Improving agricultural injury surveillance: comparing injuries captured by Iowa's workers' compensation and trauma registry data

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ABSTRACT

Background Without a comprehensive national surveillance system in the USA, the agricultural sector faces numerous obstacles to accurate and complete injury reporting and surveillance. Secondary sources are increasingly being used to conduct surveillance but have not been thoroughly evaluated for their overlap and ability to capture various types of agricultural injuries.

Methods Using two state-level systems which likely capture severe injuries, the (i) Iowa Trauma Registry (ITR) and (ii) Workers' Compensation (WC) records, we compared worker and injury characteristics found in these two data sources over a ten-year period (2005–2014) and developed a predictive model to determine which injuries are most likely captured in one data source vs the other.

Results A total of 2398 unique injuries from ITR and 3419 unique injuries from WC were found. There was very little overlap between the two sources. In general, injuries among older agricultural workers (65+) had a higher probability of capture by the ITR, while injuries among younger agricultural workers were more likely captured by WC. Young agricultural workers injured in motor vehicle traffic incidents were more likely captured by WC, but after age 25, these injuries were more likely captured by the ITR. In contrast, more machinery injuries were captured by the ITR than WC across age.

Conclusions Neither of these secondary systems fully captured all injuries. Hence, comprehensive surveillance would require multiple data sources. However, future studies involving targeted research questions could select one data source, especially when surveillance resources are limited.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Administrative datasets, such as workers' compensation (WC) and trauma registries, are often used for routine occupational injury surveillance in agriculture. Despite knowledge of probable undercounting and other omissions in these data sources, little is known about the relative likelihood that injured workers would be captured in one set of administrative data over the other.

WHAT THIS STUDY ADDS

⇒ This study uses a predictive model to determine whether injuries among agricultural workers are more likely to be captured by WC or trauma registry data, using demographics and injury characteristics as explanatory variables. In addition to reporting possible strengths and weaknesses of these two data sources, the investigators also developed a publicly available web application that illustrates the model's findings.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study can assist in designing targeted surveillance strategies for specific populations of workers or injury profiles and inform how linkages of multiple data sources may enable more comprehensive injury surveillance programmes.

INTRODUCTION

Agriculture, one of the most dangerous industries in the USA, is poorly surveilled.[1–3] The US Bureau of Labour Statistics (BLS) Survey of Occupational Injuries and Illnesses (SOII) likely underestimates agricultural injuries by 62% to 88% due in part to the exclusion of farms with fewer than 11 employees; the industry's use of seasonal, transient and undocumented workers; and willful or negligent underreporting.[1 2 4] Other systems, including the Centers for Disease Control and Prevention Childhood Agricultural Injury Survey, the BLS Occupational Injury Survey for Production Agriculture, and the US Department of Agriculture National Agricultural Workers Survey, were de-funded and halted.[5 6]

In the absence of an accurate and complete national agricultural injury surveillance system, administrative data and other secondary sources are often used. Although these sources only capture state or regional agricultural injuries, they may offer advantages over national datasets. Workers' compensation (WC) claims records may overcome certain limitations of the SOII, such as the small farm and self-employer exclusions, while also capturing the unique agricultural worker experiences of a state or region. WC also relies on no-fault indemnity to pay for the direct costs of occupational injury, instead of relying on employers' understanding of, and compliance with, BLS injury and illness reporting criteria, which contribute to undercounting in SOII.[4] WC data have been increasingly used as a surveillance tool for agricultural injury.[2 7] Other sources of agricultural injury

data include media reports and community surveillance projects, though each has costs and limitations of their own.[8–11]

Emergency department (ED) and trauma registry (TR) data, in particular, are promising sources of severe agricultural injury surveillance data collected at the point of clinical care.[12] International Classification of Diseases (ICD)-9 diagnostic codes, later revised to ICD-10 in 2015, include categories for potential work-related agricultural injury, such as 'place of occurrence—farm' and 'accidents caused by agricultural machinery'.[7] Work-relatedness in TR data can also be inferred from injuries that list WC as the expected payer, though undercounting is still likely since some patients may use Medicare, Medicaid or private insurance to pay for work-related injuries.[13 14] Using multiple data sources may be the best surveillance strategy for agriculture at this time.[7]

States have attempted to create comprehensive agricultural injury surveillance systems by aggregating cases across multiple sources. Since 2015, Michigan has run a multi-source surveillance project using both hospital and WC data and estimated agricultural injury rates between two and three injuries per 100 workers.[7 15] Using hospital discharge data supplemented with data from state-based surveillance systems to capture non-hospital injuries, Minnesota estimated agricultural injury rates of 48–74 injuries per 1000 workers between 2000 and 2011.[16] While these studies and others used multiple data sources to estimate agricultural injury rates,[17–20] none have developed models to predict and compare the types of injuries that appear in one data source vs another.

The objectives of this study were to (1) compare agricultural injury data from the Iowa Trauma Registry (ITR) and the Iowa Division of WC, (2) characterise the types of agricultural injury data available from these two databases and (3) develop a predictive model to examine characteristics that affected the probability of an agricultural injury case being captured in one database vs the other. This research can help determine which databases would be most efficient for studying trends, evaluating programmes and conducting research on agricultural injuries, especially in light of limited data available for injury surveillance.

