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## Incidence Rates and Trend of Serious Farm-Related Injury in Minnesota, 2000–2011

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**ABSTRACT.** Only about 2% of Minnesota's workers were employed in agriculture for the years 2005–2012, this small portion of the workforce accounted for 31% of the 563 work-related deaths that occurred in Minnesota during that same time period. Agricultural fatalities in Minnesota and elsewhere are well documented; however, nonfatal injuries are not. To explore the burden of injury, Minnesota hospital discharge data were used to examine rates and trends of farm injury for the years 2000–2011. Cases were identified through the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM), injury codes and external cause of injury codes (E codes). *Probable* cases were defined as E code E849.1 (occurred on a farm) or E919.0 (involving agricultural machinery). *Possible* cases were based on five less specific E codes primarily involving animals or pesticides. Multiple data sources were used to estimate the agricultural population. An annual average of over 500 cases was identified *as probable*, whereas 2,000 cases were identified *as possible*. Trend analysis of all identified cases indicated a small but significant average annual increase of 1.5% for the time period 2000–2011. *Probable* cases were predominantly male (81.5%), whereas *possible* cases were predominantly female (63.9%). The average age of an injury case was 38.5 years, with the majority of injuries occurring in late summer and fall months. Despite the undercount of less serious injuries, hospital discharge data provide a meaningful data source for the identification and surveillance of non-fatal agricultural injuries. These methods could be utilized by other states for ongoing surveillance for nonfatal agricultural injuries.

**KEYWORDS.** Agricultural injury, farm, hospital discharge data, surveillance

### INTRODUCTION

Agriculture is consistently ranked among the most dangerous industries, with a national fatality rate of 22.8 per 100,000 workers in the United States in 2012, almost 7-fold as high as the all-industry fatality rate of 3.4 per 100,000.<sup>1</sup> With some 75,000 farms, agriculture

is a significant industry in Minnesota, ranking 5th in the United States for total sales of agricultural products at just over \$21 billion in 2012.<sup>2</sup> Although only about 2% of Minnesota's workers were employed in agriculture for the years 2005–2012,<sup>3</sup> 31% of the 563 occupational fatalities during that same time period were associated with the agricultural sector, a

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rate almost 10-fold higher than the state average.<sup>4</sup> Between the years 2003 and 2010, 26% of all occupational fatalities in Minnesota occurred on a farm.<sup>5</sup>

Although agricultural fatalities are well documented, ongoing surveillance systems for non-fatal worker injuries do not capture a substantial proportion of agriculture-related injuries. Primary sources for occupational injury surveillance have included workers' compensation data and the Survey of Occupational Injuries and Illnesses (SOII) conducted by the US Bureau of Labor Statistics in collaboration with the states (based on Occupational Safety and Health Administration [OSHA] logs). However, the majority (88%) of Minnesota farming operations are small or family operated<sup>2</sup> and are not generally required to participate in workers' compensation insurance systems or maintain OSHA injury and illness logs. SOII excludes farms with <11 employees. Recent work by Leigh et al.<sup>6</sup> found that over 75% of farm-related injury is missed by the SOII. These exclusions and exemptions make it difficult for public health practitioners to ascertain the number and rate of farm-related injuries that are occurring on an annual basis.

The need for a well-developed agricultural injury surveillance system has been well documented.<sup>7–11</sup> The identification of these injuries and related pertinent information could aid in the development of intervention and prevention programs to reduce these injuries and, by extension, fatalities within the farming community. Previous studies have provided rates and examined risk factors of farm injury<sup>8,9,12–16</sup>; however, the comprehensive efforts needed to sustain a surveillance system of nonfatal farm-related injury would be difficult without the provision of dedicated continuous funding.

