Estimating the Burden of Serious Farm-Related Injury in Minnesota

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Abstract

Minnesota was ranked 6th in the United States for total sales of agricultural product, with just over $13 billion in sales in the year 2011. Only 1.1% of Minnesota's workforce was employed in agriculture for the year 2011. However, this small portion of Minnesota's workforce has one of the highest work-related fatality rates, with 28 (40%) of the 70 work-related deaths that occurred in the year 2010 associated with agriculture. While the number of agricultural fatalities that have occurred in Minnesota is well documented and counted, the number of non-fatal injuries is not. To address this issue the Minnesota hospital discharge data set was used to create counts, rates, and trends of agricultural injury for the years 2000-2011. These counts were used with the Cost of Illness model to create estimates of the economic burden of agricultural injuries in Minnesota for the years 2004-2010.

Using a set of seven external cause of injury codes, or E codes, more than 2,000 injuries per year with a relationship to agriculture were identified with the hospital discharge data set. The identified cases were categorized into *probable* or *possible* depending upon the E code present in the billing record. These designations were created as two of the E codes, E849.1 (occurred on a farm) and E919.0 (a relationship to agricultural machinery), have a greater specificity for a relationship to agriculture than the remaining five E codes. An average of over 500 cases were identified annually with a *probable* case designation. Trend analysis of all identified cases found a non-significant average increase of 1.5% annually for the study time period, 2000-2011.

Estimated annual costs, in 2010 dollars, for agricultural injury ranged between $21 and $31 million for the time period 2004-2010. The majority of the costs are attributed to the indirect costs, such as lost productivity at work and home, and the costs associated with fatal injuries. These estimated costs were found to be of similar magnitude to costs for motor vehicle and bicycle accidents, diabetes, and heart disease in Minnesota.

The research has demonstrates that hospital discharge data provides a readily available source of information for tracking agricultural injury, allowing for limited surveillance and evaluation of future intervention endeavors and policy implementation. The magnitude of the associated costs argue for better and continued surveillance of these injuries, as well as evaluation of future interventions and policy to prevent the burden of injury agricultural work imposes on workers, their families and society.

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Chapter One: Introduction

Agriculturally-Related Injury – the Impact

The agricultural industry has been consistently ranked as one of the most dangerous, with over 600 deaths nationally related to agriculture in the year 2010 (1, 2). In Minnesota, 28 (40%) of the total 70 occupational fatalities in 2010 were associated with the agricultural sector. Between years 2003–2010, 26% of all occupational fatalities in Minnesota occurred on a farm (3). The high risk of injury and death associated with agricultural work has been well established in the literature (2, 4-7). Agricultural workers are exposed to a myriad of hazards including: chemical exposures, noise, dust, animals, mechanical exposures, biological exposures, and psychological stresses, creating an environment rife with opportunities for injury and illness. While it is well understood that agricultural professionals are at increased risk of injury the number and cost of these events over time has not been well described. A method to describe the number and trend of these events on a continual basis is a much needed resource for occupational safety and health professionals to evaluate and monitor the effectiveness of established intervention and prevention strategies and policies.

Definition of Agricultural Injury

Depending upon the question of interest and data set of use, injury can be classified in a number of ways. OSHA defines a recordable case of injury as those that result in: death, loss of consciousness, days away from work, restricted work activity or job transfer, medical treatment (beyond first aid), significant work related injuries that are diagnosed by a physician or other license health care provider, any needle stick or cut from a sharp object that is contaminated with another person's blood or potentially infectious material, and any case requiring an employee be removed under the requirements of an OSHA health standard (8). Workers' compensation covers any injury caused or made worse by work or the workplace environment. Previous studies, such as the Regional Rural Injury Study – I (RRIS – I) utilized the following definition of injury: "restriction of normal activities; and/or loss of consciousness, loss of awareness, or amnesia for any length of time; and/or the use of professional medical care." (4). Work by Lubicky et al identifying fractures and amputations in children after farm equipment injuries used diagnostic codes to identify fractures, excluding skull fractures, and amputations with an accompanying E code of E919.0 (agricultural machinery related) (9). Meyer et al also used E code E919.0 in the North Carolina hospital discharge data set to identify cases of injury related to agricultural machinery (10). Zaloshnja et al used death certificate data to identify fatal incidents among youth that occurred on a farm. To identify these cases the ICD – 10 external cause of injury codes identifying the cause of death as injury with an accompanying code of W30 or V84 (Farm/Ranch location or contact with agricultural machinery; occupant of special vehicle mainly used in agriculture injured in transport accident) were used(11). Each of these studies and programs makes use of a different method to define or classify an injury based upon data capture methodology and intended use.

The definition for this study will be less expansive than the definition provided by RRIS – I. This study will define injury as any non-disease event requiring more than first aid treatment with the receipt of medical care in a hospital, emergency room, or hospital affiliated clinic with an accompanying code identifying the injury as related to agriculture. The definition for this project is limited due to the use of hospital discharge data for surveillance; therefore the study will be describing injury severe enough to require medical attention in a health care setting.

Farm or agriculture-relatedness has been previously defined as an event, injury, or task relating to the farm or agricultural operation, including activities such as transportation on roadways, raising of livestock, tending to crops, repair of machinery, and maintenance to structures on the farm property (12). As these tasks may blur the line between production and recreational work, it is difficult to ascertain when injury may have been solely related to farm production and not a recreational activity. The inclusion of these recreational or "home" related activities stem from the very nature of the farm being both a work site and place of residence; this creates a significant dilemma when trying to separate injuries related solely to the operation of the farm as often these tasks and duties are associated with both work and home life. As such a designation is not always possible, the assumption is made that all or the majority of injuries occurring on a farm are related to its operation and production. Identifying these agriculturally-related serious injuries for the creation of baseline counts and rates will aid in the evaluation of the need and success of prevention and intervention policies (2, 4, 5, 13, 14).

Agricultural Injury Counts and Rates

The Regional Rural Injury Study II, a follow up to RRIS – I, calculated an injury rate of 4.5 per 1,000 persons per year among the 16,538 individuals surveyed for a six month study period in 1999 (5). The Survey of Occupational Injuries and Illnesses (SOII) reported 7.0 total injuries and illnesses and 2.0 cases with days away from work per 100 full time equivalent employees in the agricultural and forestry industries during 2012; however this estimate excludes all farms with eleven or fewer employees (15).

The agricultural/farm environment is so varied in terms of possible exposures and mechanisms of injury, the types of injury that occur are also quite varied. The most common types of injury were abrasions, sprains or strains, and fractures of the extremities. Fingers, arms, and legs were the body parts most frequently affected (2, 9, 10, 16-23). The mechanism of injury is also varied and includes falls to another level, animals, machinery, and transportation (4, 10, 16-18, 20, 22, 24-32). Adult males were more likely than females to have an injury related to farm machinery (4, 29, 33-35). Women were more likely to become injured due to interaction with animals (28, 33, 35). Younger adults and children were more likely to be injured than older adults due to stand by or bystander events (9, 12, 34, 36-41).

Cost of Agriculturally-Related Injury

A 1992 cost estimate by Leigh et al found that injury related to work in agriculture cost the nation $4.57 billion, equivalent to almost $8 billion in 2011(42). The estimate was created using injury estimates from the Bureau of Labor Statistics (BLS) and adjusted for the known undercount associated with the annual survey. Even with this undercount the estimated cost for injury related to agriculture in 1992 exceeded the costs to treat hepatitis C cases for the nation, a chronic condition with life-long treatment requirements (42). This is the most recent estimate of the cost to society for all injury related to agriculture. Therefore we are unable to determine if the costs associated with agriculturally-related injury have changed over the past 20 years.

The financial impact of agriculturally-related injury is quite substantial. Agricultural injury cost Britain an estimated £94 million, equivalent to $148 million (1981 dollars) in U.S. dollars, between 1981 and 1982. Almost two-thirds (£62 million ($97 million)) of the cost responsibility fell to the farmer/employer (43). Costich et al found an average of $12,056 in physician payments for the 295 agricultural hospitalizations that occurred in Kentucky between the years 2003 and 2007 (44). Zaloshnja et al (45) estimate that the cost of nonfatal farm youth injury in the U.S. for the period 2001 – 2006, was approximately $1 billion, with 9.3% related to medical costs, 37.2% related to losses in work and household productivity, and 53.5% related to lost quality of life.

Farming in Minnesota

The Census of Agriculture (Ag Census) for the year 2007 recorded 80,962 farms in Minnesota, with an average farm size of 332 acres. The majority of these identified farms 70,055 (86.5%) were family or individually owned, with another 6,277 (7.7%) owned through partnerships and the remaining 4,710 (5.8%) owned by corporations, co-operatives, estates, institutions, or other unnamed entities (46). The 2007 Ag Census estimates 117, 552 farm operators were employed in Minnesota, defining an operator as,

> "one who operates a farm, either doing the work or making day-to-day decisions about such things as planting, harvesting, feeding, and marketing. The operator may be the owner, a member of the owner's household, a hired manager, a tenant, a renter, or a share cropper." (46).

The majority of these operators were male (74.3%) between 45 and 54 years of age (29.8%), had been working for 10 or more years on the current farm (77.7%) and resided on the farm they worked (77.5%). However, over half (53.6%) described another job as their primary occupation and over half of the farms (66.9%) were run and managed by a single operator (46).

Between 2002 and 2007 the Ag Census noted an increase in the number of farms nationwide, including a 0.1 – 2.0% increase in the number of farms in Minnesota (46). The advancing age of operators, the conflicting demands of their multiple jobs, and the number of other individuals engaged in agricultural work, whether for pay or not, create an increase in hazardous situations where injury could occur.

Surveillance

Surveillance of injury and illness related to occupation has been a continuing challenge to public health infrastructure (47-49). Surveillance of injury related to agriculture is further complicated by the fact that the data sources frequently utilized to create counts and rates of occupational injury do not regularly, if at all, collect data pertaining to those employed in agriculture. To date, active continual surveillance of non-fatal agricultural injury is not conducted in Minnesota. Studies have attempted to quantify the magnitude of injury within agricultural populations, but surveillance has not been conducted in an ongoing and systematic manner. The need for a system to capture agriculturally-related injury has been well documented (1, 2, 10, 17, 20, 23, 50, 51).

The SOII conducted by the BLS in co-operation with state labor departments, provides estimates of the number injuries and illnesses that occur within a given year by industry and occupation (7). These estimates are derived from a sample of employers and based on data collected and maintained in the employer's OSHA 300 log and participation is voluntary. Some employers are exempt from participating in the SOII, such as farms with fewer than 11 employees (7). The SOII does not account for family members or children, who participate in farm activities but do not receive wages and are too young for capture in the survey. Therefore, a large portion of the agricultural working population is not captured. Even with these exemptions and exclusions, the SOII estimates an incidence rate of 8.1 injuries and illnesses per 100 full-time-equivalent workers among those employed in agriculture, forestry, fishing, and hunting. Individuals employed in crop production were found to have a higher injury rate (10.3) than those working in animal production (5.3) using national estimates for the year 2011 (7).

The National Safety Council (NSC) produces a yearly report of facts and figures related to injury. In the 2010 NCS report, work in agriculture, forestry, fishing, and hunting across the nation was responsible for 3,582 fatal injuries and 5,100,000 non-fatal injuries requiring medical attention (52). To create these estimates of death, injury, and illness the NSC utilizes data from the BLS, thus the estimates have the same limitations as the SOII (i.e., the exclusion of farms with fewer than 11 employees).

The Census of Fatal Occupational Injuries (CFOI) captures all deaths related to occupation including those in the agricultural industries (53). CFOI utilizes death certificate data, media reports, coroner reports, and police reports to capture these cases of death. The CFOI requires at least two sources of data to confirm a death is related to occupation. Deaths related to agriculture are well captured by CFOI; however, a similar system for non-fatal injury has not been developed.

Workers' compensation claims datasets are also frequently utilized by health and safety specialists to estimate the counts, rates, and trends of occupational injury and illness. However, similar to the OSHA reporting guidelines, several exemptions exist that exclude farmers from having to maintain workers' compensation insurance coverage. Farms that are owner operated or have an employee population made up of family members are exempt from carrying workers' compensation insurance. Minnesota workers' compensation insurance exemptions also exist for farms with a payroll less than the legally established threshold for farms that hold liability and medical insurance coverage that meet state standards (http://www.dli.mn.gov/WC/PDF/1111c.pdf) (54). The injury cases available within the workers' compensation claims database include only the agricultural operations that did not meet one of the following exceptions: family member of a sole proprietor/farmer-employer or the payroll exemption that met state standards (MN Statute 176.04). According to the BLS Current Population Survey (CPS), almost 74,000 individuals in Minnesota were employed in either crop or animal production for the year 2010. Because the majority of Minnesota farming operations are individually or family owned and operated, the injuries that occur on these farms are unlikely to be captured by either the workers' compensation claims data or the SOII. In recent work by Leigh et al, an estimated 77.6% of all injuries and illnesses related to agriculture were missed by the SOII (55).

Specific Aims and Research Objectives

The lack of methodology for the ongoing surveillance of agriculturally-related injuries at a statewide level creates a significant obstruction in our overall vision of the magnitude of work-related injury and hinders our ability to prioritize, develop, and evaluate effectiveness of prevention strategies. The following objectives were developed to address these needs:

- Estimate the rates and trends of agriculturally-related injuries as identifiable in Minnesota hospital discharge data between 2000 and 2011.
- Estimate the economic impact of these injuries between 2004 and 2010

With limited resources and an expanding list of concerns public health professionals require information that can be utilized to prioritize and assign resources, as well as evaluate the effectiveness of public health outreach. The findings of this study document the magnitude of serious injuries requiring medical attention related to agriculture that occur in Minnesota, both in terms of rates and trends and the associated economic burden to the individuals and society. Hospital discharge data was used to estimate the frequencies, rates, and trends of agriculturally-related injuries that occur each year in Minnesota. This research then built upon these estimates to create cost models that estimate the financial burden to society created by these agriculturally-related injuries. The novel approach used to estimate the costs in this study will provide a methodological approach that could be adopted by the public health community to investigate the economic burden of agriculturally-related injuries in other states.

As described by Finkelstein et al (56), while cost estimates will not provide details on how to intervene, they do provide a starting point for quantifying the potential benefits for developing and implementing successful interventions. Also, evaluations of future injury interventions will be based upon how efficiently they reduce the burden of agricultural injury. Cost data is a useful metric when gauging the relative impact of various problems, issues, risks, concerns, setting priorities, and selecting interventions that most efficiently reduce the injury burden (11). These advantages were also described by Tormoehlen et al (57), who categorized the potential benefits of estimating the impact of farm-related injuries as follows:

- Identifying the most costly farm-related injuries
- Providing a realistic picture of the total costs
- Acquiring evidence for the justification of funding to support prevention programs
- Establishing fair and equitable estimates of the economic impact for liability from farm-related injuries
- Provides a base for the design of realistic disability and health insurance programs with adequate coverage in the event of a farm-related injury.

This study contributes to the improvement of surveillance within the Agriculture, Forestry, and Fishing (AgFF) sector and describe the nature, extent, and economic burden of occupational illnesses, injuries, and fatality, occupational hazards, and work populations at risk of adverse health outcomes (58) thereby addressing one of the National Occupational Research Agenda (NORA) Agriculture, Forestry, and Fishing (AgFF) sector strategic goals.

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Chapter Two: Literature Review

Farm Injury Studies

A review of the literature was conducted using PubMed, Google Scholar, and Endnote. Search terms included Farm, Agriculture, injury (fatal and nonfatal), machinery, animals, and costs or burden. No limitations were set regarding geography or time period as there is a limited number of publications, with current literature often building upon earlier work.

The most severe of injuries, those that result in death are well documented through systems such as the Census for Fatal Occupational Injuries (CFOI) which provides a complete count and description of all work related fatal injuries. Final data for 2011 from CFOI indicated that the national fatality rate for those with farming or ranching as a major occupation was 24.9 per 100,000, more than seven-fold higher than the all-occupation national fatality rate of 3.5 per 100,000 (1). In Minnesota in 2010, 28 (40%) of the 70 occupational fatalities that occurred within the state, were related to agriculture. In comparison 19 (31.7%) of the 60 work-related deaths that occurred in Minnesota in 2011 were related to agriculture (2).

In contrast to fatal work injury reporting there is no systematic capture of non-fatal injuries, although several studies have estimated the number of injuries related to agricultural work that have occurred in a single year. Many studies have investigated the risks associated with specific farming activities and/or exposures of individuals working with animals, crop production, agricultural machinery, weather, and chronic stress (3-18). These studies have provided valuable information detailing the numerous hazards and exposure pathways the farming population encounters on a recurring basis as well as baseline data on the number and rates of injury related to agriculture.

A set of studies, the Regional Rural Injury Studies (RRIS) I and II, are of particular interest to the current study as a portion of the population for the RRIS studies was based in Minnesota (6, 19). RRIS I measured injury outcomes in rural populations from Minnesota, Wisconsin, South Dakota, North Dakota, and Nebraska. The RRIS I collected data from a random sample of 1,600 farming operations from each of the five states. The sample was compiled from a list generated by the United States Department of Agriculture (USDA) National Agricultural Statistics Services (NASS). The RRIS I found the predominant types of injury related to farming were lacerations, contusions, and fractures. Of all the injuries, 40% were related to animal care and management, and while 83% of these injuries required some form of medical care, only 3% required hospitalization (6). The RRIS II had a random sample of 3,200 farms and ranches drawn from Minnesota, Wisconsin, North Dakota, South Dakota, and Nebraska utilizing the USDA NASS master list. RRIS II found an injury rate of 74.5 per 1,000 people, with higher rates among adults. The leading sources of injury were animals (34%), falls (24%), and large machinery (18%). Injuries requiring hospitalization had increased to 4.3% while 81.9% required some form of medical care (13, 14, 19). RRIS II also calculated an injury rate of 6.4 per 1,000 people for those classified as bystanders to daily farm activities (16, 17).

Animals and machinery are two of the most commonly cited hazards associated with the increased risk of injury associated with farming operations. Studies have found a range of 20 to 48% of hospitalized farm injuries are related to agricultural machinery. The contribution of machinery to an increased risk of injury has been replicated in many studies (5-7, 9, 10, 18, 20-31).

While injury from agricultural machinery was associated with males, injury from an animal was more frequently associated with females (10, 15, 22, 23, 27, 32). Injury to a farm operator or employee by an animal is one of the more common mechanisms of injury, including falling from or being struck by an animal (5, 23, 33, 34).

Several studies of farming communities have been completed, including studies by the Ohio Commission of the Prevention of Injury, and the Ohio, Colorado, and Iowa Farm Family Health and Hazard Surveillance Studies. Each of these studies investigated the risk factors associated with injury and illness in agricultural populations. Each study found males to be at increased risk and the Ohio study found 30 – 40 year olds at greatest risk (35, 36). Common mechanisms of injury included machinery, falls, and animals (35-38). The study of Colorado farmers found that those who were injured were more likely to have gone into debt, providing important context when describing the impact of agricultural-injury beyond health effects (35). While only a small fraction of the injury that occurs in association with farming and agricultural work requires inpatient hospitalization, the impact can be substantial as farmers are often self-employed or working seasonally.

Occupational Injury and Illness Surveillance Literature

The surveillance of occupational disease and injury is a difficult endeavor. The challenges associated with collecting complete counts of disease and injury related to occupation has been well documented (39-49).

The most widely utilized source for the tracking of occupational injuries and illnesses at both the state and national level is the Survey of Occupational Injuries and Illnesses (SOII) conducted by the Bureau of Labor Statistics (BLS). The SOII uses information captured on the OSHA 300 log from a random sample of employers to create estimates of the number of injuries and illnesses related to occupation that have occurred in a single year (50). However, recently the SOII has been criticized for producing an undercount of injuries and illnesses (51). A limitation of SOII of even greater importance to identifying agriculturally-related injuries, the SOII does not collect information on farm establishments with fewer than eleven employees. With the exclusion of small farms and the potential undercount, the SOII does not provide a complete estimate of the number of agriculturally-related injuries that occur on an annual basis. The estimates of agriculturally-related injury created by this study may be used to fill the significant gaps in coverage created by the SOII.

A second data source routinely used for evaluation of occupationally-related injury or illness is workers' compensation claims data (52-56). While workers' compensation claims data detail the injury event and outcomes, a number of external restrictions prevent a complete capture of occupationally-related injury and illness by these data systems. State laws vary by which industries and employers are required to carry workers' compensation coverage, as well as the types of injury and illness covered, and the required waiting period before an individual would be eligible to receive workers' compensation (57). Furthermore in Minnesota workers compensation companies are only required to provide cases involving indemnity to the Minnesota Department of Labor. Also there is evidence to suggest that a number of work-related injuries are never submitted as workers compensation claims for a number of reasons ranging from discouragement by management to employee beliefs that injury is "just part of the job" (58-60). These regulatory variations and limitations greatly limit the usefulness of workers' compensation data for surveillance or research of injury and illness risks for specific segments of the working population. In particular, the exclusion of small family farms, farms with fewer than 10 employees, and farms that carry liability and health insurance coverage at levels defined in statute prevent the use of workers' compensation claims for surveillance of agriculturally-related injury (61).

Other states and national programs utilize secondary datasets to create estimates of occupational injury and illness. A collaboration of epidemiologists and researchers with the Council of State and Territorial Epidemiologists (CSTE) and the National Institute of

Occupational Safety and Health (NIOSH) have created a set of indicators of occupational safety and health utilizing available secondary datasets (62). These indicators make use of a wide variety of data sets including: hospital discharge data, death certificate data, blood lead surveillance data, cancer surveillance data, selected workers' compensation data, CFOI, OSHA records, poison control center data, SOII, Census, and the Current Population Survey. Despite the limitations associated with each of these data sources, their standardized definitions and availability has greatly expanded the capacities of states to conduct ongoing surveillance of occupational injury and illnesses at a state-wide level. As of 2012, 23 states have been funded by NIOSH to collected and disseminate some 20 occupational health indicators. Funded states are also encouraged to develop, evaluate, and recommend additional indicators that could be utilized in other states. The importance of agriculture in Minnesota and many other states, the lack of methods for monitoring the rates, trends, and economic burden of nonfatal injuries in this high risk industry, and the demonstrated utility of secondary data sets to enhance surveillance provided the impetus to pursue the use of hospital discharge data to describe agriculturally-related injury.

North Carolina, South Carolina, Kentucky, and Canada have made use of hospital discharge data, trauma registries, emergency medical services run data (which capture ambulance care) and medical examiner reports or coroner data to capture injury cases related to farming and agriculture. The Canadian Agricultural Injury Surveillance Program (CAISP) makes use of hospital discharge data and medical record review to identify agriculturally related injuries. The CAISP is a national system allowing for surveillance and comparison across provinces. With the use of the CAISP system a total of 8,263 injuries were identified and verified between April 1991 and March 1995. The system identified adults 60 years of age and older at increased risk and the leading mechanism of injury involved agricultural machinery; the leading types of injury were a fracture or open wound (7).

With the use of hospital discharge data, 827 farm-related injuries were identified within the years 1996–1998 in South Carolina (63). Males between the ages of 35 and 64 were the group at greatest risk of an agricultural injury. The most common site of injury reported was to the lower limbs. To find or identify these cases of agricultural injury the external cause of injury codes (E codes) E919.0 and E849.1 were used. These two E codes are used to identify a hospitalized case as either occurring on a farm (E849.1) or related to the use of agricultural machinery (E919.0). The cases identified with the South Carolina hospital discharge data showed an approximately equivalent number of cases each year for three years (63).

A review of hospital discharge data from Kentucky for the years 2003 to 2007 identified 295 cases of injury related to agriculture (64). The identified cases were used to estimate the average cost associated with a hospitalized agricultural injury case, approximately $12,056. The data were also used to describe the pattern of payment for these injuries, noting that only 5% of cases had health care costs covered by workers' compensation and a large portion (38%) was covered by Medicare and Medicaid. The researchers used the data source to conduct surveillance and draw attention to the burden of agricultural injury in Kentucky (64).

The need for a surveillance system to capture counts, rates, and trends of agriculturally related injury and illness has been well delineated in the literature (3, 4, 8). Interestingly Gunderson et al in 1990 (3) state that "…the routine use of hospital based data was ruled out, at least until Minnesota is covered by a (statewide) hospital discharge data system" when discussing options for surveillance methods. Today Minnesota has a hospital discharge data system that covers the majority of Minnesota hospitals, excluding federal and the Indian Health service institutions, making this dataset a viable source for surveillance that should be explored further.

Cost of Occupational and Farm-Related Injury

A select few researchers have utilized these available occupational and agricultural injury studies to estimate of the economic and societal costs related to these injuries.

Leigh et al (65) estimated a total of $14.5 billion for medical costs alone in 1999 related to fourteen occupational illnesses across all industries in the United States. To create this cost estimate the attributable risk related to occupation was calculated for each disease and the associated costs from hospital care, professional services, nursing homes, and medical products were summarized. This analysis of cost associated with disease related to occupation found that circulatory disease among 24 to 64 year olds, cancer, chronic obstructive pulmonary disorder, and asthma were the top 4 conditions contributing to the large expense.

A 1992 cost estimate for California by Leigh and colleagues (66) found that occupational injury and illness within the state cost an estimated $20.7 billion. Using the human capital method the direct costs, medical and administrative, were estimated at $7.04 billion and the indirect costs, wages and benefits, and were estimated at $13.62 billion. To create these estimates the average medical costs associated with a specific injury was calculated and multiplied by the number of injuries. An average indirect cost was created and multiplied by the number of persons injured or ill. The authors noted the estimate created for California to be an underestimate of the true cost as it did not include costs associated with pain and suffering, care provided by the family, as well as a concern that the count of those injured or ill was incomplete.

Waehrer et al (67) created state cost estimates for comparison between states of the financial burden related to occupational injury. The cost estimates revealed that industries and occupations such as farming, mining, construction, manufacturing, and transportation had the greatest impact on the total costs associated with injury. Consequently costs varied by state depending on the composition of industries and occupations within its borders.

Leigh et al (65) provided a more recent estimate of the economic burden of occupational injury and illness in the United States for the year 2007. Attributable risk fractions for illness and injury related to occupation were calculated for the nation. The Cost of Illness method was then used to create direct and indirect cost estimates. These estimates were combined for a total cost estimate of occupationally related injury and illness of $250 billion, of which an estimated 77% was attributed to occupational injury (65).

Several papers have detailed the utility of cost data when considering policy and intervention changes to address the associated risk of established agricultural practices (68-73). Kelsey et al (74) provide a compelling statistic from their cost analyses of farm injury: less than five years after a fatal injury 67% of families no longer work the farm and 44% no longer lived on the farm. The total cost related to these 52 agriculture deaths was over $8.6 million.

In a 2001 article Leigh et al (75) estimated the 1992 cost to the nation of agricultural injury at $4.57 billion. With inflation these costs would be equivalent to almost $8 billion in the year 2011. Costich (64) found that only 5% of injuries related to agricultural injury in Kentucky were covered by workers' compensation, with the remaining bulk of the health care costs covered by private insurance, self-insurance, Medicare, Medicaid, and out of pocket. The economic burden from occupational, specifically agricultural, injury is significant and should be well documented for use by public health researchers, professionals, and policy makers.

Cost Estimation Models

Several methodologies exist to create estimates of costs related to injury and illness. The Willingness to Pay, Friction, Human Capital, and Cost of Illness methods have all been utilized to create cost estimates related to occupational injury and illness (76-78). The Willingness to Pay model estimates costs by attempting to assign values based upon how much people are willing to pay to avoid the disease or injury. The Friction method estimates costs by creating measures that account only for the production time lost to society; only the costs associated with the time between injury and replacement of the worker are included. The Human Capital method and the Cost of Illness method are similar to one another, although the Human Capital method includes a cost estimate to describe the economic value associated with the lost quality of life (76, 77, 79-82).

The majority of the available literature describing the burden and impact of occupational injury has made use of the Human Capital and Cost of Illness methods. These two methods are often selected as the data necessary to create cost estimates utilizing the Friction or Willingness to Pay methods are not readily or easily available. Leigh et al found that in practice the Willingness to Pay method was difficult to implement as individuals have difficulty understanding how much one would be willing to pay to avoid an occupational injury or illness (65, 66, 75, 76, 83, 84). Factors such as unemployment insurance and the need for (or to keep) income to obtain daily necessities may unduly influence an individual's willingness to participate in risky occupational endeavors. Instead Leigh et al (65, 83, 84) created direct and indirect cost estimates to fulfill the requirements of the Human Capital method. Similarly Finkelstein et al (77) utilized a method akin to the Human Capital method and the Cost of Illness method when creating estimates of the economic burden of injuries in the United States. Previously Miller et al (85) had created a document describing the incidence, costs, and consequences of nonfatal injury in the United States. Biddle et al (78, 86) continued the estimates of costs related to injury utilizing the Cost of Illness method proposed in these previous works to create estimates of the cost of fatal occupational injury in the United States, as well as by different industry sectors . The Cost of Occupational Injuries and Illnesses written by Leigh et al (76) utilized the Human Capital method; available workers' compensation claims data, and attributable risk fractions to create, direct and indirect cost estimates for specific occupational injuries and illnesses.

Previous research estimating the economic impact of agricultural injury or illness predominantly utilized the Cost of Illness or Human Capital methods. With the use of similar methodology one is able to compare cost estimates between different types of injury or illness. These methods also account for both the direct medical costs and associated administrative and care costs as well as the accompanying indirect costs such as lost wages, home production, and lost quality of life.

Limitations

Much of the available literature characterizing agriculturally-related injuries and costs represent intensive and costly research protocols that - while yielding incredibly valuable and detailed information and data – would not be sustainable for a statewide ongoing surveillance program. Resources would not be available to utilize, for example, the methodology of the RRIS studies or the Olmstead Agricultural Trauma Study.

Unfortunately the data sources available for surveillance of work-related injury and illness exclude large portions of the agricultural population and are ill-suited to the surveillance of injury related to agriculture.

While previous research documents the significant financial and societal burden of agricultural and occupational injury in various populations and time periods, this information has not been recently updated and the financial burden specific to Minnesota has not been investigated.

While the majority of studies make use of the Cost of Illness or Human Capital methods, these methods may not accurately reflect the true economic burden of injury and illness on society. However, the data necessary to estimate these costs using the Willingness to Pay or Friction methods are not easily or readily available. All methods are limited by the use of secondary data sources, and estimation of multiple variables within the models to create total cost estimates.

This study will fill significant gaps in the literature providing a method to create estimates of counts, rates, and trends of agriculturally-related injury in states. The study also provides a cost estimate of the burden related to these injuries that can be utilized by other states in describing the impact of injury. These measures will aid in understanding the impact of agricultural injury in Minnesota.

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Chapter Three: Research Design and Methods

Introduction

To address the specific aims of this study multiple secondary data sources were used. The first specific aim addresses the estimation of rates and trends of agriculturally-related injuries using Minnesota hospital discharge data for case ascertainment. However, no single dataset was sufficient to provide an appropriate count of those living and/or working on a farm in Minnesota. Eight data sources were identified and compared for their utility in providing the necessary count data, and the associated methodology is described below. The second specific aim of this study addresses the economic impact of agriculturally-related injuries. The associated methodology is described in a later section of the chapter.

This research was approved by the University of Minnesota and the Minnesota Department of Health Institutional Review Boards, Appendix 1.

Frequencies and Trends of Agriculturally-Related Injuries

To capture the burden of agriculturally-related injury requiring some form of medical treatment, including inpatient hospitalization, emergency department visits, and outpatient clinic visits, the Minnesota hospital discharge data set detailing administrative claims information was used. The hospital discharge data is collected by the Minnesota Hospital Association (MHA) and provided to the Minnesota Department of Health (MDH) for a number of activities including disease and injury surveillance. The data is provided to the MDH in a de-identified format. The hospital discharge data contain demographic details on the hospitalized individual, up to twenty-five fields for ICD-9 CM (International Classification of Disease, 9^{th} revision, clinical modification) codes and related charge data. The data are available to the MDH for disease and injury surveillance purposes under Minnesota Statute 62J.301, subdivision 3.

The Minnesota hospital discharge data set contains inpatient, hospital affiliated clinic or outpatient care, and emergency room admissions. Cases that initiate in the emergency room and are admitted or held for a period of time greater than 24 hours will appear in the inpatient data set tables. Cases that are not held or discharged in less than 24 hours, or not seen in an emergency department setting, but in a hospital-affiliated clinic or outpatient setting will appear in the outpatient tables. Cases that originated in the emergency department setting will be marked as such in both the inpatient and outpatient tables. Both inpatient and outpatient tables were searched to identify the greatest number of injury cases related to agriculture. Outpatient cases are individuals that were seen or treated at a clinic or specialty center with a billing relationship with a reporting hospital. Reporting of outpatient data is not mandated so there is an incomplete collection of all outpatient visits in Minnesota. Specifically, federal hospitals, such as the Veterans Association hospital and the Indian Health service, are not required to report to the MHA. However, the data collected and maintained by the MHA currently accounts for 95% of all Minnesota hospitalizations, accounting for the majority of inpatient cases (1).

The use of hospital discharge data for injury surveillance has steadily improved over the past several decades, allowing for greater specificity and understanding of the events preceding the hospitalization (2-5). The inclusion of external cause of injury codes (E codes) in ICD-9 with each injury case is meant to provide information detailing the mechanism, intent, and location of an injury event. E codes are never used as the primary diagnosis and between one and four E codes may be included in the administrative record depending on the system used for data capture (6). A review of the literature regarding E codes indicated that between 66% and 93% of E codes are complete, depending on the state where data collection had occurred and whether the E code was associated with the intent, mechanism, or place of injury (5, 7-9).

While a number of states have mandates that require accompanying E codes to be captured in the hospital discharge data, Minnesota is not one of these states (4). Available information from the Healthcare Cost and Utilization Project (HCUP) E code evaluation report found that 80% of inpatient injury discharges and 71.5% of emergency room injury discharges in Minnesota had an accompanying E code (10). The MDH’s injury prevention unit found that 90% of injuries had an accompanying E code and that 90% of injuries had an accurate E code when evaluating hospital discharge data for Minnesota in the year 2004 (4).

Subsets of the E codes selected for this study (described below) have been utilized in published research to describe agricultural injury in specific populations (11-14). The E codes utilized in these earlier studies were not validated for accuracy and completeness, and the authors acknowledged the possibility for error and undercount in the number of agricultural injuries identified. Despite these limitations, hospitalization discharge data appears to provide the best indication of the number of agricultural-injury incidents that occur each year in a state. The compilation of cases using this algorithm of E codes provides an estimate of the number of injuries related to agriculture that occur in Minnesota on a yearly basis.

Because the hospital discharge data provided to the MDH is completely de-identified, it is not possible to evaluate E codes related to agriculture. The available information from previous evaluations will be used when creating an estimate of the total number of injuries related to agriculture that occurred each year in Minnesota.

Inclusion Criteria

Inclusion criteria for case selection addressed age, gender, residency status, and E codes. All ages were included in the search algorithm including children. Children are relevant to the study as the farm is a unique work environment with many young children beginning to participate in chores and other farm activities early in life. Also, as the data necessary to determine if the individual was engaged in a work activity, was a bystander, or was involved in an activity un-related to farming but occurred on a farm is not included in the dataset, all ages were included. Both genders were included, and Minnesota residency was required. A defined set of E codes (appearing in the case's billing record) was identified to select cases of injury events in the Minnesota hospital discharge data set as agriculturally-related.

These E codes include the following:

- E827: Animal drawn vehicle accident
- E828: Accident involving an animal being ridden
- E849.1: Place of occurrence, farm
- E863.0 – E863.9: Accidental poisoning by agricultural and horticultural chemical and pharmaceutical preparations other than plant foods and fertilizers
- E906.8: Other specified injury caused by animal (butted by animal, fall from a horse or other animal not being ridden, being gored.)
- E919.0: Accidents caused by machinery (burned by, caught in, collapse of) agricultural machinery
- E980.7: Poisoning by solid or liquid substances, undetermined whether accidentally or on purpose inflicted – agricultural and horticultural chemical preparations other than plant food and fertilizers

The cases were provided in two data files, the first contained all inpatient hospitalization records and the second contained all outpatient records. Records were de-duplicated to avoid double count of a single case and cases were limited to those with a primary diagnosis of injury, defined as an ICD-9 CM code between 800 and 999.99. However, some cases with specific ICD-9 CM codes within the 800 – 999.99 range listed as the primary diagnosis were also excluded as the likelihood of these events being related to agriculture is extremely unlikely; see Appendix 4 for a list of exclusions.

SAS 9.2 was used to analyze the data set. To identify a case as related to one of the identified agriculturally-related E codes, SAS array statements were used as the E code could have been present in any of the available twenty-five ICD – 9 CM diagnosis fields in the discharge record. Frequencies were created to describe the variation in agriculturally-related injury by gender, inpatient status, E code, rural status, payer, and ICD – 9 CM primary diagnosis. Finally comparisons were also made among age groups to compare injuries among children, teens, adults, and the elderly.

To evaluate the E codes selection criteria on the number, rate, trend, and trend direction for injury related to agriculture, the injury cases were divided into "*probable*" cases versus "*possible*" cases. *Probable* cases were restricted to the two most specific E codes, E849.1 (occurred on a farm) and E919.0 (related to agricultural machinery). The *possible* cases refer to the remaining E codes predominantly involving animals and pesticides or herbicides (E827, E828, E86.3 - .9, E906.8, and E980.7). While these potential events may be related to agriculture or farming life, the de-identified data available do not permit an evaluation of the likelihood of an agricultural link for these E codes.

Estimates of the Agricultural Population at Risk

A total of seven data sources were reviewed for estimates of the number of individuals either living or employed on a farm in Minnesota between 2000 and 2011. These estimates provide the denominators for calculating rates and trends of injuries while accounting for changes in the number of people living or employed on a farm (and thus at-risk of an agriculturally-related injury). Data sources reviewed included: the Current Population Survey (CPS), the American Community Survey (ACS), the United States Census, the Quarterly Census of Employment and Wages (QCEW), the National Agricultural Statistics System (NASS) Farm Labor Survey, the Census of Agriculture (Ag Census), and the Bureau of Economic Analysis's Statistics on Employment and Income. Each of these data sources is described below.

Current Population Survey (CPS): the CPS is a joint program/product between the Census Bureau and the Bureau of Labor Statistics (BLS). The CPS uses a probability sample of

60,000 occupied households from all 50 states and the District of Columbia. Selected interviewees are actively enrolled for four months, inactive for eight months, and return to active status for the remaining four months of their time in the survey. The CPS is designed to produce state and national estimates of the labor force for the civilian non-institutionalized population sixteen years of age or older. In addition to the regular labor force questions the CPS often includes supplemental questions on annual work activity and income, veteran status, school enrollment, contingent employment, worker displacement, and job tenure. To code industry, the Census Industry Codes (CIC) is used. CIC 2000 was used prior to the year 2003 and CIC 2002 has been used since 2003 to code the available industry response in the CPS respondent data.

American Community Survey (ACS): the ACS is conducted by the U.S. Census, provides data every year regarding: age, sex, family and relationships, income and benefits, health insurance, education, veteran status, disabilities, place of employment, transportation options, and place of residence. The ACS also identifies the farming status of a household: this variable can be used to estimate the number of individuals living on a farm. ACS defines a farm household as any household living on at least one acre of land that yields $1,000 or more in actual sales of all “agricultural products from the property” in the prior year. The ACS samples about 1 in every 40 addresses every year, or approximately 250,000 addresses each month. For areas with large populations (65,000 or more), survey estimates are based on 12 months of ACS data. For all areas with populations of 20,000 or more the survey estimates are based on 36 months of ACS data. The Census Bureau will produce estimates for all areas, down to the census tract and block group levels, based upon 60 months of ACS data.

