ANALYSIS OF OLDER FARMER WORK-RELATED FATALITIES IN INDIANA WITH APPLICATION OF FINDINGS TO INJURY PREVENTION EFFORTS

by

Sean Tormoehlen

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STATEMENT OF COMMITTEE APPROVAL

Dr. William E. Field, Chair
Department of Agricultural & Biological Engineering

Dr. Shawn G. Ehlers
Department of Agricultural & Biological Engineering

Dr. Kenneth F. Ferraro
Department of Sociology

Approved by:
Dr. Nathan Mosier

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ABSTRACT

The primary goal of this research was to summarize the occupational farm-related fatalities of Indiana farmers 55 years and older and to recommend evidence-based intervention strategies targeting older farmers who perform activities that involve the cutting and trimming of trees. The primary activities consisted of (1) preparing a summary of occupational farm-related fatalities of farmers who were 55 years and older, (2) preparing a summary of occupational farm-related fatalities of older farmers who were performing activities in a woodlot setting or that included the occasional cutting and trimming of trees, and finally (3) the development of recommendations for evidence-based injury prevention strategies targeting older farmers who conduct occasional woodcutting activities.

The summary of older Indiana farmer fatalities identified a total of 388 fatalities reported between 1988 and 2017 with an increase in the number of reported fatalities over the period of 2012-2017. Tractors were identified as the most common source of injury (40.5%) with tractor overturns involved in no fewer than 86 cases or 22.2% of all cases. Older farmer fatalities for occasional woodcutters accounted for 40 fatalities with the cutting and trimming of trees to be the most common cause of injury (67.5%).

Core desired safety competencies were identified that were used to develop injury prevention strategies based upon the summary of injuries, areas of concerns reported in the review of literature and the results gathered from the summaries of Indiana older farmers killed while performing woodcutting activities. A pilot evidence-based intervention instructional presentation was developed with the assistance of a panel of experts to be used by Extension Educators to increase awareness of the target population of current safety practices relating to woodlot activities.

CHAPTER 1. INTRODUCTION

1.1 Statement of the Problem

Recent reports by the Purdue University Agricultural Safety and Health Program (PUASHP) have found that approximately half of all work-related farm fatalities in Indiana over the past five years have involved individuals, primarily males, 55 years of age and older. These data, along with the increasing average age of agricultural producers, have important implications to educational, engineering, and public policy efforts intended to mitigate the social and economic impact of both fatal and non-fatal injuries connected to agricultural production. A special concern with this population is how the effects of physical and cognitive limitations typically related to aging may contribute to the increased probability of sustaining a work-related injury in an occupation already recognized as high risk. A review of the current relevant literature found that there is an inadequate understanding of how the aging process contributes to a greater risk of farm work-related injuries and the prevention strategies needed to reach this relatively small, but underserved population. Of special concern is the frequency of fatalities documented by PUASHP involving older farmers during the occasional harvesting and trimming of timber, unwanted trees, and other forest products.

1.2 Background

The average age of farmers has been on the rise in the United States from 50.5 years in 1982 to 58.3 years in 2012 and 59.4 in 2017 (USDA, 1984; USDA, 2014; USDA, 2019). Indiana farmers are currently an average of 55.5 years old, substantially younger than the U.S. average (USDA, 2019). The increase in the average age of this population is attributed to factors such as increased longevity of the U.S. population, enhanced health care, earlier diagnosis and treatment of age-related diseases such as heart disease and arthritis. In addition, there are economic and possible policy factors that influence older farmers to work beyond the age of normal retirement.

This trend towards an older active farmer population is a concern because of the additional risks that farmers face in agriculture, especially when coupled with age-related health concerns. As the quality of life has improved for many farmers, they have selected to remain actively

involved in the operation of their farms, including completion of tasks generally considered too hazardous for most other occupations.

One area, often associated with many agricultural production sites, is the occasional harvesting and trimming of timber, unproductive trees, and other forest products. Recognized as highly hazardous when carried out for commercial purposes, less attention has been given to these activities within an agricultural production setting. Commercial forestry had the highest reported fatal work injury rate in 2016 at 135.9 per 100,000 full-time equivalent workers which did not include the injuries sustained by the occasional on-farm woodcutter (Census of Fatal Occupational Injuries, 2018). This is pertinent to Indiana because of its long history with forestry production, with about 87% of the state forested before settlement (IN DNR, n.d.). This number has dropped since then, but it is still a large percentage at about 20% of the state currently forested, or 5.1 million acres of trees. Much of the non-state forested areas are owned by farmers.

Indiana's forest and hardwood industry also plays a big role in Indiana's economy with a total economic impact of $13.5 billion in 2016 and $166 million paid to landowners for timber alone (Settle and Seidl, 2016). A single tree can be worth as much as $10,000, but they can take decades to grow to the optimal size. Because of this it is common to calculate the profits by acres per year, with the higher end of Indiana timber woodlots able to bring in up to $350 per acre per year (Hoover, 2013). This is comparable with the estimated revenues of common conventional crops like corn and soybeans, with high productive soils bringing in revenue of $251-310 for corn and $209-352 for soybeans (Langemeier et al, 2017).

In addition to timber, Indiana woodlots are able to produce other profitable forest products such as maple syrup and Christmas trees. According to a questionnaire to Indiana maple syrup producers, the state made 15,398 gallons of syrup and brought in $825,000 in profits for 2018 (IN DNR, 2018). Christmas trees and short rotation woody crops were also profitable with $2 million in sales in 2012, ranking 21st in the nation (Kinghorn, 2015). A case study by Cassens and Cassens (2004) showed that they earned $962 revenue per acre per year when growing Christmas trees

As noted, approximately 85% of the wooded areas in Indiana are privately owned (IN NR, 2018). Because a majority of Indiana's forests are privately owned, it is common for farmers and landowners to be exposed to cutting and trimming trees, both as a potential income source from forestry products and in land management practices.

1.3 Primary Goal

The primary goal of this research was to conduct an analysis of previously published Indiana farm work-related fatality data involving agricultural producers 55 years of age and older to identify the primary causative aspects especially related to occasional wood cutting, and to recommend evidence-based injury prevention strategies that targets this population. The research targeted fatalities associated with on-farm harvesting of timber and other forest materials that was identified as a gap in the currently available agricultural injury prevention literature.

1.4 Research Objectives

1. Complete a literature review related to: agricultural injuries among senior farmers; injury risks associated with professional logging vs. occasional wood cutting; health risks associated with senior farmers; and perceptions held by senior farmers of agricultural hazards and their risk of injury.
2. Summarize previously published fatality data of farmers 55 years of age or older documented in the Purdue Agricultural Safety and Health database, between 1988 and 2017.
3. Summarize Indiana occupational farm-related fatalities of farmers 55 years and older who perform occasional wood cutting activities documented in the Purdue Agricultural Safety and Health database, between 1988 and 2017.
4. Prepare representative case studies of farm related fatalities that involved senior farmers engaged in harvesting and trimming of trees and managing on-farm woodlots that can be incorporated into injury prevention efforts.
5. Develop evidence-based intervention educational strategies that target farm-related fatalities involving the cutting and trimming of trees, harvesting of timber and other forest materials and related activities.
6. Develop recommendations based on the findings of the study.

1.5 Methodology

1. Complete a literature review related to: Agricultural injuries among senior farmers; injury risks associated with professional logging vs. occasional wood cutting; health risks associated with

senior farmers; and perceptions held by senior farmers of agricultural hazards and their risk of injury.

i. Review previously published relevant articles in the following: Journal of Rural Health, Journal of Agromedicine, Journal of Agricultural Safety and Health Safety, and the Fatal Assessment and Control Evaluation (FACE) Program of The National Institute for Occupational Safety and Health.

ii. Search online for other related sources.

iii. Review other relevant sources of farm fatality data from other states or programs.

iv. Prepare a review of literature focusing on risks to farmers 55 years of age and older.

2. Summarize the fatalities of all Indiana farmers 55 years or older from the Purdue Agricultural Safety and Health database, between 1988 and 2017.

i. Mine the Purdue University Agricultural Safety and Health Program's fatality database for all cases involving farmers 55 years or older.

ii. Develop a coding sheet using past Purdue University Agricultural Safety and Health Program summaries, Purschwitz (1989), and Nour et al (2019)

iii. Summarize fatality data to define the extent of the problem.

iv. Prepare and submit for publication a summary of the fatality data.

3. Summarize the fatalities of Indiana farmers 55 years or older involving occasional wood cutting activities from the Purdue Agricultural Safety and Health database, between 1988 and 2017.

i. Mine the Purdue University Agricultural Safety and Health Program's fatality database for all wood cutting activity cases involving farmers 55 years or older.

ii. Create a coding sheet using past Purdue University Agricultural Safety and Health Program summaries, Purschwitz (1989), and Nour et al (2019)

iii. Summarize fatality data to define the extent of the problem.

iv. Prepare and submit for publication a summary of the occasional wood cutting fatality data.

4. Develop representative case studies

i. Based on a review of the data, prepare representative case studies of farm-related fatalities involving senior farmers. The data utilized will be derived exclusively from public sources and victims will not be identified.

ii. Design the format of the case studies for use in educational settings that are relatable to the public to better illustrate the dangers of various tasks.

5. Develop evidence-based intervention strategies that target farm-related fatalities involving the trimming of trees and harvesting of timber and other forest materials.

i. Summarize current injury intervention strategies being implemented for senior farmers to prevent woodlot-related fatalities and identify gaps that exist.

ii. Participate in safety training program that focuses on proper safety techniques in logging, tree removal, and chainsaw operation.

iii. Develop set of core designed safety competencies to be used as an aid in the creation of woodlot safety classes targeting citizens 55 years or older.

iv. Use a panel of experts to review and provide feedback on the core competencies.

6. Develop a set of recommendations for addressing the problem of farm-related fatalities involving individuals 55 and older engaged in occasional tree and timber harvesting.

CHAPTER 2. REVIEW OF RESEARCH LITERATURE

2.1 Introduction

A review of the current relevant literature was undertaken to identify prior epidemiological research on farm-related injuries to determine how the aging process contributes to a greater risk of farm work-related injuries and evidence-based prevention strategies for aging farmers in terms of the trimming and removal of unwanted trees, the harvesting of timber and other forest materials and operation of agricultural equipment in wooded areas. This review concentrates on six major areas: (1) General aging issues; (2) Health conditions associated with senior farmers that may increase the risk of injury; (3) Perceptions of farm safety held by senior farmers; (4) Agricultural injury reports of senior farmers; and (5) Injury risks associated with professional logging vs. occasional wood cutting farmer.

2.2 General aging issues

There are biological changes that occur as a person ages that can affect their physical and mental abilities. Those changes have been well documented in the literature (Hultsch et al, 2002; Agrawal et al, 2008; Pascolini and Mariotti, 2012; Bergen, 2016; CDC; 2017). Though not consistently demonstrated in all individuals, age-related impairments eventually impact everyone. These changes result in impairments to all the senses, mobility and balance, and decision making. Age-related impairments have been shown to increase the risk of injury (Ivers et al, 1998; Coleman et al, 2004; McGwin et al, 2005). For example, a reduction in mobility and balance skills, can lead to increased risk of falling. According to the CDC, one out of five falls resulted in a serious injury (CDC, 2017).

Due to the changes and loss of biological and mental abilities, older adults use various strategies to compensate. Baltes and Baltes (1990) investigated one strategy called selective optimization with compensation. Selective optimization refers to is a way that older adults adapt by using three different processes: selection, optimization, and compensation. The first process, selection, is the act of prioritizing tasks and expectations with the individual's skills, capacity to do the job, and the importance of getting the job done. The second process, optimization, refers to improving their abilities to achieve said tasks by investing more resources and energy, practicing

or learning new skills, or adopting new aids to better complete their goals. The third process, compensation, is the use of new techniques to make up for the losses of certain capacities, such as technology or psychological efforts.

Hultsch et al (2002) explored the variability of reaction time between older and younger adults. The researchers did this by examing three different types of variability: diversity, dispersion, and inconsistency. They used cross-sectional data from the Victoria Longitudinal Study (VLS), during which a group of older adults (54-87 years old) and a group of young adults (17-36 years old) were tested either every three or six years, respectively. The total sample of 862 participants was divided into four age groups: the young (Y) group of 99, 17 to 36 year olds, the young-old (YO) group of 178, 54 to 64 year olds, the mid-old (MO) group of 361, 65 to 74 year olds, and the old-old (OO) group of 224, 75 year and older. Each of the participants were part of four testing sessions that measured simple reaction time, choice reaction time, lexical decision tasks (measuring how fast people classify things as words or nonwords), and semantic decision making (subjects determine the meaning of a stimulus) by the use of a computer. The researchers found the older group had a larger amount of variability when compared to the younger adults. There was also evidence that showed a wider spread of scores at the individual level in the older adults between the four different tasks.

Aslan et al (2008) examined the effects that age has on balance performance. The data was collected from 240 subjects in Turkey ranging from 50 to 75 years old and was divided into two groups, 125 middle aged (50-64 years) and 115 elderly (65-75 years). Each of the participants completed four different tests to determine the extent of their balance performance. The researchers found that the balance of the elderly subjects was poorer in comparison to the middle-aged group in all four tests.

All of the senses of the body, especially vison and hearing, go through changes with age. These changes are significantly affected by such agents as family genetics, physical well-being, and even a person's attitude. A study by Agrawal et al (2008) investigated the amount of hearing loss in adults in the United States. The data was collected from the National Health and Nutrition Examination Survey from 1999-2004 with a total population of 5,742 participants ranging from age 20 to 69. Each participant went through an examination of their audiometric measures and then was asked a series of questions that included their self-reported hearing status and exposures to any occupational noises. They found a hearing loss of 16.1% when they combined the unilateral

and bilateral losses. The authors estimated that 29 million Americans have significant hearing loss. It was also found that white participants of both genders and all other male races showed a positive relationship between the prevalence of hearing loss and the increase in age, with nearly 100% for those in the 60-69 age range. In other words, almost all participants over 60, regardless of race, have experienced hearing loss. Limitations noted included potential bias from random sampling of demographic data that may have led to oversampling of people with existing medical issues.

According to the National Eye Institute, there has been an increase in the risk of developing age-related diseases (National Eye Institute, n.d.). A study by Pascolini and Mariotti (2012) explored how many people in the world had some sort of visual impairment for the year 2010. They collected surveys from a total of 39 countries that met the criteria to be included to determine the number of people with visual impairments, which included both blindness and low vision. Using the surveys, they were able to estimate the global number of visually impaired people to be 285 million, with 39 million being blind. It was also found that over 82% of the blind people and 65% of the visually impaired were 50 years or older. Limitations of this study included potential over or under estimations of visual impairment and blindness of approximately 20%.

A report by Bergen (2016) evaluated the number of falls and injuries sustained by adults 65 years and older in the United States during 2014. The researcher did this by using the Behavioral Risk Factor Surveillance System (BRFSS), an annual telephone survey system for people over 18 throughout the US, to ask how many times they had fallen and if they had received an injury from the incident. The sample used consisted of a population of 147,319 adults 65 years or older. The results showed that 28.7% of the adults had fallen at least once during 2014, with 37.5% of those requiring medical treatment or reducing activity for at least one day. It was also shown that an increase in age resulted in more falls and number of fall-reported injuries. When divided into age groups, the age range with the highest reported percentage of falls was the 85 years and older group at 36.5%, with 75-84 years in second (29.8%) and 65-74 years in third (26.7%). The number of fall injuries was 9.9% for 65-74 years, 11.4% for 75-84 years, and 13.5% for those 85 years and older. An analysis of the data was used to estimate the number of falls throughout the U.S. population which projected 29 million falls occurred during 2014. Limitations of the study were recall bias, the sample did not include people in long-term facilities, open definition of fall injuries, and potential for nonresponse bias.

2.3 Health and safety conditions associated with farmers 55 years and older that may increase the risk of farm-related injury

Agriculture is considered one of the more dangerous professions in the United States (National Safety Council, 2019; CFOI, 2018). The Census of Fatal Occupational Injuries reported that farmers, ranchers, and other agricultural managers had a fatal injury rate of 23.1 per 100,000 full-time equivalent workers of all ages. This injury rate was in the top ten civilian occupations with a high fatal work injury rate (CFOI, 2018). The National Safety Council also reported a high fatal work injury rate of 22.6 for farmers in 2017, compared to a 3.0 fatal work injury rate for all workers (National Safety Council, 2019). A limitation of this data is that numbers of workers representing farming have often been combined with workers in the fishing and forestry professions, also recognized as high risk, which may overstate the numbers of agricultural work-related incidents if presented without clarification.

A literature review by Salminen (2004) inspected the risk of occupational injuries for younger workers across industries. The author looked at a mixture of studies for both fatal and nonfatal occupational incidents, 63 for nonfatal and 45 for fatal, throughout different industries. The verdict was that younger workers were more likely to sustain an occupational injury, but it was less likely to be fatal compared to older age workers. Fifteen of the studies investigated workers in agriculture, with two of the studies concluding that younger workers were less likely to have a fatal injury compared to the overall rate, suggesting that older workers are more likely to have fatal injuries. The strength of the review was the number of studies included in the review and that it represented a cross section of occupations. The weakness of this review is that each study was considered with equal weight and did not take into consideration the number of subjects or injuries per study, which varied.

Voaklander et al (2006) conducted a study that examined the connection between farmers 66 and older in Alberta, Canada and medication usage. They looked at farmers who had visited a hospital for an agricultural-related injury using data from various sources from Alberta's healthcare and emergency systems. The age range 66 and older was used because of the ability to access medication histories through Alberta Blue Cross, an insurance provider. They found that there was a strong relationship between the recent usage of narcotic pain medication and nonsteroidal anti-inflammatory drugs (NSAIDs) with an increased risk of future injuries. The authors gave three different hypothesizes on why this occurred. The first was that farmers may

become distracted by untreated pain and which leads to greater risk of injuries. The second was that pain may affect the mobility and reaction time of the farmers. The third hypothesis was that the farmers could have been affected by withdrawal from pain medications. The reported limitations with this study included that it only included injuries treated at emergency rooms and hospitals; it tracked prescribed medicine bought, but not prescribed medicines taken, and no reporting of over the counter medicines or other substance was available.

Lizer and Petrea (2007) studied the health status of Illinois farmers aged 55 years and older. They did this using the SF-36 health survey, (Ware, 1999), a widely used measure of generic health status of population groups, to assess the general health status of the respondents. Data were collected from a random sample of male farmers aged 55 to 70 years from the Illinois Farm Bureau with 154 respondents, 87 (56%) of which were still working farmers. The survey showed that the farmers in the age group 55 to 64 years old were comparable to other US populations in categories such as physical function, bodily pain, vitality, and social function. They varied from the general population by having increased scores in the physical component section and a decrease in scores for role of function, emotional health, mental health, and mental component summary. The older age group of 65 to 74 years scored better in most categories, such as general health and social function, compared to the general population. The only score that was worse was mental health. The authors found that there was a significant relationship between the self-reported stress and injuries for the group of 55 to 59 years old farmers, which showed more emotional stress with this group. The authors also discussed how it was interesting that the 65 to 74 year-old farmers scored a higher physical score compared to the general population, which suggested that the physical activity associated with farming may help protect their functional ability. Reported limitations of the study included a small sample size and methodological weakness.

A study by Marcum et al (2011) explored the injury risk factors for farmers 50 years of age and older in Kentucky and South Carolina by surveying 1,394 farmers from 2002 to 2005. The author found that an increase in 10 years of age decreased odds of injury by 15%, but that certain health-related factors common with age were significantly associated with the risk of sustaining a farm-related injury. The most frequently reported health factors included hearing impairments, vision impairments, arthritis, and back problems.

Heaton et al (2012) examined how arthritis, mobility, and farm tasks affected injuries among older farmers by analyzing data from a previous study of older farmers. The study found that age

decreased the frequency of farm-related injuries. It also found that arthritis did play a role in the frequency of injuries, with farmers with mobility problems being twice as likely to get injured while performing farm tasks compared to a farmer with no self-reported mobility issues. Limitations of this study included recall bias with the data collection method used, not having a geographic representation of farmers by only sampling older farmers from the Southeastern USA, and not collecting data on how mobility issues changed over time.

Hearing loss is common with aging, especially with farming. A study by Plakke and Dare (1992) performed a study about the occupational hearing loss in farmers. They found that farmers were more likely to have hearing loss when compared to non-farmers. Fifty percent of the farmers in the age 50 and over group had a hearing impairment.

Farming has been clearly documented as a dangerous occupation. Several studies reported that aging decreases the risk of injury for farmers, but that injuries experienced were more likely to be fatal compared to younger workers (Salminen, 2004; Marcum et al, 2011; Heaton et al, 2012). Another commonality between studies was that there were age-related changes, such as arthritis or hearing and vision loss, and increased usage of certain medications that have the potential for increased risk of injury while farming (Voaklander et al, 2006; Marcum et al, 2011; Heaton et al; 2012).