Hospital discharge and emergency department data are often readily available to states and have been frequently used for public health surveillance, including occupational health. The Council of State and Territorial Epidemiologists, in collaboration with the National Institute for Occupational Safety and Health, has developed criteria for 21 "Occupational Health Indicators" that can be utilized by state-based occupational health surveillance programs using existing

data sources.<sup>17</sup> Three of these indicators utilize hospital discharge data. The introduction of "external cause of injury" codes (E codes) with the implementation of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM), has allowed greater specificity in identifying injuries associated with certain factors. In this study, we examined the use of these data to identify agricultural injuries in Minnesota.

## METHODS

The study was limited to persons residing in Minnesota who received medical treatment at an inpatient hospital setting, emergency room, or outpatient clinic with a hospital-affiliated billing relationship. Hospital discharge data in Minnesota are maintained by the Minnesota Hospital Association (MHA).<sup>18</sup> Reporting in Minnesota is mandatory with the exception of federal hospitals such as the Veterans Association and Indian Health Services. The Minnesota Department of Health (MDH) has access to these data under Statute for surveillance purposes. Variables included date of admission, date of discharge, gender, age, type of injury, ZIP code of residence, health care payment type, and E code. Potential farm-related injuries were identified and further classified based on specific E codes. This study was approved by the University of Minnesota and the Minnesota Department of Health institutional review boards.

A set of seven E codes were selected to identify and categorize cases as potentially related to agriculture:

### *Probable* farm-injury codes:

- E849.1: Place of occurrence, farm
- E919.0: Accidents caused by agricultural machinery

### *Possible* farm-injury 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 foods and fertilizers

- E906.8: Other specific injury caused by animal (butted by animal, fall from a horse or other animal not being ridden, being gored)
- 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

Two E codes, E849.1 and E919.0, were selected to describe *probable* farm-related injury based on previously published research.<sup>10,19–22</sup> The remaining five E codes included were grouped to describe cases of injury with a *possible* farm relationship. These five E codes suggest a relationship with activities often conducted in agricultural settings, but may also be associated with recreational or other nonfarming activities.

Since the hospital discharge data do not contain personal identifiers, only limited deduplication was possible. Cases were excluded based on the following criteria: any case with a V code as the primary diagnosis; 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; and 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.

To define the at risk population for the determination of injury rates, the American Community Survey (ACS) from the US Census Bureau and the Census of Agriculture (Ag Census) from the US Department of Agriculture were used. The ACS provides an estimate of the number of individuals living on a farm (defining a farm household as any household on one or more acres of land that yielded \$1,000 in actual sales of all “agricultural products for the property” in the prior year), as well as the number of individuals employed in agriculture.

The Minnesota State Demographer’s Office provided the estimates of the number of individuals living on a farm in Minnesota.<sup>23</sup> The Ag Census provides an estimate of the proportion of individuals working in agriculture who live on the farm where they work. Using the proportion of individuals living and/or working on a farm identified by the Ag Census and the counts of those employed in agriculture from the ACS, the numbers of individuals only working on a farm between 2000 and 2011 in Minnesota was estimated. These two estimates were then combined to create an estimate of the total number of individuals living and/or working on a farm. Data for the years 2000 and 2005–2011 were available from the ACS; linear regression was used to impute the years missing.

SAS 9.2 (SAS Institute, Cary, NC) was used for primary analyses. Joinpoint regression software (National Cancer Institute, version 4.0.1) was used to assess secular trends in the rates of farm injury over the 12-year study period.<sup>24</sup>

Previous research has demonstrated that E codes are missing for a portion of injury hospitalizations, and that a large fraction of farm-related injury does not require hospitalization. To roughly estimate the *total* number of farm-related injuries in Minnesota for 2000–2011, two additional data sources were used. The proportion of hospitalized injuries among all injuries was obtained from the Rural Regional Injury Studies (RRIS-I and -II),<sup>13,14,25–27</sup> and the proportion of missing E codes was obtained from the E code evaluation data from the Health Care Utilization Project (HCUP).<sup>28</sup> To begin the computation, the number of inpatient hospitalizations was used as the base number of injuries. E code evaluation data performed by the HCUP found that approximately 10% of injury cases did not have an accompanying E code, so the base number of injuries was inflated 10%. The RRIS studies indicated that only about 5% of farm-related injuries required inpatient hospitalization, so the assumption was made that the inflated base number of injuries was equivalent to 5% of all farm-related injuries, and an estimate of the *total* number of injuries was calculated.

