Review of the Literature on Agricultural Safety Contextualized for the Newfoundland and Labrador Agricultural Sector

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Abstract: This report identifies and reviews existing literature and trends in agriculture safety around the world and contextualizes the findings to the Newfoundland and Labrador agriculture industry. An understanding of the risks and hazards faced by agriculture operators in Newfoundland and Labrador may help in identifying areas of concern for farmers in rural and small agricultural operations. This report also highlights some significant opportunities for further research.

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Contents

Introduction

Newfoundland and Labrador has a comparatively small but growing agricultural sector. In 2013 there were over 500 different farms throughout the province. The sector includes beef, pork, lamb and sheep farms, dairy farms, fur farms, apiaries, operations producing vegetables and fruit, nurseries and greenhouses, and poultry and egg-producing operations. Statistics from 2013 show farm cash receipts of $137.3 million – a 5.6% increase from the previous year (Department of Natural Resources, 2014). In 2013, there were approximately 11,600 cattle and 5,100 sheep in the province and milk production rose 2.5% (to $46.6 million) from 2012. There were 39 dairy producers, 2 commercial pork producers, more than 15 mink farms, 5 fox farms, and 36 generally small commercial apiculture operations in the province (Ibid). In 2013, vegetable production was valued at $6.3 million and fruit production was valued at $0.9 million, an increase of 20% from 2012 (Ibid). The main vegetable and fruit crops include potato, turnip, carrot, strawberries, cranberries, and raspberries. In 2013, the chicken industry was valued at approximately $30 million, and egg production was valued at $18.4 million (Ibid).

In 2013, greenhouses and nurseries represented the largest crop commodity in the province, accounting for 52% of crop sales (Department of Natural Resources, 2014). The dairy sector has diversified into new products in recent years and is becoming more automated, with some operations introducing robotics into the milking process. There are plans to develop up to 2500 acres of cranberry production over the next few years (Ibid). As elsewhere, the total number of farms has declined in NL in recent years and the remaining operations have been generally getting larger (Department of Natural Resources, 2012). The organic sector, however, is experiencing overall growth throughout all parts of Canada (Statistics Canada, 2006).

Other relatively recent changes include an aging farmer demographic (Statistics Canada, 2006) and the employment of a currently undocumented number of temporary foreign workers brought in through the Seasonal Agricultural Worker Program (Employment and Social Development Canada, 2015) and the Temporary Foreign Worker Stream for Lower-Skilled Occupations of Employment and Social Development Canada (Employment and Social Development Canada, 2015).

No systematic research has yet documented the occupational health and safety hazards or the incidence trends for different types of occupational injuries, illnesses and fatalities within the agricultural sector of Newfoundland and Labrador. Compensation claims are one way of estimating incidence of injuries, illnesses and fatalities and comparing across sectors. Unlike in some other provinces and in countries like the U.S., Newfoundland and Labrador's commercial agricultural operators and their employees are eligible for workers compensation and are required to pay compensation premiums. In Newfoundland and Labrador, the compensation claims for agriculture include "claims from livestock farms, dairy farms, field crop farms,

horticultural specialities and service sectors incidental to agriculture, such as veterinary services" (WHSCC, 2013). This means NL compensation data include veterinary services, and this may not be consistent with other national and international data on compensation-related injuries, illnesses and fatalities in agriculture.

A review of trends and patterns in compensation claims in the sector produced by the Workplace Health, Safety and Compensation Commission of Newfoundland and Labrador (WHSCC-NL) for this project indicates that the incidence of lost time accident claims per 100 agricultural employees was 1.92 in 2013, and varied over the 6-year period between 2008 and 2013 from a high of 5.63 in 2009 to a low of 1.55 in 2011. Soft tissue injuries were the most prevalent injury type within lost time claims, averaging 1.9 per 100 employees between 2008 and 2013 and exhibiting a downward trend. The incidence of serious injury claims varied substantially from a high of 43.75 per 10,000 employees to a low of 7.69 during the same period, with an average rate of 25.95. The lost time incidence rate for all industries within the province for this six-year period was 10.9 (Butler, 2015).

Table 1 shows the proportion of agricultural compensation claims by nature of injury for the 11 most frequently reported types during the period of 2008-2013. Almost 50% of claims were for musculoskeletal and soft tissue injuries including sprains, strains, tears, soreness, pain, back pain, hurt back and traumatic injuries to muscles, tendons, ligaments, and joints. Animal or insect bites comprised another 9.4%, and fractures, bruises, contusions, cuts and lacerations comprised another approximately 20% of injury claims. Source of injury was not coded in 18.2% of the agricultural claims reported for this period. Bodily motion or position of the injured/ill worker comprised 15.7% of injury sources, followed by cats (8.5%), cattle (7.2%) and dogs (3.8%), pointing to the relative importance of veterinary services in these claims data. Tractors accounted for 1.9% of claims between 2008 and 2013. In terms of injuries by Newfoundland Industry Classification (NIC), dairy and fur operations accounted for the highest percentage of claims at 19.5% and 17.0% respectively for the combined period from 2008-2013, followed by poultry and egg farms at 13.5 % and fruit farms at 6.6% (Ibid).

The average compensation assessment rate between 2009 and 2013 for the NL agricultural sector was $3.98/$100 of payroll, and the average total cost of compensation for the sector between 2009 and 2013 was just under $1 million/year ($933,589). The most frequently reported occupations of those with successful claims included general farm workers (27.4%), vet/animal health technicians (8.8%) pet grooming and animal care workers (8.2%), and construction/trades helpers and labourers (8.2%). It should also be noted that 18.2% of claims fell into the not elsewhere classified (NEC) occupational category (Butler, 2015).

Table 1: Proportion of Agricultural Claims by Most Frequently Reported Nature of Injury, 2008-2013 (Source: WHSCC, 2015)

Injury type	Percentage
Sprains, strains, tears, unspecified	24.5%
Soreness, pain, hurt, except the back	11.6%
Animal or insect bites	9.4%
Fractures	7.9%
Bruises, contusions	7.2%
Back pain, hurt back	6.0
Cuts, lacerations	5.0%
Traumatic injuries to muscles, tendons, ligaments, joints, etc.	4.1%
Punctures, except bites	2.2%
Abrasions, scratches	1.9%
Crushing injuries	1.9%

Agricultural operations in NL are regulated by the OHS branch of the provincial government and are subject to inspection by OHS inspectors. According to a representative of this branch, inspections of farms were limited in the past but have become more frequent in recent years. At present, however, the Department of Government Services does not have a designated agricultural safety inspector. Hazards on NL agricultural operations identified during past inspections have varied widely. Situations have been identified where hay bales were stacked too high to be stable and to be reached safely by equipment. Confined spaces and respiratory protection issues have been noted as an area of concern with respect to silo use within the province. Rotating hazards have been reported on NL farms, particularly the use of unguarded power take-offs on tractors. Other noted rotating hazards include a lack of guards for ventilation fans, compressors and motors. Inspected powered mobile equipment has sometimes lacked back-up alarms, or has had maintenance problems or leaks. Improper blocking/chocking when doing repairs has been documented, along with problems with seat belt installation and use, and a lack of rollover protection systems on tractors. Other documented hazards include grinders, tripping hazards, holes, unguarded openings, working alone, a lack of safe work procedures (including lack of training for tasks and a lack of hearing protection), as well as shortcomings in respiratory, fall, and fire protection and in general personal protective equipment use. Inspectors have also flagged welding and burning hazards, as well as electrical hazards such as bare wires, improper fixtures or junction boxes, panels without blanks, missing panel doors, and improper electrical work done by an unqualified person. Shortcomings related to WHMIS, first aid kits and training, scaffolding and ladders,

guardrails and handrails, and eating areas, washrooms, and cleaning facilities have also been identified (D. McCurdy, Personal Communication, April 7, 2015).

