cause major changes in production, premature retirement from farming, or even death.

A growing body of research indicates agriculture involves high physical and mental demands of work, and hazardous work environments. All these factors may deteriorate the work ability of farmers as they age. Declined work ability predicts disability and early retirement. Work ability may be assessed by the standard Work Ability Index (WAI) questionnaire, which is widely used in occupational health services and research worldwide. There are few peer-reviewed studies addressing WAI within agricultural sector, but none identifying the risk factors for declined WAI among farmers.

Preventive efforts have been implemented to reduce the occupational injuries and diseases in agriculture, but to date, there is little scientific evidence that these efforts have been effective. Research confirms that occupational or other injuries are not distributed evenly in the general populations. However, there is limited information on recurrent occupational injuries and diseases among farmers.

In conclusion, better understanding of the types of disabling health conditions and specific sub-groups at highest risk of adverse health outcomes could be an important step in generating and targeting preventive measures and improving their efficiency among the present and future farmers.
2 OBJECTIVES OF THE THESIS

The objective of the thesis was to provide new scientific knowledge for targeted prevention of occupational injuries, diseases, and disability among the present and future self-employed farming population in Finland. The specific aims of the thesis were:

1. To quantify self-assessed work ability among farmers, and to evaluate the prevalence of and risk factors for declined work ability [I, II, V].

2. To identify the cumulative incidence, characteristics, and severity of, and risk factors for occupational injuries and diseases in agriculture [II, III augmented with supplemental data, IV, V].

3. To estimate current trends and future developments in occupational injury and disease statistics given the current structural changes in Finnish agriculture [Introduction, I–V augmented with supplemental data].

4. To generate recommendations for national measures for the targeted prevention of adverse health outcomes in agriculture [Introduction, I–V augmented with supplemental data].
3 MATERIALS AND METHODS

This thesis includes four separate studies reported in five peer-reviewed articles: a postal survey conducted among a sample of dairy farmers [I, II], two separate longitudinal analyses of the compensated claims among cohorts of self-employed farming population [III, IV], and a combined postal/telephone survey among case and control dairy farm couples [V]. These data were augmented with longitudinal national insurance and agricultural statistic data presented mainly in the introduction of this thesis. Overview of the materials and methods of the original studies is described in Table 1.

3.1 Study subjects

The self-assessed work ability, and the prevalence of and risk factors for declined work ability among dairy farmers [I, II] was evaluated by a postal survey consisting of two forms sent to the stratified random sample of 962 dairy farmers, one person from each at least mid-sized farm. The first form was the standard self-administrated WAI-questionnaire, and the second form contained questions about work-related and personal factors that potentially affect work ability.

Altogether 399 usable responses (245 female and 154 male; 41.5% response rate) were received. After the recruitment was closed, compensated occupational injury claim records of the respondents for a four-year period prior to the survey was received from Mela and merged with survey data into one research dataset that contained no personal identifiers. Mela administrated this voluntary mail survey in accordance with national laws on confidentiality of insurance data. The research team had no access to identifiable information on study subjects. This study will be hereafter referred to as "the postal survey".

The cumulative incidence of and risk factors for occupational injuries and diseases in agriculture [III] was identified by a retrospective cohort study including all 78,679 self-employed Finnish farmers, spouses, and other salaried family members covered by the workers’ compensation insurance during the entire calendar years 2000–2004. Data provided by Mela included compensated claims records for the insured farming population during the above-mentioned five-year period. This study will be hereafter referred to as "the five-year cohort study".

The five-year cohort study [III], and the following study ("the career-long cohort study" [IV]) as well, used existing data collected for insurance purposes, and made no contact with the study subjects. The research datasets included no personal identifiers. Confidentiality of the data was described in a signed agreement between Mela and the research team.
Table 1 Overview of the materials and methods of the original studies included in this thesis.

<table>
<thead>
<tr>
<th>Article</th>
<th>Final study subjects</th>
<th>Research method</th>
<th>Outcome variables</th>
<th>Type of potential risk factors</th>
<th>Primary statistical method(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>&quot;the postal survey&quot;</td>
<td>245 female and 154 male Finnish dairy farmers, one person per farm</td>
<td>postal survey: WAI-questionnaire</td>
<td>Work Ability Index: 4 standard categories: poor, moderate, good, and excellent</td>
<td>2 personal</td>
</tr>
<tr>
<td>II</td>
<td>&quot;the postal survey&quot;</td>
<td>the same as in the article I</td>
<td>postal survey: WAI-questionnaire augmented with a separate form</td>
<td>dichotomized WAI: declined WAI = poor or moderate WAI</td>
<td>15 personal and 23 work-related</td>
</tr>
<tr>
<td>III</td>
<td>&quot;the five-year cohort study&quot;</td>
<td>78,679 self-employed Finnish farmers, spouses, and salaried family members from 54,059 farms</td>
<td>longitudinal cohort study based on 5-year insurance records (2000–2004)</td>
<td>24,424 compensated occupational injuries and 1,684 occupational diseases</td>
<td>10 personal and 3 work-related</td>
</tr>
<tr>
<td>IV</td>
<td>&quot;the career-long cohort study&quot;</td>
<td>93,564 self-employed Finnish farmers, spouses, and salaried family members from 63,886 farms</td>
<td>longitudinal cohort study based on 26-year insurance records (1982–2008)</td>
<td>133,207 compensated occupational injuries and 9,148 occupational diseases</td>
<td>4 personal and 1 work-related</td>
</tr>
<tr>
<td>V</td>
<td>&quot;the case-control study&quot;</td>
<td>31 Finnish dairy farm couples (male &amp; female)</td>
<td>combined postal/telephone survey to case (19) and control (12) dairy farm couples</td>
<td>263 compensated occupational injuries and 20 occupational diseases</td>
<td>12 personal and 9 work-related</td>
</tr>
</tbody>
</table>

1 Articles I and II identified risk factors for declined work ability and articles III–V for occupational injuries and diseases.
2 The standard Work Ability Index questionnaire (Tuomi et al. 2006).
3 These tests were used for the basic data analysis in all the studies included in this thesis.
4 The cases had a history of recurrent compensated claims whereas the controls had neither compensated nor rejected claims.
5 Work-related variables were assessed using farm couple as the unit of analysis. Personal variables were assessed for males and females separately, using person as the unit of analysis.
Distribution and characteristics of occupational injuries and disease in agriculture [IV] was studied by a retrospective analysis of workers' compensation claims of 93,564 self-employed farmers, spouses, and other salaried family members covered by the workers' compensation insurance in 2002 and over a 26-year period (1982–2008). Persons with one or more compensated claims were divided into low- and high-risk groups of equal sizes based on their personal claim rates. This study will be referred to as "the career-long cohort study".

The combined postal/telephone survey of the characteristics of and risk factors for compensated occupational injury and disease claims in dairy farmers [V] was conducted among 31 Finnish dairy farm couples divided into case and control groups consisting of 19 and 12 farm couples, respectively. Detailed personal and farm-related data were acquired by a combined postal/telephone survey. These data included information of the division of farm work between the spouses. In addition, the respondents were asked to rank potential sources of information regarding the safety and health in farming. The last-mentioned topic was, however, reported separately. Records of the compensated claims, covering the study subjects' entire work history as insured farmers up to October 2010, originated from the insurance records of Mela.

Mela's staff identified the potential study subjects from insurance registries according to the inclusion/exclusion criteria developed by the research team. An informed consent form was prepared together with the Mela's staff. After consenting, the research team received the names, addresses, telephone numbers, and personal claim data of all voluntary study subjects from Mela. This study will be referred to as "the case-control study".

Supplemental insurance records data originating from Mela were used to examine the severity of the compensated claims of the study subjects of the five-year cohort study [III]. These data included no personal identifiers, and will be hereafter referred to as "the supplemental data".

### 3.2 Outcome variables

In the two articles based on the postal survey, the WAI score of the study subjects was either classified into four standard categories (poor, moderate, good, or excellent) [I] or dichotomized [II]. When dichotomized, the subjects with 36 points or less on a scale from 7 to 49 were classified as having declined work ability (i.e., poor or moderate WAI).

The five-year cohort study [III] included a total of 24,424 compensated occupational injuries and 1,684 compensated occupational diseases, all requiring medical care. Personal counts of injury and disease claims were constructed for each insured person over the five-year period.

The outcome variables of the career-long cohort study [IV] included a total of 133,207 compensated occupational injury claims and 9,148 compensated occupational disease claims. In addition, there were 20,167 re-
jected injury claims and 7,690 rejected disease claims during the 26-year period. Thus, about nine injury claims out of ten (86.9%) and half (54.3%) of disease claims were compensated. The national codes for work activity and cause, and the ICD-10 health outcome code were received for each compensated claim.

In the case-control study [V], the case group had a total of 263 compensated occupational injuries and 20 occupational diseases. A few variables from the insurance records of Mela were received for each compensated claim. These variables included the severity of claims, and the national codes for work activity and cause, both developed by Mela.

Work activity code describes the work activity of the person during the time of injury or exposure resulting in the occupational disease. Cause code describes the physical object, tool, or other factor in contact with the person at the time of injury or when the occupational disease exposure occurred.

Supplemental data included information regarding the severity of all the claims compensated to the study subjects of the five-year cohort study [III] during 2000–2004.

### 3.3 Potential risk factors for occupational injuries, diseases, and disability

In the postal survey, the potential risk factors (variables) for declined work ability included age and gender of the study subjects [I], and 38 work-related and personal variables [II] such as socio-demographic, injury data, farm, work, as well as rest and leisure related variables. Apart from the data regarding the total of 163 compensated occupational injury claims received from Mela, all other variables were from the second form of the postal survey.

The potential risk factors in the five-year cohort study [III] included 10 personal variables from Mela related to socio-demographic, insurance, and occupational health service membership as well as three farm-related variables from Tike for the year 2002.

The career-long cohort study [IV] focused more on the distribution and characteristics (work activity, cause, ICD-10 code) of compensated claims rather than on the identification of risk factors. However, the few tested variables included age, gender, insurance years, and the number of insured persons per farm.

The case-control study [V] included 12 potential personal variables referring to the behaviors, opinions, and demographical characteristics of the respondents. In addition, a total of 9 farm-related variables referred to the characteristics of the farm, working environment and working methods.

Supplemental data enabled tests of association between the severity of the compensated claims and the main production type of the claimants, as well as work activity during the incident.
3.4 Statistical methods

The basic data analysis used in this thesis included examining the means, standard deviations, medians, minimums, and maximums of the continuous variables and categorizing them for further analyses using Microsoft Excel. Further statistical analyses related to the test of significance were conducted using SAS version 9.2 (SAS Institute, Inc., Cary, N.C.).