2.4 Perceptions of farm safety held by older farmers

Whitman and Field (1995) studied older farmer's perception of tractor and machinery-related hazards. Data were collected from a national survey of subscribers to a major farm publication that self-identified as being over 60 years of age. A sample of 295 older farmers responded with a useable completed questionnaire. The authors found that many of the respondents reported a small number of lifetime injuries, which suggested that older farmers had a hard time remembering injuries and underestimated the risk of experiencing work-related injuries. Findings also showed that older farmers underestimated the potential severity of tractor injuries in comparison to other farm related injuries, even though 83% of the group agreed that tractor injuries were often severe. The survey also found that most older farmers agreed that rollover protection structures (ROPS) were effective at preventing injuries, but only 43% had ROPS on their primary tractor and only 26% believed that they were worth the cost. The study found that half of the older farmers perceived that their lifetime of farm-related experience and skills would contribute to them being

able to prevent injuries caused by age-related impairments. The authors recommended that programs focusing on older farmer safety for tractor and machinery operation should include two points: 1). educating participants on the risk of common tractor and machinery related hazards that have been documented for older farmers, and 2). reinforcing the perception that ROPS systems are worth the investment to improve the safety of operating farm-related machinery.

A study by Fiedler et al (1998) investigated the causes of fatalities in older farmers versus the perception of risk. Fatality data were collected for Nebraska over a 10 year period from 1987 to 1997 and the perception of older farms was estimated by a telephone survey of 414 farmers over age 55. The fatality data showed that 50.6% of cases involved farmers over the age of 55 and tractors were the leading cause of death. The authors found that the farmers perceived the greatest risk to be electrocution while moving equipment with 80.1% of respondents being "very concerned" about this hazard, and the second most dangerous job to be working with power take-off (PTO) machines at 78.1% of respondents being very concerned. The fatality data showed, however, that only one death was caused by electrocution and two by PTO operated machines. Meanwhile, only 65% of the respondents indicated that they were "very concerned" by tractor safety. The authors recommended that future educational efforts should focus on increasing the knowledge of safety risks of tractors operated by older farmers.

It is known that older farmers have strong feelings towards agriculture, which is one reason why many continue to work past the common retirement age of 65. A study by Amshof and Reed (2005) looked at older, male farmers and their perceptions of health, work, and safety. The data were collected from Kentucky and South Carolina farmers who had previously participated in a farm family study in the 1990s and a population of African American farmers 50 years and older who were identifiable by the South Carolina Agricultural Statistics Service. The survey was sent to 1423 farmers 50 years or older with 725 responding. The ethnicity of the respondents was 76% Caucasian, 23% African American, and 0.4% Native American with an average age of 67 years. The study found that 42% of farmers did not consider themselves retired and that farmers would often consider farm-related jobs to not be work if it was voluntary. Seventy percent of farmers gained personal satisfaction from performing farm work. The authors noted that 43% of farmers chose to define health as the ability to continue to work, often indicating that there is a strong relationship between the ability to work and personal health. Farmers also reported to have a 2.3 mean number of chronic health issues with the most common being arthritis, hypertension, and

hearing problems. Lastly, the survey results showed that 21% of the respondents reported an injury in the past year, half of which were related to farm work. The author recommended that health care providers ask questions in a different way to be able to gain information from farmers about their work patterns, especially since most retired farmers continue to perform farm-related jobs, often without pay for younger family members.

The study by Gullifer and Thompson (2006) looked at the self-perceptions related to aging and work by interviewing eight Australian farmers from 65 to 80 years old. The interviews showed four different themes with the farmers: a value of both mental and physical toughness, an acceptance of age-related decline of physical and sensory abilities, a huge emotional connection to specific locations, and the need to feel productive and useful to the farm. Limitations included the small sample size and one-time interview methodology.

A study by Reed and Claunch (2017) used didactic reader's theater, or a performance that included audience discussion of the themes to help relate the learned information to their lives, as an innovative learning strategy for farm safety. The authors piloted a humorous dinner theater for farmer couples that involved three different cases that used real life examples to show how aging can affect farm activities, and then conducted a phone interview with the farm couples a week later to ask questions if they had made any changes in behavior. Participants in the dinner theater were very receptive to the approach which allowed the attendees to get involved and invested in safe, non-threatening ways. For example, after a story in the play that discussed fatigue, a farmer in the crowd reported taking naps. This resulted in other farmers joining in on their sleeping habits, which helped illustrate that it was not socially unacceptable to their peers to take care of themselves by napping. The follow-up calls also showed the success of the approach in modifying behaviors, with 42% of participants stating that they had made safety related changes after a just a week and 67% stated that they intended to make changes.

A study by Voaklander et al (2012) looked at the relationship between older farmers and machinery exposure by looking at a population of Saskatchewan farmers. They did this by first surveying 2,390 active Saskatchewan farmers ranging in age from 25 to 90 years old (average age of 53) and then following specific farmers longitudinally for a two year period to analyze any farm injuries. The authors looked at the time spent by the different age groups for seven different farm activities that included: large animal activities, small animal activities, ATV use, combine maintenance, combine use, tractor maintenance, and tractor use. They found that there was a

statistically significant negative relationship between the time spent doing specific activities and the age of the farmers for small animal activities, large animal activities, and ATV use and a significant positive relationship between age and the amount of time performing tractor operations, tractor maintenance, and combine use. In other words, farmers who spent more time with a tractor were more likely to experience an injury, regardless of age. The authors found that the exposure to farm machinery does not decrease with age as much as expected because the older farmer had a larger proportion of their total time spent working with farm machinery compared to younger farmers, even though younger farmers worked more hours in total. Limitations of this study included potential bias with self-reporting, one member reporting for all the family members, and the cross-sectional nature of the data.

The severity of tractor risks with older farmers and the perception that other types of hazards were riskier, even though research said otherwise, were reported by multiple studies (Whitman and Field, 1995; Fiedler et al, 1998). This was clearly evident in Fiedler et al (1998) when farmers ranked electrocutions and PTO related injuries as the highest risks even though they only accounted for a three of the documented fatality cases. Amshof and Reed (2005) and Gullifer and Thompson (2006) both found that farmers have a strong connection to their work and got satisfaction from performing it. In addition, the method of how farmers are educated on safety measures was found to work better when using less conventional methods, such as emotional material or theater (Whitman and Field, 1995; Reed and Claunch, 2017).

2.5 Agricultural injury reports of older farmers

Several states have their own programs that document and summarize farm-related fatalities over the years to understand how they have changed over time and to design more effective injury prevention efforts.

Field and Bailey (1976) summarized farm-related fatalities on Indiana farms from 1973 to 1976. Through an arrangement with the Indiana Board of Health, the authors were able to receive, for analysis, copies of death certificates that were classified as farm-related. There were 199 death certificates collected and summarized for the four-year period. The cases did not include deaths resulting from automobile or highway vehicles, deaths during personal trips away from the farm, and injuries in the home. The top five agents of death, in order from most to least, were: tractors with 97 fatalities (48.8%); farm machinery with 40 fatalities (20.1%); falls with 15 fatalities

(7.6%); smothering or asphyxiation with 13 fatalities (6.5%); and cutting or trimming trees at 11 fatalities (5.5%), respectively. A majority of the tractor-related fatalities, 61 or 63%, were a result of overturns. The authors reported that there were at least 16 tractor-related fatalities in 1976, even with ROPS. The age groups with the highest number of tractor-upset related fatalities was a tie between 40-49 years old and 50-59 years old farmers with 11 fatalities for each group, second place also was a tie between 60-69 years old and 15-19 years old at 8 fatalities each. The age group with the highest fatalities for the other tractor-related (n=48) and machinery incidents (n=45) was 60-69 years old with 10 fatalities for both. The authors made a number of recommendations which included developing and implementing educational programs for older farmers that focused on hazardous farm-related activities that are age affected.

Voaklander et al (1999) studied the occupational farm fatalities in Canada of farmers 60 years and over from 1991 to 1995. Data were collected from a wide variety of sources from each province, including farm safety associations, occupational health agencies, and law enforcement agencies, and compiled and coded in a comprehensive set for data analysis. They found that there were 183 farm fatalities involving older farmers, representing 36.5% of all farm fatalities during the period. The age-specific fatality rate per 100,000 population was found to increase with age, with it being 23.2 for 60-69, 50.8 for 70-79, and 65.1 for 80 years and older. Limitations include the small data set when trying to extrapolate results and lack of farm work exposure data required for the calculation of rates.

Myers, Layne, and Marsh (2009) conducted a study that looked at injuries and fatalities of U.S. farmers and farm workers 55 years and older. They used data from the National Institute for Occupational Safety Occupational Injury Surveillance of Production Agriculture surveys from 2001 to 2004 and from the BLS Census of Fatal Occupational Injuries for 1992 to 2004. Their analysis found that about half of the deaths from 1992 to 2004 involved farmers over 55 years of age, with 3,671 out of the 7,064 total fatalities. The fatality rate for this age group was estimated at 45.8 deaths/100,000 workers/year, which was considerably higher than the 25.4 deaths/100,000/year for all ages of farmers.

A study by the Great Plains Center for Agricultural Health (2015) looked at fatal occupational injuries that were farm-related as reported in the Census of Fatal Occupational Injuries (CFOI) Midwest region from 2005 through 2012. The CFOI Midwest region includes: Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, North Dakota, Nebraska, Ohio, South Dakota,

and Wisconsin. The data were collected from the CFOI database that was collected by the Bureau of Labor Statistics (BLS). The data were required to have two sources from documents that can include death certificates, workers' compensation reports, government reports, and first responders and hospital reports that prove that the fatality was actually work-related. Ages were grouped into five different categories: under 16, 16-24, 24-44, 45-64, and 65+. A total of 1,858 fatalities were identified. The average number of agricultural fatalities per year was around 232 per year from 2005 to 2012, with a decreasing trend during the period of 2011-2012. The authors found that there was a trend of agriculture-related fatalities increasing with age, as seen in Figure 1. The 65+ age group had the highest number of fatalities at 766 (41%) with the 45-64 group second at 673 fatalities (36%). The researchers found that 77% of all the agricultural-related deaths from 2005 through 2012 occurred to those 45 years and older. The most common agent of death was vehicular injury, which accounted for over half of the fatalities (55%). The next common agent of death was machinery (15%), which stayed consistent between all of the age groups. The third highest cause of fatality differed between age groups was falls for the 65+ age range and assaults/violent activities for the 45-64 age range. The injuries in each category generally increased with age, except for harmful substances/environmental exposures which had the highest number of fatalities with the 45-64 years old group with 34 cases and 14 for the 65+ years old. The authors also found that the number of deaths in which the time of death was reported 24 to 48 hours after the incident increased with age. One hundred thirty of the fatalities were reported as taking place 24 to 48 hours after the incident, with 79% of them involving adults 45 and older and 48% involving to adults 65+. It was even more prevalent with the 61 fatalities that took place two weeks later, with 90% occurring to adults 45 and older and 59% to adults 65 and over. Even though it was shown that the older population showed a high fatality rate with 41% of cases involving adults aged 65 and older, people under 25 years old actually had the highest frequency of fatalities, even though they only represented 9% of the reported cases. A limitation noted by this report is the potential underestimation in the number of cases due to the strict policies during data collection by the BLS, such as considering most victims under the age of 16 as not being farm work-related.

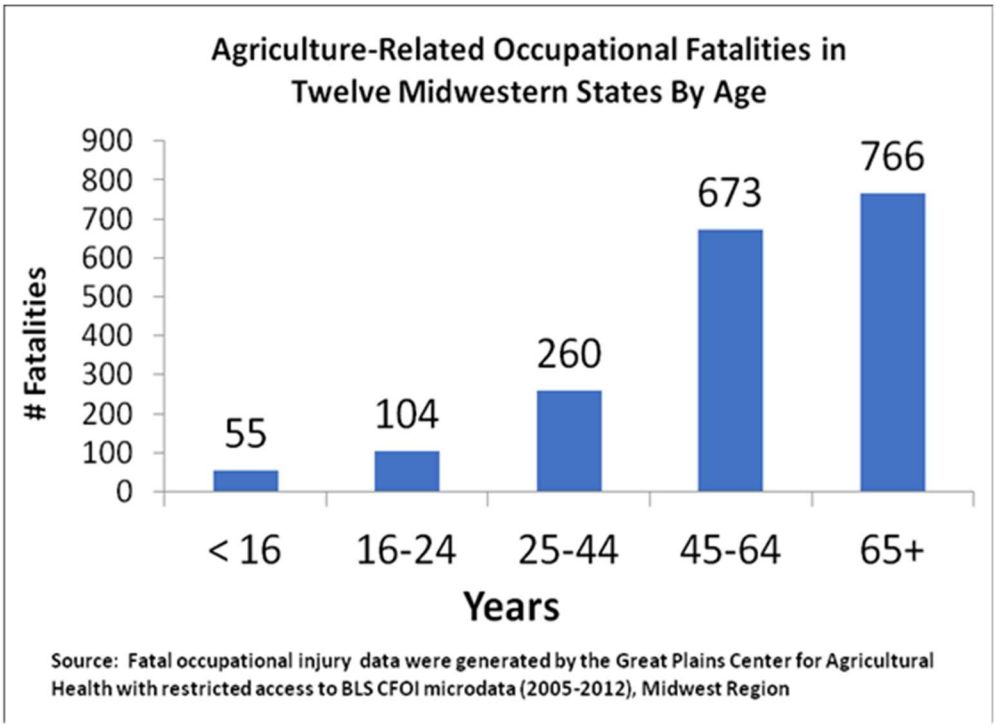

Figure 1. Agricultural-related occupational fatalities in twelve midwestern states by age (Great Plains Center for Agricultural Health, 2005)

The Agricultural Safety and Health Program at Pennsylvania State University made available farm fatality data compiled since 1980. Cases were collected from a variety of sources that included death certificates, police and coroner investigation reports, newspapers, media, and personnel from county Extension offices and rural emergency medical services. Every case entered was required to have several sources to be deemed credible. The five-year summary by Gorucu et al (2017) looked at Pennsylvania farm fatalities from 2010 to 2014. They found a total of 141 farm-related deaths with the most common agent of death to be vehicles, which included tractors. The authors found that about one third of farm fatalities (34%) involved people aged 65 and older with 50 fatalities, even though this age group only accounted for 22.6% of the farm household population. The data suggested that this population of adults aged 65 and older were at a higher risk of being involved in a fatality compared to a child aged 14 and under.

Purdue University's Agricultural Safety and Health Program (PUASHP) maintains one of the more developed databases of farm-related fatalities with summaries dating back to 1960. Fatality cases were compiled from sources that included news reports, death certificates, web searches, and interviews with extension staff or individuals. The annual summaries of fatalities have been

compared to work-related fatalities reported to the Indiana Department of Labor and federal sources, including CFOI to evaluate the reliability of the database. A summary of cases since 1970 found the annual number of fatalities have been on the decline, but since 2008, there have been a steady rise in the number of cases with 2016 being the third highest number of cases in 47 years as shown in Figure 2. The most frequent documented cause of death was tractors with 45% of all cases from 1994 to 2017 and 36% of cases in 2017. The summary also found that farmers 60 years and older accounted for 50% of the 36 cases in 2017 and nearly half of fatality cases over the past 5 years (Cheng and Field, 2018). Data prior to 1970 exists but have not been added into the database and are not included in the summaries.

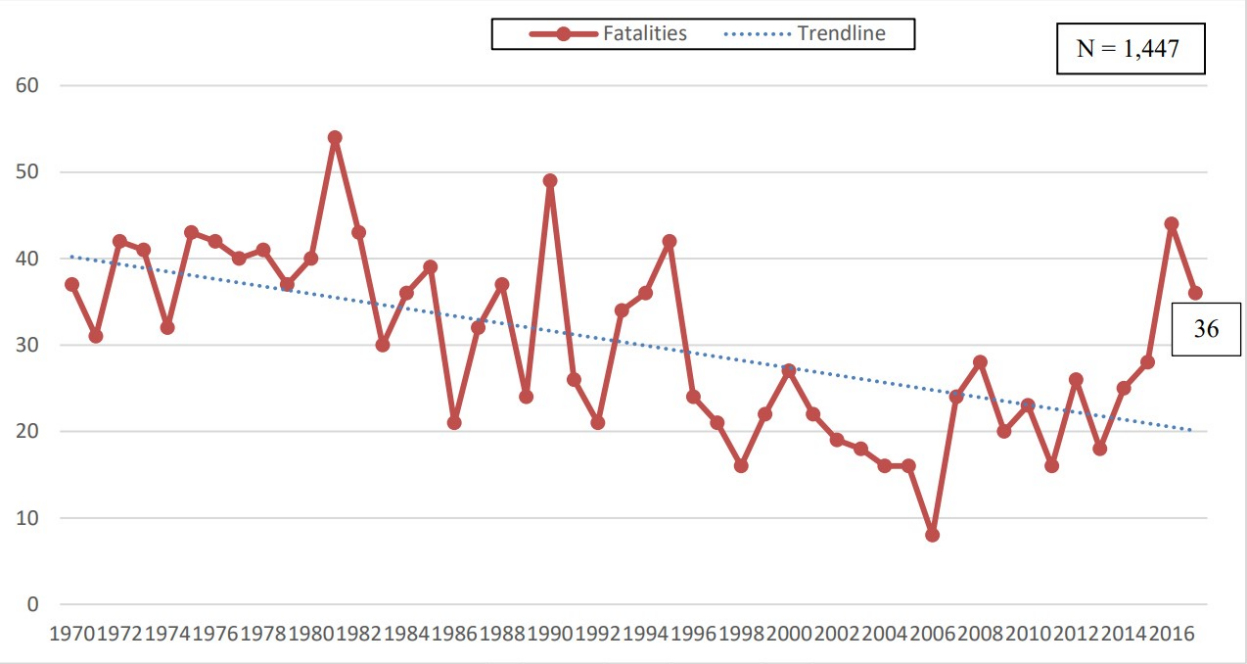

Figure 2. Number of Indiana fatalities per year – 1970-2017 (Cheng and Field, 2018)

The University of Illinois Agricultural Safety and Health program (Aherin and Petrea, n.d.) collected farm related injury and fatality data for 26 years from 1986 to the end of 2012. The data were collected either through a clipping service or from a mixture of clippings and death certificates from the Illinois Department of Public Health. They found that there were 808 deaths over the 26 year period. The most common agent of death reported was tractor-related. They also looked at the age of the victims and found that 270 of the 808 (33.4%) were 65 or older over the period of 1986 to 2012.

The OSU Agricultural Safety and Health Program (n.d.) established the Farm Fatality and Injury Database of Ohio using data from a number of sources, including death certificates, newspaper clippings, agency injury reports, and personal testimonies. The data have shown that there is currently a downwards trend in the number of farm-related fatalities from 34 fatalities in 2001 to 21 in 2010. The report of Ohio's farm fatalities from 2007 to 2016 showed that the number has decreased even further with only 6 reported in 2016. The total number of deaths over the ten-year period was 128. The most common cause of death was tractors with 57 cases (44.5%) and the second being a tie between equipment, machinery and wagons, and unknown at 12 fatalities each (9%). The ages of farm fatalities were separated into ten-year groups going to 71-80 years old, seen in Figure 3. The age group with the largest number of fatalities was the 61-70 years old with 25 fatalities, second was 71-80 years old with 21 fatalities, and the third was the 51-60 years old with 18 fatalities.

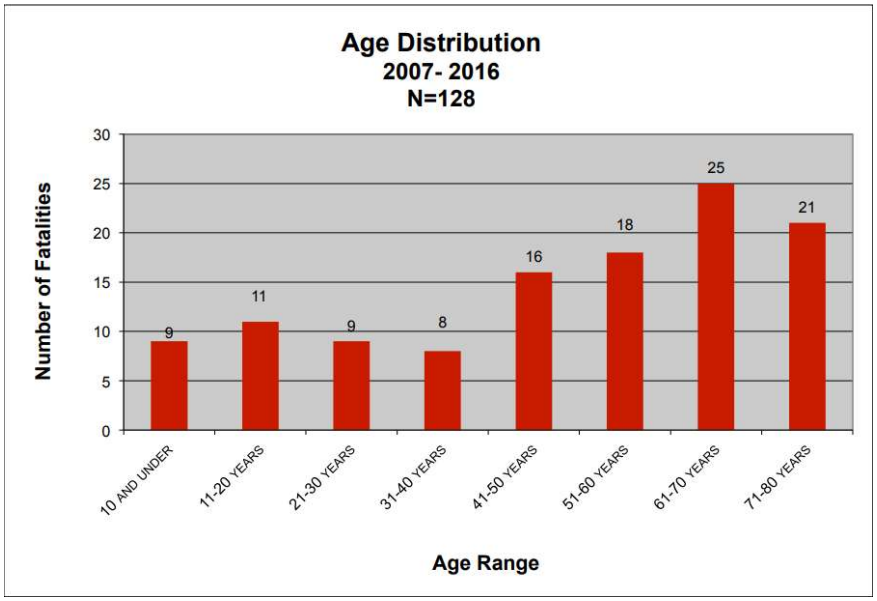

Figure 3. Age distribution of Ohio farm-related fatalities, 2007-2016 (OSU Agricultural Safety and Health Program, n.d.)