The United States Census: the Census produces intercensal estimates each decade by adjusting the existing time series of postcensal estimates to create a smooth transition between census data collections. The intercensal estimates provide approximations of the state and county population by age, sex, race, and Hispanic origin. These estimates can be used to quantify the rural population size from year to year in a state.

The Quarterly Census of Employment and Wages (QCEW): the QCEW is produced by the Minnesota Department of Employment and Economic Development (DEED). Minnesota DEED makes use of the available unemployment insurance premiums data to create estimates of the labor force, wages, and benefits for the Minnesota working population. There is an undercount of the number of farmers and agricultural workers as these populations are exempt from unemployment and workers' compensation insurance coverage and thus excluded from the dataset.

The Census of Agriculture (Ag Census): the Ag Census is conducted by the National Agricultural Statistics Service (NASS), United States Department of Agriculture (USDA). It is conducted every five years and is a complete count of U.S. farms and ranches and the people who work them. All farms with an income of $1,000 or more are identified by the USDA and survey forms are mailed to farm and ranch operators. There may be an over-count of the number of operators reported by the Ag Census as the survey asks each respondent to identify the total number of individuals employed on the farm for that year. If an individual worked at a variety of establishments they may be double counted.

The Farm Labor Survey (FLS): the FLS is conducted by the National Agricultural Statistics Service (NASS). Selection of the farms and ranches included in the survey was completed by randomly selecting geographic areas and identifying all agricultural establishments within the geographic bounds. The counts of farm labor may be slightly inflated as the primary operator was asked to identify the number of workers on the farm at any time during the entire year. This methodology may lead to an over-count as an individual may work for several establishments over the course of a year. Unfortunately the Farm Labor Survey discontinued producing state level employment estimates in 2002 and now only produces estimates at a regional level.

The Bureau of Economic Analysis's (BEA) report on GDP and Personal Income: the BEA creates estimates of employment for the U.S. Department of Commerce using data from the Census County Business Patterns, the CPS, the QCWE, and BEA's annual industry accounts, and wage and salary disbursements to account for employment and wages not covered by unemployment insurance programs. Supplemental information, specifically ratios from the Ag Census is used to create the state estimates of agricultural labor. The employment estimates create area counts of the number of jobs, not the number of workers, so that a worker's activity in each industry and location of employment is reflected in the estimate.

Impact of Farming Population Estimates on Agricultural Injury Rates

Several rates were produced to compare the impact the selected denominator sources (farming population estimates) has upon the estimated rates: Figures 1-3. Figure 1, Agricultural Worker Population Estimates, provides the counts and trends for eight different denominators from six of the sources estimating the *number of individuals working in agriculture* for all available years between 2000 and 2011. Figure 2, Farm Household Estimate, uses the available data for years 2000 and 2005 to 2011 from the ACS to estimate the *number of individuals living on a farm* between 2001 and 2004. Figure 3, Estimated Working Only Farm Population, uses data from the ACS from 2005 to 2011 to estimate the *number of individuals employed in agriculture but not living on a farm* in Minnesota between 2000 and 2004.

Estimates of the number of individuals living on a farm in Figure 2 were computed by using computations provided by the Minnesota State Demographer's Office. The estimates provided by the MN State Demographer's office were created using ACS microdata for the available years 2000 and 2005 to 2011, and estimated the number of individuals living on a farm (15). The unavailable years, 2001 through 2004, were then imputed using linear regression, Figure 2. The created estimates provide the number of individuals living on farms but exclude estimates of those that work but do not live on farms.

Figure 3 estimates the number of individuals working on farms in Minnesota derived from the 2007 Ag Census. The Ag Census estimates that of all individuals working on farms 17% do not reside on the farm they work. This percentage was applied to the ACS estimates of the number of individuals working in agriculture between 2005 and 2011, and estimates of the number of individuals living and working on farms in Minnesota between 2000 and 2011 were created using the available data and linear regression. These estimates were then used to create rates of agricultural injury per 1,000 individuals living and/or working on farms in Minnesota between 2000 and 2011.

Rates were also calculated using the data from the CPS. The CPS state estimates were available for all twelve years of the study time period. The CPS has been utilized by a number of researchers describing different industry populations including agricultural production (16, 17). To account for the possible influence the change in coding methodology between 2002 and 2003 may have on the trend analysis, two analyses were completed. The first investigated the trend between 2000 and 2011 and the second analyzed the trend between 2003 and 2011. As the CPS only includes individuals sixteen years of age and older, the numerator cases of injury related to agriculture was similarly restricted. The BLS provides the margin of error for each CPS estimate in the Geographic Profile (http://www.bls.gov/opub/fp/laugp.htm). These margins of error were used to create 90% confidence intervals for the denominator and rate estimates.

To compare the effect the choice of denominator has on the rate, the estimates of the Minnesota farm labor population between 2000 and 2011 created by the BEA were also used to create rates of injury.

Because both the CPS and BEA estimates are subject to error and exclude individuals fifteen years of age and younger, a final data sources was utilized to examine the trend of agriculturally-related injury in Minnesota. An estimate of the rural/non-metropolitan population between 2000 and 2011 was created. To create an estimate of the Minnesota non-metropolitan population the Rural-Urban Continuum Codes were used to identify Minnesota counties as rural or urban on a scale of one to seven. Those with a score between one and three were classified as urban and those with a score of four or above were classified as rural (18). The Rural-Urban Continuum Codes from 2003 were used to classify rural counties. Data from the Minnesota State Demographic Center was used to gather population estimates from each county (19). Once all non-metropolitan/rural counties had been identified, the population estimates for each were summed to create a total non-metropolitan/rural population estimate for each year. These estimates were then used to create rates for all ages by all, *probable*, and *possible* injury status for the years 2000 through 2011.

The rates created with each of these denominator sources were then compared to describe the impact of each denominator source on the variation and trend of injury related to agriculture in Minnesota.

Trend Analysis

To investigate the trend in these rates Joinpoint modeling was used. Joinpoint has been referred to as piecewise linear regression, segmented line modeling, broken line modeling, or spline regression (20). The Joinpoint Regression Program (4.0.1) http://surveillance.cancer.gov/joinpoint/ was developed and disseminated by the National Cancer Institute and is often used in cancer surveillance for trend analysis while controlling for small rates, unstable variance, and small population size. The program uses permutation testing to determine the number of “joins” or “points” where the trend changes direction, fitting the data most appropriately (21). The model with the fewest number of joins (zero) is set as the null hypothesis, the analysis is then run to find the model with the smallest sum of squared errors. A log-linear model can be produced to describe the average annual percent change in the trend.

Joinpoint was used to determine the number and direction of trend in the number of injuries related to agriculture.

To evaluate the effect the specificity of the E codes had on the rates of injury, codes categorized as *probable* in their relationship to agriculture (E849.1 and E919.0) were categorized separately from codes with a *possible* relationship to agriculture (E827, E828, E863, E906.8, and E980.7) and used to create *probable* and *possible* rates. These sub-group rates were then tested for trends and compared to the total rate.

Economic Burden of Agriculturally-Related Injury in Minnesota

Model

To describe the economic impact of injury related to agriculture in Minnesota three cost models were considered. These included the cost of illness method, the willingness to pay model, and the friction model. The willingness to pay model creates cost estimates based upon the amount individuals in society are willing to pay to avoid injury, illness, or death. Willingness to pay is constrained by the individual’s monetary worth and it can be difficult to ascertain these values as there is no simple method to discern the price someone would place on avoiding a specific injury or illness. The frictional method estimates the time period between injury and replacement of the individual in the workplace, or the period of lost production. Unlike the cost of illness model, the friction model assesses only the lost time associated with the loss in production, instead of the time loss to the injured individual. The estimates of the frictional time period, or lost production period, are difficult to estimate for an agricultural population as the data necessary to create such estimates is unavailable. The cost of illness model has been used by a number of researchers estimating the cost of occupationally related injury and disease and is applicable to this endeavor as well (22-26). The cost of illness model creates a total cost estimate with the combining of the related direct and indirect costs to the injury event. As there is variation in the methodology from study to study, specifically regarding the inclusion or exclusion of specific cost categories, a sensitivity analysis was performed to describe the impact the variation in these variables have on the total cost estimate. The estimation of costs associated with injury related to agriculture in Minnesota was limited to the years 2004 through 2010, as the necessary variables to create direct cost estimates were available for this time period.

Cost Equations

The economic burden associated with agriculturally-related injury in Minnesota was estimated with three cost equations, including direct costs, nonfatal indirect costs, and fatal indirect costs. The cost equation was organized into several components depending on the injury outcome: fatal or non-fatal and hospitalized or non-hospitalized. The equation was also broken into direct or indirect costs calculations. The division into these four categories was necessary as the equations account for the probability of disability. The probability of disability is used only for the non-fatal cases and is differentiated by the hospitalization status of the injured individual. As such it is necessary to note these distinctions when calculating the indirect costs for fatal and non-fatal as well as hospitalized and non-hospitalized injuries.

For this study *direct costs* are defined as medical and administrative costs, and *indirect costs* are defined as lost wages, lost home production value, and lost quality of life. The first equation was used to estimate the direct costs associated with an injury: the medical charges, a cost to charge ratio, administrative charges, coroner or medical examiner costs, and costs associated with emergency transport.

Direct Costs

$$\sum_{i=1}^{k}[(m_i)(R) + (a)(m_i)(R) + (Q)(E)](n_i)$$

n_i: number of individuals with injury type i
m_i: average medical charges for injury type i
R: cost to charge ratio
a: administrative percentage applied to average medical costs
Q_i: proportion of cases with injury type i requiring transportation
E: emergency transportation
*sum the direct costs related to each injury type i and multiply by the number of injuries of type i

The second equation was used to estimate the indirect costs associated with a non-fatal injury: the probabilities of disability, the length of lost work time, the value of work production, the value of home production, and the discount rate.

Indirect Costs (nonfatal)

$$(n_i)(NF_i)\sum_{i=1}^{k} H_i[P_{si}^{h=1}(t_i[w_i + .09q_i]) + P_{ppi}^{h=1}(f_i[W_i + Q_i]) + P_{pti}^{h=1}[W_i + Q_i] + (1 - P_{si}^{h=1} - P_{ppi}^{h=1} - P_{pti}^{h=1})(0)] +$$

$$(1 - H_i)[P_{si}^{h=0}(t_i[w_i + .09q_i]) + P_{ppi}^{h=0}(f_i[W_i + Q_i]) + P_{pti}^{h=0}[W_i + Q_i] + (1 - P_{si}^{h=0} - P_{ppi}^{h=0} - P_{pti}^{h=0})(0)]$$

P_{si}: Probability of short term disability given injury type i
t_i: Average or median short term lost time given injury type i
w: average weekly wage
q: average weekly home production value
H_i: Proportion of injury cases i that were hospitalized (Hospitalized cases will have short term disability for at least their hospital stay duration)
1 - H_i: Proportion of injury cases i that were not-hospitalized (outpatient and ED cases)
P_{ppi}: Probability of permanent partial disability given injury type i (h = 1, hospitalized)
P_{pti}: Probability of permanent total disability given injury type i (h = 1, hospitalized)
f: impairment fraction
W: average remaining working lifetime wages and benefits
Q: average value of remaining working home production
n_i: number of cases with injury type i
NF_i: proportion of cases with injury type i that were non-fatal

(Disability terms are defined as follows: *permanent total disability* is complete disability for longer than one year, *short term disability* is complete disability but for less than one year, and *permanent partial disability* allows the individual to continue working but at reduced capacity – the probability of permanent or partial permanent disability changes by whether or not one was hospitalized)
*sum the lost production per year of injury type i and multiply by the number of injuries of type i that were fatal.

Indirect costs for non-fatal injuries would differ by whether the injury required hospitalization or not. For the proportion of injury type I who required hospitalization (H_i), three health states were possible: a short term disability, a permanent partial disability, or a permanent total disability such that the probabilities for each state (P_{si}, P_{ppi}, and P_{pti}, respectively) summed to 1. The proportion of injury I with a short term disability (P_{si}) had indirect costs derived from the product of the average farm wage rate (w_i) and the time unable to work (t_i) plus unable to engage in household production (q_i). The proportion of injury I with a permanent but partial disability (P_{ppi}) had indirect costs derived fromt eh product of the average farm wage for the remaining working lifetime (W_i) plus the product of the average value of household productions for the remaining household working lifetime (Q_i) adjusted by an impairment fraction. The proportion of injury I with a permanent total disability (P_{pti}) had indirect costs derived from the product of the average farm wage for the remaining working lifetime (W_i) plus the product of the average value of household production for the remaining household working lifetime (Q_i). The indirect costs related to permanent partial and total disability were discounted, where as those for short term disability were not discounted as short term disability is defined as disability with duration shorter than one year. For the proportion of injury type I that did not require hospitalization (1-H_i), four health states were possible: no disability, a short term disability, a permanent partial disability, and a permanent total disability. The indirect costs for those with no disability were zero as the individual accrued no lost work time or lost home production. Indirect costs for short-term disability, permanent partial disability, and permanent total disability were calculated in the same way for hospitalized injuries as non-hospitalized. The probabilities for short term, permanent partial, and permanent total disabilities, developed by Miller et al, differed depending upon whether the individual was hospitalized, therefore the hospitalization status of the injury case was necessary to assign the appropriate probabilities to the injury.

The third equation was used to estimate the indirect costs associated with a fatal injury: the length of lost work time, the value of work production, the value of home production, the impairment fraction and the discount rate.

Indirect Costs (fatal)

$$\sum_{i=1}^{k}(n_i)(1-NF_i)\left[\sum_{s=y_i}^{74}(D_{s})[W_s+H_s]\left[\frac{(1+g)^{s-y_i}}{(1+r)^{s-y_i}}\right]\right]$$

s = age of individual if they had survived
k = age at retirement (74)
y_i = average age of individual at death for injury type i
D_s = probability that the individual at age y_i will survive to age s
W = annual earnings (wages and benefits) of person at age s
H = home production estimate of person at age s
g = wage growth attributable to experience and length of service
r = real discount rate (3%)
*sum the lost production per year of injury type i and multiply by the number of injuries of type i that were fatal (22).

Injury Counts

The counts created in the first study aim were used to estimate the cost of *non-fatal* hospitalized and non-hospitalized agriculturally-related injury that occurred in Minnesota between 2004 and 2010. The cost measures produced are for a shorter time frame than the estimated injury surveillance counts as the necessary cost data was only available for this time frame. To estimate the costs associated with *fatal* agriculturally-related injuries between 2004 and 2010 in Minnesota data from the Census for Fatal Occupational Injuries (CFOI) was used. The CFOI collects data on all deaths (excluding diseases) related to occupation that occur in the United States and provides counts by state, industry, occupation, and age. These statistics are collected by the Minnesota Department of Labor in partnership with the United States Bureau of Labor Statistics (BLS) and are available for the years 2003 through 2012 (27). The CFOI uses a number of sources including death certificates, news reports, coroner's reports, and police reports to capture all deaths related to occupation, it is believed to be a complete count of all occupationally-related fatal injuries. As it was previously determined that the Minnesota hospital discharge dataset only captured a small portion of the deaths related to agriculture in Minnesota between 2000 and 2011, the CFOI was utilized to create counts for the estimation of the costs associated with agriculturally-related injuries resulting in death.

Direct Cost Data Sources

The medical charges related to care provided for an agriculturally-related injury were available in the hospital discharge dataset. The cost-to-charge ratio was applied to the available charge data to create an approximation of the costs associated with provided medical care. A hospital specific cost to charge ratio at the time of patient discharge was used. The cost to charge ratio was developed and maintained at the MDH (28), and only available for years 2004 to 2010.

A flat fee of $212 for the year 2000 was established for provided emergency transportation services. This fee was developed by Finkelstein et al with the use of Medicare ambulance claims that were E coded for the year 2000 (25). Finkelstein et al also created an estimate of the number of injury cases, approximately 50%, that required some form of emergency transport services. The available flat fee was inflated to 2010 dollars and applied to 50% of the identified cases. The Leigh et al estimate of 15% of the medical costs for related administrative medical costs was used (23).

Indirect Cost Data Sources

Home Production

The average weekly wage for those working in agriculture was obtained from the MN Department of Employment and Economic Development (DEED) Quarterly Census of Employment and Wages (QCEW). Information regarding the average weekly wage is collected from employers required to maintain unemployment insurance. This may skew the data to some degree as many agricultural workers are self-employed or are not required to participate in the unemployment system. Data from the QCEW is available on the MN DEED website. The website maintains a QCEW query tool that allows data selection by geography, industry groups, and years of interest (29). Estimates of weekly benefits were set at 16% of weekly wages as estimated by the Iowa Extension Service (30).

The QCEW was also used to create two measures of home production. The two measures were created to adjust for assumptions made regarding the value of household production and the impact to the final cost estimate. The first method assumes a person's time spent on tasks related to household production is equivalent in value to the wage the individual receives for time spent on wage related activities outside of the home. This method was utilized by Leigh et al (23) when estimating the value of lost home production related to occupational injury and illness. The second method assumes the value of the time spent on household production has a market value that has been assigned by society and can be estimated using the average wage of one engaged in housekeeping, cooking, etc. for wages. This second method was utilized by Finkelstein et al (25) when estimating the economic burden of injury in America. To create the first estimate the average wage of one engaged in agricultural activities in Minnesota for the years 2004 to 2010 was obtained from the QCEW query. The QCEW query tool was also used for the second estimate; however, the average wage of those employed in the industrial grouping “leisure and hospitality” was selected.

Disability Probabilities and Lost Work Time

As hospital discharge data was used to estimate the number of injuries related to agriculture in the state, follow up information regarding recovery time and disability were not available. To estimate the probability of disability and the average length of time an individual would be unable to participate in the workforce, estimates created by Miller et al (26, 31) were used. These estimates of the probability of short-term, permanent-partial, and total-permanent disability as well as the average and median length of time lost by type of injury were created by Miller et al using the National Council on Compensation Insurance (NCCI) Detailed Claim Information (DCI) database. Probabilities of disability were available by hospitalized and non-hospitalized case status. The average and median length of lost work time were available for non-hospitalized cases (26). Lost work time for hospitalized individuals was available from the hospital discharge data as the length of stay was provided.

Biddle et al (22) set a retirement age of 64 when estimating the economic burden related to all occupational injuries in the United States. However, there is evidence to suggest that those engaged in agricultural work tend to do so for longer periods of time than the average employee (32). Therefore, the age of retirement for this study population was set at 75 years of age.

Wage Growth, Survivability, and Discount Factor

The career growth adjustment factors created by Biddle et al (22) were used to adjust wages for fatal injuries related to agriculture in Minnesota. Biddle created the wage growth adjustment using the Employment Cost Index (ECI) which measures the change in the cost of labor and includes changes in the wages and salaries as well as benefits. Biddle then used the Current Population Survey to account for the change in wages due to an individual's experience as an employee (22).

To create a cost estimate for fatal injuries, the probability of survival to the following year of life was necessary. Probability of survivorship for each year of life was obtained from the life tables produced by the Center for Disease Control's (CDC) National Center for Health Statistics (33). A discount rate of 3% was used to bring future costs to present value. The use of a 3% rate was recommended by Gold and colleagues as the most appropriate for estimating societal costs (34). This rate is also the rate most frequently used in the literature, including several of Leigh's cost estimates of occupational disease and injury (23, 35-37).

Sensitivity Analysis

The Cost of Illness Model creates cost estimates that include the entire lost work time of the individual. A sensitivity analysis was performed to investigate the impact of varying the lost work time or lost production time in the indirect cost equation. The loss to society when an individual dies or is permanently disabled is the value of the lost work and home production they created while alive. The time period in which an individual may be replaced is not well defined, thus two time periods were suggested based upon possible production replacement scenarios. The first suggested lost time period was six months, with the assumption that designating a replacement of the individual would occur with a family member or already established working member of the farm. The second suggested lost time period was six years, with the assumption that the family of the individual could not maintain the farm in the absence of the individual and it was then sold. The time period of six years would account for the time to sell the farm as well as the time necessary for the new owners to bring production up to previous levels. These estimates were compared with the original study cost estimate that includes all years of working-life lost, similar to the work presented by Leigh et al (23) and Finkelstein et al (25).

Quality of Life

Change in the quality of life after an injury related to agriculture was estimated using data from the Medical Expenditures Panel Survey (MEPS) (38). Comparable data is not available in the MN hospital discharge dataset; thus MEPS was investigated as a potential source to describe the impact these types of events would have on an individual's quality of life.

The MEPS is a set of large scale surveys of individuals, their families, their health care providers, and employers to understand health insurance coverage, health care utilization, health care access and provided services, and health care satisfaction. Over 12,000 households (over 30,000 individuals) are randomly selected into the MEPS each survey cycle or panel. Participation includes five survey rounds that occur over a two year period. Information collected includes: demographic information, health conditions, health insurance coverage, employment, perceived health status, access to care, and much more. Data on each of these areas is collected in each round of the survey allowing for longitudinal analysis.

For this analysis, survey years from 2002 to 2007 (7 panels) were utilized. The number of individuals identifying themselves as a farm worker or sustaining an injury related to work was too small for analysis (N=69). Therefore individuals suffering from an injury unrelated to a motor vehicle accident, sports injury, firearm, or other weapon inflicted injury were used as a surrogate for those that had sustained an injury related to agricultural work. Using the methodology developed by Nyman et al (39), this population was used to investigate the impact injury has upon the self-reported quality of life.

Individuals were categorized into injured and non-injured groups. The perceived health status for the injured group was determined using the information in the round prior to injury and the round after the injury to define pre and post health status. For those without injury, perceived health status was determined using two non-consecutive rounds with a similar time frame between rounds as for those who were injured. Differences in mean perceived health status pre and post injury by recovery level were assessed for those among the injured group. An ordered generalized probit model was used to understand the relationship between perceived health status pre and post injury while controlling for demographic variables including age, sex, marital status, education, race, recovery status, and income.

Conclusion

The above methodology provides a sustainable method to track counts, rates, trends and costs associated with agriculturally-related injuries. These estimates provide previously unavailable data as well as a method to quantify the human toll associated with this important, but high risk industry. The cost estimates associated with injury related to agriculture in Minnesota will focus attention on the burden of agriculture and lead to the possible allocation of additional resources for education and prevention programs. The provided methodology can also be implemented by other programs and states to ascertain the impact of agriculturally-related injury.

Figures

Figure 1: Agricultural Worker Population Estimates

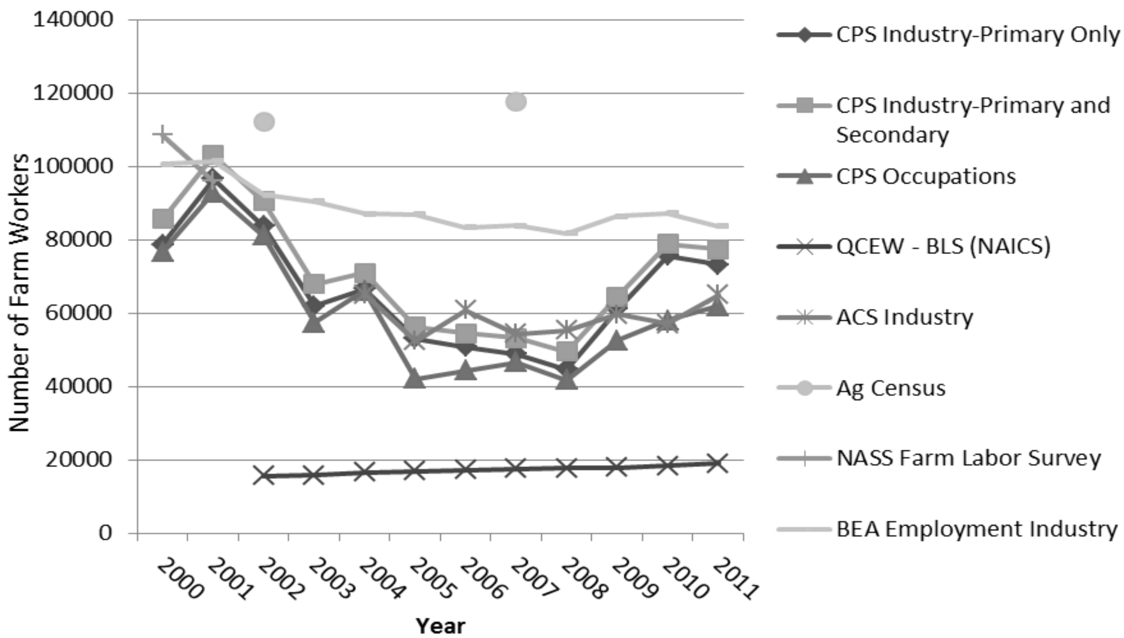


Figure 2: Imputed Values of the Number of Individuals Living on a Farm

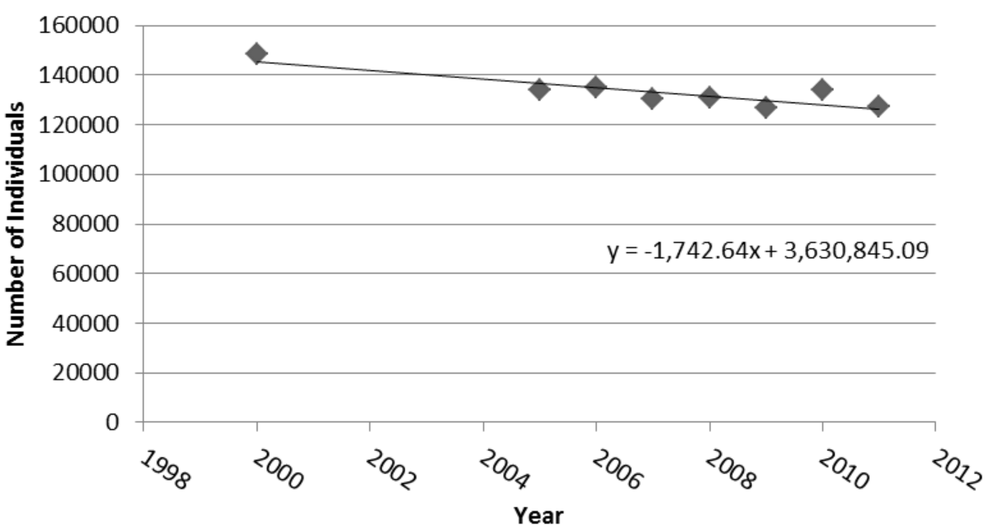
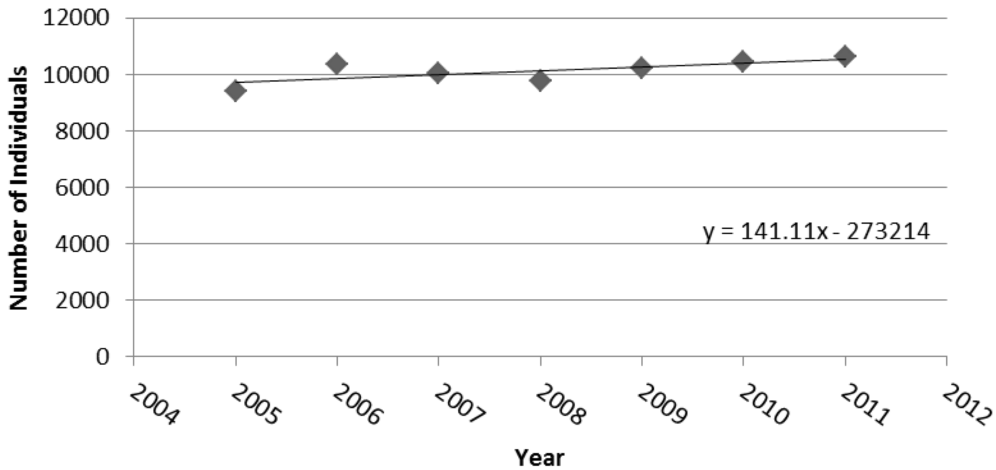


Figure 3: Imputed Values of the Number of Individuals Working but Not Living on a Farm



Tables

Table 1: Exclusion Criteria

	Code	Description
All V Codes		Supplementary classification of factors influencing health status and contact with health services. 1. When someone who is not currently sick encounters the health services for some specific purpose. 2. When a person with a known disease or injury, whether it is current or resolving, encounters the health care system for a specific treatment of that disease or injury. 3. When some circumstance or problem is present which influences the person's health status but is not in itself a current illness or injury.
E codes		
	E800	Railway accident involving collision with rolling stock
	E802	Railway accident involving derailment without antecedent collision
	E804	Falling on, or from, a railway train
	E849.2	Place of occurrence, mine or quarry
	E849.3	Place of occurrence, industrial place and premises
	E849.4	Place of occurrence, place for recreation or sport
	E849.5	Place of occurrence, street and highway
	E849.6	Place of occurrence, public building
	E849.7	Place of occurrence, residential building
	E870 – E879	Misadventures due to patient care
	E904	Hunger, thirst, exposure, and neglect
	E919.0 – E910.2	Accidental drowning – recreational
	E919.4	Accidental drowning – bathtub
	E930 – E949	Adverse effects of drugs – therapeutic use
	E977	Late effects of injuries due to legal intervention
	E978	Legal execution
	E990 – E999	Injury resulting from operations of war
ICD 9 CM Codes		
	960 – 970	Poisoning by drugs, medicinal, and biological substances
	990	Effects of radiation, unspecified
	995	Certain adverse effects NEC (complications of surgical and medical care)
	995.5	Child maltreatment syndrome
	995.6	Anaphylactic shock due to adverse food reaction

	995.8	Other specified adverse effects NEC
	995.9	Systemic inflammatory response syndrome
	996	Complications peculiar to certain specified procedures (complications NEC in that use of artificial substances [e.g. Dacron, metal, plastic, Teflon] or natural resources [e.g, bone] involving: anastomosis, graft, implant, internal device, catheter, electronic, fixation, prosthetic, re-implant, transplant)
	997	Complications affecting body systems NEC
	998	Other complications of procedures, NEC
	999	Complications of medical care NEC (complications NEC of: dialysis, extracorporeal circulation, hyperalimentation therapy, immunization, infusion, inhalation therapy, injection inoculation, perfusion, transfusion, vaccination, ventilation therapy)

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Chapter Four: Incidence Rates and Trends of Injury Related to Agriculture in Minnesota, 2000-2011

Abstract

Agriculture is consistently ranked among the most dangerous industries with 566 deaths nationwide related to agriculture occurring in 2011 (1-3). Surveillance activities for fatalities related to agriculture are well developed; however, methodology for non-fatal injury surveillance related to agriculture is lacking. To address this need the Minnesota hospital discharge data set was used to identify cases of both *probable* and *possible* injury related to agriculture, and requiring medical care. A *probable*, agriculturally-related injury case has an assigned E code specific to agriculture, E849.1, location-farm, and E919.0, related to agricultural machinery. In contrast, a *possible* injury is defined as one where there is less clarity and the assigned E code is less specific to agriculture. Between 2000 and 2011 in Minnesota, more than 2,000 injuries with a *probable* relationship to agriculture were identified from both inpatient and outpatient hospital discharge records. An average of 504 injuries per year were identified as occurring on a farm or related to agricultural machinery. Annual rates of *probable* agriculturally-related injury ranged between 2.9 to 4.3 injuries per 1,000 individuals living and/or working on a farm over the twelve year study period. Trend analysis of <u>all</u> agriculturally-related injury, both *probable* and *possible*, suggests a non-significant increase between 2000 and 2011 of approximately 1.5% each year. While total and *possible* agriculturally-related injuries were found to have a non-significant increasing trend over the twelve year period, *probable* agriculturally-related injuries were found to have a non-significant decreasing trend of 2.2% annually. The majority of *probable* cases of agriculturally-related injuries were sustained by males (81.5%), and involved admission to the emergency room (57.7%) or physician referral to the hospital (37.1%). While the use of hospital discharge data provides an undercount of the total injury related to agriculture, the counts and rates produced by this study demonstrate the utility of this dataset for identification of agriculturally-related injury and the information it can provide for injury prevention and reduction prioritization. Evaluation of current policies, prevention practices, and allocated resources regarding agriculturally-related injury may be warranted.

Background

"Traumatic injury was and is arguably the leading cause of identifiable work-related death and injury of agricultural workers" (2). The national fatality rate for those with farming or ranching as a major occupation was 27.9 per 100,000 in 2010, more than ten-fold higher than the all-occupation national fatality rate of 3.96 per 100,000 the same year (3). In Minnesota, 28 (40%) of the total 70 occupational fatalities in 2010 were associated with the agricultural sector. Between the years 2003–2010, 26% of all occupational fatalities in Minnesota occurred on a farm (4). While agricultural fatalities in Minnesota are well documented, the statewide rates for non-fatal agricultural injuries are not well known.

The primary source of data for non-fatal occupational injuries and illnesses is the Survey of Occupational Injuries and Illnesses (SOII) conducted by the Bureau of Labor Statistics (BLS). Workers' compensation claims represent an additional source of data on occupational injuries. However, the majority (86%) of Minnesota farming operations (5) are small or family operated and are generally exempt from carrying workers' compensation insurance or complying with Occupational Safety Health Administration (OSHA) record keeping requirements for work-related injury and illness (Appendix 2-3) (6) . While these exemptions relieve the employer of the responsibility and burden of injury reporting, they pose challenges to ascertaining the number of serious injuries related to agriculture that occur in Minnesota. Although specific research studies and surveillance programs have been conducted to characterize the burden of agriculturally-related injury in various populations and time periods, these efforts were not designed as long-term sustainable injury surveillance mechanisms. Thus, existing surveillance mechanisms miss large portions of the true burden of non-fatal agricultural injury and illness. Identifying a system that will provide a more complete picture of the burden of agriculturally-related injury will provide information essential for developing effective prevention programs and policy.

Public health surveillance is a core component of public health practice and researchers and practitioners increasingly exploit existing data sources for disease and injury surveillance. The Minnesota Department of Health (MDH) and 23 other state agencies funded by NIOSH conduct state-based occupational health surveillance base, in part, on 20 defined Occupational Health Indicators (OHIs). Four of the 20 OHIs are derived from hospitalization billing records (7). Along with these four OHIs, hospital discharge data are currently utilized to ascertain the number of severe injuries, coronary heart events, asthma hospitalizations, and strokes in a number of states (including Minnesota) and nationwide (8). This study estimates the number of serious agriculturally-related injuries in Minnesota requiring trained medical attention by building upon work conducted by NIOSH, the Council of State and Territorial Epidemiologists (CSTE), and other public health practitioners, and the recent improvements in collection and maintenance of hospital discharge data.

The need for a well-developed agricultural injury surveillance system has been well documented (1, 2, 9-11). Over the past several decades many researchers have estimated the burden of agricultural injury and have reported on the need for a standardized method of continual surveillance (9, 11-14). The increased use of electronic medical records, and the inclusion of a greater number of data fields to address injury in the medical record, has significantly improved the ability to conduct surveillance for a number of injury types, including agricultural injury. Previous studies have examined the rates and risk factors of agricultural injuries, providing an important foundation for the proposed study. Studies that have contributed to the understanding of the agricultural injury burden include: a series of studies investigating serious injury in regional rural and agricultural populations by Gerberich et al (15-17); a comparison of agricultural trauma surveillance systems in Minnesota by Gunderson et al (9); an investigation of work-related injuries among U.S. youth in the agriculture sector by Hard et al (2, 18); and an estimate of the occupational morbidity for migrant workers in New York by Earle-Richardson et al (13). However, these comprehensive efforts are not sustainable by state surveillance systems due to constrained resources.

Methods

This study aims to characterize the counts, rates, and trends of agriculturally-related injury in Minnesota during the period 2000-2011. The study was limited to persons residing in Minnesota who received medical treatment in an inpatient hospital setting, an Emergency Room, or an outpatient clinic with a hospital affiliated billing relationship. Variables included date of admission, date of discharge, gender, age, type of injury, and health care payment type. Injuries were separated into *probable* and *possible* categories depending upon the E code used to identify the case in the Minnesota Hospital Discharge data set. This study was approved by the University of Minnesota and Minnesota Department of Health Institutional Review Boards. SAS 9.2 was used for all analyses.

Case Ascertainment

Hospital discharge data is utilized in various ways to detail rates of injury and chronic disease events that occur at state and national levels. To better understand the impact of agricultural injury in Minnesota, an algorithm was developed to capture hospitalization events related to agriculture from the available administrative hospital billing data.

Hospital discharge data is provided by almost all Minnesota hospitals (144 of 147 in 2013) to the Minnesota Hospital Association (MHA). MHA in turn provides these data to the MDH for a variety of specified purposes, including disease and injury surveillance (Minnesota statute, section 62J.321). The data provided to MDH is de-identified; therefore follow up of individual cases of agriculturally-related injury or linkage to other data sets (such as Workers' Comp) is not possible.

Each hospitalized case may have up to twenty-five ICD – 9 CM diagnosis codes, including the possibility of four external causes of injury codes, or E codes. E codes are supplemental codes that describe the external cause of injury or poisoning, the intent, and the place of occurrence. E codes were created with the intention of providing data for injury research and prevention strategies; they are not federally mandated to be collected, although some states (not Minnesota) do require their collection. E codes are not meant to be used as the primary diagnosis and E codes may be included in the record depending on the available information in the medical chart and the system used for data capture (19). The following list of E codes was used in this study to identify a case as related to agriculture:

- E827: Animal drawn vehicle accident
- E828: Accident involving an animal being ridden
- E849.1: Place of occurrence, farm
- E863.0 – E863.9: Accidental poisoning by agricultural and horticultural, chemical and pharmaceutical preparations other than plant foods and fertilizers
- E906.8: Other specified injury caused by animal (butted by animal, fall from a horse or other animal not being ridden, being gored)
- E919.0: Accidents caused by machinery (burned by, caught in, collapse of) agricultural machinery
- E980.7: Poisoning by solid or liquid substances, undetermined whether accidentally or on purpose inflicted – agricultural and horticultural chemical preparations other than plant food and fertilizers.

For this study two E codes, E849.1 and E919.0, were selected to describe *probable* agricultural injury as had been done in previously published research (10, 12, 14, 20). The remaining five E codes included were selected and grouped to describe cases of injury with a *possible* relationship to agriculture.

Interviews were conducted with three large hospital systems in Minnesota to understand the degree to how and which E codes are collected for the billing record. These limited interviews make apparent that E codes are not a required element in the billing record. Among the E codes, codes such as location codes (E849.1) are given less priority in collection in comparison to mechanism of injury codes (E919.0). As such all these codes were used to identify potential cases of agriculturally-related injury in Minnesota.

Cases are reviewed by the Division of Health Policy at the MDH and potential duplicate cases are identified. These duplicates are identified using date of admission, age, gender, and other demographic and diagnostic characteristics. These cases were removed and specific case exclusions were applied. These exclusions included any case with a V code as the primary diagnosis as these cases are unrelated to agricultural activity and denote care related to circumstances other than disease or injury. Cases with an E code identifying the case as related to railway activity, occurring on a property unrelated to agriculture, accidental drowning, adverse effects of drugs, legal execution, and injury resulting from operations of war were also excluded. Finally, cases with a primary diagnosis of poisoning by drugs, medicinal and biological substances, effects of radiation, complications of previous medical care or medical implant/device/graft, and adverse food reactions were also excluded (Appendix 4).

Cases were included if of the twenty-five ICD – 9CM diagnosis code fields included one or more of the case-defining E codes. Farm-relatedness categories were created from the E codes with E849.1 and E919.0 categorized as *probable* cases of farm or agriculturally-related injury. The remaining E codes, E827, E828, E83.0 – E863.9, and E980.7 suggest a relationship with activities often conducted in agricultural settings, though these activities may be more recreational in nature than solely for production-related activities of the farm, and as such these cases were categorized as *possible*.