The Pearson correlation coefficients were calculated for selected continuous variables [I–V]. Two-tailed t-test was used for continuous variables [I, IV, V], and two-tailed chi-square test [I–IV, supplemental data] or Fisher’s exact test [V] was used for categorical variables to compare the differences of proportions between the selected study groups.

The methods used for identifying risk factors for the studied adverse health outcomes included either univariate [IV, V], or first univariate and then multivariate [II] logistic regression analysis using the stepwise procedure for final model selection. In addition, Poisson regression analysis was used for constructing first the univariate models, and then the final multivariate model using the stepwise procedure [III].

In the logistic regression analysis the outcomes were binary, i.e., subjects either had or did not have the outcome of interest. In Poisson regression analysis the outcome of interest was in the form of counts, i.e., the number of compensated claims per person in this case. According to the methodological article of Bender (2009) and a growing body of related research, these are standard methods in epidemiologic studies identifying risk factors for adverse health outcomes.

These methods produced either odds ratios [II, IV, V] or rate ratios [III] that are presented with their 95% confidence limits for the levels of the explanatory variables (risk factors). The odds ratios and rate ratios need to be interpreted relative to selected reference groups. The results are reported at p<0.05 level unless otherwise stated [II–V].

Potential 2-way interactions and multicollinearity between selected explanatory variables (i.e., identified risk factors) were tested using the VIF (variance inflation factor), TOL (detection tolerance), and COLLIN (collinearity analysis including condition index) procedures in SAS [II, III]. There are indicative limit values available for the VIF, TOL, and COLLIN, which were applied to this thesis (IDRE 2012).

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4 Interaction between two or more explanatory variables, that are independent by default, may complicate multiple regression models; instead of "normal" additive effect, interactive variables may have synergistic or antagonistic effect. As for multicollinearity, this phenomenon refers to instability of the multivariate model due to "extreme" correlations. (IDRE 2012).
4 Results

The results of this thesis include two major parts. The first part concerns occupational disability among dairy farmers. The original articles I, II, and V produced information about this topic. The second part focuses on occupational injuries and diseases among the self-employed farming population. The corresponding articles were II, III augmented with supplemental data, IV, and V. More detailed information regarding the presented results as well as few secondary results can be found in the original articles.

4.1 Occupational disability among farmers

Two studies included in this thesis were either focused on or dealt partially with the risk of disability among Finnish dairy farmers. Firstly, the postal survey [I, II] examined the self-assessed work ability, and evaluated the prevalence of and risk factors for declined work ability. Secondly, the case-control study [V] included examination of the self-assessed current work ability compared with the lifetime best (hereafter referred to as "CWA").

4.1.1 Self-assessed work ability

In the postal survey [I] conducted among a total of 399 dairy farmers, the mean WAI score of the respondents was 37.2. Among the seven items of the WAI, the CWA had a high positive correlation with the WAI calculated from the whole questionnaire (Table 2). The mean CWA of the respondents was 7.6 points on the scale from 0 to 10 [I revisited]. The CWA of the females was statistically significantly lower than that of their male peers.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Variable</th>
<th>&lt;35</th>
<th>35–44</th>
<th>45–54</th>
<th>55–64</th>
<th>All</th>
<th>Pcc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males (n=154)</td>
<td>Mean WAI</td>
<td>42.9</td>
<td>39.5</td>
<td>38.5</td>
<td>34.8</td>
<td>39.0</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Mean CWA</td>
<td>8.4</td>
<td>8.1</td>
<td>7.7</td>
<td>7.2</td>
<td>7.9</td>
<td></td>
</tr>
<tr>
<td>Females (n=245)</td>
<td>Mean WAI</td>
<td>41.1</td>
<td>37.9</td>
<td>34.4</td>
<td>29.5</td>
<td>36.0</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>Mean CWA</td>
<td>8.5</td>
<td>7.8</td>
<td>6.9</td>
<td>6.5</td>
<td>7.5</td>
<td></td>
</tr>
</tbody>
</table>

1 The Pearson correlation coefficient between the WAI and the CWA: p<0.0001.
2,3 WAI scale 7 (worst) to 49 (best), and CWA scale 0 (worst) to 10 (best).
4,5 Significant difference between males and females (t-test): p<0.05.

The WAI was systematically better among male farmers than their female peers of all ages [I]. Age was significantly and negatively correlated with WAI (Pearson correlation coefficient r=-0.39, p<0.001). Both genders
experienced a decrease in WAI with age (Table 2). This decrease was more prominent among females than males. In addition, the decrease was relatively consistent among males but progressive with age among females (see Figure 3 in the original article I).

The proportion of females in the poor work ability category was twice as high compared to that of males (Table 3). Conversely, the proportion of males in the excellent work ability category was nearly twice as high compared to that of females. Approximately one in four females and one in ten males of at least 45 years of age had poor WAI.

Table 3 Work Ability Index (WAI) by gender [I].

<table>
<thead>
<tr>
<th>Work ability categories and corresponding scores</th>
<th>Frequency N (%)</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor (7–27)</td>
<td>11 (7.1)</td>
<td>45 (11.3)</td>
</tr>
<tr>
<td>Moderate (28–36)</td>
<td>38 (24.7)</td>
<td>112 (28.1)</td>
</tr>
<tr>
<td>Good (37–43)</td>
<td>59 (38.3)</td>
<td>155 (38.8)</td>
</tr>
<tr>
<td>Excellent (44–49)</td>
<td>46 (29.9)</td>
<td>87 (21.8)</td>
</tr>
<tr>
<td>All</td>
<td>154 (100.0)</td>
<td>399 (100.0)</td>
</tr>
</tbody>
</table>

1,2 Significant difference between males and females (chi-square test): p<0.05.

According to the third item of the WAI-questionnaire, nearly two-thirds of the males and nearly three-fourths of the females had at least one "current or recurrent disease or injury (occupational or other) diagnosed or treated by a physician" [I]. In addition, both genders reported self-diagnosed or treated current or recurrent diseases or injuries, males more than females. Only a small proportion of respondents considered themselves disease and injury free (17% of males, 12% of females).

The prevalence of declined work ability (i.e., poor or moderate WAI score) was 39% overall (Table 4). This rate was statistically significantly higher among females than males in general and among females over 50 years of age in particular.

Table 4 Prevalence of declined work ability (poor or moderate Work Ability Index) among dairy farmers by age and gender [II].

<table>
<thead>
<tr>
<th>Age group</th>
<th>Male (n=154)</th>
<th>Frequency N (%)</th>
<th>All (n=399)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;40</td>
<td>6 (13.6)</td>
<td>17 (22.4)</td>
<td>23 (19.2)</td>
</tr>
<tr>
<td>40–49</td>
<td>19 (33.9)</td>
<td>41 (45.1)</td>
<td>60 (40.8)</td>
</tr>
<tr>
<td>≥50</td>
<td>24 (44.4)</td>
<td>50 (64.1)</td>
<td>74 (56.1)</td>
</tr>
<tr>
<td>All</td>
<td>49 (31.8)</td>
<td>108 (44.1)</td>
<td>157 (39.3)</td>
</tr>
</tbody>
</table>

1 Declined current work ability: 6 points or less in a scale of 0 to 10, where 0 = completely unable to work and 10 = work ability at its best.
2 Differences in proportions were significant (chi-square test): p<0.05.

The prevalence of declined work ability was 55% among respondents with one or several current or recurrent diseases or injuries diagnosed by a physician vs. 5% among respondents with no such incidents [II revisited].
Musculoskeletal, respiratory, and skin diseases were the most common categories of physician-diagnosed diseases. Injuries of the leg or foot were the most common categories of physician treated injuries [II revisited].

The case-control study [V] conducted among 31 dairy farm couples included a question regarding the CWA. The CWA was dichotomized for further analyses: persons with 6 points or less on a scale from 0 to 10 were classified as having declined CWA. Over one-third of the study subjects had declined CWA, which was statistically significantly more common among case-females than control-females (Table 5). However, case-males did not differ statistically significantly from control-males regarding this issue.

Table 5 Prevalence of declined current work ability among the case and control dairy farmers [V revisited].

<table>
<thead>
<tr>
<th>Gender</th>
<th>Case group</th>
<th>Control group</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency N (%)</td>
<td>Frequency N (%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>6 (32)</td>
<td>2 (17)</td>
<td>8 (26)</td>
</tr>
<tr>
<td>Female</td>
<td>12 (63)</td>
<td>1 (8)</td>
<td>13 (42)</td>
</tr>
<tr>
<td>All</td>
<td>18 (47)</td>
<td>3 (13)</td>
<td>21 (34)</td>
</tr>
</tbody>
</table>

1 Declined current work ability: 6 points or less in a scale of 0 to 10, where 0 = completely unable to work and 10 = work ability at its best.
2 Significant difference between the study groups (Fisher's exact test): p<0.01.

4.1.2 Risk factors for declined work ability

In the postal survey [II], altogether 38 potential risk factors (variables) were tested in the initial univariate modeling stage. Half of the variables had no statistically significant association with the work ability. A total of 18 variables were statistically significant in univariate models and five of them were statistically significant in the final multivariate model as well. When adjusted for each other, older age, small dairy herd size, lack of mental breaks from work, inadequate leisure, and non-use of alcohol were statistically significantly associated with declined work ability.

The results of the multivariate analysis indicate that the risk of declined work ability increased with age (Table 6). Compared to their peers under 40 years of age (i.e., the reference group), the odds were over three times higher (OR: 3.40; 95% CI: 1.56–7.43) for farmers in their forties, and nearly five times higher for farmers in their fifties and older.

The total number of cattle (cows, heifers, calves, and bulls) on the farm was associated with work ability. Respondents with less than 50 cattle had higher odds of reduced work ability. Inadequate mental breaks from work and inadequate leisure were risk factors for reduced WAI as well.

Using no alcohol doubled the odds of reduced WAI compared to the reference group that consumed alcohol moderately. A greater proportion of females (51%) than males (34%) reported using no alcohol [II revisited].
Table 6 Risk factors for declined work ability among dairy farmers (n=399) [II].

