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RESEARCH ARTICLE

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Characteristics of agricultural and occupational injuries by workers' compensation and other payer sources

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Abstract

Background: Workers' compensation claims data are routinely used to identify and describe work-related injury for public health surveillance and research, yet the proportion of work-related injuries covered by workers' compensation, especially in the agricultural industry, is unknown.

Methods: Using data from the Iowa Trauma Registry, we determined the sensitivity and specificity of the use of workers' compensation as a payer source to ascertain work-related injuries requiring acute care comparing agriculture with other rural industries.

Results: The sensitivity of workers' compensation as a payer source to identify work-related agricultural injuries was 18.5%, suggesting that the large majority of occupational agricultural injuries would not be accurately identified through workers' compensation records. For rural nonagricultural, rural occupational injuries, the sensitivity was higher (64.2%). Work-related agricultural injuries were most frequently covered by private insurance (39.6%) and public insurance (21.4%), while rural nonagricultural injuries were most frequently covered by workers' compensation (65.2%).

Conclusions: Workers' compensation claims data will not include the majority of work-related agricultural injuries.

KEYWORDS
agricultural industry, and specificity, sensitivity, workers' compensation, work-related injuries

1 | INTRODUCTION

Agriculture is a hazardous occupation that exposes farmers and their family members to high risk for fatal and nonfatal injuries. Agricultural injuries place a heavy burden on families, farm operations, insurers, and the economy. The total national medical and productivity cost for agricultural injuries has been estimated at $4.57 billion annually.[1] Farm operations are complicated workplaces because farm properties often involve hazardous terrain, animals and crops, machinery, work buildings, as well as one or multiple homes. Farming can be a primary or secondary source of income as well as a hobby. In addition, farms range from very small to very large operations and can have a range of business registrations that vary by ownership status and business organization—each of which has implications for insurance coverage.

Workers' compensation insurance covers medical expenses and lost wages resulting from occupational injuries and illnesses.[2] Workers' compensation programs were established to cover costs of workplace injuries and to limit workers' rights to sue employers. Some studies have reported shifting of work-related injury costs from workers' compensation to other healthcare coverage and/or to workers themselves.[3-8] Coverage for agricultural injuries might be even more complicated than other workplaces because injuries could be covered by property, home, or personal health insurance, even

when the injury was occupational in nature. Although studies have reported cost-shifting from workers' compensation to other insurance coverage systems, the magnitude of this practice is not clear.[9,10] As a result of these factors, the performance metric of using workers' compensation claims to reliably capture work-related injuries is not known. In addition, it is not clear what types of factors are associated with the type of insurance used to cover the direct healthcare costs of an agricultural injury.

From the research perspective, understanding the characteristics of payer sources is important because insurance claims data are often used to identify the incidence of health conditions such as injuries. In particular, workers' compensation claims are a common source of information on work-related injury, including the identification of injury incidence, emerging injury trends, high-risk populations, and risk factors, and the evaluation of compensation policies and programs.[11-17] To the extent that other payer sources cover work-related injuries, reliance on workers' compensation data would lead to underestimates of workplace injury incidence and introduce bias in trend and risk factor analyses.

The use of workers' compensation claims as a research tool is also limited because of the variability in state laws, which hinders comparison and generalizability. A total of 31 states require that all agricultural operations regardless of size have workers' compensation insurance. Other states provide exemptions for agriculture. In the state of Iowa, all agricultural operations with a payroll exceeding $2500 must carry workers' compensation for their employees.[18] However, the employer's family members are exempt. Studies that utilize workers' compensation may suffer from potential self-selection since workers' compensation is not universally required of all agricultural operations. Therefore, studies that examine the utilization of workers' compensation, as well as other payer sources, are essential to understanding the scope of agricultural injury.

Using a state trauma registry that independently identifies farm status and occupational injuries, this study examines trends in payer sources. The first objective was to determine the sensitivity and specificity of workers' compensation as an indicator of work-related agriculture injuries compared with rural injuries from other industries. The second objective was to describe the distribution and characteristics of occupational injuries based on the payer, comparing agricultural and rural nonagricultural work-related rural injuries. Lastly, we aimed to investigate factors associated with length of hospital stay and hospital charges for agricultural and rural nonagricultural work-related injuries based on payer source.