Research done in other industrialized contexts has identified many hazards in the agricultural sector, as well as high rates of injury, illness and fatality. It has also indicated that agricultural workers are often not covered by workers compensation, making it difficult to compare incidence rates across provinces and countries. The sector may also be particularly vulnerable to under-reporting of work-related safety and health issues.

The remainder of this paper reviews existing research on agricultural safety with a focus on the kinds of hazards, injuries, illnesses and at-risk groups of workers that are most relevant to agricultural operations in NL. It starts by outlining the methodology used to carry out a systematic search for relevant sources, and for deciding which to include in the review. Subsequent sections discuss the hazards and injury types most commonly found, followed by illnesses, and then at-risk groups.

Methodology

The literature search was designed to identify publications that reviewed existing research on the types of occupational health and safety (OHS) risks found on agricultural operations similar to those in Newfoundland and Labrador. A systematic search strategy was devised using combinations of specific key words (Table 2). A process for identifying additional studies – a major component of which involved reviewing reference lists – was also employed. Inclusion criteria limited our selected studies to those that had titles directly related to health and safety in agriculture, that had been published since 1990 (unless nothing current could be found), and that were written in English.

Table 2: Search Strategy Key Terms

review	occupation* work*	safety health welfare protect* prevent* risk* exposure* hazard* injur* disease* illness*	agricultur* agrifood* farm* cultivat* harvest*	*horticultur** *poultry* *chicken* *egg** *dairy* *livestock* *husbandry* *fur* *apicultur** *organic*

		fatalit* death* accident* incident*		

The search could be kept broad by omitting the final (italicized) column, or made more specific by including it. Also, other types of specific keywords could be added to the search in order to tease out articles on a particular sub-topic. For example, we added keywords such as "compensat*" in order to find information on compensation coverage/costs for these issues, or "temporary foreign workers" to find information about how these issues affect that particular group of workers.

The initial online search of databases was conducted from January to July of 2015 using combinations of the keywords listed in Table 2. In total, 6 electronic databases – Pubmed, Google Scholar, SCOPUS, EbscoHost, MedLine, and NIOSHTIC – were used to find studies meeting the inclusion criteria. The search was constrained to articles published after 1990 (except for one published in 1989), and to those published in English. Over 16,000 citations were returned from the initial scan. After a review of abstracts for direct relevance, the removal of duplicates, and a review of reference lists, 44 articles, texts and reports were included in the review. Table 3 lists and provides a brief overview of the reviewed literature. Of the 44 sources reviewed, 18 were other literature reviews, 3 were program evaluations and 19 were individual studies. Also included in the review were 3 reports and one recent textbook on agricultural OHS, *Agricultural Health and Safety: Workplace, Environment, Sustainability.*

The material reviewed discusses a wide variety of agricultural safety topics, from general farm hazards to specific injuries, illnesses, and at-risk groups. A review of Table 4 shows, however, that in this contextualized literature some agricultural safety hazards have received much more attention from researchers than others. For instance, multiple studies and reviews focus on respiratory conditions and illnesses associated with agriculture and machinery-related injuries are also commonly addressed, but we found only one article on needle-stick injuries. Likewise, there are multiple studies on safety in dairy farming, but we found no articles on safety hazards associated with fur farming.

Methodologically, most of the materials reviewed are based on mixed methods research; some draw on government documents and publications. Case studies, postal surveys, telephone interviews, and in-person interviews are all employed in the source material. In addition most of the studies were carried out in the U.S., Canada, the U.K., and New Zealand. In the sources identified using our search strategy, there is little research done in other countries and regions, including Northern Europe. The source composition may partly reflect a spatial bias in the

existing research but is probably also a result of our targeted search for research on agriculture similar in character (commodity types) to the Newfoundland and Labrador industry for the review.

Many of the selected studies rely on self-reporting and/or recall for injury identification (Hagel et al., 2007; Hoppin et al., 2014). This can result in under- or over-reporting, as well as reporting bias. Furthermore, many of the studies from the U.S. are based on data from Iowa (Jennissen et al., 2011; Sprince et al., 2002; Sprince et al., 2007; Thu, 1998; Waggoner et al., 2012; Padgitt et al., 1995). Some of these draw on data from the Agricultural Health Study (AHS), a cohort of approximately 89,000 participants who have been followed since the 1990s. The AHS cohort includes farmers and their spouses but does not include farm workers or seasonal workers, including foreign workers. Furthermore, the AHS focuses on pesticide applicators, so the composition of its study population is not representative of farm operators in Iowa, the U.S., or elsewhere. This limits the generalizability of findings from this research (Spring et al., 2011). The Sprince et al. (2011) study evaluated only a small number of low back injury cases so some of the observed associations may not be generalizable. The same limitation applies to the findings in Jennissen et al.'s (2010) study of unintentional needle-stick incidents.

Hartling et al.'s review of North American interventions to reduce childhood farm injuries has limited validity because much of the literature it draws on has not undergone peer review. The methodology used in some other reviews (Frank et al., 2004; Linaker & Smedley, 2002; Purschwitz & Field, 1990; May et al., 2012) is not clearly defined making it difficult to assess the validity of the findings.

While most of the sources reviewed were published after 2000, we included some studies that were published in the early 1990s (Etherton et al., 1991; Pickett et al., 1995; Wiggins & Castanares, 1995; Padgitt et al., 1995; Purschwitz & Field, 1990) and even a couple of studies that used data from the late 1980s (Horsburgh et al., 2001; Etherton et al., 1991). Sources focusing on general farm hazards tended to be older (Thu, 1998; Purschwitz & Field, 1990; Pickett et al., 1995; Runyan, 1993; White & Cessna, 1989). After that period researchers in this sample of the literature seem to have started looking more closely at specific illnesses, and at interventions and programs aimed at reducing farm injuries. The reason for the lack of recent research on general hazards is unknown and outside the scope of this review, however it does point to questions related to the accuracy and relevancy of the issues and challenges identified in this older research for today's farmers, especially considering the changes that have occurred in the industry in areas such as machinery and regulations.