A summary by Purschwitz and Ellis (n.d.) looked at the Wisconsin farm-related fatalities during the 10 year period of 1996-2005. They used data from the annual farm-related fatality reports from the University for Wisconsin's Center for Agricultural Safety and Health (WISCASH) and annual editions of the National Safety Council's Injury Facts. A total of 308 fatality cases were documented during the 10 year period with an average number of 31 fatalities

per year. The most common cause of death was tractors with 113 fatalities (36.7%), second was other farm machinery with 80 fatalities (26%), and third was animal-related incidents with 37 fatalities (12%). The ages of each fatality were also grouped using the standards of the National Safety Council, as seen in Figure 4. Each of the age extremes, young and old, had a higher number of fatalities reported. Almost two thirds of the fatalities were 45 years or older with 197 fatalities (64%), and 95 fatalities for persons 65 years and older (30.8%). Limitations included missing data which were estimated by WISCASH using linear regression methods to estimate the missing data from 2002-2005 by using the older data from 1996-2001.

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
0 - 4	2	3	2	2	2	3	2	1	2	1	20
5 - 9	4	1	1	0	1	0	0	0	1	2	10
10 -14	0	2	1	2	1	0	4	4	0	0	14
15 -19	3	0	4	2	1	0	0	2	1	0	13
20 -24	0	1	0	2	0	0	1	0	2	2	8
25 -44	4	12	5	3	1	6	4	5	3	3	46
45 -64	14	10	8	9	14	10	7	12	11	7	102
65+	8	12	8	6	12	10	6	13	5	15	95
Total	35	41	29	26	32	29	24	37	25	30	308

Figure 4. Breakdown of ages of Wisconsin farm-related fatalities per year (Purschwitz and Ellis, n.d.)

A large portion of fatalities reported in the literature were older farmers in the age ranges of 50s and 60s (Field and Bailey, 1976; Voaklander et al, 1999; Gorucu et al, 2017; Great Plains Center for Agricultural Health, 2015; Cheng and Field, 2018; Aherin and Petrea, n.d.; Purschwitz and Ellis, n.d.). In addition, the proportion of fatalities involving farmers in the age range of 65 years and older seemed to be consistently around 30% (Purschwitz and Ellis, n.d.; Aherin and Petrea, n.d., Voaklander et al, 1999; Gorucu et al, 2017; Cheng and Field, 2018). The literature showed that the issue of a large number of reported fatalities occurring to older farmers was not new(Field and Bailey, 1976). In addition, the literature also showed that tractors were the most likely cause of injury for older farmers, with a majority of the incidents resulting from overturns (Field and Bailey, 1976; Gorucu et al, 2017; Cheng and Field, 2018; Aherin and Petrea, n.d.; Purschwitz and Ellis, n.d.). The number of fatalities per state were not consistent with some states showing a historically decreasing frequency, such as Ohio, while others, such as Indiana, showed

some increases in recent years (Cheng and Field, 2018; OSU Agricultural Safety and Health Program, n.d.).

2.6 Injury risks associated with professional logging vs. occasional wood cutting farmer

Even though there have been a large number of studies that have looked into the safety and injury risks of tractor and machinery usage with farmers, including older farmers, little research has been conducted into the associated risks of farm-related harvesting of timber, trimming and cutting trees, and harvesting other forest materials by farm operators and workers. Considering that the logging profession has had one of the highest reported fatal work injury rates, including 135.9 per 100,000 full-time equivalent workers in the U.S in 2016, the absence of this research was unexpected (CFOI, 2018).

West, Shkrum, and Young (1996) explored fatalities associated with commercial logging in Ontario, Canada. The authors used data from the Chief Coroner's Office of Ontario to find 52 fatalities of commercial loggers over the period of 1986 to 1991. The age of the victims ranged from 20-72 years old with a mean age of 44 years old. The age group with the highest fatalities was 50-59 at 17 deaths and the 2nd highest was a tie between 30-39 years and 40-49 years with 10 deaths. Eight of the deaths (15%) were the result of natural causes, all cardiac diseases, and the remaining 44 deaths (85%) were work-related. The most common cause of injuries for the work-related fatalities was due to falling of dead standing trees (chicots) and felled trees suspended by branches (hang-ups). Many of these fatalities also included machinery, with 36 (82%) of work-related deaths associated with fellers and skidder operations.

A study by Browning et al (1998) surveyed farmers over the age of 55 in Kentucky to identify the agricultural injuries sustained. A one-year sample of 998 farmers over the age of 55 was interviewed using a telephone survey method that asked about injuries. The leading causes of farm injuries involved falls at 24.9%, machinery at 22.5%, wood-cutting at 14.6%, and animal related events at 14.3%. The two types of injuries most commonly identified from woodcutting incidents were either injuries resulting from splitting wood with an axe, or fractures and cuts from falling trees or branches

A study by Scott (2004) explored the fatalities of commercial loggers over the period of 1992 to 2000 in the United States. Data were collected from the Bureau of Labor Statistics CFOI database. A total of 780 fatalities occurred, with Figure 5 showing the number of fatalities per

year. The logger mortality rate started with a slow decline from 1992 to 1995, but it increased during 1996-2000. The top five common causes of injuries were: 1) treefall/cutting with 285 deaths (36.5%), 2) treefall/unknown with 189 deaths (24.2%), 3) rollover/skidding with 56 deaths (7.2%), 4) limb fall/cutting with 46 deaths (5.9%), and 5) limb fall/unknown with 37 deaths (4.7%). The sum of the three treefall categories accounted for 62.8% of all logger fatalities. The authors found that the number of fatalities had decreased, due to a great increase in mechanical harvesting with feller-bunchers replacing on the ground fellers and buckers, compared to a past study of logger fatalities by Myers and Fosbroke (1994) over the period of 1980-1988.

Table 2 Logger mortality rate (LMR; per 1000)

Year	No of loggers	Logger fatalities	LMR	95% Confidence interval
1992	79000	97	1.2	1.0 to 1.5
1993	94000	93	1.0	0.8 to 1.2
1994	86000	89	1.0	0.8 to 1.3
1995	97000	85	0.9	0.7 to 1.1
1996	75000	95	1.3	1.0 to 1.5
1997	79000	96	1.2	1.0 to 1.5
1998	60000	69	1.2	0.9 to 1.5
1999	66000	80	1.2	1.0 to 1.5
2000	66000	76	1.2	0.9 to 1.4

Numerator: Bureau of Labor Statistics CFOI 1992–2000 data set; denominator: Bureau of Labor Statistics Current Population Survey.[18]

Figure 5. U.S. logger mortality rate per year per 1000 – 1992-2000 (Scott, 2004)

A study by Fischer et al (2005) looked at the injury of occasional wood cutters in comparison to professional loggers. The data were collected for 90 individuals from 14 emergency and urgent care departments in Wisconsin and by conducting a follow up telephone survey to get information on the injury with 71 participants. The occasional workers were injured more than three times in comparison to professional loggers (54 to 17). The majority of occasional woodcutters (36%) were clearing trees from their property when injured, with the second highest being cutting firewood (32%). The type of injuries sustained included being hit, machine injuries, falls, or cuts with lacerations being the most common injury at 57.4%. The head and upper extremities were the most common body part injured with 33.3% and 37%, respectively. The authors also found that 38% of the participants were alone at the time of sustaining an injury. The occasional woodcutters in the 50-85 year group often claimed that the injury sustained was unavoidable and more injuries

were caused by being struck by objects (78%), instead of machinery use (22%) (Fischer et al, 2005). This was inconsistent with the younger group of 13-49 years old who had a larger percentage of machinery injuries (59%) versus falling objects (41%). Limitations of the study include case reporting being voluntary and incomplete, and working with a small number of emergency rooms.

A study by Lindroos et al (2008) looked at incidents that occurred during firewood production with family operations in the Umea region of Sweden. Data were collected from the Umea Accident Analysis Group at the University Hospital, with 1,466 injuries from 1996 to 2001, and from a questionnaire sent out asking about injuries relating to firewood production. The mean age of injured person was 52.8 years and the age group with most reported injuries was 50-59 years old, with the 60-69 years old age group second. The most common injury during firewood production was crushing during wedge splitting (34.5%), increasing to 53.5% when coupled with cut by blade or chain. The limitations of the study were an unwillingness to respond, memory, and misunderstandings of questions.

A report by the Centers for Disease Control and Prevention (2008) reviewed cases of non-occupational logging fatalities in Vermont over an 11-year period from 1997 to 2007. The data were collected by looking at medical examiner data. The report shows that there were 18 fatalities from non-occupational woodcutting activities, with tree felling being the cause of 15 fatalities. Three of the factors associated with these fatalities were lack of personal protective equipment (PPE), unsure of where the tree would land, and being alone. The median age was 58 with a range of 19 to 83 years. The report recommended that there should be an increase in promoting safe tree-felling practices and an increase in PPE usage.

A Swedish study by Lindroos and Burström (2010) explored the injury rates and causes for private forest owners from 1996 to 2001. Data were collected from three sources, the Swedish Work Environment Authority, Labor Insurance Organization, and the University Hospital in Umea. They found that over the six-year period there were 507, 193, and 225 incidents from the three sources, respectively. Twenty-nine of the incidents reported by the authorities and 4 of the incidents reported by insurance were fatalities. No fatalities were included with the hospital data. The most common ages for injuries relating to woodlots were people in the 40-49 and 50-59 year old age range (Figure 6). Fatalities ranged between 37 and 78 years old. The equipment that was most commonly associated with the insurance and hospital data, respectively, were chainsaws

(16% and 29%), firewood splitters or cutters (4% and 32%), and tractors or other vehicles (16% and 9%). The most common cause of the injuries was falls, being hit by the tree, or being hit by moving machinery. The majority of the fatalities were caused by falling trees, with 59% represented by the Swedish Work Environment Authority data and 75% of the insurance data. Limitations of the study include lack of a clear definition of self-employed work in forests and potential discrepancies between the data sources.

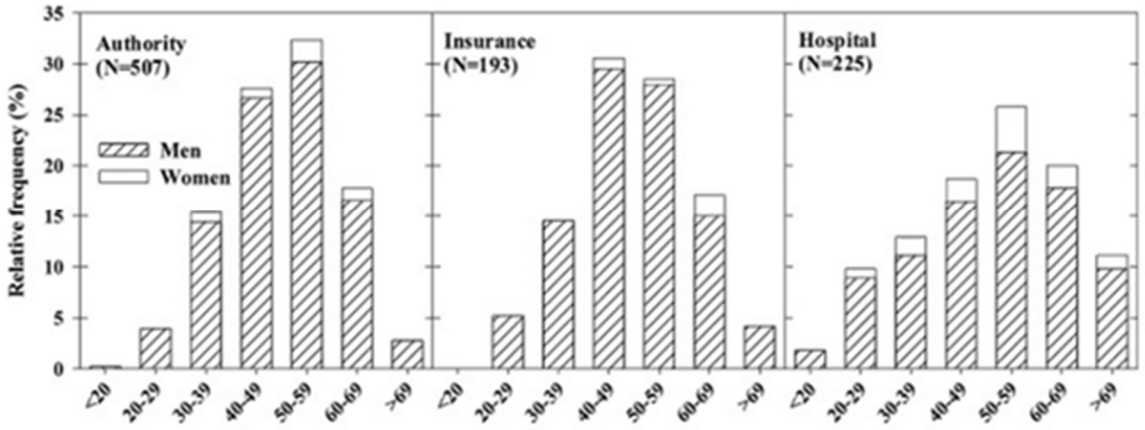

Figure 6. Age ranges of Swedish forest owners injuries per data source (Lindroos and Burström, 2010)

Hammig and Jones (2015) conducted a study of chainsaw-related injuries in the United States. Data of chainsaw injuries from the National Electronic Injury Surveillance System (NEISS) was analyzed during the time period of 2009 to 2013. There were 115,895 injuries related to chainsaws reported during the time period, with an annual frequency of 23,179 injuries. No fatalities were reported. The top three number of hospital visits by age groups were people 50-59 years old (4,558 or 18.8%), second was 60-69 years old (3.227 or 13.9%), and third was 70+ years old (1,526 or 6.6%). The most common diagnosis of the hospital visits were lacerations with 81% of cases. The location of the injuries was most commonly found on the lower half of the person's bodies, with 70% of the injuries occurred on four parts of the body: hand/fingers, knees, lower leg or ankle, and upper leg. Limitations noted include difficulties with recording fatality data because it was entered in as either death on arrival to the emergency department or death in the emergency department, and that it is hard to ensure that the lacerations were caused by chainsaws from just narrative text entries.

Another safety aspect of older farmers working in woodlot activities is the usage of machinery. Professional logging operations use machinery that is specifically designed for work in woods, but it is expensive and not commonly used by farmers. Instead they may use machines that are designed for agricultural production, such as farm tractors. Farm tractors are, generally, not recommended for use in wooded areas due to a lack of traction, too large or tall to fit in between trees and under tree cover, and a lack of protection for the driver from falling trees and limbs or branches with a falling object protective structure (FOPS) (Murphy, Stover, and Harshman, 2014).

A study by Degroot et al (2011) looked at farm-related fatalities that involved rollover of machinery with Canadian agriculture using data from the Canadian Agricultural Injury Surveillance Program (CAISP). They found that the highest number of backward rollovers occurred during forestry related activities with 39 fatalities (36.4%), and second was tied between field work and towing (extraction) (21.5%). The factors of dragging logs/implements and pulling stumps were the third most common causes of fatalities at 19 (17.7%) and 14 (13%), respectively. Limitations included lack of fatality data in Quebec during 2004-2005, and lack of information collected on individual fatalities.

Professional logging is known to be a dangerous profession, especially with older loggers (West, Shkrum, and Young, 1996; Scott, 2004; CFOI, 2008). This trend is similar with occasional wood cutters who experienced a higher number of injuries or death with age (Fischer et al, 2005; Lindroos et al, 2008; Lindroos and Burstrom, 2010; Hammig and Jones, 2015). The most common age range for injuries was reported in the 50-59 years old with either 40-49 or 60-69 reported as the second most common (West, Shkrum, and Young, 1996; Lindroos et al, 2008; Lindroos and Burström, 2010; Hammig and Jones, 2015). The most common agent of injury was not consistent between studies, with some reporting that cuts and injuries from wedges and others identifying being struck by falling trees and branches (Browning et al, 1998; CDC; 2008). Multiple studies found that performing wood cutting and trimming activities alone increased the risk of being injured (Fischer et al, 2005; CDC, 2008). It was not commonly referred to in the literature, but Degroot et al (2011) suggested that machinery, such as tractors, used during woodcutting for occasional woodcutters was an area of concern. In addition, chainsaws were not commonly reported to be the cause of fatalities but for non-fatal injuries (Browning et al, 1998; Fischer et al, 2005; Lindroos et al, 2008; CDC, 2008; Lindroos and Burström, 2010; Hammig and Jones, 2015).

CHAPER 3. SUMMARY OF INDIANA FARM FATALITIES INVOLVING INDIVIDUALS 55 YEARS AND OLDER - 1988-2017

This chapter was published as an article in *Safety*.

Tormoehlen, S. A., & Field, W. E. (2019). Summary of Indiana Farm Fatalities Involving Individuals 55 Years and Older—1988–2017. *Safety*, 5(2), 39.

3.1 Abstract

Agriculture has historically been one of the most hazardous of all occupations, with a variety of potential safety risks to workers and even higher risks documented for older agricultural workers. This study was undertaken to document and summarize Indiana farm work-related fatalities involving persons 55 years and older over the 30 year period from 1988 to 2017. Data were mined from the Purdue University Agricultural Safety and Health Program's Fatality Database that dates back to the 1960s. A total of 388 fatalities involving persons 55 years and older was documented. The average age of the victims was 69.3 years old, and an overwhelming majority of the cases involved males (96.1%). The average number of deaths per year has remained fairly consistent, though it has occasionally been erratic, with an unanticipated increase in the number of documented fatalities over the period 2012–2017. There appeared to be a direct positive correlation between the level or intensity of agricultural production in a county and the frequency of fatalities. The type of fatal injury most commonly reported was crush/run-over, with 229 cases (59%). The most common agent or source of injury involved was tractors, with 157 cases (40.5%). Another noted contributing factor was the high frequency of incidents in which the victim was reported to be working alone at the time of death. Findings will be used to develop evidence-based injury prevention strategies, including the development of agricultural safety training materials and methods more relevant to older farmers. A special emphasis should be placed on reducing the risk of tractor and farm machinery overturns, especially when older, non-roll over protection structure (ROPS) equipped tractors are being operated.

3.2 Introduction

The purpose of this summary was to identify the primary contributing factors of Indiana farm work-related fatalities involving agricultural producers 55 years of age and older. It was anticipated that findings would provide a detailed look at documented characteristics and trends of fatalities over the 30 year period from 1988 to 2017, with an analysis of selected causative factors. The research was undertaken in response to the recent upward trend in the number of annual fatalities documented within this age group.

3.2.1 Review of Literature

The average age of U.S. farm operators has been on the rise for the past 30 years, with the average going from 50.5 in 1982, to 58.3 in 2012, and to 59.4 in 2017 (USDA-NASS, 1984; USDA-NASS, 2014; USDA-NASS, 2019). The three highest age categories for principal operator—55 to 64 years old, 65 to 74 years old, and 75 years and older—showed an increase of 1.9%, 7.6%, and 5.8% from 2007 to 2012 and 28.8%, 45.0%, and 35.1% from 2012 to 2017, respectively (USDA-NASS, 1984; USDA-NASS, 2009; USDA-NASS, 2014).

Farming is well documented as a dangerous profession for all ages. The Census of Fatal Occupational Injuries (CFOI) reported in 2016 that farmers, ranchers, and other agricultural managers of all ages had a fatal injury rate of 23.1 per 100,000 full-time equivalent workers, as compared to the all-worker fatal injury rate of 3.5 (CFOI, 2018). The injury rate has been reported to be even higher for older farmers, with a fatality rate of 45.8/100,000 reported for farmers 55 years and older between 1992 and 2004 (Myers, Layne and Marsh, 2009).

The increased risk of injury due to aging has been well documented. All of the senses and functions of the body go through changes with age. Mobility issues, such as those caused by arthritis, increase the risk of injury with age (Davis and Kotowkis, 2007, Lawrence et al, 2008). The risk of eye injuries and diseases that impair vision increases with age (Iftikhar et al, 2019). Age-related hearing impairments are common and are considered the second most common handicapping condition in the United States (Huang and Tang, 2010). Cognitive changes also take place, with reaction times slowed in comparison to younger adults (Rogers et al, 2005).

Older farmers, however, have generally been shown to have a lower risk of obtaining a non-fatal injury as compared to younger farmers (Salminen, 2004; Marcum et al, 2011; Heaton et al, 2012).

In a study of farmers 50 years and older, Marcum et al. (2011) found that an incremental increase of 10 years for a farmer reduced their non-fatal injury risk by 15%. Salminen (2004) conducted a literature review that looked at the risk of occupational injuries for younger workers across industries, including agriculture. He found that older farmers who had sustained injuries were more likely to die from their injuries.

Summaries of farm-related occupational fatalities have often reported large representations of older farmers (Voaklander et al, 1999; Mitchell et al, 2002; Myers, Layne, and Marsh, 2009; Great Plains Center for Agricultural Health, 2015; Gorucu, Harshman, and Murphy, 2017; Cheng and Field, 2018). Voaklander et al. (1999), for example, found that 36.5% of all farm fatalities during 1991–1995 in Canada were 60 years or older and that the fatality rate per 100,000 increased with age. Gorucu et al. (2017) found that 34% of Pennsylvania farm fatality cases from 2010 to 2014 consisted of farmers 65 years and older, even though this age group only accounted for 22.6% of the farm household populations. Another study by Cheng and Field (2018) found that about half of the fatality cases in Indiana since 2012 have been farmers 60 years or older.

It has also been reported that common aging related changes in the body, such as arthritis, hearing and vision impairment, and mobility or medication usage, could increase the risk of sustaining specific types of farm-related work injuries (Voaklander et al, 2006; Marcum et al, 2011; Heaton et al, 2012; Geng, Stuthridge, and Field, 2013). In the study of how arthritis, mobility, and farm tasks affected injuries among older farmers, Heaton et al. (2012) found that farmers with mobility issues were twice as likely to be injured by a farm-related task.

Even considering the higher risk of potential injuries, there seems to be limited attention given to agricultural safety material that is designed and oriented for older farmers. An example would be tree cutting and chainsaw safety materials developed and disseminated by organizations such as extension programs. The majority of the publications reviewed did not mention any potential issues to worker safety due to age-related changes in the body or other challenges more specific for the older farmer population involved in chainsaw operations (Walters, 1979; Baker and Cutter, 1996; Baker and Cutter, 2011; New York Department of Health, 2012; Bauske, Hutcheson, and Orellana, 2018). A review of the images contained in these publications and related audio–visual material found that most depicted younger workers.

Nationally, the documentation of farm-related fatalities, has, in general, also been problematic for several reasons including: The lack of federal or state reporting requirements for farms with

less than 11 hired workers; the lack of a central site for documenting and storing farm fatality data; and the nature of current reporting protocols that may not document a fatality when the injuries to the victim resulted in death sometime after the injury occurred (OSHA, 1989; Nour et al, 2019). This lack in reporting requirements and inadequacies in the classification process contributes to the historical failure of the Bureau of Labor Statistics' (BLS) records of national farming fatalities to include fatalities that occur on smaller farms relying primarily on family labor or with few employees (Murphy, 1992). The BLS data were also known to combine their data of farming fatalities with fatalities that may not be occupational-related, such as operating all-terrain vehicles (ATVs) on farm land, or unrelated occupations, such as fishing, forestry, and hunting (Cheng and Field, 2018). Another source of federal fatality data was CFOI, which gathers descriptive data and counts of fatalities nationally (Runyan, 1993). A concern regarding the completeness of farm fatalities reported through the CFOI is that the individual was required to have been employed at the time of the incident, generally excluding children and unpaid family labor, such as retired family workers (Swanton, Young, and Peek-Asa, 2016). Historically, the CFOI has significantly under reported Indiana farm-related fatalities.