Data Sources for Estimation of the Agricultural Population at Risk

It was necessary to assess and integrate multiple data sources to create estimates of the agricultural labor population for the denominator of our injury rates. In total seven sources were identified as possibilities for the creation of the denominator. These sources included the Current Population Survey (CPS), the American Community Survey (ACS), the Quarterly Census of Employment and Wages (QCEW), the Census of Agriculture (Ag Census), the National Agricultural Statistics System (NASS) Farm Labor Survey, the United States Census, and the Bureau of Economic Analysis's (BEA) Gross Domestic Product (GDP) and Personal Income Data report. Each data source had unique strengths and weaknesses which were evaluated before selection occurred. Figure 1displays the variation in the farm labor estimates from six of the identified sources. The U.S. Census was not included in the figure as it was used to describe Minnesota's rural population and was not limited to those with an agricultural relationship. Each data source collects information pertinent to employment from different sources, and thus is subject to error and limitations. Coding methodology and categorization also differ among the data sources contributing to some of the discrepancies noted among the sources. To create rates of agriculturally-related injuries for this study, estimates of the number of individuals living and/or working on farms in Minnesota were needed. To create estimates for both working and non-working agricultural populations, data from the ACS, the Census of Agriculture, and the U.S. Census were used to provide an estimate of Minnesota's rural population and an estimate of the number of individuals living and/or working on a farm in Minnesota.

Estimates of the number of individuals living in farm households were developed by researchers at the Minnesota State Demographers Office using microdata from the American Community Survey (ACS) conducted by the U.S. Census (21). The ACS is an annual household survey that provides comprehensive data based upon a random sample of approximately 250,000 addresses selected each month. The ACS provides annual population estimates for areas with a population of 65,000 or more. Data from ACS includes: age, sex, family and relationships, income and benefits, health insurance, place of employment, and place of residence. It also collects household information and defines a farm household as any household on one or more acres of land that yielded $1,000 in actual sales of all "agricultural products from the property" in the prior year. Data for the years 2000 and 2005-2011 were available from the ACS. Estimates of those individuals living on a farm in Minnesota between 2001 and 2004 were imputed using linear regression and estimates provided by the Minnesota Demographer's Office (Figure 2).

To estimate the number of individuals working, but not living, on a farm in Minnesota between 2000 and 2011 data from the Ag Census 2007 and the ACS were used. However, because the necessary data is not available for the full duration of interest, imputation was necessary as described here. The Ag Census estimates approximately 17% of individuals working on farms do not reside there. This percentage was applied to the estimates of the number of individuals employed in agriculture created with the available ACS data. An estimate of the number of people working, but not living on farms in Minnesota was available for the years 2005 to 2011 and that information was also used. Linear regression was used to impute an estimate of the number of individuals working, but not living on farms between 2000 and 2004 (Figure 3). These two estimates were combined to create a composite estimate of the number of people living and/or working on farms in Minnesota between 2000 and 2011. These estimates were then used to provide the denominators needed to create rates of injury related to agriculture.

Estimates of the Agricultural Population at Risk

The first of the alternative data sets selected for creation of a denominator was the Current Population Survey (CPS). The CPS is sponsored jointly by the U.S. Census Bureau and the U.S. Bureau of Labor Statistics (BLS). The CPS is the primary source of labor force statistics for the United States and is administered by the Census Bureau using a probability sample of about 60,000 occupied households from all 50 states and the District of Columbia. Participants are actively enrolled for 4 months, inactive for 8 months, and return to active status for the remaining 4 months of survey participation. This design ensures a high degree of continuity from one month to the next. Survey eligible individuals must be16 years of age and not in the armed forces, nor reside in any institution such as prisons, long-term care hospitals, and nursing homes. No upper age limit is used, and full-time students are treated the same as non-students. In general, the BLS publishes labor force data only for people aged 16 years of age and over, since those under 16 are limited in their labor market activities by compulsory schooling and child labor laws.

To code responses regarding employment activities into industry designations, the Census Industry Codes (CIC) were used. Creation of the denominator was based upon classifying individuals into the following three industry categories: crop production, animal production, and support activities for agriculture listed as either the primary or secondary job. DataFerrett, a product of the U.S. Census, was used to obtain these estimates of Minnesota's working agricultural populations (22). Some error will exist in the creation of these labor estimates from the CPS survey data. However, the BLS provides a margin of error dependent upon the estimated sample size that may be used to create 90% confidence intervals for the population estimates (23). These margins of error were applied to create 90% confidence intervals for all twelve years of the Minnesota agricultural worker population estimates.

To evaluate the impact the denominator data source has on the injury rates created for this study, the GDP and Income data produced by the Bureau of Economic Analysis (BEA) was also used to create rates. The estimates created by the BEA are a measure of the number of jobs available in a given industry field, unlike the CPS which measures the number of individuals employed in an industry. The BEA makes use of the CPS, the Census County Business Patterns, the BEA's Annual Industry Accounts, the Quarterly Census of Employment and Wages, and wage and salary disbursements and employment data the BEA maintains. Both the national and state estimates of farm self-employment are prepared by the application of a series of ratios to the annual estimates of the number of all farms provided by the National Agricultural Statistics Service (NASS), U.S. Department of Agriculture (USDA). For the state estimates, ratios are drawn from the Ag Census; the ratios are interpolated between census years and incorporated into the final estimate of farm labor for each state. In this study the numerator was limited to individuals 16 years of age or older as both of the CPS and BEA produce counts of limited to that age threshold.

A third data source was also utilized to examine the trend in agriculturally-related injury using the Minnesota non-metropolitan/rural population because both the CPS and BEA estimates are subject to error and exclude individuals fifteen years of age or younger. To create an estimate of the Minnesota non-metropolitan population, the Rural-Urban Continuum Codes were used to identify Minnesota counties as rural or urban on a scale of one to seven. Those with a score between one and three were classified as urban and those with a four or above were classified as rural (24). The Rural-Urban Continuum Codes from 2003 were used to identify the rural counties. Data from the U.S. Census maintained by the Minnesota State Demographic Center was used to gather population estimates from each county (25). Once all non-metropolitan/rural counties had been identified the population estimates for each were summed to create rates for all ages by agriculturally-related injury status (all, probable, and possible) for the years 2000-2011.

Analytic Plan

The Joinpoint Regression Program (4.0.1) (http://surveillance.cancer.gov/joinpoint/), developed by the National Cancer Institute was used to conduct trend analysis of the rates of injury related to agriculture. Joinpoint has also been referred to as piecewise linear regression, segmented line modeling, broken line modeling, or spline regression (26). Joinpoint fits models to determine if trend and directional change of that trend occur at any point along the defined time period. The program uses sequential permutation testing to control for over-fitting of the data. The analyses test the linearity of the model by determining if a model with X number of joins is more probable than a model with fewer or no joins.

Twelve age categories were created to facilitate comparison of injuries between groups, such as child (0-9) vs. teen (10-19) and adult (20-54) vs. individuals 65 years of age and older because previous studies have demonstrated differences in agriculturally-related injury rates by age.

Results

Descriptive Findings: All Cases

The initial step in case identification involved conducting a query of all potential cases of agriculturally-related cases (*probable* and *possible*) identified with the use of the selected E codes. A total of 44,554 agriculturally-related injuries by E code were identified (Table 1). As a total of four E codes may be assigned to one case the dataset was queried and cases broken down by year of admission, for a total of 43,531 identified cases (Table 2). After removal of identified duplicates and the exclusions identified in Appendix 4, a breakdown by E code identified 30,171 cases, with some cases having more than one E code assigned (Table 3). Categorizing these cases by year a total of 29,459 cases of injury related to agriculture were identified in the Minnesota hospital discharge data set between the years 2000 and 2011 (Table 4). Figure 4 depicts the number of agriculturally-related injuries by total, *probable*, and *possible* status.

Health Care Utilization, Sources of Insurance and Injury Diagnoses

Source of hospital admission for all cases was primarily the emergency room (53% of cases), followed closely by physician referral (41.6% of cases) (Table 5). The average length of stay was two days with a range of 1 to 82 days for the inpatient population.

Sources of insurance coverage and payment are not displayed, but the majority of cases, 21,398 (72.4%), were covered by some form of private health insurance. The second largest category of payer was public insurance, e.g., Medicare/Medicaid/MinnesotaCare (MNCare) with 5,206 (17.6%) of the cases. Self-pay made up 1,713 (5.9%) of the cases, and worker's compensation accounted for only 651 (2.2%) of the cases.

A total of 28 fatalities were identified in the twelve years of data among both outpatient and inpatient cases: 26 individuals were simply reported as "expired" while 2 individuals were explicitly noted to have "expired at home". The majority of non-fatal cases (91.1%) were discharged to their home or self-care with transfer to another short-term hospital as the second most common method of discharge (3.7%) (Table 6).

While the most frequent primary diagnosis among all cases of injury identified for the study was the general category of " injury other and unspecified" (8.4%), the most common categories of specific primary diagnoses with more than 1000 cases each included: contusion of lower limb (and other unspecified sites) (7.8%), open wound of head (6.8%), contusion of the trunk (5.9%), fracture of radius and ulna (4.9%), concussion (3.9%), and contusion of the upper limb (3.7%) (Table 7). The distribution pattern of the outpatient cases is more similar to the all case distribution than the distribution of the inpatient cases. For example, while the top three specific primary diagnoses for outpatient cases mirror the distribution pattern of all cases, the three most common, specific primary diagnoses of inpatient cases include fracture of vertebral column without mention of spinal cord injury, fracture of tibia and fibula, and fracture of the ankle.

Demographics, Seasonality, and Location

The majority of all cases were female, 16,067 (54.5%). The average age for all men and women was 38.5 years of age (Table 8).

While injuries were distributed across all months the most injuries occurred during April through October with a peak in August with 13% of all cases (Table 9).

The majority of cases reside in non-metropolitan Minnesota (defined as the 80 counties outside the seven county metropolitan area comprised of: Hennepin, Ramsey, Anoka, Washington, Carver, Scott, and Dakota counties). As the location of where the injury occurred is not recorded in the billing record, the available data regarding the county or zip code of patient residences is used as a proxy for where the individual was injured in Minnesota. The majority of individuals injured reside in the non-metro Minnesota area. Of the seven counties that make up the metropolitan area Hennepin and Ramsey are the two most urban counties (representing 31.3% of the state population). Of all the individuals with a potential agriculturally-related injury only 3,466 (11.8%) reside within these two counties.

Descriptive Findings: *Probable* Cases of Agricultural Injury

Of the set of E codes used to identify cases potentially related to agriculture, two of these E codes are more specific for farm or agricultural-relatedness than the remaining E codes. The E codes E849.1 (location on a farm) and E919.0 (related to agricultural machinery) provide a level of confidence that the cases identified are most likely related to agriculture. As such these cases will be referred to as *probable* cases of agricultural – injury and the cases identified with the remaining five E codes will be referred to as *possible*.

Among *probable* cases of agricultural-injury the annual number of injuries ranged between 397 and 643 over the twelve year study period (Table 10).

Health Care Utilization, Sources of Insurance and Injury Diagnoses

Of the 6,052 *probable* cases of agriculturally-related injuries, the most frequent point of access into the health care system was admission through the emergency room (57.7% of cases); physician referral was the second most frequent point of access (37.1% of cases) (Table 11). The average length of stay was two days with a range from 1 to 82 days.

The majority of cases were discharged to their home, (87.4%) with the second largest percentage of cases discharged to a short-term general hospital, 388 (6.4%), and the third most common category of those discharged to a skilled nursing facility, 58 (0.9%). In total 16 of these cases were listed as deceased upon discharge, with 6 of the individuals receiving inpatient care and the remaining 10 seen either in the emergency room or the outpatient setting.

The majority of these cases, 4,132 (69.4%) had some form of private non-group health insurance. A total of 1,108 (18.6%) had their care covered by Medicare/Medicaid/MNCare. Only 290 (4.8%) were covered by workers' compensation, 41 (0.7%) were self-insured, and 372 (6.3%) were listed as self-pay for the receipt of health care.

The most common, specific primary diagnoses for all 6,052 *probable* cases were: open wound of the finger (10.9%), open wound of the head (6.3%), and fractures of one or more fingers of the hand (5.0%). The distribution of the most frequent conditions for all *probable* outpatient cases was comparable to those of all *probable* cases. In contrast, the most common specific primary diagnoses for all *probable* inpatient cases included fracture of the radius and ulna (21.5%), crushing injury of upper limb (21.3%), and fracture of the ankle (18.9%) (Table 12).

Demographics, Seasonality, and Location

The majority of the 6,052 cases occurring on a farm or related to agricultural machinery were experienced by males (81.5%). These proportions were similar when comparing the frequency distribution of gender among inpatient and outpatient cases. *Probable* cases occurred more frequently among adults 25-64 years of age (59.2%) with a peak in frequency for those 45 to 54 years of age (17.1%). Inpatient care was most common among persons 35 – 74 years of age (64.8%), with the highest frequency among persons 55-64 years of age (37.4%). The frequency distribution of outpatient care was consistent with the pattern observed in all cases (Table 13). Given the seasonality of agricultural work, the *Probable* injuries were most frequent May through October, peaking in June and July (11.4% - 11.3% respectively) (Table 14). Of all the *probable* cases the majority (85.3%) occurred outside of the seven county metro area, and only 4.8% occurred within Hennepin and Ramsey counties (Table 15).

Descriptive Findings: *Possible* Cases of Agricultural Injury

As previously described cases categorized as *possible* agriculturally-related injuries were identified by any of the five following E codes: E827 (animal drawn vehicle accident), E828 (accident involving an animal being ridden), E863.0 – E863.9 (accidental poisoning by agricultural and horticultural chemical and pharmaceutical preparations other than plant food and fertilizers), E906.8 (other specified injury caused by animal (butted by animal, fall from a horse or other animal not being ridden, being gored)), and E980.7 (poisoning by solid or liquid substances, undetermined whether accidentally or on purpose inflicted – agricultural and horticultural chemical preparations other than plant food and fertilizers). A total of 23,407 cases were identified, ranging between 1,654 and 2,079 cases per year over the twelve year study period (Table 16).

Health Care Utilization, Sources of Insurance and Payer, and Injury Diagnoses

The primary admission source for *possible* cases was the emergency room, 12,167 (51.9%), and secondarily, physician referral, 10,013 (42.8%) (Table 17). The majority, 21,541 (92%), of *possible* cases, regardless of inpatient or outpatient status, were discharged to home or self-care. The second most common discharge route for *possible* cases, 762 (3.3%) was to another type of institution for care.

The majority of cases (74.5%) had some form of private non-group health insurance. Very few cases were associated with the use of workers' compensation benefits (1.6%), or self-insurance (0.3%) to cover health care costs, and a few cases paid for out of pocket (5.8%).

The most common primary injury diagnosis after other and unspecified was contusion of lower limb and other unspecified sites (8.6%), contusion trunk (6.6%), and other open wound of head (6.3%), among all and outpatient cases. The most common primary diagnoses for inpatient cases included fracture of vertebral column without mention of spinal cord injury (11.1%), fracture of tibia and fibula (7.4%), and fracture of pelvis (5.7%) (Table 18).

Demographics, Seasonality, and Location

In sharp contrast to the gender distribution of *probable* cases, females made up 14,950 (63.9%) of the inpatient and outpatient *possible* cases, while males only made up 8,454 (36.1%) of the *possible* cases.

One third (33.3%) of all *possible* cases were observed among persons 35 – 44 years of age. This age range was also most common among inpatient (42.8%) and outpatient cases (32.5%) (Table 19).

Similar to *probable* cases the greatest number of *possible* injuries occurred in the summer months with July and August having the greatest number of injuries (Table 20).

Among all the *possible* cases, the majority (71.6%) resided outside of the seven county metro area and only 13.5% of cases resided within Hennepin and Ramsey counties (Table 21).

Demographics for *Probable*, *Possible*, and All Cases

Age was divided into seven categories for comparison of very young children (0-9 years of age), teens (15-19 years of age), young adults (20-34 years of age), adults (35-64 years of age), older adults (65-84 years of age), and the elderly (84+ years of age). Over the twelve year period the number of injuries in the youngest age category (0-9 years of age) has declined and the number of injuries in the oldest age category (85+ years) has increased (Appendix 5, Tables A – C, and Figures 5-7).

Frequencies by age category for gender, metro-area residence, and primary diagnosis were also created to better understand how individuals in different demographic categories were injured (Appendix 6, Tables A – D). Among *probable* agricultural injury cases males had higher frequency of injury among all age groups; while the reverse was true of the *possible* cases, with more injured females, except in regards to age group 65 – 84 years of age. Distributions by residency status within or without the seven county metro area found a greater number of individuals regardless of age category to reside outside the seven county metro area.

Denominator Estimates, Agricultural Injury Rates and Trends

As previously described multiple data sources were investigated as potential denominator estimates for the creation of agriculturally-related injury rates. The first set of rates was created with the ACS estimates of the number of individuals living and working on farms. The annual rates of all (both *probable* and *possible*) agriculturally-related injuries ranged between 14.0 and 18.5 per 1,000 individuals living and/or working on a farm between 2000 and 2011 in Minnesota (Tables 22-23). The annual rates of *probable* agriculturally-related injuries ranged between 2.9 and 4.3 injuries per 1,000 individuals living and/or working on a farm in Minnesota between 2000 and 2011.

The second data set utilized to create rates of agriculturally-related injury was the CPS estimate of the number of individuals working in agriculture between 2000 and 2011 in Minnesota. Since the CPS is limited to those sixteen years of age or older, the numerator was similarly restricted. The frequencies of those injured by year as well as by *probable* vs. *possible* agriculturally-related status are presented in Table 24. Table 25 provides the estimated agricultural working population produced from the CPS. The estimates provided are of individuals with either a primary or secondary job categorized in one of the following industries: crop production, animal production, and agricultural support services. The table provides the 90% confidence interval for each year's population estimate based upon the available margin of error provided by the BLS(23). Rates were calculated for each year of data for total, *probable*, and *possible* agriculturally-related injuries, for both inpatient and outpatient categories. The annual rates produced are per 1,000 individuals employed in agriculture sixteen years of age or greater (Table 26). The rate of injury per 1,000 individuals ranged between 19.1 and 40.9 during the time period of 2000 to 2011. The rate of *probable* injury per 1,000 individuals ranged between 5.4 and 8.8 between 2000 and 2011.

A third data set to estimate denominators was based upon the BEA data, annual rates were created for comparison (Table 27). Annual rates created with the BEA denominator ranged between 16.2 and 24.8 agriculturally-related injuries per 1,000 farm laborers during the time period 2000 and 2011. *Probable* injury rates created with the BEA denominator ranged between 4.6 and 5.3 per 1,000 farm laborers during 2000 and 2011.

Joinpoint regression analysis was conducted to determine whether agriculturally-related injury rates changed over time. Logistic regression models were completed to ascertain the average annual percent change over the twelve year span. A logistic Joinpoint model created for all, *probable*, and *possible* agriculturally-related injury annual rates per 1,000 individuals living and/or working on a farm found linear models to be the most probable with zero joins. The rates for all agriculturally-related injury were found to have an annual percent change of 1.5%, (Figure 8). The rates of *probable* agricultural injury were found to have a downward slope and an annual percent change of – 2.2%, (Figure 9). Annual rates of *possible* agricultural injury, had an annual percent change of 5.9% before leveling off in 2005. Joinpoint analysis found that only the trend for *probable* agriculturally-related injuries (slope/average percent change = -2.2, CI = -3.7, -0.7) was significant (Z statistic, p = .008).

Initial analysis of all agriculturally-related injury annual rates for the twelve year period, (CPS denominator) finds an average annual percent change of 10.6% per year between 2000 and 2008. The model finds a significant change in trend direction beginning in the year 2008 when the rates showed an 18% decline annually from 2008 to 2011 (Figure 11). Examining this model with no joinpoint included suggests an average annual percent change of almost 4% from 2000 to 2011 (Figure 12). The inclusion of a single join produces a substantially more significant model, with a shift in the p value from .044 to .004 and a significant reduction of the sum of squared error from 1044.6 to 171.2. This trend pattern was also found for both *probable* and *possible* injuries (Figures 13-14). While the trend among *possible* injuries had a sharp increase prior to 2008 the trend among all injuries had an inverse relationship with a much sharper decline than increase when the trend direction changed in 2008. To examine the impact of a change in the Census Industry Codes (CIC) that occurred in 2002, trends were also analyzed limiting the analysis to the years with the same coding schemes, 2003 to 2011. The trend analysis produced similar results as those with all years included; with trend increasing until 2008 followed by a subsequent decline (Figures 16-17).

Trends were also analyzed using rates based on the BEA estimates of the farm labor population (Table 27). Similar to the trends based on the available CPS population data a single join was found significant among the rates for all agriculturally-related injury and for the *possible* agriculturally-related injuries. The analysis for trend of the *probable* agriculturally-related injury found no significant change in trend in either direction over the twelve year time period. For the *possible* agriculturally-related injuries the trend analysis found an average annual percent change of 11.2% from 2000 to 2004 with a leveling off and a shift to an average annual percent change of 0.8% from 2004 to 2011. The trend analysis of the *probable* agriculturally-related injuries produced a non-significant average annual percent change of -0.8% (Figures 18-20). A comparison of the rates created using the CPS and BEA denominators is provided in Figure 21.

Further exploration of the impact the choice in denominator had on the trend in the rate was completed using estimates of the non-metropolitan/rural Minnesota population (Tables 28-29). The use of the non-metropolitan/rural Minnesota population allows for the creation of a rate including all age categories. The rates created describe the number of agriculturally-related injuries per 100,000 people. Trend analysis was also completed for these rates, investigating the trend among all, *probable*, and *possible* injuries. The trend analysis for all injuries found no significant trend over the twelve year period with a non-significant average annual percent change of 0.13%. Interestingly the trend analysis for *probable* agriculturally-related injuries found a significant average annual percent change of -3.5%, while the trend analysis for *possible* agriculturally-related injuries found a non-significant annual average percent change of 1.1% (Figures 22-24).

Potential Undercount of Agricultural Injuries

The number of injuries identified with the use of the Minnesota hospital discharge data is not a complete count of all agriculturally-related injuries that occur in Minnesota. The Minnesota hospital discharge dataset only captures those injuries that seek medical care and are seen in an inpatient or outpatient facility that reports to MHA. The Rural Regional Injury Studies I and II produced estimates of the proportion of agriculturally-related injury that required hospitalization (17, 27, 28). Using these estimates as well as the underestimation of E code use captured by the evaluation completed by the MDH Injury Program (29), the total number of agriculturally-related injuries were estimated. Using the ratios produced by the RRIS studies, the count of inpatient agricultural-injury cases recorded in the discharge dataset was used to extrapolate the total number of agriculturally-related injuries (Table 30). Using the evaluation completed by the MDH Injury Unit in 2006, in which 10% of injury cases were found to be unaccompanied by an E code; total agriculturally-related injury estimates of the number of inpatient cases were inflated to account for these missing cases (29). RRIS – I found that 3% of agriculturally-related injuries required inpatient hospitalization. The final adjustment was made using the estimate that 83% of all agriculturally-related injury required some form of medical attention, leaving 17% requiring first aid or less. Using the *probable* agriculturally-related injuries identified in this study, between 1,000 and 2,700 injuries related to agriculture per year are estimated to have occurred (Table 30).

Discussion

Minnesota Hospital Discharge Data Utility

Despite the potential undercount, the utility of hospital discharge data for the identification and surveillance of agricultural injury has been demonstrated by this study. In addition to providing an indication of the rates and trend of agriculturally-related injuries, these data identified risk factors or trends associated with agricultural injury previously found in the literature. For example the discharge data confirmed the majority of machinery injuries occurred among males and the majority of animal-related injuries occurred among females, consistent with other studies (30, 31). The distribution of injury by age and type of injury identified in the hospital discharge data were also similar to the distributions previously found in the literature (32-34). Also the overwhelming majority of the identified injuries (85.3% in the case of *probable* injuries) occurred in non-metropolitan areas of Minnesota, where the majority of agricultural activity takes place.

While workers' compensation data have frequently been utilized for surveillance of work-related injuries, very few farms are required to carry workers' compensation insurance (Appendix 2) and the vast majority of the identified injuries in this study (76%) were covered by private health insurance. Consequently, workers' comp data will identify only a fraction of the injury cases that can be identified through the hospital discharge data. While the hospital discharge dataset does not capture the universe of injury related to agriculture due to the lack of completeness and specificity of E codes, it does provide a much more complete picture of the rates and trends of injury related to agriculture occurring each year.

As previously noted, all work-related fatalities, agriculturally-related included, are well captured and reported by the BLS Census of Fatal Occupational Injuries (CFOI). This study reveals the inadequacies of using hospital discharge data for the identification of fatalities related to agriculture. A total of 28 deaths were identified in the discharge data during the 12-year study period. In contrast CFOI identified 28 deaths related to agriculture, forestry, and fishing for the year 2010 alone. Between 2003 and 2011 CFOI identified a total of 192 deaths related to agriculture, forestry, and fishing. As not every death will occur in an inpatient or outpatient setting, the hospital discharge data should not be used in lieu of the CFOI activity.

Identifying At Risk Populations

Understanding the population subgroups most at risk of agriculturally-related injury cases provides insights for potential interventions and future research. Distributions by age reveal persons age 35 – 44 and 45 – 54 have the highest frequencies of injury, consistent with earlier studies (12, 34). Distributions of cases by gender show more women than men sustained an injury involving an animal (E827 and E828) and more men than women sustained an injury involving agricultural machinery (E919.0) (28, 30, 35, 36). Public health professionals may want to consider a variety of venues such as trade shows, fairs, safety shows, and auctions to engage identified age groups in discussion of primary causes of injury and to design and pilot-test injury prevention interventions.

The most common categories of specific primary diagnoses among all agriculturally-related injuries, with more than 1000 total cases each included contusions (lower and upper limbs, trunk), open wound of head, fractures (radius and ulna), and concussions. The most common specific primary diagnoses for all inpatient cases were fractures (e.g., vertebral column, tibia, fibula, and ankle). The most common, specific primary diagnosis for all *probable* cases were open wounds (fingers and head), and fractures (one or more fingers). In contrast, the most common specific primary diagnoses for all known inpatient cases also included fractures (radius, ulna, and ankle), and crushing injury of upper limbs. The injuries identified most commonly in the hospital discharge dataset are consistent with those previously identified as common injuries in working agricultural populations (2, 10, 13, 14, 31, 36-41).   While the Minnesota hospital discharge dataset will miss a substantial portion of agriculturally-related injuries that require medical attention it provides a method and means to identify injuries to quantify trend and create total burden estimates of agriculturally-related injury in the state.

Estimating Agricultural Population Size

The impact the choice in denominator had on the rate of agriculturally-related injury is very apparent from the differences seen in trend analysis of the rates created with different denominators. The calculation of rates to better understand the impact and trend of these injuries is complicated by the need for an appropriate and complete denominator. Seven data sources were identified for the creation of an appropriate denominator. Six of these data sources created rates focusing on the working agricultural population. As these data sources would exclude a portion of the total population, those less than 16 years of age, these injuries were removed from the numerator. Each data source identified had specific strengths and weaknesses.

Although based on survey data, the ACS was identified as the most appropriate denominator as it provided an estimate of population that was living on a farm as well as the population working on farms. The denominator created with the use of the ACS and Ag Census data is the most appropriate as it captures the total population of interest as well as being robust in nature, providing accurate estimates of the population. A limitation included the need to impute several years of the data. However, this denominator is the most specific of those available for the study population. The ACS provides a denominator that allows for public health professionals to account for all injuries, including children and bystanders, not just those injuries sustained by those of working age (age 16 and greater).

The CPS was developed to create statistics and measures related to industry and labor. It was utilized for this study as it was available for all years of interest, was of sufficient size, and due to its sampling methodology should capture all agricultural operations regardless of farm size or employment practices. However the CPS is a survey and will have inherent sampling error. The margin of error provided by the BLS was used in the creation of the denominator estimate and rates. While examining the rates created and accompanying 90% confidence intervals, there does not appear to be a statistically significant difference from year to year (alpha = .10). The rates calculated with the CPS estimates had a lot more fluctuation than the rates created with the denominator estimates from the ACS and BEA. Some of this may be due in part to two factors: the industry coding changes that took place in 2002, and changes in migrant labor availability and the economic recession that occurred in the mid 2000's. Both of these factors may have had effects on small and family farms that are not well documented. The denominator estimates provided by the CPS and BEA are similar in magnitude though not necessarily in variation and trend. The rates created with each demonstrate an increase in the number of injuries at the beginning of the decade with a leveling off or decline in the latter part of the decade. Each of these denominators provides a method to further explore agriculturally-related injury in Minnesota as well as evaluate the rates created with the ACS.

The variation seen in the trends may be directly attributable to the choice of denominator. The use of a denominator based upon Minnesota's rural population and those living and/or working on farms produces agriculturally-related injury rates that have been fairly stable over the twelve year study period, in comparison to the denominators affected by changes in the economy and industry hiring practices. However the rate of *probable* injuries appears to be declining slightly (p = .008) over the twelve year period while the rate of *possible* injuries (and predominantly caused by interaction with animals) were increasing (2000 – 2005) at a statistically significant rate of change before leveling off.

Limitations

There are a number of limitations of this research study. The first limitation is an artifact of using a secondary data set. The case definition is created using available fields and variables in the hospital discharge dataset, which are neither 100% accurate nor complete. The lack of completeness and accuracy is in large part due to the collection of the data for the billing purposes not for injury research. As such information necessary or useful to surveillance or research questions may not be collected as they are unnecessary for billing. Consequently, the case definition may not be as specific or sensitive as necessary. Evaluation of E codes, conducted by the MDH Injury program, suggests approximately 10% of injuries are lacking the accompanying E code (29). However, there has been little or no evaluation of the completeness of E codes depending on the type of E code used. Do animal-related E codes have a greater likelihood of use than E codes detailing the geographic location of injury? These potential nuances in E coding (or the future ICD-10CM external cause codes) throughout the hospital discharge record need to be evaluated to understand the degree to which an undercount may occur. Another limitation of hospital discharge data is the absence of an indicator to determine work-relatedness of an injury or illness. While it may be possible to determine a relationship between agriculture and injury, it is usually not possible to determine whether the injury occurred during a work-related activity. To address this limitation one would need to be able to interview the identified cases to determine the proportion of injured individuals that were engaged in a work-related activity when the injury occurred. This type of data collection is resource intensive and currently not possible as the discharge dataset is de-identified.

Interviews with three large hospital systems in Minnesota were conducted to understand how hospital discharge data is collected and how that may impact the counts of injury related to agriculture. From this limited sample of interviews it was made clear that E codes are not a required element, and preference is given to E codes that support the primary diagnosis such as mechanism and nature of injury. Location codes, such as on a farm, are given less priority. Hospitals with trauma centers may have a higher likelihood of including a greater number of E codes such as those for location. Given these considerations it is possible that the estimated 10% of injuries that are not E coded from previous evaluation (29) is itself an under-estimation of missing E codes related to agriculturally-related injuries.

Each data source investigated as a potential denominator (i.e., the agricultural population at risk of injury) had its own set of limitations. Both the CPS and ACS are surveys with error due to sample design and survey error. To address the limitations and error created with the use of the ACS and CPS survey data, margin of error estimates were used to create confidence intervals for the estimated denominators as well as the rates. These confidence intervals allow for comparison of rates across years as well as an understanding of the error introduced in the rate by using these data sources for denominator.

A second concern regarding the CPS is the exclusion of those younger than 16 years of age in regards to employment. The exclusion of this age group may have a unique effect on the estimates of farm labor as children 16 and under may contribute to the production of the farm. The exclusion of those younger than 16 occurs as well with the QCEW and the ACS.

The limitations present in each data source create difficulties when attempting to estimate the number of individuals employed and or living on farms in a geographic area. The use of multiple data sets provides better understanding of these limitations and supports the selection of one denominator data source over another.

Future Endeavors

The mandatory conversion from ICD-9CM to ICD-10CM scheduled for October 2015 will bring about a conversion from E codes to a vastly expanded (over 5-fold) number of V, W, X, and Y external cause morbidity codes. Where implemented (use of these codes are not mandated nationally or in Minnesota), this expanded menu of external cause codes would provide greater sensitivity and specificity in characterizing nature, location, cause, and other accompanying attributes of injury. Consequently, to the extent that these codes are adopted, the use of hospital discharge data as a surveillance tool for injury related to agriculture should further improve.

This study has demonstrated that agriculturally-related injury is occurring with reliable frequency, and injury related to animals appears to be increasing steadily. Research is needed to understand the degree to which E codes and their upcoming ICD-10-CM replacements are used in hospital discharge data and the impact this has on the completeness and the validity of the identified cases. Currently, the proportion of hospitalized injury related to agriculture that has been missed or miss-coded remains unknown. The data demonstrate that agriculture is still an industry at risk of injury and efforts to improve safety are warranted.

Conclusion

While there are noted concerns regarding the completeness and accuracy of E codes for identifying non-fatal agricultural-related injuries from hospital discharge data, this approach provides a more complete picture of the rates and trends of these injuries compared to other surveillance systems such as workers' comp and the SOII. These data aid in understanding the numbers, rates, and trends of agricultural injury within a state and to a limited degree the mechanism (animal or machinery) of those injuries, types of injuries, and other descriptive data. These data are potentially useful to public health professionals and policy makers in prioritizing of resources and identifying and evaluating prevention and intervention strategies. Examples might include whether to intensify efforts to install roll over cages on all tractors, or modifying laws and regulations regarding agricultural safety practices, or possibly pursue the development and implementation of health and safety training availability at non-traditional learning locations to facilitate access to education by adult agricultural workers. This method of surveillance described in this paper is cost-effective and the data source will be readily available on an annual basis and can be further utilized to evaluate prevention and intervention practices and policies that are developed and implemented. This study has demonstrated the value and utility of hospital discharge data for the surveillance of agriculturally-related injuries within a state.