2 | MATERIALS AND METHODS

2.1 | Data source and study populations

Data were from the Iowa State Trauma Registry, which is a statewide trauma patient database managed by the Iowa Department of Public Health. The trauma registry is the surveillance component used to measure the statewide performance of the Iowa Trauma System. The Trauma System encompasses all of the state's 122 acute care facilities, each accredited as providing trauma care at Level I, II, III, or IV. Trauma Level I facilities provide the highest level of care as well as leadership in education, research, and system planning; Level II trauma care facilities provide definitive trauma care for all levels of severity; Level III trauma care facilities provide stabilization for all trauma patients and may provide surgical and/or critical care when appropriate; and, Level IV trauma care facilities provide initial evaluation and stabilization, and may manage less severe trauma or transfer to a higher level of care if necessary.

Iowa trauma care facilities accredited as Level I, II, or III are required to report specific data about trauma patients to the Iowa Trauma Registry. Level IV facilities report on a voluntary basis, and each year approximately 50% of facilities submit data. To ensure consistency in the information collected, the Iowa Department of Public Health and the University of Iowa Injury Prevention Research Center provide a trauma registry data dictionary with training for all hospitals. Abstracted information from medical records is submitted by trauma nurses/registrars at each trauma care facility within 90 days of the injury and entered into the trauma registry. The University of Iowa Injury Prevention Research Center has served as the trauma system evaluator for many years and has access to the data through a Data Sharing Agreement (DSA 268).

The sample used in this study included patients treated from 2005 through 2013 who had a rural residence. Rural residence was identified through Rural-Urban Continuum Codes of 7 (small town core) to 10 (unincorporated). This group was then categorized based on whether the injury was agricultural or not. Agricultural injuries were defined as "a nonhousehold injury incurred on the farm (International Classification of Diseases [ICD], Clinical Modification, 9th edition, 849.1) by any farmer, farmworker, farm family member, or other individuals, or any nonfarm injury incurred by a farmer, farmworker, or farm family member in the course of handling, producing, processing, transporting, or warehousing farm commodities." The sample was also categorized based on whether the injury was work-related or not. An injury was defined as work-related if it occurred at a workplace or during an activity related to work-function (eg, traveling to a meeting). Of the 113 662 occupational injuries among rural patients in the trauma registry, there were 3935 (3.4%) agricultural injuries, 107 728 (94.8%) rural nonagricultural injuries, and 1999 (1.8) missing.

2.2 | Study variables

Patient variables included age, sex, and injury information. Injury variables included mechanism measured through external cause of injury ICD codes (machinery, transportation, fall, cut/pierce, struck by/against, and other), type of injury measured through ICD diagnosis codes (amputation, burn, crushing, dislocation/sprain, fracture, head injury/spinal cord injury/nerves, internal organ/blood vessels, open wound, other Injury), severity of injury measured by injury severity score (ISS), length of hospital stay, and hospital charges. ISS is an anatomically based consensus-driven scoring system that measures injury severity based on the threat to life in

trauma patients. ISS-based ISSs have been validated for predicting mortality and scores are categorized as mild (ISS = 1-8), moderate (ISS = 9-15), and severe (ISS = 16+). We further created three age groups: less than 18 years, 18 to 64 years, and 65+ years; and three injury severity groups: minor injuries (ISS = 1-8), moderate injuries (ISS = 9-15), and severe injuries (ISS = 16+).[19] Hospital trauma level based on the American College of Surgeons levels of I through IV, described above, was collected for each patient.[20]

Payer source was the main exposure variable in this analysis. Payer source was collected through the medical record as part of the trauma registry, and represent payers to which a claim was submitted. Payer source had 18 categories that were combined into five payer groups: public (Medicare, Medicare/Medicaid, Medicaid, welfare, other federal government, other local government, and other state government, CHAMPUS, CHAMPUS/VA); private (HMO, PPO, self-insured, auto insurance, commercial insurance); uninsured (charity, no charge, and self pay); other (research fund, teaching fund, victim's fund, other), and workers' compensation as a separate fifth category. Employer-provided health insurance would be classified as private insurance. An injury hospitalization could be billed to five separate payer sources. Of the total sample size (113 662), 22.9% and 81.3% had unknown/missing responses for the first payer and second payer sources, respectively. Because a missing response on the second payer source could mean there was no other payer, we limited our analysis to the primary payer source (first payer). However, we used workers' compensation information from any of the five payer fields to ensure complete information on workers' compensation payer. Workers' compensation was the second payer source for fewer than 3% of cases.