<table>
<thead>
<tr>
<th>Factor</th>
<th>Category</th>
<th>Frequency (%)</th>
<th>Adjusted WAI OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>≥50</td>
<td>132 (33)</td>
<td>4.67</td>
<td>2.17-10.25</td>
</tr>
<tr>
<td></td>
<td>40 to 49</td>
<td>147 (37)</td>
<td>3.40</td>
<td>1.56-7.43</td>
</tr>
<tr>
<td></td>
<td>&lt;40 (Ref.)</td>
<td>120 (30)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Over 50 cattle (cows, heifers, calves, and bulls)</td>
<td>No</td>
<td>246 (62)</td>
<td>2.04</td>
<td>1.03-4.03</td>
</tr>
<tr>
<td></td>
<td>Yes (Ref.)</td>
<td>151 (38)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Adequate mental breaks from work</td>
<td>No</td>
<td>123 (32)</td>
<td>2.71</td>
<td>1.41-5.22</td>
</tr>
<tr>
<td></td>
<td>Yes (Ref.)</td>
<td>260 (68)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Adequate free time vs. farm work</td>
<td>No</td>
<td>278 (73)</td>
<td>2.47</td>
<td>1.17-5.20</td>
</tr>
<tr>
<td></td>
<td>Yes (Ref.)</td>
<td>105 (27)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Alcohol usage on average</td>
<td>No</td>
<td>173 (46)</td>
<td>2.23</td>
<td>1.21-4.09</td>
</tr>
<tr>
<td></td>
<td>Yes (Ref.)</td>
<td>204 (54)</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

1 Fully adjusted model.
2 No = work-related problems distress quite often or daily.
3 No = abstainer; Yes = consumes 1 to 7 standard drinks per week on average.

In addition, univariate risk factors for reduced WAI included female gender; having not expanded the production within seven years prior to study; having manual feeding systems in the barn; having farm work at least 8 hours per day, 7 days per week; having at least 3 hours of domestic work per day; or having insufficient sleep (see Table 3 in the original article II).

Compensated occupational injuries, originating from Mela’s insurance records, were included in the initial univariate modeling as well, and they were significantly associated with declined work ability (chi-square test, p<0.0001) [II]. The prevalence of declined work ability was 55% among respondents with one or several injuries vs. 32% among those with no reported injuries within a four-year period prior to the survey. However, injuries were excluded from the final multivariate model due to their association with the injury component of the WAI (item 3).

Potential multicollinearity and 2-way interactions between the explanatory variables in the multivariate model were tested [II]. Albeit some of the variables were interrelated, neither any meaningful interactions nor multicollinearity between the variables was detected.

4.2 Occupational injuries and diseases among farmers

All four separate studies [II–V] included in this thesis were either focused on or dealt partially with compensated claims of the Finnish farmers based on longitudinal insurance data. The postal survey [II] included solely occupational injuries while the rest of the studies [III–V] and the supplemental data included both occupational injuries and diseases.
4.2.1 Cumulative incidence of occupational injuries and diseases

According to the postal survey [II], almost one-third of the respondents had one or more compensated occupational injuries within a four-year period prior to the survey (Table 7). The four-year injury rate was higher among males than females: 35 and 31 per 100 persons, respectively. However, this difference was not statistically significant.

Table 7 Compensated occupational injuries among dairy farmers based on four-year insurance records [II].

<table>
<thead>
<tr>
<th>Outcome category</th>
<th>Males</th>
<th>Females</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persons with no injuries</td>
<td>100 (64.9)</td>
<td>170 (69.4)</td>
<td>270 (67.7)</td>
</tr>
<tr>
<td>Persons with one or more injuries</td>
<td>54 (35.1)</td>
<td>75 (30.6)</td>
<td>129 (32.3)</td>
</tr>
<tr>
<td>All</td>
<td>154 (100.0)</td>
<td>245 (100.0)</td>
<td>399 (100.0)</td>
</tr>
</tbody>
</table>

In the five-year cohort study [III] conducted among 78,679 Finnish farmers, spouses, and salaried family members who were insured during the entire five-year period 2000–2004, nearly two-thirds (64%) of the study subjects were males. About half of the study subjects (52%) and farms (47%) were engaged in livestock farming in 2002 – the middle year of the observation period. Over one-third (35%) of the study subjects and over two-thirds (67%) of the livestock producers were engaged in dairy farming which was the largest main production type.

Majority of the study subjects had neither of the studied outcomes, i.e., occupational injuries or diseases (see Table 3 in the original article III). The five-year cumulative incidence (percentage of persons with one or more cases) was 20% for injury and 2% for disease. Among persons with compensated claims, most had only one compensated injury or disease case. However, approximately 5,000 persons had two or more injuries or diseases, up to 18 injuries or 5 diseases for one person. In addition, some had both injuries and diseases in their records.

Over half of the injuries and over one tenth of the diseases occurred to those with recurrent claims. Males represented almost three-fourths of those with injuries and nearly two-thirds of those with diseases.

While representing half of the farming population, livestock producers were significantly overrepresented regarding compensated claims in many respects (chi-square test, p<0.05). Livestock producers accounted for over two-thirds of all claimants and nearly three-fourths of all compensated claims. Furthermore, they represented the majority of those with two or more injuries, two or more diseases, or both injuries and diseases.

As for the career-long cohort study [IV], nearly half (47%) of the self-employed farming population (n=93,564) had no compensated claims during their entire insured working career (mean 24 years). However, some of them (5%) had one or more rejected claims.
The proportion of individuals with (one or more) compensated claims was 53% overall; 51% for occupational injuries and 8% for diseases [IV]. In many cases (5,721 persons; 6%) one individual had compensated claims for both injuries and diseases.

Twenty percent of the population had 71% of all injury and disease claims [IV]. Ten percent of the population had half of the injuries. In that population the median was six injuries per person (range 4 to 60 injuries per person). Three percent of the population had half of the diseases with a median of one disease per person (range 1 to 8 per person).

During the 26-year period, almost half of the rejected injury claims and over one-third of the rejected disease claims did not fulfill the criteria of an occupational injury or disease [IV]. Further, some rejected injury and disease claims had become void because the claimant did not provide requested information. Although the actual claim was rejected, almost one-third of the rejected injury claims and over three-fifths of the rejected disease claims involved examination costs compensated to the farmer.

In the case-control study [V] conducted among dairy farm couples, the cases had 263 compensated occupational injuries and 20 occupational diseases. The controls had neither any compensated nor rejected claims during their work history as insured farmers. All the cases had a minimum of four compensated claims. Among the cases, their occupational injury rate was 24.7 per 100 person-years and occupational disease rate was 1.9 per 100 person-years covered by insurance.

### 4.2.2 Characteristics of occupational injuries and diseases

In the career-long cohort study [IV], compensated claims were classified into five main work activity categories: crop production, animal husbandry, forestry work, construction work, and other farm work (Table 8). All main categories included sub-categories (see Table 4 in the original article IV). Specific work task codes were available for injuries but not for occupational diseases.

**Table 8** Work activity classification of the compensated occupational injuries and diseases in the Finnish farming population (n=93,564) based on 26-year insurance records [IV].

<table>
<thead>
<tr>
<th>Work activity: main category</th>
<th>Occupational injuries Frequency N (%)</th>
<th>Occupational diseases Frequency N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop production</td>
<td>21,247 (16.0)</td>
<td>1,425 (15.6)</td>
</tr>
<tr>
<td>Animal husbandry</td>
<td>55,049 (41.3)</td>
<td>5,673 (62.0)</td>
</tr>
<tr>
<td>Forestry work</td>
<td>10,938 (8.2)</td>
<td>750 (8.2)</td>
</tr>
<tr>
<td>Construction work</td>
<td>9,367 (7.0)</td>
<td>389 (4.3)</td>
</tr>
<tr>
<td>Other farm work¹</td>
<td>26,341 (19.8)</td>
<td>643 (7.0)</td>
</tr>
<tr>
<td>Unknown work activity</td>
<td>10,265 (7.7)</td>
<td>266 (2.9)</td>
</tr>
<tr>
<td>Total</td>
<td>133,207 (100.0)</td>
<td>9,148 (100.0)</td>
</tr>
</tbody>
</table>

¹ Includes work tasks such as repair and maintenance of machines and equipment, preparation of firewood, and farmstead and road maintenance.
Work activities related to animal husbandry and one of its subcategories coded as dairy and beef cattle work accounted for the largest share of both injuries and diseases [IV]. These included transporting and moving cattle, milking dairy cows, moving feed for cattle, and feeding cattle. Work activities related to crop production accounted for the second largest share of diseases and the third largest share of injuries. The main category "other farm work" accounted for the second largest share of injuries, and its subtask "repair and maintenance of machines and equipment" had more injuries than any other single task.

Among 17 main categories, various specific causes related to the outdoor working environment accounted for the largest share of injuries (Table 9). Every fifth injury was related to these causes such as slippery terrain or ice, or uneven terrain.

Table 9 Causes of the compensated occupational injuries and diseases in the Finnish farming population (n=93,564) based on 26-year insurance records [IV].

<table>
<thead>
<tr>
<th>Causes</th>
<th>Frequency N (%)</th>
<th>Main category</th>
<th>Occupational injuries</th>
<th>Occupational diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation vehicles</td>
<td>9,433 (7.1)</td>
<td></td>
<td>40 (0.4)</td>
<td></td>
</tr>
<tr>
<td>Tillage and planting equipment</td>
<td>1,728 (1.3)</td>
<td></td>
<td>9 (0.1)</td>
<td></td>
</tr>
<tr>
<td>Harvest and handling equipment</td>
<td>4,716 (3.5)</td>
<td></td>
<td>14 (0.2)</td>
<td></td>
</tr>
<tr>
<td>Other equipment</td>
<td>10,269 (7.7)</td>
<td></td>
<td>70 (0.8)</td>
<td></td>
</tr>
<tr>
<td>Electrical equipment</td>
<td>236 (0.2)</td>
<td></td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Hand tools</td>
<td>6,967 (5.2)</td>
<td></td>
<td>26 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td>3,271 (2.5)</td>
<td></td>
<td>9 (0.1)</td>
<td></td>
</tr>
<tr>
<td>Persons</td>
<td>98 (0.1)</td>
<td></td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Animals</td>
<td>23,979 (18.0)</td>
<td></td>
<td>860 (9.4)</td>
<td></td>
</tr>
<tr>
<td>Structures</td>
<td>17,973 (13.5)</td>
<td></td>
<td>17 (0.2)</td>
<td></td>
</tr>
<tr>
<td>Outdoor working environment</td>
<td>26,762 (20.1)</td>
<td></td>
<td>1,010 (11.0)</td>
<td></td>
</tr>
<tr>
<td>Farm chemicals</td>
<td>1,072 (0.8)</td>
<td></td>
<td>263 (2.9)</td>
<td></td>
</tr>
<tr>
<td>Working motions and postures</td>
<td>14,245 (10.7)</td>
<td></td>
<td>2,304 (25.2)</td>
<td></td>
</tr>
<tr>
<td>Biological agents</td>
<td>11 (0.0)</td>
<td></td>
<td>2,586 (28.3)</td>
<td></td>
</tr>
<tr>
<td>Physical agents</td>
<td>–</td>
<td></td>
<td>693 (7.6)</td>
<td></td>
</tr>
<tr>
<td>Chemical agents</td>
<td>–</td>
<td></td>
<td>418 (4.6)</td>
<td></td>
</tr>
<tr>
<td>Other cause</td>
<td>3,831 (2.9)</td>
<td></td>
<td>524 (5.7)</td>
<td></td>
</tr>
<tr>
<td>Unknown cause</td>
<td>8,616 (6.5)</td>
<td></td>
<td>305 (3.3)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>133,207 (100.0)</td>
<td></td>
<td>9,148 (100.0)</td>
<td></td>
</tr>
</tbody>
</table>

– = None compensated.