Figures

Figure 1: Estimates of the Minnesota Agricultural Working Population

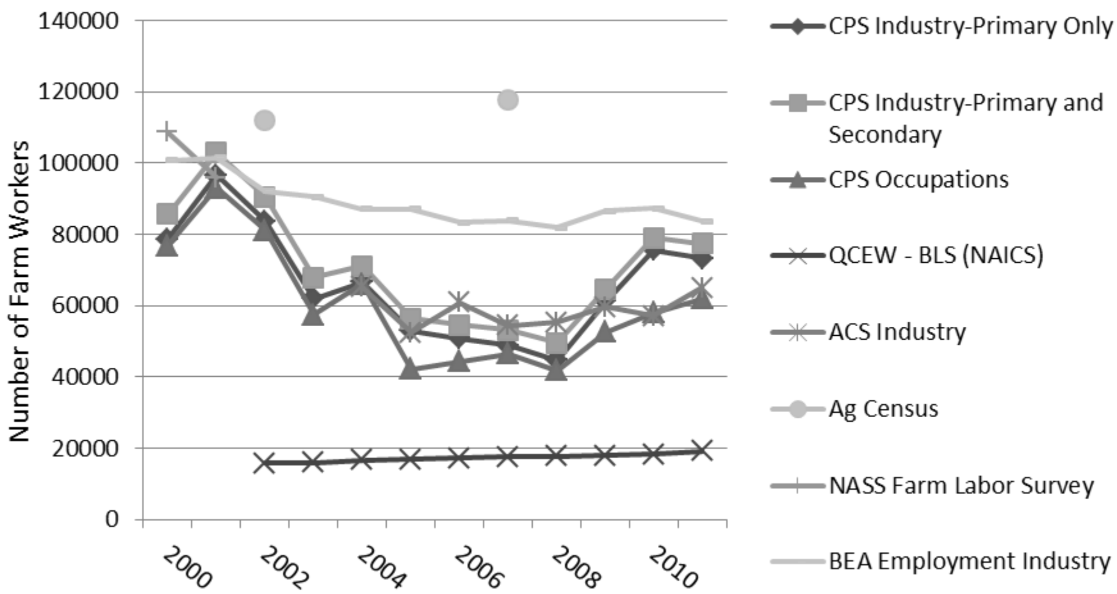


Figure 2: Imputed Values of the Number of Individuals Living on a Farm in Minnesota

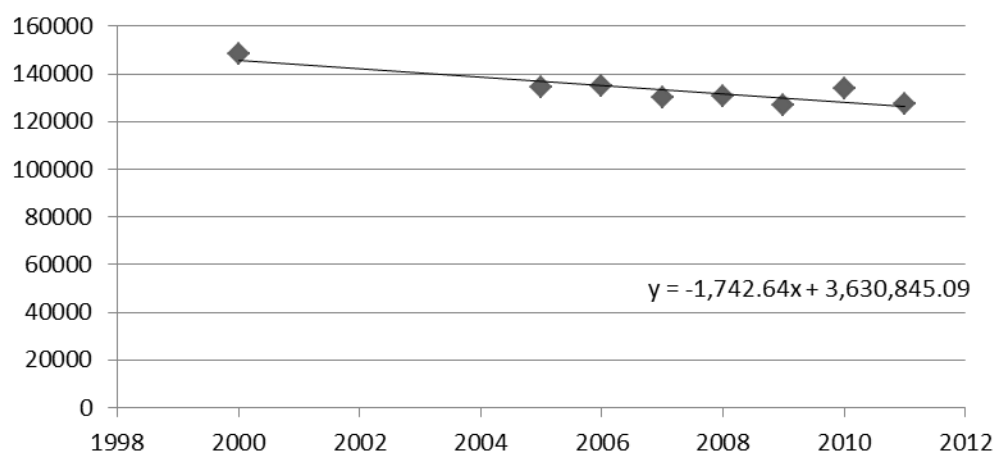


Figure 3: Imputed Values of the Number of Individuals Working but Not Living on a Farm in Minnesota

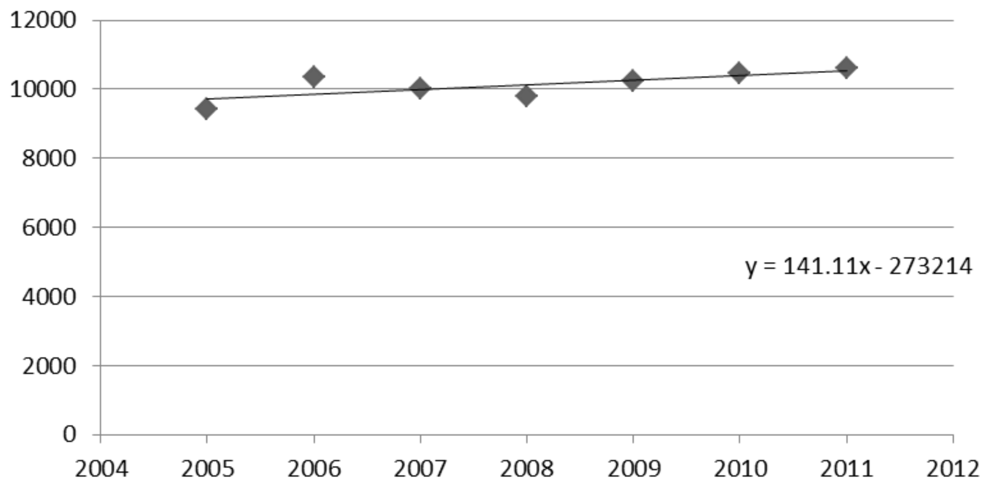


Figure 4: Number of Agriculturally-Related Injuries by Year

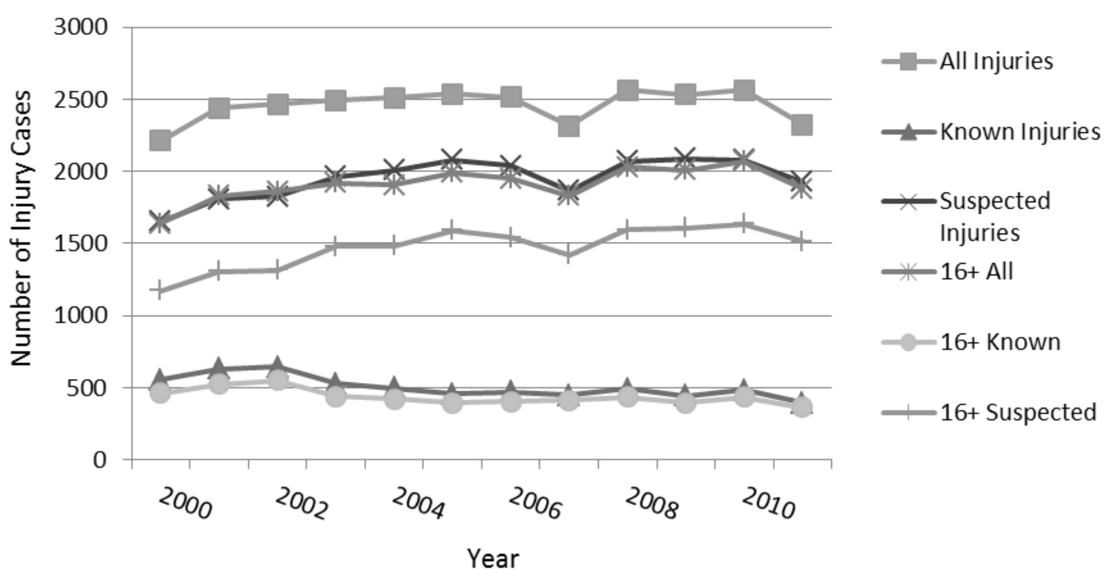


Figure 5: All Agricultural Injury by Age Category

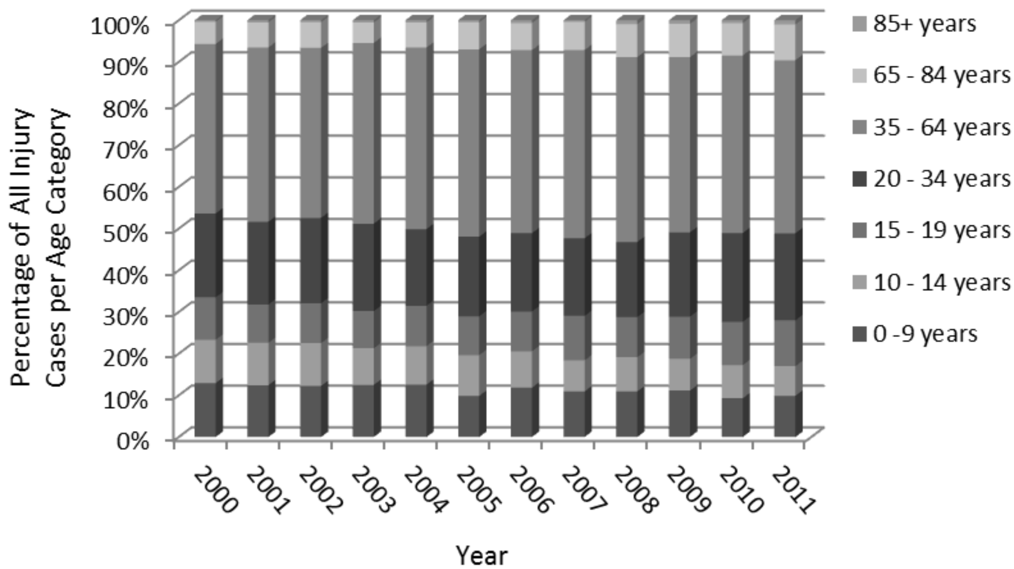


Figure 6: *Probable* Agricultural Injury by Age Category

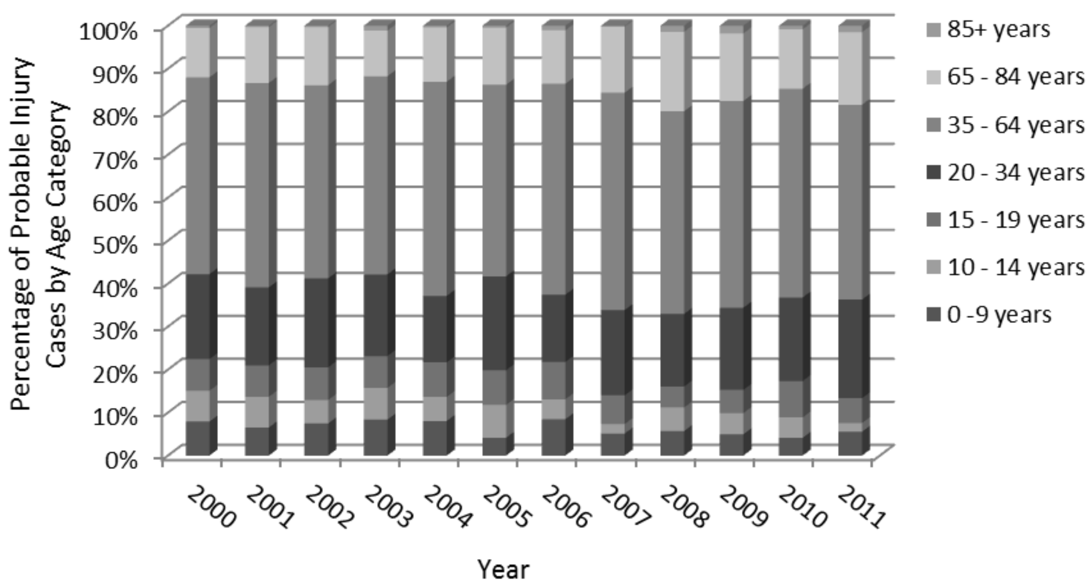


Figure 7: *Possible* Agricultural Injury by Age Category

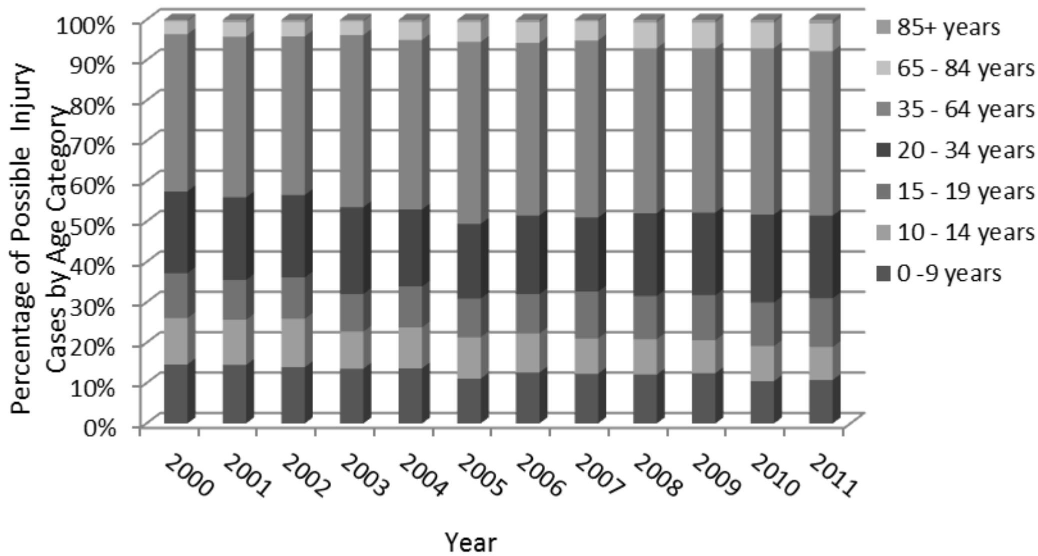
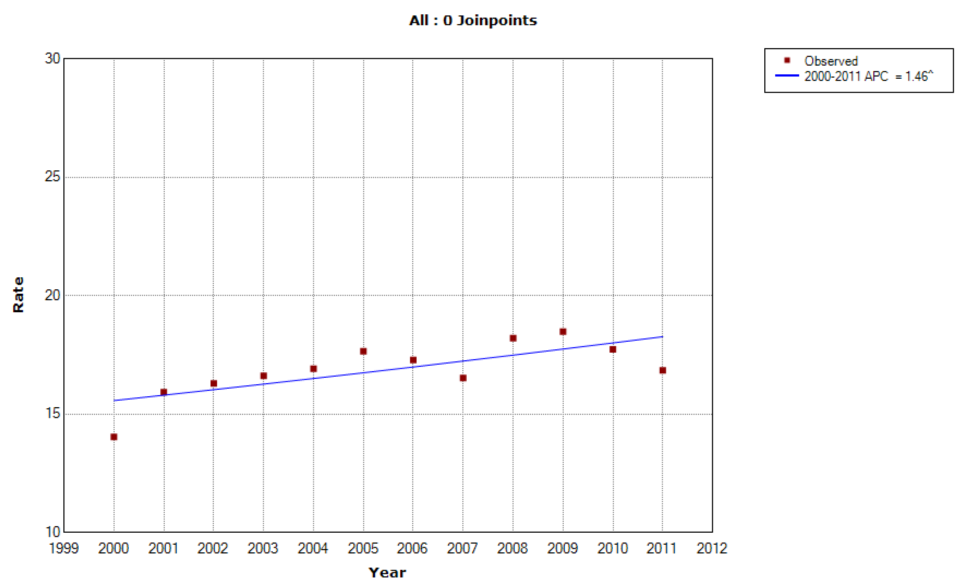
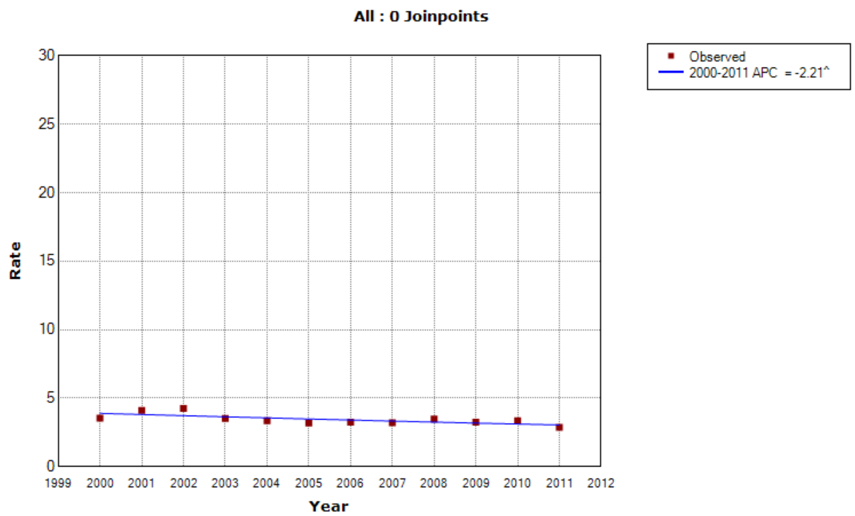


Figure 8: Trend Analysis of All Agriculturally-Related Injury Rate per 1,000 Individuals Living and/or Working on Farms in Minnesota between 2000 and 2011 (Logistic Model)



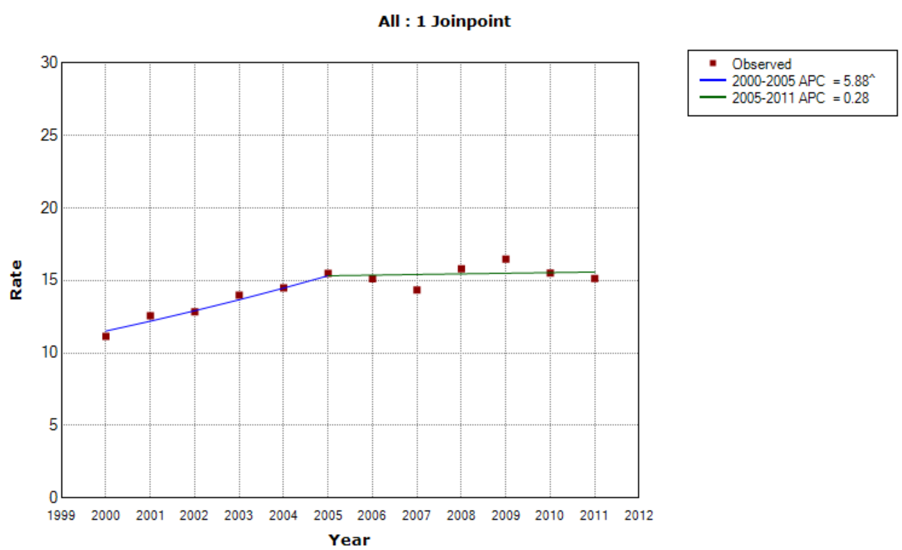
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 9: Trend Analysis of *Probable* Agriculturally-Related Injury Rate per 1,000 Individuals Living and/or Working on Farms in Minnesota between 2000 and 2011 (Logistic Model)



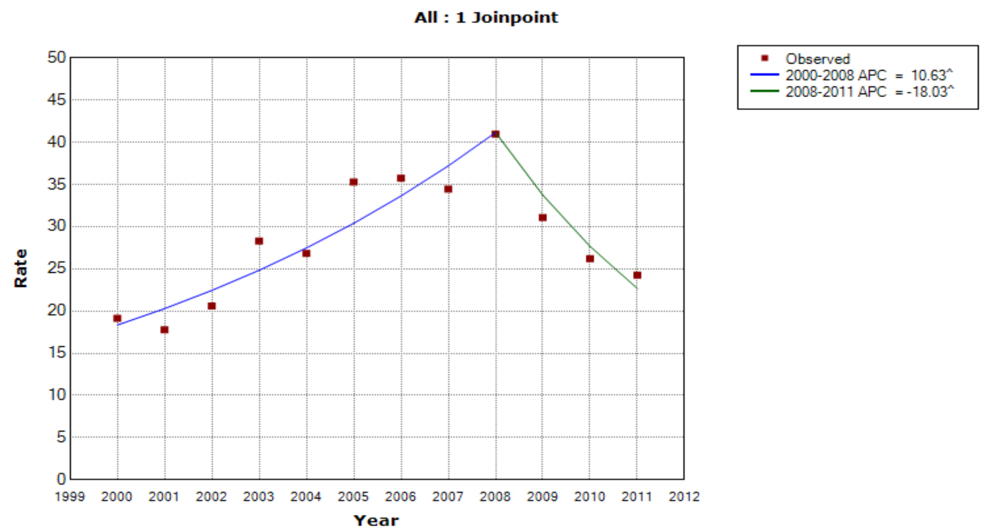
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 10: Trend Analysis of *Possible* Agriculturally-Related Injury Rate per 1,000 Individuals Living and/or Working on Farms in Minnesota between 2000 and 2011 (Logistic Model)



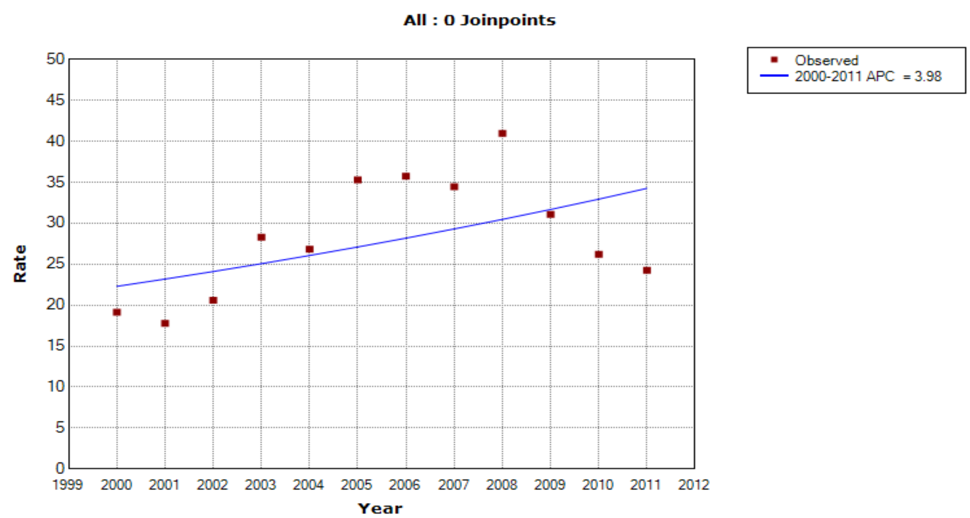
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 11: Trend Analysis of All Agriculturally-Related Injury Rate per 1,000 Individuals Employed in Agriculture 16 Years of Age or Older (Logistic Model)



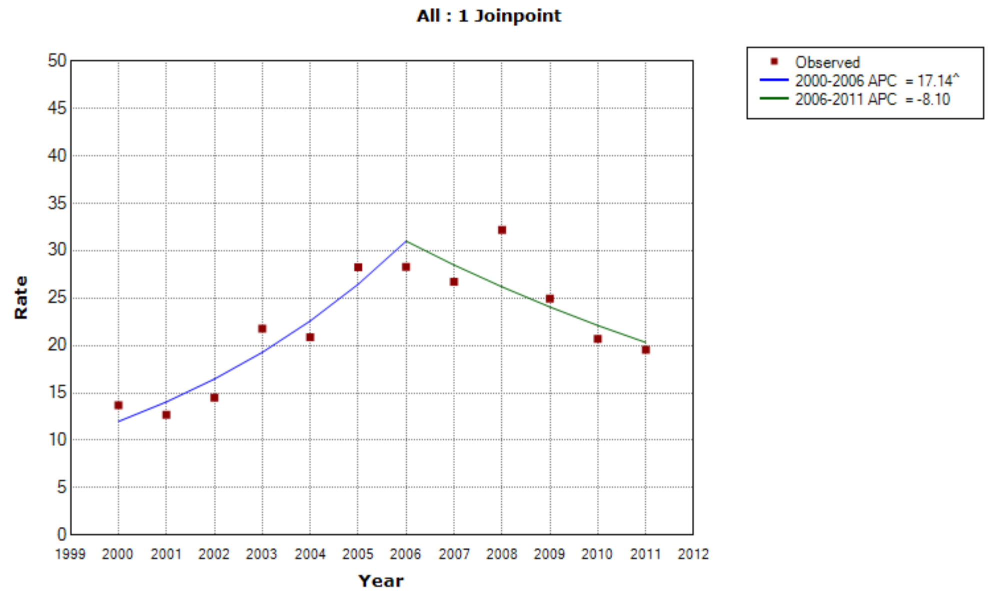
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 12: Zero Join Model - Trend Analysis of All Agriculturally-Related Injury Rate per 1,000 Individuals Employed in Agriculture 16 Years of Age or Older (Logistic Model)



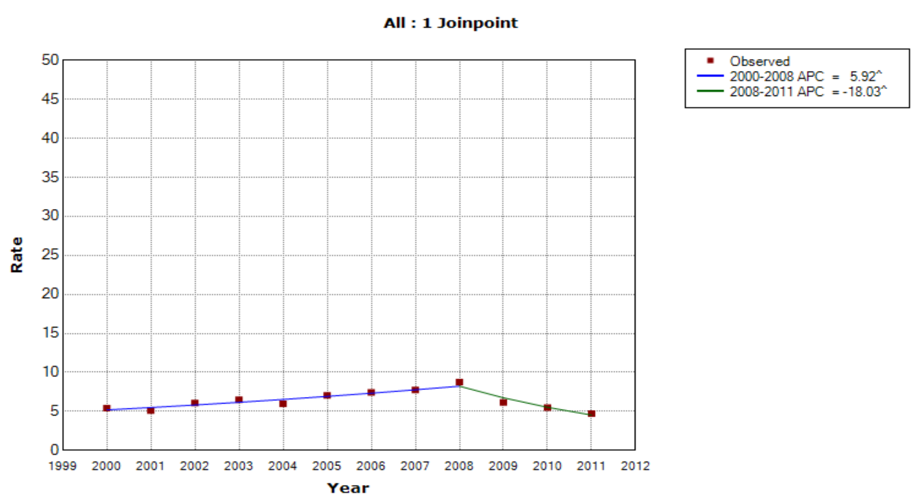
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 13: Trend Analysis of *Possible* Agriculturally-Related Injury Rate per 1,000 Individuals Employed in Agriculture 16 Years of Age or Older (Logistic Model)



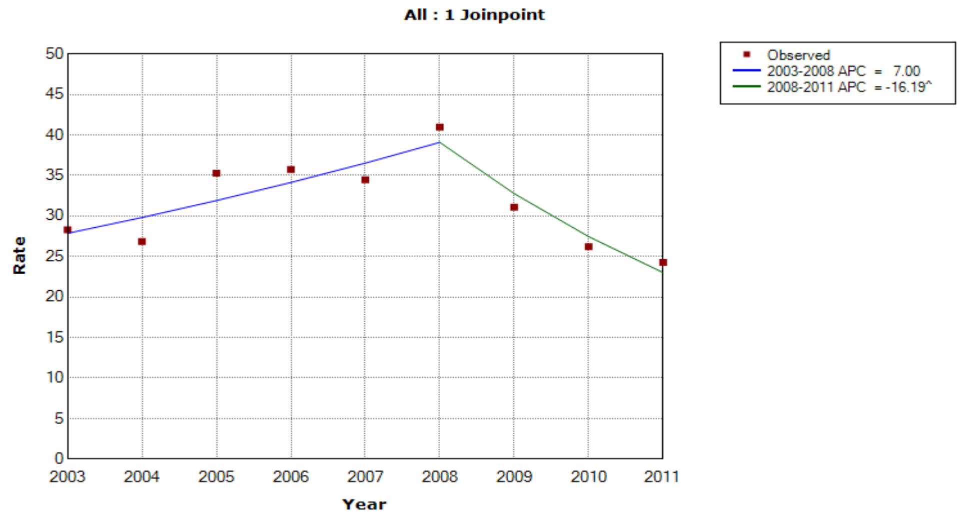
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 14: Trend Analysis of *Probable* Agriculturally-Related Injury Rate per 1,000 Individuals Employed in Agriculture 16 Years of Age or Older (Logistic Model)



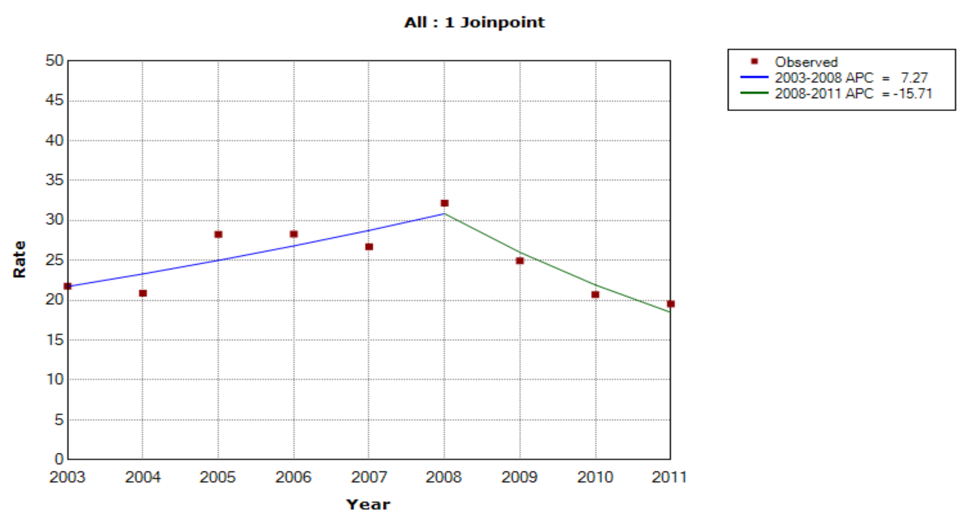
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 15: Trend Analysis of All Agriculturally-Related Injury Rate per 1,000 Individuals Employed in Agriculture 16 Years of Age or Older between 2003 and 2011 (Logistic Model)



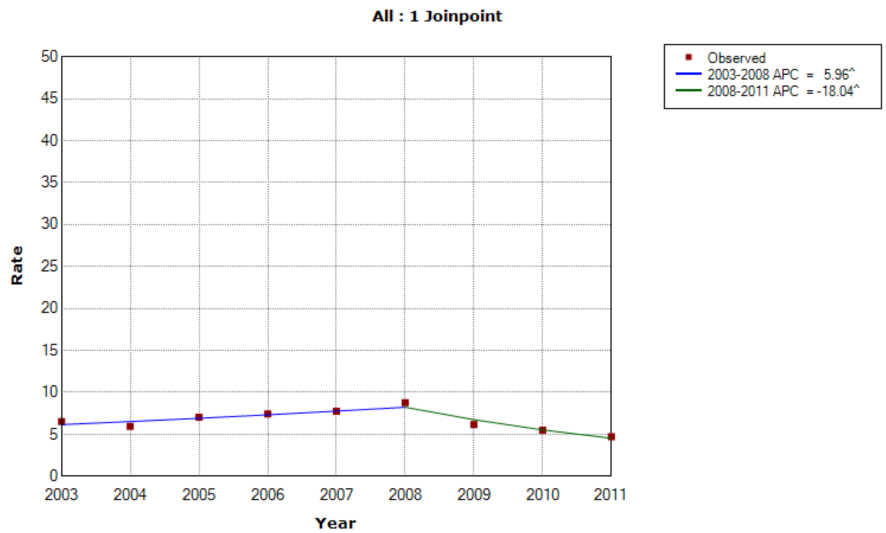
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 16: Trend Analysis of *Possible* Agriculturally-Related Injury Rate per 1,000 Individuals Employed in Agriculture 16 Years of Age or Older Between 2003 and 2011 (Logistic Model)



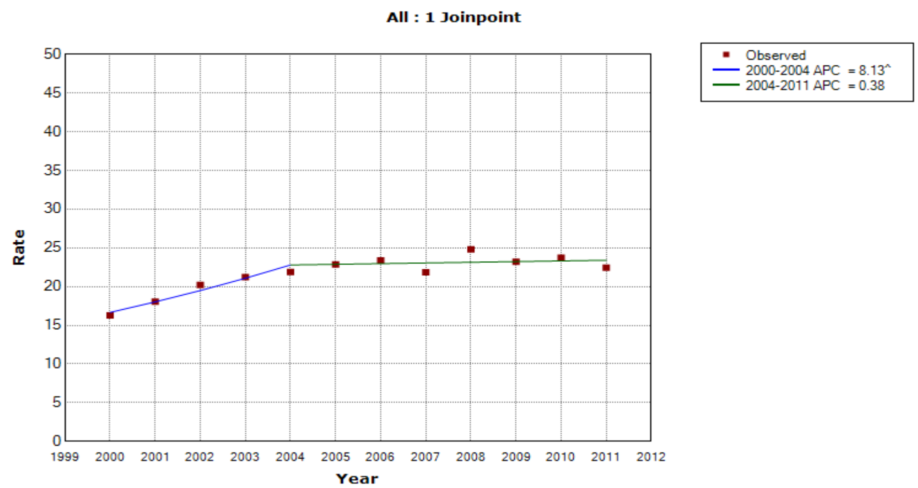
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 17: Trend Analysis of *Probable* Agriculturally-Related Injury Rate per 1,000 Individuals Employed in Agriculture 16 Years of Age or Older Between 2003 and 2011 (Logistic Model)



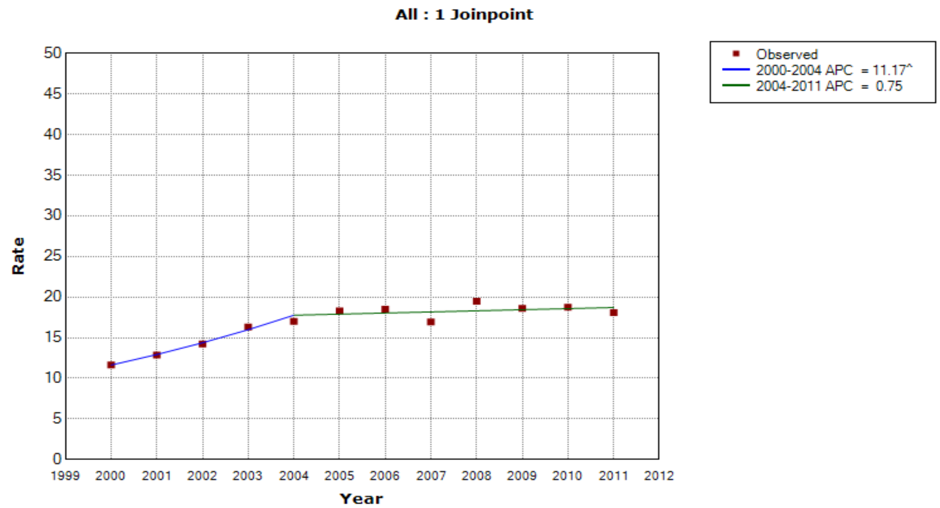
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 18: Trend Analysis of All Agriculturally-Related Injury with Bureau of Economic Analysis Denominator between 2000 and 2011 (Logistic Model)



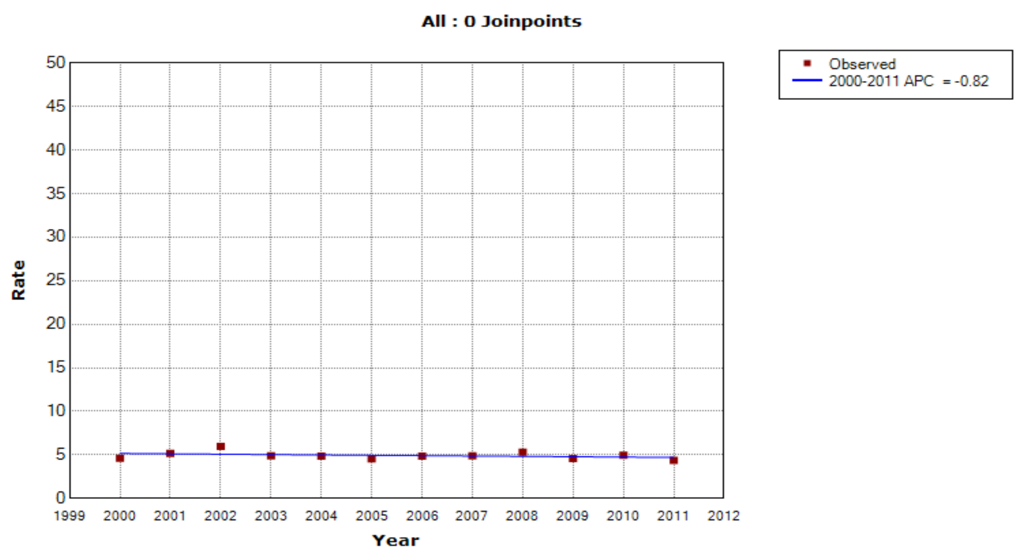
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 19: Trend Analysis of *Possible* Agriculturally-Related Injury with Bureau of Economic Analysis Denominator between 2000 and 2011 (Logistic Model)



*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 20: Trend Analysis of *Probable* Agriculturally-Related Injury with Bureau of Economic Analysis Denominator between 2000 and 2011(Logistic Model)



*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 21: Injury Rates per 1,000 Agricultural Workers, Comparison of Current Population Survey and Bureau of Economic Analysis Denominators

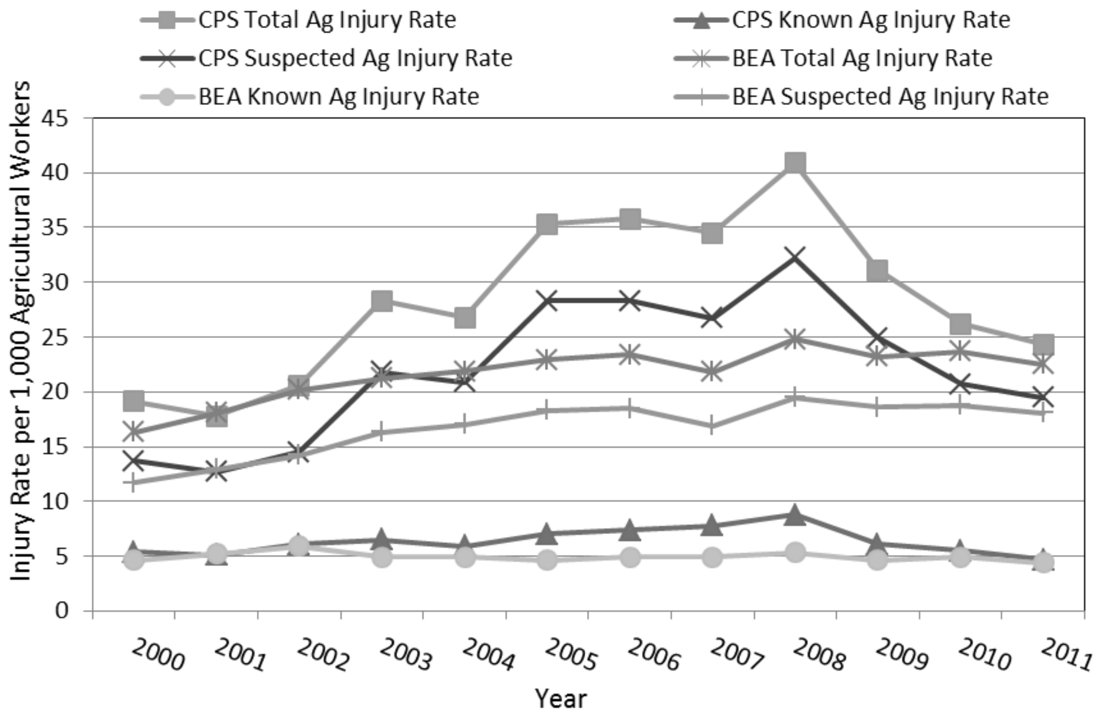
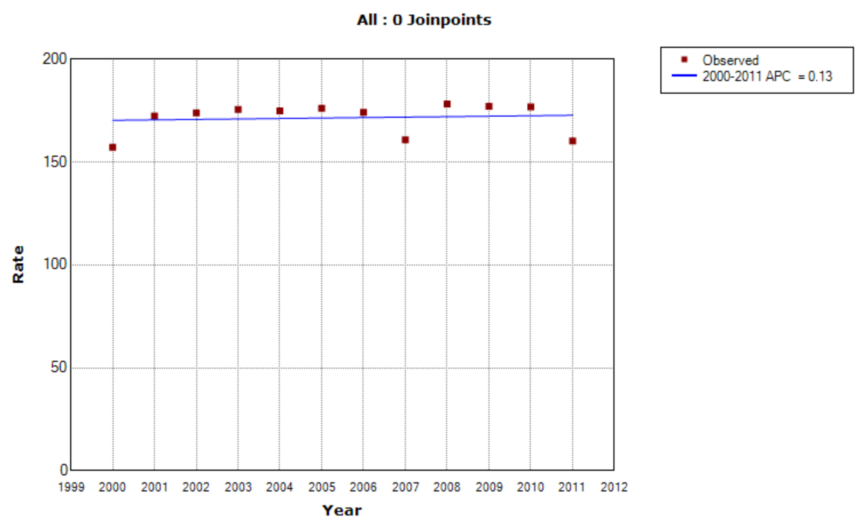
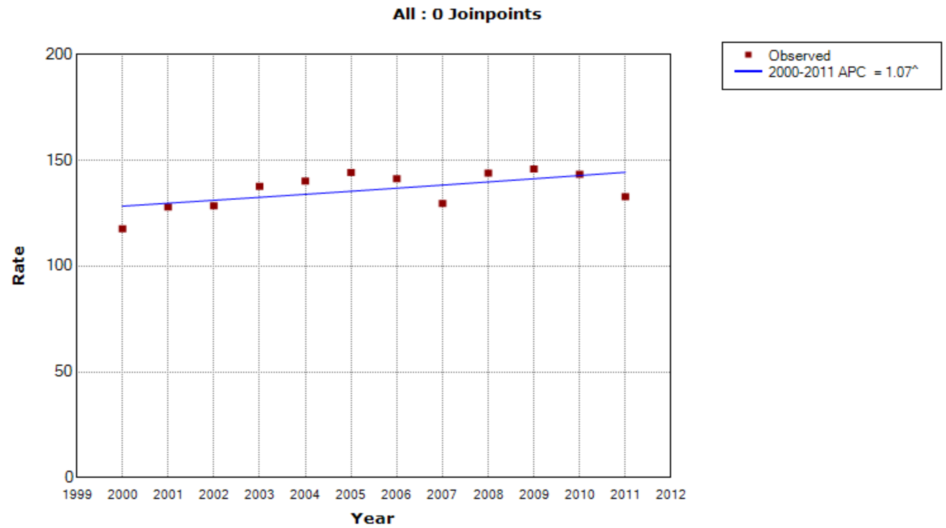


Figure 22: Trend Analysis of All Agriculturally-Related Injuries per 1,000 People among Minnesota's Non-Metropolitan/Rural Population between 2000 and 2011 (Logistic Model)



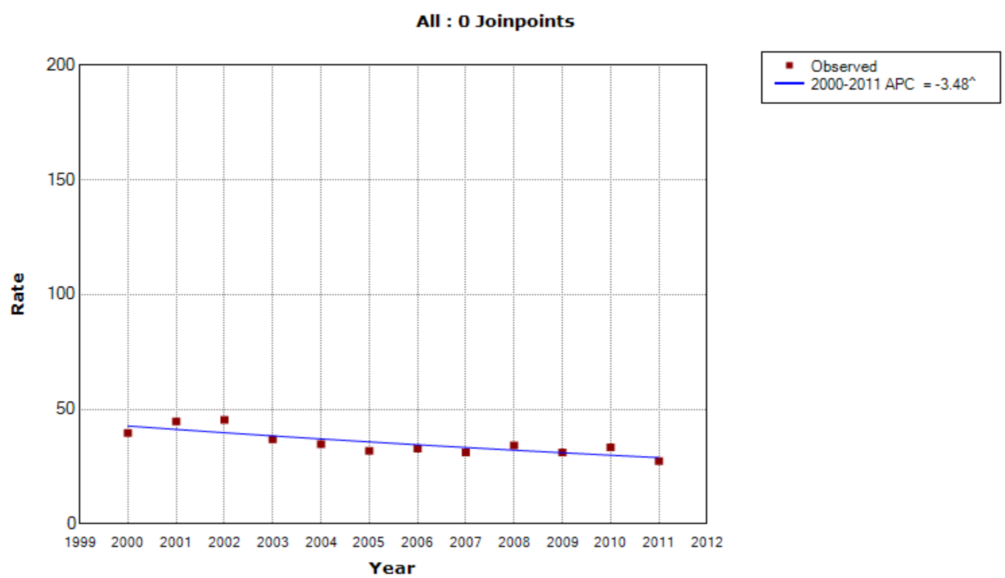
*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 23: Trend Analysis of *Possible* Agriculturally-Related Injuries per 100,000 People among Minnesota's Non-Metropolitan/Rural Population between 2000 and 2011 (Logistic Model)



*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Figure 24: Trend Analysis of *Probable* Agriculturally-Related Injuries per 100,000 People among Minnesota's Non-Metropolitan/Rural Population between 2000 and 2011 (Logistic Model)



*APC: Average percent change. The symbol ^ refers to the statistical significance of the slope.

Tables

Table 1: Initial Query of Minnesota Hospital Discharge Data, Cases by E Code*

E Code	Number of Cases with Code Present	Number of Inpatient Cases	Number of Outpatient Cases
E827.0 – 827.9	235	24	211
E828.0 – 828.9	16,387	1621	14,766
E849.1	5,313	476	4,837
E863.0 – 863.9	644	58	586
E906.8	17,349	858	16,491
E919.0	4,575	482	4,093
E980.7	50	11	39
Total	44,553	4,530	41,023

*As multiple E codes may be assigned to a case, some double counting will occur. This will create a higher total than the full case count of 43,531.