## RESULTS

A total of 29,459 cases of *probable* and *possible* farm injury between the years 2000 and 2011 were identified in the Minnesota hospital discharge data (Tables 1 and 2, see Supplemental Data). Of all identified cases, 6,052 (20.5%) were categorized as *probable* and 23,407 (79.5%) were *possible* cases. The most common source of admission was the emergency room with 53% of cases. The average length of stay was 2 days, with a range of 1–82 days, for inpatient hospitalizations. The majority of cases (72.4%) were covered by some form of private health insurance, with workers' compensation coverage only accounting for 2.2% of the identified cases. A total of 28 fatalities were identified over the 12-year study period. The majority of nonfatal cases (91.1%) were discharged to their home or self-care. Whereas the most frequent primary diagnosis among all cases of injury was the general category of "injury other and unspecified" (8.4%), the most common categories of a specific primary diagnosis, with more than 1,000 cases each, included contusion of the 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%).

The injury case average age was 38.5 years (range: 1–89), with those between the ages of 35 and 44 incurring the greatest proportion (16.9%) of injuries (Table 3, see Supplemental Data). Although the majority of all cases was female (54.5%), there was a sharp gender difference between *probable* and *possible* cases. *Probable* cases (E codes E849.1 and E919.0) were predominantly male (81.5%), whereas possible cases were predominantly female (63.9%). Although injuries were distributed across all months, the majority of injuries (78%) occurred during April through October. Peak months for injuries included July and August, together accounting for 26% of all cases. Using the listed ZIP code of residence as a proxy for the location of injury, 88.2% of the injury cases occurred in rural counties (i.e., outside the seven-county Minneapolis-St. Paul metropolitan area).

The annual rate of all farm-related injury ranged between 14.0 and 18.5 per 1,000 individuals living and/or working on a farm in Minnesota over the time period 2000–2011. The annual rate of *probable* farm injury ranged between 2.9 and 4.3 per 1,000 individuals living and/or working on a farm in Minnesota for the years 2000–2011. The annual rate of *possible* farm injury ranged between 11.1 and 16.5 per 1,000 individuals living and/or working on a farm in Minnesota for the years 2000–2011 (Table 4, see Supplemental Data).

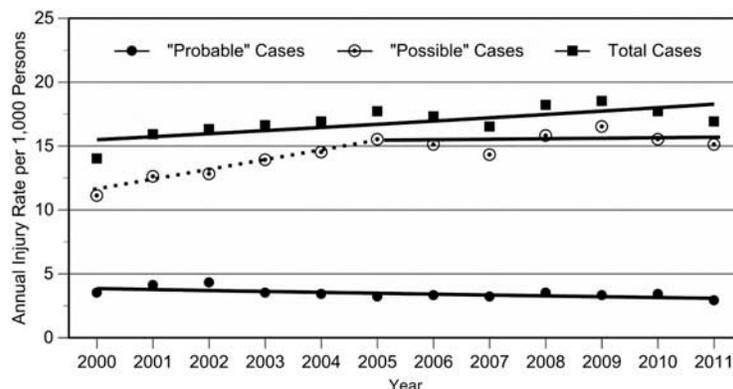
Trend analyses revealed different patterns for *probable*, *possible*, and *all* injury rates over the 12-year period. There was a small but statistically significant 1.5% average annual increase for all farm injuries over the 12-year study period. For *probable* cases, a 2.2% significant annual average decline was found over the study period. For *possible* injuries, a significant average annual 5.9% increase was found between the years 2000 and 2005, with no increase or decrease during the years 2005–2011 (Figure 1).