2.3 | Statistical analysis

The data showed a relatively high percentage of missing data (22.9%) on the main exposure, primary payer source. Missingness was differential by work-relatedness of injury (main outcome), patient age, sex, injury severity, type of injury, hospital level, and calendar year, suggesting that the primary payer source was missing in a nonrandom manner. Because the main outcome (ie, work-related injury) was fully observed, we used multiple imputations of five simulated datasets for this analysis.[21] Variables incorporated into the imputation model included age, sex, the severity of the injury, length of hospital stay, trauma care level, primary payer, hospital charges, type of injury, year of hospitalization, and survival status at discharge (alive or deceased).

We determined the sensitivity and specificity of the use of workers' compensation to identify work-relatedness of an injury, calculated separately for agricultural and rural nonagricultural injuries. Sensitivity and specificity were calculated using the trauma registry designation of work-relatedness as the gold standard. Sensitivity measured the probability of correctly identifying a true work-related injury (an accepted case definition of the trauma registry) by workers' compensation as a payer source. Specificity measured the proportion of nonwork-related injuries that were correctly identified as such by workers' compensation.

To examine the distribution of payer sources for work-related injuries based on whether they were agricultural or not, we further restricted our analysis to only work-related injuries. Of the 9079 work-related injuries, there were 2074 (22.8%) agricultural injuries; 6816 (75.1%) rural nonagricultural injuries; and 189 (2.1%) missing. This subset of patients was also used to examine factors associated with workers' compensation use and to investigate factors related to the length of hospital stay and hospital charges. We calculated the percentages of work-related injuries billed to each payer source. We reported the uncertainty around these percentages as well as the uncertainty around the sensitivity and specificity to account for the use of five imputed datasets described above.

Adjusted logistic regression models were used to examine factors associated with the odds of work-related injury hospitalization being billed to workers' compensation. Adjusted models included age, sex, the severity of the injury, mechanism of injury, and trauma care level. We found that hospital charges were not normally distributed and corrected this through a log transformation. All analyses were conducted in SAS (version 9.4; SAS Institute, Cary, NC).

3 | RESULTS

Table 1 shows the sensitivity and specificity of using workers' compensation to identify work-related injuries that required acute care. For rural nonagricultural occupational injuries, the sensitivity was 64.2%, which indicates that of all occupational injuries 33.8% would not be identified by using workers' compensation as a defining criterion. A sensitivity of 18.5% was much lower for agricultural work-related injuries, indicating that 81.5% of such injuries would not be identified through workers' compensation claims databases (high proportion of false negatives). However, the specificity of workers' compensation was high for both agricultural (98.8%) and rural nonagricultural injuries (95.5%), suggesting that few nonworkplace injuries have workers' compensation as a payer source (low proportion of false positives).

Figure 1 shows the percentages of injury hospitalizations billed to different categories of payer source. Among work-related injuries, workers' compensation was less frequently used as a payer source for agricultural injuries compared with rural nonagricultural injuries. A higher proportion (39.6%) of agricultural injuries was paid by private insurance (HMO, PPO, self-insured, auto insurance, commercial insurance). Public sources were the second most frequent payer of agricultural injuries (21.4%). Other work-related rural injuries were most frequently covered by workers' compensation (65.2%), followed by private insurance (12.3%).

For both males and females, fewer than 20% of agricultural work-related injuries were billed to workers' compensation insurance (Table 2). In agriculture, a higher proportion (not statistically significant) of men's occupational injuries was charged to workers' compensation (19.1%) than women (16.7%). In other industries, 70.1% of women's and 64.3% of men's occupational injuries had workers' compensation as the payer ($P < .05$). Minors less than 18 years of age

TABLE 1 Sensitivity and specificity of using workers' compensation to predict work-related injury