Table 3: Descriptions of Articles Included in the Contextualized Review

AUTHOR	TITLE	YEAR	LOCATION	METHODS/APPROACH
Bentley et al.	Investigating slips, trips and falls in the New Zealand dairy farming sector	2007	New Zealand	Followed up with 39 cases of slip/trip/fall compensation claims. Semi-structured interviews used. N=39.
Biddle and Kean	Action learning: A new method to increase tractor rollover protective structure (ROPS) adoptions	2012	United States	Recruited participants to be part of face-to-face problem-solving discussions using action learning as a tool. N=24.
Drul	Agricultural fatalities in Canada 1990-2008	2011	Canada	Used data from a national surveillance system and various provincial and national records to determine agriculture deaths in Canada over an 18 year period. N=1975.
Etherton et al.	Agricultural machine-related deaths	1991	United States	Examined U.S. death certificates for the period of 1980-1985 to identify deaths involving agricultural machinery. N=369.
Frank et al.	Issues of agricultural safety and health	2004	United States	Literature review of prevalent agriculture health and safety issues.
Hartling et al.	A systematic review of interventions to prevent childhood farm injuries	2004	Canada and United States	Literature review of North American interventions to prevent childhood farm injuries. N=23.
Hagel et al.	Economic worry and the presence of safety hazards on farms	2013	Saskatchewan, Canada	Cross-sectional survey of farm operators; mail survey. N=2390.
Hennebry	Permanently temporary? Agricultural migrant workers and their integration in Canada	2012	Ontario, Canada	Report using empirical data, interviews and research on agricultural migrants in Ontario.

Hoppin et al.	Respiratory disease in United States farmers	2014	United States	Looked at Agriculture Health Study self-responding respiratory outcomes. Found that participants had higher prevalence of respiratory symptoms, but fewer respiratory diseases. N= 43548.
Horsburgh et al.	Fatal work related injuries in agricultural production and services to agriculture sectors of New Zealand 1985-94	2001	New Zealand	Cases selected from a dataset of all work related injuries in New Zealand from 1985-94. N= 159.
Hwang et al.	Severe farm injuries among New York farmers	2001	New York, United States	Participants completed two telephone interviews in which they reported all injuries over a 12-month period. N=1706.
Jennissen et al.	Unintentional needlestick injuries in livestock production: A case series and review	2011	Iowa, United States	Case study of patients who received medical care at the University of Iowa Hospital. N=9.
Kennedy et al.	Suicide and accidental death in Australia's rural farming communities: A review of the literature	2014	Australia	Literature review overviewing suicide and accidental death in farming communities with a focus on Australian farmers.
Lilley et al.	Effective occupational health interventions in agriculture	2009	Various	Literature review of interventions to reduce injuries.
Linaker and Smedley	Respiratory illness in agriculture workers	2002	Various	Literature review of respiratory diseases and symptoms across North America and Europe.
Lindahl et al.	Occupational health and safety aspects of animal handling in dairy production	2013	Various	Literature review of OHS aspects of animal handling. specifically in dairy farms.

Marlenga et al.	Evaluation of the North American Guidelines for Children's Agricultural Tasks using a case series of injuries	2004	United States and Canada	Examined cases involving children injured from farm work. N= 283.
May et al.	Respiratory health effects of large animal farming environments	2012	Various	Literature review with no defined methodology.
McBride et al.	Noise exposure and hearing loss in agriculture: A survey of farmers and farm workers in the Southland region of New Zealand	2003	New Zealand	Cross sectional survey, random subsample selected. N= 586.
McCurdy and Carroll	Agricultural injury	2000	United States	Literature review with no defined methodology.
McDuffie et al.	Agricultural Health and Safety	1995	Various	Edited book.
Morgaine et al.	The FarmSafe Programme in New Zealand: Process evaluation of year one	2003	New Zealand	Evaluation of a New Zealand initiative.
Murphy et al.	Tractors and rollover protection in the United States	2010	Various	Literature review prepared for ASHCA/NIOSH conference.
Osborne et al.	Risk factors for musculoskeletal disorders among farm owners and farm workers: A systematic review	2012a	Various	Literature review of musculoskeletal disorders among farmers. N=33.
Osborne et al.	Prevalence of musculoskeletal disorders among farmers: A systematic review	2012b	Various	Literature review of musculoskeletal disorders. N=24.

Padgitt et al.	Agricultural pesticide exposure, safety, precautions, and pesticide-attributed illnesses among Iowa farmers	1995	Iowa, United States	Mail questionnaire sent to agricultural pesticide applicators in Iowa. N= 973.
Pickett et al.	Nonfatal farm injuries in Ontario: A population-based survey	1995	Ontario, Canada	Population-based mail survey sent to 2000 farms, response rate of 1364 (74%). Crude rate of farm injury 5.8/100 per year.
Purschwitz & Field	Scope and magnitude of injuries in the agricultural workplace	1990	Various, United States	Overview of types of accidents and injuries, including fatal work accidents.
Rademaker	Occupational contact dermatitis among New Zealand farmers	1998	New Zealand	Tested 46 farmers' dermatitis to determine if it was work related. Work-related dermatitis was present in 23 cases.
Runyan	A review of farm accident data sources and research: Recently published and current research	1993	United States	Overviews types of injuries and illnesses and their causes, as well as farmers' perceptions of safety.
Reynolds et al.	Systematic review of respiratory health among dairy workers	2013	Various	Literature review of respiratory health issues in farmers. N=30.
Schenker	General health status and epidemiological considerations in studying migrant and seasonal farmworkers	1995	Various	Literature review of these issues. Identified 203 articles from 1966-1989.
Sheldon et al.	Fatal farm work related injuries involving children and adolescents in Wisconsin and Indiana	1995	Wisconsin and Indiana, United States	Data drawn from state farm injury fatality records between 1970 and 1990; fatal farm work related injuries in adolescents were identified. N =460.

Solomon	Accidental injuries in agriculture in the U.K.	2002	United Kingdom	Examines accident statistics from two databases: Reporting of Injuries, Diseases and Dangerous Occurrences Regulations, and Labour Force Survey. Total fatal injuries = 602 and non-fatal injuries = 1950.
Sorenson et al.	Encouraging the installation of rollover protective structures in New York State: The design of a social marketing intervention	2008	New York State, United States	Looks at the design process for planning a social marketing intervention.
Sprince et al.	Farm activities associated with eye injuries in the agricultural health study	2008	Iowa, United States	Mixed method mail and phone survey of self-reported injuries amongst a randomly sampled population. N=36.
Sprince et al.	Risk factors for low back injury among farmers in Iowa: A case-control study nested in the agricultural health study	2007	Iowa, United States	Case-controlled study using mail screener (N=6115) and phone follow-up (N=431), as well as low back injury participants. N=49.
Springfeldt	Rollover of tractors – International experiences	1996	Various	Examined ROPS regulations for Sweden, Denmark, Norway, Finland, Great Britain, West Germany, Switzerland, Spain, USA, Canada, Australia and New Zealand.
Thu, K.M.	The health consequences of industrialized agriculture for farmers in the United States	1998	United States	Review based on group interviews in Iowa and Nebraska, as well as recent survey data and literature. N=56.
Voaklander et al.	Older farmers and machinery exposure – Cause for concern?	2012	Canada and the United States	Followed up with male farmers over 25 from a baseline survey after two years. N=2751.