Based on the estimated proportions of injuries that are missing E codes and that require hospitalization, the total number of farm injuries in Minnesota was projected to range from 7,500 to 10,400 annually over the 12-year study period. The annual rate of total farm injury ranged between 48 and 74 injuries per 1,000 individuals living and/or working on a farm in Minnesota between the years 2000 and 2011 (Table 5, see Supplemental Data).

## DISCUSSION

Although there are noted concerns regarding the completeness and accuracy of E codes for identifying nonfatal farm injuries from hospital discharge data, this approach provides a more complete picture of the rates and trends of these injuries compared with other surveillance systems such as workers' compensation or the SOII. The number of injuries related to agriculture identified through the use of hospital discharge data were almost 3-fold (8,000 vs. 22,343) as high as than those identified by the SOII<sup>29</sup> for the same time period. These data aid

FIGURE 1. Trend analysis of total, “possible,” and “probable” farm injury rates per 1,000 individuals living and/or working on farms in Minnesota between 2000 and 2011. APC = average annual percent change. See text for explanation of Joinpoint trend analysis. The APC for total farm injury was +1.46% (statistically significant,  $P = .007$ , CI: [0.5, 2.4]). The APC for “probable” farm injury was  $-2.21\%$  (statistically significant,  $P = .008$ , CI: [-3.7, -0.7]). The APC for “possible” farm injury was +5.88% between 2000 and 2005 (statistically significant,  $P = .004$ , CI: [2.5, 9.1]) and +0.28% between 2005 and 2011 (not statistically significant).



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 resources and identifying and evaluating prevention and intervention strategies.

Hospital discharge data have been used by a number of public health programs, professionals, and researchers to identify and describe the rates and trends of disease and injury in populations. E codes were introduced to hospital billing records to improve injury research, and they have been used successfully in the past to identify injury cases.<sup>30–34</sup> Previous research has used hospital discharge data to conduct surveillance of asthma prevalence,<sup>35</sup> heart disease and stroke prevalence,<sup>36</sup> work-related burns, work-related low back pain, and work-related hospitalizations, to name a few.<sup>37</sup> These data are often selected for research, as they are cost-effective and come close to a complete count of serious injury events in a state. Although E codes are not mandatory in Minnesota, the states that have enforced collection of the E code in the discharge record often have E code completeness of almost 99%.

Mandatory reporting of E codes in the discharge record in all states could lead to greater case capture.<sup>28</sup> The cost-effectiveness of using hospital discharge data for disease and injury surveillance has been demonstrated repeatedly, and this study further demonstrates its utility and application to farm-related injury specifically. Hospital discharge data also provide the ability to conduct investigations into the cost and burden of these injuries, as the charges associated with the care provided are also present.

Although hospital discharge data are useful in identifying nonfatal agricultural injuries, the same cannot be said for fatal injuries. For the 2000–2011 time period, the Census of Fatal Occupational Injuries identified 244 deaths<sup>1</sup> related to agriculture in Minnesota, whereas only 28 deaths were identified within the hospital discharge data during that same period. In many cases, a fatal injury will result in death before the patient can be admitted or treated within a hospital setting, and these cases would not be captured within this data set.

The denominator may have limited the analysis in that it provides only a rough estimate of the number of individuals living and/or working on a farm in any given year in Minnesota, but it provides a more accurate denominator than simply using the number of individuals

living in rural Minnesota or the state population. The selected denominator approaches a more accurate description of those at risk of an injury related to agriculture, and further refinement, such as the number of hours present on the farm or the age and sex of the individual, would provide refinement of the denominator. Further exploration of the data provided by the American Community Survey and the Ag Census or future surveys capturing data to describe these variables would be valuable to the continuation of these investigative efforts.

The method of surveillance described in this paper requires minimal expenses beyond the time of the analyst and the cost, if any, for acquiring hospital discharge data. The data sources are generally readily available on an annual basis and can be further utilized to evaluate prevention and intervention programs and policies. This study has demonstrated the value and utility of hospital discharge data for the ongoing surveillance of nonfatal farm injuries within a state.