Animals in general and dairy and beef cattle (including suckler cows) in particular accounted for the second largest share of injuries. Two main categories, biological agents and working motions and postures, stand out among the causes of occupational diseases. Together they caused over half of the disease claims. The latter category was among the main causes of injuries as well.

Compensated claims were classified under the 22 chapters of the ICD-10 coding system. The majority of injury claims were related to chapter titled "Injury, poisoning and certain other consequences of external causes" (Table 10). These injuries were typically wounds, contusions, sprains, strains, and fractures or a combination of them in one or several
Injuries of the knee and lower leg, wrist and hand including fingers, and ankle and foot including toes were most common. Sprains, strains and a variety of other injuries in the back were also common. In the ICD-10 chapter titled "Diseases of the musculoskeletal system and connective tissue", a variety of injuries causing back pain, including lumbago and low back pain, were most common.

**Table 10** The ICD-10\(^1\) classification of the compensated occupational injuries and diseases in the Finnish farming population (n=93,564) based on 26-year insurance records [IV].

<table>
<thead>
<tr>
<th>Chapter title</th>
<th>Occupational injuries</th>
<th></th>
<th>Occupational diseases</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain infectious and parasitic diseases</td>
<td>184 (0.1)</td>
<td>859 (9.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neoplasms</td>
<td>12 (0.0)</td>
<td>1 (0.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases of the blood and blood-forming (^2)</td>
<td>1 (0.0)</td>
<td>1 (0.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endocrine, nutritional and metabolic diseases</td>
<td>5 (0.0)</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental and behavioral disorders</td>
<td>2 (0.0)</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases of the nervous system</td>
<td>30 (0.0)</td>
<td>8 (0.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases of the eye and adnexa</td>
<td>246 (0.2)</td>
<td>33 (0.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases of the ear and mastoid process</td>
<td>33 (0.0)</td>
<td>287 (3.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases of the circulatory system</td>
<td>7 (0.0)</td>
<td>6 (0.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases of the respiratory system</td>
<td>33 (0.0)</td>
<td>3,094 (33.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases of the digestive system</td>
<td>519 (0.4)</td>
<td>6 (0.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases of the skin and subcutaneous tissue</td>
<td>155 (0.1)</td>
<td>1,618 (17.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases of the musculoskeletal system and ...</td>
<td>8,505 (6.4)</td>
<td>2,976 (32.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases of the genitourinary system</td>
<td>3 (0.0)</td>
<td>11 (0.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy, childbirth and the puerperium</td>
<td>2 (0.0)</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Certain conditions originating in the perinatal ...</td>
<td>2 (0.0)</td>
<td>1 (0.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congenital malformations, deformations and ...</td>
<td>3 (0.0)</td>
<td>1 (0.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symptoms, signs and abnormal clinical and ...</td>
<td>40 (0.0)</td>
<td>22 (0.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injury, poisoning and certain other ...</td>
<td>114,489 (85.9)</td>
<td>43 (0.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External causes of morbidity and mortality</td>
<td>76 (0.0)</td>
<td>1 (0.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factors influencing health status and ...</td>
<td>3 (0.0)</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Codes for special purposes</td>
<td>–</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown code</td>
<td>8,857 (6.6)</td>
<td>180 (2.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>133,207 (100.0)</td>
<td>9,148 (100.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^-\) = None compensated.

\(^1\) International Statistical Classification of Diseases and Related Health Problems.

\(^2\) Titles are presented in detail in the Table 6 in the original article IV.

Over one-third of the occupational diseases in the career-long cohort study [IV] were "Diseases of the respiratory system" such as allergic rhinitis, allergic asthma, and hypersensitivity pneumonitis due to organic dust (including "farmer's lung"). Nearly one-third was "Diseases of the musculoskeletal system and connective tissue" such as lateral epicondylitis (commonly known as "tennis elbow") and synovitis and tenosynovitis. "Diseases of the skin and subcutaneous tissue", such as allergic contact dermatitis and irritant contact dermatitis, was the third most common chapter for occupational diseases.
The frequencies of injuries and diseases differed statistically significantly in many work activities, causes, and ICD-10 codes between low- and high-risk farmer groups (see Tables 4–6 in the original article IV). For example, claims related to animal husbandry in general and dairy and beef cattle work in particular were relatively more common among high-risk farmers indicating these types of injuries and diseases tend to be frequent among those with a higher incident rate. Correspondingly, crop production and forestry work-related injuries as well as crop production-related diseases were more common among low-risk farmers.

Injuries related to working motions and postures, and animals were relatively more common among high-risk than low-risk farmers [IV]. Correspondingly, claims related to harvesting and handling equipment were relatively more common among low-risk farmers. Furthermore, injuries and diseases related to musculoskeletal system and skin diseases were relatively more common among farmers with high injury risk.

According to the case-control study [V], dairy and beef cattle accounted for the largest share of compensated occupational injuries. Various causes related to the outdoor working environment accounted for the second largest share of injuries, and causes related to the working motions and postures (sudden, unusual, or repetitive movements or postures) accounted for the third largest share of injuries and largest share of diseases.

Animal husbandry work was divided quite evenly between males and females in both study groups [V]. Crop production, construction, and forestry work were male-dominated, whereas females took the main responsibility for domestic work. Compensated injuries and diseases related to animal husbandry were divided evenly between the spouses, but all other types of injuries and diseases occurred mostly to males.

Farmer's own and his/her family's experiences, professional magazines and newspapers, and experiences of other farmers were most highly valued sources of farm safety and health related information among both the case and control farm couples (Karttunen and Rautiainen 2012), [V revisited].

4.2.3 Risk factors for occupational injuries and diseases

In the five-year cohort study [III], all 13 potential risk factor variables were associated either with occupational injuries or diseases or both in the univariate Poisson regression models. Hence, all variables were entered into the multivariate analyses. Age of the insured person and years covered by insurance were correlated (Pearson correlation coefficient $r=0.68$, $p<0.001$). Since the latter variable was more consistently associated with both outcomes, it was included in the final model instead of the age.

The results of the final fully adjusted Poisson regression model indicated that males had higher risk of injury compared to females (RR: 1.69; 95% CI: 1.64–1.75), but there was no statistically significant difference between the genders regarding diseases (see Table 2 in the original article III).
Persons with higher number of insurance years had consistently elevated risk of injury. In contrast, the risk of disease declined consistently with longer insured career. 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. FOHS membership, which was most common among dairy farmers with large-size farm operations, was associated with increased risk of both injury and disease as well. However, the increase of risk was more prominent regarding diseases.

Main type of farm production was associated with the risk of both outcomes. All other types of crop and livestock farming except poultry farming increased the injury risk compared to growing cereal crops. Several forms of livestock farming were associated with increased risk of disease as well. All three types of cattle farming (dairy, beef, and suckler cows) stood out as both injury and disease prone.

All risk factors included in the final multivariate model were associated with one or several of the other factors. However, multicollinearity (i.e., extreme correlations) was not detected. Albeit some significant 2-way interactions in the univariate Poisson regression models were detected, meaningful interactions in the final multivariate model were not detected.

According to the career-long cohort study [IV], age and years covered by insurance were statistically significantly correlated (Table 11) – similar to the above-mentioned five-year cohort study [III]. Age was associated with compensated occupational injuries, and insurance coverage years were associated with both injuries and diseases (t-test, p<0.0001).

<table>
<thead>
<tr>
<th>Outcome category</th>
<th>Frequency N (%)</th>
<th>Age²</th>
<th>Years insured²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persons without any compensated claims</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persons with one or more occupational injuries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persons with one or more occupational diseases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total farming population</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 11** Distribution of compensated occupational injuries and diseases in the Finnish farming population based on 26-year insurance records [IV].

1 Figures for the total farming population and its sub-groups are not equal as 5,721 farmers had both occupational injuries and diseases.
2 Mean age (in 2008) and number of years insured.
3 Positive correlation (Pearson correlation coefficient) r=0.61: p<0.0001.

Persons with injuries were older and and had been insured longer than those without injury claims [IV]. These differences were smaller between those who had compensated disease claims and those with no
claims. Persons with injuries were significantly older than persons with diseases (t-test, p<0.0001), but there was no significant difference in their length of insurance coverage.

Nearly two-thirds of the study subjects were males [IV]. Slightly over two-fifths of males and almost three-fifths of females had no compensated claims (Table 11). Male gender was statistically significantly associated with injuries and diseases. The relative proportion of males was significantly higher among persons with injuries than among those with diseases (chi-square test, p<0.0001).

The number of insured persons on the farm was associated with compensated claims in the career-long cohort study (chi-square test, p<0.01) [IV]. Persons without any compensated claims were operating their farms most often alone, whereas those with injuries and particularly diseases were operating their farms most often with another insured person. There were no statistically significant differences in claims between those operating their farms with two peers. Having 4–7 insured persons on the farm was rare but protective against injuries in particular.

In the case-control study [V], altogether 21 potential risk factors (variables) were tested in the initial univariate modeling stage. A total of 8 variables had statistically significant association with the recurrent compensated occupational injury or disease claims in the univariate models. In addition, few variables of specific interest were presented and discussed further [V].

Work-related risk factors for claims among dairy farm couples are presented in Table 12. Significant odds ratios (associations) are presented in bold. The results of the univariate analysis indicated that the risk of claims was increased for those farm couples with a conventional stanchion barn. Compared to their peers with a loose housing barn (i.e., the reference group), the odds of the farm couples with a stanchion barn were over ten times higher (OR: 12.86; 95% CI: 1.27–130.53). Stanchion barns were on average older than loose housing barns; respective mean ages were 16 and 10.

**Table 12** Work-related risk factors for compensated occupational injury and disease claims among dairy farm couples (n=31) [V].