	Agricultural occupational injuries		Rural nonagricultural occupational injuries	
	Sensitivity (%) and 95% confidence intervals	Specificity (%) and 95% confidence intervals	Sensitivity (%) and 95% confidence intervals	Specificity (%) and 95% confidence intervals
All	18.5 (16.8, 20.2)[a]	98.8 (98.3, 99.3)[b]	64.2 (63.1, 65.4)[a]	99.5 (99.4, 99.5)[b]
By subgroups				
Male	18.8 (17.0, 20.5)	98.8 (98.1, 99.4)	63.4 (62.2, 64.7)	99.3 (99.3, 99.4)
Female	15.8 (10.0, 21.5)	99.1 (98.2, 100.0)	69.0 (66.0, 72.0)	99.6 (99.6, 99.7)
Age (y) <18	10.8 (1.5, 20.0)	99.7 (99.2, 100.0)	39.6 (23.4, 55.7)	99.8 (99.7, 99.9)
18-64	21.6 (19.3, 24.0)	98.8 (98.2, 99.5)	65.1 (63.9, 66.3)	99.2 (99.1, 99.3)
65+	7.1 (4.4, 9.8)	99.6 (98.9, 100.0)	54.5 (49.5, 59.5)	99.8 (99.7, 99.8)
Injury severity: minor[c]	18.6 (16.4, 20.7)	99.0 (98.4, 99.6)	66.7 (65.3, 68.1)	99.4 (99.3, 99.5)
Injury severity: moderate	17.3 (13.5, 21.1)	98.3 (96.9, 99.7)	61.6 (58.8, 64.3)	99.5 (99.4, 99.6)
Injury severity: severe	20.5 (15.3, 25.7)	98.8 (97.1, 100.0)	54.9 (51.2, 58.5)	99.6 (99.4, 99.7)

Abbreviation: ISS, injury severity score.

[a]Indicates that 82.5% of agricultural work-related injuries and 35.8% of rural nonagricultural work-related injuries would not be identified as work-related if using workers' compensation as a defining criterion (high proportion of false negatives).

[b]Indicates that 1.2% of agricultural nonwork-related injuries and 0.5% of rural nonagricultural nonwork-related injuries would be identified as work-related if using workers' compensation as a defining criterion (low proportion false positives).

[c]Injury severity was determined by the ISS, with scores of 1-8 as minor, 9-15 as moderate, and 16 and above as severe.

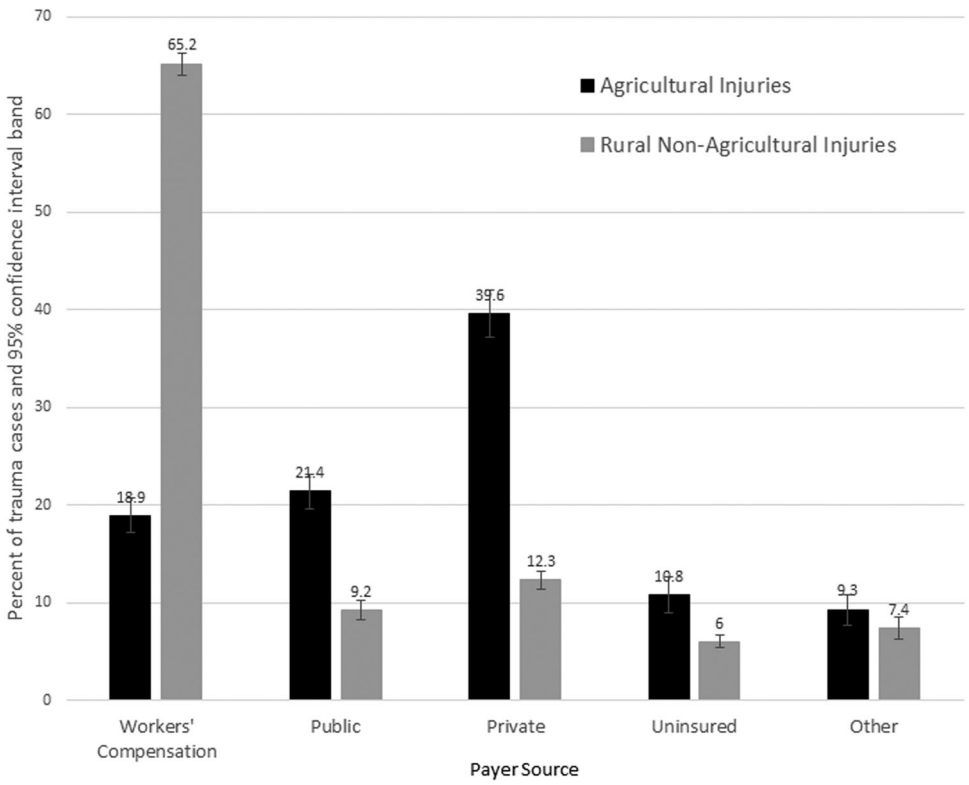

FIGURE 1 Frequency distributions of agricultural versus rural nonagricultural occupational injuries by payer source and 95% confidence interval

TABLE 2 Characteristics of agricultural and nonagricultural occupational injuries by mechanism, severity, and type