Table 2: Initial Query of Minnesota Hospital Discharge Data, Cases by Year

Year	Number of Cases	Inpatient Cases	Outpatient Cases
2000	3,108	251	2,857
2001	3,502	242	3,260
2002	3,404	272	3,132
2003	3,538	308	3,230
2004	3,581	260	3,321
2005	3,779	315	3,464
2006	3,775	325	3,450
2007	3,500	288	3,212
2008	3,826	301	3,525
2009	3,876	250	3,626
2010	4,009	310	3,699
2011	3,633	283	3,350
Total	43,531	3,405	40,126

Table 3: Agriculturally-Related Injury Cases by E Code after Exclusions Applied*

E Code	Number of Cases with Code Present	Inpatient Cases	Outpatient Cases
E827.0 – 827.9	150	22	128
E828.0 – 828.9	11,340	1,472	9,868
E849.1	3,438	374	3,064
E863.0 – 863.9	433	21	412

E906.8	11,920	606	11,314
E919.0	2,874	433	2,441
E980.7	16	1	15
Total	30,171	2,929	27,242

*As a case may have more than a single E code assigned some double counting may occur.

Table 4: Agriculturally-Related Injury Cases by Year

Year	Number of Cases (%)	Inpatient Cases (%)	Outpatient Cases (%)
2000	2,211 (7.5)	198 (7.0)	2,013 (7.6)
2001	2,438 (8.3)	193 (6.9)	2,245 (8.4)
2002	2,467 (8.4)	224 (8.0)	2,243 (8.4)
2003	2,490 (8.5)	252 (9.0)	2,238 (8.4)
2004	2,508 (8.5)	217 (7.7)	2,291 (8.6)
2005	2,535 (8.6)	271 (9.6)	2,264 (8.5)
2006	2,512 (8.5)	268 (9.5)	2,244 (8.4)
2007	2,316 (7.9)	259 (9.2)	2,057 (7.7)
2008	2,561 (8.7)	248 (8.8)	2,313 (8.7)
2009	2,534 (8.6)	197 (7.0)	2,337 (8.8)
2010	2,563 (8.7)	252 (9.0)	2,311 (8.7)
2011	2,324 (7.9)	233 (8.3)	2,091 (7.8)
Total	29,459	2,812	26,647

Table 5: Agriculturally-Related Injury Cases by Admission Source

Admission Source	Total Cases (%)	Inpatient Cases (%)	Outpatient Cases (%)
Physician referral	12,257 (41.6)	677 (24.1)	11,580 (43.5)
Clinic referral	680 (2.3)	63 (2.2)	617 (2.3)
HMO referral	6 (0)	1 (0)	5 (0)
Transfer from hospital	294 (1.0)	229 (8.1)	65 (0.3)
Transfer from Skilled Nursing Facility	2 (0)	1 (0)	1 (0)
Transfer from another facility	21 (0)	7 (0.3)	14 (0)
Emergency room	15,656 (53.2)	1,822 (64.8)	13,834 (51.9)
Court/law enforcement	3 (0)	0 (0)	3 (0)
Unknown	533 (1.8)	6 (0.2)	527 (2.0)
Transfer from critical access	7 (0)	6 (0.2)	1 (0)

Table 6: Agriculturally-Related Injury Cases by Discharge Status

Discharge Source	Count (%)	Inpatient Cases (%)	Outpatient Cases(%)
Home or self-care	26,831 (91.1)	2,396 (85.2)	24,435 (91.7)
Transferred to another short-term general hospital for inpatient care	1,104 (3.8)	68 (2.4)	1,036 (3.9)
Transferred to skilled nursing facility	148 (0.5)	110 (3.9)	38 (0.1)
Transferred to intermediate care facility	917 (3.1)	7 (0.2)	910 (3.4)
Transferred to another type of institution for inpatient care	20 (0)	20 (0.7)	0 (0)
Transferred to home health care	104 (0.4)	98 (3.5)	6 (0)
Left against medical advice	38 (0.1)	5 (0.2)	33 (0.1)
Transferred to home IV provider	6 (0)	2 (0)	4 (0)
Expired	26 (0)	14 (0.5)	12 (0)
Still patient	17 (0)	0 (0)	17 (0)
Expired at home	2 (0)	0 (0)	2 (0)
Reserved for national assignment	2 (0)	1 (0)	1 (0)
Hospice – home	1 (0)	0 (0)	1 (0)
Hospice – medical facility	1 (0)	0 (0)	1 (0)
Transferred within this institution to hospital based Medicare approved swing bed	11 (0)	10 (0.4)	1 (0)
Reserved for national assignment	96 (0.33)	65 (2.3)	31 (0.1)
Transferred/referred to another institution for outpatient services	121 (0.4)	16 (0.6)	105 (0.4)
Transferred/referred to this institution for outpatient services	5 (0)	0 (0)	5 (0)

Table 7: Agriculturally-Related Injury Cases by Most Common Primary Diagnosis

ICD 9 Code	Primary Diagnosis Description	Frequency (%)	Inpatient Cases (%)	Outpatient Cases (%)
959	Injury other and unspecified	2,463 (8.4)	29 (1.0)	2,434 (9.1)
924	Contusion of lower limb and other unspecified sites	2,295 (7.8)	44 (1.6)	2,251 (8.5)
873	Other open wound of head	1,863 (6.3)	16 (0.6)	1,847 (6.9)
922	Contusion of trunk	1,738 (5.9)	68 (2.4)	1,670 (6.3)
813	Fracture of radius and ulna	1,445 (4.9)	135 (4.8)	1,310 (4.9)
850	Concussion	1,167 (3.9)	116 (4.1)	1,051 (3.9)
923	Contusion of upper limb	1,091 (3.7)	3 (0.1)	1,088 (4.1)
883	Open wound of finger	887 (3.0)	5 (0.2)	882 (3.3)
918	Superficial injury of eye and adnexa	801 (2.7)	2 (0)	799 (3.0)
807	Fracture of rib(s), sternum, larynx, and trachea	642 (2.2)	142 (5.1)	500 (1.9)
847	Sprains and strains of other and unspecified parts of back	617 (2.1)	10 (0.4)	607 (2.3)
824	Fracture of ankle	605 (2.1)	189 (6.7)	416 (1.6)
920	Contusion of face, scalp, and neck except eye	592 (2.0)	5 (0.2)	587 (2.2)
805	Fracture of vertebral column without mention of spinal cord injury	587 (1.9)	270 (9.6)	317 (1.2)
910	Superficial injury of face, scalp, and neck except eye	564 (1.9)	0 (0)	564 (2.1)
812	Fracture of humerus	547 (1.9)	126 (4.5)	421 (1.6)
816	Fracture of one or more phalanges of hand	540 (1.8)	19 (0.7)	521 (1.9)
882	Open wound of hand except finger(s) alone	513 (1.7)	11 (0.4)	502 (1.9)
823	Fracture of tibia and fibula	468 (1.6)	212 (7.5)	256 (0.9)
810	Fracture of clavicle	420 (1.4)	38 (1.4)	382 (1.4)
802	Fracture of face bones	331 (1.1)	69 (2.5)	262 (0.98)
808	Fracture of pelvis	291 (1.0)	155 (5.5)	136 (0.5)
860	Traumatic internal injury of pneumothorax and hemothorax	188 (0.7)	141 (5.0)	47 (0.2)
927	Crushing injury of upper limb	187 (0.7)	37 (1.3)	150 (0.6)
801	Fracture of base of skull	166 (0.6)	97 (3.5)	69 (0.3)
820	Fracture of neck of femur	126 (0.4)	91 (3.2)	35 (0.1)

852	Subarachnoid, subdural, and extradural hemorrhage, following injury	114 (0.4)	62 (2.2)	52 (0.2)
865	Injury to spleen	96 (0.3)	72 (2.6)	24 (0)
821	Fracture of other and unspecified parts of femur	83 (0.3)	54 (1.9)	29 (0)
864	Injury to liver	71 (0.2)	49 (1.7)	22 (0)

Table 8: Agriculturally-Related Injury by Age Category

Age Category	Frequency (%)	Inpatient Cases (%)	Outpatient Cases (%)
0-4	1,537 (5)	38 (1.4)	1,499 (5.6)
5-9	1,810 (6.1)	104 (3.7)	1,706 (6.4)
10-14	2,595 (8.9)	160 (5.7)	2,435 (9.1)
15-19	2,799 (9.8)	161 (5.7)	2,738 (10.3)
20-24	2,099 (7.1)	135 (2.3)	1,964 (7.4)
25-34	3,709 (12.6)	274 (9.7)	3,435 (12.9)
35-44	4,973 (16.9)	455 (16.2)	4,518 (16.9)
45-54	4,886 (16.6)	658 (23.4)	4,228 (15.9)
55-64	2,784 (9.5)	465 (16.5)	2,319 (8.7)
65-74	1,277 (4.3)	211 (7.5)	1,066 (4.0)
75-84	701 (2.4)	123 (4.4)	578 (2.2)
85+	189 (0.6)	28 (0.9)	161 (0.6)

Table 9: Agriculturally-Related Injury by Month

Month	Frequency (%)	Inpatient Cases (%)	Outpatient Cases (%)
January	1,076 (3.7)	87 (3.1)	989 (3.7)
February	981 (3.3)	91 (3.2)	890 (3.3)
March	1,522 (5.2)	104 (3.7)	1418 (5.3)
April	2,305 (7.8)	222 (7.9)	2083 (7.8)
May	3,341 (11.3)	332 (11.8)	3009 (11.3)
June	3,485 (11.8)	325 (11.6)	3160 (11.7)
July	3,770 (12.8)	365 (12.9)	3405 (12.8)
August	3,835 (13.0)	382 (13.6)	3453 (12.9)
September	3,237 (10.9)	327 (11.6)	2910 (10.9)
October	2,935 (9.9)	290 (10.3)	2645 (9.9)
November	1,790 (6.1)	206 (7.3)	1584 (5.9)
December	1,182 (4.0)	81 (2.9)	1101 (4.1)

Table 10: *Probable* Agriculturally-Related Injury by Year

Year	Total Cases (%)	Inpatient Cases (%)	Outpatient Cases (%)
2000	557 (9.2)	60 (7.9)	497 (9.4)
2001	629 (10.4)	60 (7.9)	569 (10.7)
2002	643 (10.6)	79 (10.5)	564 (10.7)
2003	527 (8.7)	72 (9.5)	455 (8.6)
2004	498 (8.2)	59 (7.8)	439 (8.3)
2005	458 (7.6)	65 (8.6)	393 (7.4)
2006	473 (7.8)	55 (7.3)	418 (7.9)
2007	449 (7.4)	62 (8.2)	387 (7.3)
2008	492 (8.1)	66 (8.7)	426 (8.0)
2009	445 (7.4)	48 (6.3)	397 (7.5)
2010	484 (7.9)	69 (9.1)	415 (7.8)
2011	397 (6.6)	61 (8.1)	336 (6.3)
Total	6,052	756	5,296

Table 11: *Probable* Agriculturally-Related Injury by Admission Source

Admission Source	Total Cases (%)	Inpatient Cases (%)	Outpatient Cases (%)
Physician referral	2244 (37.1)	179 (23.7)	2,065 (38.9)
Clinic referral	86 (1.4%)	18 (2.4)	68 (1.3)
HMO referral	1		1
Transfer from a hospital	106 (1.8)	73 (9.7)	33 (0.6)
Transfer from another facility	6	3 (0.4)	3
Emergency room	3489 (57.7)	475 (62.8)	3,014 (56.9)
unknown	115 (18.5)	4 (0.5)	111 (2.1)
Transfer from a critical access hospital	5	4 (0.5)	1
total	6,052	756	5,296

Table 12: *Probable* Agriculturally-Related Injury by Most Common Primary Diagnosis

ICD 9 Code	Primary Diagnosis Description	Total	Inpatient Cases	Outpatient Cases
883	Open wound of finger(s)	662	3 (0.5)	659 (99.5)
873	Other open wound of head	383	4 (1.0)	379 (99.0)
959	Injury, other and unspecified	316	9 (2.8)	307 (97.2)
816	Fracture of one or more phalanges of hand	305	13 (4.3)	292 (95.7)
882	Open wound of hand except finger(s) alone	279	10 (3.6)	269 (96.4)
924	Contusion of lower limb and of other and unspecified limbs	270	9 (3.3)	261 (96.7)
923	Contusion of upper limb	197	2 (1.0)	195 (99.0)
922	Contusion of trunk	197	14 (7.1)	183 (92.9)
886	Traumatic amputation of other finger(s)	180	12 (6.7)	168 (93.3)
891	Open wound of knee, leg(except thigh), and ankle	184	18 (9.8)	166 (90.2)
881	Open wound of elbow, forearm, and wrist	151	4 (2.6)	147 (97.4)
813	Fracture of radius and ulna	162	28 (17.3)	134 (82.7)
927	Crushing injury of upper limb	161	34 (21.1)	127 (78.9)
824	Fracture of ankle	143	48 (33.6)	95 (66.4)
845	Sprains and strains of ankle and foot	124	1 (0.8)	123 (99.2)
807	Fracture of rib(s), sternum, larynx, and trachea	108	30 (27.8)	78 (72.2)
823	Fracture of tibia and fibula	92	49 (53.3)	43 (46.7)
928	Crushing injury of lower limb	72	21 (29.2)	51 (70.8)
825	Fracture of one or more tarsal and metatarsal bones	72	16 (22.2)	56 (77.8)
805	Fracture of the vertebral column without mention of spinal cord injury	61	30 (49.2)	31 (50.8)
812	Fracture of humerus	59	18 (30.5)	41 (69.5)
808	Fracture of pelvis	58	32 (55.2)	26 (44.8)
802	Fracture of face bones	56	16 (28.6)	40 (71.4)
860	Traumatic pneumothorax and hemothorax	37	30 (81.1)	7 (18.9)
820	Fracture of neck of femur	31	19 (61.3)	12 (38.7)
801	Fracture of base of skull	28	17 (60.7)	11 (39.3)

Table 13: *Probable* Agriculturally-Related Injury by Age Category

Age Category	Frequency (%)	Inpatient Cases (%)	Outpatient Cases (%)
0 – 4	152 (2.5)	11 (1.5)	141 (2.6)
5 – 9	239 (3.9)	25 (3.3)	214 (4.0)
10 – 14	335 (5.5)	29 (3.8)	305 (5.8)
15 – 19	435 (7.2)	25 (3.3)	410 (7.7)
20 – 24	416 (6.9)	36 (4.8)	380 (7.2)
25 – 34	734 (12.1)	65 (8.6)	669 (12.6)
35 - 44	1005 (16.6)	99 (13.1)	906 (17.1)
45 – 54	1039 (17.1)	134 (17.7)	905 (17.1)
55 – 64	814 (13.4)	149 (19.7)	665 (12.6)
65 – 74	537 (8.9)	108 (14.3)	429 (8.1)
75 – 84	299 (4.9)	60 (7.9)	239 (4.5)
85+	48 (0.8)	15 (1.9)	33 (0.6)

Table 14: *Probable* Agriculturally-Related Injury by Month of Admission

Month of Admission	Total Cases (%)	Inpatient Cases (%)	Outpatient Cases (%)
January	236 (3.9)	33 (4.4)	203 (3.8)
February	209 (3.5)	28 (3.7)	181 (3.4)
March	284 (4.7)	34 (4.5)	250 (4.7)
April	475 (7.8)	56 (7.4)	419 (7.9)
May	617 (10.2)	88 (11.6)	529 (9.9)
June	689 (11.4)	71 (9.4)	618 (11.7)
July	682 (11.3)	88 (11.6)	594 (11.2)
August	653 (10.8)	74 (9.8)	579 (10.9)
September	651 (10.8)	80 (10.6)	571 (10.8)
October	847 (13.9)	109 (14.4)	738 (13.9)
November	467 (7.7)	69 (9.1)	398 (7.5)
December	242 (3.9)	26 (3.4)	216 (4.1)

Table 15: *Probable* Agriculturally-Related Injury by Geographic Area

Geographic Area	Total Cases (%)	Inpatient Cases (%)	Outpatient Cases (%)
Within Hennepin or Ramsey Counties	288 (4.8)	56 (7.4)	232 (4.4)
Without Hennepin or Ramsey Counties	5764 (95.2)	700 (92.6)	5064 (95.6)
Within 7 County Metro	890 (14.7)	126 (16.7)	764 (14.4)
Without 7 County Metro	5162 (85.3)	630 (83.3)	4532 (85.6)

Table 16: *Possible* Agriculturally-Related Injury by Year

Year	Total Cases (%)	Inpatient Cases (%)	Outpatient Cases (%)
2000	1,654 (7.1)	138 (6.7)	1,516 (7.1)
2001	1,809 (7.7)	133 (6.5)	1,676 (7.9)
2002	1,824 (7.8)	145 (7.1)	1,679 (7.9)
2003	1,963 (8.4)	180 (8.8)	1,783 (8.4)
2004	2,010 (8.9)	158 (7.7)	1,852 (8.7)
2005	2,077 (8.9)	206 (10.0)	1,871 (8.8)
2006	2,039 (8.7)	213 (10.4)	1,826 (8.6)
2007	1,867 (7.9)	197 (9.6)	1,670 (7.8)
2008	2,069 (8.8)	182 (8.9)	1,887 (8.8)
2009	2,089 (8.9)	149 (7.3)	1,940 (9.1)
2010	2,079 (8.9)	183 (8.9)	1,896 (8.9)
2011	1,927 (8.2)	172 (8.4)	1,755 (8.2)
Total	23,407	2,056	21,351

Table 17: *Possible* Agriculturally-Related Injury by Admission Source

Admission Source	Total Cases (%)	Inpatient Cases (%)	Outpatient Cases (%)
Physician referral	10,013 (42.8)	498 (24.2)	9,515 (44.6)
Clinic referral	594 (2.5)	45 (2.2)	549 (2.6)
HMO referral	5 (.02)	1 (.05)	4 (.02)
Transfer from a hospital	188 (.8)	156 (7.6)	32 (.15)
Transfer from another facility	17 (.07)	5 (.2)	12 (.05)
Emergency room	12,167 (51.9)	1,347 (65.5)	10,820 (50.7)
Court/Law enforcement	2 (.01)	0	2 (.01)
unknown	418 (1.8)	2 (.1)	0
Transfer from a critical access hospital	2 (.01)	2 (.1)	0
total	23,407	2,056	21,351

Table 18: *Possible* Agriculturally-Related Injury by Most Common Primary Diagnosis

ICD 9 Code	Primary Diagnosis Description	Frequency	Inpatient Cases	Outpatient Cases
959	Injury, other and unspecified	2147	20 (0.9)	2127 (99.1)
924	Contusion of lower limb and of other and unspecified sites	2023	33 (1.6)	1990 (98.4)
922	Contusion of trunk	1540	53 (3.4)	1487 (96.6)
873	Other open wound of head	1478	10 (0.7)	1468 (99.3)
813	Fracture of radius and ulna	1278	102 (7.9)	1176 (92.1)
850	Concussion	1065	100 (9.4)	965 (90.6)
923	Contusion of upper limb	894	1 (0.1)	893 (99.9)
918	Superficial injury of eye and adnexa	754	2 (0.3)	752 (99.7)
847	Sprains and strains of other and unspecified parts of back	557	8 (1.4)	549 (98.6)
807	Fracture of rib(s), sternum, larynx, and trachea	530	108 (20.4)	422 (79.6)
805	Fracture of vertebral column without mention of spinal cord injury	515	229 (44.5)	286 (55.5)
824	Fracture of ankle	455	134 (29.5)	321 (70.5)
812	Fracture of humerus	484	104 (21.5)	380 (78.5)
823	Fracture of tibia and fibula	366	153 (41.8)	213 (58.2)
808	Fracture of pelvis	227	117 (51.5)	110 (48.5)
860	Traumatic pneumothorax and hemothorax	146	106 (72.6)	40 (27.4)
801	Fracture of vault of skull	134	76 (56.7)	58 (43.3)

Table 19: *Possible* Agriculturally-Related Injuries by Age Category

Age Category	Frequency (%)	Inpatient Cases (%)	Outpatient Cases (%)
0 – 4	1385 (5.7)	27 (1.3)	1358 (6.4)
5 – 9	1571 (6.7)	79 (3.8)	1492 (6.9)
10 – 14	2261 (9.8)	131 (6.4)	2130 (9.9)
15 – 19	2464 (10.5)	136 (6.6)	2328 (10.9)
20 – 24	1683 (7.2)	99 (4.8)	1584 (7.4)
25 – 34	2975 (12.7)	209 (10.2)	2766 (12.9)
35 - 44	3968 (16.9)	356 (17.3)	3612 (16.9)
45 – 54	3847 (16.4)	524 (25.5)	3323 (15.6)
55 – 64	1970 (8.4)	316 (15.4)	1654 (7.8)
65 – 74	740 (3.2)	103 (5.0)	637 (2.9)
75 – 84	402 (1.7)	63 (3.1)	339 (1.6)
85+	141 (0.6)	13 (0.6)	128 (0.6)

Table 20: *Possible* Agriculturally-Related Injuries by Month

Month of Admission	Total Cases (%)	Inpatient Cases (%)	Outpatient Cases (%)
January	840 (3.6)	54 (2.6)	786 (3.7)
February	772 (3.3)	63 (3.1)	709 (3.3)
March	1238 (5.3)	70 (3.4)	1168 (5.5)
April	1830 (7.8)	166 (8.1)	1664 (7.8)
May	2724 (11.6)	244 (11.9)	2480 (11.62)
June	2796 (11.9)	254 (12.4)	2542 (11.9)
July	3088 (13.2)	277 (13.5)	2811 (13.2)
August	3182 (13.6)	308 (14.9)	2874 (13.5)
September	2586 (11.1)	247 (12.0)	2339 (10.9)
October	2088 (8.9)	181 (8.8)	1907 (8.9)
November	1323 (5.7)	137 (6.7)	1186 (5.6)
December	940 (4.0)	55 (2.7)	885 (4.2)

Table 21: *Possible* Agriculturally-Related Injuries by Geographic Location

Geographic Area	Total Cases (%)	Inpatient Cases (%)	Outpatient Cases (%)
Within 7 County Metro	6,643 (28.4)	618 (30.1)	6,025 (28.2)
Without 7 County Metro	16,764 (71.6)	1,438 (69.9)	15,326 (71.8)
Within Hennepin or Ramsey Counties	3,178 (13.6)	282 (13.7)	2,896 (13.6)
Without Hennepin or Ramsey Counties	20,229 (86.4)	1,774 (86.3)	18,455 (86.4)

Table 22: Number of Individuals Living and/or Working on Farms in Minnesota 2000 to 2011

Year	Living on Farm*	Working on Farm Only*	Total
2000	148,441	9,006	15,7447
2001	145,645	9,147	153,050
2002	143,903	9,288	151,448
2003	142,160	9,429	149,846
2004	140,417	9,570	148,245
2005	134,176	9,425	143,601
2006	134,984	10,359	145,343
2007	130,188	10,036	140,224
2008	130,838	9,783	140,621
2009	126,874	10,239	137,113
2010	134,089	10,454	144,543
2011	127,297	10,611	137,908

*Data obtained from the American Community Survey

Table 23: Rate of Agriculturally-Related Injury by All, *Probable*, and *Possible* Status per 1,000 Individuals Living and/or Working on Farms in Minnesota, 2000 to 2011

Year	Total Rate	Confidence Interval	Probable Rate	Confidence Interval	Possible Rate	Confidence Interval
2000	14.0	(13.2, 15.0)	3.5	(3.3, 3.8)	11.1	(9.9, 11.3)
2001	15.9	(14.9, 17.1)	4.1	(3.8, 4.4)	12.6	(11.1, 12.7)
2002	16.3	(15.2, 17.5)	4.3	(3.9, 4.6)	12.8	(11.3, 12.9)
2003	16.6	(15.5, 17.9)	3.5	(3.3, 3.8)	13.9	(12.2, 14.1)
2004	16.9	(15.8, 18.3)	3.4	(3.1, 3.6)	14.5	(12.6, 14.6)
2005	17.7	(16.5, 19.1)	3.2	(2.9, 3.4)	15.5	(13.5, 15.6)
2006	17.3	(15.9, 18.9)	3.3	(3.0, 3.6)	15.1	(12.9, 15.3)
2007	16.5	(15.4, 17.8)	3.2	(2.9, 3.5)	14.3	(12.4, 14.4)
2008	18.2	(16.8, 19.9)	3.5	(3.2, 3.8)	15.8	(13.6, 16.1)
2009	18.5	(17.2, 20.0)	3.3	(3.0, 3.5)	16.5	(14.2, 16.5)
2010	17.7	(16.2, 19.6)	3.4	(3.1, 3.7)	15.5	(13.2, 15.9)
2011	16.9	(15.6, 18.3)	2.9	(2.7, 3.1)	15.1	(12.9, 15.1)

Table 24: Agriculturally-Related Injuries by *Probable* and *Possible* Status by Year and Hospitalization Status for Those Greater than 15 Years of Age

Year	All Injuries	All *Probable* Ag Injuries	All *Possible* Ag Injuries	All Inpatient Injuries	All Inpatient *Probable* Ag Injuries	All Inpatient *Possible* Ag Injuries	All Outpatient Injuries	All *Probable* Outpatient Injuries	All *Possible* Outpatient Injuries
2000	1638	464	1174	170	57	113	1468	407	1061
2001	1831	525	1306	174	55	119	1657	470	1187
2002	1863	550	1313	190	74	116	1673	476	1197
2003	1920	442	1478	222	61	161	1698	381	1317
2004	1906	424	1482	175	53	125	1728	371	1357
2005	1989	397	1592	234	57	177	1755	340	1415
2006	1949	406	1543	235	52	183	1714	354	1360
2007	1832	412	1420	236	59	177	1596	353	1243
2008	2030	435	1595	224	58	166	1806	377	1429
2009	2007	397	1610	179	44	135	1828	353	1475
2010	2069	434	1635	226	53	163	1843	371	1472
2011	1878	365	1513	210	54	156	1668	311	1357

Table 25: Minnesota Agricultural Working Population Estimates, 2000 to 2011

Year	Agricultural Population Estimate*	90% Confidence Interval Lower Limit	90% Confidence Interval Upper Limit
2000	85,651	62,651	108,651
2001	102,969	81,969	123,969
2002	90,409	69,409	111,409
2003	67,881	52,881	82,881
2004	71,019	58,019	84,019
2005	56,356	43,356	69,356
2006	54,517	41,517	67,517
2007	53,163	40,613	66,613
2008	49,573	33,576	65,573
2009	64,570	52,570	76,570
2010	78,930	66,930	90,930
2011	77,413	65,413	89,413

*Data obtained from the Current Population Survey

Table 26: Minnesota Agriculturally-Related Injury Rate per 1,000 Persons Employed in Agriculture 16 years of age or Greater by *Probable* or *Possible* and Hospitalization Status, 2000 to 2011

Year	All Injury Rate	All *Probable* Ag Injury Rate	All *Possible* Ag Injury Rate	All Inpatient Injury Rate	All Inpatient *Probable* Ag Injury Rate	All Inpatient *Possible* Ag Injury Rate	All Outpatient Injury Rate	All *Probable* Outpatient Injury Rate	All *Possible* Outpatient Injury Rate
2000	19.1 (15.1, 26.2)	5.4 (4.3, 7.4)	13.7 (10.8, 18.7)	1.9 (1.0, 2.7)	0.7 (0.5, 0.9)	1.3 (1.0, 1.8)	17.1 (13.5, 23.4)	4.8 (3.8, 6.5)	12.4 (9.8, 16.9)
2001	17.8 (14.8, 22.3)	5.1 (4.2, 6.4)	12.7 (10.5, 15.9)	1.7 (0.9, 2.1)	0.5 (0.4, 0.7)	1.6 (0.9, 1.5)	16.1 (13.4, 20.2)	4.6 (3.8, 5.7)	11.5 (9.6, 14.5)
2002	20.6 (16.7, 26.8)	6.1 (4.9, 7.9)	14.5 (11.8, 18.9)	2.1 (1.0, 2.7)	0.8 (0.7, 1.1)	1.3 (1.0, 1.7)	18.5 (15.0, 24.1)	5.3 (4.3, 6.9)	13.2 (10.8, 17.3)
2003	28.3 (23.2, 36.3)	6.5 (5.3, 8.4)	21.8 (17.8, 27.9)	3.3 (1.9, 4.2)	0.9 (0.7, 1.2)	2.4 (1.9, 3.0)	25.0 (20.5, 32.1)	5.6 (4.6, 7.2)	19.4 (15.9, 24.9)
2004	26.8 (22.7, 32.9)	5.9 (5.1, 7.3)	20.9 (17.6, 25.5)	2.5 (1.5, 3.1)	0.8 (0.6, 0.9)	1.8 (1.5, 2.2)	24.3 (20.6, 29.8)	5.2 (4.4, 6.4)	19.1 (16.2, 23.4)
2005	35.3 (28.7, 45.9)	7.0 (5.7, 9.2)	28.3 (22.9, 36.7)	4.2 (2.6, 5.4)	1.0 (0.8, 1.3)	3. (2.6, 4.1)	31.1 (25.3, 40.5)	6.0 (4.9, 7.8)	25.1 (20.4, 32.6)
2006	35.8 (28.9, 46.9)	7.5 (6.0, 9.8)	28.3 (22.9, 37.2)	4.3 (2.7, 5.7)	0.9 (0.8, 1.3)	3.4 (2.7, 4.4)	31.4 (25.4, 41.3)	6.5 (5.2, 8.5)	24.9 (20.1, 32.8)
2007	34.5 (27.5, 45.1)	7.8 (6.2, 10.1)	26.7 (21.3, 34.9)	4.4 (2.7, 5.8)	1.1 (0.9, 1.5)	3.3 (2.7, 4.4)	30.0 (23.9, 39.3)	6.6 (5.3, 8.7)	23.4 (18.7, 30.6)
2008	40.9 (30.9, 60.5)	8.8 (6.6, 12.9)	32.2 (24.3, 47.5)	4.5 (2.5, 6.7)	1.2 (0.9, 1.7)	3.4 (2.5, 4.9)	36.4 (27.5, 53.8)	7.6 (5.8, 11.2)	28.8 (21.8, 42.6)
2009	31.1 (26.2, 38.2)	6.2 (5.18, 7.6)	24.9 (21.0, 30.6)	2.8 (1.8, 3.4)	0.7 (0.6, 0.8)	2.1 (1.8, 2.6)	28.3 (23.9, 34.8)	5.5 (4.6, 6.7)	22.8 (19.3, 28.1)
2010	26.24 (22.8, 30.9)	5.5 (4.8, 6.5)	20.7 (17.9, 24.4)	2.9 (1.8, 3.4)	0.7 (0.6, 0.8)	2.1 (1.8, 2.6)	23.4 (20.3, 27.5)	4.7 (4.1, 5.5)	18.7 (16.2, 21.9)

2011	24.3 (21.0, 28.7)	4.7 (4.1, 5.6)	19.6 (16.9, 23.1)	2.7 (1.8, 3.2)	0.7 (0.6, 0.8)	2.0 (1.8, 2.4)	21.6 (18.7, 25.5)	4.0 (3.5, 4.8)	17.5 (15.2, 20.8)

Table 27: Minnesota Agriculturally-Related Injury Rate per 1,000 Persons Employed in Agriculture 16 years of age or Greater by *Probable* or *Possible* and Hospitalization Status, 2000 to 2011, with BEA Agricultural Employment Estimates

Year	BEA Farm Worker Population Estimate	All Injury Rate	All *Probable* Ag Injury Rate	All *Possible* Ag Injury Rate	All Inpatient Injury Rate	All Inpatient *Probable* Ag Injury Rate	All Inpatient *Possible* Ag Injury Rate	All Outpatient Injury Rate	All *Probable* Outpatient Injury Rate	All *Possible* Outpatient Injury Rate
2000	100,675	16.27	4.61	11.66	1.69	0.56	1.12	14.58	4.04	10.54
2001	101,381	18.06	5.18	12.88	1.72	0.54	1.17	16.34	4.64	11.71
2002	92,186	20.21	5.97	14.24	2.06	0.80	1.26	18.15	5.16	12.98
2003	90,484	21.22	4.88	16.33	2.45	0.67	1.78	18.77	4.21	14.56
2004	87,109	21.88	4.87	17.01	2.04	0.61	1.44	19.83	4.26	15.58
2005	86,995	22.86	4.56	18.29	2.69	0.66	2.04	20.17	3.91	16.27
2006	83,325	23.39	4.87	18.52	2.82	0.62	2.19	20.57	4.25	16.32
2007	83,868	21.84	4.91	16.93	2.81	0.70	2.11	19.03	4.21	14.82
2008	81,843	24.80	5.32	19.49	2.74	0.71	2.03	22.07	4.61	17.46
2009	86,492	23.20	4.59	18.61	2.07	0.51	1.56	21.14	4.08	17.05
2010	87,210	23.72	4.97	18.75	2.59	0.61	1.87	21.14	4.25	16.88
2011	83,653	22.45	4.36	18.09	2.51	0.65	1.87	19.94	3.72	16.22

Table 28: Agriculturally-Related Injuries by *Probable* and *Possible* Status by Year and Hospitalization Status

Year	All Injuries	All *Probable* Ag Injuries	All *Possible* Ag Injuries	All Inpatient Injuries	All Inpatient *Probable* Ag Injuries	All Inpatient *Possible* Ag Injuries	All Outpatient Injuries	All *Probable* Outpatient Injuries	All *Possible* Outpatient Injuries
2000	2211	557	1654	198	60	138	2013	497	1516
2001	2438	629	1809	193	60	133	2245	569	1676
2002	2467	643	1824	224	79	145	2243	564	1679
2003	2490	527	1963	252	72	180	2238	455	1783
2004	2508	498	2010	217	59	158	2291	439	1852
2005	2535	458	2077	271	65	206	2264	393	1871
2006	2512	473	2039	268	55	213	2244	418	1826
2007	2316	449	1867	259	65	197	2057	387	1670
2008	2561	492	2069	248	66	182	2313	426	1887
2009	2534	445	2089	197	48	149	2337	397	1940
2010	2563	484	2079	252	69	183	2311	415	1896
2011	2324	397	1927	233	61	172	2091	336	1755

Table 29: Minnesota Agriculturally-Related Injury Rate per 100,000 Persons Residing in Non-Metropolitan Counties by *Probable* or *Possible* and Hospitalization Status, 2000 to 2011

Year	Non-Metro Population Estimate	All Injury Rate	*Probable* Ag Injury Rate	*Possible* Ag Injury Rate	All Inpatient Injury Rate	Inpatient *Probable* Ag Injury Rate	Inpatient *Possible* Ag Injury Rate	All Outpatient Injury Rate	*Probable* Outpatient Injury Rate	*Possible* Outpatient Injury Rate
2000	1,406,717	157.2	39.6	117.6	14.1	4.3	9.8	143.1	35.3	107.8
2001	1,414,815	172.3	44.5	127.9	13.6	4.2	9.4	158.7	40.2	118.5
2002	1,419,539	173.8	45.3	128.5	15.8	5.6	10.2	158.0	39.7	118.3
2003	1,426,881	174.5	36.9	137.6	17.7	5.0	12.6	156.9	31.9	124.9
2004	1,434,839	174.8	34.7	140.1	15.1	4.7	11.0	159.7	30.6	129.1
2005	1,440,269	176.0	31.8	144.2	18.8	4.5	14.3	157.2	27.3	129.9
2006	1,443,155	174.1	32.8	141.3	18.6	3.8	14.8	155.5	28.9	126.5
2007	1,441,357	160.7	31.2	129.5	17.9	4.5	13.7	142.7	26.9	115.8
2008	1,436,920	178.2	34.3	143.9	17.3	4.6	12.7	160.9	29.6	131.3
2009	1,431,455	177.0	31.1	145.9	13.8	3.4	10.4	163.3	27.7	135.5
2010	1,450,790	176.7	33.4	143.3	17.4	4.8	12.6	159.3	28.6	130.7
2011	1,450,800	160.2	27.4	132.8	16.1	4.2	11.9	144.1	23.2	120.9

Table 30: Estimated Number and Rate of Agriculturally-Related Injuries, 2000 to 2011

Year	Injury Status	Number of Injuries from Hospital Data	Estimated Number after adjustments	Rate per 1,000 individuals living and/or working on a farm
2000	Total	170	7510	47.7
	Probable	57	2518	15.9
	Possible	113	4992	31.7
2001	Total	174	7687	50.2
	Probable	22	972	6.4
	Possible	119	5257	34.3
2002	Total	190	8393	55.4
	Probable	74	3269	21.6
	Possible	116	5124	33.8
2003	Total	222	9807	65.5
	Probable	61	2695	19.9
	Possible	161	7113	47.5
2004	Total	178	7863	53.0
	Probable	53	2341	15.8
	Possible	125	5522	37.2
2005	Total	234	10337	71.9
	Probable	57	2518	17.5
	Possible	177	7819	54.5
2006	Total	235	10382	74.4
	Probable	52	2297	18.6
	Possible	183	8084	55.8
2007	Total	236	10426	71.4
	Probable	59	2607	15.8
	Possible	177	7819	55.6
2008	Total	224	9896	70.4
	Probable	58	2562	18.2
	Possible	166	7333	52.5
2009	Total	179	7908	57.7
	Probable	44	1944	14.2

	Possible	135	5964	43.5
2010	Total	226	9984	69.1
	Probable	53	2341	16.2
	Possible	163	7201	49.8
2011	Total	210	9277	67.3
	Probable	54	2386	17.3
	Possible	156	6892	19.9

*Adjustments were made using data from the RRIS-I and RRIS-II studies with the MDH Injury Unit E code evaluation.

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Chapter Five: The Economic Impact of Injury Related to Agriculture in Minnesota, 2004 – 2010

Abstract

With just over $13 billion in sales Minnesota ranked 6th for overall sales of agricultural produce in the nation for the year 2011 (1). In 2011 only 1.1% of Minnesota's workforce was employed in agriculture. This small portion of Minnesota's workforce has one of the highest known rates for work-related fatalities with almost ten times that of all industries combined (2). While only a small fraction of the employed population, injury, illness, and fatality among agricultural workers can have a significant impact on society as a whole. Leigh et al (3) estimated that injury related to agriculture cost the nation $4.57 billion in 1992. The cost of injury related to agriculture in Minnesota is unknown and a significant gap in understanding the impact of agriculturally-related injuries. The 2007 Census of Agriculture established that 70,055 out of 80,992 (87%) of Minnesota farms were family or individually owned (1). Severe injuries or death on these small and family farms may have a serious economic impact, possibly leading to abandonment of the farming lifestyle (4). To estimate the cost of agriculturally-related injuries, the number of injuries related to agriculture was estimated using Minnesota hospital discharge data. The Cost of Illness (COI) model was used to estimate the cost of injury related to agriculture in Minnesota between 2004 and 2010. Estimated costs, in 2010 dollars, for injury related to agriculture ranged between $21 million and $31 million annually during the time period 2004-2010 in Minnesota. The majority of these costs are attributed to indirect costs of injury such as lost productivity at work and home, and costs associated with fatalities. The magnitude of the costs associated with these injuries argues for better surveillance of these injuries to monitor rates and trends for the evaluation of the effectiveness of intervention and prevention programs.