3.3 Methods

The data used were drawn from the Purdue University Farm Fatality Database and previously published in annual summaries by the Purdue Agricultural Safety and Health program (PUASHP). A total of 1,452 reported farm work-related fatalities have been recorded by PUASHP in Indiana since 1970. A variety of sources have been used to document these incidents, including death certificates, news clippings, web searches, obituaries, and post-incident interviews with family members, extension educators, first responders, expert witnesses in litigation, and others associated with the incidents. The general information included the date, county, age, sex, type of incident, and a short narrative of the incident. For this study, only data of confirmed fatalities of farmers 55 years and older that occurred during the period from 1988 to 2017 were extracted for review. The definition of an older worker used, as being workers over the age of 55, was taken from current published studies, including the National Institute for Occupational Safety and Health (NIOSH), that found that farm workers, aged 55 years and older, were at higher risk of injury and death (Myers, Layne, and Marsh, 2009). No follow-up investigations of individual cases were conducted by the authors other than the review of summarized sources.

The coding sheet used for classifying the data was adapted from previously published coding sheets and the Farm and Agricultural Injury Code (FAIC) (Purschwitz, 1989; Purschwitz and Field, 1989; American Society of Agricultural and Biological Engineering, 2007; Nour et al, 2019). The coding sheet helped to categorize the fatality cases to allow for summarization by reported type of fatal injury and the contributing agents. FAIC codes were not used due to a lack of sufficient data for the majority of reported cases (American Society of Agricultural and Biological Engineering, 2007).

3.3.1 Limitations

The primary limitation of the summary relates to the comprehensiveness of the data due to the data collection and documentation methods. As noted, since there is no official centralized site where these data are gathered, PUASHP used a variety of sources to identify cases and related information. For more recent years, the data were compared with the Indiana Department of Labor's annual summary of work-related fatalities to identify any differences. These differences were generally due to the different criteria used by the U.S. Department of Labor to fulfill federal reporting requirements, such as excluding children under 16 who are often not identified as being involved in work-related activities. The use of on-line reports or media "clippings" can also be problematic, since these reports are not always reliable due to the abilities of the individual doing the reporting (Murphy, 1992; Cheng and Field, 2018; Nour et al, 2019). Though the data are not recognized as comprehensive, they remain the best possible representation of Indiana farm-related fatalities.

The introduction of the internet in recent years has increased access to information on fatality cases. This new flow of data, however, may distort the overall data set because it may mean that the increase in number of recent cases may be due to better reporting versus an actual increase in fatality cases as compared to past years. These additional cases during the latter part of the period studied could affect any projected trends. Online sources also appear to increase the risk of multiple reporting of the same incidents, with widely differing accounts that suggest multiple incidents when, in fact, all were reporting on the same incident (Murphy, 1992; Nour et al, 2019).

3.4 Results

The total number of fatalities documented and used in this summary for the 30 year period was 388, making up 43.8% of all reported cases over the time period.

3.4.1 Age

The average age of the 388 older farmers was 69.3, while the average age of all documented fatalities during the same period was 49.0 years old. The average age of current farm owner/operators in Indiana is 57.4 years old (USDA-NASS, 2019). The oldest victim reported was 93 years old.

The number of fatalities decreased rapidly with age, as seen in Figure 7. There were peaks at 69, 72, and 75, which offset the downward trend. When the ages were put into 10-year groups of 55–64 years, 65–74 years, and 75 years and older, as seen in Table 1, there was a fairly similar age distribution. The high percentage of victims over the age of 75 was not anticipated

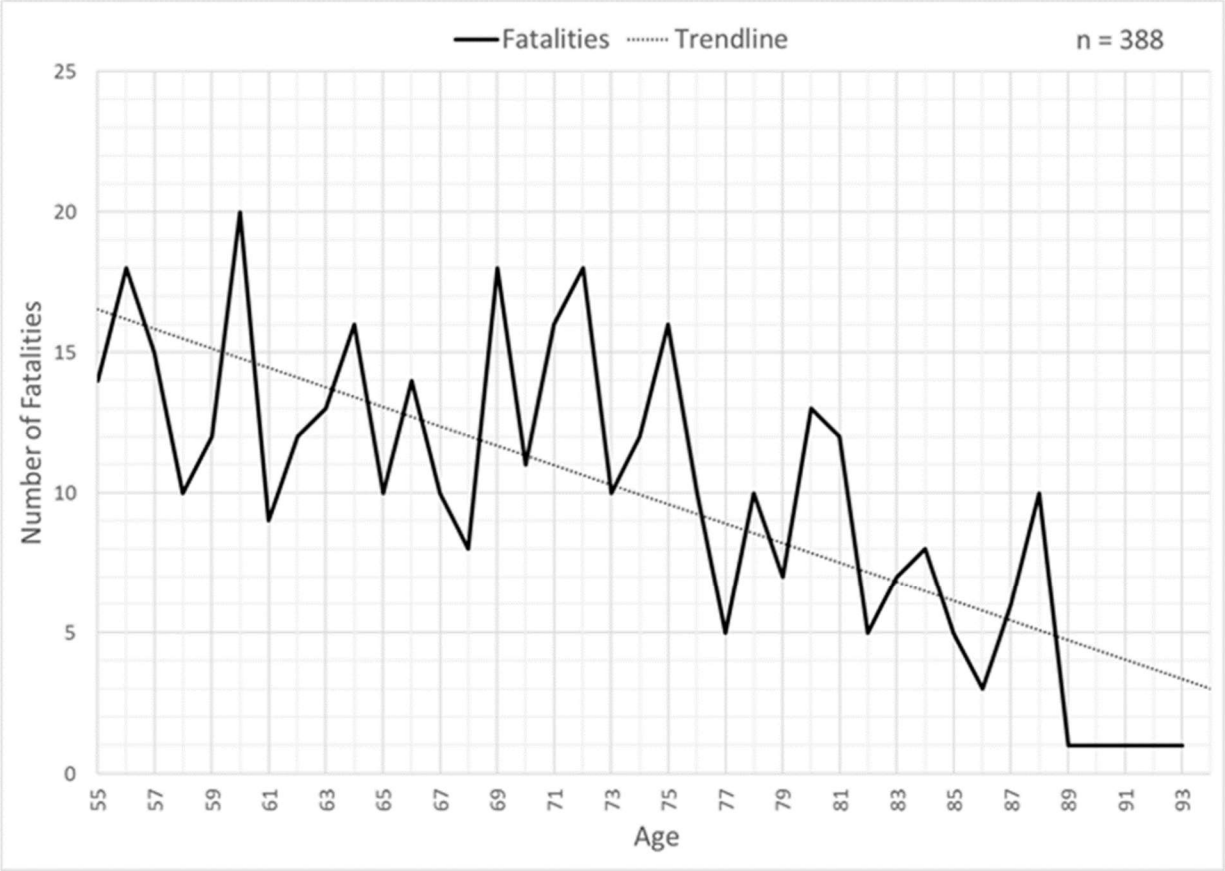

Figure 7. Age distribution of Indiana farm-related fatalities for age 55 to 93, 1988-2017

Table 1. Ages of occupational Indiana farm fatalities by group

Category	Frequency	Percent
55 to 64 years old	139	35.8%
65 to 74 years old	127	32.7%
75 years and older	122	31.5%
Total	388	-

3.4.2 Year

The distribution of fatalities per year is shown in Figure 8. The data shows variation over the 30 year period with a positive trend that is statistically significant over time for farmers 55 years and older, which is inconsistent with the negative trend for farm fatalities for Indiana farmers of all ages. The years with the highest number of fatalities were 2016 with 24, 2017 with 23, and a tie between 2015 and 1994 with 21 each. The years with the lowest number of fatalities were 2006

with four, 1993 with six, and a tie between 2005 and 1990 with seven each. The past five years, 2012 to 2017, have shown a strong positive trend, with some of the highest number of fatalities in 30 years.

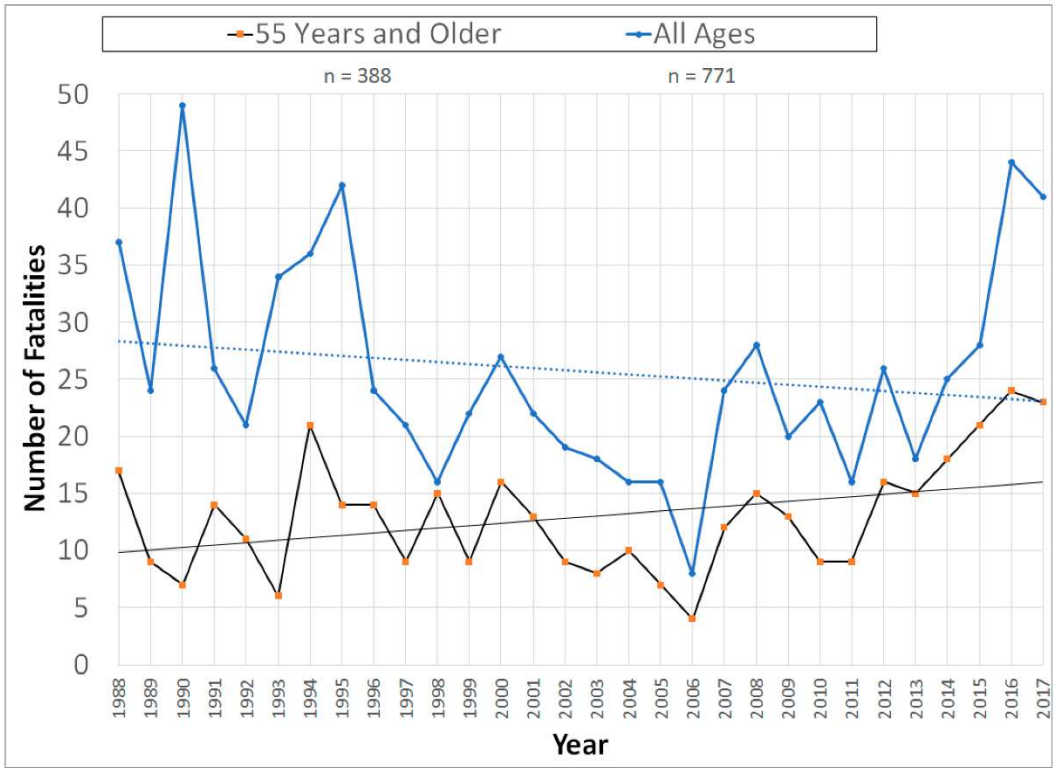

Figure 8. Number of Indiana farm-related fatalities per year

3.4.3 Month

The distribution of fatalities per month, when known, as seen in Figure 9, showed a bimodal pattern. The two highest peaks were May with 59 fatalities (15.2%) and September with 53 fatalities (13.7%) reflecting the two periods of the year with the most intense agricultural production activities. The month with the lowest number of reported cases was March with 10 cases (2.6%), and the second lowest was February with 11 cases (2.8%). This monthly distribution also confirms other studies, indicating a distribution based upon seasonal work (Wilkinson and Field, 1990; McCurdy and Carroll, 2000; Gorucu, Harshman, and Murphy, 2017).

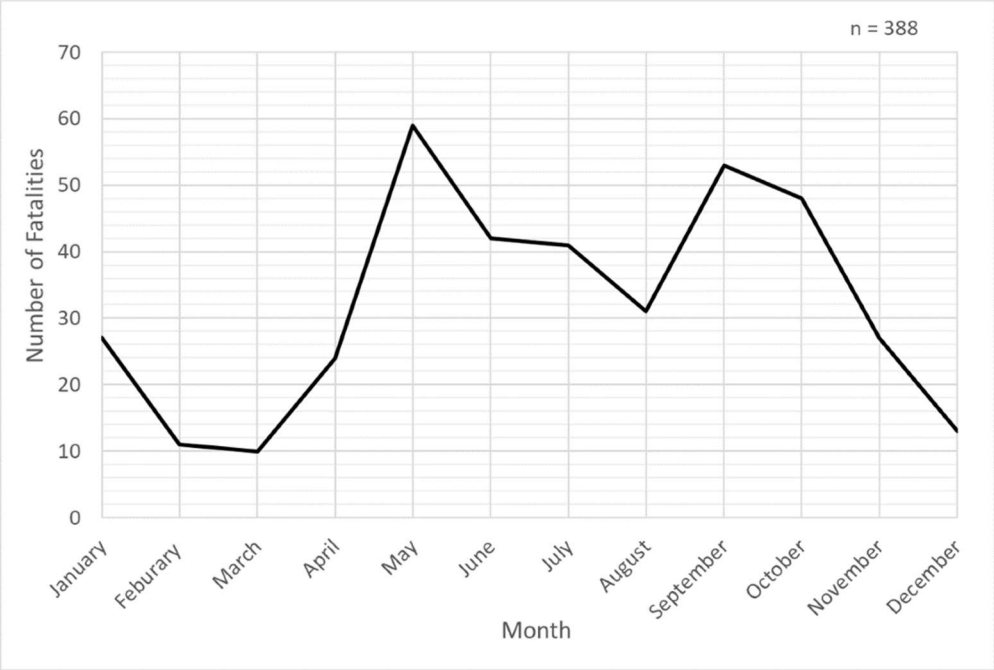

Figure 9. Number of Indiana farm-related fatalities per month (1988-2017)

3.4.4 Gender

Of the 388 documented fatalities, 373 (96.1%) were males, and 15 (3.9%) were females in the same age range. Due to the recent upward trend in the number of female farmer fatalities, the data were analyzed to see if there were any trends for older female agriculture workers. The dataset is small, with only 15 deaths over the 30 year period, so it was not possible to accurately infer trends, but the trend line from the available data shows that the number of female fatalities has been steady over the 30 year period. The number of female deaths per year (Figure 10) shows an increase of deaths during 2016 and 2017 (Cheng and Field, 2018). The small increase in the number of female fatalities in recent years may be due to an increase in number of principal female farmers, increasing 235% from 2002 to 2017 (USDA-NASS, 2014; USDA-NASS, 2019). However, the frequency of older females in fatal farm work incidents has historically been minimal and remains so.

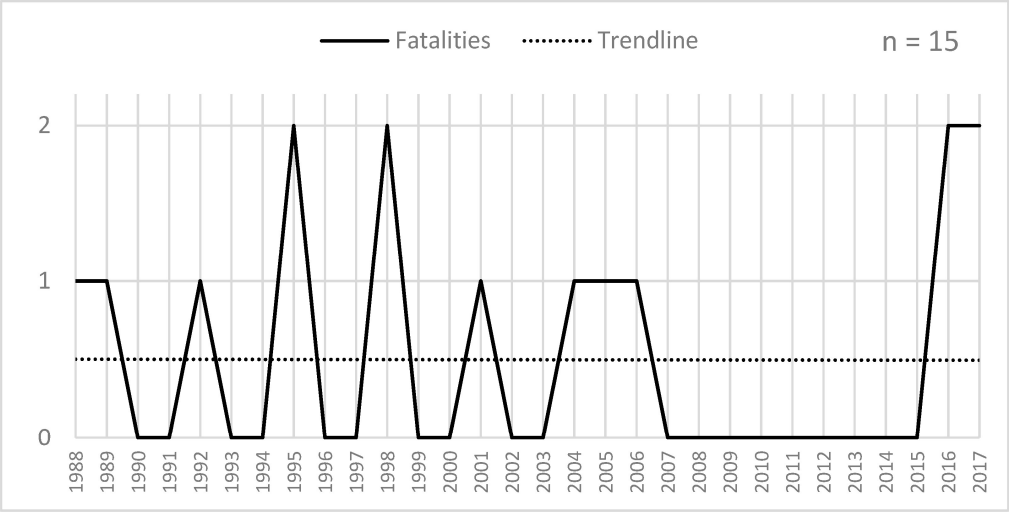

Figure 10. Female Indiana farm-related fatalities per year

The types of fatalities that affected older females are shown in Table 2. The most common type of fatality was roadway related, with almost half of the 15 cases (46.7%). Tractors, including tractor rollovers, were the third highest with three cases (20%). Fourteen of the 15 documented fatalities involved the operation of or exposure to farm machinery and tractors.

Table 2. Reported agent of fatal injury of Indiana female cases

Category	Frequency	Percent
Roadway	7	46.7
Farm Machinery-related	4	26.7
Tractors	3	20.0
Smothering and Asphyxiation	1	6.6
Total	15	-

3.4.5 County

Fatalities were identified in almost all of Indiana's 92 counties during the 30 year period. Only Scott, Union, Vermillion, and Warrick counties did not experience a documented farm fatality over the age of 55. The top five counties with the highest number of fatalities were Allen with 10 (2.6%); Harrison with 9 (2.3%); Lawrence with 9 (2.3%); Dubois with 8 (2.1%); and Morgan with 8 (2.1%).

Allen County has a large number of Amish/Old Order farm families, with the 10th largest Amish community in the United States as of 2017 (Young Center for Anabaptist and Pietist Studies, 2018). Historically Amish/Old Order communities have represented a disproportionate

share of farm-related deaths in Indiana (Cheng and Field, 2018). There are 24 other counties with a high density of Amish/Old Order members, such as LaGrange and Elkhart, but these counties did not represent a disproportionate number of older fatalities (Manns, 2012). Due to the tendency for Amish/Old Order farmers to retire from many more hazardous farm work activities at an earlier age due to their large families, the risk to older Amish/Old Order farmers may be less than anticipated (Hostetler, 1993). In addition, the intensity of agriculture is an important part of the economy of those counties reporting high numbers of farm fatalities, including Allen County, which had the state's third highest total gross domestic agricultural product impact and the top producer of soybeans in the state for 2012 (Kinghorn and Ortuzer, 2015). The county is home to 1,725 farms, ranking second in the state (USDA-NASS, 2018). The population of the county was 372,877 in 2017, reflecting a high mix between urban and agricultural use of land increasing the risk of roadway crashes involving farm equipment (U.S. Census Bureau, 2018).

The other four counties, although not as highly ranked in the number of fatalities, have strong agricultural-based economies. An example of this would be the strong animal production that takes place in Lawrence County, a leading producer of beef cattle, and Dubois County, first in value of sales for turkeys for 2017–2018 (USDA-NASS, 2018). There does appear to be a positive correlation between the level of agricultural production, especially livestock production, and the larger number of farm fatalities involving older farmers.

The distribution of fatal cases of farmers 55 years and older by county is shown in Figure 11, with each heart representing a farm work fatality that occurred during the period of 1988 to 2017. A geographic distribution of all documented Indiana farm fatalities from 1980 to 2017 can be found in a study by Cheng and Field (2018). The geographic distribution of incidents was divided in half between the northern and southern parts of the state, with the dividing line running along U.S. 40. The two regions were then compared, since the southern portion tends to have rougher terrain, greater proportions of timber land, and older and smaller farms due to the state being settled from the south to the north, which can be seen in Figure 12. The northern part of the state had 181 fatalities, and the southern portion had 160 fatalities, indicating no significant difference.