	Agricultural occupational injuries			Rural nonagricultural occupational injuries		
Variables	Workers' compensation N (row %)	Nonworkers' compensation N (row %)	All N	Workers' compensation N (row %)	Nonworkers' compensation N (row %)	All N
Sex[a]						
Male	373 (19.1)	1583 (80.9)	1956	3826 (64.3)	2124 (35.7)	5950
Female	27 (16.7)	135 (83.3)	162	709 (70.1)	302 (29.9)	1011
All	400 (18.9)	1718 (81.1)	2118	4535 (65.1)	2426 (34.9)	6961
Age[a,b](y)						
<18	6 (12.0)	44 (88.0)	50	23 (53.5)	20 (46.5)	43
18-64	369 (21.8)	1324 (78.2)	1693	4286 (65.8)	2230 (34.2)	6516
65+	25 (6.7)	350 (93.3)	375	226 (56.2)	176 (43.8)	402
All	400 (18.9)	1718 (81.1)	2118	4535 (65.1)	2426 (34.9)	6961
Injury severity[a]						
Minor	270 (19.0)	1150 (81.0)	1420	3134 (67.6)	1500 (32.4)	4634
Moderate	82 (18.2)	368 (81.8)	450	958 (62.3)	580 (37.7)	1538
Severe	48 (19.4)	200 (80.6)	248	443 (56.1)	346 (43.9)	789
All	400 (18.9)	1718 (81.1)	2118	4535 (65.1)	2426 (34.9)	6961
Mechanism[a,b]						
Machinery	69 (16.8)	342 (83.2)	411	758 (74.6)	258 (25.4)	1016
Transportation	49 (17.0)	239 (83.0)	288	616 (62.5)	369 (37.5)	985
Fall	96 (23.2)	317 (76.8)	413	1576 (63.0)	927 (37.0)	2503
Cut/pierce	18 (16.7)	90 (83.3)	108	317 (63.8)	180 (36.2)	497
Struck by/against	56 (19.7)	228 (80.3)	284	497 (68.8)	225 (31.2)	722
Other[c]	112 (18.2)	502 (81.8)	614	771 (62.3)	467 (37.7)	1238
All	400 (18.9)	1718 (81.1)	2118	4535 (65.1)	2426 (34.9)	6961
Type[a,b]						
Amputation	23 (28.8)	57 (71.2)	80	311 (76.4)	96 (23.6)	407
Burn	15 (15.8)	80 (84.2)	95	218 (50.8)	211 (49.2)	429
Crushing	19 (27.9)	49 (72.1)	68	239 (74.9)	80 (25.1)	319
Dislocation/sprain	29 (17.8)	134 (82.2)	163	203 (59.4)	139 (40.6)	342
Fracture	136 (18.6)	596 (81.4)	732	1986 (67.7)	946 (32.3)	2932
Head/spinal cord	59 (22.4)	204 (77.6)	263	630 (61.0)	403 (39.0)	1033
Internal organ	26 (19.4)	108 (80.6)	134	209 (60.6)	136 (39.4)	345
Open wound	51 (14.6)	298 (85.4)	349	503 (66.4)	254 (33.6)	757
Other injury	42 (17.9)	192 (82.1)	234	236 (59.4)	161 (40.6)	397
All	400 (18.9)	1718 (81.1)	2118	4535 (65.1)	2426 (34.9)	6961

[a]Comparison of rural nonagricultural injuries is significant ($P < .05$).
[b]Comparison of agricultural injuries is significant ($P < .05$).
[c]Other = fire/burn, natural environment, and unspecified.

(12.0%) and workers over age 65 years (6.7%) were also less likely to have workers' compensation as a payer. Age differences were significant for both agricultural and rural nonagricultural injuries. Among agricultural injury mechanisms, falls had the highest proportion billed to workers' compensation (23.2%) and cutting/piercing injuries (16.7%) and machinery (16.8%) the lowest ($P < .05$). In contrast, among rural nonagricultural occupational injuries, machinery had the highest proportion billed to workers' compensation (74.6%) with transportation (62.5%) and falls (63.0%) the lowest ($P < .05$). For both agricultural and rural nonagricultural occupational injuries, amputation, and crushing injuries had the highest proportion of workers' compensation as a payer source. Burns were the least likely to use workers' compensation.