Waggoner et al.	Mortality in the agricultural health study, 1993-2007	2010	North Carolina and Iowa, United States	Used data from the Agricultural Health Study cohort, specifically pesticide applicators and their spouses. N= 89,656.
White and Cessna	Occupational hazards of farming	1989	United States and Canada	Review of various types of hazards and their health concerns for farmers.
Wiggins & Castanares	Mental and psychosocial health issues among migrant and seasonal farmworkers in Oregon: Preliminary research with intervention applications	1995	Oregon, United States	Report written on the Healthy Child Project (El Nino Sano), a community health program aimed at children of migrant and seasonal farmworkers that ran from 1998-1991.
Yoder and Murphy	Using social marketing to address barriers and motivators to agricultural safety and health best practices	2012		Overviews and guides in using social marketing to address agri-safety.

Table 4: Hazards, Illnesses, and At Risk Groups Identified in the Literature Reviewed

AT RISK GROUPS	REFERENCES
Older Farmers	Frank et al., 2004; Sprince et al., 2011; Voaklander et al., 2012; Solomon, 2002; Pickett et al., 1995
Children	Hartling et al., 2004; Marlenga et al., 2004; McCurdy & Carol, 2000; Kennedy et al., 2013; Sheldon et al., 1995
HAZARDS	**REFERENCES**
Machinery	Runyan, 1993; White & Cessna, 1989; Etherton et al., 1991; Purschwitz & Field, 1990; Sorensen et al., 2008; Sorensen et al., 2006; Springfeldt, 1996; Biddle and Keane, 2012; Horsburgh et al., 2001; McCurdy & Carroll, 2000; Waggoner et al., 2010;

	Voaklander et al., 2012
Falls	Sprince et al., 2003; McCurdy & Carroll, 2000; Bentley et al., 2007; Solomon, 2002
Animal Handling	Lindahl et al., 2013; Horsburgh et al., 2001; McCurdy & Carroll, 2000; Jennissen et al., 2011
Chemical Exposure	Waggoner et al., 2010; Frank et al., 2004; Runyan, 1993; White & Cessna, 1989; Rademaker, 1998; Padgitt et al, 1995
ILLNESSES	REFERENCES
Respiratory	Linaker & Smedley, 2002; Hopping et al., 2014; Frank et al., 2004
Noise Induced Hearing Loss	Sprince et al., 2003; Sprince et al., 2011; Hwang et al., 2001; Frank et al, 2004; McBridge et al, 2003
Musculoskeletal	Sprince et al., 2011; Osbourne et al., 2012; Osborne et al., 2012b; Frank et al., 2004.
Mental Health	Runyan, 1993; White & Cessna, 1989; Kennedy et al., 2013; Wiggins & Castanares, 1995

Results

Agriculture is one of the most hazardous sectors in many countries; it has some of the highest reported death and injury rates across industries and sectors (Frank et al., 2004; Thu, 1998). In the United States, for instance, the 2001 fatality rate in agriculture was 21.3 per 100,000 workers, compared to an average industry rate of 3.9 per 100,000 in the same year (Frank et al., 2004, p. 230). In Canada, 1,975 people were killed in agricultural injury events during the period of 1990-2008, and the agricultural fatality rate was 12.9 per 100,000 (including non-workers on farms) (Drul, 2011). Higher rates of unintentional fatal injuries have also been documented in farming than in the general population in the U.S. (Waggoner et al., 2010). While the number of farms and the fatalities associated with working on them tend to be decreasing (Drul, 2011; Frank et al., 2004), many consider the mortality and morbidity rates to still be too high, with agriculture leading the way as one of the most hazardous industries in the U.S., Canada, and other countries throughout the world (Drul, 2011; McCurdy and Carroll, 2000; Waggoner et al., 2011). Furthermore, recent data from Ontario actually showed an increase in farm-related deaths for the year 2013-2014, when there were 6, compared to 1 for the previous year (Bergeron-Oliver, 2015). Furthermore, reports from the U.K. have shown a 22% increase in farm deaths from 2013-2014 despite an increased focus on safety (Case, July 2015).

Farmers and farm workers are susceptible to a variety of illnesses and injuries including those caused by tractors and machinery, animals, slips/trips/falls, water, and electricity. Occupational

illnesses associated with agriculture include respiratory diseases from chemical and dust exposures, occupational cancers, pesticide poisoning, dermatitis, musculoskeletal injuries, noise induced hearing loss, and stress and mental health issues. While the most common sources of injuries can vary between commodity groups, reports have indicated that livestock, machinery and falls are the most important sources of occupational injury on farms in the United States (McCurdy & Carroll, 2000, p. 471), and that sprains, strains, fractures, and amputations are some of the most common injuries (Ibid). McCurdy and Carroll reviewed studies that show a predominance of musculoskeletal injuries in farming in California (p. 471). A study of 1998 U.S. Bureau of Labour statistics reported that skin conditions account for the majority (56%) of agricultural occupational illnesses, followed by cumulative trauma disorders (14%) and respiratory diseases (13%) (as cited in Frank et al., 2004, p. 231). Meanwhile, the same review reported findings of an increased age-adjusted prevalence of cardiovascular disease, arthritis, and amputations for farmers when compared to other manual labourer workers (p. 231).

Certain populations are more at risk of injury, illness and fatality on farms than others. Those most at risk include children, older farmers, and migrant workers. For example, McCurdy and Carroll (2000) pointed to numerous studies that show increased risk for persons under 19 and over 65 years of age (p. 465). Older persons are at an increased risk of mortality (Ibid). Farm workplace characteristics including farm size, income, and the presence of non-resident workers are also associated with increased relative risk (McCurdy & Carroll, 2010). McCurdy and Carroll's review of the literature found that risks are higher on beef, dairy, and fruit farms (Ibid); Hwang et al. (2001) also found elevated risk of injury on dairy and livestock operations (p. 35). Risk tends to be higher in the spring and fall, the seasons when labour input is highest (Ibid).

Hazards and Injuries

Machinery

Machinery is often identified as the leading cause of death in agriculture (Waggoner et al., 2010), predominantly from injuries associated with loading equipment, power take-off devices, augers, hay balers, tractors, and motor vehicles (as cited in McCurdy & Carroll, 2000, p. 472). Waggoner et al. found machinery-related incidents to have the highest mortality rates in their sample, followed by motor vehicle non-traffic accidents, and collisions with objects (2010, p. 73). Common machinery-related injuries include entanglement, run-overs, and being pinned (Ibid). In their New Zealand study, Horsburgh et al. (2001) indicated that machinery incidents accounted for over 50% of all accidents in their dataset (p. 491).

Horsburgh et al. (2001) found that 71% of machinery incidents were related to tractors. McCurdy and Carroll (2000) indicated that tractors accounted for 69% of machine-related

deaths between 1980 and 1985 in the U.S. (p. 473). They also cited the National Traumatic Occupational Fatality survey carried out from 1990 to 1993, which found that tractors are the most common cause of occupational fatality in agriculture, accounting for nearly one-fifth of fatalities in the U.S. (Ibid). In the U.S., farm tractors were the primary reason for nearly a third of all work-related farming deaths between 1992-2010 (Biddle & Keane, 2012).