METHODS

We accessed two state-based repositories of injury information from 2005 to 2014.

Iowa trauma registry

Established in 1996 under Iowa Administrative Code 641 Chapter 136, the ITR serves as a statewide hospital-based system for collecting data on trauma cases.[21] Patients who were admitted, treated in an ED, transferred from another facility or died prior to arrival are included in the ITR if (i) diagnosed with 'major or minor tissue damage or destruction caused by intentional or unintentional exposure to thermal, mechanical,

Table 1 Descriptive statistics for agricultural injury cases in the Iowa trauma registry (ITR) and workers' compensation (WC) data sources; Effect estimates for predicting the odds of an agricultural injury case being captured in WC vs the ITR

	Total (n=5817)	ITR (n=2398)	WC (n=3419)	Logistic regression estimates* (95% Wald CI)
Model intercept				1.80
Injury characteristics – N (%)				
Cause of injury				
Cut/pierce or struck by/against	912 (15.7)	421 (17.6)	491 (14.4)	–0.33 (–0.49, 0.18)
Falls	1232 (21.2)	425 (17.7)	807 (23.6)	0.21 (0.06, 0.36)
Fire/burn	149 (2.6)	90 (3.8)	59 (1.8)	0.35 (–0.13, 0.83)
Machinery	770 (13.2)	623 (26.0)	147 (4.3)	–1.80 (–1.98, 1.60)
Motor vehicle traffic	440 (7.6)	296 (12.3)	144 (4.2)	–0.99 (–1.20, 0.79)
Natural/environment	545 (9.4)	244 (10.2)	301 (8.8)	–0.21 (–0.40, 0.02)
Other†	1064 (18.3)	233 (9.7)	831 (24.3)	0.88 (0.72, 1.04)
Missing/unspecified	705 (12.1)	66 (2.8)	639 (18.7)	1.90 (1.65, 2.14)
Nature of injury				
Amputation	157 (2.7)	104 (4.3)	53 (1.6)	–0.03 (–0.40, 0.33)
Burns	141 (2.4)	89 (3.7)	52 (1.5)	–1.07 (–1.55, 0.58)
Fractures, dislocations, sprains or strains	2811 (48.3)	902 (37.6)	1909 (55.8)	0.75 (0.60, 0.91)
Open wound, superficial or contusion	912 (15.7)	381 (15.9)	531 (15.5)	0.58 (0.40, 0.76)
Other‡	940 (16.2)	568 (23.7)	372 (10.9)	–0.47 (–0.63, 0.29)
Missing/unspecified	856 (14.7)	354 (14.8)	502 (14.7)	0.23 (0.05, 0.41)
Demographics				
Sex—N (%)				
Male	5038 (86.7)	2212 (92.5)	2826 (82.7)	–0.40 (–0.49, 0.30)
Female	770 (12.3)	180 (7.5)	590 (17.3)	0.40 (0.30, 0.50)
Age—Mean (SD)	44.7 (15.7)	49.4 (17.1)	41.6 (13.6)	–0.03 (–0.04, 0.03)

*The logistic regression model used explanatory variables found in both data sources: age, gender, injury cause and injury nature. For categorical predictors (gender, injury cause and injury nature), we used effects coding instead of reference coding so that the average effect would be zero. Additionally, effect estimates are reported out to 0.01 for a greater degree of precision for reproducibility of predicted probabilities.
†Categories for Cause of Injury follows the Centers for Disease Control's (CDC) External Cause of Injury Matrices classification. Due to small cell sizes, other cause category contains causes of injury related to firearm, poisoning, suffocation, drowning, overexertion, self-harm, assault and the CDC's classification for other specified causes.
‡Categories for Nature of Injury follows the Barrel Injury Diagnostics Matrix. Other nature of injury category contains nature of injuries related to internal organs, blood vessels, crushing, nerves and system wide/late effects.