Table 3 shows the percent difference in hospital charges for factors associated with work-related agricultural and rural nonagricultural injuries that required acute care. For example, compared with public payers, average charges for agricultural injuries paid by workers' compensation were 77% less and for rural nonagricultural injuries were 59.8% less. Severity of injury, payer source, and trauma care level were associated with hospital charges in both models. Higher levels of care and higher severity of injury were associated with larger hospital charges. Compared with public coverage, workers' compensation and private insurance coverage were associated with lower hospital charges. The data show that age and sex were not associated with hospital charges.

Table 4 shows factors associated with occupational injuries billed to workers' compensation insurance. For both work-related agricultural and rural nonagricultural injuries, older adults were less likely to have work-related injuries covered by workers' compensation. Compared with hospital Level IV (community hospitals), hospitals Levels II and III were more likely to have work-related injuries billed to workers' compensation. The rural nonagricultural injury data showed that the most severe injuries as well as injuries resulting from fall, cut/pierce, and other mechanisms (fire, burn, environment,

TABLE 3 Percentage differences in hospital charges for characteristics of work-related agricultural and nonagricultural injuries

Variables	Agricultural occupational injuries		Rural nonagricultural occupational injuries	
	Percent difference in hospital charges (95% CI)[a]	*P* value	Percent difference in hospital charges (95% CI)[a]	*P* value
Payer				
Workers' compensation	−77.26 (−110.83, −43.70)	<.0001	−59.79 (−79.28, −40.31)	<.0001
Private	−75.84 (−111.29, −40.40)	<.0001	−53.22 (−77.41, −29.05)	.0006
Uninsured	−14.44 (−58.58, 29.71)	.49	−41.57 (−61.29, −21.85)	.0001
Other	13.69 (−28.72, 56.09)	.50	13.41 (−10.15, 36.97)	.24
Public (ref)	0.00		0.00	
Age (y)				
<18	13.50 (−35.72, 62.72)	.59	−2.99 (−53.38, 47.40)	.90
18-64 (ref)	0.00		0.00	
65+	−20.64 (−55.13, 13.85)	.22	−20.45 (−34.35, −6.55)	.0041
Sex (male)	11.01 (−15.30, 37.31)	.42	−3.90 (−12.39, 4.59)	.37
Injury severity				
Minor (ref)	0.00		0.00	
Moderate	64.77 (36.73, 92.82)	.0002	47.92 (39.28, 56.58)	<.0001
Severe	118.28 (93.59, 142.97)	<.0001	93.67 (83.53, 103.82)	<.0001
Mechanism				
Machinery	31.41 (5.41, 57.42)	.02	−8.12 (−20.78, 4.53)	.21
Transportation	19.80 (−9.28, 48.48)	.18	6.09 (−6.36, 18.54)	.34
Fall	21.05 (−3.62, 45.72)	.09	6.53 (−4.71, 17.77)	.25
Cut/pierce	−9.57 (−50.61, 31.47)	.64	−29.03 (−46.14, −11.92)	.001
Other	2.86 (−22.99, 28.72)	.83	−20.20 (−31.97, −8.43)	<.0001
Struck by/against (ref.)	0.00		0.00	
Trauma care level[b]				
I	118.67 (97.03, 140.32)	<.0001	70.67 (58.73, 82.61)	<.0001
II	106.24 (84.05, 128.43)	<.0001	32.88 (21.35, 44.41)	<.0001
III	38.58 (18.40, 58.62)	.0002	16.63 (4.70, 28.57)	.0066
IV (ref)	0.00		0.00	

Abbreviation: CI, confidence interval.
[a]Percent difference indicates the percentage change compared with the reference.
[b]See text for definition.

etc) were less likely to be billed to workers' compensation compared with minor injuries and injuries resulting from struck by/against, respectively. The results from the rural nonagricultural injury data also showed that injuries treated at a Level I hospital were less likely to bill work-related injuries to workers' compensation compared with Level IV.

4 | DISCUSSION

Based on its low sensitivity, workers' compensation as a payer source would not be a good measure to identify all work-related injuries that require acute care. In particular, workers' compensation would fail to identify 71.5% of work-related agricultural injuries and 35.7% of rural nonagricultural injuries. However, those injuries identified through workers' compensation would be accurately identified as work-related, as indicated by its high specificity. Consistent with previous results, workers' compensation data do not provide an accurate measure of injury incidence. In a study conducted in the state of Washington, 27.4% of work-related injuries did not have workers' compensation listed as a payer.[9] An analysis of the Illinois trauma registry showed that 25% of occupational injuries did not have workers' compensation listed as a payer.[22] Other studies based on hospital discharge or emergency department data have also reported a considerable fraction (20%) of occupational injuries not covered by workers' compensation programs.[23,24] In contrast, Canada, with a national workers' compensation insurance program, reported that 95% of work-related injuries were covered by the national system.[25] No previous studies have examined agricultural injuries specifically. Our findings show that agricultural work-related injuries are far less likely than other industries to use workers' compensation as a payer source.