Background

Demand for economic assessment of the burden of specific diseases has increased in recent years. The ability to provide economic data supporting the value of a prevention program or policy, or advocating for continued support of public health programs has become a necessary product for public health professionals. The Centers for Disease Control and Prevention (CDC) have created two such tools: the Web based Injury Statistics Query and Reporting System (WISQARS) and the Chronic Disease Cost Calculator 2.0. These programs have been made readily available to public health practitioners to aid in evaluation programs and advocating for continued or new funding. Unfortunately neither of these tools can produce estimates of the costs associated with occupational injury and illness. This paper provides a much needed understanding of the burden of agricultural injury in Minnesota.

An economic analysis conducted by the United States Department of Agriculture (USDA) found that 14% of all farm-operator households lacked health insurance (5). The study findings also revealed that operator households spend more on health care than other U.S. households, in large part, due to the purchase of private non-group health insurance policies, and associated large out of pocket health expenses (5). The financial impact of disability from injury is significant for these owner/operators or self–employed individuals. The extent to which these injuries can be debilitating and detrimental to farm life is well recognized. The AgrAbility program sponsored by the USDA provides disabled farmers, ranchers, and other agricultural workers with support measures necessary to maintain a high quality of life while continuing to pursue a career in agriculture (6). The services provided by and resources allotted to AgrAbility demonstrate the need and degree to which maintaining an able bodied working farm population is of value to society.

While the economic impact of occupational injuries as a whole has been described by several researchers, the economic impact of injury related to agriculture has not been well documented. This limitation is due in large part to the unavailability of data describing the number of injuries and illnesses related to work that occur within agricultural populations. Leigh and colleagues have estimated the impact of all occupational injury and illness on the nation and on individual states, including Minnesota (3, 7-15). Leigh has also estimated the cost of agricultural injury for the entire United States, at approximately $4.57 billion in 1992 (3). The human capital method was used to create direct and indirect costs for these estimates. The majority of the costs were attributed to indirect costs: lost earnings, lost fringe benefits, lost home production, and training/re-staffing. The cost estimate of injury related to agriculture represented 3.58% of the estimated cost for all occupational injuries in all industries for the nation in the year 1992 (3). A 2007 estimate of the cost of injury and illness related to all occupations was found to be approximately $250 billion, with the majority comprised by indirect costs (7).

The burden this places on society is substantial as workers compensation is estimated to pay only 25% of these costs, and in the case of agriculture, even less (7).

These estimates are helpful when placing the impact of occupational injury and illness, into context and providing a method to discuss the implications of these injuries and illnesses on the nation. However, these estimates are not available for agricultural injury at the state level, limiting the ability of public health researchers and practitioners to better understand the economic burden of these injuries and to prioritize the allocation of resources.

Methods

Data sources used in previous research of the costs associated with occupational injury and illness specifically, workers' compensation and the Survey of Occupational Injuries and Illnesses (SOII), are inadequate for this cost estimate as both sources miss the majority of agricultural injury. To address the lack of information regarding agricultural injury in Minnesota, it was necessary to first develop a method to estimate the number of agricultural injuries. Injuries were identified from the Minnesota hospital discharge database for the years 2000 to 2011 by utilizing a set of E codes which describe the location, mechanism, and nature of injury in the billing record. Fatal injuries related to agriculture were identified with the use of the annual Census of Fatal Occupational Injuries (CFOI). These estimates were then utilized to build the cost estimates associated with these injuries in Minnesota between 2004 and 2010.

Model

To describe the economic impact of agricultural injury in Minnesota, several cost models were considered. These included the willingness to pay model, the friction model, and the cost of illness model. The cost of illness model has been used by a number of researchers to estimate the cost of occupational injury and disease and is applicable to this endeavor as well (7, 8, 16-18). The cost of illness model creates a total cost estimate by combining the direct and indirect costs specific to the injury event. The willingness to pay model creates cost estimates based upon the amount individuals in society are willing to pay to avoid injury, illness, or death. This model is constrained by the amount the individual is monetarily worth and it can be difficult to ascertain these values as there is no simple method to discern the price someone would place on avoiding a specific injury or illness. The friction method estimates the time period between injury and replacement of the individual in the workplace, or the period of lost production. Unlike the cost of illness model, the friction model assesses only the lost time associated with the loss in production instead of the time loss to the injured individual. The estimates of the frictional time period, or lost production period, are difficult to estimate for an agricultural population as the data necessary to create such estimates are unavailable. As the available literature has predominately made use of the cost of illness model, this model was selected to allow for comparison of the study findings with other previously published works. Studies vary in methodology, regarding the inclusion or exclusion of specific cost categories; thus a sensitivity analysis was performed to describe the impact of the variation in these variables on the total cost estimate.

Cost Equations

To create these estimates, cost equations were developed from the available literature to describe the components of the total costs associated with agricultural injury. The equations were broken into direct and indirect costs and fatal vs. non-fatal injuries. The equation for fatal injuries was provided previously in the literature by Biddle et al(18).

Direct Costs

$$\sum_{i=1}^{k}[(m_i)(R) + (a)(m_i)(R) + (Q)(E)](n_i)$$

n_i: number of individuals with injury type i

m_i: average medical charges for injury type i

R: cost to charge ratio

a: administrative percentage applied to average medical costs

Q_i: proportion of cases with injury type i requiring transportation

E: emergency transportation

*sum the direct costs related to each injury type i and multiply by the number of injuries of type i

The second equation was used to estimate the indirect costs associated with a non-fatal injury: the probabilities of disability, the length of lost work time, the value of work production, the value of home production, and the discount rate.

Indirect Costs (nonfatal)

$$(n_i)(NF_i)\sum_{i=1}^{k} H_i[P_{si}^{h=1}(t_i[w_i + .09q_i]) + P_{ppi}^{h=1}(f_i[W_i + Q_i]) + P_{pti}^{h=1}[W_i + Q_i] + (1 - P_{si}^{h=1} - P_{ppi}^{h=1} - P_{pti}^{h=1})(0)] +$$

$$(1 - H_i)[P_{si}^{h=0}(t_i[w_i + .09q_i]) + P_{ppi}^{h=0}(f_i[W_i + Q_i]) + P_{pti}^{h=0}[W_i + Q_i] + (1 - P_{si}^{h=0} - P_{ppi}^{h=0} - P_{pti}^{h=0})(0)]$$

P_{si}: Probability of short term disability given injury type i
t_i: Average or median short term lost time given injury type i
w: average weekly wage
q: average weekly home production value
H_i: Proportion of injury cases i that were hospitalized (Hospitalized cases will have short term disability for at least their hospital stay duration)
1 - H_i: Proportion of injury cases i that were not-hospitalized (outpatient and ED cases)
P_{ppi}: Probability of permanent partial disability given injury type i (h = 1, hospitalized)
P_{pti}: Probability of permanent total disability given injury type i (h = 1, hospitalized)
f: impairment fraction
W: average remaining working lifetime wages and benefits
Q: average value of remaining working home production
n_i: number of cases with injury type i
NF_i: proportion of cases with injury type i that were non-fatal

(Disability terms are defined as follows: *permanent total disability* is complete disability for longer than one year, *short term disability* is complete disability but for less than one year, and *permanent partial disability* allows the individual to continue working but at reduced capacity – the probability of permanent or partial permanent disability changes by whether or not one was hospitalized)
*sum the lost production per year of injury type i and multiply by the number of injuries of type i that were fatal.

Indirect costs for non-fatal injuries would differ by whether the injury required hospitalization or not. For the proportion of injury type I who required hospitalization (H_i), three health states were possible: a short term disability, a permanent partial disability, or a permanent total disability such that the probabilities for each state (P_{si}, P_{ppi}, and P_{pti}, respectively) summed to 1. The proportion of injury I with a short term disability (P_{si}) had indirect costs derived from the product of the average farm wage rate (w_i) and the time unable to work (t_i) plus unable to engage in household production (q_i). The proportion of injury I with a permanent but partial disability (P_{ppi}) had indirect costs derived fromt eh product of the average farm wage for the remaining working lifetime (W_i) plus the product of the average value of household productions for the remaining household working lifetime (Q_i) adjusted by an impairment fraction. The proportion of injury I with a permanent total disability (P_{pti}) had indirect costs derived from the product of the average farm wage for the remaining working lifetime (W_i) plus the product of the average value of household production for the remaining household working lifetime (Q_i). The indirect costs related to permanent partial and total disability were discounted, where as those for short term disability were not discounted as short term disability is defined as disability with duration shorter than one year. For the proportion of injury type I that did not require hospitalization ($1-H_i$), four health states were possible: no disability, a short term disability, a permanent partial disability, and a permanent total disability. The indirect costs for those with no disability were zero as the individual accrued no lost work time or lost home production. Indirect costs for short-term disability, permanent partial disability, and permanent total disability were calculated in the same way for hospitalized injuries as non-hospitalized. The probabilities for short term, permanent partial, and permanent total disabilities, developed by Miller et al, differed depending upon whether the individual was hospitalized, therefore the hospitalization status of the injury case was necessary to assign the appropriate probabilities to the injury.

The third equation was used to estimate the indirect costs associated with a fatal injury: the length of lost work time, the value of work production, the value of home production, the impairment fraction and the discount rate.

Indirect Costs (fatal)

$$\sum_{i=1}^{k}(n_i)(1 - NF_i)\left[\sum_{s=y_i}^{74}(D_s)[W_s + H_s]\left[\frac{(1+g)^{s-y_i}}{(1+r)^{s-y_i}}\right]\right]$$

s = age of individual if they had survived
k = age at retirement (75)
y_i = average age of individual at death for injury type i
D_s = probability that the individual at age y_i will survive to age s
W = annual earnings (wages and benefits) of person at age s
H = home production estimate of person at age s
g = wage growth attributable to experience and length of service
r = real discount rate (3%)
*sum the lost production per year of injury type i and multiply by the number of injuries of type i that were fatal (22).

The equations describe costs for four distinct injury groups: fatal, non-fatal, hospitalized, and non-hospitalized injuries. The distinction between fatal and non-fatal is necessary as non-fatal injuries required an estimation of the probability of disability (short-term, permanent partial, and total permanent) associated with the injury of interest. This creates the first division within the indirect costs equation. The indirect cost calculation for fatalities is simpler in nature as it does not need to account for the probability of disability but does need to account for the probability of survival to the next year if the individual had lived. In contrast to fatal injuries, the indirect cost calculation for non-fatal injuries must account for the probability the individual will incur some form of temporary or permanent disability and account for the loss of, or reduced, productivity.

The second distinction is in regards to the hospitalization status of the case among non-fatal injuries. Hospitalization status was a concern as the probabilities of disability utilized for this cost estimate were based upon whether the individual had been hospitalized. These probabilities of disability were gathered from work completed by Miller et al (17, 19). Miller et al used the National Council on Compensation Insurance (NCCI) data to create estimates of the probability of disability by the nature or site of injury and whether the individual had been hospitalized or not (19). These estimates of disability were complimented with an average and median length of lost work time based upon the nature or site of injury. Since both of these estimates varied depending upon the hospitalization status of the case, a distinction in the indirect cost equation for non-fatal injuries was made between hospitalized and non-hospitalized cases.

Direct Costs

Agricultural injury data was collected from the Minnesota hospital discharge data set. Charge data related to the injury visit was available in the dataset, and these data were converted into costs prior to entry into the equation. This charge data as well as the cost-to-charge ratio available at the Minnesota Department of Health for years 2004 to 2010, was used to create estimates of the costs associated with the medical care received (20). The associated administrative costs were assigned a value of 15% of medical costs based on the work of Leigh et al (3, 9). Emergency transportation is expected for 50% of all hospitalized injuries (21). Finkelstein et al provided an estimate of the national average for emergency transportation in the year 2000; this estimate was inflated with the Consumer Price Index (CPI) for medical expenses to the year 2010.

Indirect Costs

Wages

The Quarterly Census of Employment and Wages (QCEW) maintained by the MN Department of Employment and Economic Development (DEED) was used to create estimates of the average weekly wage an individual employed in agriculture in Minnesota would expect to receive (22). Estimates of wages were available for all years, 2004 to 2010. The benefit rate was estimated using 15% of wages based upon research conducted by the Iowa Extension Services specific to those employed in agriculture (23).

Home Production

Home production accounts for the time lost on home-related tasks such as cooking, cleaning, care-giving, and other care-related activities. Home production can be estimated using a variety of methods such as using the individuals working wage to assign a value to the home-related activities or using the average wage of one employed in the hospitality (cooking, cleaning, etc.) industry. Leigh and Miller both used a percentage of the individual’s wage to create cost estimates for home production (9, 19). Finkelstein however used an estimate based upon the average wages earned by those who work as cooking and maid service professionals (21). The home production estimate for this study made use of wage rates for those in hospitality and leisure services. The wage rates for those in hospitality and leisure services was selected for the home production value as these industry groups had previously been used by Finkelstein, Miller, and Biddle in the creation of cost estimates related to injury (18, 19, 21, 24). These reported wage estimates were obtained from the Minnesota DEED QCEW (22).

Disability and Lost Work Time

As the non-fatal injury cases were obtained from the Minnesota hospital discharge data set, the final status (disabled, partially-recovered, fully-recovered, or deceased) of the case is unknown. The Minnesota hospital discharge data set describes only the care provided during the hospitalization period. The dataset does not provide information such as whether follow up care was required, the length of disability, when the individual returned to work, permanent disability status, or when the individual died if they did not die during the hospitalized care encounter. To account for the possibility of disability, whether short term, permanent partial, or total permanent disability, probabilities of disability developed by Pindus and Miller (17, 19) were used. The probabilities of disability were developed using data from the Detailed Claims Information (DCI) database maintained by the National Council on Compensation Insurance (NCCI). This dataset followed an individual case for a period of up to six months in duration after injury and then annually until the case had either recovered and rejoined the workforce or was on permanent disability (17). The ability to follow a large number of injury cases to their conclusion allowed Pindus and Miller to develop estimates of the average and median time lost as well as the probability of short-term, permanent partial, and permanent total disability by nature of injury and by body part of injury. The Pindus and Miller estimates of the probability of disability were developed separately for those with an injury requiring hospitalization and injuries treated in an outpatient, or non-hospitalized, setting. These estimates of the probability of disability were applied to the non-fatal injury cases based upon nature of injury and whether the injury cases had been hospitalized. Both the mean and median estimated lost work times for short term disability were entered into the equation to compare the impact these estimates had on the total cost estimate.

A retirement age of 75 was set for permanent partial disability, permanent total disability, and fatal injury cases for the creation of lost time estimates. Biddle et al (25) set a retirement age of 64 when estimating the economic burden related to all fatal occupational injuries in the United States. However, there is evidence to suggest that those engaged in agricultural work tend to work for longer periods of time than an individual employed in other industrial sectors (26) and the age of retirement for this study population was set at 75 years of age.

Wage Growth, Survivability, Age, and Discount Factor

The career growth adjustment factors created by Biddle et al (25) were used to adjust wages for fatal injuries related to agriculture in Minnesota. Biddle created the wage growth adjustment using the Employment Cost Index (ECI) which measures the change in the cost of labor and includes changes in the wages and salaries as well as benefits. Biddle then used the Current Population Survey (CPS) to account for the change in wages due to an individual's employment experience (25).

To create a cost estimate for fatal injuries, the probability of survival to the following year of life was necessary. Probability of survivorship for each year of life was obtained from the life tables provided by the Center for Disease Control's (CDC) National Center for Health Statistics (27).

The average age by injury type was determined for both the non-fatal hospitalized and non-hospitalized groups using the case data provided in the Minnesota hospital discharge dataset. Unfortunately, the specific ages of the fatal case are not provided in the publicly available CFOI data set. Instead aggregate statistics are provided by age categories, spanning a total of 10 years per category. Therefore, the mid-point of the age category in which the fatal case was assigned was used as the age at death.

A discount rate of 3% was used to bring future costs to 2010 dollars. The use of a 3% rate was recommended by Gold and colleagues as the most appropriate for estimating societal costs (28). A rate of 3% is most frequently cited in the literature including several of Leigh's cost estimates of occupational disease and injury (7, 9, 10, 13).

Sensitivity Analysis

The cost of illness method creates cost estimates that include the entire lost work time of the individual. To evaluate these estimates a sensitivity analysis was performed. The analysis investigated the impact of varying the lost work or production time in the indirect cost equation.

When an individual dies or is permanently disabled the loss to society is the lost production they were responsible for creating. Because the time period in which an individual may be replaced, either temporarily or permanently, has not been studied for agricultural workers, data was unavailable. Two time periods were hypothesized based upon possible agricultural production replacement scenarios. These hypothesized time periods were suggested by the work of Kelsey et al which found that the family farm is usually sold within five years of a death (4). The first hypothesized time period was six months, with the assumption that designating a replacement of the individual would occur with a family member or already established working member of the farm. The second hypothesized lost time period was six years, with the assumption that the family of the injured or deceased individual could not maintain the farm in the absence of the individual, and the farm was then sold (Figure 1). The time period of six years would account for the time needed to sell the farm, as well as the time necessary for the new owners to bring production up to previous levels. These estimates were compared with that of the reference case estimate similar to the methodology presented by Leigh et al (9) and Finkelstein et al (21).

Change in Self-Reported Health Status (Quality of Life)

Since data regarding the change in the quality of life after an injury related to agriculture was unavailable in the Minnesota hospital discharge dataset, the Medical Expenditures Panel Survey (MEPS) (29) was used.

The MEPS is a set of large scale surveys of individuals, their families, their health care providers, and their employers to understand health insurance coverage, health care utilization, health care access and provided services, and health care satisfaction. Over 12,000 households (over 30,000 individuals) participated in the MEPS each survey cycle or panel. Participation includes five survey rounds that occur over a two year period. Information collected includes: demographic information, health conditions, health insurance coverage, employment, perceived health status, and access to care. Data on each of these areas is collected in each round of the survey allowing for longitudinal analysis.

For this analysis, survey years 2002 to 2007 (7 panels) were utilized. The number of individuals identifying themselves as a farm worker and sustaining an injury was too small for analysis (N = 69). Therefore, individuals currently employed who had sustained an injury unrelated to a motor vehicle accident, sports injury, firearm, or other weapon were used as a surrogate for those that had sustained an injury related to agricultural work. Using the methodology developed by Nyman et al (30), this population was used to investigate the impact of injury on self-reported health status. To estimate the impact an injury related to agriculture might have on an individual, the MEPS variable for perceived health status was used. The MEPS asks participants to rank their health status as poor, fair, good, very good, and excellent during each interview round. As this variable is collected during all interview rounds, researchers can investigate the change in perceived health status over time. Nyman et al provide a method to convert these changes in perceived health status into a measure of the decrement in the quality of life.

Individuals were categorized into injured and non-injured groups. The perceived health status for the injured group was determined using the information gathered in the round prior to injury and the round immediately after injury, defining pre and post-injury health status. For those without an injury, perceived health status was determined using two consecutive rounds with a similar time frame between rounds as those that were injured. Differences in mean perceived health status pre- and post-injury by recovery level (fully-recovered, partially recovered, and permanent disability) were assessed for those among the injured group. Several non-injured comparison populations were created, as individuals in MEPS may fall into several categories: have no injury or illness, injury only, or illness only. The first comparison population (population A) were individuals with no injury; the second population (population B) were those with no injury or other chronic underlying condition; and the final group (population C) had no injury and was matched on age, sex, and race to the injured group. Differences in a change in perceived health status across different demographic groups is a possibility as such matching was pursued to ensure that these characteristics were not overshadowing the effect of injury on perceived health status. Ordered generalized probit models were used to understand the relationship between perceived health status pre- and post-injury while controlling for demographic variables including age, sex, marital status, education, race, recovery status, and income.

Results

Cases of non-hospitalized and hospitalized injury events related to agriculture were identified from the Minnesota hospital discharge dataset. Cases of fatal injuries related to agriculture were identified from the Census of Fatal Occupational Injuries (CFOI). Between 197 and 271 hospitalized injuries with a relationship to agriculture were identified each year between 2004 and 2010. During the same time period between 2,057 and 2,337 non-hospitalized agricultural injuries were identified each year. CFOI identified between 17 and 28 deaths each year among those employed in forestry, farming, and fishing for the time period 2004 to 2010.

To compare across years and between hospitalization and fatality status, all costs were calculated in 2010 dollars (Table 1). Costs were discounted to the year of injury for those that occurred prior to the year 2010. Total annual costs for hospitalized injuries between the years 2004 and 2010 ranged between $4.5 and $7.08 million. Total annual costs for non-hospitalized injuries between 2004 and 2010 were similar with a range of $5.02 and $ 7.4 million. Fatal injuries were the most expensive with a range of $8.6 to $17.4 million per year between 2004 and 2010. For injuries related to agriculture, hospitalized, non-hospitalized, and fatal, the annual cost ranged from $18.2 and $31.9 million for the time period 2004 to 2010. The majority of the costs associated with agricultural injuries were attributed to indirect costs. The indirect costs associated with fatal injuries accounted for the greatest proportion of all costs. The indirect costs 35 to 40 fold greater than direct costs over the seven year period. While hospitalized injuries occurred with a frequency one tenth that of non-hospitalized injuries, the total costs associated with each hospitalization group were similar in magnitude over the seven year period. The direct costs for the hospitalized injuries were almost double those of non-hospitalized injuries, demonstrating the serious nature of these injuries and the extra care necessary for the individual to recover.

Sensitivity Analyses

A number of assumptions must be made when selecting specific data sources or resources to provide variable estimates. These assumptions can influence the total cost estimate depending upon whether they over- or under-value the true cost of the variable. The variables of interest for the sensitivity analysis were home production and lost work time or production. The impact each of these selected variables had on the reference case cost estimate is presented in Table 2.

The first analysis investigated the use of the mean number of lost work days versus the median number of lost work days. The reference case estimate made use of the mean number of days of lost work time; the sensitivity analysis investigated the change in total cost if the median number of lost work days was used (Appendix 7, Table A). The use of the median number of lost days versus the mean number of lost days found an approximate 9% reduction in the cost estimate. This reduction in the estimated cost reflects the log normal distribution of the median number of lost work days. The median number of lost work days is consistently fewer than the mean regardless of injury type as it is less sensitive than the mean to extreme values.

The second analysis investigated the impact that the home production estimate had on the total cost estimate (Appendix 7, Table B). The reference case made use of the reported wages for those employed in the hospitality and leisure sector in Minnesota. Using these estimates, one assumes the value assigned to the tasks related to home production (cooking, cleaning, etc.) by society are correct. However, this may undervalue the individual's home production because this assumes that if the individual were not participating in some form of home production they could be participating in some form of employed production and receiving their assigned wage for those tasks. To assess the impact of the change in home production estimate on total cost, an estimate was created using the individual's agricultural wage rate. Those employed in agriculture had a higher yearly average wage ($21,580) than those in employed in leisure and services ($11,856) in the year 2010. With the use of the wage paid to those employed in agriculture for the value of home production, the total cost for agricultural injury between 2004 and 2010 among those hospitalized ranged between $4.7 and $7.3 million per year (in 2010 dollars). Among non-hospitalized cases total costs ranged between $5.4 and $7.9 million. The total cost for fatal injuries when using the wage estimate for those employed in agriculture ranged between $9.1 and $18.4 million per year (Appendix 7, Table B). This increase in the probability of disability and the lost work/home production time will in turn cost more as the associated estimated value (home production) has been increased. The use of the agricultural wages for home production creates a larger total cost estimate when compared to the reference case. This change in choice of home production value estimate led to a 5% increase when compared to the reference case cost estimate (Table 2).

The final two sensitivity analyses make use of the friction method (Appendix 7, Tables C – D). The friction method counts only the lost production time between when an individual is injured and when they return to, or are replaced, in the workplace. The first of these two analyses used a frictional time period of six months. This time frame was selected under the assumption that if an individual were totally or partially permanently disabled or fatally injured, a family member or current employee could step in and within six months return the farm to original production levels (Figure 1). The second time frame selected was six years. This time frame assumes that there was no immediate replacement available; requiring the farm to be sold and a number of years would be required before the farm was producing at original levels. The use of these lost time periods resulted in a great reduction in the indirect cost estimates. The use of a six month lost time period resulted in an almost 65% reduction in total costs and the use of a six year lost time period resulted in a 40% reduction in total costs (Table 2).

Change in Health Status (Quality of Life) Analysis

Review of the MEPS indicated a total of 578 individuals were classified as a farmer under the industry variable. Of those 578 individuals only 69 had any type of injury and of those 21 did not have the necessary information to assign recovery status (fully recovered, currently recovering, permanent disability). As such, the case population definition was expanded and any individual over 16 years of age without an injury related to: sports, gun violence, motor vehicle, or other weapon was included. A total of 3,567 individuals were categorized into the injured group and 73,497 were categorized as uninjured. Those categorized as injured had no other chronic condition present. Those with an ICD – 9CM code between 800 and 999 were categorized as injured. The majority of individuals in both the injured and non-injured groups were white (72% and 73% respectively). The average age of those injured was 40.3 years and of those not injured was 42.5 years. Among the injured population at the time of follow up, 74% were fully recovered, 25% were still recovering, and 1% were permanently disabled (Table 3). Small differences in perceived health status pre- and post-injury were seen for groups categorized by recovery health status. Among the injured population, a small decline in perceived health status was measured for those who originally reported a perceived health status of excellent or very good across all three recovery groups (Table 4). In contrast, for those individuals who originally reported a perceived health status of good, fair, or poor, a small improvement was seen in the perceived health status at follow up across all three recovery groups. In total, a non-significant increase in the perceived health status was found for all three recovery groups. However, the ordered probit model found only those within the *fully recovered* group had a significant predicted probability of a change in perceived health status after injury (Table 5). The model found that only those in the *still recovering* group had a decrement in perceived health status after injury; however, this decrement was not significant.

The MEPS collects information on a number of conditions, including: asthma, heart disease, cancer, and injury. As the individuals in the non-injured group may have been living with a chronic condition, this may affect the comparison between the injured and non-injured groups. Those living with a chronic condition or experiencing a significant non-injury health-related event may have a greater change in their perceived health status over the study time period compared to those with an injury. The non-injured group was further refined to exclude all individuals with an injury as well as any other chronic condition. Once all exclusions had been made, the total injured population numbered 3,567 and the non-injured group was comprised of 2,787 people. The majority of individuals included in both groups were white (72% and 71% respectively). The average ages were 40.3 and 44.4 years of age (respectively). Of the injured group 74% were fully recovered, 25% were still recovering and 1% was permanently disabled (Table 6). As was seen with the non-refined study population a small decrease in pre- and post-injury health status was found among those with a baseline perceived health status of excellent and very good, whereas a small increase was seen among those who originally identified as good, fair, and poor over all three recovery groups (Table 7). Similarly, a non-significant increase was seen in the total change in perceived health status for all three recovery groups. As was seen with the original probit model, a predicted decline in perceived health status was only found for those still recovering and this was non-significant (Table 8). The only significant change was a predicted increase in perceived health status for the fully recovered group.

The final analysis made use of matched cases and controls to limit the impact that age, race, and gender may have had on the outcome. There were 3,567 cases and 3,567 controls; the average age was 39.6 and the majority of individuals were white. Of the injury cases, 74% were fully recovered, 25% were still recovering, and 1% was permanently disabled (Table 9). The only difference seen with this analysis in comparison to the previous analyses was the predicted changes in perceived health status produced by the ordered probit model (Table 10). In the final model differences in predicted perceived health status across the different recovery levels were found; however, this was not consistent or significant across recovery and health status levels (Table 11).

Discussion

Cost Analysis

While a number of assumptions were made to create the cost estimates of agricultural injuries in Minnesota, these estimates have not been previously available and they provide valuable context when addressing the economic burden of injury and disease in Minnesota. In

2005 heart disease accounted for $1 billion in hospital charges annually for Minnesota (31). For the years 2005 to 2008, hospital costs associated with inpatient ischemic amputation (related to peripheral artery disease) in Minnesota were estimated between $21.4 and $23.5 million annually over the four year study period (in 2008 dollars) (20). Diabetes cost the state over $2.3 billion annually for medical costs, disability, lost work and premature death (32). Considering that 125,000 people in Minnesota reported ever having a heart attack for the year 2005, and over 250,000 Minnesotans have diabetes, the costs of the 3,000 agricultural injuries that occurred in a single year are comparable to these expensive and chronic conditions. The cost analysis by Leigh et al found the costs associated with occupational injuries in agriculture for the nation in 1992 were on par with the costs associated with Hepatitis C, a costly chronic condition (3). The estimated costs attributed to agricultural injury in Minnesota are similar in magnitude to the estimated costs related to bicycle injuries due to interaction with motor vehicles in 1999 at approximately $24.5 million (33). The bicycle injury costs include an estimate of the impact to the individual's quality of life, which was not included in the cost estimates of agricultural injury. As the agricultural injury costs do not contain an estimate of the change in quality of life, most likely the costs related to agricultural injury will exceed those of motor-vehicle and bicycle injuries once these costs are included. The published costs associated with bicycle and motor vehicle injuries has aided in producing programs and policy supporting the use of helmets, the creation of bike only paths and lanes, and the development of media campaigns to increase awareness of bikes on the road. The cost of agricultural injuries may help support the pursuit of similar activities to further reduce the human and economic toll of these injuries.

The cost of agricultural injury in Minnesota remained constant over the study period. The lack of change suggests that the severity and impact of these injuries has not diminished over the seven year period. While the majority of the cost is attributable to indirect costs, the direct costs associated with these injuries are substantial. And these costs in all likelihood underestimate the true cost of associated medical care and don't include costs related to follow up care and rehabilitation. A crude conservative estimate of the medical costs related to the 6,888 estimated non-fatal farm related injuries in Indiana equaled $8.0 million in economic losses for the year 2012 (34). These findings are similar to our study findings. Indiana is somewhat similar to Minnesota in terms of the number of farms (62,000 farms) and the number of agricultural fatalities (10 to 26 deaths during 2000-2010). The study findings are consistent with findings in other states and suggest that agricultural injury remains a substantial burden for both the individual and society.

Quality of Life Analysis

Despite the novel approach of using MEPS data to estimate changes in quality of life associated with agricultural injuries, findings reveal that the MEPS data set is limited for the study of this specific population. While the MEPS provides a significant amount of data with special emphasis on specific chronic conditions, the data set is limited when attempting to address disease and injury outcomes among specific industrial or occupational populations. The number of individuals identifying as farmers among the MEPS study population was very small, requiring the use of a surrogate population. Also, as there was no designation of an injury related to farming within the MEPS dataset, a surrogate for agricultural injuries was used. The selected surrogate injuries included those that were unrelated to motor vehicles, sports and recreation, gun violence, and other violence. These selection criteria were established as the change in quality of life due to motor vehicle injuries had been previously investigated by Nyman et al (30). The exclusion of sports injuries, gun violence, and injuries from other violence was done to best capture injuries that would be most similar to agricultural injury. However, the majority of individuals were fully recovered by the time of the follow up questionnaire period, and the serious injuries that might be expected among people recovering from an injury involving agricultural machinery or an animal were not found. Consequently, the selection criteria imposed upon the MEPS sample in an attempt to create a surrogate population for those employed in agriculture may have been biased to less severe injuries and the estimates for the change in the quality of life due to injury may not be accurate. To address this issue of the change in quality of life due to injury, the questions used to ascertain the perceived health status should be incorporated into a study specifically investigating injury related to agriculture and collected pre and post injury.

Limitations

The use of multiple data sources to create these cost estimates will introduce error into the estimates. To address and account for the error introduced by the use of these secondary data sources, a sensitivity analysis was completed to estimate the range of potential cost estimates and quantify possible error. The use of the average wage and the average length of work time lost may not adequately reflect the variability in the severity of injury and the variability in wages and experience.   Also, the use of surveys and samples such as the Quarterly Census of Employment and Wages and the outcome data from Miller et al from the DCI data will introduce sampling bias. These variables were adjusted and used in the sensitivity analysis to evaluate possible bias in the total cost estimate.

Previous studies to estimate the costs of injury and illness related to occupation utilized different sources of injury and illness data than this study. Previous published works have typically used workers' compensation and the Survey of Occupational Injuries and Illnesses (SOII) for counts of injury and illness related to occupation.   As previously noted these sources are not adequate for identifying agricultural injury in Minnesota, and the Minnesota hospital discharge dataset was used to identify cases of agricultural injury.   While more complete than other existing data sets, the Minnesota hospital discharge dataset is not a census of all agricultural injury and there will be an undercount of agricultural injuries. Consequently, the cost estimates created from hospital discharge data are also an underestimation of the financial impact of agricultural injury in Minnesota.

To completely address and correct for these errors one would need to follow a cohort of agricultural workers over an extended period of time to collect pertinent data pertaining to wages, injury type, injury outcomes, lost work time, decrements in quality of life, etc.   As this type of data is currently unavailable the sources identified were used to estimate the necessary components of the cost estimate.   While this is only an estimate and underestimates the true financial burden it provides necessary data and information to understand the full impact of agricultural injury in the state of Minnesota.

Conclusion

The estimated costs of agricultural injuries in Minnesota ranged from $18.2 and $31.9 million per year for the time period 2004-2010. Fatalities related to agriculture and the associated indirect costs appear to create the largest economic burden for Minnesota. This has not declined over time. These injuries can have long lasting effects that impact not only the injured individual but the family, farming community, and society as a whole.   Estimates of the economic burden of agricultural injuries provide much needed context regarding the human and financial toll associated with one of the most hazardous industries.

Tables

Table 1: Direct and Indirect Cost Estimates by Hospitalization and Fatality Status (2010 Dollars)

Year	Injury Group	Total Number of Injuries	Direct Cost Total	Indirect Cost Total	Total Costs
2004					
	Hospitalized	217	1,812,700.89	2,773,925.01	4,586,625.90
	Non Hospitalized	2291	1,345,317.45	3,675,167.91	5,020,485.36
	Fatal	19	233,654.43	8,357,363.01	8,591,017.44
	Total	2527	3,391,672.77	14,806,455.93	18,198,128.70
2005					
	Hospitalized	271	3,136,507.72	2,622,885.55	5,759,387.28
	Non Hospitalized	2264	1,472,153.97	3,698,296.14	5,170,450.11
	Fatal	22	280,450.91	9,629,483.66	9,909,934.57
	Total	2557	4,889,106.60	15,950,665.35	20,839,771.96
2006					
	Hospitalized	268	2,316,458.89	3,732,764.88	6,049,223.76
	Non Hospitalized	2244	1,668,132.67	3,903,991.60	5,572,124.27
	Fatal	23	303,540.79	11,470,216.00	11,773,756.79
	Total	2535	4,288,132.35	19,106,972.48	23,395,104.82
2007					
	Hospitalized	259	2,227,930.93	3,449,479.89	5,677,410.82
	Non Hospitalized	2057	1,680,696.24	3,697,701.66	5,378,397.90
	Fatal	17	232,004.75	7,995,640.27	8,227,645.02
	Total	2333	4,140,631.92	15,142,821.82	19,283,453.74
2008					
	Hospitalized	248	2,993,196.08	3,253,326.55	6,246,522.62
	Non Hospitalized	2313	1,887,256.90	4,248,595.34	6,135,852.24
	Fatal	25	352,431.26	13,803,243.11	14,155,674.37
	Total	2586	5,232,884.24	21,305,165.00	26,538,049.23
2009					
	Hospitalized	197	2,094,727.88	2,673,724.10	4,768,451.98
	Non Hospitalized	2337	2,316,422.05	4,624,711.56	6,941,133.61
	Fatal	20	290,943.26	10,300,691.72	10,591,634.97
	Total	2554	2,386,829.35	17,599,127.38	22,301,220.56
2010					
	Hospitalized	252	3,029,411.26	4,049,099.95	7,078,511.21
	Non Hospitalized	2311	2,719,080.08	4,758,640.69	7,477,720.77
	Fatal	28	419,918.10	16,983,959.19	17,403,877.29
	Total	2591	6,168,409	25,791,699	31,960,109

Table 2: Sensitivity Analysis of Total Costs of All Agriculturally-Related Injuries (2010 Dollars)

	Cost estimate in millions (range*)	Amount above (+) or below (-) preferred estimate	Percent above (+) or below (-) preferred estimate
Preferred estimate	18.2 – 31.9	0	0
Alternative assumption, inside model			
1. Use of Median number of lost days instead of the average/mean number of lost work days	16.4 – 29.7	(-) 1.8 – 2.3	(-) 9.3
2. Use of Agricultural workers wages for estimated value of home production	19.2 – 33.8	(+) 1.0 – 1.7	(+) 5.2
3. Frictional analysis – assume only 6 *months* of lost work time for partial permanent, permanent disability, and fatal injuries	8.7– 10.3	(-) 9.5 – 21.7	(-) 52.2
4. Frictional analysis – assume only 6 *years* of lost work time for partial permanent, permanent, and fatal injuries	10.5 – 17.1	(-) 8.2 – 14.9	(-) 42.5

*The range in estimated costs, low to high, found in the time period 2004 to 2010 is provided

Table 3: Descriptive Analyses of Total Medical Expenditures Panel Survey (MEPS) Comparison Population (A)*

	Injury	Non-Injured
Number of observations	3567	73497
Age	40.29	42.45
Race/Ethnicity		
White Non-Hispanic	2577 (72)	51197 (70)
Black Non-Hispanic	377 (11)	8752 (12)
Hispanic	531 (15)	11374 (15)
Asian	82 (2)	2174 (3)
Education		
Less than college	2490 (70)	46875 (64)
More than college	1077 (30)	26622 (36)
Female	1607 (45)	45292 (61)
Married	1884 (53)	43248 (59)
Income		36113.33
Income > 400% FPL	280 (8)	7436 (10)
200% FPL < Income < 399.9% FPL	470 (13)	10784 (15)
125% FPL < Income < 199.9% FPL	851 (24)	17991 (25)
100% FPL < Income < 124.99% FPL	439 (12)	8134 (11)
Income < 100%	1527 (43)	29152 (40)
Self-Reported health status in round prior to injury		
Excellent	794 (22)	15359 (21)
Very Good	1270 (36)	25063 (34)
Good	1101 (31)	22515 (31)
Fair	343 (10)	8529 (12)
Poor	59 (2)	2031 (3)
Self-Reported health status in round after injury		
Excellent	825 (23)	12670 (17)
Very Good	1319 (37)	24352 (33)
Good	1061 (30)	24270 (33)
Fair	309 (8)	9562 (13)
Poor	53 (2)	2643 (4)
Recovery Status		
Fully recovered	2630 (74)	
Partially recovered	878 (25)	

Permanent disability	59 (1)	

*Original comparison population – limited exclusions applied, all individuals had to be employed and those in the non-injured group may have had a chronic condition. Those in the injured group had no other condition present (A).