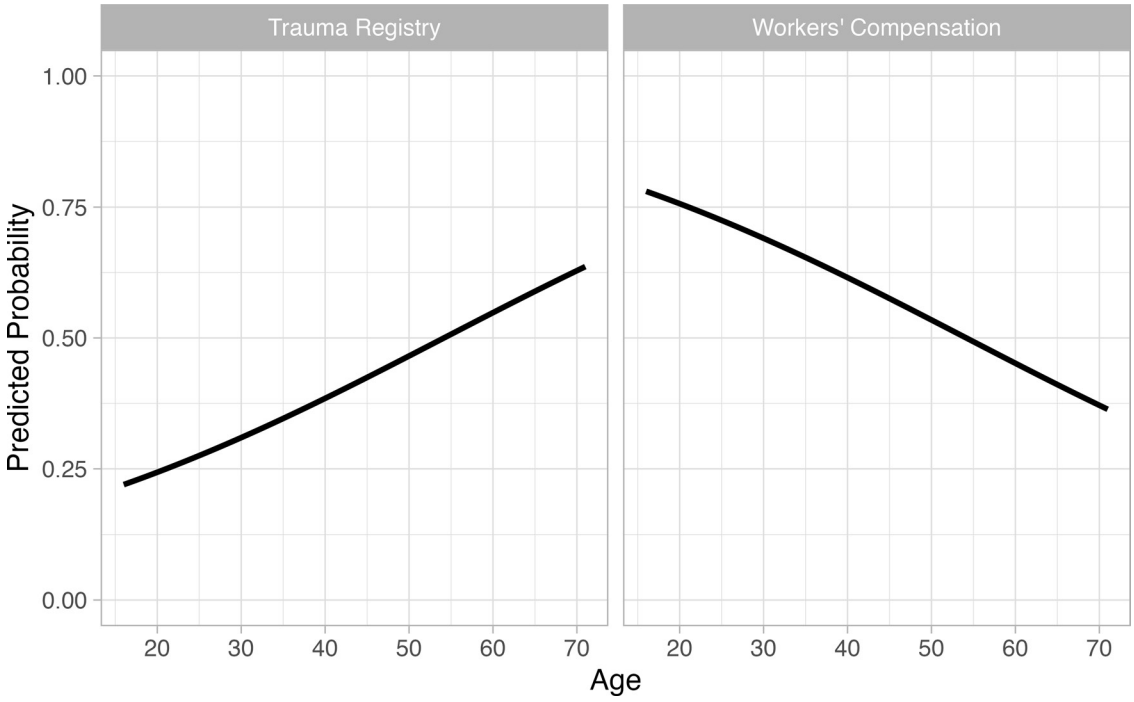

Figure 1 Predicted probabilities of a farm-related injury being captured by the Iowa trauma registry or workers' compensation across age adjusted for the effects of sex, and cause and nature of injury.

electrical or chemical energy, or by the absence of heat or oxygen', or (ii) treated by the trauma activation team, regardless of disposition. The external causes and natures of injury are captured by the ICD-9 codes E800.0–E999.9) and documented. The registry includes trauma cases reported by all Level I, II, III and IV hospitals across the state.

Inclusion criteria. Trauma cases identified as occurring "on a farm…or in the course of handling, producing, processing, transporting, warehousing farm commodities " were included.[22] To address possible misclassification of farm-relatedness, we also included trauma cases that were not identified as farm-related but had the ICD External Cause of Injury codes (E-codes) identified as *probable agricultural injuries* (E491, E849.1 (place of occurrence, farm) and E919.0 (accidents caused by agricultural machinery)) and *possibly agricultural injuries* that possibly occur on farms but may also be recreational or non-farming (E827, E828 and E906.8 (animal-related); and E863.0-E863.9 and E980.7 (poisoning-related)).[16]

WC

US WC programmes are state-based insurance systems that pay for medical care and partial wage replacement for workers injured on the job. Requirements and coverage vary by state. In Iowa, agricultural employers, their spouses and their immediate family members; partners, officers of a family farm corporation and members of a limited liability corporation; and farm operations with less than $2500 in revenue are exempt.[23] The Iowa Division of WC collects all indemnity claims of compensable work-related injuries, including agricultural injuries not exempt by law, that result in 3+ days of incapacitation, permanent or partial disability or death.

Inclusion and exclusion criteria: for this study, we included WC cases that occurred in agriculture, identified using the Standard Industrial Classification (SIC) codes 01XX (Agricultural Production- Crops), 02XX (Agricultural Production- Livestock) and 07XX (Agricultural Services) or North American Industry Classification System subsector codes 111 (Crop Production), 112 (Animal Production and Aquaculture) and 115 (Support Activities for Agriculture and Forestry). Two members screened cases and excluded non-trauma cases (eg, chest pain, asbestosis, pneumoconiosis, dermatitis, mental disorder, loss of hearing, contagious disease), chronic/cumulative injuries and cases resulting from repetitive motions, noise or mould.

Data linkage

ITR and WC injury cases were linked. Deterministic linking was based on the injured person's date of birth (DOB), injury date and sex. Probabilistic linking was based on combinations of variables including DOB, varying windows of time around the injury date (from a minimum of 1 day to a maximum of 30 days), sex, body region injured, cause of injury, nature of the injury and an indicator in the ITR if WC paid for medical expense. Linked cases were reviewed by at least two members of the research team to adjudicate proposed matches. Matched cases were removed to create the mutually exclusive dataset of injury cases. Because coding structures differed (see online supplemental tables 1 and 2 showing cause of injury as an example), we created cause and nature of injury categories following the Barrell Injury Diagnostics and External Cause of Injury Matrices (https://www.cdc.gov/nchs/injury/injury_tools.htm). Cell sizes required collapsing of categories.