Future work investigating the grouping, pattern, and trend of specific injuries by gender, age, and E code will provide further insight into potential areas for prevention and intervention. Continued surveillance will provide information to evaluate the introduction of new policy or intervention programs to reduce the number of these injuries and fatalities.

Evaluation of the validity and accuracy of these E codes would provide further refinement of this methodology. The evaluation would allow for a closer approximation of the true number of injuries related to agriculture. With the implementation of ICD-10 approaching, future work to continue these surveillance efforts include a crosswalk between ICD-9 and ICD-10 as well as evaluation of the codes used to identify these cases as agriculturally related, either through chart review or interview.

### **Limitations**

This study has several limitations. One limitation is a by-product of the use of administrative data for surveillance purposes. E codes are not mandated in Minnesota, and usage of these codes in the billing record is determined

on an institutional basis. Evaluations of E code usage in the billing record have been completed by HCUP and the Minnesota Department of Health (MDH) Injury program.<sup>28,38</sup> These evaluations found that approximately 90% of all hospitalized cases with injury diagnostic codes in the Minnesota hospital billing record system had an accompanying E code; however, these evaluations do not account for the accuracy or completeness of specific E codes. Up to four E codes can be entered into the billing record, denoting location, cause, nature, and mechanism. Interviews with three administrators of large Minnesota hospital billing systems indicated preferential usage of codes for cause, nature, and mechanism, and less so for location. This bias may be due in large part to the intended purpose of billing data, to provide the necessary information to support the diagnostic and procedural services for billing purposes. The preference for the inclusion of E codes for cause, nature, and mechanism over location suggests that there may be an undercount of the number of injuries identified solely with E code E849.1, occurred on a farm. Also, as the use of E codes has improved over the same time period as this analysis, the increase in the number of identified probable cases, those identified with codes unrelated to location, may have been influenced by this improvement.

No personal identifiers are included in the Minnesota hospital discharge data set; consequently, it was not possible to evaluate and confirm by questionnaire or interview the relationship between the injury case and agriculture. The hospital discharge data are also limited in that they only provide the information related to a specific admission; the case is not followed over time, and subsequent care and visits are not linked to the identified admission. These aspects of hospital discharge data limit the degree to which investigation of specific cases of farm injury can be pursued. Another concern regarding hospital discharge data is the completeness of the outpatient cases. Outpatient billing information is not required to be submitted to the MHA, and the data that are supplied are through hospitals with a billing relationship with these outpatient clinics. As such, the estimates and counts collected are only a sample of the injuries

related to agriculture that occur within the state. This limitation will create an undercount of the cases not requiring inpatient care.

The estimate of the *total* number of farm-related injuries using the available percentages from the HCUP evaluation and RRIS studies is subject to the error and assumptions made in the original studies. The HCUP evaluation of E codes does not evaluate the accuracy of the E code usage, but rather whether the E code was included in the recording of an injury. The RRIS studies made use of a random sample of farm households to describe rates of injury in farm household populations. The *total* estimates of farm-related injury may be an undercount of the true number of farm-related injuries due to the compounding of error by using the hospital discharge estimates with the HCUP and RRIS estimates.

### CONCLUSION

This study addressed a serious gap in information by describing the incidence of serious nonfatal injuries among Minnesota's agricultural workforce. Analysis of hospital discharge data using E-codes revealed an annual average of over 500 probable cases and 2,000 possible cases, with an overall increase of 1.5% between 2000 and 2011. Despite the undercount of less serious injuries, hospital discharge data provided a more complete indicator than other data sources for the identification and surveillance of nonfatal agricultural injuries, providing a feasible method for potential use by other states interested in conducting surveillance of nonfatal agricultural injuries.

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### SUPPLEMENTAL DATA

Supplemental data for this article can be accessed on the publisher's [website](#). The data includes Tables 1–5.

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