Table 4: Change in Means Pre and Post Injury for the Identified Injured Among the MEPS Total Comparison Population (A)

	Mean of the Marginal Effects for Each Individual	QOL Weights	Expected Change in QOL: Mean of Individuals Marginal Effects
Fully Recovered Group			
Excellent	-0.52	0.941	-0.49
Very Good	-0.064	0.903	-0.58
Good	0.403	0.844	0.34
Fair	0.626	0.711	0.45
Poor	1.083	0.498	0.54
Sum			0.79
Partially Recovered Group			
Excellent	-0.49	0.941	-0.46
Very Good	-0.23	0.903	-0.21
Good	0.26	0.844	0.22
Fair	0.66	0.711	0.47
Poor	1.20	0.498	0.60
Sum			0.62
Permanently Disabled Group			
Excellent	-0.80	0.941	-0.75
Very Good	-0.31	0.903	-0.28
Good	0.15	0.844	0.13
Fair	0.20	0.711	0.14
Poor	2.33	0.498	1.16
Sum			0.40

Table 5: Ordered Probit Model Results: the Log-Odds an Injured Individual has a Change in Perceived Health Status. (MEPS Total Non-Injured Population as the Referent Category (Population Group A))

	Poor vs. All other Categories (95% CI)	Fair or Poor vs. Excellent, Very Good, and Good (95% CI)	Good, Fair, or Poor vs. Excellent or Very Good (95% CI)	Other categories vs. Excellent (95% CI)
Age	-0.0162** (-.019,-.013)	-0.0164** (-.018, -.015)	-0.0137** (-.0149, -.0124)	-0.0113** (-.013, -.009)
Black Non-Hispanic (White as reference group)	0.1680* (.036, .299)	-0.2227** (-.289, -.156)	-0.2066** (-.259, -.154)	-0.0274 (-.097, .042)
Hispanic	-0.0371 (-.150, .076)	-0.4107** (-.469, -.352)	-0.3316** (-.379, -.284)	-0.1187** (-.183, -.055)
Other Racial/ethnic Group	0.0054 (-.305, .316)	0.0426 (-.104, .189)	-0.2383** (-.335, -.141)	0.0296 (-.075, .161)
Education (more than college = 1)	0.1109** (.006, .215)	0.1846** (.132, .237)	0.2745** (.237, 311)	0.1701** (.124, .216)
Very Good (Excellent as reference group)	-0.3823** (-.626, -.139)	-0.5802** (-.682, -.478)	-0.8587** (-.908, -.809)	-1.8570** (-1.90, -1.81)
Good	-1.0943** (-1.32, -.868)	-1.6663** (-1.76, -1.57)	-2.3208** (-2.37, -2.27)	-2.7814** (-2.85, -2.72)
Fair	-2.7855** (-3.00, -2.57)	-3.4689** (-3.57, -3.37)	-3.6131** (-3.69, -3.53)	-3.9537** (-4.12, -3.79)
Poor	-4.8180** (-5.04, -4.59)	-4.6789** (-4.82, -4.54)	-4.2115** (-4.40, -4.02)	-4.3445** (-4.75, -3.94)
Married (married = 1)	0.0779 (-.011, .167)	0.1374** (.091, .184)	0.0438** (.009, .079)	-0.01593** (-.061, -.029)
Income <100% FPL (400% > FPL as reference group)	-0.6155** (-.731, -.499)	-0.5077** (-.577, -.438)	-0.4186** (-.477, -.360)	-0.3663** (-.433, -.299)
100% FPL < Income < 124.9% FPL	-0.2815** (-.343, -.219)	-0.2815** (-.343, -.219)	-0.2815** (-.343, -.219)	-0.2815** (-.343, -.219)
125% FPL < Income <	-0.0364 (-.173, .100)	-0.1866** (-.261, -.112)	-0.2352** (-.292, -.177)	-0.2971** (-.362, -.232)

199.9% FPL				
200% FPL < Income < 399.9% FPL	-0.0770** (-.133, -.021)	-0.0770** (-.133, -.021)	-0.0770** (-.133, -.021)	-0.0770** (-.133, -.021)
Gender (Female = 1)	0.0001 (-.091, .091)	0.0130 (-.034, .059)	0.0028 (-.032, .037)	-0.0590** (-.102, -.016)
Full recovery (non-injured reference group)	1.1637** (.685, 1.64)	0.5374** (.373, .702)	0.4568** (.355, .559)	0.4057** (.292, .519)
Partial Recovery	0.2376** (.089, .386)	0.2376** (.089, .386)	0.2376** (.089, .386)	0.2376** (.089, .386)
Permanent Disability	14.2335 (-1446.8, 1475.4)	-0.5394 (-1.39, .310)	0.5194 (-.228, 1.27)	-0.7647 (-2.04, .511)
Constant	5.9788** (5.66, 6.29)	4.2724** (4.12, 4.43)	2.3138** (2.21, 2.42)	0.7782** (.659, .896)

Abbreviation **p < .05

Table 6: Descriptive Analyses of MEPS First Refined Comparison Population (B)*

	Injury	Non-Injured
Number of observations	3567	2787
Age	40.29	44.37
Race/Ethnicity		
White Non-Hispanic	2577 (72)	1970 (71)
Black Non-Hispanic	377 (11)	364 (13)
Hispanic	531 (15)	367 (13)
Asian	82 (2)	86 (3)
Education		
Less than college	2490 (70)	1752 (63)
More than college	1077 (30)	1035 (37)
Female	1607 (45)	1636 (59)
Married	1884 (53)	1731 (62)
Income		
Income > 400% FPL	1527 (43)	987 (35)
200% FPL < Income < 399.9% FPL	439 (12)	318 (11)
125% FPL < Income < 199.9% FPL	851 (24)	730 (26)
100% FPL < Income < 124.99% FPL	470 (13)	452 (16)
Income < 100%	280 (8)	300 (11)
Self-Reported health status in round prior to injury		
Excellent	794 (22)	672 (24)
Very Good	1270 (36)	945 (34)
Good	1101 (31)	758 (27)
Fair	343 (10)	317 (11)
Poor	59 (2)	95 (3)
Self-Reported health status in round after injury		
Excellent	825 (23)	599 (21)
Very Good	1319 (37)	990 (36)
Good	1061 (30)	810 (29)
Fair	309 (8)	308 (11)
Poor	53 (2)	80 (3)
Recovery Status		
Fully recovered	2630 (74)	
Partially recovered	878 (25)	
Permanent disability	59 (1)	

*First refined non-injured comparison population – exclusions were applied to the non-injured comparison population. The non-injured group could not have any chronic condition or injury throughout the entire panel (B).

Table 7: Change in Means Pre and Post Injury for the Identified Injured Among the MEPS First Refined Comparison Population (B)

	Mean of the Marginal Effects for Each Individual	QOL Weights	Expected Change in QOL: Mean of Individuals Marginal Effects
Fully Recovered Group			
Excellent	-0.52	0.941	-0.49
Very Good	-.06	0.903	-0.05
Good	0.39	0.844	0.33
Fair	0.65	0.711	0.46
Poor	1.20	0.498	0.59
Sum			0.84
Partially Recovered Group			
Excellent	-0.52	0.941	-0.49
Very Good	-0.21	0.903	-0.19
Good	0.26	0.844	0.22
Fair	0.73	0.711	0.52
Poor	1.30	0.498	0.65
Sum			0.71
Permanently Disabled Group			
Excellent	-0.56	0.941	-0.53
Very Good	-0.25	0.903	-0.23
Good	0.38	0.844	0.32
Fair	0.00	0.711	0.00
Poor	2.33	0.498	1.16
Sum			0.72

Table 8: Ordered Probit Model Results: the Log-Odds an Injured Individual has a Change in Perceived Health Status. (MEPS First Refined Non-Injured Comparison Population as the Referent Category (Population Group B))

	Poor vs. All other Categories (95% CI)	Fair or Poor vs. Excellent, Very Good, and Good	Good, Fair, or Poor vs. Excellent or Very Good	Other categories vs. Excellent
Age	-.0277** (-.043, -.012)	-.0153** (-.022, -.008)	-.0148** (-.019, -.010)	-.0090** (-.014, -.004)
Black Non-Hispanic (White as reference group)	-.1110 (-.266, .044)	-.1110 (-.266, .044)	-.1110 (-.266, .044)	-.1110 (-.266, .044)
Hispanic	-.5971** (-1.09, -.109)	-.1993 (-.437, .039)	-.1242 (-.295, .046)	.0858 (-.119, .291)
Other Racial/ethnic Group	-.0185 (-.321, .284)	-.0185 (-.321, .284)	-.0185 (-.321, .284)	-.0185 (-.321, .284)
Education (more than college = 1)	-.6934** (-1.10, -.284)	.1111 (-.096, .319)	.2520** (.118, .386)	.0809 (-.068, .229)
Very Good (Excellent as reference group)	2.6751** (2.19, 3.16)	1.0321** (640, 1.42)	.4934 (-.100, 1.09)	.6124 (-.863, 2.09)
Good	4.1175** (3.59, 4.65)	2.9339** (2.55, 3.32)	1.6736** (1.11, 2.34)	1.8948** (.497, 3.29)
Fair	5.2946** (4.52, 6.07)	4.2762** (3.85, 4.71)	3.2109** (2.65, 3.77)	2.5898** (1.19, 3.98)
Poor	6.0073** (4.58, 7.43)	5.3238** (4.71, 5.93)	4.1579** (3.58, 4.73)	4.5759** (3.18, 5.97)
Married (married = 1)	-.0545 (-.156, .047)	-.054 (-.156, .047)	-.0545 (-.156, .047)	-.0545 (-.156, .047)
Income <100% FPL (400% > FPL as reference group)	-.2477** (-.453, -.042)	-.2477** (-.453, -.042)	-.2477** (-.453, -.042)	-.2477** (-.453, -.042)
100% FPL < Income < 124.9% FPL	-.0081 (-.502, .486)	-.2359 (-.502, .030)	-.2654** (-.476, -.055)	-.4952** (-.719, -.275)
125% FPL < Income < 199.9% FPL	-.4317** (-.654, -.209)	-.4317** (-.654, -.209)	-.4317** (-.654, -.209)	-.4317** (-.654, -.209)

200% FPL < Income < 399.9% FPL	-.4159** (-.612, -.220)	-.4159** (-.612, -.220)	-.4159** (-.612, -.220)	-.4159** (-.612, -.220)
Gender (Female = 1)	-.1382** (-.236, -.040)	-.1382** (-.236, -.041)	-.1382** (-.236, -.041)	-.1382** (-.236, -.041)
Full recovery (non-injured reference group)	.1928** (.087, .299)	.1928** (.087, .299)	.1928** (.087, .299)	.1928** (.087, .299)
Partial Recovery	-.0174 (-.165, .130)	-.0174 (-.165, .130)	-.0174 (-.165, .130)	-.0174 (-.165, .130)
Permanent Disability	.4123 (-1.72, 2.54)	-.6870 (-1.41, .034)	.4551 (-.151, 1.06)	-.3665 (-1.22, .484)
Constant	2.3205** (1.48, 3.16)	0.24450 (-.288, .777)	-1.1378** (-1.77, -.503)	-3.3526** (-4.78, -1.92)

*Abbreviation ** p<.05

Table 9: Descriptive Analyses for MEPS Second Refined and Matched Comparison Population (C)*

	Injury	Non-Injured
Number of observations	3567	3567
Age	39.57	39.57
Race/Ethnicity		
White Non-Hispanic	2577 (72)	2577 (72)
Black Non-Hispanic	377 (11)	377 (11)
Hispanic	531 (15)	531 (15)
Asian	82 (2)	82 (2)
Education		
Less than college	2490 (70)	2186 (61)
More than college	1077 (30)	1381 (39)
Female	1607 (45)	1607 (45)
Married	1884 (53)	1991 (56)
Income		
Income > 400% FPL	1527 (43)	1381 (39)
200% FPL < Income < 399.9% FPL	439 (12)	390 (11)
125% FPL < Income < 199.9% FPL	851 (24)	745 (21)
100% FPL < Income < 124.99% FPL	470 (13)	615 (17)
Income < 100%	280 (8)	436 (12)
Self-Reported health status in round prior to injury		
Excellent	794 (22)	862 (24)

Very Good	1270 (36)	1329 (37)
Good	1101 (31)	891 (25)
Fair	343 (10)	388 (11)
Poor	59 (2)	97 (3)
Self-Reported health status in round after injury		
Excellent	825 (23)	923 (26)
Very Good	1319 (37)	1387 (39)
Good	1061 (30)	963 (27)
Fair	309 (8)	206 (6)
Poor	53 (2)	88 (3)
Recovery Status		
Fully recovered	2630 (74)	
Partially recovered	878 (25)	
Permanent disability	59 (1)	

*Second refined comparison population – the comparison non-injured population was matched to injured cases on age, sex, and race (C).

Table 10: Change in Means Pre and Post Injury for the Identified Injured Among the MEPS Second Refined and Matched Comparison Population (C)

	Mean of the Marginal Effects for Each Individual	QOL Weights	Expected Change in QOL: Mean of Individuals Marginal Effects
Fully Recovered Group			
Excellent	-0.52	0.941	-0.49
Very Good	-.056	0.903	-0.051
Good	0.39	0.844	0.33
Fair	0.65	0.711	0.46
Poor	1.20	0.498	0.59
Sum			0.84
Partially Recovered Group			
Excellent	-0.52	0.941	-0.49
Very Good	-0.21	0.903	-0.19
Good	0.26	0.844	0.22
Fair	0.73	0.711	0.52
Poor	1.30	0.498	0.65
Sum			0.71

Permanently Disabled Group			
Excellent	-0.56	0.941	-0.53
Very Good	-0.25	0.903	-0.23
Good	0.38	0.844	0.32
Fair	0.00	0.711	0.00
Poor	2.33	0.498	1.16
Sum			0.72

Table 11: Ordered Probit Model Results: the Log-Odds an Injured Individual has a Change in Perceived Health Status. (MEPS Second Refined and Matched Non-Injured Comparison Population as the Referent Category (Population Group C))

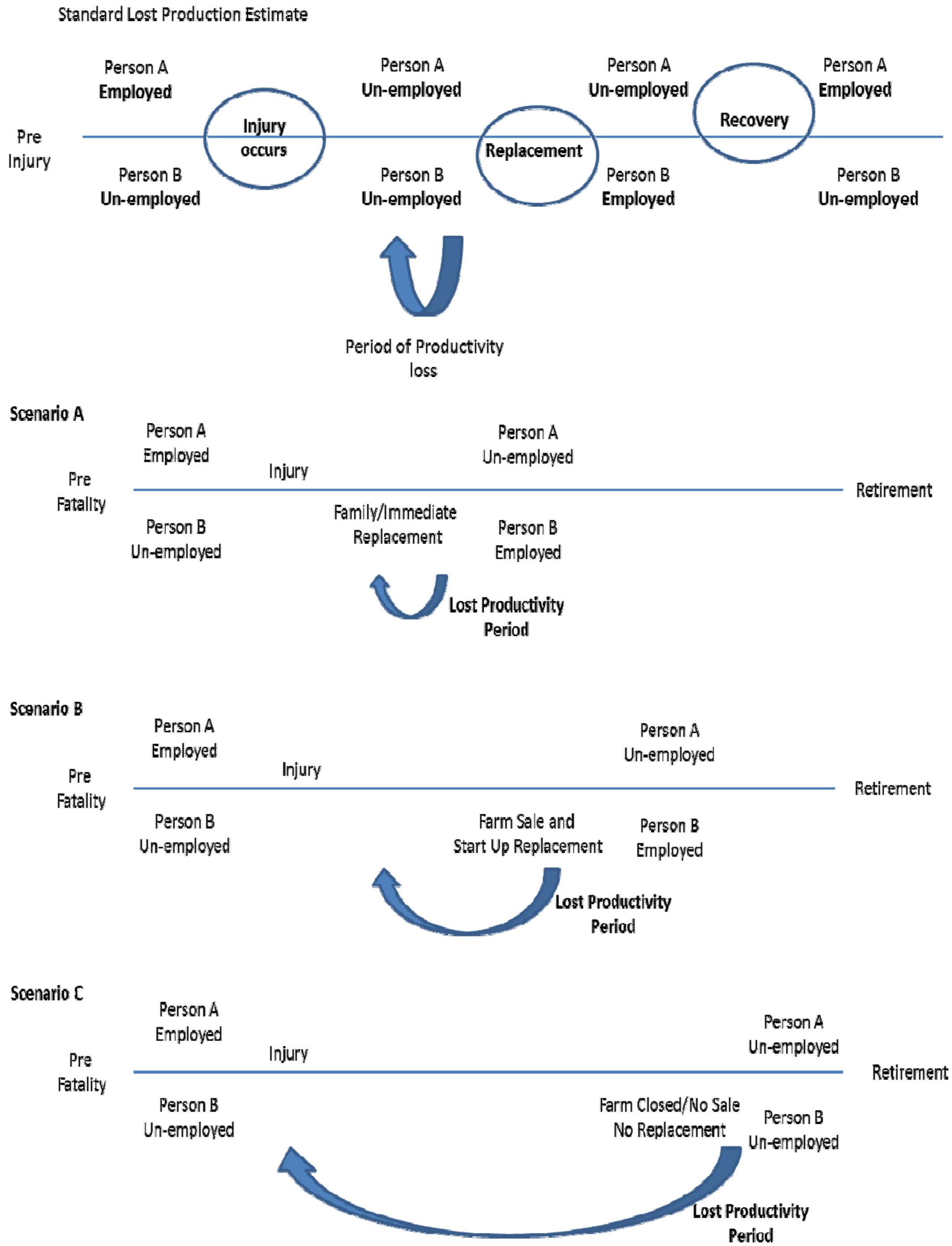
	Poor vs. All other Categories (95% CI)	Fair or Poor vs. Excellent, Very Good, and Good (95% CI)	Good, Fair, or Poor vs. Excellent or Very Good (95% CI)	Other categories vs. Excellent (95% CI)
Age	-.01634** (-.030, -.003)	-.0027 (-.011, .005)	-.021** (-.025, -.016)	-.0050 (-.010, .000)
Black Non-Hispanic (White as reference group)	1.5180** (.889, 2.15)	-.4352** (-.709, -.162)	-.4084** (-.593, -.224)	.2463** (.034, .456)
Hispanic	-.6384** (-1.15, -.129)	-.7802** (-1.01, -.548)	-.4105** (-.571, -.249)	.0964 (-.096, .289)
Other Racial/ethnic Group	-.0384 (-.346, .269)	-.0384 (-.346, .269)	-.0385 (-.346, .269)	-.0385 (-.346, .269)
Education (more than college = 1)	-2.1306** (-2.69, -1.57)	.0775 (-.151, .306)	.1133 (-.017, .244)	.4358** (.293, .579)
Very Good (Excellent as reference group)	2.4682** (1.96, 2.98)	.0625 (-.335, .460)	-.5708** (-.989, -.152)	2.2144** (.229, 4.19)
Good	5.5322** (4.78, 6.28)	1.8593** (1.47, 2.25)	.2979 (-.092, .685)	2.4860** (.512, 4.46)
Fair	7.1641** (5.62, 9.60)	3.8245** (3.34, 4.31)	1.9084** (1.52, 2.29)	2.9862** (1.01, 4.95)
Poor	5.1587** (3.70, 6.61)	4.7057** (4.05, 5.36)	3.4425** (3.02, 3.87)	5.3256** (3.35, 7.29)
Married (married = 1)	.6430** (.180, 1.11)	.04035 (-.154, .235)	-.1211 (-.244, .002)	.0545 (-.005, .281)
Income <100% FPL (400% > FPL as reference group)	.8766 (-.042, 1.79)	-.6373** (-.971, -.303)	-.5513** (-.769, -.334)	-.9648** (-1.19, -.731)
100% FPL < Income <	1.5529** (.899, 2.21)	-.4672** (-.749, -.185)	.0254 (-.179, .229)	-.4899** (-.701, -.279)

124.9% FPL				
125% FPL < Income < 199.9% FPL	-.5898 (-1.31, .131)	-.3046 (-.636, .027)	.0154 (-.219, .250)	-.5294** (-.782, -.276)
200% FPL < Income < 399.9% FPL	-.5054** (-.691, -.320)	-.5054** (-.691, -.320)	-.5054** (-.691, -.320)	-.5054** (-.691, -.320)
Gender (Female = 1)	-.2327 (-.642, .177)	-.0844 (-.272, .103)	-.2659** (-.383, -.148)	-.3940** (-.527, -.261)
Full recovery (non-injured reference group)	1.7393** (1.21, 2.27)	-.27711** (-.488, -.067)	-.09118 (-.215, .032)	-.01950 (-.155, .116)
Partial Recovery	1.5217** (.924, 2.12)	-.4765** (-.736, -.217)	-.2734** (-.447, -.099)	-.2705** (-.488, -.053)
Permanent Disability	1.9412 (-.114, 3.99)	-1.2452** (-1.97, -.524)	.1444 (-.459, .748)	-.6162 (-.150, .269)
Constant	.5465 (-.576, 1.67)	1.3562** (.772, 1.94)	.9222** (.458, 1.39)	-3.6620** (-5.65, -1.67)

Abbreviation ** p < .05

Figures

Figure 1: Estimation of Productivity Costs



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Chapter Six: Discussion

The overall purpose of this dissertation was to investigate the burden of agricultural injuries in Minnesota. The rationale for the pursuit of this study was the limited information available regarding counts, rates, and trends of agricultural injury and the economic burden these injuries placed on Minnesota society. Identification of a cost-effective method to estimate the number of these injuries that occur annually and the associated costs would aid in allocating resources and evaluating future interventions and policy changes.

Aim One

The study had two specific aims. For the first aim the rates and trends of agriculturally-related injuries were estimated using Minnesota hospital discharge data between 2000 and 2011. Over 2,000 injuries annually with a potential relationship to agriculture were identified using the hospital discharge data. Several sources were evaluated as potential denominators for the creation of injury rates. The American Community Survey was selected as it captured both those who work and live on a farm for the majority of the study period. Trend analysis of the created rates found a non-significant average annual increase of 1.5% over the twelve year study period, 2000-2011.

The work completed demonstrates the utility Minnesota hospital discharge data provides in identifying injury related to agriculture and the potential for it to serve as a means of public health surveillance. The dataset captures 95% of inpatient hospital events (1), allowing for a more complete understanding of injury related to agriculture than other available datasets. Alternative data sources have limited coverage of the population of interest. Workers' compensation captures a portion of all injury related to agriculture, predominantly those that occur on large farming operations, as exemptions exist for family farms or farms that meet set standards allowing for exclusion from workers' compensation insurance requirements (2). The Survey of Occupational Injuries and Illnesses (SOII) also only captures a portion of injury related to agriculture as farms with fewer than 11 employees are not included in the survey (3). State hospital discharge data are also valuable given the number of years for which data exist, allowing for trend analysis and possible evaluation of programs, practices, and policies that may have, or will be, implemented to reduce the number of injuries related to agriculture that occur in a year.

One of the most advantageous qualities of hospital discharge data is that the data set is readily available and requires limited resources for access and use. These qualities are of importance in the current political climate of limited funding provided for public health surveillance activities.

While hospital discharge data is readily available and captures the majority of inpatient hospitalizations, the methods in which data coding and collection occur can influence the reliability and validity of the surveillance measures. The injury case definition for this study relied heavily on the presence of an external cause of injury codes (E codes). However E codes are not a required data element in the hospital billing record so not every injury case will have an accompanying E code. This variability in the inclusion of the E code in the billing record will have an impact on the completeness of case collection.

Personal interviews were conducted by this author with several administrators of coding operations for hospital billing records at three institutions. Findings from the interviews revealed variability in the inclusion of an E code within the record, and an institutional preference for the type of E code included. E codes related to the nature and mechanisms of injury are more frequently included in the record than those describing location, such as: work, home, farm, or recreational facility. The E codes describing nature and mechanism of injury are more frequently used as they support and provide justification for billing for services. Thus the E code E849.1, occurred on a farm, while very specific and useful in identifying an injury related to agriculture may be used with less frequency than the E code E919.0, agricultural machinery involved. If an injury occurs on a farm but does not involve agricultural machinery, the billing record may not include an E code that would in some way identify the injury as related to agriculture. These nuances in the use of E codes will affect the completeness of case capture and lead to an undercount or misclassification of agricultural injuries.

The sensitivity and specificity in the case definition is affected by the available codes used to describe the injury case in the dataset. The use of a secondary dataset limits the usage of the data. Often data that is pertinent to the research question may not have been collected or has been formatted in a method that is inadequate for the project. Two of the selected E codes, E849.1 and E919.0, are very specific in regards to the relationship between agriculture and the injury event. The remaining E codes used in the definition are less specific and there is the possibility that the injury has been misclassified. However, to exclude these injuries would potentially exclude a significant portion of agricultural injury. Thus error has been introduced into the measure as there is some portion of the identified injuries that have been incorrectly included in the count. To account for this error follow up research would need to be completed to investigate the accuracy of the number of injuries with the remaining E codes to establish the validity of their association with agriculture.

The Minnesota hospital discharge data is primarily collected for purposes of billing. The descriptive information that would be useful to injury and illness research is not always available or collected for this dataset. This requires further research to fully describe injury events related to agriculture. The current study provides an understanding of the types of injury that occur in relation to agricultural activities providing baseline data and information for tracking of rates and trends over time.

Aim Two

The second aim of this study was to estimate the economic impact of injuries related to agriculture in Minnesota between 2004 and 2010. Estimated costs, in 2010 dollars, for agricultural injury were between $21 and $31 million for the study time period. The majority of the costs were attributed to indirect costs, such as lost work and home production, and costs associated with fatal injuries. Costs were consistent across the seven year study period, demonstrating the continued burden of these injuries.

The purpose of this study was to provide an estimate of the costs associated with agricultural injury. These cost estimates are extremely useful for placing the human and economic burden these injuries inflict into context. As cost estimates for diabetes, heart disease, stroke, cancer, and hypertension are annually updated and readily available (4), this study provides estimations of the costs associated with agricultural injury which have not been readily available to date. Costs related to injuries due to events between bicycle riders and motor vehicles averaged about $24.5 million, comparable to the costs found in this study. Diabetes cost Minnesota over $2.3 billion annually for medical costs, disability, lost work, and premature death. Considering over 250,000 Minnesotans have diabetes the cost per case of the agricultural injuries that have occurred in a single year are comparable to these expensive and chronic conditions. The published costs associated with motor vehicle and bicycle accidents have provided support for programs aimed at reducing these incidents with the creation of bike only paths and lanes, helmet usage, and media campaigns to increase awareness of bicycles on the road. Recently the

Centers for Disease Control and Prevention (CDC) released version 2.0 of the Chronic Disease Cost Calculator (http://www.cdc.gov/chronicdisease/resources/calculator/). The CDC also produces the Web-based Injury Statistics Query and Reporting System (http://www.cdc.gov/injury/wisqars/) to calculate costs related to injury. Niether system allows the user to calculate costs for agricultural or work-related injury. To remain a participant in the conversation surrounding resource allocation for the limited funds available for the reduction and prevention of injury and disease, occupational public health practitioners need the information provided by these cost assessments.

As with the previous aim the use of secondary data sets introduces error into the estimate. Secondary data sets were used to estimate both the direct and indirect costs for the total cost measure. The Minnesota hospital discharge database and a cost-to-charge ratio were used to create measures of the cost associated with the care received. However, often a negotiation process occurs between the hospital and insurance company regarding the final amount paid for services. The amount recorded in the discharge database may not represent the true cost of the services provided. Secondly, an average cost per injury type was applied to the cost estimate removing the variability that can be present between injury cases. Averages were also used for wages and benefits as the length of employment, seniority, and experience for the individual injured was unknown.

The cost of illness model was selected for this study. However, there are a number of alternative models that could have been selected each with distinct advantages and disadvantages. As the aim of the study was to estimate the burden placed upon society when these injuries occur the cost of illness model may produce an overestimation. Specifically while the loss in production over a lifetime is of importance to the individual or their immediate family, as long as there is a replacement of that production that enables society to consume, the lost production time estimate will be much shorter for non-cost of illness models. The type of cost estimate described is most often calculated using the friction method; however, the necessary information regarding lost production times due to agricultural injury are not known. To account for this limitation hypotheses regarding lost production time were used in a sensitivity analysis to evaluate the impact the choice of cost estimation method has on the total cost estimate. Adjustment of these lost work time estimates produced an estimate 9% to 50% smaller than the preferred cost of illness method.

Home production has been estimated in a number of ways. Two common approaches in estimating home production have been to use either the working wage of the individual or the wages of those employed in hospitality. A sensitivity analysis made use of these home production estimates to assess the impact the selection of the approach to estimation of this variable would have on the total cost estimate. The choice of the agricultural worker wage for home production produced a 5% increase over the preferred estimate. This is expected as those in agriculture on average received a higher wage than those employed in the hospitality and leisure services. While the cost of illness model may overestimate the total costs related to agricultural injury, to participate in the conversations regarding the relative costs of other health outcomes and diseases, the use of this model was necessary.

The Medical Expenditure Panel Survey (MEPS) provides a great deal of information regarding health care access, usage, and satisfaction, disease and injury status, and basic demographic information. However, the specificity and sample size necessary to investigate the change in perceived health status among those employed in agriculture with an injury is not available in the MEPS. The lack of an estimate in the change in the quality of life after an agricultural injury limits the completeness of the cost estimate as it does not account for all losses related to the injury.

Future Research

Several areas for future research regarding agricultural injury exist. The first area of research is the evaluation of the completeness, accuracy, specificity, and sensitivity of E codes in the hospital discharge record. This work would aid in evaluating hospital discharge data as a means of surveillance for not only injury related to agriculture but other work related injury and illness. It could also provide information necessary to improve the quality of the data collected within the hospital discharge billing record for surveillance purposes.

With the move from ICD – 9CM to ICD – 10CM a cross walk and research into the impact this will have on the accuracy and completeness of the data within the hospital discharge record will be needed. ICD – 10CM is alphanumeric with up to 7 characters, unlike ICD – 9CM which was predominantly numeric with up to 5 characters. The switch to ICD – 10CM will provide for more robust and descriptive case coding possibly allowing for greater capture of information pertaining to the case. This change in coding is expected to occur on or after October

1, 2015. Understanding the impact this change in coding will have regarding case capture will influence the utility of this data source as a means of surveillance for not only agricultural injury but other injuries and conditions.

The change in the quality of life following an agricultural injury is necessary to fully understand the economic impact and burden associated with these injuries, as there is very little information detailing the impact work-related injury has on an individual's quality of life. Currently research detailing the costs attributed to occupational injury and illness make use of workers' compensation and jury awards to estimate costs associated with pain and suffering (5, 6); the use of these data sources to quantify the loss in quality of life makes a number of assumptions and leads to an underestimation of the impact these injuries have on the quality of life. The addition of the question, "Would you describe your health as: poor, fair, good, very good, or excellent" to a longitudinal study investigating agricultural injury would be one method to collect the information necessary to assess the change in quality of life. With the collection of the perceived health status pre- and post-injury and the methodology developed by Nyman et al (7), an estimate in the quality of life decrement after injury for agricultural populations could be determined.

A final area of research would be continued use of the algorithm to track injury events related to agriculture pre- and post-intervention or policy change. The identification of behaviors and exposures that increase risk or protect individuals from risk of injury taken from the available hospital discharge data in combination with findings from the proposed evaluation of E codes could provide methods to prevent future injury. If interventions or policies were developed and implemented the algorithm could be used to evaluate the effectiveness of these new programs.

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Appendices

Appendix 1

University of Minnesota IRB Exemption

1307E37481 - PI Kari - IRB - Exempt Study Notification 1 message

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irb@umn.edu <irb@umn.edu> Wed, Jul 3, 2013 at 1:37 PM

To: kari0041@umn.edu

TO : pmcg@umn.edu, kari0041@umn.edu, will0242@umn.edu,

The IRB: Human Subjects Committee determined that the referenced study is exempt from review under federal guidelines 45 CFR Part 46.101(b) category #4 EXISTING DATA; RECORDS REVIEW; PATHOLOGICAL SPECIMENS.

Study Number: 1307E37481

Principal Investigator: Adrienne Kari

Title(s):

Estimating the Burden of Serious Farm Related Injury in Minnesota

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This e-mail confirmation is your official University of Minnesota HRPP notification of exemption from full committee review. You will not receive a hard copy or letter. This secure electronic notification between password protected authentications has been deemed by the University of Minnesota to constitute a legal signature.

The study number above is assigned to your research. That number and the title of your study must be used in all communication with the IRB office.

If you requested a waiver of HIPAA Authorization and received this e-mail, the waiver was granted. Please note that under a waiver of the HIPAA Authorization, the HIPAA regulation [164.528] states that the subject has the right to request and receive an accounting of Disclosures of PHI made by the covered entity in the six years prior to the date on which the accounting is requested.

If you are accessing a limited Data Set and received this email, receipt of the Data Use Agreement is acknowledged.

This exemption is valid for five years from the date of this correspondence and will be filed inactive at that time. You will receive a notification prior to inactivation. If this research will extend beyond five years, you must submit a new application to the IRB before the study's expiration date.

Upon receipt of this email, you may begin your research. If you have questions, please call the IRB office at (612) 626-5654.

You may go to the View Completed section of eResearch Central at http://eresearch.umn.edu/ to view further details on your study.

The IRB wishes you success with this research.

Appendix 2

Workers' Compensation Legislation

176.041 EXCLUDED EMPLOYMENTS; APPLICATION, EXCEPTIONS, ELECTION OF COVERAGE.

Subdivision 1.Employments excluded.

This chapter does not apply to any of the following:

(1) a person employed by a common carrier by railroad engaged in interstate or foreign commerce and who is covered by the Federal Employers' Liability Act, United States Code, title 45, sections 51 to 60, or other comparable federal law;

(2) a person employed by a family farm as defined by section 176.011, subdivision 11a;

(3) the spouse, parent, and child, regardless of age, of a farmer-employer working for the farmer-employer;

(4) a sole proprietor, or the spouse, parent, and child, regardless of age, of a sole proprietor;

(5) a partner engaged in a farm operation or a partner engaged in a business and the spouse, parent, and child, regardless of age, of a partner in the farm operation or business;

(6) an executive officer of a family farm corporation;

(7) an executive officer of a closely held corporation having less than 22,880 hours of payroll in the preceding calendar year, if that executive officer owns at least 25 percent of the stock of the corporation;

(8) a spouse, parent, or child, regardless of age, of an executive officer of a family farm corporation as defined in section 500.24, subdivision 2, and employed by that family farm corporation;

(9) a spouse, parent, or child, regardless of age, of an executive officer of a closely held corporation who is referred to in clause (7);

(10) another farmer or a member of the other farmer's family exchanging work with the farmer-employer or family farm corporation operator in the same community;

(11) a person whose employment at the time of the injury is casual and not in the usual course of the trade, business, profession, or occupation of the employer;

(12) persons who are independent contractors as defined by sections 176.043 and 181.723, and any rules adopted by the commissioner pursuant to section 176.83 except that these exclusions do not apply to an employee of an independent contractor;

(13) an officer or a member of a veterans' organization whose employment relationship arises solely by virtue of attending meetings or conventions of the veterans' organization, unless the veterans' organization elects by resolution to provide coverage under this chapter for the officer or member;

(14) a person employed as a household worker in, for, or about a private home or household who earns less than $1,000 in cash in a three-month period from a single private home or household provided that a household worker who has earned $1,000 or more from the household worker's present employer in a three-month period within the previous year is covered by this chapter regardless of whether or not the household worker has earned $1,000 in the present quarter;

(15) persons employed by a closely held corporation who are related by blood or marriage, within the third degree of kindred according to the rules of civil law, to an officer of the corporation, who is referred to in clause (7), if the corporation files a written election with the commissioner to exclude such individuals. A written election is not required for a person who is otherwise excluded from this chapter by this section;

(16) a nonprofit association which does not pay more than $1,000 in salary or wages in a year;

(17) persons covered under the Domestic Volunteer Service Act of 1973, as amended, United States Code, title 42, sections 5011, et seq.;

(18) a manager of a limited liability company having ten or fewer members and having less than 22,880 hours of payroll in the preceding calendar year, if that manager owns at least a 25 percent membership interest in the limited liability company;

(19) a spouse, parent, or child, regardless of age, of a manager of a limited liability company described in clause (18);

(20) persons employed by a limited liability company having ten or fewer members and having less than 22,880 hours of payroll in the preceding calendar year who are related by blood or marriage, within the third degree of kindred according to the rules of civil law, to a manager of a limited liability company described in clause (18), if the company files a written election with the commissioner to exclude these persons. A written election is not required for a person who is otherwise excluded from this chapter by this section; or

(21) members of limited liability companies who satisfy the requirements of clause (12).

Subd. 1a.Election of coverage.

The persons, partnerships, limited liability companies, and corporations described in this subdivision may elect to provide the insurance coverage required by this chapter.

(a) An owner or owners of a business or farm may elect coverage for themselves.

(b) A partnership owning a business or farm may elect coverage for any partner.

(c) A family farm corporation as defined in section 500.24, subdivision 2, clause (c), may elect coverage for any executive officer.

(d) A closely held corporation which had less than 22,880 hours of payroll in the previous calendar year may elect coverage for any executive officer if that executive officer is also an owner of at least 25 percent of the stock of the corporation.

(e) A limited liability company which had less than 22,880 hours of payroll in the previous calendar year may elect coverage for any manager if that manager is also an owner of at least 25 percent membership interest in the limited liability company.

(f) A person, partnership, limited liability company, or corporation hiring an independent contractor, as defined by rules adopted by the commissioner, may elect to provide coverage for that independent contractor. A person, partnership, limited liability company, or corporation may charge the independent contractor a fee for providing the coverage only if the independent contractor (1) elects in writing to be covered, (2) is issued an endorsement setting forth the terms of the coverage, the name of the independent contractors, and the fee and how it is calculated.

(g) The persons, partnerships, limited liability companies, and corporations described in this subdivision may also elect coverage for an employee who is a spouse, parent, or child, regardless of age, of an owner, partner, manager, or executive officer, who is eligible for coverage under this subdivision. Coverage may be elected for a spouse, parent, or child whether or not coverage is elected for the related owner, partner, manager, or executive director and whether or not the person, partnership, limited liability company, or corporation employs any other person to perform a service for hire. Any person for whom coverage is elected pursuant to this subdivision shall be included within the meaning of the term employee for the purposes of this chapter.

(h) Notice of election of coverage or of termination of election under this subdivision shall be provided in writing to the insurer. Coverage or termination of coverage is effective the day following receipt of notice by the insurer or at a subsequent date if so indicated in the notice. The insurance policy shall be endorsed to indicate the names of those persons for whom coverage has been elected or terminated under this subdivision. An election of coverage under this subdivision shall continue in effect as long as a policy or renewal policy of the same insurer is in effect.

(i) Nothing in this subdivision shall be construed to limit the responsibilities of owners, partnerships, limited liability companies, or corporations to provide coverage for their employees, if any, as required under this chapter.

Subd. 2.Extraterritorial application.

If an employee who regularly performs the primary duties of employment within this state receives an injury while outside of this state in the employ of the same employer, the provisions of this chapter shall apply to such injury. If a resident of this state is transferred outside the territorial limits of the United States as an employee of a Minnesota employer, the resident shall be presumed to be temporarily employed outside of this state while so employed.

Subd. 3.Temporary out-of-state employment.

If an employee hired in this state by a Minnesota employer receives an injury while temporarily employed outside of this state, such injury shall be subject to the provisions of this chapter.

Subd. 4.Out-of-state employment.

If an employee who regularly performs the primary duties of employment outside of this state or is hired to perform the primary duties of employment outside of this state receives an injury within this state in the employ of the same employer, such injury shall be covered within the provisions of this chapter if the employee chooses to forgo any workers' compensation claim resulting from the injury that the employee may have a right to pursue in some other state, provided that the special compensation fund is not liable for payment of benefits pursuant to section 176.183 if the employer is not insured against workers' compensation liability pursuant to this chapter and the employee is a nonresident of Minnesota on the date of the personal injury.

Subd. 5.

[Repealed, 1974 c 486 s 6]

Subd. 5a.Out-of-state injuries.

Except as specifically provided by subdivisions 2 and 3, injuries occurring outside of this state are not subject to this chapter.

Subd. 5b.North Dakota employers.

Notwithstanding the provisions of subdivision 4, workers' compensation benefits for an employee hired in North Dakota by a North Dakota employer, arising out of that employee's temporary work in Minnesota, shall not be payable under this chapter. North Dakota workers' compensation law provides the exclusive remedy available to the injured worker. For purposes of this subdivision, temporary work means work in Minnesota for a period of time not to exceed 15 consecutive calendar days or a maximum of 240 total hours worked by that employee in a calendar year.