Predictive model

We developed a logistic regression model to predict probabilistically which data source captured an injury case, given their injury characteristics and personal demographics. The predictive model used explanatory variables found in both data sources: age, gender, injury cause and injury nature. For categorical predictors (gender, injury cause and injury nature), we used effects coding instead of reference coding so that the average effect would be zero. We examined the main effects model as

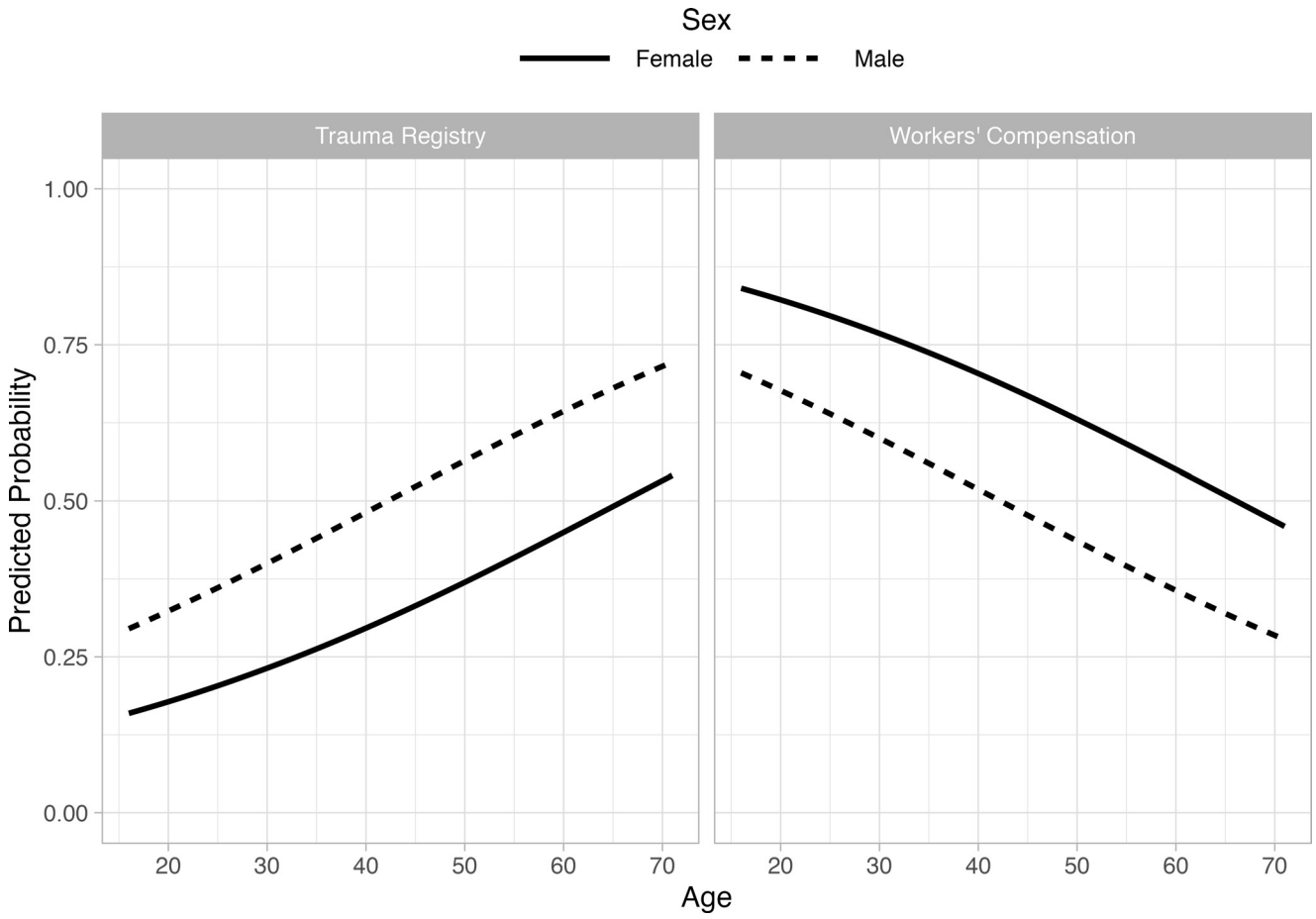

Figure 2 Predicted probabilities of capture by the Iowa trauma registry or workers' compensation by sex across age adjusted for the effects for cause and nature of injury.

well as all two-way interaction models between sex and the other variables and between age and the injury characteristics. The main effects model resulted in the best penalised model fit as determined by the smallest value of the Bayesian Information Criterion.

Based on the predictive model, we estimated the probabilities of an agricultural injury being in either the ITR or WC from the parameter estimates associated with the levels of the explanatory variables that characterise the injury of interest. To calculate each probability, we first estimated the log odds of capture by WC and converted it to a probability using the inverse logit transform. The probability of the same injury case being found in the trauma registry was estimated by subtracting the predicted WC probability from one. For each predicted probability, we also computed a 95% Wald CI.

We used the parameter, variance and covariance estimates from the selected model to create an *R Studio Shiny* web application.[24] This application calculates the predicted probabilities (with 95% CIs) of an injury being captured in the WC or ITC based on user-specified profiles of the worker and injury. For a detailed description of the application, see https://ph-ivshiny.iowa.uiowa.edu/deboonstra/agstudy1app/. This research was determined to be not human subjects by the University of Iowa Institutional Review Board.

RESULTS

A total of 2508 agricultural injuries were reported in the ITR, while 3529 claims were reported in the WC database. Only 110 cases were identified in both data sources, representing 4.4% of the ITR and 3.1% of the WC cases (106 cases were linked deterministically, and four cases were linked probabilistically). The final, mutually exclusive dataset was comprised of 2398 injuries from the ITR and 3419 claims from WC.