Compared with other studies, the sensitivity of workers' compensation for the rural nonagricultural injuries was also low, at 64.2%. Studies of other workplace injuries have reported workers' compensation sensitivity to be higher, including a study of a sample of patients from New Jersey's hospital discharge database that found workers' compensation sensitivity of 83%.[23] A study of the Washington state trauma registry found that 73% of work-related injuries listed workers' compensation as the payer.[9] This suggests that perhaps rural workplaces are less likely to have workers' compensation coverage, which is possible given the higher proportion of very small businesses. These studies, as well as this one, all included only injuries that required medical care.

TABLE 4 Characteristics associated with worker's compensation used as a payer source, compared with all other sources, for work-related agricultural and nonagricultural injuries

	Agricultural occupational injuries	Rural nonagricultural occupational injuries
Variables	**aORs and 95% CI**	**aORs and 95% CI**
Age		
<18	0.46 (0.17, 1.22)	0.62 (0.32, 1.21)
18-64 (ref)	1.00	1.00
65+	0.24 (0.15, 0.38)	0.68 (0.54, 0.85)
Sex		
Male	1.19 (0.74, 1.91)	0.77 (0.65, 0.90)
Female	1.00	1.00
Injury severity		
Minor (ref)	1.00	1.00
Moderate	0.92 (0.67, 1.28)	0.91 (0.79, 1.05)
Severe	0.95 (0.63, 1.43)	0.76 (0.63, 0.93)
Mechanism		
Machinery	0.68 (0.42, 1.09)	1.21 (0.96, 1.52)
Transportation	0.80 (0.50, 1.27)	0.81 (0.65, 1.01)
Fall	1.20 (0.77, 1.86)	0.70 (0.58, 0.84)
Cut/pierce	0.71 (0.38, 1.32)	0.69 (0.53, 0.90)
Other	0.93 (0.61, 1.41)	0.76 (0.61, 0.95)
Struck by/against (ref)	1.00	1.00
Trauma care level[a]		
I	0.96 (0.67, 1.37)	0.81 (0.68, 0.97)
II	4.23 (3.08, 5.81)	3.79 (3.16, 4.55)
III	1.28 (0.90, 1.81)	2.25 (1.88, 2.69)
IV (ref)	1.00	1.00

Abbreviations: aORs, adjusted odds ratios; CI, confidence interval.
[a]See text for definition.

The agricultural industry is complex. Most US farms are family-owned and operated, with a high proportion of sole-proprietor family farms and relatively fewer operated via trusts and corporations.[26] Businesses operating through trusts and corporations have requirements to cover employees by workers' compensation and a variety of insurance options to purchase coverage. All employees of the business are covered. However, farmers who operate as sole proprietors or partnerships are self-employed and have no workers' compensation requirements; and therefore, have the option of obtaining personal insurance to have some coverage in the event of injury. In the State of Iowa, sole proprietors and limited liability company members are not required to purchase workers' compensation insurance but may choose to cover themselves.[18] Adding to the complexity, certain types of workers are exempted by the State of Iowa from mandatory coverage by workers' compensation insurance, including domestic/casual workers who make under $1500 from their employer during the last year before injury; agricultural workers whose employer has a cash payroll of less than $2500 in the year before the injury; agricultural exchange labor; and, officers of a family farm corporation as well as their family members.[18] Optional coverage such as a commercial provider and self-insurance are available for some approved businesses.

Furthermore, the medical costs of work-related injuries might not be covered by workers' compensation programs if adjudication determines the injury is not work-related.[27] If claimants need to delay medical treatment after a claim has been filed, the medical costs are likely to be paid by other payers or the injured workers themselves. Several studies have reported a significant portion of work-related injuries that were assigned zero-cost workers' compensation medical claims due to delayed care. For example, 15.9% of workers' compensation claimants had zero-cost medical claims in an analysis of administrative data of 16 employers across the United States.[27] Other studies have also reported the issue of zero-cost workers' compensation medical claims.[28-33] The zero-cost workers' compensation medical claims are commonly seen in less-acute injuries.[31] We also found that workers' compensation had the lowest charges for all payer sources, with workers' compensation compared with public sources 77% and 60% lower. These lower charges may serve as a disincentive for healthcare facilities to send claims to workers' compensation insurers.