Many studies have found that tractor overturns are the single most common agricultural fatal injury event (Horsburgh et al., 2001; Sorensen et al., 2008; Voaklander et al. 2012). Rollover Protection Structures (ROPS), when paired with seatbelts, are widely recognized as the most effective source of protection in the event of an overturn (Sorensen et al., 2006; Springfeldt, 1996). Efforts to increase their prevalence through regulatory requirements for their use may soon have significant impact on rates of tractor-related deaths, particularly as older tractors are retired out. ROPS structures have undergone technological improvements in recent years and are required on newer tractors in most jurisdictions including Canada, the U.S., Australia, New Zealand, the U.K., and the E.U. (Springfeldt, 1996). Murphy et al. (2010) caution that most research indicates a need for ROPs usage to exceed 75% in order for overturn fatalities to be reduced to near zero (p. 251), yet certain characteristics, such as a small farms, older operators, and low annual income farms can be associated with a decreased prevalence of ROPS on tractors (Loringer & Myers, 2008). It is important to note that deaths associated with tractor rollovers may have declined in recent years.

While tractors represent the form of agricultural machinery in existing research most commonly associated with machine-related deaths and injuries, other agricultural machinery is also implicated in farm injuries and fatalities. One study of 35 U.S. states indicated that 17.6% of farm work injuries were caused by agricultural machinery, excluding tractors (Purschwitz and Field, 1990, p.184). Augers, combines, hay balers, mowers (Etherton et al., 1991, p. 766), swathers, rock pilers, and round balers (White & Cessna, 1989) have all been contributing factors in farm fatalities. While run-overs and rollovers are common injury events with tractors, in machinery other than tractors various types of injury events can occur. Some of the more frequently cited events include being struck by or against the machine, entanglements, and falls from machines (Runyan, 1993).

Slips, Trips, Falls, and Falls from Height

Slips, trips, falls, and falls from heights are common hazards for farmers and farm workers. In the U.K., falls from height were the second most common fatal farm events between 1986 and 1999, and were in the top five reported causes of non-fatal injuries (Solomon, 2002, p. 465). A U.S. study found that up to a quarter of injury cases on farms were the result of falls (McCurdy & Carroll, 2000, p. 473). In 2000, falls accounted for 18% of all nonfatal injuries and illnesses in the U.S. agricultural industry (Sprince et al., 2003, p. 265). Meanwhile, a study of dairy farms in

New Zealand indicated that 60% of cases reported foot slips as the most common fall-initiating event (Bentley et al., 2007, p. 1014). The same study also identified a number of key risk factors for slips, trips, and falls including running or taking short cuts, poor design of the plant or equipment, poor work organization, surface contamination, inappropriate footwear, and concurrent visual tasks (doing more than one thing at a time) (Bentley et al., 2007). The same study found that the most common underfoot surface associated with slips, trips, and falls was concrete, followed by grass or mud (Ibid). One case-controlled study found that fall-related farm injuries were significantly associated with four worker characteristics – middle-aged (40-64 years) farmers, doctor-diagnosed arthritis/rheumatism, difficulty hearing normal conversation (even while wearing a hearing aid), and taking medications regularly (Sprince et al., 2003). The same study also found that over half of the falls in their study population occurred from September to November, during harvest (Ibid).

Animal Handling

Animals are frequently cited as one of the most significant occupational injury hazards on farms (McCurdy & Carroll, 2000), with many studies implicating large animals, particularly horses and cattle, as primary sources of non-fatal injuries on farms. U.S. research conducted in the 1990s found that injuries caused by animals accounted for between 12% and 33% of injuries on farms (McCurdy & Carroll, 2000). A New Zealand study by Horsburgh et al. (2001) found that 116 male workers in animal production were fatally injured between 1985 and 1994 – a rate of 17/100,000 worker-years, over three times the rate of all occupations combined (p. 489). An injury can occur during any of the many tasks involved in working with animals, ranging from moving cattle to vaccinating, caring for hooves, ear tagging, milking, and loading animals onto vehicles (Lindahl et al., 2013, p. 274). McCurdy and Carroll (2000) also identified a variety of risk factors for animal-related injuries, including activities such as those done by dairy cattle workers that increase proximity and exposure to animals (p. 474). In their recent review of dairy farm injuries in New Zealand, Lindahl et al. (2013) concluded that younger age, older age, male sex, greater number of hours worked, hearing difficulties, and arthritis/rheumatism are risk factors for livestock injuries (p. 276). They also showed that, of injuries resulting from direct contact with cattle, 90% took place on dairy farms and a majority of those injury events involved the worker being kicked, stepped on, hit, or crushed by cattle (Lindahl et al., 2013, p. 275). Dairy bulls present a high risk of worker injury (Ibid).

A variety of secondary injury types can be associated with animal handling, such as needle-stick injuries. These injuries have been documented in the handling of most types of livestock including hogs, chickens, cattle, and sheep. A variety of complications can arise from needle-stick injuries, but serious complications are infrequent. The extent of complications depends on where in the body the needle-stick occurs, what is being injected, and whether or not the injury

is treated by a health official. Some case studies of needle-stick injuries have shown that these can result in cellulitis, abscesses and soft tissue damage. Severe cases of cellulitis and severe abscesses may require surgery (Jennissen et al., 2011, p. 67).

Chemical Exposures

The research reviewed here often identified chemical exposures as a key hazard for farmers and farm workers. Many different studies have examined pesticide or other chemical exposures and their health effects.

Much literature has indicated that farmers may be at increased risk of certain cancers (Runyan, 1993; Cessna & White, 1989; Waggoner et al., 2011; Frank et al., 2004), and that chemical exposure may be one cause for this (Cessna & White, 1989; Frank et al., 2004). From their Agricultural Health Study-based investigation of pesticide applicators from Iowa and North Carolina, Waggoner et al. (2011) identified elevated mortality rates from lymph hematopoietic malignancies and cancers of the prostate, lip and eye within this population. Cessna and White (1989) cited a 1986 Canadian study that points to increased risks of lymphoma and skin and lip cancers. Meanwhile, in their agricultural hazards review, Frank et al. (2004) found that the strongest association between cancer and pesticide exposures was between non-Hodgkin's lymphoma and exposure to 2,4-D phenoxyacetic acid herbicide. Generally, however, findings regarding the risks of certain cancers in agricultural populations have tended to be somewhat conflicted. Frank et al. (2004) identified limitations on data validity and problems with comparisons between time periods, geographic regions, types of farming operations, and the use of farm operators versus hired workers in different studies as possible explanations for these discrepancies. On a more positive note, Waggoner et al. (2010, p. 75) have determined that while farmers may be at increased risk of certain cancers and unintentional fatal injuries, they also have lower rates of most other major causes of death including cardiovascular disease, lung cancer, and diabetes. The authors attributed these outcomes to higher physical activity levels among the farming population relative to the general population in the U.S., as well as to a high prevalence of never-smokers pointing to the presence in this population of the healthy worker effect that is often observed in working populations.