<table>
<thead>
<tr>
<th>Factor</th>
<th>Category</th>
<th>Frequency (%)</th>
<th>Unadjusted OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of barn</td>
<td>Stanchion</td>
<td>25 (81)</td>
<td>12.86</td>
<td>1.27-130.53</td>
</tr>
<tr>
<td></td>
<td>Loose housing (Ref.)</td>
<td>6 (19)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Increase of farm production</td>
<td>Not at all</td>
<td>11 (35)</td>
<td>12.22</td>
<td>1.31-114.40</td>
</tr>
<tr>
<td></td>
<td>Some or a lot (Ref.)</td>
<td>20 (65)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Size of the current</td>
<td>Small-size</td>
<td>13 (42)</td>
<td>6.87</td>
<td>1.17-40.37</td>
</tr>
<tr>
<td>farm production^1</td>
<td>Large-size (Ref.)</td>
<td>18 (58)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Working methods</td>
<td>Unimproved</td>
<td>17 (55)</td>
<td>4.33</td>
<td>0.93-20.24</td>
</tr>
<tr>
<td></td>
<td>Improved^2 (Ref.)</td>
<td>14 (45)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

^1 Arable land area, number of cattle, or both expanded during the recent decade.
^2 Includes both arable land area (small: ≤49 ha) and number of dairy cattle (small: ≤25 cows).
^3 Improved = both mechanized/automated roughage feeding system and a milking parlor or automatic milking in a loose housing barn or milking rails and automatic teat cup removers in a stanchion barn.
Nearly two-thirds of the farm couples had expanded their mixed livestock-crop production "some or a lot" during the past decade. Those who had not expanded their farm operation at all had higher odds of claims than those who had expanded. "Small-size" current farm operation was a significant risk factor for claims as well.

Compared to the cases, the controls had more frequently "improved working methods" in animal husbandry. In practice, all loose housing barns and about one-third of the stanchion barns had improved working methods. However, this variable was only approaching statistical significance as a protective factor in this study.

Personal risk factors for claims were assessed for males and females separately (see Table 3 in the original article V). The results of the univariate analysis indicated that the risk of claims increased with the duration of accident insurance. The odds were over ten times higher for both female and male dairy farmers with over 25 years of insurance coverage (vs. fewer years).

The declined CWA was associated with an increased risk of claims among the female dairy farmers. Both females and males with physician- or self-diagnosed musculoskeletal disease or related symptoms, as well as females with corresponding respiratory conditions, had elevated risk of claims. In addition, socially active male dairy farmers had higher odds of claims.

Univariate associations of identified risk factors were also tested. However, due to the limited number of subjects, multivariate analyses with requisite tests of multicollinearity and interactions were not conducted.

### 4.2.4 Severity of occupational injuries and diseases

Supplemental dataset regarding the severity of the compensated occupational injury and disease claims was acquired from the insurance records of Mela. These data were based on the study population of the five-year cohort study [III] and covered their compensated claims over a five-year period from 2000 to 2004. Claims were grouped by the main production type of the claimant (in 2002), work activity during the incident, and the cause of the claim. These data were not included in the original articles.

Dairy farming stands out among all other types of farming regarding the absolute frequency of compensated claims (Table 13). While dairy farmers represented approximately one-third of the study subjects, they accounted for the majority of the minor and serious occupational injuries and particularly diseases.

However, the relative frequency of the serious injury claims was highest in cereal crop farms, followed by other crop farms, other livestock farms, and dairy farms. In comparison to cereal crop farms, all the other proportions were significantly smaller (chi-square test, p=0.01 or smaller).

As for the serious disease claims, the relative frequency of them was highest in dairy farms, followed by other crop farms, other livestock farms, and cereal crop farms. In comparison to dairy farms, the proportion of serious diseases was significantly smaller in cereal crop farms (chi-square test, p<0.01).
Table 13 Production type classification of the compensated occupational injury and disease claims in a cohort of self-employed Finnish farming population (78,679 persons) based on 5-year insurance records [III augmented with supplemental data].

<table>
<thead>
<tr>
<th>Main type of production</th>
<th>Frequency N (Relative frequency %)(^1)</th>
<th>Occupational injuries</th>
<th>Occupational diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>Minor(^3)</td>
<td>Serious(^3)</td>
</tr>
<tr>
<td>Dairy cattle</td>
<td>12,740</td>
<td>9,870</td>
<td>2,870</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(77.5)</td>
<td>(22.5)</td>
</tr>
<tr>
<td>Other livestock</td>
<td>4,948</td>
<td>3,821</td>
<td>1,127</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(77.2)</td>
<td>(22.8)</td>
</tr>
<tr>
<td>Cereal crops</td>
<td>4,049</td>
<td>2,943</td>
<td>1,106</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(72.7)</td>
<td>(27.3)</td>
</tr>
<tr>
<td>Other crops</td>
<td>2,165</td>
<td>1,639</td>
<td>526</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(75.7)</td>
<td>(24.3)</td>
</tr>
<tr>
<td>Other production</td>
<td>64</td>
<td>47</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(73.4)</td>
<td>(26.6)</td>
</tr>
<tr>
<td>Unknown</td>
<td>458</td>
<td>314</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(68.6)</td>
<td>(31.4)</td>
</tr>
<tr>
<td>Total</td>
<td>24,424</td>
<td>18,634</td>
<td>5,790</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(76.3)</td>
<td>(23.7)</td>
</tr>
</tbody>
</table>

\(^1\) Relative frequency (percentage) indicates the frequency of minor or serious claims divided by the frequency of all claims in each category.
\(^2\) Production type is based on data from the national agricultural statistics service.
\(^3\) Minor claim causes ≤ 30 and serious claim causes ≥ 31 disability days.

Work tasks related to animal husbandry stand out among all other main categories of farm work activity regarding the absolute frequency of compensated minor and serious claims (Table 14).

Table 14 Work activity classification of the compensated occupational injury and disease claims in a cohort of self-employed Finnish farming population (78,679 persons) based on 5-year insurance records [III augmented with supplemental data].

<table>
<thead>
<tr>
<th>Work activity</th>
<th>Frequency N (Relative frequency %)(^1)</th>
<th>Occupational injuries</th>
<th>Occupational diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>Minor(^3)</td>
<td>Serious(^3)</td>
</tr>
<tr>
<td>Animal husbandry</td>
<td>11,643</td>
<td>8,995</td>
<td>2,648</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(77.3)</td>
<td>(22.7)</td>
</tr>
<tr>
<td>Crop production</td>
<td>4,158</td>
<td>3,111</td>
<td>1,047</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(74.8)</td>
<td>(25.2)</td>
</tr>
<tr>
<td>Forestry work</td>
<td>1,970</td>
<td>1,477</td>
<td>493</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(75.0)</td>
<td>(25.0)</td>
</tr>
<tr>
<td>Construction work</td>
<td>1,614</td>
<td>1,216</td>
<td>398</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(75.3)</td>
<td>(24.7)</td>
</tr>
<tr>
<td>Other farm work</td>
<td>5,026</td>
<td>3,826</td>
<td>1,200</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(76.1)</td>
<td>(23.9)</td>
</tr>
<tr>
<td>Unknown</td>
<td>13</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(69.2)</td>
<td>(30.8)</td>
</tr>
<tr>
<td>Total</td>
<td>24,424</td>
<td>18,634</td>
<td>5,790</td>
</tr>
<tr>
<td></td>
<td>(100.0)</td>
<td>(76.3)</td>
<td>(23.7)</td>
</tr>
</tbody>
</table>

\(^1\) Relative frequency (percentage) indicates the frequency of minor or serious claims divided by the frequency of all claims in each category.
\(^2\) Work activity classification is based on the coding system of Mela.
\(^3\) Minor claim causes ≤ 30 and serious claim causes ≥ 31 disability days.

40
However, the relative frequency of the serious occupational injury claims was highest in work tasks related to crop production, followed by forestry work, construction work, other farm work, and animal husbandry. In comparison to work tasks related to crop production, the proportion of serious injuries was significantly smaller in work tasks related to animal husbandry (chi-square test, p<0.05).

As for the serious occupational disease claims, the relative frequency of them was highest in work tasks related to animal husbandry, followed by crop production, forestry work, construction work, and other farm work. In comparison to animal husbandry, all the other proportions were significantly smaller (chi-square test, p<0.05).

Animals – typically production animals such as cattle or swine – accounted for the majority of compensated occupational injuries (Table 15). However, specific causes related to the outdoor working environment, especially slippery terrain or ice, and uneven terrain, accounted together for the largest share of serious occupational injuries. Animals were the second most common cause for serious injuries. In addition, dairy and beef cattle including suckler cows accounted for more injuries in general and serious injuries in particular than any other specific cause. Structures such as floors, steps, stairs, ladders, and scaffoldings were the third most common cause for serious injuries.

Biological agents (typically undefined) accounted for the majority of the minor and serious occupational diseases. Strenuous and repetitive working motions and postures, and chemical agents such as animal epithelia also stand out among causes of serious occupational diseases.

However, the relative frequency of the serious occupational injury claims was highest in claims caused by the above-mentioned structures, followed by tillage and planting equipment, transportation vehicles, outdoor working environment, harvest and handling equipment, and animals. In comparison to claims caused by animals, the proportion of serious injuries was significantly higher in claims caused by all the other above-mentioned causes except for those caused by harvest and handling equipment (chi-square test, p<0.05).

As for the serious occupational disease claims, the relative frequency of them was highest in claims caused by biological agents, followed by chemical agents, outdoor working environment, animals, and working motions and postures. In comparison to claims caused by biological agents, the proportions of serious injuries were significantly smaller in claims caused by all the other above-mentioned causes but chemical agents (chi-square test, p<0.05).
Table 15 Causes of the compensated occupational injury and disease claims in a cohort of self-employed Finnish farming population (78,679 persons) based on five-year insurance records [III augmented with supplemental data].