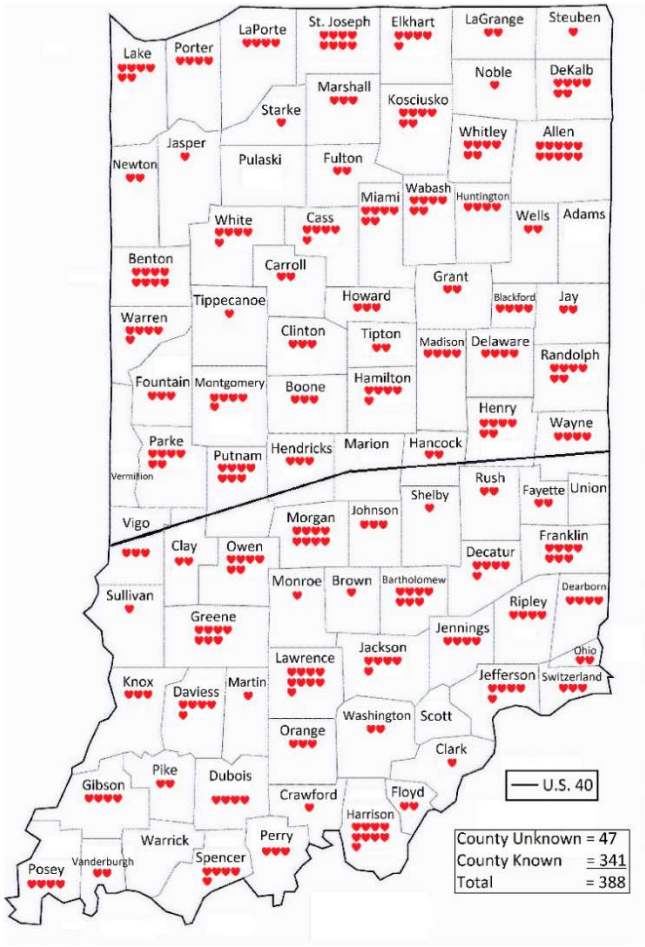

Figure 11. Distribution of Indiana farm-related fatalities per county

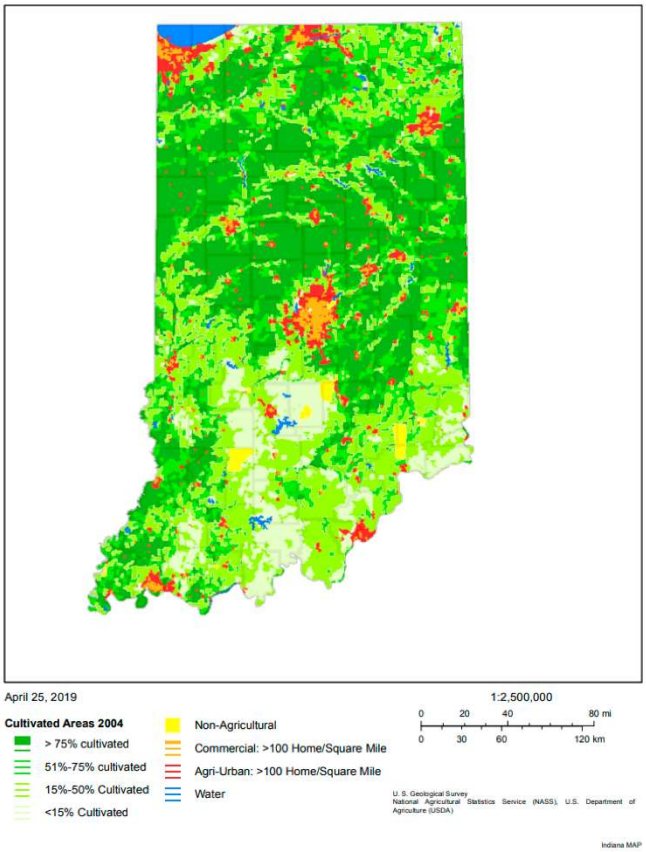

Figure 12. Map of Indiana's Agriculture Cultivated Areas during 2004 (Indiana Geological Survey)

3.4.6 Reported Type of Fatal Injury

In the majority of cases, no official or medically determined cause of death was available. The reported, generally unofficial, types of fatal injuries were divided into ten categories based upon the terminology used in the reporting source. The distribution by type is shown in Table 3. The most common fatalities by far were caused by crushing/run-over injuries, accounting for over half of all cases (59%). The unknown category was high because some documented cases only reported the fatality but did not include any background information on type of injury, cause of death, or other causative factors.

Table 3. Reported type of agricultural fatal injuries in Indiana

Category	Frequency	Percentage
Crushed/Runover	229	59
Trauma from impact	61	15.7
Asphyxiation	15	3.9
Entanglement/Caught in machinery	13	3.4
Burns	12	3.1
Head injury	9	2.3
Other	9	2.3
Drowning	5	1.3
Chemical exposure	2	.5
Unknown	33	8.5
Total	388	-

There was no attempt to pursue additional information on the reported cause of death, and access to official death certificates was limited to only the first decade of the study period. The "other" categories included: A work-related heart attack, fatal electrocutions, an unintentional on-farm shooting, strikes by lightning, heat, and bleeding out (with cause not identified).

3.4.7 Type of Contributing Agent

The contributing agents involved were divided into ten different categories: Tractors, farm machinery-related, roadway, smothering and asphyxiation, falls, cutting and trimming trees, fires/burns/explosions, livestock, other, and unknown. Table 4 provides a distribution of the categories of agents when known. The most common agent involved, by far, was tractors, with 157 incidents (40.5%); farm machinery-related was the second highest, with 87 incidents (22.4%). Case information did not provide sufficient information to determine whether or not tractors involved were equipped with roll over protection structure (ROPS) or that the ROPS were in use at the time of incident. The five incidents in the other category included two cases of round bales rolling onto the victim, an unintentional shooting, a heart attack while attempting to remove a dead pig, and collapsing due to unknown issues, such as heat stress or a heart condition.

Table 4. Type of contributing agent to Indiana farmers 55 years and above

Category	Frequency	Percentage
Tractors	157	40.5
Farm Machinery-related	87	22.4
Roadway	31	8.0
Cutting and Trimming Trees	27	7.0
Smothering and Asphyxiation	20	5.2
Falls	18	4.6
Livestock	17	4.4
Fires, Burns, and Explosions	16	4.1
Unknown	9	2.3
Other	6	1.5
Total	388	-

Incidents were broken down further to better understand the primary causes of tractor-related fatalities, as seen in Table 5. The most common incident type largely involved tractor rollovers, with 86 cases (54.8%), or 22.1% of all documented incidents. The second most common incident type was tractor runovers, with 33 cases (21.0%), or 8.5% of all cases. The third most common was pinned against, between, or underneath a tractor, with 18 cases (11.5%), or 4.6% of all cases.

Table 5. Indiana fatal tractor-related incidents

Category	Frequency	Percentage	Percentage of all cases
Tractor rollover	86	54.8	22.1
Tractor runover	33	21.0	8.5
Pinned against, between, or underneath the tractor	18	11.5	4.6
Fall from a tractor	17	10.8	4.4
Unspecified tractor incident	3	1.9	0.8
Total	157	-	40.5

The next breakdown made was the machinery-related incidents, as shown in Table 6. The most common incident type was “pinned against, between, or underneath an object or equipment,” with 27 cases (31.0%). The second most common was “equipment rollover,” with 16 cases (18.4%), and the third most common was “equipment runover,” with 14 cases (16.1%).

Table 6. Indiana fatal machinery-related incidents

Category	Frequency	Percentage	Percentage of all cases
Pinned against, between, or underneath an object or equipment	27	31.0	6.9
Equipment rollover	16	18.4	4.1
Equipment runover	14	16.1	3.6
Entanglement in PTO driveline	9	10.4	2.3
Struck by flying, falling, or thrown material	8	9.2	2.1
Fall from equipment	4	4.6	1.0
Entanglement in other, non PTO components	4	4.6	1.0
ATV incident during farm-related work	4	4.6	1.0
Equipment incident, unspecified	1	1.1	0.3
Total	87	-	22.4

The breakdown of roadway incidents is shown in Table 7. The most common fatality type was "roadway collisions involving farm tractors or equipment," with 21 cases (67.7%), and the second highest was "farm truck incident during farm work," with six cases (19.4%). Based upon Indiana fatal motor vehicle crash data, the number of farmers involved in fatal work-related crashes, especially those involving farm trucks, is most likely under reported (IIHS-HLDI, 2018).

Table 7. Indiana fatal roadway incidents

Category	Frequency	Percentage	Percentage of all cases
Roadway collision involving farm tractor or equipment	21	67.7	5.4
Farm truck incident during farm work	6	19.4	1.5
Roadway collision at railroad crossing	2	6.5	0.5
Roadway incident, unspecified	2	6.5	0.5
Total	31	-	8.0

The breakdown of incidents involving cutting and trimming trees is shown in Table 8. All of the cases fell under the category of struck by a tree or tree limb (27 cases), or 6.9% of all cases. No fatality cases were reported relating to injuries sustained during the operation of chainsaws.

Table 8. Indiana fatal cutting and trimming tree incidents

Category	Frequency	Percentage	Percentage of all cases
Struck by a tree or tree limb	27	100	7.0
Chainsaw	0	0	0
Total	27	-	7.0

The smothering and asphyxiation categories of fatality cases are shown in Table 9. The most common type of incidents was "entrapped and suffocated by grain, feed, or other loose material," with 13 cases (65.0%). The second most common type was "drowning in pond, lagoon, or stream," with five cases (25.0%). In some cases, it appears that the drownings were associated with being trapped beneath an overturned tractor or mowing equipment.

Table 9. Indiana fatal smothering and asphyxiation incidents

Category	Frequency	Percentage	Percentage of all cases
Entrapped and suffocated by grain, feed, or other loose material	13	65.0	3.4
Drowning in pond, lagoon, or stream	5	25	1.3
Asphyxiation or poisoning from gases	2	10	0.5
Total	20	-	5.2

The breakdown of the category of falls is shown in Table 10. The most common cases were "falls from farm structures," with nine cases (50.0%), and the second were "fall from ladder," with five cases (27.8%). Data on falls that occurred in the home, though identified in some reports, were not considered work-related and therefore not included in the data set. Considering the age of the population being studied, the number of non-work fatal falls could have been significant (Sattin, 1992; Rubenstein, 2006).

Table 10. Indiana fatal fall incidents

Category	Frequency	Percentage	Percentage of all cases
Fall from farm structure	9	50	2.3
Fall from ladder	5	27.8	1.3
Fall incident, unspecified	4	22.2	1.0
Total	18	-	4.6

The breakdown of the livestock fatality type is shown in Table 11. The most common type of incident involved bulls, with six cases (35.3%), and the second involved cows, with five cases (29.4%). The exotic livestock cases involved a wildebeest and a buffalo.

Table 11. Indiana fatal livestock incidents

Category	Frequency	Percentage	Percentage of all cases
Bull	6	35.3	1.5
Cow	5	29.4	1.3
Horse	4	23.5	1.0
Exotic livestock	2	11.8	0.5
Total	17	-	4.4

The breakdown of the "fires, burns, and explosions" fatality categories is shown in Table 12. The most common type of incident involved explosions, with five cases (29.4%). The second most common type of incident was tied between "caught on fire with accelerant", "electrocutions", and "other fire-related incidents" with three cases each.

Table 12. Indiana fatal fire, burn, and explosion Incidents

Category	Frequency	Percentage	Percentage of all cases
Explosion	5	29.4	1.3
Caught on fire with accelerant	3	17.6	0.8
Electrocution	3	17.6	0.8
Other fire-related incident	3	17.6	0.8
Farm structure fire	2	11.8	0.5
Smoke inhalation	1	5.9	0.3
Total	17	-	4.1

3.6 Discussion

The data showed that the number of fatalities involving older farmers has been on the rise from 2012 to 2017, with 2015–2017 having the highest reported number. This increase does not reflect the general decrease in the frequency of older fatal farm incidents over the same time period (Cheng and Field, 2018). The increase could be the result of several factors, including the increasing age of current farmers, farmers putting off retirement, older non-farmers becoming beginning farmers as part of their retirement, or due to improvements in reporting. The average age of all farm operators increased from 50.5 in 1982, to 58.3 in 2012, and to 59.4 in 2017 (USDA-

NASS, 1984; USDA-NASS, 2014; USDA-NASS, 2019). A survey by Amshoff and Reed (2005) of 725 male farmers 50 years or older found that 42% stated they were not retired from farm work, even though the average age of the sample was 67 years. In addition, the number of principal operators of farms increased for the age groups of 55 to 64 years old, 65 to 74 years old, and 75 years and older from 2012 to 2017 by 28.8%, 45.0%, and 35.1%, respectively (USDA-NASS, 2019). The frequency of fatalities involving older farmers is clearly increasing, while the distribution of fatal incidents for all ages appears to be on a slight but continuous, decline. The increase in the number of small farms owned and operated by retired people cannot be ignored as a contributing factor. There was a 10.8% increase in the number of farms owned by operators 65 years and older from 2007 to 2012 (USDA-NASS, 2009; USDA-NASS, 2014). In some of these cases involving new and beginning farmers, the lack of experience and safety training in the use of agricultural tractors and equipment may have played a significant role in the fatality. It is also important to mention that new methods in reporting, such as the internet, may have caused the increase in the number of recent cases.

The distribution of the victims' age showed a decrease around age 75 up into the 90s. This may be explained by the fact that there is a smaller population of farmers still active at that age. The large number of fatalities in this age range, however, follows the literature that farmers work longer than the general workforce, with 178 fatalities reported over 70, and the oldest case being 93 years of age (Amshoff and Reed, 2005; USDA-NASS, 2019). It appears that this trend parallels the 6% increase in the total number of farmers who were 70 years or older from 2007 to 2012 in Indiana (USDA-NASS, 2014). This is a concern because farm-related injuries occurring to older farmers are more likely to be fatal or result in long term or permanent disability. As noted, it is well documented that certain age changes, such as arthritis or hearing and vision impairments, contribute to increased risk of sustaining both non-fatal and fatal injuries.

Regarding type of contributing injury agents, tractors were identified as an area of concern, representing 40.5% of the reported fatality cases. This finding aligns with other reports for the most common type of contributing agent for all ages (Field and Bailey, 1976; Etherton et al, 1991; Hard, Myers, and Gerberich, 2002; Gorucu, Harshman, and Murphy, 2017; Cheng and Field, 2018). The second highest type of fatality was farm machinery-related, with 87 fatalities that accounted for 22.4% of the deaths. The third and fourth highest fatality types were roadway and the cutting and trimming of trees, with 31 and 27 fatalities, respectively.

Tractor rollover incidents were clearly the most significant event, accounting for 22.1% of cases, with most frequently reported fatal injuries of broken or crushed pelvis, broken bones, loss of blood, collapsed lungs, and chemical or other burns. Other similar studies have reported that tractor rollovers, or overturns, have also been historically the most common type of fatal incident (Field and Bailey, 1976; Karlson and Noren, 1979; Etherton et al, 1991; Centers for Disease Control and Prevention, 1996; Brown et al, 1997; Myers and Hendricks, 2010; Cheng and Field, 2018). It has also been reported that farm operators 65 years and older are more likely to be operating a tractor without a ROPS (Loringer and Myers, 2008).

Occupational farm-related injuries and fatalities have a huge cost, estimated to be $8.3 billion in 2015 due to medical costs and reduced productivity (ASHCA, 2015). Tractor overturns alone were projected to have a social cost of $1.5 billion over 25 years (Myers, Cole, and Westneat, 2008). The problem gets even more complex when coupled with a large percentage of farmers and household members, 10.7%, not having any health insurance in 2015 (USDA-ERS, 2018). With respect to older farmers, the length of recovery and rehabilitation costs associated with serious injuries can become unmanageable.

3.7 Conclusion

This study identified the most prevalent types of contributing injury agents and reported types of fatal injuries, as well as other demographic factors of Indiana farmers 55 years and older. The data are important to help guide the development and delivery methods of agricultural safety material to create a safer worker environment by illustrating what risks are most prevalent for older farm workers. The summary suggests that agricultural safety material and practices should be focused towards farm worker incidents relating to tractors, farm machinery, roadways, cutting and trimming trees, and smothering and asphyxiation risks.

Educational materials should clearly address how the aging process contributes to the increased risk of injury and measures needed to reduce the impact of age-related functional limitations. The most significant risk that should be addressed with this population is the potential for tractor overturn and the well-recognized hazard of operating older tractors without ROPS.

The findings from this study should be an important tool to be given to stakeholders, including farm families and extension educators, so they can be better informed about the health and safety of the older farmers in their families and communities. Findings should assist in initiating a

discussion on ways to enhance the safety of these workers while still allowing them to continue contributing to the farm operation.

Future research is needed to better understand how this population perceives risks and to better understand the values and behaviors of older farmers, compared to other age groups, which motivate them to remain involved in performing hazardous farm-related tasks. Work is also needed to develop and field test injury prevention strategies that are effective at modifying behaviors and attitudes that contribute to a higher risk of farm work injuries among this population.

CHAPTER 4. SUMMARY OF INDIANA FARM OCCASIONAL WOOD CUTTING FATALITIES INVOLVING INDIVIDUALS 55 YEARS AND OLDER

This chapter will be submitted to the Journal of Agricultural Safety and Health in 2019 for publication.

4.1 Abstract

Forestry related activities, such as tree cutting and harvesting of forest resources, have been documented as dangerous tasks with increased risk of injuries and fatalities. These hazards are well known in the professional logging community, but there is less attention given to farmers who perform occasional tree trimming and cutting activities, especially for the older farmer population. This study examines Indiana farm work-related fatalities from 1988 to 2017 involving farmers 55 years and older while performing occasional wood cutting activities. Fatality cases were mined from the Purdue University Agricultural Safety and Health Program's Fatality Database. A total of 40 fatality cases were reported, representing 10.3% of all reported farm fatalities of farmers 55 years and older over the time period. The average age of the victims was 67.4 with 65% of cases involving victims 65 years or older. All victims were males. Wood cutting fatalities increased over the observation period. The most frequently reported injury type was being crushed by tree or tree limbs with 16 cases (40%) and the most common cause of fatality was due to the cutting and trimming of trees with 27 cases (67.5%). It was determined that the incidents were largely preventable and that future injury-prevention strategies should address the risks associated with aging, the added risk of being struck by limbs or trees due to unsafe felling practices, the need for appropriate personal protective equipment, and the hazards involved with operating agricultural tractors in wooded areas.

4.2 Introduction

Older farmers, defined here as over the age of 55, are at risk of both fatal and non-fatal injuries when performing tasks related to removal of unwanted trees, such as in fence rows, harvesting of commercial timber and other forest products for sale, and when operating agricultural equipment

in wooded areas (Browning et al, 1998; Lindroos et al, 2008; CDC, 2008; Hammig and Jones, 2015; Tormoehlen and Field, 2019). This problem was especially notable for farmers in their late 60's and 70's, when most non-farm workers have retired or discontinued performing such high-risk activities.

The purpose of this article is to examine work-related fatality data of older Indiana farmers involved in occasional, on-farm tree and woodlot related activities that were documented during the 30-year period 1988 to 2017, and to identify key contributing factors for use in designing more effective injury prevention strategies for use with this population.

4.3 Review of Literature

The average age of farmers has been on the rise in the U.S. from 55.3 years in 2002 to 59.4 in 2017 (USDA-NASS, 2004; USDA-NASS, 2019). The number of older principal farm operators has increased as well, with the number of farm operators 55 year and older increasing 34% from 2002 to 2017 (USDA-NASS, 2004; USDA-NASS, 2019).

The higher risk of injury due to multiple age-related changes to the body has been well documented. The reaction time and reflexes of older adults have been shown to be slowed with age (Fozard et al, 1994; Hultsch et al, 2002; Williams et al, 2005). It is harder for older adults to 'multitask' or split their attention between multiple tasks (Brouwer et al, 1991, Clapp et al, 2011). The second most common disability condition in the United States is age-related hearing loss, with almost everyone over 60 experiencing it to some level (Gates and Mills, 2005; Agrawal et al, 2008; Huang and Tang, 2010). Finally, adults 50 years and older accounted for 65% of the visually impaired population globally (Pascolini and Mariotti, 2012).

Older farmers also face higher injury risks than younger adults (Layne and Landen, 1997; Gelberg, Struttmann, and London, 1999; Nilsson et al, 2010; Collin and Sprufera, 2011). When compared to younger workers, farmers have more severe hearing loss (Plakke and Dare, 1992; Lie et al, 2016), which is associated with the greater risk of sustaining farm injuries (Choi et al, 2005; Voaklander et al, 2009). Farmers with some types of mobility impairment, such as arthritis, were found to be twice as likely to get injured (Voaklander et al, 2009; Heaton et al, 2012). There is also higher risk of injury when certain types of medications, such as pain or depressant medications, including opioids, are used by older farmers (Voaklander et al, 2006; Tiesman et al, 2006).

The injuries that affect older farmers are more likely to require hospitalization for treatment, require longer rehabilitation times, and make up a large percentage of farm fatalities (Layne and Landen, 1997; Gelberg, Struttmann, and London, 1999; Myers, Layne, and Marsh, 2009). A study of reported injuries and fatalities of U.S. farmers who were 55 years and older found that around half of the deaths from 1992 to 2004 happened to farmers 55 years and older, accounting for 3,671 of 7,064 farm fatalities (Myers, Layne, and Marsh, 2009). Other reports reveal that fatalities of farmers 65 years and older consistently represented around 30% of all farm-related fatalities (Voaklander et al, 1999; Gorucu et al, 2017; Cheng and Field, 2018). Tormoehlen and Field (2019) found that 43.8% (388) of all farm fatality cases in Indiana from 1988 to 2017 involved farmers 55 years and older.

People who perform woodcutting activities, such as loggers, are at a high risk of injury. The logging profession had the second highest fatal work-injury rate reported in 2017 with 84.3 per 100,000 workers, compared to the all-worker fatal injury rate of 3.5 (CFOI, 2018). Chainsaw usage is a common cause of injuries while cutting and trimming of wood. Hammig and Jones (2015) found there were a total of 115,895 emergency department visits for chainsaw related injuries from 2009 to 2013, with 39.3% of cases involving people 50 years or older. However, contact with the cutting components or the chain of chainsaws during operation are rarely the cause of fatal injuries when cutting or trimming wood (Demetriades et al, 1996; Koehler et al, 2004; Hammig and Jones, 2015). Fatal injuries are more likely, however, to be caused by being struck by a tree or limb during felling and that it is a major non-fatal injury risk (Browning et al, 1998; Fischer et al, 2005; CDC, 2008; Tormoehlen and Field, 2019).

Woodcutting and woodlot related injuries are also reported in published summaries of farmer injuries across the nation (Browning et al, 1998; Schaufler, 2017; Cheng and Field, 2018). Browning et al (1998) reported that the third highest external cause of farm injury in Kentucky was due to wood-cutting events. Schaufler (2017) found that tree related injuries, such as being hit by a branch or having a tree fall on the victim, tied for third most common cause of farm-related fatalities in Pennsylvania from 2010 to 2014. Tormoehlen and Field (2019) found that the trimming and cutting of trees was the fourth most frequent cause of farm-related fatalities from 1988 to 2017 in Indiana.