More than 90% of ITR cases were male, compared with 84% of WC cases. WC cases were slightly younger (mean age=41) than ITR cases (mean age=49). Among ITR cases, the leading causes of injury were from machinery (26%), falls (18%) and being cut/pierced or struck by/against an object (18%) (table 1). The most frequent injury in the WC database was falls (24%) and being cut/pierced or struck by/against an object (14%). Fractures, dislocations, sprains or strains were common injury natures in both data sources, but occurred at a notably higher rate in the WC (56%) than ITR (38%) (table 1).

Table 1 also shows the logistic regression parameter estimates based on workers' demographics and injury characteristics for calculating the log odds of an injured person being captured in the WC database, compared with the ITR. Age was a strong predictor of data capture; the odds of an injured worker being captured in the WC dataset decreased by a multiplicative factor of 3% for each year of age. Females had increased odds of being recorded in WC than the ITR. Falls and superficial wounds/contusions had increased odds of being captured by WC, while injuries caused by traffic crashes, machinery and nature/environment and burns had increased odds of being captured by the ITR.

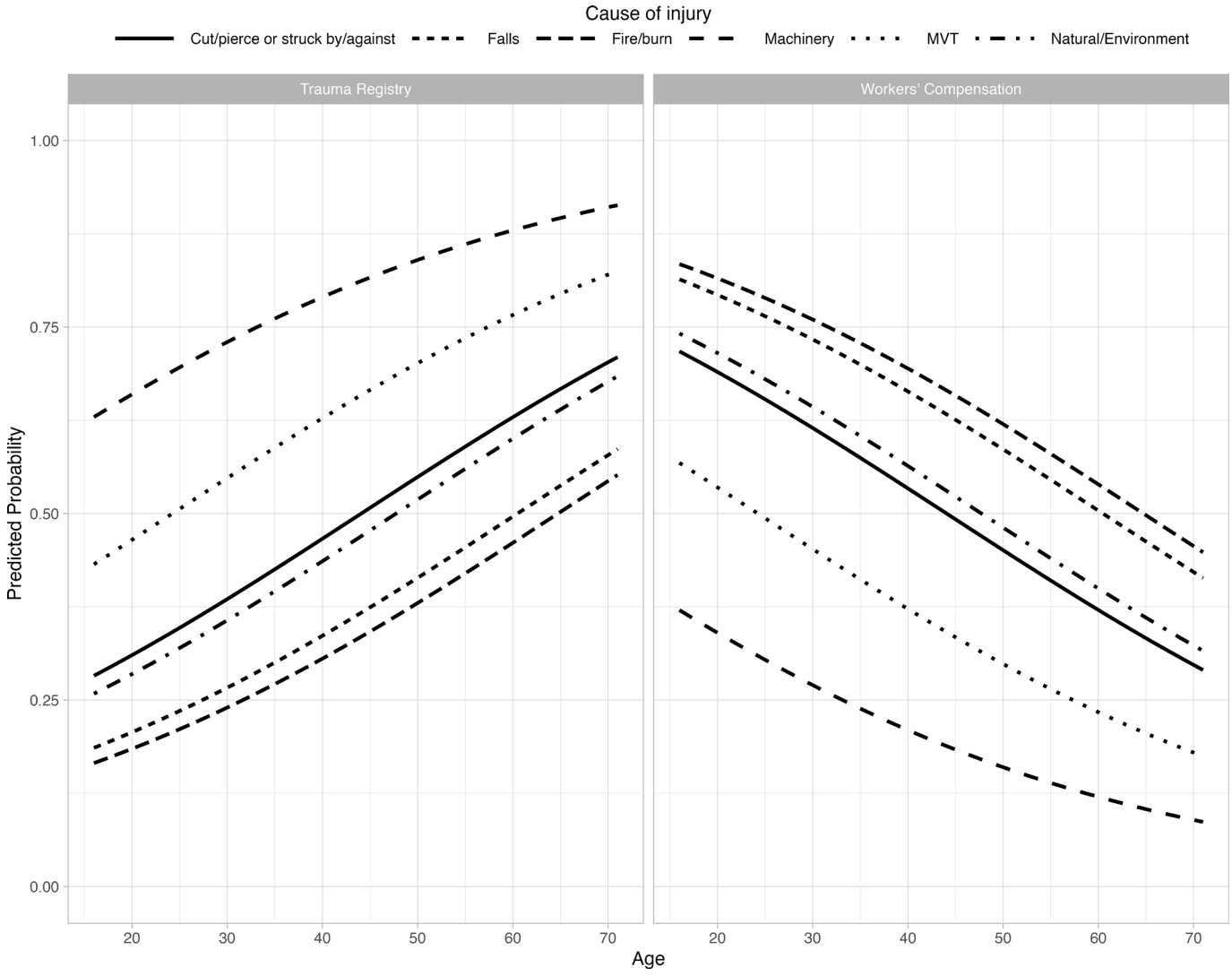

Figure 3 Predicted probabilities of being recorded in the Iowa trauma registry or workers' compensation by cause of injury across age adjusted for the effects of sex and nature of injury.

Figure 1 shows the predicted probabilities for inclusion in ITR and WC by age. Farm-related injury among younger workers was more likely to be captured by WC (age-specific maximum probability of 78% at the age of 16) than in the ITR. At age 55, the probability of capture in the two registries was essentially equal. Injuries among the oldest workers were more likely to be captured in the ITR than WC datasetsfigure 1.