<table>
<thead>
<tr>
<th>Causes: main category²</th>
<th>Frequency N (Relative frequency %)¹</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Occupational injuries</td>
<td>Occupational diseases</td>
<td>All</td>
<td>Minor³</td>
<td>Serious³</td>
<td>All</td>
<td>Minor³</td>
</tr>
<tr>
<td>Transportation vehicles</td>
<td>1,482</td>
<td>1,069</td>
<td>413</td>
<td>8</td>
<td>8</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(72.1)</td>
<td>(27.9)</td>
<td>(100.0)</td>
<td>(100.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tillage and planting equipment</td>
<td>392</td>
<td>280</td>
<td>112</td>
<td>1</td>
<td>1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(71.4)</td>
<td>(28.6)</td>
<td>(100.0)</td>
<td>(100.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvest and handling equip.</td>
<td>895</td>
<td>665</td>
<td>230</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(74.3)</td>
<td>(25.7)</td>
<td>(100.0)</td>
<td>(80.0)</td>
<td>(20.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other equipment</td>
<td>2,008</td>
<td>1,543</td>
<td>465</td>
<td>15</td>
<td>13</td>
<td>2</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(76.8)</td>
<td>(23.2)</td>
<td>(100.0)</td>
<td>(86.7)</td>
<td>(13.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical equipment</td>
<td>79</td>
<td>62</td>
<td>17</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(78.5)</td>
<td>(21.5)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Hand tools</td>
<td>1,315</td>
<td>1,133</td>
<td>182</td>
<td>11</td>
<td>10</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(86.2)</td>
<td>(13.8)</td>
<td>(100.0)</td>
<td>(90.9)</td>
<td>(9.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td>671</td>
<td>555</td>
<td>116</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(82.7)</td>
<td>(17.3)</td>
<td>(100.0)</td>
<td>(50.0)</td>
<td>(50.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persons</td>
<td>30</td>
<td>22</td>
<td>8</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(73.3)</td>
<td>(26.7)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Animals⁴</td>
<td>5,520</td>
<td>4,239</td>
<td>1,281</td>
<td>105</td>
<td>80</td>
<td>25</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(76.8)</td>
<td>(23.2)</td>
<td>(100.0)</td>
<td>(76.2)</td>
<td>(23.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structures</td>
<td>3,433</td>
<td>2,450</td>
<td>983</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(71.4)</td>
<td>(28.6)</td>
<td>(100.0)</td>
<td>(71.4)</td>
<td>(28.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor working environment</td>
<td>4,910</td>
<td>3,553</td>
<td>1,357</td>
<td>185</td>
<td>135</td>
<td>50</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(72.4)</td>
<td>(27.6)</td>
<td>(100.0)</td>
<td>(73.0)</td>
<td>(27.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm chemicals</td>
<td>162</td>
<td>146</td>
<td>16</td>
<td>11</td>
<td>10</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(90.1)</td>
<td>(9.9)</td>
<td>(100.0)</td>
<td>(90.9)</td>
<td>(9.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working motions and postures</td>
<td>2,809</td>
<td>2,363</td>
<td>446</td>
<td>318</td>
<td>260</td>
<td>58</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(84.1)</td>
<td>(15.9)</td>
<td>(100.0)</td>
<td>(81.8)</td>
<td>(18.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biological agents</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>462</td>
<td>299</td>
<td>163</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(66.7)</td>
<td>(33.3)</td>
<td>(100.0)</td>
<td>(64.7)</td>
<td>(35.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical agents</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>278</td>
<td>240</td>
<td>38</td>
<td>–</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>–</td>
<td>(100.0)</td>
<td>(86.3)</td>
<td>(13.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical agents</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>197</td>
<td>141</td>
<td>56</td>
<td>–</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>–</td>
<td>(100.0)</td>
<td>(71.6)</td>
<td>(28.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other cause</td>
<td>677</td>
<td>527</td>
<td>150</td>
<td>58</td>
<td>46</td>
<td>12</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(77.8)</td>
<td>(22.2)</td>
<td>(100.0)</td>
<td>(79.3)</td>
<td>(20.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown cause</td>
<td>35</td>
<td>23</td>
<td>12</td>
<td>19</td>
<td>16</td>
<td>3</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(65.7)</td>
<td>(34.3)</td>
<td>(100.0)</td>
<td>(84.2)</td>
<td>(15.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>24,424</td>
<td>18,634</td>
<td>5,790</td>
<td>1,684</td>
<td>1,270</td>
<td>414</td>
<td>–</td>
</tr>
<tr>
<td>(100.0)</td>
<td>(76.3)</td>
<td>(23.7)</td>
<td>(100.0)</td>
<td>(75.4)</td>
<td>(24.6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

– = None compensated.

¹ Relative frequency (percentage) indicates the frequency of minor or serious claims divided by the frequency of all claims in each main category.

² Classification of causes is based on the coding system of Mela.

³ Minor claim causes ≤ 30 and serious claim causes ≥ 31 disability days.

⁴ Includes 120 injuries and 15 diseases caused by other than production animals.
5 DISCUSSION

This chapter will firstly compare the key results of this thesis with the previous studies. Secondly, one of the well-established occupational safety models and its national applications will be briefly introduced. Thirdly, the primary strengths and limitations of the thesis are described and discussed.

5.1 Comparison with the previous studies

This thesis examined the distribution and characteristics of and risk factors for occupational injuries, diseases, and disability among the self-employed farming population in Finland. Current trends and future developments in occupational injury and disease statistics given the current structural changes in agriculture were discussed as well. The concluding aim of the thesis was to provide information for targeted prevention of adverse health outcomes in agriculture.

5.1.1 Work ability among farmers

This thesis included two survey studies [I, II, V] which quantified the self-assessed work ability among Finnish dairy farmers, and evaluated the prevalence of and risk factors for declined work ability. Based on these studies, occupational or other injuries and diseases diagnosed by a physician were observed to be strongly associated with declined work ability among dairy farmers measured either by the standard WAI, or a single question addressing the respondent's self-assessed CWA compared with the lifetime best.

Current occupational or other injuries and diseases are an essential structural part of the WAI-questionnaire. They contribute directly to the third item of the WAI, which is the count of current diseases and injuries diagnosed by a physician. The fourth item asks if the current diseases or injuries are a hindrance to the current job of the respondent. Evidently, both physician and self-diagnosed diseases and injuries affect the fourth item, and the rest of the items may be affected indirectly by these adverse health outcomes (see the WAI-questionnaire in Tuomi et al. 2006).

In this thesis, occupational or other injuries and diseases had been detected prior to self-assessment of work ability. The prevalence of declined work ability was over tenfold (55% vs. 5%) higher among dairy farmers with such a disease or injury or both compared to their peers with no such incidents. Based on this result, it was rare to have declined work ability without any priorly diagnosed adverse health outcomes. However,
without knowledge of the respondents work ability before these incidents, no firm conclusions about causality can be drawn.

In addition, this thesis provided information regarding the interaction of age, gender and WAI among farmers. According to the postal survey [I, II], both genders experienced a decrease in WAI with age. This decrease was more prominent among females than males. In addition, the decrease was relatively consistent among males but progressive with age among females. Correspondingly, female gender was a univariate risk factor for declined work ability. However, gender was not a statistically significant risk factor in the final multivariate model adjusted for, e.g., age and dairy herd size of the respondent.

Apart from the postal survey included in this thesis, there are no peer-reviewed studies addressing age, gender, or other potential risk factors for declined WAI among farmers. However, two Finnish studies (Peltoniemi 2005, Saarni et al. 2008) have used the complete WAI-questionnaire and included a group of Finnish full-time farmers. They both concluded that farmers on average had poorer work ability than other entrepreneurs and salaried workers. In addition, Nevala-Puranen (1996) included the WAI in her study conducted among male and female farmers experiencing low back or shoulder pain.

According to Saarni et al. (2008), full-time farmers had poorer quality of life as well, and these results were mostly due to psychosocial problems, physical discomfort, and poor subjective work ability. They recommended that farmers should be categorized separately from other forms of entrepreneurship, and that farmers were in need of psychosocial interventions. Peltoniemi (2005) found that farmers’ own prognosis of their work ability two years forward was more pessimistic than that of the other entrepreneurs and salaried workers. This result was most evident among female farmers. Nevala-Puranen (1996) recommended rehabilitation courses for farmers experiencing low back or shoulder pain. In her study, these courses produced positive effects on farmers’ work ability, work techniques, and subjective well-being.

In this thesis, the self-assessed CWA had a high positive correlation with the complete questionnaire-based WAI. It was concluded that CWA could be used as a condensed version of the WAI, if the same correlation is found in future studies. Similar results and conclusions have later been presented by Ahlstrom et al. (2010), who conducted a follow-up study among females working in human service organizations.

5.1.2 Clustering of occupational injuries and diseases

This thesis included two separate longitudinal analyses of the compensated occupational injuries and diseases among cohorts of the insured self-employed farming population. The cumulative incidence was 20% for injury and 2% for disease in a five-year observation period. The "career-long" proportion of persons with (one or more) compensated claims was
53% overall; 51% for occupational injuries and 8% for diseases. The latter study [IV] covered the study subjects' insurance records over a 26-year period from the very beginning of the workers' compensation scheme in 1982 until 2008. The mean number of years as insured farmer was 24 among the latter study subjects.

In addition, many persons had either recurrent injuries or diseases or both. Repeat claimants accounted for over half of the injuries and over one tenth of the diseases in the five-year cohort study. According to the career-long cohort study, 20% of the population had 71% of the compensated claims. Further, 10% of the population had 50% of the injuries, and 3% had 50% of the diseases.

Previous studies conducted among the Finnish self-employed farming population as a whole (Rautiainen et al. 2009) and with full-time operations (Virtanen et al. 2003), or among a sample of Danish farmers and farm workers (Rasmussen et al. 2000) have reported similar albeit less evident results regarding the clustering of occupational injuries. Rautiainen et al. (2009) included few results regarding occupational diseases as well.

Based on the results presented in this thesis, both outcomes (i.e., occupational injuries and diseases) clustered among the study populations [II–V]. These repeat claimants may have specific personal or work-related risk factors. It is also possible that some have learned to abuse the workers' compensation system. A positive finding was that a notable part of the farming population (43%) had been able to work for years – many even decades – with neither compensated nor rejected claims. These persons may have specific protective factors, some of which are presented and discussed later in this chapter.

Agriculture seems not to be different from other industries, where this clustering phenomenon has been confirmed earlier by the meta-analysis of Visser et al. (2007). This thesis adds to the knowledge of the intensity and other features of the clustering phenomenon of the compensated occupational injuries and diseases among the self-employed farming population.

It is noteworthy, that occupational injuries and diseases may not be commensurable in regard to their long-term health effects. Both serious injuries and diseases may cause permanent decline in work ability and quality of life, and major changes in production as well. Similar to Sweden (Jansson et al. 2004), repeat claimants may cause considerable costs also in Finland. The long-term health effects and costs of injuries and diseases were, however, out of the scope of this thesis. Among others, Rautiainen et al. (2005b) and Sinisalo (2012) have examined these issues.

The number of rejected claims was notable among the study subjects in this thesis [IV]. Over one tenth of injury claims and almost half of disease claims were rejected in the 26-year observation period. However, slightly over two-fifths of the rejected claims involved examination costs compensated to the farmer albeit the actual claim was rejected. A disproportionate number of rejected disease claims in particular require further attention; awareness of the compensable occupational diseases could be improved.
There is shortage of prior studies reporting on rejected claims in agriculture. Possible trends in the distribution, characteristics, or percentage of rejected claims over the past decades were not examined in this thesis either. However, according to the subjective opinion of the claimant, both compensated and rejected claims have involved a work-related incident causing an adverse health outcome. Hence, also rejected claims could add to the knowledge of threats to health and safety of farmers.