A high-risk exposure period for homeowners or farmers is when trimming, cutting, and removing of tree debris in response to storm damage. Hospitals in Cincinnati, OH reported an

increase in injuries, including lacerations from chainsaws, by 55 injuries /day/million population a few days after the 2008 windstorms from Hurricane Ike (Schmidlin, 2011). Fayard (2009) reviewed the fatal work injuries associated with natural disasters and found that 18% of the injuries during hurricane cleanup were due to tree trimming and removal. Geehr et al (1989) examined the health impact after a strong storm. They found that lacerations from chainsaws were a common injury several days after the initial storm.

Overall the literature suggests a more intense focus on estimating the prevalence of and preventing injuries associated with professional or commercial loggers and arborists. However, there is very limited current evidence-based literature on the problem of injuries of the occasional wood cutter population, such as farmers. Fischer et al (2005) compared injuries between loggers and the occasional wood cutter in Wisconsin and found that occasional wood cutters were three times more likely to get injured. The CDC (2008) reported that there were more non-occupational logging fatalities compared to professional loggers over the ten-year period from 1997 to 2007 in Vermont.

A wide variety of educational materials were identified that were geared towards the general public on how to safely operate a chainsaw and proper techniques in felling trees. These were primarily developed and disseminated by organizations such as Land Grant Extension programs (Walters, 1979; Baker and Cutter, 1996; University of New Hampshire Extension, 2001; Baker and Cutter, 2011; New York Department of Health, 2012; Stelzer, 2017; Taber, 2017; Bauske et al, 2018). These materials cover important topics that involve what personal protective equipment wood cutters need to wear, how to properly maintain a chainsaw, and different complications that can occur while cutting trees. The materials, however, are generally geared more towards general homeowners and do not specifically target age-related safety issues of woodlot-related farm tasks undertaken by older farmers. A review of the images in these documents further indicates that the materials were designed for a younger audience.

4.4 Methods

Data used in this report were drawn from the Purdue University Farm Fatality Database with annual summaries published by the Purdue Agricultural Safety and Health Program (PUASHP). PUASHP gathers farm-related fatality cases through sources that include death certificates, web

searches, news clippings, Extension educators, first responders and others associated with the incident, and obituaries and post-incident interviews with family members.

The data base currently contains approximately 1452 reports of farm work-related fatalities documented between 1970 and 2017. Annual summaries are posted at www.farmsafety.org. The data mined included the date, age, sex, county, the type of incident that occurred and a short description of what happened. Only fatalities that occurred from 1988 and 2017 were used in this study. The age range of victims 55 years and older was selected to compare the results of this study to previously published studies, such as from the National Institute for Occupational Safety and Health (NIOSH) that found that farmers 55 years and older were at a higher risk of injury and death (Myers, Layne, and Marsh, 2009). No follow-up investigations were conducted by the authors other than the review of original sources.

Farm-related work fatalities reported in the study involved any cases that occurred from occasional woodcutting incidents on a farm, such as the trimming and removal of unwanted trees, fence-row clearing, the harvesting of on-farm timber and other forest materials for firewood, and operation of agricultural-equipment, including tractors, in wooded areas. None of the reported fatalities were professional loggers.

The coding sheet used to categorize the individual cases was adapted from previously publishing coding sheets (Purschwitz, 1989; Purschwitz and Field, 1989; ASABE, 2007; Nour et al, 2019).

Related case studies were also gathered and summarized from the NIOSH State Fatality Assessment and Control Evaluation (FACE) programs. The cases occurred outside the state of Indiana and were not included in the data summarized in the study. They, however, represented the types of cases that were included, provided in depth analysis of selected cases, and confirm that these cases are occurring nationwide.

4.5 Findings

During the 30-year observation period, 40 reported fatalities were documented and used in the analysis. Each case is described in Table 13. These cases represented 10.3% of the total number of cases of farmers 55 years and older over the time period.

Table 13. Description of documented Indiana farm-related fatalities while performing wood cutting tasks

Date	Age	Sex	County	Description
Oct 2016	56	Male	Clay	Working in a wooded area when a tree fell on his head
Oct 2016	57	Male	Wabash	ATV hit tree while working in wood lot
Sep 2016	70	Male	Hancock	Cutting wood on farm when a tree split and landed on him
Jun 2016	65	Male	Brown	Struck by limb
Apr 2016	55	Male	Fulton	Crushed under tree, asphyxiation
Jan 2016	59	Male	Gibson	Crushed under tree, asphyxiation
Dec 2015	57	Male	Miami	Tractor overturned in woods
Nov 2015	69	Male	Ohio	Struck by falling tree
Jan 2015	76	Male	Jackson	Struck by falling tree
Nov 2014	66	Male	Bartholomew	Struck by falling tree
Oct 2014	74	Male	Parke	Struck by falling tree
Jul 2013	71	Male	Bartholomew	Struck by falling tree
Jun 2013	56	Male	Howard	Struck by falling tree
Dec 2012	69	Male	Starke	Struck by limb
Nov 2012	59	Male	Parke	Struck by limb
Mar 2012	71	Male	Bartholomew	Struck in head by limb
Sep 2011	63	Male	Vigo	Struck by log
Apr 2010	81	Male	Jackson	Hit by tree limb while felling tree
Sep 2009	66	Male	Decatur	Struck by falling tree
Jul 2009	66	Male	Miami	Struck by log
Sep 2008	67	Male	Whitley	Tractor overturned pushing logs up hill
May 2008	56	Male	Hendricks	Tractor overturned rearward when plow caught tree roots
Jan 2008	57	Male	Harrison	Stuck by falling tree
Jul 2003	65	Male	Gibson	Tractor overturned in wooded area.
Sep 2002	64	Male	Delaware	Tractor overturned while trying to remove a tree
Sep 2002	56	Male	Morgan	Tractor overturned while pulling a log
Nov 2001	84	Male	Elkhart	Tractor overturned after hitting a stump
Sep 2000	80	Male	Washington	Tractor operator struck by tree limbs

Table 13 continued

Jul 1999	84	Male	Warren	Runover by tractor - Knocked off tractor by tree branch
Nov 1994	73	Male	Dearborn	Overturned tractor crushed operator while towing logs uphill
Sep 1994	81	Male	Randolph	Struck by falling tree
May 1994	65	Male	Jennings	Struck on head by flying limb while operating a rotary mower and backing into brush
Feb 1994	70	Male	Spencer	Struck on head by branch when cutting wood.
Oct 1992	59	Male	Elkhart	Struck by falling tree
Aug 1992	66	Male	DeKalb	Pinned against tree
Aug 1990	74	Male	Unknown	Tractor overturned and pinned operator against a tree
Sep 1989	87	Male	Unknown	Tractor overturned on victim
Oct 1988	57	Male	Unknown	Tractor overturned while harvesting firewood
Nov 1988	76	Male	Unknown	Struck by falling tree while cutting firewood; wind apparently shifted causing tree to fall on operator
Nov 1988	70	Male	Unknown	Struck back of head and neck by vine while bulldozing in wooded area

4.5.1 Age

The average age of the older farmers killed while wood cutting was 67.4 years old. The average age of current farm owner/operators in Indiana is 57.4 years old (USDA-NASS, 2019). The data showed variation of ages over the 30-year period with a decreasing trend line by age as seen in Figure 13. Peak ages were 56, 57 and 66, each with 4 cases. When divided into age groups, as seen in Table 14, the 65 to 74-year-old group had the highest number of cases (18) and the 75-year and older group had the lowest (8 reported cases). The oldest case reported was 87 years old.

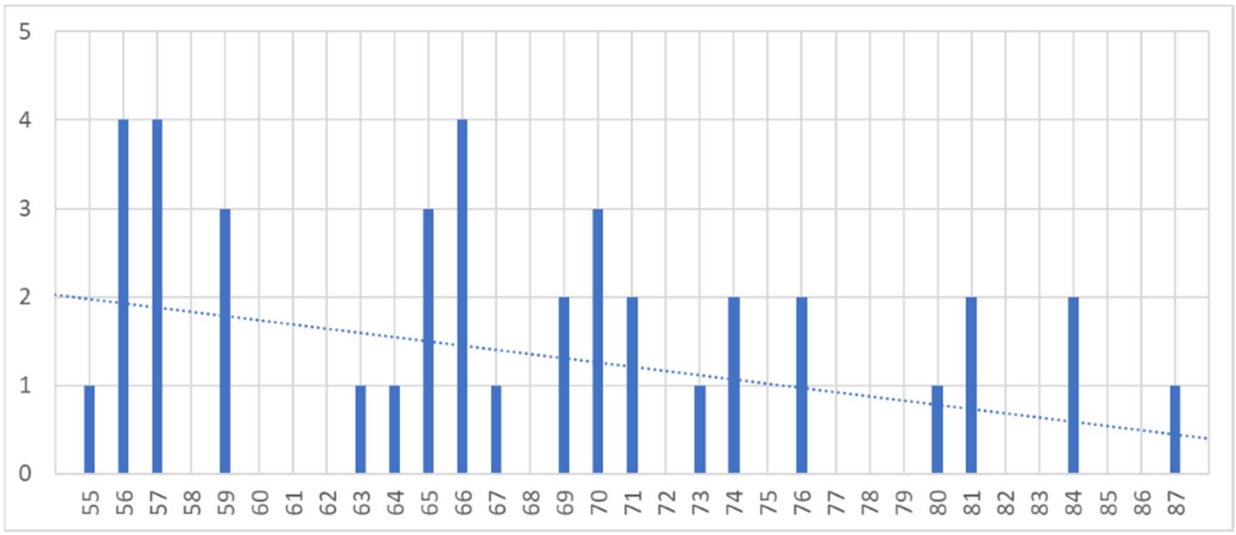

Figure 13. Age distribution of Indiana wood cutting fatalities of farmers 55 years and above

Table 14. Indiana wood cutting fatalities by age group from 1988 to 2017

Category	Frequency	Percentage
55 to 64 years old	14	35
65 to 74 years old	18	45
75 years and older	8	20
Total	40	100

4.5.2 Gender

All 40 victims were males. This follows earlier reported findings of studies of non-professional chainsaw or woodcutting related injuries or fatalities where males were the overwhelming majority (Fischer et al, 2005; CDC, 2008; Degroot et al, 2011; Hammig and Jones, 2015).

4.5.3 Month

The distribution of fatalities by month is shown in Figure 14. The data show a unimodal pattern with the largest peak occurring in September with nine cases and November in second at seven cases. Indiana is known to have severe weather in the fall, with a number of high wind storms and tornados reported between July to November (National Weather Service, 2015; National Weather Service, 2016). The peak in the Fall season reflects the period of the year firewood is collected and storm-related tree damages are cleaned up.

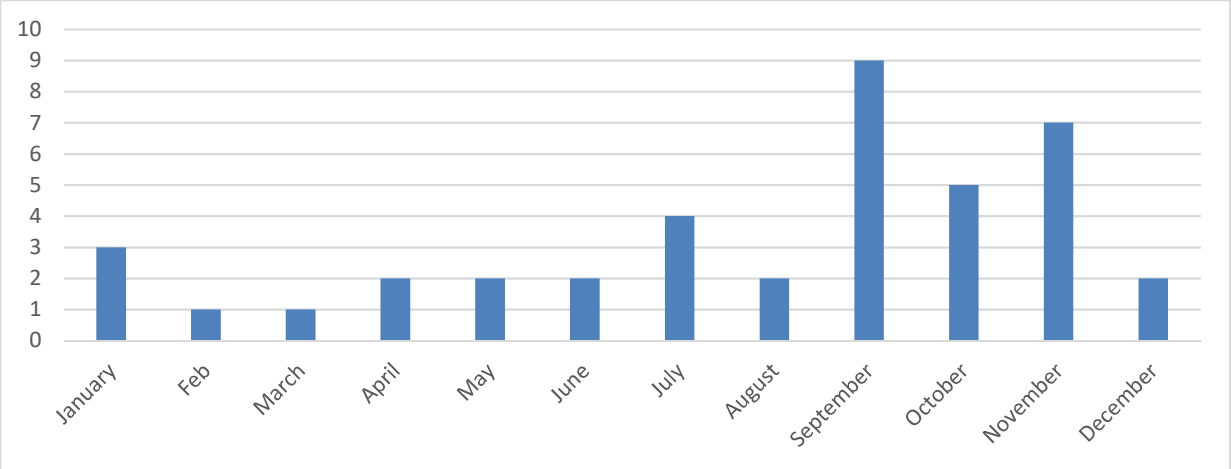

Figure 14. Month distribution of Indiana wood cutting fatalities of farmers 55 years and above

4.5.4 Year

The distribution of fatalities by year between 1988 and 2017 is shown in Figure 15. The data show variation over the 30-year period with an increasing trend line over time. The years with the highest number of fatalities were 2016, with 6, and 1994 with 4. Eleven of the years had zero fatalities with the most recent being 2017 and 2007. This trend is inconsistent with the continuing decline in the number of all Indiana farm work-related fatalities as reported by Cheng and Field (2018).

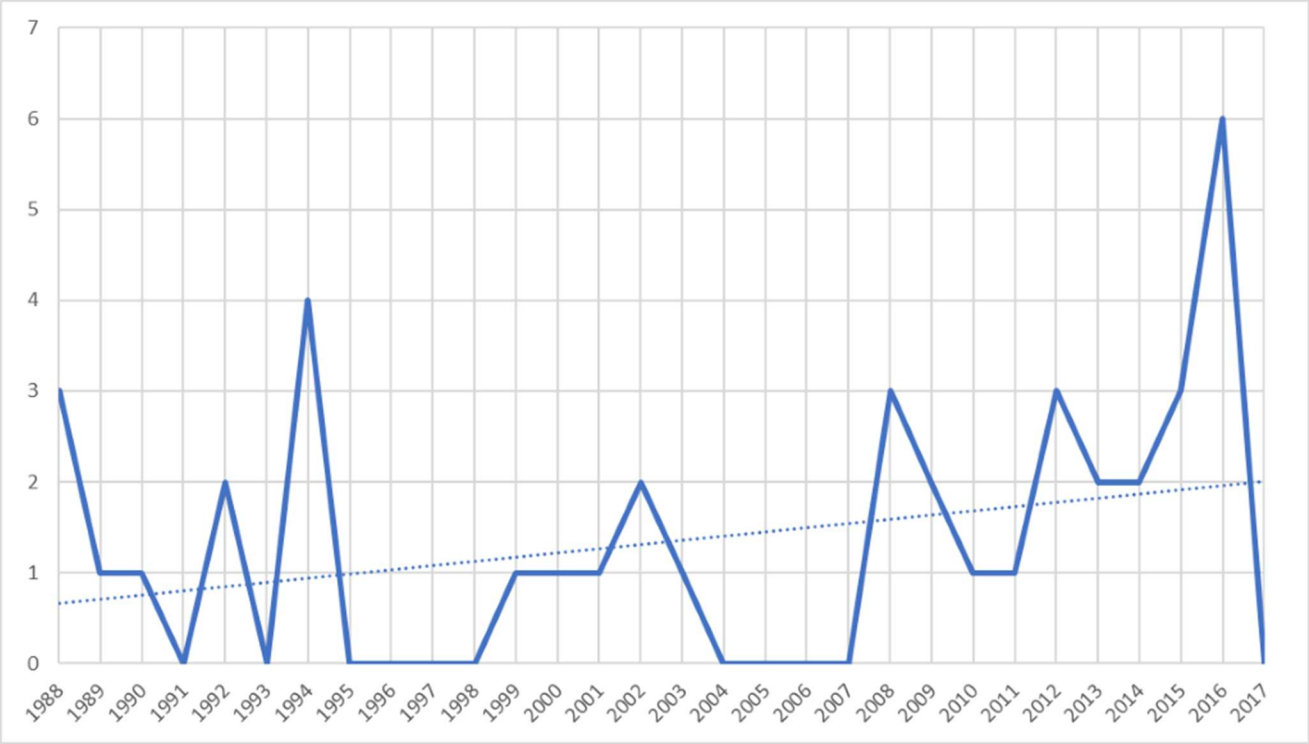

Figure 15. Number of fatalities by year for Indiana farmers 55 years and older

4.5.5 County

Fatalities were identified in 29 different Indiana counties during the 30-year period. The top five counties with the highest number of fatalities were Bartholomew with 3 (7.5%) and Elkhart, Gibson, Miami, and Parke with 2 (2.5%) each.

The distribution of fatal cases of farmers 55 years and older by county is shown in Figure 16. The geographic distribution of incidents was divided in half between the northern and southern parts of the state, with the dividing line running along U.S. 40, in order to compare the two regions due to the fact that the south has a greater proportion of forested land and larger number of small farms with wooded areas. The northern portion of the state had 15 and the southern portion had 20 reported incidents.

The four counties with the highest number of documented incidents have considerable forested areas, and Elkhart and Parke counties have a high density of Old Order/Amish responsible for a disproportionate number of Indiana farm-related fatalities (Cheng and Field, 2018). The Old Order/Amish are also heavily involved in the harvest of timber for use as firewood and finished wood products.

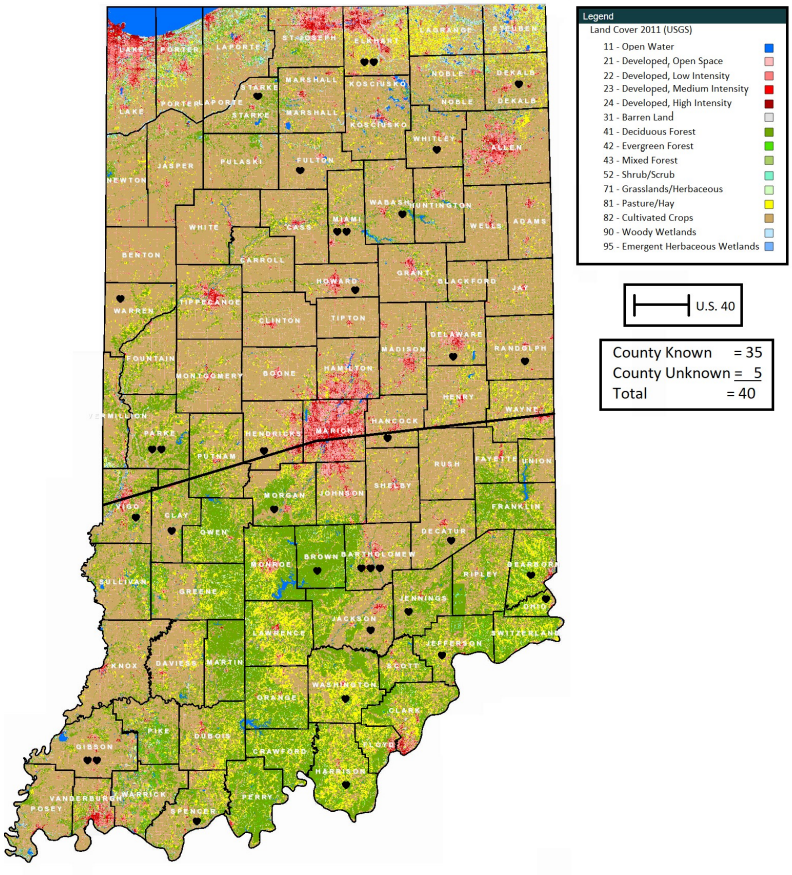

Figure 16. Distribution of fatalities per county on map of Indiana's land cover during 2011 (Indiana Geological Survey, n.d.)

4.5.6 Reported Type of Injury

In the majority of cases, no official or medically determined cause of death was available. The reported types of fatal injuries were divided into categories based on the language used in the reporting source. The most common was crushed under a tree or tree limb with 40% of the cases as seen in Table 15. When combined with tractor overturns, 70% of the cases were reported as involving crush related injuries.

Table 15. Reported type of injury of fatal farm-related wood cutting fatalities of farmers 55 years and older

Category	Frequency	Percentage
Crushed under a tree	16	40.0
Crushed under a tractor	12	30.0
Trauma from impact	7	17.5
Head Injury	5	12.5
Total	40	-

4.5.7 Type of Agent Involved

The most common agent or activity involved was cutting and trimming trees with 27 incidents (67.5%) with the second highest, tractor-related with 12 incidents (30%), and the last was ATV-related with 1 incident (2.5%) as seen in Table 16. It is known that other ATV-related fatalities occur in wooded areas especially involving collisions with trees. It was anticipated that more of these incidents would be documented in this study due to the 243 ATV related fatalities reported in Indiana from 1982-2013, but in the cases reviewed, they were either recreational-related versus farm work-related, or involved younger operators (United States Consumer Product Safety Commission).

Table 16. Breakdown of agent involved in wood cutting tasks performed by farmers 55 years and older

Category	Frequency	Percentage
Cutting and trimming trees	27	67.5
Tractors	12	30
ATV-related	1	2.5
Total	40	-

Incidents were broken down further to better understand primary causes of each type of injury. The most common incident type for cutting and trimming of trees was struck by a tree or tree limb with 27 cases or 67.5% of all cases. No fatality cases were reported relating to the exposure to chainsaw hazards, such as blood loss due to lacerations or kickback injuries.

The next breakdown examined tractor-related incidents, as is seen in Table 17. The most common type of incidents was tractor rollovers with 11 cases (91.6%). The second most common type was tractor runovers with 1 case (8.4%). There was no way to determine whether

or not the tractors were equipped with rollover protection structure (ROPS) or falling object protective structure (FOPS), or if they were in deployed at the time of the incident.