Given the strong age effect, we examined its interaction with sex, cause of injury and nature of injury (figures 2–4). 'Missing/unspecified' and 'Other' injury cause and nature categories were excluded because they were difficult to interpret. Unlike female agricultural workers, the capture of injured male agricultural workers was highly dependent on age. Younger male workers were more likely to be found in WC. As age increases, male workers become increasingly likely to appear in the ITR, with the ITR becoming the more probable data location starting at age 41. In contrast, female workers were less likely to be captured in the ITR until age 67. The probability that a female agricultural worker's injury is reported in WC ranges by age from 47% to 84% (figure 2).

Predicted probabilities for database capture across age also differed by cause of injury. Injuries caused by machinery were more likely captured by the ITR than WC (predicted probabilities from 63–91%) across all ages (figure 3). Injuries from younger workers were more likely captured by WC than ITR for all other injury causes. Youth/young adult agricultural workers injured in a motor vehicle traffic crash were more likely captured by WC, but, after age 25, they were more likely captured by the ITR. Agricultural workers younger than 45 years of age and injured by cutting/piercing/striking objects were more likely captured by WC (probabilities from 50% to 72%); after age 45, they had a maximum probability of 70% of being captured in the ITR. Up to age 61, workers injured from falls have probabilities ranging from 50% to 81% to be captured by WC. After the age of 62, workers injured from falls have a maximum probability of 58% of being captured in the ITR (figure 3).

Across all ages, fractures, dislocations, sprains or strains had a greater probability of capture by WC than the ITR (figure 4). For open wounds/superficial injuries/contusions or amputations, younger workers were more likely captured by WC, and older workers more likely captured by the ITR. Youth agricultural workers who suffered burns were captured by the WC, but after age 20, they were captured by ITR. Up to age 52, farmers who experienced amputations were more likely found in the WC, but after age 53, they were more likely found in the ITR (figure 4).