Exposure to pesticides has been linked to pesticide toxicity, dermatitis, and poisoning. Symptoms of pesticide toxicity include dizziness, vomiting, headache, fatigue, drowsiness, and skin rashes (Runyan, 1993). A 1980s Saskatchewan study documented 34 accidental pesticide poisonings over a five-year period, all of which required hospitalization (White & Cessna, 1989). Frank et al. (2004) indicated that the number of pesticide poisonings had steadily decreased over previous years, pointing to a California Pesticide Illness Prevalence Program that shows a decrease of 30% from 1999-2000 (p. 233). White and Cessna (1989) also showed that pesticide application can result in dermatitis, while a mail study of 973 farmers from Iowa showed that

21% of farmers in Iowa reported skin irritation from pesticide exposure (Padgitt, et al., 1995). Similarly, in a 1998 study of New Zealand farmers, researchers found that for 80% of those who had work-related dermatitis, pesticides were the cause (Rademaker, 1998).

Occupational Illness

Noise-Induced Hearing Loss

Noise-induced hearing loss (NIHL) is an occupational impairment that can result from excessive noise exposure to various farm sounds, including machines and animals. Studies have shown that various types of activities on farms can expose agricultural workers to unsafe noise levels. Chainsaws, tractors without cabs, pig sheds at feeding times, sheep sheds during shearing (McBride et al, 2003, p. 1281), as well as grain dryers and brush hogs have all been implicated in high noise exposure (White & Cessna, 1989). It is estimated that noise-induced hearing loss (NIHL) affects 55-72% of the farming population (Frank et al., 2004, p. 234). Studies cited in the Runyan (1993) review found that hearing loss affected about a quarter of younger farmers, and one half of older farmers (May & Dennis, 1992; Novello, 1991 as cited in Runyan, 1993). An older study of New York dairy farmers showed that farmers can experience both pure tone hearing loss and high frequency hearing loss, and that, in their study population, the left ear showed significantly more hearing loss than the right (May et al., 1990). Older farmers, in particular, are at an increased risk for hearing loss, and several studies have found associations between hearing loss and agricultural injury (Sprince et al., 2011). Sprince et al. (2011) suggested some potential reasons for these associations, such as the possibility that limited hearing makes it more difficult for farmers to react quickly to avoid injury from machines or animals, or that hearing difficulties are indicative of increased exposure to noise from sources like machines and animals, which are risk factors for farm related injury (p.14). While noise-induced hearing loss has been a well-known hazard for farmers and farm workers, some studies have indicated a large proportion of farmers are not wearing protective devices. A New Zealand study found that only 8.3% of study participants wore hearing protection “most of the time”, and 76.7% did not wear hearing protection during their work tasks (McBride et al., 2003, p. 1282). This is concerning, since some studies have shown that hearing loss may also be a risk factor for other farm injury events (Sprince et al, 2003; Hwang et al, 2001). Hwang et al (2001) found that hearing loss almost doubles the odds of a severe injury (p. 35).

Respiratory Disease

There is an elevated risk of occupational respiratory illnesses among some agricultural workers. Data suggest that farmers have higher morbidity and mortality from certain respiratory illnesses than the general population (Linaker & Smedley, 2002). Both acute and chronic conditions have been associated with exposures to organic dusts, animals, chemicals, and other

toxins (Frank et al., 2004, p.231; Hoppin et al., 2014). The prevalence, causes, and effects of such respiratory conditions are, however, often hard to estimate as occupational mechanisms have not always been actively studied (Linaker & Smedley, 2002; Hoppin et al., 2014).

Some of the respiratory diseases reported in the farming population include bronchitis, organic dust toxic syndrome, occupational asthma, mucus membrane inflammation syndrome, sinusitis (Frank et al., 2004, p. 232) and farmer's lung (Hoppin et al., 2014). Additionally, certain symptoms, such as wheeze, cough, and dyspnoea, are reported to be very high in the farm worker population (Linaker & Smedley, 2002). However, the prevalence, causes, effects, and mechanisms for these respiratory diseases and symptoms are often difficult to determine because many variables, including commodity group, co-exposures, varied working environments, different climates, and other factors may impact assessment (Linaker & Smedley, 2002). The Hoppin et al. (2014) study of pesticide applicators in the U.S. from 2005-2010 found that participants had a higher prevalence of self-reported respiratory symptoms than the general population, but showed lower rates of respiratory diseases such as asthma, chronic bronchitis, emphysema, chronic obstructive pulmonary disease, and farmer's lung (Hoppin et al., 2014). Specific symptoms prevalent in the study population included wheeze, cough, and phlegm, indicating potentially higher respiratory irritation (Ibid). Given that the study population excluded seasonal, temporary or other agricultural workers, and was representative of only the Midwestern and Southern U.S., findings from this study are not applicable to the entire farming population within that country. High wheeze prevalence has, however, been reported in other studies and regions, including in Sweden, New Zealand, and New York (Ibid).

In their in-depth review, Linaker and Smedley (2002) indicated that rhinitis is likely the most common and well-defined respiratory disorder amongst farmers. It is most commonly associated with grain farming, livestock breeding, dairy farming, and flax and hemp processing. The authors documented findings from Finland, Northern Germany, and the U.S. that support this conclusion (p. 452). Their review of existing research also examined the risk of asthma in farmers and their children, pointing to reports that show an increased risk for asthma among farmers, including from the Surveillance of Work Related Respiratory Disease in the U.K. and from the European Community Respiratory Health Survey (p. 453). While this review also indicated that hypersensitivity pneumonitis (farmer's lung) is an issue, the authors highlighted challenges with determining the extent and severity of the illness, noting that clear trends are difficult to identify (Ibid). Linaker and Smedley (2002) also identified organic dust toxic syndrome, asthma-like syndrome, chronic obstructive airways disease, toxic gas inhalation, and respiratory infections as documented respiratory disorders amongst agricultural workers. They noted, however, that there is significantly less literature on these conditions, their causes and pathology, and their prevalence.

Many of the occupational respiratory illnesses identified above are closely associated with specific types of agricultural activities, including work in animal production facilities. Large-scale animal operations for cattle, swine and chickens have all been associated with an increased risk of respiratory diseases (Reynolds et al., 2013; May et al., 2012; Runyan, 1993). Frank et al. (2004, p. 232) indicated that mucus membrane inflammation syndrome occurs in 20%-50% of animal feed operators, and sinusitis in 25%. Their review concluded that bronchitis is the most common respiratory disease among agricultural workers, and that its incidence is elevated in grain elevator workers and in animal and grain production workers (Ibid). Their findings contrast with those in the Linaker and Smedley (2002) study which found rhinitis to be the most common documented respiratory illness in agriculture, citing the American Thoracic Society's report *Respiratory Health Hazards in Agriculture* (p. 457).