Table 17. Reported fatal tractor incidents of farmers 55 years and older

Category	Frequency	Percentage	Percentage of all cases
Tractor rollover	11	91.6	27.5
Tractor runover	1	8.4	2.5
Total	12	-	30

4.6 Case Studies

The NIOSH FACE reports included numerous detailed case studies involving farmers killed during occasional wood cutting activities. The following descriptions represent incidents involving older farmers, over the age of 55. These cases were examined to enhance the understanding of the circumstances, especially the diversity of the agents involved in wood cutting incidents. Each occurred during the time frame of the incidents reported in this study.

In August of 2005, a 58-year-old male, a retired teacher, who did some part-time farming, was mowing with a tractor-operated rotary mower on his property. He was using a 1957 John Deere 420 U Model tractor with no (ROPS) that was pulling a 5-6 foot wide rotary mower that was wider than the tractor. The victim's wife left the property before the victim started mowing the morning of the incident. The victim was clearing a stretch of land between the driveway and a bean field. The year prior, the victim had done some cleanup work that involved cutting down some trees in the same stretch of land, leaving stumps that had not been removed. As the victim was mowing, he ended up hitting one of the stumps with either the tractor, the rotary mower, or both, causing a side overturn of the tractor to occur. The victim was pinned between the tractor seat and steering wheel. The victim was not found until early the next morning due to his wife thinking that he had gone out to the local county fair and returned late after she went to bed. He was declared dead on scene by the emergency personal (MIFACE, 2005).

During the winter of 2012, a male in his upper 50s was cutting trees on a farmer's property. At the time of the incident he was cutting a box elder tree that was 3-4 feet in diameter with a chainsaw. He made a horizontal 6-inch cut about 3 feet from the ground. This resulted in a "barber-chair", or the splitting of the tree causing a portion of the trunk to spring up and strike the victim

in the head. The victim was found after another worker in an adjacent field noticed that the tree moved in an unusual way, leading him to investigate. He found the victim in a sitting position with his face pinned to the ground by the tree. He was declared dead at the scene. Recommendations made as a result of the fatality investigation were that trees should be assessed to determine aspects, such as the lean, and to properly carry out safe felling techniques (MIFACE, 2012).

In March 1995, a 61-year-old man was working alone moving logs around with a backhoe tractor equipped with a front-end loader in preparation to cut the logs into firewood. As he was moving a 40ft tree with multiple large branches still attached, the tree moved and fell off of the bucket, sliding down the arms of the loader. One of the large branches, around 8-10 inches in diameter, hit the man in the head and neck. It took several hours for a neighbor to find the victim who was pinned by the tree limb while still on the tractor. His wife came out and operated the hydraulics to try and free the victim, which led to the tree shifting and throwing both the wife and the victim to the ground. Emergency personal arrived about 20 minutes later and the victim was transported to the hospital where he was declared dead. Cause of death was reported as "multiple injuries due to a tree falling upon him." The tractor involved did not have a ROPS or any form of overhead protection, the victim was not wearing a hard hat or other PPE, and no measures were taken to prevent sliding of the logs off the front loader-end, such as hooks (Iowa State FACE program, 1995).

In April 1995, an 86-year-old farmer was riding his 1980's model John Deere tractor with a front loader to the pasture area of his 183-acre farm to check on his cattle. His wife's care-taker noticed that the farmer did not return for lunch, which was unusual, and saw the tractor out in the pasture not moving. She called a grandson to ask him to check on the missing man. When the grandson got to the tractor he found the victim on the ground under a tree 40 yards away from the tractor's location; he was dead. What is believed to have happen was that the front loader was extended all of the way up, forcing the victim to drive underneath an elm tree to avoid nearby utility pole wires. The victim either failed to see or had tried to move the mineral supplement feeder trough that was suspended from the branch of the elm tree and drove forward. As the victim continued to travel the branch that held the mineral trough snapped and hit the victim in the skull, launching him off the tractor. He was pronounced dead on the scene. The cause of death was determined to be massive head trauma from being struck by a tree limb. Previously, family members reported that the victim had poor eyesight and recounted an incident of him running into

a utility pole about a week before, along with other health issues. The victim's field of view may have also been obstructed by the front loader because it was fully raised and he may have had potential side effects from prescription medications he was taking (Kentucky State FACE program, 1995).

A review of the available FACE reports found a wide range and large number of incidents involving farmers involved with tree cutting, trimming and transporting.

4.7 Discussion

The annual number of on-farm wood-cutting fatalities in Indiana has increased over time, with 2016 having the most cases out of the 30-year period with 6 cases. The increase in fatalities could be a result of how inexpensive and easy it is for farmers and the public to buy high speed, efficient and lightweight chainsaws and due to the fact that there is no requirement for a license or safety training for the occasional woodcutter (CDC, 2008). It is estimated there are around 3 million chainsaws sold every year (Koehler et al, 2004). Another potential reason is due to the increase in the number of beginner farmers, many of whom have acquired small, often wooded farms requiring considerable land clearing and general maintenance. In 2017 there were a total of 674,940 beginner farmers, or principal producers who had been on their current farm for 10 years or less (USDA-NASS, 2019). During the same period in Indiana 17,836 farmers, or 23.8% of all farmers, were beginning farmers (USDA-NASS, 2019). This may be a population of farmers who are inexperienced in using a chainsaw or felling trees. Inexperience with cutting and trimming of trees has been documented to lead to a higher risk of injury (Doyle and Conroy, 1989; Parker and Ashby, 2005; CDC, 2008).

The average age of the farm-related woodlot fatalities was 67.4 years old. This is higher than the average retirement age of all industries with 63.9 years for men and 61.9 years for women as of 2013 (Munnell, 2015). The increase in age affects the variability of the farmer's reaction time and can lead to a decrease in hearing and vision senses (Plakke and Dare, 1992; Hultsch et al, 2002; Agrawal et al, 2008; Pascolini and Mariotti, 2012). Studies also show that an increase in age raises the risk of an injury being fatal for farmers (Salminen, 2004; Myers, Layne, and Marsh, 2009). All of these age-related changes may contribute to the risk of getting injured in a woodlot incident. Moreover, the aging farm population is related to the increase in the number of fatal wood-cutting incidents.

It could not be determined from available data the number of fatalities indirectly related to woodlot management. Cutting, felling, and processing wood products during land maintenance or collection of firewood is strenuous for the operator (Toyokawa, 1999; Eroglu, Yilmaz, and Kayacan, 2015; Cheţa, Marcu, and Borz, 2018). Many elderly operators may not be accustom to the bodily strains associated with this type of labor. Heart attack, stroke, and heat-related illnesses may occur as a result of woodlot management. In addition to the increased strains from the physical labor, it has been shown that noise and vibrations, such as from small engine usage, increases the operator's heart rate variability (Ising and Kruppa, 2004; Björ et al, 2007; Sim et al, 2015). While fatalities may occur indirectly as a result of cutting, clearing or processing wood products, the underlying medical condition may be the documented cause of death with no references to the activity at the time of death or the condition leading to seeking medical attention.

This analysis of Indiana farm-related fatalities of workers 55 years and older found that all of the cases were male. This may be due to the fact that women engaged in work activities in agriculture still represent a small portion of the farming population, especially of those performing production-related tasks. Primary producers that were females accounted for 31.5% (489,000) of the U.S. farmer population and 24.4% (18,256) of Indiana farmers (USDA, 2019). Of this group a significant percentage are retired and/or rent out their acreage to other farmers.

The breakdown of reported types of injuries showed that the largest category was being struck by a tree or tree limb while cutting and trimming trees. This is consistent with previous findings on professional logger fatalities which show that tree felling was the highest category (Scott, 2004). There are many factors that need to be taken into consideration as a tree is being cut down, including the lean of the tree, weak overhead limbs, and rot or decay (Baker and Cutter, 2011).

Another category with a large number of cases documented was tractor-related fatalities. This may be due to the fact that farm tractors are readily available to farmers and are commonly used to pull stumps/trees and tow logs, which has been shown to contribute to a high risk for backwards rollover (DeGroot et al, 2011). In general, agricultural tractors are not designed to be operated in wooded areas and other lack safety features, such as FOPS designed to protect the operator.

The data used in this analysis did not include the type of personal protection equipment (PPE), if any, being used at the time of the incident. PPE is an important safety measure to use during the cutting and trimming of trees to prevent injuries. The most important PPE for logging is reported

to be safety boots, safety pants, helmets and eye protection (Klen and Vayrynen, 1984). The use of PPE by farmers, in general, has been shown to be very limited.

A common finding in the cases studies and previously published literature is the increased risk of injury due to working alone (Kentucky State FACE program, 1995; Iowa State FACE program, 1995; MIFACE, 2005; Fischer et al, 2005; CDC, 2008; MIFACE, 2012). This could contribute to not exploring safer alternatives while performing wood cutting activities, decreased co-worker accountability, and increased response times from emergency personnel due to the isolation of the site and not being able to report the incident.

An area that seems to be somewhat overlooked is the role that farmers play in cleanup activities following severe weather. Many farmers have access to chainsaws, skid steers loaders, bulldozers, and other equipment that allows them to respond to damage on their own property and nearby neighbors. Removing damaged trees and fallen limbs has been documented to pose a high risk of injury, especially for the occasional wood cutter. Because of the unique nature of disaster clean-up activities, it is believed they should be addressed separately.

4.8 Conclusion

This study identified the most common types of reported injury and fatalities for farmers 55 years and older who conducted occasional wood-cutting activities. The data are important to assist in the formation and delivery of intervention-based educational material to help address issues the older farmer population face when cutting and trimming wood. The analysis suggests that the focus of agricultural safety material and practices should emphasize preventing injuries resulting from being struck by trees and limbs and hazards associated with tractor operation in wooded areas.

Future research is needed to determine the best methods to promote and achieve usage of both improved safety behaviors and proper felling techniques, and to identify the risk of injury relating to storm damage cleanup for older farmers.

CHAPTER 5. EVIDENCE-BASED INTERVENTION EDUCATIONAL STRATEGIES FOR FARM-RELATED OCCASIONAL WOOD CUTTING INJURIES

5.1 Introduction

The principal goal of this research was to develop recommendations for evidence-based intervention educational strategies targeting farm-related fatalities resulting from the cutting and trimming of trees, harvesting of timber and other forest materials and related activities. This chapter reviews current intervention strategies identified as being used for the reduction of farm-related woodlot injuries geared toward older farmers, the identification of research gaps, and recommendations of evidence-based intervention strategies that could be incorporated into programs targeting older farmers who performed woodlot activities.

5.1.1 Review of the Current Injury Intervention Strategies

A review of current injury intervention strategies currently available for older farmers to reduce/prevent occasional wood cutting related fatalities was conducted to identify key components, methods, and existing gaps.

There are a number of educational materials geared toward the public on how to safely operate a chainsaw or proper techniques in felling trees that were developed and disseminated by organizations such as Extension programs, equipment manufacturers, and state departments (Walters, 1979; Baket and Cutter, 1996; University of New Hampshire Extension, 2001; Baker and Cutter, 2011; New York Department of Health, 2012; Stelzer, 2017; Taber, 2017; Bauske et al, 2018). These materials cover important topics involving what personal protective equipment (PPE) to wear, how to properly maintain a chainsaw, and safety hazards that may exist during wood cutting operations. The materials were generally geared toward general homeowners and did not specifically look at age-related safety issues of wood cutting related tasks completed by older farmers. For example, visuals used reflected a younger sample of workers or chainsaw operators.

Several databases of agriculture safety materials have been made available by state Extension programs or other organizations. The National Ag Safety Database (NASD) is a project funded by NIOSH that provides information and resources relating to occupational safety in agriculture from

various safety professionals and organizations around the country (NASD, n.d.). These database contains information geared toward both professional loggers and the occasional wood cutter. An example of the occasional woodcutter geared material is the educational fact sheet by Cyr and Johnson (2002) which discussed recommended safety gear to use, the process of preparing to fell a tree, and potential hazards that could occur. None of the safety information reviewed from NASD mentioned any increased safety risks due to aging when cutting or trimming trees, although one did mention that younger operators were more likely to be injured (Hetzel and Butler, 1996).

Another database of agriculture safety material is eXtension that is supported by the United States Cooperative Extension System. The goal of eXtension is to be a resource of evidence-based information and material for both Extension Educators and the general public (eXtension, n.d.). Searches in the database showed a wide variety of resources relating to chainsaw and tree felling safety ranging from safety publications to training workshops held by various state Extension systems. No publications relating to the increased safety risks of older farmers or occasional wood cutters were identified.

The potential risks of using farm tractors for woodlot-related activities is covered by Murphy et al (2014). The focus of this Extension publication was to identify situations of cutting and trimming of trees that are either suited or unsuited for farm tractors and what additional equipment could reduce the safety risks. The material was geared towards farmers but did not include any discussion or images on how age of the worker can play a role in increasing risk of injury.

Other nations have responded differently to this issue. For example, Ireland addressed the concerns of safety relating to tree felling by requiring a felling license granted by the Minister for Agriculture, Food and the Marine (Ireland Forest Service, 2017). Ireland's Health and Safety Authority mentions that both children and the elderly should stay away from using chainsaws (Health and Safety Authority, n.d).

5.2 Training workshops

An Internet search of workshops and training events on wood cutting identified a variety of options for safety training being offered by a variety of organizations. The author attended a safety training program held by a Safety and Woods Worker (SAWW) certified trainer and obtained a certification for SAWW Training programs, levels 1 and 2. The training was attended by seven participants, including the author. Although everyone was welcome to sign up for this training,

there was a focus towards giving hands-on experience to local university students in the forestry department of a Land Grant university. Two of the seven participants were woodlot owners 55 years or older.

The training took place over two days and covered both level 1 and level 2 of the SAWW training programs. The topics included in level 1 were an overview of OSHA regulations and lectures on the type of gear, PPE and safe techniques for limbing, bucking, topping and felling. The objectives of level two included a mixture of hands-on and lecture teaching that covered chainsaw maintenance, precision felling with a focus towards notching, forming a hinge, differences between species, and terrain challenges. The program ended with each student having to successfully fell a tree (SAWW Training, n.d.).

There are additional options for chainsaw safety programing other than just the SAWW training. Many of the trainings identified were held by organizations such as the Division of Forestry in the Indiana Department of Natural Resources, universities, or conservation clubs that had a focus toward either professional loggers or university students studying forestry (NWCG, 2019; Michigan United Conservation Clubs, 2019; The Ohio Forestry Association, n.d; Game of Logging, n.d). Generally, the public was welcome to attend if spots were available. None of the trainings were identified to have a focus towards specific safety practices for older farmers or woodlot owners.

5.3 Development of core safety competencies for older farmers performing occasional wood cutting activities

Using the findings from the review of accessible literature and the analysis of fatality data, a preliminary set of corresponding desired core competencies, or learning outcomes, was drafted. The parameters for the competencies included the need to address the most frequent causes of injury, be measurable, and presentable within a limited time frame. No assumption was made that adoption of the core competencies as safe work practices would result in a specific individual always making safe choices and not engaging in unsafe behavior. The preliminary list of core competencies is located in Appendix A.

The preliminary list of core competencies, or designed learning outcomes, was then reviewed during a focus group comprised of a panel of individuals experienced in chainsaw operation, tree cutting, and trimming. The individuals involved in the review are listed in Table 18 including two

individuals over the age of 65 who continue to manage private woodlots. Included in the review process was an attempt to prioritize the core competencies due to the recognized time limitation of any instructional method. This resulted in numerous modifications to the preliminary list. The result was a list of 12 competencies that were determined to be essential in a curriculum or course outline for instructing of wood cutting safety that targets older farmers. The list is not exhaustive, but rather an attempt to prioritize the instructional content recognizing that there is always finite time for these types of instructions.

Table 18. List of experienced individuals included in review panel of core competencies

- William Hoover, Professor Emeritus in the Forestry and Natural Resources Department at Purdue University (woodlot owner and maintains woodlot of local Boy Scout camp)
- Lenny Farlee, Sustaining Hardwood Extension Specialist in the Forestry and Natural Resources Department at Purdue University (maintains Purdue University owned woodlots)
- Shawn Ehlers, Assistant Clinical Professor in the Agricultural and Biological Engineering Department at Purdue University (chainsaw user and woodlot owner)
- Eugene Matzat, Extension Educator - Agriculture & Natural Resources in LaPorte County, Indiana
- Edward Sheldon, Staff Member with the Purdue University Safety and Health Program (former Extension Educator, Landscape company owner)
- William Field, Professor in the Agricultural and Biological Engineering Department at Purdue University (woodlot owner)
- Sean Tormoehlen, Graduate Research Assistant in the Agricultural and Biological Engineering Department at Purdue University

The finalized core competencies are listed in Table 19, and includes specific supporting content.

Table 19. Set of desired core competencies for older farmer occasional wood cutter safety training

1. **Explain why the hazards associated with occasional wood cutting, including timber harvesting, tree removal and trimming are important safety issue for older farmers.**
    a. 7% of all farm fatalities in Indiana involve occasional woodcutting
    b. Wood cutting injuries are expensive (over $350 million per year)
    c. Litigation costs if employee or farm visitor is injured
    d. Wood cutting operations may not be covered by farm liability policies or worker compensation plans

2. **Explain why older farmers/farm owners are at greater risk of injury during occasional wood cutting activities**
    a. 30% of all farm fatalities are older farmers
    b. Older farmers may experience age-related impairments to vision, hearing, mobility, and reaction times which may increase their risk of injury
    c. Older farmers may be using older equipment that is less safe, i.e. tractors without ROPS, and equipment with fewer guards
    d. Older farmers may be more likely to be working alone
    e. Older farmers may not carry personal communication devices, such as cell phones

3. **List the items that should be considered in conducting a hazard assessment before undertaking wood cutting activity**
    a. Is the level of training and experience sufficient to conduct the job safely
    b. Is there a safer alternative to cutting or removing the tree or limbs
    c. Is the equipment available suitable to safely completing the task, i.e. size of the saw, is the chain sharp
    d. Should I seek a professional opinion
    e. Assess the area
        i. Signs of rot or decay on/in the tree
        ii. Nearby hazards around the tree, i.e. other trees, power lines, and buildings
        iii. Loose or dead limbs “widowmakers”
    f. Plan escape routes
        i. Plan two routes opposite of the intended felling direction at 45 degree angles
        ii. Clear any obstacles and trip hazards

Table 19 continued

4. **Identify primary causes of non-fatal and fatal injuries while occasional woodcutting.**
    a. Contact with chainsaw chain
    b. Impact from falling trees and limbs
    c. Falls while working on ladders
    d. Tractor related, including overturns
    e. Striking a limb while operating equipment in the woods

5. **Explain why working alone during wood cutting activities increases the risk of fatal injuries.**
    a. Location are usually isolated, not easily located
    b. No assistance readily available
    c. Slower response time if medical assistance is needed
    d. Lack of co-worker accountability

6. **Identify and explain the function of the following PPE.**
    a. Hard hat
        i. Protects the user from overhead hazards and falling objects
        ii. Must comply with the ANSI Z89.1-2014 standard
    b. Leg chaps
        i. Prevent injuries from chainsaws due to woven fabric, such as Kevlar, which bind and kill the chainsaw before any serious injuries
        ii. OSHA requires the protection to extend from upper thigh to the boot top
        iii. Chaps may not provide same level of protection with new high speed saws
    c. Eye protection
        i. Protects the eyes from potential injury to the eyes or face from foreign materials
        ii. Must comply with ANSI standards Subpart I, ANSI z89.1-1986
    d. Hearing protection
        i. Chainsaw noises can reach 120 dB
        ii. Over 85 dB can lead to hearing loss
        iii. Some use both ear plugs and protective muffs
    e. Safety footwear
        i. Provide protection to the feet from the chainsaw
        ii. OSHA requires coverage of the ankle and to be constructed of cut-resistant material
        iii. Metatarsal and steel/composit toe safety shoes

Table 19 continued

7. Identify and explain the safety design features of a current chainsaw.

a. Front hand guard
    i. Bar in front of the top handle the prevents the hand from hitting the chain if slipped
b. Chain Brake
    i. Stops the chain in the event of a kickback
c. Throttle trigger interlock
    i. Prevents the operation of the throttle without proper grip on the handle.
d. Rear hand guard
    i. Prevents injury from a broken or jumping chain
e. Chain catcher
    i. Prevents injury from a broken or jumping chain
f. Tip guard
    i. Reduces the risk of as kickback
g. Easy to reach stop switch
    i. Reachable by the right thumb without letting go of the chainsaw
h. Use low-kickback saw chains
    i. Reduces the risk of kickback

8. Describe the primary causes of chainsaw kickback.

a. Cutting within the kickback zone
    i. tip of the guide bar (kickback zone)
b. Contacting another limb/cutting multiple pieces at once
c. Pinched chain
d. Speed of chain insufficient when contacting the wood to be cut
e. Striking an imbedded object such as ingrown metal
f. Chain type
    i. Safety vs chisel

9. Identify the kickback zone of chain bar.

a. Include a photo of the kickback zone of the chain bar
    i. Located on the top tip of the chain bar
    ii. Increased risk in a kickback occurring when operating in the kickback zone

Table 19 continued

10. Describe each of the following steps related to safe tree felling.

a. Selection of the location of the cut (i.e. the desired direction the tree is to fall)
    i. Whenever possible make the cut to take advantage of the natural direction of the fall
b. Determine the center of gravity and factors that would make the tree fall from the center of gravity
    i. Lean
    ii. Balance of limbs
c. Top cut
    i. Starting point
        1. Just leave room for undercut
    ii. Angle of attack
        1. Cut at an angle of 45 degrees
    iii. Ending point
        1. Stop when cut reaches 1/4 to 1/3 of trunk's diameter
d. Bottom cut
    i. Starting point
        1. cut horizontally from the bottom of the top cut
    ii. Angle of attack
        1. No angle
    iii. Ending point
        1. Stop at the end of the top cut to make a 45 degree notch
e. Back cut
    i. Starting point
        1. Opposite side one inch over the notched corner
    ii. Angle of attack
        1. Stay horizontal
    iii. Ending point
        1. Stop when there's a hinge of 1/10th of the tree's diameter

11. Describe the role of a hinge in controlling the direction of a tree as it falls.

a. Holds the tree as it falls
b. Help guide the fall in the intended direction
c. Prevent the tree from splitting, barber chairs, and other dangerous situations

Table 19 continued

12. Describe the primary types of tractor related incidents while working in wooded areas. a. Rollover due to steep terrain b. Rollover from improper hitching above the draw bar c. Struck by overhead limbs d. Logs rolling back onto operator using front end loaders e. Upset when hitting a stump

5.4 Safety educational strategies for older farmers performing occasional wood cutting activities

5.4.1 Occasional wood cutting safety presentation for older farmers

Based upon the 12 prioritized core competencies, a PowerPoint-based presentation was developed and pilot tested with a group attending a Farm Woodlot Management Workshop at Bedford, IN on June 8th, 2019. A copy of the presentation is located in Appendix B. The session consists of a mixture of PowerPoint presentation and hands-on time with safety gear and tools relating to the cutting and trimming of trees. The presentation covered the safety risks associated with cutting and trimming trees, why older farmers have an increased risk of injury, what types of personal protective equipment to wear, and safety practices to follow. It ended with real life case studies to help the participants to engage and identify what preventative measures could have been taken to reduce the risk of injury. Time did not allow for participants to take part in hands-on wood cutting activities

The presentation provided the opportunity to give additional feedback on the contents of the training to assess general acceptance. The case studies really helped get the audience to participate and engage, and attendees came up afterwards to talk about what methods they used to fell or trim trees. It is believed that additional presentations would help further refine the contents.