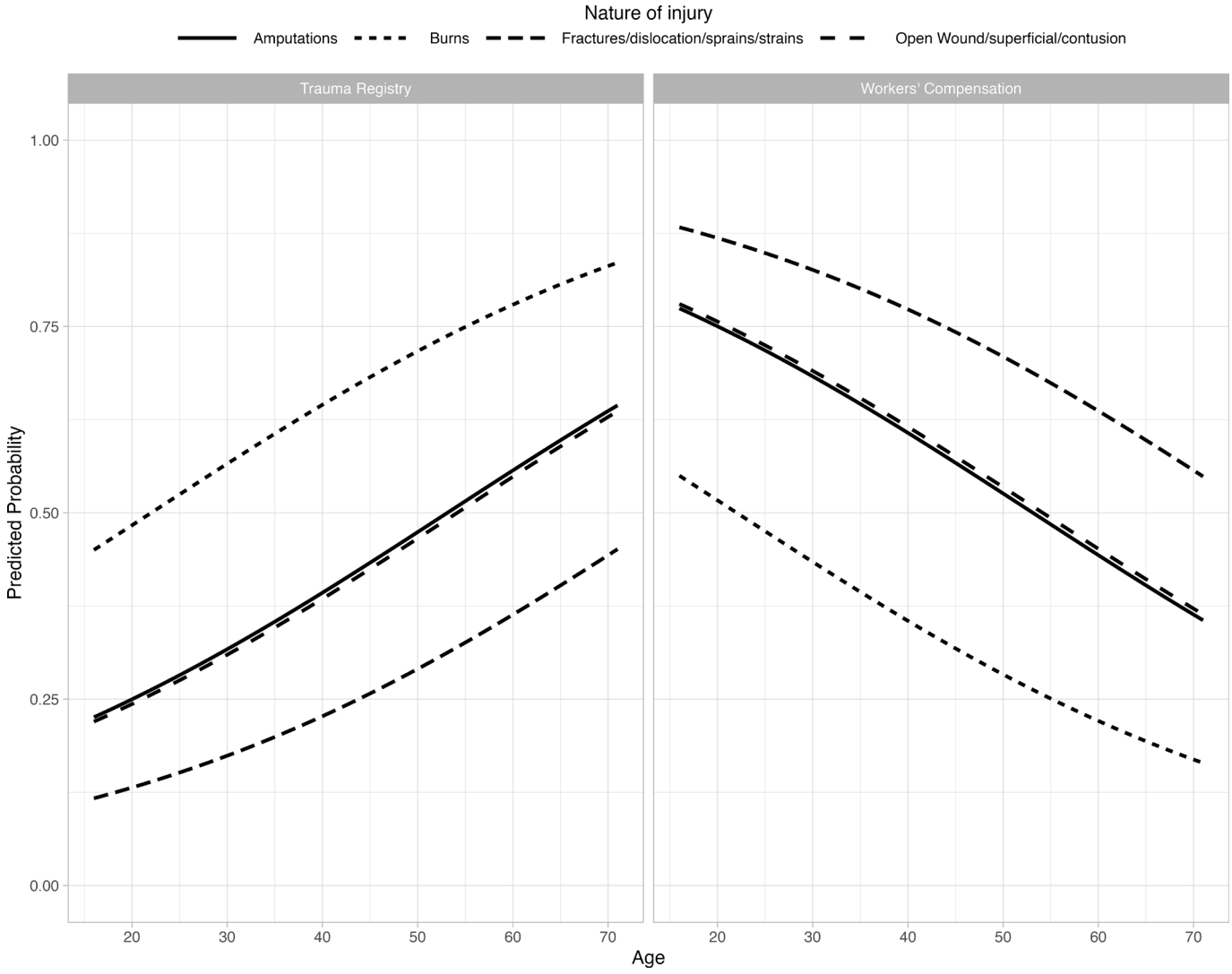

Figure 4 Predicted probabilities of being recorded in the Iowa trauma registry or workers' compensation by nature of injury across age adjusted for the effects of sex and cause of injury.

To apply these research findings to practice, our *R Studio Shiny* (https://ph-ivshiny.iowa.uiowa.edu/deboonstra/agstudy1app/) application asks users to input characteristics of injuries (ie, age, sex, type of injury and/or cause of injury) to estimate, based on the predictive model presented here, which dataset would have the highest probability of including a specific agricultural injury of interest. A demonstration using the Shiny application is found in online supplemental table 3.

DISCUSSION

This is the first study of which we know to use predictive modelling to compare agricultural injuries across WC and trauma registry data with the goal of providing information about their respective relative surveillance capabilities. Understanding the relative strengths and weaknesses of independent but potentially overlapping data sources can allow researchers to more efficiently allocate resources for robust injury surveillance projects that ultimately inform areas for targeted prevention efforts.

Surprisingly, there was little direct overlap of cases (3–4%) between the WC and ITR data sources based on our linkage methods, despite ostensibly covering the same population of agricultural workers in Iowa. Notable differences and exclusions might explain this observation. WC is required only of farmers who earn over $2500 and excludes family operations. WC tends to be underused as a source of payment for the care of agriculture injuries, partially because of the industry's reliance on undocumented or informal workers, estimated to be as high as 53% of the farm workforce nationwide, who may forgo filing WC claims.[1] Due to the small overlap of cases across trauma registry and WC data sources, multiple data sources are especially important for comprehensive agricultural surveillance.[7]

Data linkage can be a resource-intensive procedure, often requiring collaboration between multiple agencies. The necessity of data linkages depends on a project's research question and focus. Researchers with limited resources who are interested in younger farm workers may find that WC data alone may be sufficient for examining causes and the nature of injuries. Our model predicted that injured workers under 20 would have a 75% predicted likelihood of being captured in WC instead of the ITR, regardless of injury cause or nature. However, research with a wider demographic scope would quickly require additional data sources, as injured workers aged 50–59 are equally likely to be captured in either the ITR or WC.

Good surveillance of agricultural injuries should also characterise cause and nature of injury. Trauma records contain detailed procedures and diagnoses of agricultural injuries, but

WC data document comprehensive information on causes such as type of agricultural machinery. Furthermore, it is important to consider the extent to which cases are captured by a given data source, as our findings reveal. Trauma registries may be preferable to WC data as a source for conducting surveillance on machinery-related injuries, with a minimum probability of capturing injuries of 63%, and increasing to 91% at age 70. Fall-related injuries more equally straddle the two data sources and may require data linkages for a more complete analysis. These trends may possibly be explained by certain inherent differences in the injuries themselves, such as whether care can be delayed or sought at an outpatient clinic instead of a trauma centre. Importantly, no data source in this study captured 100% of any given injury type or demographic group. Thus, a comprehensive prevalence study may require multiple data sources.

Limitations

Because no gold standard for identification of agricultural injury exists, overall sensitivity or specificity could not be estimated. Rather, we examined the relative likelihood that a given known injury observation would be captured by one source or the other. Furthermore, the injury records were likely underreported and misclassified, as both WC and trauma registry data are subject to various filters and differences in how cases are recorded.[14 25 26] Additionally, hospital administrative data are collected primarily for reimbursement purposes and therefore prioritise diagnostic and procedure codes over E-codes. E-codes often have missing location and activity, leading to under-identification of agricultural injuries. Finally, as discussed earlier, WC is underused, and coverage is limited to selected populations. While findings are limited to the state of Iowa, this study was strengthened by the state's centralised repository of WC claims and a TR that identifies farm-related trauma cases. The methods used here can be adapted to other states with comparable Trauma and WC systems.

CONCLUSION

Researchers interested in comprehensive surveillance should prioritise the linkages of multiple injury reporting systems. However, targeted research based on certain injury characteristics or worker demographics may be accomplished with one injury data source. The publicly available web application developed from this project can help researchers, government officials, employers and farm employees predict the likely repositories of injury data for various injury and worker characteristics. These predictions could support agricultural injury surveillance efforts when resources are limited and lead to informed outreach and safety interventions.

Contributors MRR conceived and planned the study. DEB and JEC conducted analysis. MRR, CC, FG and AFM interpreted results. All authors prepared the manuscript. MRR is the guarantor.

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Patient consent for publication Not applicable.

Ethics approval Not applicable.