There is, in conclusion, a lack of consensus on respiratory illness in agriculture in the literature. Sigurdson et al.'s 2008 Icelandic study (as cited in Hoppin et al., 2014) did not find any significant differences in respiratory disease and illness between farmers and estimates based on the national population. Some other European studies have also found no significant differences in respiratory symptoms, such as wheeze, shortness of breath, and asthma between farmers and the general population. To illustrate, two 2001 studies (Monso et al., 2001; Radon et al., 2001) of farmers in Denmark, Germany, Switzerland and Spain found that amongst animal farmers, respiratory symptoms were lower than among the general population (with the exception of phlegm), and that amongst crop farmers, the prevalence of respiratory symptoms was similar to that of the general public (as cited in Hoppin et al., 2004).

Musculoskeletal Disorders

Musculoskeletal disorders (MSDs) and injuries include a variety of injury types to which farmers and farm workers are prone. Case-controlled and cohort studies show that farmers have a higher prevalence of MSDs than non-farmer control groups (Osborne et al., 2012b). These disorders are often caused by chronic developments over time. Repetitive motion, excessive force, prolonged posture, sitting, and standing have all been associated with MSDs (Osborne et al., 2012a). Farmers in particular face many of these hazards throughout the workday – heavy lifting and carrying, sustained motions and postures, risks of trips and falls, and exposures to vibrations from machinery and vehicles (Ibid). Some of the more common types of musculoskeletal problems reported by farmers are chronic back pain, arthritis, sprains, and strains (Frank et al., 2004) as well as consequences of trauma such as sprains, fractures, and dislocations (Osborne et al., 2012b). These disorders can lead to many serious consequences for farmers and farm workers, including long-term pain, reduced work ability, lower farm income, poor quality of life, and the onset of other health problems (Ibid). The frequencies of certain musculoskeletal issues reportedly vary amongst commodity groups. For example, Frank

et al. (2004) found that chronic back pain was reported in 25% of Colorado farmers and ranchers, and almost 50% of dairy farmers, while low back pain was reported in 71% of swine producers (p. 234). Osborne et al. (2012) found in their review that working with tree crops posed a higher risk of developing back pain for farmers, while upper extremity risk factors were more common in pig and dairy farms (p. 385). Some risk factors that are associated with MSDs – and lower back pain in particular – include a greater number of years in farming, tractor work, milking for four or more hours a day (Osborne et al., 2012b), age, difficulty hearing, and asthma (Sprince et al., 2011, p. 13). However, further associations with asthma have not been discovered (Sprince et al., 2011). Additionally, studies show conflicting evidence as to whether young age or old age is a risk factor for MSDs, particularly low back injuries (Sprince et al., 2011; Osborne et al., 2012b).

Mental Health Issues

Farming is often considered to be a high stress occupation, with many factors – such as climate, economics, and health – being regular stressors for farmers and farm workers. Many of the stressors that farmers face are chronic issues, and many of them are unique to the farming industry (White & Cessna, 1989). One report indicated that farming is one of the most stressful occupations in North America (White & Cessna, 1989). Because of this, farmers are at an increased risk for mental health issues with farmers, farm workers, and farm family members all having high rates of stress-related mental disorders, particularly depression (Runyan, 1993). Additionally, compared with other occupational groups, farmers and farm workers have been identified as an at-risk group for suicide death (Kennedy et al., 2014). Agricultural labourers and farmers have higher suicide rates than those of other occupational groups in some countries, such as Australia (Ibid).

At-Risk Groups

Children

Children in agriculture have a high work fatality rate (Sheldon & Field, 1995, p. 355). Obtaining accurate information on this group is difficult as they are not normally encompassed under employment and earning statistics, despite the fact that they are often working in various capacities on farms (McCurdy & Carroll, 2000). While data are scarce, some studies indicate that those less than 16 years of age incur approximately 14-24% of fatal farm injuries (McCurdy & Carroll, 2000, p. 474). One review in particular has indicated that farm children experience high rates of premature death, morbidity, and disability, and that they account for approximately 19% of agricultural injury hospitalizations and fatalities in Canada (Hartling et al., 2004, p. 483). In a 2004 study of U.S. and Canadian pediatric farm injuries, Marlenga et al. found that of the pediatric farm injury cases, 30.3% were children involved in farm work (2004,

p. 350). Of those children engaged in farm work, 24% of the events resulted in fatalities (Marlenga et al., 2004, p. 352). The most commonly reported injurious events included machinery entanglement, being struck by animals, run-overs, and roll-overs. Fatalities were largely caused by roll-overs, run-overs, and entanglements (Ibid). Other reports have found similar sources of agricultural injury, citing machinery, animals and falls (McCurdy & Carroll, 2000, p. 475). However, an Australian report, which indicated that 17% of all farm fatalities are children, identified drowning as a cause of almost half of child farm deaths (Kennedy et al., 2014, p. 6). The McCurdy and Carroll review (2000) concluded that the primary contributing factors to injuries amongst this group include an economic need for them to work on family-earned farms, being part of a migrant farm-working family, and a lack of child care services forcing parents to bring children to work sites (p. 474). Studies have also indicated that many pediatric injuries occur because children are exposed to specific occupational hazards, such as machinery use (Sheldon & Field, 1995). However, there is little to no regulatory policy aimed at occupational safety for child labour in agriculture, leaving this group particularly vulnerable (Sheldon & Field, 1995; Hartling et al., 2004).

Older Farmers

The agricultural industry exhibits a prominent trend toward an aging workforce. The National Agricultural Statistics Service reported that as of 2002, the average age of principal famers in the U.S. was 55.3 years (Voaklander et al., 2012). Farmers tend to work beyond the typical retirement age of workers, and consistently engage in activities that require heavy physical labour, work from heights, or interactions with large animals/livestock (Ibid). Many studies indicate that this group of farmers is an at-risk group, experiencing elevated numbers of deaths and illnesses. For example, a U.K. study of agricultural deaths found that farmers aged 55 and older had higher death rates (Solomon, 2002) and an Ontario study based on self-reported farm injuries indicated that a disproportionate number of hospital-admitted injured farmers were either younger than 16 or older than 65 (Pickett et al., 1995). Meanwhile, a NIOSH report identified that older workers are the group at highest risk for occupational exposures, diseases, and injuries (Frank et al., 2004). One study of older farmers investigated their exposures to various types of work and found that older farmers spend a larger proportion of time working with machinery and that the equipment they use may be some of the oldest on the farm (Voaklander et al., 2012), which could lead to added vulnerabilities for this group. This study found that the leading sources of fatalities for older farmers include tractors, animals, and mowing machines, accounting for more than 60% of deaths (Ibid), while some of the most common sources of older farmer injuries are tractors, machinery, and falls (Ibid). Older farmers are also at increased risk for a number of other farm-related impairments and illnesses, including noise-induced hearing loss (Sprince et al., 2011, p. 14).