Subd. 6.Commissioner of labor and industry; additional powers.

Whenever an employee is covered by subdivision 2, 3 or 4, the commissioner may enter into agreements with the appropriate agencies of other states for the purpose of resolving conflicts of jurisdiction or disputes concerning workers' compensation coverage. An agreement entered into pursuant to this subdivision may be appealed in the same manner and within the same time as if the appeal were from an order or decision of a compensation judge to the Workers' Compensation Court of Appeals or the district court.

History:

1953 c 755 s 4; Ex1967 c 40 s 6; 1971 c 669 s 1; 1973 c 657 s 2; 1974 c 286 s 1; 1975 c 271 s 2; 1975 c 359 s 5; 1977 c 342 s 5; 1978 c 722 s 2; 1979 c 15 s 1; 1979 c 74 s 2; 1979 c 92 s 4; 1981 c 346 s 60; 1983 c 290 s 34; 1983 c 311 s 8; 1984 c 432 art 1 s 3; 1986 c 444; 1986 c 461 s 3-6; 1987 c 332 s 10-12; 1993 c 137 s 6; 1994 c 512 s 1,2; 2005 c 90 s 2; 2008 c 250 s 2; 2009 c 89 s 1

Appendix 3

Unemployment Tax Rules

STATE UNEMPLOYMENT INSURANCE TAXES

Coverage

All firms or organizations having services performed for them in Minnesota are subject to the provisions of the Minnesota Unemployment Insurance Law, and most of these firms or organizations are required to pay unemployment insurance taxes. In lieu of taxes, governmental entities and some non-profits reimburse unemployment benefits paid to their former employees on a dollar-for-dollar basis. Whether or not a business is required to report wages and pay unemployment insurance taxes depends on the amount and type of employment, the amount of wages paid and other factors present in special situations. As discussed in “FEDERAL UNEMPLOYMENT TAXES” above, the wages paid to an owner/officer who owns 25 percent or more of a corporation or limited liability company (LLC), and has not chosen to be covered under the Minnesota Unemployment Insurance (UI) Program, are not subject to Minnesota unemployment insurance tax, nor do they need to be reported on the Wage Detail Report (discussed below in “Wage Detail Reports”).

Registering for a Minnesota Unemployment Insurance (UI) Employer Account

All entities that pay wages to employees performing covered services in Minnesota are required to register with the Minnesota Unemployment Insurance (UI) Program. Registration is done either online or by automated phone system, and should be completed as soon as possible after wages are paid to employees performing covered services in Minnesota, but not later than the due date of the first Wage Detail Report (discussed below in “Wage Detail Reports”). Based on the information provided, the Minnesota Unemployment Insurance (UI) Program will determine if the entity is required to report the wages paid to its employees and pay Minnesota unemployment insurance taxes on those wages, or (if eligible) reimburse any unemployment benefits that are paid to the entity’s former employees. If the entity meets the reporting requirements, it will be assigned an unemployment insurance employer account number.

The following entities do not need to register for a Minnesota Unemployment Insurance (UI) Employer Account:

•sole proprietorships whose only employees are the spouse, parents, and/or minor children of the sole proprietor, or;

• Corporations and LLCs whose only employees are owner/officers who directly or indirectly own 25 percent or more of the business and have not chosen to be covered under the Minnesota Unemployment Insurance Program, or;

• Partnerships whose only workers are the partners of the partnership.

Appendix 4

Exclusion Criteria

V codes:

If a record has a primary diagnosis as a V code the record will be excluded as these codes are for supplementary classification of factors influencing health status and contact with health services.

E codes:

- E800: Railway accident involving collision with rolling stock
- E802: Railway accident involving derailment without antecedent collision
- E804: Fall in, on, or from railway train
- E849.2: Place of occurrence, mine and quarry
- E849.3: Place of occurrence, industrial place and premises
- E849.4: Place of occurrence, place for recreation and sport
- E849.5: Place of occurrence, street and highway
- E849.6: Place of occurrence, public building
- E849.7: Place of occurrence, residential institution
- E870-E879: Misadventures due to patient care
- E904: Hunger, thirst, exposure, and neglect
- E910.0 – 910.2: Accidental drowning – recreational
- E910.4: Accidental drowning – bathtub
- E930 – 949: Adverse effects of drugs-therapeutic use
- E977: Late effects of injuries due to legal intervention
- E978: Legal execution
- E990 – E999: Injury resulting from operations of war

ICD 9 Codes – if listed as primary diagnosis

-960 – 979: Poisoning by drugs, medicinal and biological substances

- 960: Poisoning by antibiotics
- 961: Poisoning by other anti-infectives
- 962: Poisoning by hormones and synthetic substitutes
- 963: Poisoning by primarily systemic agents

- 964: Poisoning by agents primarily affecting blood constituents
- 965: Poisoning by analgesics, antipyretics, and antireheumatics
- 966: Poisoning by anticonvulsants and anti-parkinsonism drugs
- 967: Poisoning by sedatives and hypnotics
- 968: Poisoning by other central nervous system depressants and anesthetics
- 969: Poisoning by psychotropic agents
- 970: Poisoning by central nervous system stimulants
- 971: Poisoning by drugs primarily affecting the autonomic nervous system
- 972: Poisoning by agents primarily affecting the cardiovascular system
- 973: Poisoning by agents primarily affecting the gastrointestinal system
- 974: Poisoning by water, mineral, and uric acid metabolism drugs
- 975: Poisoning by other agents primarily acting on the smooth and skeletal muscles and respiratory system
- 976: Poisoning by agents primarily affecting skin and mucous membrane, ophthalmological, otorhinolaryngological, an dental drugs
- 977: Poisoning by other and unspecified drugs and medicinal substances
- 978: Poisoning by bacterial vaccines
- 979: Poisoning by other vaccines and biological substances

- 990: Effects of radiation, unspecified
- 995: Certain adverse effects NEC (complications of surgical and medical care)
- 995.5: Child maltreatment syndrome
- 995.6: Anaphylactic shock due to adverse food reaction
- 995.8: other specified adverse effects NEC
- 995.9: Systemic inflammatory response syndrome
- 996: Complications peculiar to certain specified procedures (complications NEC in the use of artificial substitutes [e.g. Dacron, metal, silastic, Teflon] or natural sources [e.g. bone] involving: anastomosis, graft, implant, internal device: catheter, electronic, fixation, prosthetic, reimplant, transplant.
- 996.0: Mechanical complication of cardiac device, implant, and graft
- 996.1: Mechanical complication of other vascular device, implant, and graft

- 996.3: Mechanical complication of genitourinary device, implant, or graft
- 996.4: Mechanical complication of internal orthopedic device, implant, and graft
- 996.5: Mechanical complication of other specified prosthetic device, implant, and graft
- 996.6: Infection and inflammatory reaction due to internal prosthetic device, implant, and graft
- 996.7: Other complications of internal (biological) (synthetic) prosthetic device, implant, and graft
- 996.8: Complications of transplanted organ
- 996.9: Complications of reattached extremity or body part
    - 997: Complications affecting body systems NEC
- 997.0: Nervous system complications
- 997.1: Cardiac complications
- 997.2: Peripheral vascular complications
- 997.3: Respiratory complications
- 997.4: Digestive system complications
- 997.5: Urinary complications
- 997.6: Amputations stump complication
- 997.7: Vascular complications of other vessels
    - 998: Other complications of procedures NEC
- 998.0: Postoperative shock
- 998.1: Hemorrhage or hematoma or seroma complicating a procedure
- 998.2: Accidental puncture or laceration during a procedure
- 998.3: Disruption of operation wound
- 998.4: Foreign body accidentally left during a procedure
- 998.5: Postoperative infection
- 998.6: Persistent postoperative fistula
- 998.7: Acute reaction to foreign substance accidentally left during a procedure
- 998.8: Other specified complications of procedures NEC
- 998.9: Unspecified complication of procedure NEC

- 999: Complications of medical care NEC (complications NEC of: dialysis, extracorporeal circulation, hyperalimentation therapy, immunization, infusion, inhalation therapy, injection, inoculation, perfusion, transfusion, vaccination, ventilation therapy)

- 999.0: Generalized vaccinia
- 999.1: Air embolism
- 999.2: Other vascular complications
- 999.3: Other infection
- 999.4: Anaphylactic shock due to serum
- 999.5: Other serum reaction
- 999.6: ABO incompatibility reaction
- 999.7: RH incompatibility reaction
- 999.8: Other transfusion reaction
- 999.9: Other and unspecified complications of medical care NEC

Appendix 5

Table A: Agriculturally-Related Injuries by Year and Age Category*

Age Category	Child (0-9 years)	Pre-Teen (10-14 years)	Teen (15-19 years)	Young Adult (20-34 years)	Adult (35-64 years)	Older Adult (65-84 Years)	Elderly (85+ Years)	Year Total
Year of Discharge								
2000	286 (8.5/12.9)	230 (8.4/10.4)	225 (7.8/10.2)	445 (7.7/20.1)	899 (7.1/40.7)	117 (5.9/5.3)	9 (4.8/.4)	2,211 (7.5)
2001	303 (9.1/12.4)	248 (7.4/10.2)	224 (7.7/9.2)	484 (8.3/19.9)	1019 (8.1/41.8)	147 (7.4/6.0)	13 (6.9)	2,438 (8.3)
2002	302 (9.0/12.2)	254 (7.6/10.3)	236 (8.1/9.6)	505 (8.7/20.5)	1006 (7.9/40.8)	152 (7.7/6.2)	12 (6.3/.5)	2,467 (8.4)
2003	311 (9.3/12.5)	219 (6.5/8.8)	222 (7.7/8.9)	522 (8.9/20.9)	1080 (8.5/43.4)	122 (6.2/4.9)	14 (7.4/.6)	2,490 (8.5)
2004	315 (9.4/12.6)	232 (8.9/9.3)	243 (8.4/9.7)	461 (7.9/18.4)	1092 (8.6/43.5)	152 (7.7/6.1)	13 (6.9/.5)	2,508 (8.5)
2005	250 (7.5/9.9)	248 (9.6/9.8)	236 (8.1/9.3)	484 (8.3/19.1)	1140 (9.0/44.9)	164 (8.3/6.5)	13 (6.9/.5)	2,535 (8.6)
2006	297 (8.9/11.8)	219 (8.4/8.7)	240 (8.3/9.6)	472 (8.1/18.8)	1103 (8.7/43.9)	163 (8.2/6.5)	18 (9.5/.7)	2,512 (8.5)
2007	253 (7.6/10.9)	173 (6.7/7.5)	247 (8.5/10.7)	431 (7.4/18.6)	1046 (8.3/45.2)	157 (7.9/6.8)	9 (4.8/.4)	2,316 (7.9)
2008	280 (8.4/10.9)	210 (8.1/8.2)	247 (8.5/9.6)	461 (7.9/18.0)	1136 (8.9/44.4)	203 (10.3/7.9)	24 (12.7/.9)	2,561 (8.7)
2009	282 (8.4/11.1)	193 (7.4/7.6)	257 (8.9/10.1)	512 (8.8/20.2)	1065 (8.4/42.0)	203 (10.3/8.0)	22 (11.6/.9)	2,534 (8.6)

2010	238 (7.1/9.3)	204 (7.9/7.9)	266 (9.2/10.4)	546 (9.4/21.3)	1092 (8.6/42.6)	199 (10.1/7.8)	18 (9.5/.7)	2,563 (8.7)
2011	230 (6.9/9.9)	165 (6.4/7.1)	256 (8.4/11.0)	485 (8.4/20.9)	965 (7.6/41.5)	199 (10.1/8.6)	24 (12.7/.1)	2,324 (7.9)
Age Category Total	3,347 (11.4)	2,595 (8.8)	2,899 (9.8)	5,808 (19.7)	12,643 (42.9)	1,978 (6.7)	189 (.64)	29,459

*(column/row percentage)

Table B: Probable Agriculturally-Related Injuries by Year and Age Category*

Age Category	Child (0-9 years)	Pre-Teen (10-14 years)	Teen (15-19 years)	Young Adult (20-34 years)	Adult (35-64 years)	Older Adult (65-84 Years)	Elderly (85+ Years)	Year Total
Year of Discharge								
2000	44 (11.3/7.9)	40 (11.9/7.2)	41 (9.4/7.4)	110 (9.6/19.7)	255 (8.9/45.8)	64 (7.1/11.5)	3 (6.3/.5)	557 (9.2)
2001	41 (10.5/6.5)	45 (13.5/7.2)	46 (10.6/7.3)	114 (9.9/18.1)	299 (10.5/47.5)	82 (9.8/13.0)	2 (4.2/.3)	629 (10.4)
2002	48 (12.3/7.5)	35 (10.5/5.4)	49 (11.3/7.6)	133 (11.6/20.7)	289 (10.1/44.9)	87 (10.4/13.5)	2 (4.2/.3)	643 (10.6)
2003	44 (11.3/8.3)	39 (11.7/7.4)	39 (8.9/7.4)	100 (8.7/18.9)	243 (8.5/46.1)	56 (6.7/10.6)	6 (12.5/1.1)	527 (8.7)
2004	40 (10.2/8.0)	28 (8.4/5.6)	40 (9.2/8.0)	77 (6.7/15.5)	248 (10.7/49.8)	63 (7.5/12.7)	2 (4.2/.4)	498 (8.3)
2005	19 (4.9/4.1)	35 (10.5/7.6)	37 (8.5/8.1)	100 (8.7/21.8)	204 (7.1/44.5)	61 (7.3/13.3)	2 (4.2/.4)	458 (7.6)
2006	40 (10.2/8.5)	22 (6.6/4.7)	41 (9.4/8.7)	74 (6.4/15.6)	232 (8.1/49.1)	59 (7.1/12.5)	5 (10.4/1.1)	473 (7.8)
2007	23 (5.9/5.1)	10 (2.9/2.2)	30 (6.7/6.7)	89 (7.7/19.8)	227 (7.9/50.6)	69 (8.3/15.4)	1 (2.1/.2)	449 (7.4)
2008	28 (7.2/5.7)	27 (8.1/5.5)	24 (5.5/4.9)	83 (7.2/16.9)	232 (8.1/47.2)	91 (10.9/18.5)	7 (14.6/1.4)	492 (8.1)

2009	22 (5.6/4.9)	22 (6.6/4.9)	24 (5.5/5.4)	85 (7.4/19.1)	214 (7.5/48.1)	70 (8.4/15.7)	8 (16.7/1.8)	445 (7.4)
2010	20 (5.1/4.1)	23 (6.9/4.8)	41 (9.4/8.5)	94 (8.2/19.4)	235 (8.2/48.6)	67 (8.0/13.8)	4 (8.3/.8)	484 (7.9)
2011	22 (5.6/5.5)	8 (2.4/2.0)	23 (5.3/5.8)	91 (7.9/22.9)	180 (6.3/45.3)	67 (8.0/16.9)	6 (12.5/1.5)	397 (6.6)
Age Category Total	391 (6.5)	334 (5.5)	435 (7.2)	1150 (19.0)	2858 (47.2)	836 (13.8)	48 (.8)	6052

*(column/row percentage)

Table C: *Possible* Agriculturally-Related Injuries by Year and Age Category*

Age Category	**Child (0-9 years)**	**Pre-Teen (10-14 years)**	**Teen (15-19 years)**	**Young Adult (20-34 years)**	**Adult (35-64 years)**	**Older Adult (65-84 Years)**	**Elderly (85+ Years)**	**Year Total**
Year of Discharge								
2000	242 (8.2/14.6)	190 (8.4/11.5)	184 (7.5/11.1)	335 (7.2/20.3)	644 (6.6/38.9)	53 (4.6/3.2)	6 (4.3/.4)	1,654 (7.1)
2001	262 (8.8/14.5)	203 (8.9/11.2)	178 (7.2/9.8)	370 (7.9/20.5)	720 (7.4/39.8)	65 (5.7/3.6)	11 (7.8/.6)	1,809 (7.7)
2002	254 (8.6/13.9)	219 (9.7/12.0)	187 (7.6/10.3)	372 (7.9/20.4)	717 (7.3/39.3)	65 (5.7/3.6)	10 (7.1/.5)	1,824 (7.8)
2003	267 (9.0/13.6)	180 (7.9/9.4)	183 (7.4/9.3)	422 (9.1/21.4)	837 (8.6/42.6)	66 (5.8/3.4)	8 (5.7/.4)	1,963 (8.3)
2004	275 (9.3/13.7)	204 (9.0/10.1)	203 (8.2/10.1)	384 (8.2/19.1)	844 (8.6/41.9)	89 (7.8/4.4)	11 (7.8/.5)	2,010 (8.6)
2005	231 (7.8/11.1)	213 (9.4/10.3)	199 (8.1/9.6)	384 (8.2/18.5)	936 (9.6/45.1)	103 (9.0/4.9)	11 (7.8/.5)	2,077 (8.9)
2006	257 (8.7/12.6)	197 (8.7/9.7)	199 (8.1/9.8)	398 (8.5/19.5)	871 (8.9/42.7)	104 (9.1/5.1)	13 (9.2/.6)	2,039 (8.7)

2007	230 (7.8/12.3)	163 (7.2/8.7)	217 (8.8/11.6)	342 (7.3/18.3)	819 (8.4/43.9)	88 (77/4.1)	8 (5.7/.4)	1,867 (7.9)
2008	252 (8.5/12.2)	183 (8.1/8.8)	223 (9.1/10.8)	378 (8.1/18.3)	904 (9.2/43.7)	112 (9.8/5.4)	17 (12.1/.8)	2,069 (8.8)
2009	260 (8.8/12.4)	171 (7.6/8.2)	233 (9.5/11.2)	427 (9.2/20.4)	851 (8.7/40.7)	133 (11.6/6.4)	14 (9.9/.7)	2,089 (8.9)
2010	218 (7.4/10.5)	181 (8.0/8.7)	225 (9.1/10.8)	452 (9.7/21.7)	857 (8.8/41.2)	132 (11.6/6.3)	14 (9.9/.7)	2,079 (8.9)
2011	208 (7.0/10.8)	157 (6.9/8.1)	233 (9.5/12.1)	394 (8.5/20.4)	785 (8.0/40.7)	132 (11.6/6.9)	18 (12.8/.9)	1,927 (8.2)
Age Category Total	2956 (12.6)	2261 (9.7)	2464 (10.5)	4658 (19.9)	9785 (41.8)	1142 (4.9)	141 (0.6)	23,407

*(column/row percentage)

Appendix 6

Table A: Agriculturally-Related Injuries by Gender and Age Category

Age Category	Child (0-9 years)	Pre-Teen (10-14 years)	Teen (15-19 years)	Young Adult (20-34 years)	Adult (35-64 years)	Older Adult (65-84 Years)	Elderly (85+ Years)	Year Total
Gender	Total (*probable/ possible* cases)							
Female	1,805 (131/1674)	1,777 (85/1,692)	1,953 (95/1,858)	3,267 (241/3,026)	6,507 (467/6,040)	633 (89/544)	125 (9/116)	16,067 (1,117/14,950)
Male	1,540 (260/1,280)	818 (249/569)	946 (340/606)	2,541 (909/1,632)	6,135 (2391/3,744)	1,345 (747/598)	64 (39/25)	13,389 (4935/,8454)

Table B: Agriculturally-Related Injuries by Metro-Area Residency and Age Category

Age Category	Child (0-9 years)	Pre-Teen (10-14 years)	Teen (15-19 years)	Young Adult (20-34 years)	Adult (35-64 years)	Older Adult (65-84 Years)	Elderly (85+ Years)	Year Total
7 County Metro Resident	Total (*probable/possible* cases)							
Resident	1,117 (75/1042)	652 (52/600)	724 (66/658)	1,541 (206/1335)	3,088 (399/2689)	373 (83/290)	48 (9/39)	7,543 (890/6,653)
Non-Resident	2,272 (358/1914)	1,953 (282/1671)	2,175 (369/1806)	4,267 (944/3323)	9,555 (2459/7096)	1,605 (753/852)	141 (39/102)	21,968 (5,204/16,764)

Table C: Agriculturally-Related Injuries by Ramsey and Hennepin County Residence and Age Category

Age Category	Child (0-9 years)	Pre-Teen (10-14 years)	Teen (15-19 years)	Young Adult (20-34 years)	Adult (35-64 years)	Older Adult (65-84 Years)	Elderly (85+ Years)	Year Total
2 County Metro Resident	Total (*probable/possible* cases)							
Resident	569 (21/548)	268 (13/255)	295 (22/273)	697 (72/625)	1403 (132/1271)	199 (24/175)	35 (4/31)	3,466 (288/3,178)
Non-Resident	2,778 (370/2408)	2,327 (321/2006)	2,604 (413/2191)	5,111 (1078/4033)	11,240 (2726/8514)	1,779 (812/967)	153 (43/110)	25,992 (5,763/20,229)

Table D: Agriculturally-Related Injuries by Common Primary Diagnosis and Age Category*

Age Category		Child (0-9 years)	Pre-Teen (10-14 years)	Teen (15-19 years)	Young Adult (20-34 years)	Adult (35-64 years)	Older Adult (65-84 Years)	Elderly (85+ Years)
Primary Diagnosis Code	**Diagnosis Description**	(*Probable/ Possible* Cases)						
800	Fracture of vault of skull	23 (7/16)	4 (0/4)	0 (0/0)	0 (0/0)	7 (2/5)	4 (2/2)	0 (0/0)
801	Fracture of base of skull	33 (9/24)	18 (2/16)	9 (0/9)	13 (0/13)	64 (13/61)	2 (1/1)	2 (0/2)
802	Fracture of face bones	21 (0/21)	20 (0/20)	33 (0/33)	65 (8/57)	164 (32/132)	14 (7/7)	1 (0/1)

805	Fracture of vertebral column without mention of spinal cord injury	3 (0/3)	9 (0/9)	42 (0/42)	94 (0/94)	381 (40/341)	39 (13/26)	2 (2/0)
807	Fracture of rib(s), sternum, larynx, and trachea	4 (0/4)	5 (1/4)	6 (1/5)	49 (5/44)	469 (58/411)	66 (40/26)	4 (3/1)
808	Fracture of pelvis	3 (3/0)	11 (3/8)	19 (0/19)	23 (0/23)	179 (22/157)	83 (22/61)	7 (4/3)
812	Fracture of humerus	130 (7/123)	99 (7/92)	20 (1/19)	49 (0/49)	173 (0/173)	16 (16/0)	6 (1/5)
813	Fracture of radius and ulna	209 (22/187)	209 (23/286)	137 (0/137)	200 (19/181)	507 (60/457)	46 (20/26)	5 (0/5)
816	Fracture of one or more phalanges of hand	16 (12/4)	11 (11/0)	22 (22/0)	67 (67/0)	273 (150/123)	42 (42/0)	1 (1/0)
820	Fracture of neck of femur	4 (1/3)	3 (0/3)	1 (1/0)	6 (1/5)	48 (8/40)	39 (16/23)	11 (4/7)
821	Fracture of other and unspecified parts of femur	27 (8/19)	5 (2/3)	5 (1/4)	5 (5/0)	25 (6/19)	7 (2/5)	4 (4/0)
823	Fracture of tibia and fibula	21 (5/16)	14 (0/14)	22 (0/22)	88 (17/71)	263 (43/220)	45 (22/23)	1 (1/0)
824	Fracture of ankle	14 (2/12)	49 (10/39)	51 (7/44)	113 (22/91)	319 (77/242)	49 (22/27)	0 (0/0)
825	Fracture of one or more tarsal and metatarsal bones	7 (2/5)	11 (1/10)	22 (9/13)	19 (19/0)	124 (33/91)	28 (22/6)	3 (3/0)
826	Fracture of one or more phalanges of foot	2 (2/0)	12 (2/10)	16 (4/12)	30 (5/25)	97 (27/70)	9 (7/2)	0 (0/0)
831	Dislocation of shoulder	0 (0/0)	5 (1/4)	16 (1/15)	58 (9/49)	142 (0/142)	11 (11/0)	1 (0/1)
840	Sprains and strains of shoulder and upper arm	5 (1/4)	16 (3/13)	24 (1/23)	57 (8/49)	176 (0/176)	11 (11/0)	1 (1/0)

844	Sprains and strains of knee and leg	4 (0/4)	14 (0/14)	39 (8/31)	106 (15/91)	172 (0/172)	23 (9/14)	1 (1/0)
845	Sprains and strains of ankle and foot	11 (3/8)	9 (9/0)	80 (15/65)	141 (44/97)	136 (0/136)	12 (6/6)	0 (0/0)
847	Sprains and strains of other and unspecified parts of back	20 (0/20)	44 (5/39)	94 (0/94)	184 (0/184)	224 (0/224)	11 (5/6)	1 (1/0)
850	Concussion	76 (10/66)	136 (0/136)	204 (11/193)	204 (0/204)	441 (0/441)	40 (15/25)	1 (1/0)
852	Subarachnoid, subdural, and extradural hemorrhage, following injury	7 (0/7)	7 (0/7)	2 (0/2)	12 (0/12)	64 (2/62)	21 (5/16)	1 (0/1)
860	Traumatic pneumothorax and hemothorax	5 (0/5)	6 (1/5)	41 (1/40)	14 (1/13)	122 (19/103)	29 (13/16)	2 (2/0)
864	Injury to liver	12 (0/12)	12 (0/12)	8 (0/8)	9 (1/8)	29 (2/27)	0 (0/0)	0 (0/0)
865	Injury to spleen	14 (0/14)	8 (0/8)	9 (0/9)	11 (0/11)	36 (4/32)	6 (3/3)	0 (0/0)
867	Injury to pelvic organs	1 (0/1)	1 (0/1)	2 (2/0)	1 (0/1)	5 (1/4)	0 (0/0)	0 (0/0)
870	Open wound of ocular adnexa	95 (0/95)	26 (1/25)	17 (1/16)	61 (5/56)	19 (5/14)	7 (1/6)	0 (0/0)
873	Other open wound of head	**521 (68/453)**	159 (22/137)	127 (28/99)	300 (55/245)	679 (177/502)	70 (30/40)	3 (3/0)
881	Open wound of elbow, forearm, and wrist	9 (6/3)	12 (8/4)	12 (12/0)	58 (29/29)	149 (75/74)	82 (19/63)	**27 (0/27)**
882	Open wound of hand except finger(s) alone	17 (9/8)	13 (13/0)	18 (18/0)	53 (53/0)	125 (125/0)	113 (58/55)	**21 (3/18)**
883	Open wound of finger(s)	22 (22/0)	34 (34/0)	63 (63/0)	133 (133/0)	344 (344/0)	92 (66/26)	4 (0/4)

886	Traumatic amputation of arm and hand (complete)(partial)	8 (8/0)	2 (2/0)	9 (9/0)	38 (38/0)	105 (105/0)	18 (18/0)	0 (0/0)
891	Open wound of knee, leg, (except thigh), and ankle	15 (15/0)	21 (21/0)	10 (10/0)	36 (36/0)	130 (0/130)	61 (19/42)	15 (0/15)
892	Open wound of foot except toe(s) alone	16 (7/9)	9 (4/5)	10 (10/0)	30 (21/9)	56 (40/16)	12 (9/3)	0 (0/0)
910	Superficial injury of face, neck, and scalp except eye	**288 (0/288)**	50 (0/50)	23 (1/22)	85 (0/85)	98 (4/94)	15 (2/13)	1 (0/1)
913	Superficial injury of elbow, forearm, and wrist	58 (0/58)	21 (1/20)	25 (0/25)	64 (2/62)	116 (0/116)	52 (0/52)	15 (0/15)
914	Superficial injury of hand(s) except finger(s) alone	23 (1/22)	17 (1/16)	14 (0/14)	54 (3/51)	81 (5/76)	46 (0/46)	6 (0/6)
916	Superficial injury of hip, thigh, leg, and ankle	47 (3/44)	19 (5/14)	19 (0/19)	44 (10/34)	76 (5/71)	27 (0/27)	6 (0/6)
918	Superficial injury of eye and adnexa	191 (0/191)	45 (4/41)	47 (5/42)	209 (0/209)	257 (0/257)	16 (3/13)	1 (0/1)
920	Contusion of face, scalp, and neck except eye(s)	11 (11/0)	55 (0/55)	71 (0/71)	112 (0/112)	162 (0/162)	39 (17/22)	1 (0/1)
922	Contusion of trunk	92 (0/92)	134 (0/134)	177 (0/177)	364 (0/364)	826 (112/714)	85 (27/58)	3 (2/1)
923	Contusion of upper limb	14(14/0)	123 (8/115)	168 (20/148)	281 (56/225)	323 (0/323)	36 (16/20)	2 (1/1)
924	Contusion of lower limb and of other and unspecified sites	110 (13/97)	**275 (24/251)**	**332 (24/308)**	**543 (53/490)**	**926 (110/816)**	**104 (44/60)**	3 (2/1)
926	Crushing injury of trunk	3 (1/2)	1 (1/0)	9 (7/2)	11 (7/4)	17 (9/8)	8 (6/2)	0 (0/0)
927	Crushing injury of upper limb	11 (9/2)	3 (3/0)	13 (13/0)	30 (23/7)	92 (92/0)	21 (21/0)	0 (0/0)
928	Crushing injury of lower limb	8 (4/4)	10 (4/6)	7 (7/0)	31 (8/23)	35 (35/0)	15 (14/1)	1 (0/1)

943	Burn of upper limb, except wrist and hand	1 (1/0)	0 (0/0)	3 (3/0)	3 (3/0)	14 (14/0)	4 (4/0)	0 (0/0)
959	Injury, other and unspecified	234 (24/210)	**289 (29/260)**	**316 (32/284)**	**527 (60/467)**	**987 (135/852)**	**92 (33/59)**	6 (3/3)
989	Toxic effect of other substances, chiefly nonmedicinal as to source	262 (0/262)	4 (0/4)	29 (1/18)	47 (12/35)	80 (7/73)	13 (0/13)	3 (0/3)

*bolded numbers are among the most common injury in that age category

Appendix 7

Table A: Sensitivity Analysis, Use of Median Number of Days by Injury Type for Lost Production Time

Year	Injury Group	Total Number of Injuries	Direct Cost Total	Indirect Cost Total	Total Costs
2004					
	Hospitalized	217	1,812,700.89	2,773,925.01	4,586,625.90
	Non Hospitalized	2291	1,345,317.45	1,898,654.40	3,243,971.85
	Fatal	19	233,654.43	8,357,363.01	8,591,017.44
	Total	2527	3,391,672.77	13,029,942.42	16,421,615.19
2005					
	Hospitalized	271	3,136,507.72	2,622,885.55	5,759,387.28
	Non Hospitalized	2264	1,472,153.97	1,882,362.62	3,354,516.59
	Fatal	22	280,450.91	9629483.66	9,909,934.57
	Total	2557	4,889,106.60	14,134,731.83	19,023,838.44
2006					
	Hospitalized	268	2,316,458.89	3,732,764.87	6,049,223.76
	Non Hospitalized	2244	1,668,132.67	2,948,293.84	4,616,426.51
	Fatal	23	303,540.79	11,470,216.00	11,773,756.79
	Total	2535	4,288,132.35	18,151,274.71	22,439,407.06
2007					
	Hospitalized	259	2,227,930.93	3,449,479.89	5,677,410.82
	Non Hospitalized	2057	1,680,696.24	1,895,622.62	3,576,318.86
	Fatal	17	232,004.75	7,995,640.27	8,227,645.02
	Total	2333	4,140,631.92	13,340,742.78	17,481,374.70
2008					
	Hospitalized	248	2,993,196.08	3,253,326.54	6,246,522.62
	Non Hospitalized	2313	1,887,256.90	2,196,903.35	4,084,160.25
	Fatal	25	352,431.26	13,803,243.11	14,155,674.37
	Total	2586	5,232,884.24	19,253,473.00	24,486,357.24
2009					
	Hospitalized	197	2,094,727.88	2,673,724.10	4,768,451.98
	Non Hospitalized	2337	2,316,422.05	2,411,597.19	4,728,019.24
	Fatal	20	290,943.26	10,300,691.72	10,591,634.97
	Total	2554	2,386,829.35	15,386,013.01	20,088,106.19
2010					
	Hospitalized	252	3,029,411.26	4,049,099.95	7,078,511.21
	Non Hospitalized	2311	2,719,080.08	2,487,017.93	5,206,098.01
	Fatal	28	419,918.10	16,983,959.19	17,403,877.29
	Total	2591	6,168,409	23,520,077	29,688,486

Table B: Sensitivity Analysis, Use of Farmers Wages for Home Production

Year	Injury Group	Total Number of Injuries	Direct Cost Total	Indirect Cost Total	Total Costs
2004					
	Hospitalized	217	1,812,700.89	2,930,855.82	4,743,556.70
	Non Hospitalized	2291	1,345,317.45	4,050,740.47	5,396,057.92
	Fatal	19	233,654.43	8,823,273.53	9,055,008.86
	Total	2527	3,391,672.77	15,804,869.82	19,194,623.48
2005					
	Hospitalized	271	3,136,507.72	3,893,927.07	7,030,428.79
	Non Hospitalized	2264	1,472,153.97	4,073,738.08	5,545,892.05
	Fatal	22	280,450.91	10,164,099.04	10,444,549.95
	Total	2557	4,889,106.60	18,131,764.19	23,030,870.79
2006					
	Hospitalized	268	2,316,458.89	3,943,593.54	6,260,052.43
	Non Hospitalized	2244	1,668,132.67	4,300,106.96	5,968,239.62
	Fatal	23	303,540.79	12,107,027.11	12,410,567.91
	Total	2535	4,288,132.35	20,350,727.61	19,268,859.93
2007					
	Hospitalized	259	2,227,930.93	3,644,518.08	5,872,449.01
	Non Hospitalized	2057	1,680,696.24	4,073,155.99	5,753,852.23
	Fatal	17	232,004.75	8,439,547.99	8,671,552.74
	Total	2333	4,140,631.92	16,157,222.06	20,297,853.98
2008					
	Hospitalized	248	2,993,196.08	3,438,158.89	6,431,354.97
	Non Hospitalized	2313	1,887,256.90	4,683,058.64	6,570,315.54
	Fatal	25	352,431.26	14,569,578.02	14,922,009.28
	Total	2586	5,232,884.24	22,690,795.55	27,923,679.79
2009					
	Hospitalized	197	2,094,727.88	2,825,288.36	4,920,016.24
	Non Hospitalized	2337	2,316,422.05	5,089,338.79	7,405,760.84
	Fatal	20	290,943.26	10,872,577.12	11,163,520.38
	Total	2554	2,386,829.35	18,787,204.27	23,489,297.46
2010					
	Hospitalized	252	3,029,411.26	4,278,037.25	7,307,448.51
	Non Hospitalized	2311	2,719,080.08	5,237,246.06	7,956,326.14
	Fatal	28	419,918.10	1,4947,292.03	18,346,802.80
	Total	2591	6,168,410	24,462,600	33,610,600

Table C: Sensitivity Analysis, Use of a Six Month Time Period for Lost Production Time

Year	Injury Group	Total Number of Injuries	Direct Cost Total	Indirect Cost Total	Total Costs
2004					
	Hospitalized	217	1,812,700.89	122,216.85	1,934,917.74
	Non Hospitalized	2291	1,345,317.45	2,644,685.95	3,990,003.39
	Fatal	19	233,654.43	269,865.49	503,519.92
	Total	2527	3,391,672.77	3,036,768.29	6,428,441.05
2005					
	Hospitalized	271	3,136,507.72	187,766.71	3,324,268.43
	Non Hospitalized	2264	1,472,153.97	2,679,871.01	4,152,024.97
	Fatal	22	280,450.91	323,415.23	603,860.54
	Total	2557	4,889,106.60	3,191,052.95	8,080,153.94
2006					
	Hospitalized	268	2,316,458.89	155,051.42	2,471,510.30
	Non Hospitalized	2244	1,668,132.67	2,776,811.31	4,444,943.98
	Fatal	23	303,540.79	351,672.94	655,213.73
	Total	2535	4,288,132.35	3,283,535.67	7,571,668.01
2007					
	Hospitalized	259	2,227,930.93	148,496.77	2,376,427.70
	Non Hospitalized	2057	1,680,696.24	2,666,696.33	4,347,692.57
	Fatal	17	232,004.75	267,957.83	499,962.58
	Total	2333	4,140,631.92	3,083,450.93	7,224,082.85
2008					
	Hospitalized	248	2,993,196.08	165,557.18	3,858,753.26
	Non Hospitalized	2313	1,887,256.90	3,075,435.25	4,962,692.15
	Fatal	25	352,431.26	434,828.25	787,259.51
	Total	2586	5,232,884.24	3,675,820.68	9,563,227.51
2009					
	Hospitalized	197	2,094,727.88	129,493.62	2,224,221.49
	Non Hospitalized	2337	2,316,422.05	3,295,506.85	5,611,928.89
	Fatal	20	290,943.26	336,342.72	627,285.97
	Total	2554	2,386,829.35	3,761,343.20	8,463,436.35
2010					
	Hospitalized	252	3,029,411.26	175,484.47	3,204,895.73
	Non Hospitalized	2311	2,719,080.08	3,414,469.95	6,133,550.03
	Fatal	28	419,918.10	486,850.00	906,768.10
	Total	2591	6,168,409	4,076,804	10,245,213

Table D: Sensitivity Analysis, Use of a Six Year Lost Production Time Period

Year	Injury Group	Direct Cost Total	Indirect Cost Total	Total Costs	Total Number of Injuries
2004					
	Hospitalized	1,812,700.89	575,024.24	2,387,725.12	217
	Non Hospitalized	1,345,317.45	2,779,830.35	4,125,147.79	2291
	Fatal	233,654.43	3,725,131.53	3,958,785.99	19
	Total	3,391,672.77	7,079,986.12	10,471,658.90	2527
2005					
	Hospitalized	3,136,507.72	799,101.08	3,935,602.80	271
	Non Hospitalized	1,472,153.97	2,820,360.80	4,292,514.77	2264
	Fatal	280,450.91	4,394,719.42	4,675,164.72	22
	Total	4,889,106.60	8,014,181.30	12,903,282.29	2557
2006					
	Hospitalized	2,316,458.89	775,007.69	3,091,466.58	268
	Non Hospitalized	1,668,132.67	2,930,894.62	4,599,027.29	2244
	Fatal	303,540.79	4,732,832.95	5,036,373.75	23
	Total	4,288,132.35	8,438,735.26	12,726,867.57	2535
2007					
	Hospitalized	2,227,930.93	752,427.99	2,980,358.92	259
	Non Hospitalized	1,680,696.24	2,814,151.04	4,494,847.28	2057
	Fatal	232,004.75	3,722,418.44	3,954,423.19	17
	Total	4,140,631.92	7,288,997.47	11,429,629.39	2333
2008					
	Hospitalized	2,993,196.08	765,668.81	3,758,864.89	248
	Non Hospitalized	1,887,256.90	3,245,890.15	5,133,147.05	2313
	Fatal	352,431.26	5,551,525.22	5,903,956.48	25
	Total	5,232,884.24	9,563,084.18	14,795,968.42	2586
2009					
	Hospitalized	2,094,727.88	643,964.25	2,738,692.12	197
	Non Hospitalized	2,316,422.05	3,478,470.35	5,794,892.39	2337
	Fatal	290,943.26	4,672,585.85	4,963,529.10	20
	Total	2,386,829.35	8,795,020.45	13,497,113.61	2554
2010					
	Hospitalized	3,029,411.26	832,876.22	3,862,287.48	252
	Non Hospitalized	2,719,080.08	3,607,475.59	6,326,555.59	2311
	Fatal	419,918.10	6,498,925.93	6,918,844.03	28
	Total	6,168,409	10,939,277	17,107,687	2591