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Tractor-Related Injuries: An Analysis of Workers' Compensation Data

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ABSTRACT. Previous studies have reported that tractors are responsible for high proportions of fatal and nonfatal agricultural injuries. However, many common and preventable risk factors, conditions, and associated costs related to tractor-related injuries have not been investigated. This case-based study used workers' compensation data to investigate tractor-related injuries. The objectives of this study were to (1) identify and describe tractor-related injuries, (2) assess medical and indemnity costs associated with tractor-related injuries, and (3) determine contributing factors associated with those injuries. Tractor-related injury claims data from Colorado workers' compensation records were analyzed for a 12-year period (1992–2004). Descriptive analyses of the costs, characteristics, and contributing factors associated with tractor-related injuries were conducted. The epidemiological agent-host-environment model was used to analyze injury event descriptions. A total of 23,484 agricultural-related injury claims were analyzed. Through an event description analysis, a total of 642 claims were identified as being tractor-related. Over 60% of tractor-related claims involved sprains/strains and contusions. A total of 21% of tractor-related claims were associated with the worker mounting or dismounting a tractor, and an additional 10% of claims were associated with the worker falling, jumping, or slipping off a tractor. Among all claims associated with tractor mounting or dismounting, 35% involved the ankle and 15% involved the knee. Nearly three-quarters of tractor-related claims were medical-only claims. The median medical claim cost was \$319, and the median medical plus indemnity claim cost was \$335. Claim costs associated with tractor-overturn injuries were higher than tractor-related injury claims in general. This study

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determined that a large percentage of tractor-related injury claims were associated with tractor mounting and dismounting. These findings are consistent with previous research and suggest the need to further investigate tractor design criteria related to mounting and dismounting.

KEYWORDS. Agriculture, injury, tractor, workers' compensation

INTRODUCTION

Agricultural work involves tasks that expose workers to a high risk of injuries and fatalities.^{1,2} The development of effective injury prevention strategies has been hampered by a lack of data regarding agricultural injury characteristics and contributing factors.¹ This lack of information regarding agricultural injuries has been recognized as an obstacle in the development of effective injury prevention measures. The major causes of agricultural injuries consistently reported in the literature include farm machinery, falls, and livestock-handling.^{1,2}

Previous studies have reported machinery is a primary cause of farm-related injuries^{3,4} and the cause of death or disability in many cases.^{5,6} Tractor overturns have been reported as the primary cause of agricultural work-related fatalities.^{5,7} Although tractors are consistently identified as a major source of agricultural injuries, many studies present tractors and machinery as one category, limiting the specificity of risk factor identification that can be attributed to tractors.⁸ Information is limited regarding the spectrum of tractor-related injuries, including nonfatal events.⁹

This paper presents a case-based study that investigated tractor-related injuries. The objectives of this study were to analyze workers' compensation data to (1) identify and describe tractor-related injuries, (2) assess medical and indemnity costs associated with tractor-related injuries, and (3) determine contributing factors associated with tractor-related injuries.

METHODS

Colorado Workers' Compensation

The Colorado Division of Workers' Compensation requires all employers to maintain

workers' compensation coverage if they employ one or more employees. Business owners and corporate officers are not required to maintain workers' compensation coverage for themselves. Workers' compensation benefits include payment for medical expenses, wage-replacement, permanent impairment or disfigurement, and death benefits. Wage-replacement benefits (indemnity) include payment of lost wages, up to two-thirds of the injured worker's normal earnings. An injured worker was eligible for indemnity benefits after three lost days of work due to injury.

Data Sample and Source

Electronic injury claims data were provided by Pinnacol Assurance (Colorado), the largest state workers' compensation insurer. Pinnacol Assurance provides coverage for more than 50% of Colorado agriculture operations that are required by law to maintain a policy of workers' compensation coverage. The claim data set included injuries occurring in Colorado from January 1, 1992, through December 31, 2004. Injury claims were derived from First Reports of Injury. Completion of a First Report of Injury was a workers' compensation administrative requirement when filing an injury claim, and information was provided directly by the injured or by their foreman, supervisor, or business owner. Injury characteristic data included injury source, cause, nature, and body part. Injury sources included origins of energy that ultimately was transferred to the worker resulting in injury. Injury causes included methods of energy transferred to the worker resulting in injury. Injury natures included types of injury. Body part injured included the anatomical location of an injury. A description of the injury event taken from the First Report of Injury provided a narrative account of the injury event. Each injury claim included medical and indemnity cost data.

Data Collection

The database was queried by the workers' compensation provider with the goal of capturing all tractor-related claims. All claims in the Standard Industrial Classification (SIC) group Agriculture Production-Crops (SIC code 01) were queried. Claims data were extracted from Oracle (Redwood Shores, CA) relational databases using Hyperion Explorer 6.6.4 (Sunnyvale, CA). Strict confidentiality of all injury data was enforced throughout the investigation, and personal identifiers were removed prior to transmission of data to the investigators. The Colorado State University Human Subjects Review Committee reviewed and approved this study.