Migrant Workers

Migrant workers represent a difficult-to-capture group within the agricultural sector. True mortality and injury rates are unknown due to a multitude of sociological, economic, and health factors (McDuffie, 1995). Health issues often pose a greater burden for migrant workers as they are not always encompassed under a health care system, and data are difficult to find because their employment is frequently undocumented (McCurdy & Carroll, 2000). While these groups are exposed to the same hazards and potential illnesses as farm workers and owners, they also face additional factors that could increase their risk for injury and illness, including poor language skills, a lack of safety training or education, longer work hours, and piecemeal pay rates that change their work habits (McDuffie, 1995; Frank et al., 2004; McCurdy & Carroll, 2000). While data for these groups is very difficult to find, many researchers propose that injuries and fatalities among them are drastically under-reported (McCurdy & Carroll, 2000; Frank et al., 2005). Studies of U.S. migrant workers in California and Texas have indicated that some migrant populations are at greater risk for injury and infection, including infectious causes of death (Schenker, 1995). Studies that included migrant and seasonal workers in their data found a greater risk of mortality from falls and other injuries (Ibid). One study actually found that of disabling injuries in farm workers, a majority occurred among migrant and seasonal workers (Ibid). Additionally, studies in Oregon have found that Mexican migrant and seasonal workers in that state are at risk for mental and psychosocial health issues (Wiggins & Castanares, 1995).

While data on migrant workers in Canada is limited, the existing reports have recounted similar trends and figures for temporary migrant workers in the agricultural industry in this country. In the IRPP Study *Permanently Temporary? Agriculture Migrant Workers and Their Integration in Canada,* Hennebry (2012) outlined some characteristics of migrant workers that contribute to elevated health risks. These include a lack of English skills (which can make for dangerous situations and poor understanding of safety procedures and precautions), longer work hours, physically challenging work environments, a lack of protective equipment, exposure to heat, sun, dust, and animal borne diseases, depression and anxiety due to isolation and family separation, exposure to hazardous conditions, and a fear of reporting accidents and injuries (2012). Studies of Mexican and Jamaican migrant workers in Canada found overall illness and injury rates to be approximately 25%, and found that 32% of Jamaican workers reported a long-term illness as a result of an injury obtained while in Canada (Rusell, 2003 as cited in Hennebry, 2012). Furthermore, the Hennebry report (2012) and other studies have noted that injuries and fatalities for this group are drastically underreported (Hennebry, 2012; McCurdy and Carroll, 2000; Frank et al, 2005). A Work safe BC study found that there were fewer compensation claims for temporary foreign workers than for the overall population, with a 2 per 100 rate of claims for temporary foreign workers as compared with a 3 per 100 rate for the general

population (as cited in Hennebry, 2012). Additionally, a 2010 study indicated that 55% of 600 Ontario migrant farm workers reported working despite illness or injury to avoid losing paid hours, and 45% reported that colleagues worked in similar conditions out of fear of telling employers (Hennebry, Prebisch, & McLaughlin, 2010, as cited in Hennebry, 2012). Hennebry outlined one specific example of an unreported accident in which a Seasonal Agriculture Worker Program (SAWP) worker from Mexico said he did not tell his supervisor that he was injured by a forklift because he could not speak English (Shomberg, 2005 as cited in Hennebry, 2012).

Conclusion

The findings from this contextualized literature review highlight a number of trends and issues that may be of concern for the province of Newfoundland and Labrador. Certain types of agriculture, such as fur, berry, and organic farming, have been the focus of little to no research either globally or within this province, but have nevertheless been identified as having high claim rates by the NL WHSCC[i]. Dairy farms, on the other hand, have been the focus of substantial research with many studies examining hazards and risks to farmers within this specific commodity group. Machinery, animals, and falls have all been identified as major hazards facing agricultural workers. Some hazards, injuries, and illnesses – particularly related to machinery, musculoskeletal disorders, and respiratory issues – have also been identified by Service NL and the WHSCC in their review of results from inspections and an analysis of compensation claims.

The results of this review also highlight some significant opportunities for further research. First, some of the research discussed in this review suggests specific avenues of further investigation. For example, the Sprince et al. (2011) and Hwang et al. (2001) reviews point to an opportunity for research in the area of noise-induced hearing loss and its impact on compounded injury risk for people working in farm environments. Linaker and Smedley (2002) identified hypersensitivity pneumonitis (farmer's lung) as an issue, but highlighted challenges with determining the extent and severity of the illness. Additionally, Frank et al. (2004) emphasized the need for further research focusing on machinery and equipment, as rapid changes in technology have ever-changing implications for the occupational health of people working in agriculture.

Second, the occupational hazards associated with agricultural operations producing certain commodities (such as fur, berries, and organic products) appear to be under-studied. Fur farming, in particular, is a part of the agricultural sector that uses a great deal of dangerous machinery, including grinders and feed carts, and involves working with densely housed animals. All of these could contribute to risks of injury and illness among fur farmers.

Third, occupational health risks have received little attention in some geographical regions of Canada and in other parts of the world. Recent research on Canadian farms is not representative of the industry across the entire country (Hagel et al., 2013; Pickett et al., 1995; Voaklander et al., 2012) and the province of Newfoundland and Labrador is not represented at all in this research. A majority of the research reviewed here comes from the U.S., New Zealand, Australia, Canada, and the U.K., however, these are not the only industrialized countries with significant agriculture industries.

Finally, some illnesses, injuries and at-risk groups have not been studied extensively or existing research is somewhat out-of-date. One specific example of this is the issue of mental health in farming. While research from Australia has begun to look into this issue, it has not yet received significant academic attention in North America. Similarly, sun safety and sun hazards among farmers and farm workers present an opportunity for further research. Only one such article was found in our initial search, but was not included in this review. Much of the research examining general, overall farm safety hazards and illnesses was published before 2000, and there have been many changes in regulations, policies, and equipment since then. As Frank et al. (2004) observed, changes in technology and machinery and their implications for farm workers need greater attention. Meanwhile, temporary foreign workers and migrant workers are groups that play a crucial and growing role in agricultural operations and who have been shown to be at elevated risk of injury, illness and fatality. While Canada has programs aimed entirely at hiring temporary agricultural workers, their challenges and safety concerns have not been a priority in research, despite work-related deaths within this population (Mackrael et al., February 7, 2012). Closely related to this group are volunteer farm workers. While temporary foreign workers are identified as an at-risk group in some literature, farm volunteers and their work safety challenges are not represented at all. Yet, WWOOFERS (World Wide Opportunities on Organic Farms), and the use of them and other volunteers on farms, is a growing trend (Butler et al., 2015, Unpublished Manuscript; WWOOF Nations Around the World, 2015; Underhill and Rimmer, 2014). The hazards faced by volunteers are unknown and undocumented, but it is unlikely they are covered under compensation systems or any type of employee protective structures such as unions or work safe programs. Furthermore, it is unknown whether they receive adequate, if any, safety training.

Agricultural workers in Newfoundland and Labrador form a small but significant part of the provincial workforce and are employed in dispersed and diverse enterprises that differ substantially in terms of the size of the operations, commodities produced and who are at risk. This contextualized literature review has demonstrated that those working in agriculture face numerous hazards and a high potential for injury, illness and fatality. It has also highlighted some important gaps in existing research and areas where work needs to be done not simply to document problems but also to ensure prevention programs are designed, implemented and

evaluated in the province. While compensation rates remain high, and workers are faced with stress and precarious work conditions, it is necessary to research this group further to ensure that their occupational safety and health needs are being adequately addressed.

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[i] Provide evidence in the text of the report.