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REFERENCES

1 Leigh JPP, Du JP, McCurdy SA. An estimate of the U.S. government's undercount of nonfatal occupational injuries and illnesses in agriculture. *Ann Epidemiol* 2014;24:254–9.
2 Baidwan NK, Ramirez MR, Gerr F, *et al*. Cost, Severity and Prevalence of Agricultural-Related Injury Workers' Compensation Claims in Farming Operations from 14 U.S. States. *Int J Environ Res Public Health* 2021;18:4309.
3 Missikpode C, Peek-Asa C, Wright B, *et al*. Characteristics of agricultural and occupational injuries by workers' compensation and other payer sources. *Am J Ind Med* 2019;62:969–77.
4 Wuellner SE, Adams DA, Bonauto DK. Workers' compensation claims not reported in the Survey of Occupational Injuries and Illnesses: Injury and claim characteristics. *Am J Ind Med* 2017;60:264–75.
5 Patel K, Watanabe-Galloway S, Gofin R, *et al*. Non-fatal agricultural injury surveillance in the United States: A review of national-level survey-based systems. *Am J Ind Med* 2017;60:599–620.
6 Hendricks KJ, Hendricks SA, Layne LA. A National Overview of Youth andInjury Trends on U.S. Farms, 2001-2014. *J Agric Saf Health* 2021;27:121–34.
7 Kica J, Rosenman KD. Multisource surveillance for non-fatal work-related agricultural injuries. *J Agromedicine* 2020;25:86–95.
8 Scott EE, Earle-Richardson G, Krupa N, *et al*. A correction factor for estimating statewide agricultural injuries from ambulance reports. *Ann Epidemiol* 2011;21:767–72.
9 Earle-Richardson GB, Jenkins PL, Scott EE, *et al*. Improving agricultural injury surveillance: a comparison of incidence and type of injury event among three data sources. *Am J Ind Med* 2011;54:586–96.
10 New-Aaron M, Semin J, Duysen EG, *et al*. Comparison of agricultural injuries reported in the media and census of fatal occupational injuries. *J Agromedicine* 2019;24:279–87.
11 Weichelt BP, Gorucu S, Burke RR, *et al*. Agricultural youth injuries: An updated review of cases from U.S. news media reports, 2016-2021. *Front Public Health* 2022;10:1045858.
12 Cook A, Fry R, Desai Y, *et al*. Agricultural Injury Surveillance Using a Regional Trauma Registry. *J Surg Res* 2022;273:181–91.
13 Groenewold MR, Baron SL. The proportion of work-related emergency department visits not expected to be paid by workers' compensation: implications for occupational health surveillance, research, policy, and health equity. *Health Serv Res* 2013;48:1939–59.
14 Bush AM, Bunn TL, Liford M. Identification of work-related injury emergency department visits using International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes. *Inj Prev* 2021;27:i3–8.
15 Harduar Morano L, Rosenman KD. Non-Fatal Work-Related Farm Injuries Occurring to Michigan Adults and Youths. *J Agromedicine* 2024;29:155–61.
16 Landsteiner AMK, McGovern PM, Alexander BH, *et al*. Incidence Rates and Trend of Serious Farm-Related Injury in Minnesota, 2000-2011. *J Agromedicine* 2015;20:419–26.
17 Boden LI. Capture-recapture estimates of the undercount of workplace injuries and illnesses: sensitivity analysis. *Am J Ind Med* 2014;57:1090–9.
18 Scott EE, Krupa NL, Sorensen J, *et al*. Electronic merger of large health care data sets: cautionary notes from a study of agricultural morbidity in New York State. *J Agromedicine* 2013;18:334–9.
19 Mustard CA, Chambers A, McLeod C, *et al*. Comparison of data sources for the surveillance of work injury. *Occup Environ Med* 2012;69:317–24.
20 Rosenman KD. Perspective on new evidence showing injury under-reporting among precarious workers. *Occup Environ Med* 2022;79:1–2.
21 Iowa trauma registry report 2021. Des Moines, Iowa, 2022. Available: https://hhs.iowa.gov/sites/default/files/portals/1/userfiles/286/iowa_2021_trauma_registry_report_final_20220808.pdf
22 Iowa Department of Health Human Services. *Iowa trauma patient data dictionary*. Des Moines, Iowa: Department of Public Health (IDPH) Bureau of Emergency and Trauma

Services (BETS), 2017. Available: https://hhs.iowa.gov/sites/default/files/portals/1/userfiles/186/trauma_registry_data_dictionary_jan_%202017.pdf
23 Public Services and Regulation [Chs. 80-122c], Subtitle 2. Employment Services [Chs. 84-96a], Chapter 85. Workers' Compensation (Refs & Annos), Subchapter I. General Provisions.
24 Chang W, Cheng J, Allaire J, *et al*. shiny: Web application framework for R. R package version 1.7.4. 2022. Available: https://CRAN.R-project.org/package=shiny
25 Azaroff LS, Levenstein C, Wegman DH. Occupational injury and illness surveillance: conceptual filters explain underreporting. *Am J Public Health* 2002;92:1421–9.
26 Fan ZJ, Bonauto DK, Foley MP, *et al*. Underreporting of work-related injury or illness to workers' compensation: individual and industry factors. *J Occup Environ Med* 2006;48:914–22.