Identification of Tractor-Related Injuries

The claims data set did not include "tractor" as a possible injury source classification. The source of injury for tractor-related claims was classified as "machinery." Therefore, event descriptions were reviewed to determine tractor-relatedness. A keyword search was conducted on each event description. Possible tractor-related claims were identified by locating the keywords "tractor," "truck," "steering," "driver," "driving," "climbing," "riding," "implement," "control," "trailer," "run over," "snow plow," "rolled," "rollover," "flipped," "hill," "incline," "throw," "tipped," and "tip over." Keywords were selected a priori by the research team based on an evaluation of a sample of claims, existing literature and personal knowledge. After keyword identification, each event description was reviewed to determine tractor-relatedness.

Data Analysis

Descriptive analyses included the frequency of claims by injury nature, body part, and month of injury. Descriptive analyses were also performed on the costs (medical and indemnity) associated with each tractor-related claim. Event descriptions were analyzed using the classic agent-host-environment epidemiological model¹⁰ to identify contributing factors of tractor-related injuries. According to this model, an

injury is the product of an interaction of the *host* (i.e., person injured), an *agent* (e.g., mechanical energy such as a rotating power take-off shaft) that injures, and the *environment* (e.g., snow or ice on ground) that promoted the exposure. Agents of injury have been identified as various forms of energy: mechanical, thermal, chemical, electrical, ionizing radiation, or lack of life-sustaining elements as in the case of asphyxiation.¹¹ A *vector* or *vehicle* transmits the energy from the agent to the host (e.g., tractor or tractor part). Each contributing factor in each event description was classified. To our knowledge, this is the first study to apply this model to investigate agricultural tractor-related injuries using workers' compensation data.

RESULTS

A total of 23,484 agricultural-related injury claims from 1992 to 2004 were analyzed. Through an event description analysis, a total of 642 claims were identified as being tractor-related. Among these tractor-related injuries, 13 involved tractor-overturns including one fatality.

Injury Characteristics

Body parts most frequently injured from tractor-related events were the hand (18.5%), foot (18.4%), spine/back (13.6%), leg (13.2%), arm (8.7%), and face (8.1%) (Table 1). Of the 130 mounting/dismounting related injuries, 35% involved the ankle and 15% involved the knee. Tractor-related injuries with the highest frequencies included sprains/strains (35.2%), contusions (25.2%), lacerations (10.0%), and fractures (8.7%). Strain (i.e., overexertion) injuries accounted for 24.8% of tractor-related injury claims, and fall or slip events accounted for 20%. Seventeen percent of overexertion injuries were caused by lifting, 14.5% by twisting, and 8.2% by pushing or pulling. The highest proportion of tractor-related injuries (65.8%) occurred from April through September, whereas a quarter of injuries occurred in May and June. Only 19.3% of injuries occurred from November through February.

TABLE 1. Body Part Locations of 642 Tractor-Related Injuries Among Colorado Agriculture Workers

Body part group	Body part	<i>n</i>	%	<i>n</i>	%
Arm	Elbow	11	1.7		
	Lower arm	13	2.0		
	Shoulder(s)	16	2.5		
	Upper arm (incl. clavicle and scapula)	16	2.5		
Arm total				56	8.7
Chest (incl ribs, sternum, soft tissue)					
Face	Ear(s)	1	0.2		
	Eye(s)	29	4.5		
	Mouth	3	0.5		
	Nose	2	0.3		
	Other facial soft tissue	13	2.0		
	Teeth	4	0.6		
Face total				52	8.1
Foot	Ankle	58	9.0		
	Foot	48	7.5		
	Toe(s)	12	1.9		
Foot total				118	18.4
Hand	Finger(s)	64	10.0		
	Hand	28	4.4		
	Thumb	17	2.6		
	Wrist	10	1.6		
Hand total				119	18.5
Internal organs	Heart	1	0.2		
	Internal organs	9	1.4		
Internal organs total				10	1.6
Leg	Hip	6	0.9		
	Knee	52	8.1		
	Lower leg	24	3.7		
	Upper leg	3	0.5		
Leg total				85	13.2
Lower trunk	Abdomen including groin	6	0.9		
	Buttocks	1	0.2		
	Pelvis	2	0.3		
Lower trunk total				9	1.4
Multiple areas		28	4.4	28	4.4
Multiple head injury		7	1.1	7	1.1
Multiple lower extremities		3	0.5	3	0.5
Multiple trunk		9	1.4	9	1.4
Multiple upper extremities		9	1.4	9	1.4
Neck	Multiple neck injury	13	2.0		
	Neck, soft tissue	4	0.6		
Neck total				17	2.6
Skull		9	1.4	9	1.4
Spine/back	Disc	2	0.3		
	Low back (lumbar & lumbo-sacral)	77	12.0		
	Neck vertebrae	4	0.6		
	Upper back area	4	0.6		
	Spine/back total			87	13.6
Totals		642	100.0	642	100.0

Claim Costs

Nearly three-quarters of the 642 tractor-related injuries were medical-only claims (71.8%, 461 claims) (Table 2). The median medical claim cost was \$319, and the median indemnity claim cost was \$0. The median medical plus indemnity cost total for all tractor-related injury claims was \$335. The median medical plus indemnity cost of injuries to the ankle and knee associated with tractor mounting and dismounting was \$402 and \$595, respectively. The median medical plus indemnity cost for tractor overturn claims was \$338.