According to this thesis, livestock farmers were at risk of injury and disease in many respects, while representing half of the farming population (in 2002). Livestock farmers accounted for over two-thirds of all claimants and nearly three-fourths of all compensated claims in a five-year observation period. In addition, they represented the majority of recurrent injury and disease claims. This issue is further discussed below.

Based on the national farm bookkeeping records regarding the annual labor hours on Finnish farms (MTT 2013), livestock farmers in general and dairy farmers in particular could be considered having full-time operations in comparison to crop farmers. However, there is vast variation in the annual working hours between farms and also within farms having the same main type of production. (MTT 2013). Annual labor hours per person or per individual work task are not currently available. Albeit exposure hour data are difficult and costly to collect in detail, future longitudinal studies would benefit from inclusion of them.

According to the supplemental data augmenting the five-year cohort study, livestock farmers in general and dairy farmers in particular accounted for the majority of both minor and serious occupational injuries and diseases. Logically, these outcomes were related to the work activities and specific causes of animal husbandry. Latter results are confirmed by two other studies [IV and V] included in this thesis.

Dairy and beef cattle – kick, butt, push, stamp, or other physical contact by cattle – accounted for more minor and serious injuries than any other specific cause in the coding system of Mela [supplemental data]. In addition, the relative frequency of the serious occupational disease claims was highest among dairy farmers and in work activities related to animal husbandry. Animal husbandry included strenuous working motions and postures, which resulted in recurrent injuries and diseases of the musculoskeletal system.

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5 MTT Agrifood Research Finland publishes national farm bookkeeping records regarding the annual labor hours in Finnish farms by production type. According to these statistics, a "farming family" worked, on average, 2150 hours in 2010. Dairy farming stands out as labor intensive among other types of livestock farming. Dairy farm required, on average, 4020 hours of labor (range 2610–5170). The foregoing figure includes 3010 hours of animal husbandry work, 630 hours of crop production work, and 380 hours of other farm work activities. The hours of labor for farms with swines, beef cattle, cereal crops, other crops, or indoor horticulture were 3290, 2510, 950, 910, and 3620 hours, respectively. (MTT 2013).
5.1.3 Risk and protective factors for adverse health outcomes

This thesis identified several personal and work-related risk and protective factors either for occupational injuries, diseases, or disability (i.e., declined self-assessed work ability). Some of these risk factors were common for all three adverse health outcomes; aging livestock farmers in general and dairy farmers in particular had elevated risk of all these outcomes. These farmers typically had a long work history (i.e., long exposure time) of mixed livestock and crop farming, likely including some forestry work as well.

Above results were consistent throughout the studies included in this thesis. They were also in accordance and add to the previous studies such as Rasmussen et al. (2000), Hartman et al. (2004), Rautiainen et al. (2009), and Douphrate et al. (2009). These studies and this thesis as well emphasize livestock farming in general and dairy farming in particular as a high-risk operation. However, this thesis provided strong and detailed information regarding, e.g., the severity and distribution of both occupational injury and disease claims using longitudinal workers’ compensation data covering exceptionally large cohorts of the farming population.

The relative frequency of the serious injury claims was highest among cereal crop farmers and second highest among other crop farmers based on five-year observation period. Farm bookkeeping records suggest these farmers typically have part-time operations (MTT 2013). In addition, the relative frequency of the serious injury claims was highest among specific work activities related to seasonal crop farming and second highest in forestry work regardless of the claimants’ main type of production.

Sinisalo (2012) examined both the probability and severity of the compensated occupational injuries among Finnish farmers. In her study, cereal crop production, followed by dairy production, was identified as the riskiest type of agricultural production. This thesis confirms the results reported by Sinisalo (2012) and provides detailed additional information regarding the severity of compensated claims.

Slippery terrain or ice, and uneven terrain, as well as floors, steps, stairs, ladders, and scaffoldings were frequent causes of both minor and serious injuries in this thesis. This indicates slip, trip, and fall-related injuries (i.e., STF injuries) are a major problem in Finnish agriculture. This result is in accordance with the studies of Kaustell et al. (2007) and Mattila et al. (2008a). These studies included detailed recommendations for improved prevention of STF injuries.

This thesis suggested that high-risk dairy farmers had small and middle-sized farms which were not expanded, at least not within the past decade. These farmers typically had arduous and outdated working conditions in a traditional stanchion barn. In contrast, expanding dairy operation and having a loose housing barn, as well as modern working environment and methods, protected against adverse health outcomes. Albeit these results based on two survey studies seem plausible, they are indicative only and need to be confirmed in future studies with more representative study
samples. Nevertheless, they are supported by earlier studies such as Bewley et al. (2001) and Wagner et al. (2001), who reported experiences of dairy farmers who had modernized their operations.

As for the detected gender differences in daily and seasonal farm work and corresponding claims, Dimich-Ward et al. (2004) suggested gender may be an indicator of different exposures rather than being a risk factor in itself. McCoy et al. (2002), and Kallioniemi and Kymäläinen (2012) have also examined the role of females and their specific exposures.

According to Mattila et al. (2007), farmers perceive maintaining safety, health, and the ability and motivation to work both important and difficult. Experiential knowledge gained through own experiences or hearing or reading of other farmers' experiences is regarded as the most important source of safety and health related information (Karttunen and Rautiainen 2012). Chapman et al. (2011), and Kaustell et al. (2011) had similar findings; the enabling factors for health and safety improvements on farms included good, or alarming and thus activating, examples from peer farmers and acknowledged authorities. However, Lien et al. (2006) found that full-time and part-time farmers' risk perceptions and management strategies differ substantially.

In Finland, particularly full-time livestock farmers have voluntarily joined the FOHS, which aims to prevent occupational injuries and diseases. However, based on this thesis and supported by a recent study of Leppälä et al. (2013), the effectiveness of the FOHS needs improvements.

5.1.4 Work safety and health in modern farming

According to the introductory chapter of this thesis, current structural changes in Finnish agriculture have reduced especially the number of small-scale livestock farms, many of them arguably with outdated production facilities and methods. Farms with poor working conditions may involve potential risks not only for the farm families but for regularly hired workers, farm relief workers, veterinarians, artificial inseminators, livestock truck drivers, and other occasional workers and visitors as well.

This thesis supports the common conception (Hansen 2000, Bewley et al. 2001, Perkiö-Mäkelä and Hentilä 2005, Mattila et al. 2008b) that investing in and modernization of farm production may have positive effects on the work quality and quantity, and safety and health of farmers and hired farm workers as well. Automatic milking systems represent modern technology that may save labor time, increase labor flexibility, and improve quality of life (Mathijs 2004, Bijl et al. 2007, Oudshoorn et al. 2012).

However, the latest technology and machines as such do not necessarily attract and motivate, as Lunner Kolstrup (2012) found in her survey. Common opinion of her study subjects was that "work should be fun with interesting, meaningful and varied work tasks". These results indicate that access to modern technology may nowadays be taken for granted while the mental aspects of work are emphasized.
Despite of modernization, large-size livestock farms in particular have not, however, achieved optimal working conditions. According to reviews of Davis and Kotowski (2007) and Osborne et al. (2012a, 2012b), and studies of Pinzke (2003) and Kolstrup et al. (2006), musculoskeletal diseases and disorders, caused especially by repetitive working motions and postures in animal husbandry, are still serious problems.

Research indicates modernized farming may involve other safety risks as well such as increased number of farm machinery (Suutarinen 2004), or increased use of tractors (Pinzke et al. 2012), combine harvesters (Voaklander et al. 2012), and all-terrain vehicles (O’Connor et al. 2009). Stress and other mental symptoms (Thomas et al. 2003, Saarni et al. 2008, Kallioniemi et al. 2011) may increase, if the competence of the farmer does not meet the changing demands and operational environments of farming. Leppälä et al. (2012) have presented a comprehensive risk management tool "The Farm Risk Map" that could be of help in risk identification and sustainable management on farms.

The introductory chapter of this thesis described the national insurance reform (Full Compensation Act) implemented in 2005. In addition, the annual workers’ compensation data of Finnish farmers during the last decade was reviewed. According to this review, the annual number and rate of both occupational injury and disease among the self-employed farming population peaked in 2005. These peaks were mostly due to minor claims regarding both outcomes, similar to other industries (TVL 2010). Furthermore, a downward trend in the annual number and rate of both outcomes between 2005 and 2010 was detected. However, the annual rate of serious injuries remained relatively stable during the whole decade. Further, there was a statistically significant increase in the proportion of serious injuries between 2005 and 2010. Similar phenomena were not detected in the serious diseases; their annual number fluctuated.

Current structural changes in Finnish agriculture were also reviewed in the introductory chapter of this thesis. These changes include expanding of livestock or crop production or both, transition from full-time mixed livestock and crop farming to seasonal crop farming, continuation of farming as before for the time being, or retirement and selling or renting of fields. Simultaneously, the average age of the owner-operators is increasing. Described structural changes indicate the above-mentioned trends in the annual number and rate of both minor and serious occupational injury and disease may prevail in the future.

Occupational fatalities were out of the scope of this thesis. According to the contact person from Mela, there have been annually several occupational fatalities among the self-employed farming population during the past decade in Finland. In addition, fewer uninsured minors, seniors, or visitors have died from work-related injuries on Finnish farms annually (Rissanen and Taattola 2003).

Research typically includes all work-related fatalities regardless of the status of the victim (Rautiainen and Reynolds 2002, Thelin 2002, Myers et al. 2009, Shah et al. 2011). Future studies should include the overall work-related mortality rate in Finnish agriculture including work-related fatalities of all persons living or working on farms.
5.2 The system approach towards human error

This thesis did not examine occupational health and safety models and theories. They have been reviewed by Khanzode et al. (2012). However, a brief glance of one of the well-established occupational safety models and how some of its premises are applied in a Finnish network of enterprises and organizations is presented in the following. It will be of help in the formulation of the conclusions and recommendations of this thesis.

There is an abundance of articles focusing on and titled with the phrase: "to err is human". According to Reason (1984), human errors causing the worst accidents are indistinguishable in nature from trivial slips of everyday life; it is the conditions that make the difference. There are two approaches towards the human error; the person approach and the system approach (Reason 2000). The person approach focuses on the unsafe acts of people: people are fallible and they make errors and procedural violations. "Naming, blaming, and shaming" may be emotionally satisfying but unhelpful towards human error. Traditional countermeasures include instructions, retraining, and disciplinary measures aiming to reduce unwanted variability in human behavior. (Reason 2004).

As for the system approach, the basic premise of it is that human errors are to be expected even in the most advanced organizations that pay high attention to health and safety issues. These organizations rehearse continuously typical scenarios of failure and try hard to imagine new ones. (Reason 2000). The system approach concentrates on the conditions under which individuals work and takes effort in building defences, barriers, and safeguards to prevent errors or to mitigate their effects. In the case of an adverse event, the system approach focuses on how and why the defences failed. (Reason 2004).