We found that both agricultural work-related injuries and rural nonagricultural work-related injuries not paid by workers' compensation were associated with older age. This finding is consistent with the results from another study showing older workers were much more likely to have their work-related injury hospitalizations billed to a nonworkers' compensation payer.[10] In general, older workers have Medicare coverage as typical health insurance beginning at age 65. This may make it easier for employers to shift their occupational injury costs from workers' compensation to Medicare. From the perspective of Medicare, if an older worker with Medicare gets injured on the job, workers' compensation pays first on healthcare services.[34] Therefore, workers' compensation should be the primary payer for occupational injuries in workers with Medicare. The high likelihood of occupational injuries billed to a nonworkers' compensation payer among older workers deserves further attention to determine whether financial drivers are influencing billing decisions or if other factors are contributing. It is possible that the presence of comorbidities, often common in the elderly, may interfere with the attribution of work-relatedness to an injury in an older worker. It is also possible that older workers have more resources to draw on for health and income benefits than workers' compensation benefits. This latter explanation is supported by a study of occupational injuries showing that higher income and older age were associated with not filing for a compensation claim.[35] This type of cost-shifting will have a much greater impact in industries with a high proportion of workers over the age of Medicare eligibility, such as agriculture, which has a very high proportion of workers over the age of 65.

From the perspective of occupational injury surveillance, workers' compensation claims data sources can lead to an underestimate the incidence of work-related injuries and introduce bias into research studies. Understanding the limitations of the use of workers' compensation to ascertain work-related injuries can help researchers identify potential biases, as well as justifying the use of multiple data sources to better capture work-related injuries.

From the policy perspective, the role of workers' compensation in farm operations requires consideration because of the complexities of determining premiums and charge schedules. Workers' compensation introduces incentives to reduce injuries through the premiums paid on coverage, which are often determined based on the number and severity of injuries (eg, if injuries are low, premiums will be low).[36] Although workplaces also have incentives to reduce charges to employer-provided health insurance, these costs are not tied to workplace safety through premium negotiations.

To our knowledge, this was the first study to assess whether there is a difference in the ability of workers' compensation insurance to capture work-related injuries occurring in the agricultural industry compared with other occupational industries. Our use of the state trauma registry offered a more complete method for capturing occupational injuries because the trauma registry has a specific feature for identification of agricultural and nonagricultural injuries and work-related and nonwork-related injuries. The trauma registry has five payer fields, and we were careful to include workers' compensation from any fields. Most of the factors associated with the occupational injury not billed to workers' compensation were similar to those observed in other studies, lending robustness to our findings.

Perhaps the most important limitation of this study is generalizability because injuries treated in hospitals generally represent the most severe injuries. It remains possible that this study was unable to capture the full burden of occupational injuries. These data are from a single state, and each state has its own policies and organization for workers' compensation coverage. Thus, generalizability to other states is limited. We were not able to measure information bias regarding inaccurate reporting of an injury event as truly meeting the criteria of a work-related injury. Our analysis focused exclusively on occupational injuries. The analytic sample in this study included occupational injuries that required acute medical care, most often through an Emergency Department. Many workers' compensation injuries are seen in occupational clinics, when available, or other types of settings. Thus, these findings reflect only the most severe occupational injuries. The potential for workers' compensation to under-represent occupational illness may be similar or even larger (since illnesses are less likely to be tied to occupation than injuries).[37,38] We conducted multiple imputations as the best way to account for data missing at random, but any time imputation is used bias may be introduced.

The results of this study indicate that workers' compensation is not an accurate source to identify the incidence of work-related injuries, especially in the agricultural industry. Workers' compensation samples could be biased in their representation of injured workers by age, injury severity, and mechanism of injury.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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Rodney Ehrlich declares that he has no conflict of interest in the review and publication decision regarding this article.

AUTHORS CONTRIBUTIONS

CPA conceptualized the work, and CM, BW, and MR contributed to the analytic plan. CPA acquired the data, CM conducted the analysis, and all authors contributed to the interpretation of the findings. CM and CPA developed an outline for the manuscript and CM created the first draft. All authors have contributed to and approved the final version, and all authors are accountable for this work.

ETHICS STATEMENT

This project was approved by the University of Iowa Human Subjects Office. Data were obtained through a Data Use Agreement with the Iowa Department of Public Health.

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