5.4.2 Educational displays and presentations

Educational poster displays and presentations addressing the issues with safety for older farmers were displayed at events, such as academic conferences and campus events. The goal of the educational display and presentations was to increase awareness of the safety concerns older

farmers face when performing occasional wood cutting activities. The events that posters were display at were:

- ISASH annual international meeting – 2019
- AgrAbility National Training Workshop - 2019
- Various Purdue University campus events – two during 2018
- AgrAbility National Training Workshop - 2018
- ASABE annual international meeting – 2018

The most common feedback from poster viewers were stories shared about safety issues, either from friends and family or personal experiences. Another common reaction was people being surprised by the frequency of events and injuries. Examples of reactions included being unaware of the number of occasional woodcutter fatalities or expecting ATV-related fatalities to be more common.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 Review of Research Literature

The review of literature confirmed that older farmers were at a higher risk of injury due to age related changes who accounted for approximately 30% of all reported fatalities. Older farmers generally had a more difficult time recognizing which activities have the highest risk of personal injury, and that tractors were the most frequent agent of death for older farmers. Research investigating fatalities relating to the cutting and trimming of trees found that occasional woodcutter's, such as farmers, accounted for a higher percentage of the reported injuries when compared to professional loggers, being alone while felling or cutting trees increased the risk of injury, being struck by a tree or limb was one of the more reoccurring causes of fatality, most injuries occurred to people between 50 and 59 years old, and operating tractors in wooded areas contributed to roll-over-related fatalities among older farmers.

6.1.2 Summary of Indiana Farmer Fatalities Involving Individuals 55 Years and Older

The summary of all Indiana farm fatalities found that fatalities involving older farmers, age 55 years and above, had a positive trend over time and represented 43.8% of Indiana farm-related fatalities of all ages documented from 1988 to 2017. Farmers 65 years and older accounted for 64.2% of the fatalities of older farmers, age 55 years and above, with the oldest fatality case identified as 93 years old. Males accounted for 96.1% of the cases. Analysis found that tractors were the most common agent of fatality (40.5%) with a focus specifically towards tractor overturns. Cutting and trimming trees was the fourth highest cause of fatality (7%) with no fatalities occurring from chainsaw injuries. Data showed that nearly every county in Indiana had an older farmer fatality over the 30-year period with a link to high agricultural production areas of the state.

6.1.3 Summary of Indiana Farm Occasional Wood Cutting Fatalities Involving Individuals 55 Years and Older

The summary of woodlot related farm fatalities found that cases relating to the cutting and trimming of trees, harvesting of forest timbers, and cleaning of fence rows represented 10.3% of all the older farmer fatalities with an increase in the number of cases over time. The age group 65 to 74 years old accounted for 45% of the fatalities over the time period and all cases were males. Data showed that the most common type of injury was being crushed by either a tree (40%) or under a tractor (30%). The most common type of fatality was from cutting and trimming trees, representing over half of the cases (67.5%) and no fatalities were reported from injuries sustained by a chainsaw.

6.1.4 Evidence-Based Intervention Educational Strategies for Farm-Related Occasional Wood Cutting Injuries

A review of the current relevant literature confirmed that a gap exists in educational resources that promote safety of the cutting and trimming of trees performed by older farmers. A set of core competencies were developed with the help of a panel of experts to aid in the design of intervention educational strategies. The strategies involved developing an educational safety PowerPoint-based presentation with hands-on examples of safety gear and presenting displays and presentations at several educational events.

6.2 Applications of Research

The summaries of older Indiana farm fatalities involving occasional wood cutters presented in this research shows which activities have higher risk of injuries. Findings can be used to assist in safety efforts that seek to reduce the number of fatalities by promoting a better understanding of how age plays a part in increasing the risk and what agents are most commonly involved. In addition, the data illustrate which counties or areas of the state have a larger need for intervention-based safety material and trainings due to a historically higher number of reported farm fatalities.

The set of core competencies used in the design of the evidence-based intervention strategy for older occasional wood cutters can aid in the development of educational safety material and programs. The list of 12 core competencies gives safety personnel and educators a resource

prioritized instructional content that can be used to design safety instructions that can be tailored to difference lengths of available time.

6.3 Limitations of research

The comprehensiveness of the fatality data reporting and surveillance methods used in the summary portions of this research had limitations due to the lack of an official centralized reporting site gathering data and differences in reporting criteria, such as not including, in some cases, older victims who were not recognized as employees and therefore not victims of work-related fatalities. The sources used to report farm fatalities by PUASHP had limitations as well, with possible distortions in reporting over time with the introduction of the internet increasing the awareness of cases across the state. In addition, some information like whether a ROPS or PPE was used during the incident was not able to be collected.

6.4 Recommendations for Continued Research

Findings provide a starting point in addressing the critical issue of farm fatalities of older farmers in Indiana, especially for injuries resulting from the occasional cutting and trimming of trees. It is recommended that future research should address additional field testing of educational strategies to determine which methods are the most effective at promoting changes in safety behavior within this publication, and to provide more in-depth analyses of older farmer fatality reports from across the nation. Additional recommendations as follows:

- Develop experimental safety programs with farmers 55 years and older to promote safe practices for occasional wood cutters and assess which educational techniques are the most effective. Different techniques could include use of case studies as relatable stories, images of injuries sustained from different agents, or use of personal stories from people who have been injured during a wood cutting incident. Work is also needed on the media most effective to communicate safety messages to this audience.
- Expand surveillance of cases of occasional wood cutting incidents of farmers 55 years and older nationwide and summarize what agents and injuries were the most common, where they happened, and other descriptive data. This would help determine what incidents are

most common across the nation to help tailor intervention-based strategies for other locations.

- Develop a training video that specifically targets older farmers and land owners who may be exposed to chainsaw operation and occasional wood cutting activities.
- Encourage manufacturers and distributors of chainsaws to offer easily accessible training opportunities to purchasers that incorporates the added risk to older operators, importance of appropriate PPE, and safe felling practices.
- Rural emergency management training should incorporate content of safe chainsaw operation and removal of damaged trees.

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APPENDIX A. PRELIMINARY LIST OF CORE COMPETENCIES

1. **Explain why older farmers/farm owners are at risk of injuries during occasional wood cutting, including timber harvesting, tree removal, and trimming.**
    a. 30% of all farm fatalities are older farmers
    b. 7% of all farm fatalities are occasional woodcutting related
    c. Chainsaw injuries can be expensive (over $350 million per year in the U.S.)
    d. Litigation costs (can cost $100,000+)
    e. Not covered by insurance policies
2. **Identify and explain the function of the following PPE.**
    a. Hard hat
        i. Protects the user from overhead hazards
        ii. Comply with the ANSI Z89.1-1986 standard
    b. Leg chaps
        i. Prevent injuries from chainsaws due to woven fabric, such as Kevlar, which bind and kill the chainsaw before any serious injuries
        ii. OSHA requires the protection to extend from upper thigh to the boot top
    c. Eye protection
        i. Protects the eyes from potential injury to the eyes or face from foreign materials
        ii. Must comply with ANSI standards Subpart I, ANSI Z89.1-1986
    d. hearing protection
        i. chainsaw noises can reach 120 dB
        ii. Over 85 dB can lead to hearing loss
    e. safety footwear
        i. Provide protection to the feet from the chainsaw
        ii. OSHA requires coverage of the ankle and to be constructed of cut-resistant material

3. **Identify and explain the safety design features of a current chainsaw.**
    a. Front hand guard
        i. Bar in front of the top handle the prevents the hand from hitting the chain if slipped
    b. Chain Brake
        i. Stops the chain in the event of a kickback
    c. Throttle trigger interlock
        i. Prevents the operation of the throttle without proper grip on the handle.
    d. Rear hand guard
        i. Prevents injury from a broken or jumping chain
    e. Chain catcher
        i. Prevents injury from a broken or jumping chain
    f. Tip guard
        i. Reduces the risk of as kickback
    g. Easy to reach stop switch
        i. Reachable by the right thumb without letting go of the chainsaw

4. **Describe the primary causes of chainsaw kickback.**
    a. Cutting with the kickback zone
        i. tip of the guide bar (kickback zone)
    b. Contacting another limb/cutting multiple pieces at once
    c. Pinched chain

5. **Identify the kickback zone of chain bar.**

6. **Identify primary causes of non-fatal and fatal injuries while occasional woodcutting.**
    a. Contact with chainsaw chain
    b. Impact from fall trees and limbs
    c. Falls while working on ladders
    d. Tractor related
    e. Striking a limb

7. Explain why working alone increases the risk of fatal injuries.

1. No assistance
2. Slower response time
3. Accountability

8. Describe each of the following steps related to safe tree felling.

a. Top cut [12]
   i. Starting point
      1. Just leave room for undercut
   ii. Angle of attack
      1. Cut at an angle of 45 degrees
   iii. Ending point
      1. Stop when cut reaches ¼ to 1/3 of trunk's diameter

b. Bottom cut [13]
   i. Starting point
      1. cut horizontally from the bottom of the top cut
   ii. Angle of attack
      1. No angle
   iii. Ending point
      1. Stop at the end of the top cut to make a 45 degree notch

c. Back cut [14]
   i. Starting point
      1. Opposite side one inch over the notched corner
   ii. Angle of attack
      1. Stay horizontal
   iii. Ending point
      1. Stop when there's a hinge of $1/10^{th}$ of the tree's diameter

9. Describe conducting a hazard assessment prior to tree/limb cutting.

a. Assess the area [9]
   i. Signs of rot or decay on the tree
   ii. Obstacles in the around (i.e. other trees or power lines)
   iii. loose or dead limbs

b. Escape route
    i. Plan two routes opposite of the tree at 45 degree angles
    ii. Clear any obstacles

10. Describe the role of a hinge in controlling the direction of a tree as it falls.

a. Holds the tree as it falls
b. Help guide to fall in the intended direction
c. Prevent the tree from splitting, barber chairs, and other dangerous situations

11. Describe the primary types of tractor related incidents while working in wooded areas.

a. Rollover due to steep terrain
b. Rollover from improper hitching
c. Struck by limbs
d. Logs rolling back onto operator
e. Upset when hitting a stump

APPENDIX B. OCCASIONAL WOOD CUTTING SAFETY PRESENTATION FOR OLDER FARMERS

Woodlot Safety Considerations

SEAN TORMOEHLEN, M.S. GRADUATE STUDENT
W. E. FIELD, PROFESSOR
AGRICULTURAL SAFETY AND HEALTH PROGRAM
PURDUE UNIVERSITY
WEST LAFAYETTE, IN

Woodcutting is hazardous

- Estimated 115,895 emergency department visits due to injuries from chain saws in the US from 2009 to 2013 (Hammig & Jones, 2015)
  - Most were due to lacerations
  - Average chainsaw injury requires 110 stitches
- Average medical cost was $12,000 in 2000
- Occasional woodcutters are more likely to get injured compared to professional loggers (Fischer et al, 2005)
  - A study in Wisconsin find more than three times the occasional wood cutters were injured
  - Lack of experience
- Represented 7% of all farm fatalities for farmers 55 years and older in Indiana from 1988 to 2017

I may be getting old, but I can still spot safety violations. This man has no hard hat, no safety glasses, no hearing protection and no gloves!

What kind of injuries

- Contact with chainsaw chains
  - Most lacerations happen to hand/fingers, knee, lower leg or ankle, and upper leg
- Impact from falling trees and limbs
  - Cause the most fatal injuries
- Tractor-related
  - Overturns
  - Logs rolling onto the operator
- Falls while working on ladders

Sritharan et al. 2018

How to prepare?

- Chainsaw
  - Make sure you know how to operate
    - Read the owner's manual
    - Attend a chainsaw usage and felling safety class
      - Held by extension, universities, and other organizations
  - Maintenance
    - Make sure the chain is sharp
      - A dull chain makes cutting harder and increases the risk of injury (USDA Forest Service, 2006)
    - Chain tension
      - The chain can slip off if too lose or bind and overheat if too tight

https://www.harborfreight.com/3-piece-chain-saw-file-set-91992.html

How to prepare?

- Chainsaw chaps (USDA Forest Service, 2006)
  - Prevent serious lacerations to the legs
  - Made of Kevlar fibers designed to get pulled out and jam the chainsaw
  - Must properly fit - 2 inches past boot
- Hard hat
  - Check to make sure they comply with ANSI Z89. 1-1986 to ensure they pass proper testing requirements
  - *"Measures to reduce nonoccupational logging fatalities should focus on promoting safe tree-felling practices and increasing helmet use among nonprofessional woodcutters."* (CDC, 2008)

https://i.ytimg.com/vi/wmstQAE_bpI/maxresdefault.jpg

https://www.husqvarna.com/au/parts-accessories/personal-protective-equipment/

https://bit.ly/2ZoFaRc

How to prepare?

- Full-face shield or safety goggles
  - Prevent eye injuries from flying wood chips, twigs, and sawdust
- Ear protection (USDA Forest Service, 2010)
  - Chainsaws have a noise level of 89 to 110 dB
  - Over 85 dB can lead to hearing loss
    - Exposure time to 106 dB for just 4 minutes can cause hearing loss
- Boots
  - High top ankle support to protect from lacerations (The Ohio State University Extension, 2006)
- Work in pairs
  - Never work alone

https://www.sterlinghearingcenter.com/types-hearing-protection/

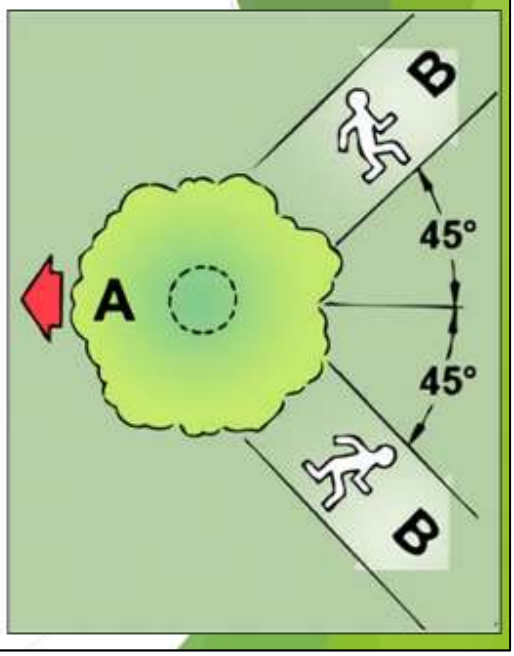
Preparing to fell a tree

- Perform a hazard assessment of the work area (MU extension, 2017)
  - Look at lean of the tree and for any uneven distribution of branches
  - If the tree is decaying or rotten
  - Any loose, dead limbs that may fall while cutting
  - No obstacles in the way of the tree falling to the ground
- Determine your skill level
  - Okay to seek a professional opinion
  - Look for alternatives to cutting
    - Herbicide applications
    - Does it need to be cut?

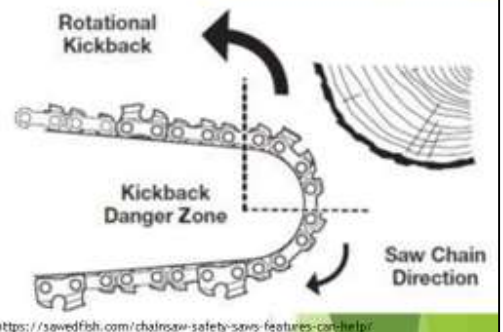
https://www.bartlett.com/blog/2016/12/tree-pruning/structural-pruning

Preparing to fell a tree

- Plan two escape routes
  - Make them opposite of planned direction and at 45 degree angles
  - Remove any tools, branches, or other objects in the way
  - Don't run with a chainsaw
- Make sure others are out of the way



What could go wrong?



https://sawedfish.com/chainsaw-safety-saws-features-can-help/

- Kickback (eXtension, 2016)
  - Generally referred to as the most dangerous reaction force
  - Happens when the chain is pinched or stopped for a second
  - Resulting reaction forces cause the chainsaw bar to be thrown towards the head, neck or shoulder area of the operator
  - Kickbacks result in the chainsaw moving up to 30 mph (Pratt, 1985)
  - What you can do (UGA extension, 2013)
    - Do not cut with the kickback danger zone
    - Maintain a firm grip with both hands
    - Safety features on the chainsaw
      - Chain brake - designed to stop kickbacks in a fraction of a second
      - Anti-kickback chain - reduce the forces on the chain

http://extension.uga.edu/publications/detail.html?number=B1364&title=Chainsaw%20Safety%20Tips

Case Study 1

- "*Handyman Died When Tree He Was Felling Split Vertically and Struck Him*" (MI FACE report, 2013)
  - During winter of 2012 a male in his later 50s was cutting down a tree for a farmer
    - Had recently retired and worked part-time for the farmer
    - Had successfully cut down trees for the farmer previously
  - The victim was working alone to cut down a 3-4 foot diameter box elder
    - Tree was at a 45-degree angle
  - As the victim made a cut the tree barber-chaired at the cut and struck the victim
    - Did a straight cut on the opposite side of the lean with no undercut
  - Tree landed on his back and pinned him face down in a sitting position
  - The farmer was on his tractor and noticed that the tree fell the wrong way from a distance
  - He found the victim and called 911

Case Study 1

- Potential Preventative Measures
  - Important for tree fellers to perform a tree assessment before any cutting
    - What to look for includes:
      - Intended direction of the fall
      - Natural lean of the tree
      - Any unusually heavy limb structure
      - Surrounding trees and obstacles
      - Wind direction and speed
  - Use the best felling technique for the specific tree
    - In this scenario the tree had a strong forward lean
    - Different cuts would have reduced the chance of a barber-chair
  - Always work in pairs
  - Understand when you may be in over your head
    - Better to be safe than try to do action that makes you uncomfortable

Case Study 2

- "*Timber Cutter Dies After Being Struck by the Tree He Was Felling in West Virginia*" (WV FACE report, 2003)
  - In 2002 A 48 year-old male was cutting timber for a logging operation
    - Had been felling trees for over 25 years
    - Refused to attend chainsaw safety training programs
    - Was not wearing PPE at the time of the incident
  - Was cutting down a 15 inch diameter maple with a slight uphill lean
  - His partner expressed some concerns and offered to help the victim to direct it downhill
    - The victim refused and was reported to perform the cutting very quickly with no notch or hinge
    - Failed to clear an escape route
  - Once cut the tree began to fall in the wrong direction up the hill
  - One of the victim's feet got entangled in brush as he escaped
  - The tree ended up striking the victim in the chest
  - Emergency personnel arrived after 30 minutes and the victim died on the scene

Case Study 2

- Potential Preventative Measures
  - Important to understand proper chainsaw and tree felling techniques
    - Attend trainings
    - Seek professional opinions
    - Know when you are in over your head
  - Perform a risk assessment
    - Do not rush
    - Determine the lean to see if any adjustments need to be made
  - Clear an escape route before making any cuts
    - Easy to trip on vegetation