Reason (2000) stated concisely: "We cannot change the human condition, but we can change the conditions under which humans work." Albeit the behavior-based approach presented by Geller (2005) as well as the review of Geller and Wiegand (2005) suggest that "human condition" is changeable as well, this fundamental thought of Reason is in agreement with the principals of The Finnish Zero Accident Forum. This forum is a voluntary network of close to 300 Finnish workplaces representing enterprises and organizations of a different size promoting the application of the Vision Zero\(^{6}\) approach and practices in accordance with it (FIOH 2013a).

The members of the Finnish Zero Accident Forum have pledged to pursue the level of zero (occupational) injuries in their operation, and a few

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\(^6\) According to Swuste (2012), Vision Zero was firstly introduced in Sweden in 1997. It was the start of a new way of thinking about safety, first in road transport in Sweden, and later in other countries and other domains such as occupational safety. According to the Kuopio Declaration issued in 2006, the Nordic agriculture should have reached Vision Zero regarding work-related fatalities by the year 2012 (Lundqvist and Alwall Svennefelt 2012). Unfortunately, that is not the case.
of the members have already attained this goal. The key principles of this network state that there are no acceptable or accidental occupational injuries; each of them is preventable – if not right away, then in time; and each adverse event or near-accident is a learning opportunity that needs to be openly discussed and reacted upon. (FIOH 2013b).

5.3 Strengths and limitations of the thesis

The primary strengths of this thesis included the linkage of the results of the original studies to the national insurance and agricultural statistic data over the past decade and beyond. Compared to studies using short observation periods, analysis of longitudinal data contributed to better understanding of the long-term risk of various adverse health outcomes in the changing agriculture. Furthermore, the core data of this thesis consisted of compensated occupational injuries and diseases requiring medical care. Compared to self-reported data from surveys, insurance record-based data have less bias from recall (Jenkins et al. 2002, Warner et al. 2005).

This thesis included the combination of the well-validated WAI-questionnaire and a form containing a large variety of questions regarding the individual and work-related factors potentially affecting work ability. These results responded to the previous shortage of peer-reviewed studies addressing the prevalence of and risk factors for declined work ability within the agricultural sector.

Both of the survey studies [I, II, V] conducted among dairy farmers included study subjects only from mid-sized and larger farms. Given the progressing structural change, these farmers were more likely to continue their production in the coming years than their peers from smaller farms. This improved the sustainability of the respective results. Furthermore, the unique way to construct the study groups in the case-control study enabled identification of personal and farm-related risk factors for recurrent compensated claims.

As for the two retrospective cohort studies included in this thesis [III, IV], the first one augmented with the supplemental data, all compensated occupational injury and disease claims requiring medical care were available for these exceptionally large cohorts of farming population. Similar data resources are not typically available for the self-employed workers in the agricultural sector. These longitudinal insurance data with high statistical power enabled both precise and accurate identification of the distribution, characteristics and severity of and risk factors for occupational injuries and diseases. Further, both of the cohort studies contributed to the knowledge of clustering of occupational injuries and diseases in agriculture.

The primary limitations of the thesis included lower than desired participation rate to the survey studies [I, II, V]. In the case-control study [V], the small number of subjects, especially that of controls, impaired that
study significantly and caused, e.g., wide confidence intervals to the identified univariate risk factors.

According to a meta-analysis of Shih and Fan (2009), response rate in postal surveys have varied greatly (range 11–85%). Based on a brief review of recent postal surveys conducted among European farmers, their response rate has varied between 19–73% (Van den Broucke and Colémont 2011, Hansson et al. 2012, Rantamäki-Lahtinen and Väre 2012, Vesala and Vesala 2012, Espetvedt et al. 2013). The high volume of record keeping and reporting burden in farming may reduce farmers’ interest to participate in voluntary surveys. The pros and cons of different survey types and their methods have been reviewed by McCluskey and Topping (2011).

It was also possible that both surveys [I, II, V] included bias from self-selection, and it remained unknown which way it could have affected the results. Furthermore, the larger than average farm size of the study subjects may have introduced bias to the results. Respective findings may not be generalizable to the entire dairy farming population, let alone to the general farming population, as the smallest farms were excluded.

Limitations of the longitudinal cohort studies [III, IV] included the lack of working hour data. While the injury and disease coding was very detailed, similar data were not available on exposure hours, and therefore, it was not possible to establish rates for various injury and disease types relative to working hours. However, general reasoning regarding the full-time/part-time nature of different main types of production based on national bookkeeping records was included in this thesis. Another limitation was being confined to those rather general potential risk factor variables that were available in the administrative insurance data.

Focusing on insurance record-based data may involve possible sources of bias. The applied approach resulted in a loss of information regarding particularly unclaimed – presumably minor – cases. Assuming the pyramid model of compensated occupational injuries, presented by Rautiainen et al. (2009), is applicable in unclaimed cases as well, their annual number is substantial. Presented evidence regarding the clustering of occupational injuries and diseases in agriculture indicates unclaimed cases may have partly occurred to those with compensated claims as well. However, some farmers that are now considered as injury or disease free may have had one or more unclaimed (minor) cases.
6 CONCLUSIONS

This final chapter includes the conclusions of this thesis including recommendations for future research and national measures for the targeted prevention of adverse health outcomes in agriculture.

6.1 Self-assessed work ability among farmers

This thesis showed that occupational or other injuries and diseases, diagnosed by a physician, were strongly associated with declined work ability among Finnish dairy farmers measured either by the standard WAI, or a single question addressing the respondent's self-assessed CWA compared with the lifetime best.

Even though both injuries and diseases had occurred prior to self-assessment of work ability, and it was rare to have declined work ability without any reported adverse health outcomes, each condition may have eventually contributed to the other. The temporal order of these health conditions requires further study: a follow-up study conducted among farmers is recommended.

Self-assessed CWA – the first item of the WAI-questionnaire – had a high positive correlation with the complete questionnaire-based WAI, and this correlation has been reported in a later study by other researchers as well. Based on these results, CWA could be used in surveys as a condensed version of the WAI.

Identified risk factors indicated the risk of declined work ability was particularly high among aging dairy farmers with mid-sized or smaller dairy herd. In contrast, younger age and larger herd size were protective against declined work ability. Results suggested these persons had expanded farms with modernized working conditions.

6.2. Occupational injuries and diseases among farmers

According to longitudinal analyses, occupational injuries and diseases clustered among the self-employed Finnish farming population. Those with repeated claims had over half of the compensated claims. The intensity of the clustering phenomena became evident when a longer observation period was used.

In contrast, a notable part of the population had been able to work for years – many even decades – with neither compensated nor rejected claims. Rejected claims were included in some analyses as they may add to the knowledge of threats to health and safety of farmers.
Livestock farmers, arguably with full-time operations, were at risk of injury and disease in many respects. Work activities and causes related to labor-intensive animal husbandry accounted for the largest shares of both minor and serious compensated claims. Physical contact with dairy and beef cattle accounted for more serious injuries – and minor injuries as well – than any other specific cause. Furthermore, strenuous working motions and postures in animal husbandry resulted in recurrent injuries and diseases of the musculoskeletal system. However, the relative frequency of the serious (vs. minor) injury claims was highest among cereal crop farmers and second highest among other crop farmers. Serious injuries in seasonal crop farming and forestry work were frequent regardless of the claimants’ main type of production.

Identified personal and work-related risk and protective factors indicated the risk of occupational injuries and diseases was particularly high among aging livestock farmers in general and dairy farmers in particular. These farmers typically had a long work history of mixed livestock and crop farming including some forestry work as well.

Results suggested that high-risk dairy farmers had middle-sized or smaller farms with no recent expansion and arduous working conditions. In contrast, expanding the operation and improving working environments and methods protected against adverse health outcomes. Albeit plausible and partly supported by previous research, these results need to be confirmed in future studies.

6.3 Current trends and future developments in farming with regard to safety and health at work

Current structural changes in Finnish agriculture have reduced the number of small-scale livestock farms, many of them arguably with outdated production facilities and methods. Modernization of the production processes and working conditions on the remaining farms may have positive effects to the overall safety and health of the self-employed farming population, hired workers, and also other professionals involved.

Despite of modernization, larger livestock farms may not have optimal working conditions. Musculoskeletal diseases and disorders caused by repetitive working motions and postures in animal husbandry are still a serious problem.

Reviewed national insurance data showed downward trends in the annual number and rate of both occupational injury and disease among the self-employed farming population after the national insurance reform in 2005. Simultaneously, the proportion of serious injuries has grown statistically significantly. Described current structural changes including aging of farmers and transition from full-time mixed livestock and crop farming to seasonal crop farming indicates these trends may prevail in the future.
6.4 Recommendations for national measures for the targeted prevention of adverse health outcomes

In conclusion, to increase the cost-effectiveness of preventive efforts in Finland and elsewhere, segmentation of the self-employed farming population, based on the identified phenomena, and risk and protective factors, is emphasized. Segmentation of the target populations is commonly used in marketing of products and services. This approach could be beneficial also for health and safety in agriculture. Farmers should no longer be considered as a homogeneous group where one prevention method fits all.

Improved knowledge of the disabling health conditions and specific populations with either elevated or reduced risk could speed up the overall development of health, safety, and wellbeing in agriculture. Hence, these data should be included more thoroughly to both vocational and extension education of the current and future farmers, farm relief workers, and hired non-family workers as well.

In addition to formal education, repetitive informing and counseling is imperative. This should be a coordinated task between farm advisors and journalists, and the personnel of the farmers’ occupational health service (FOHS), the farmers’ union, the insurance sector, and researchers themselves. Positive examples from real life including information regarding especially the identified protective factors are advisable.

Experiential knowledge is a highly valued source of farm safety and health related information among farmers. They should be encouraged to openly discuss and react to each adverse event and near-accident. This is one of the key principles of Vision zero -ideology, which could be promoted among farmers.

Particularly farmers with recurrent or serious claims or both could be approached by the insurance sector. Similarly, young farmers taking over a farm which has a history of adverse health outcomes indicating potentially high-risk working conditions could be approached as well. Insurance incentives conditional to defined improvements in the working conditions could be offered to farmers in general and specifically to young farmers.

Periodic FOHS health screenings provide an opportunity to detect health concerns early, and to intervene at a younger age. Checklists and surveys used in the FOHS could be updated based on the identified risk factors. Current automatic discount on insurance premiums for FOHS members could be partially conditional on improvements of the identified deficiencies in the working conditions.

To conclude, various combinations of the above-mentioned and other measures are suggested to prevent disabling working conditions, adverse health outcomes, and premature retirement from farming among Finnish farmers.
REFERENCES