A more detailed analysis of high-cost claims was conducted. All claims ranked in the 75th percentile based on total claim cost (i.e., medical plus indemnity) were classified as high-cost claims. A total of 161 claims were classified as high-cost. High-cost tractor-related injury claims were associated with the lower extremity (31.0%) and upper extremity (29.2%). Nearly 17% of high-cost claims were associated with the

spine/back. High-cost claims were also associated with sprains/strains (33.0%), fractures (18.0%), contusions (15.5%), and lacerations (6.8%).

Contributing Factors

Analysis of event descriptions identified contributing factors associated with tractor-related injuries (Table 3). An average 3.9 factors from each event description were identified. Over 15% of claims involved the worker performing tractor maintenance or repair. Nearly 8% of claims involved attachment of an implement and 7% of claims driving a tractor. Twenty-one percent of injury claims were associated with the worker mounting or dismounting the tractor. Ten percent of claims were associated with the worker falling, jumping, or slipping off a tractor. Two percent of injury claims were associated with a tractor bucket hitting a worker, and only 2% of claims were associated with a tractor-overturn. A weather-related factor was mentioned in 5% of the claims, and 4.5% of claims mentioned a terrain factor. Despite limited environmental information, cold, ice, snow, mud, and driving on slopes or over holes were frequently mentioned as contributing factors. Seven of the 13 tractor-overturns involved driving on an incline or slope.

TABLE 2. Cost of Tractor-Related and Tractor Overturn Injuries Among Colorado Agriculture Workers

	Tractor-related	Tractor overturn only
Total claims	642	13
Total medical-only claims	461	8
Total medical plus indemnity claims	181	5
Injury costs ^a		
Medical ^b		
Mean	2,582	4,481
Median	319	288
Range	0–91,404	0–49,639
Indemnity		
Mean	4,932	24,283
Median	0	0
Range	0–353,739	0–261,523
Medical plus indemnity total		
Mean	8,361	28,764
Median	335	338
Range	0–461,231	0–261,523

^aMeans, medians, and standard deviations rounded to nearest whole dollar.

^bAdjusted to 2007 U.S. dollars.

DISCUSSION

Workers' compensation data have been used to investigate agricultural injuries.^{12–14} The present study was the first to analyze workers' compensation data to investigate agricultural tractor-related injuries. This study provided information on the characteristics, costs, and contributing factors associated with tractor-related injury claims among hired agricultural workers. The present study determined that a wide variety of tractor-related injuries were associated with numerous body parts. Sprains/strains and contusions were the two most frequent types of tractor-related injuries, accounting for over 60% of claims combined. Tractor-related injury claims most frequently involved the lower extremity.

TABLE 3. Contributing Factors of 642 Tractor-Related Injury Claims Among Colorado Agriculture Workers

Host (worker)	n	%	Agent (tractor)	n	%	Environment	n	%
Job activity			Tractor action			Weather conditions		
Performing maintenance on tractor	97	15.1	Rollover	13	2.0	Cold	12	1.9
Hitching implement or equipment	48	7.5	Bucket hit body part	15	2.3	Ice	8	1.2
Driving tractor	46	7.2	Tires rolled over body part	8	1.2	Snow	5	0.8
Mowing/harvesting/ planting/watering	10	1.6	Went into ditch	5	0.8	Dusty	5	0.8
Engaging/disengaging PTO	4	0.6	Hit worker while moving	5	0.8	Cloudy	1	0.2
Hauling hay	3	0.5	Hit from behind	4	0.6	Rain	1	0.2
Cultivating soil	3	0.5	Collided with vehicle	3	0.5			
Snow removal	2	0.3	Implement rolled over body	3	0.5	Terrain		
Hole digging	2	0.3	Tractor MVA with vehicle	3	0.5	Muddy	7	1.1
Unloading tractor	1	0.2	Jumped out of gear	2	0.3	On slope	7	1.1
Pulling wagon	1	0.2				Drove over hole	5	0.8
			Tractor parts			In ditch	4	0.6
Worker action			Body part caught in PTO	7	1.1	Rugged	3	0.5
Dismounting tractor	101	15.7	Trailer tongue broke/fell	7	1.1	On highway	2	0.3
Mounting tractor	29	4.5	Face hit windshield	5	0.8	Bumpy road	1	0.2
Repeated mounting/dismounting	5	0.8	Battery exploded in face	5	0.8			
Fell off tractor	25	3.9	Body hit steering wheel	4	0.6	Location		
Foot slipped off tractor	23	3.6	Implement rolled over body	3	0.5	Between tractor and implement	51	7.9
Jumped off tractor	15	2.3	Lever/gear shift	3	0.5	Standing behind tractor	4	0.6
Body part hit tractor	14	2.2	Tire jack slipped	3	0.5	Standing near tractor	3	0.5
Thrown off tractor	2	0.3	Tire blew while driving	1	0.2	Driving under tree limbs	1	0.2
Pushing lever/gear	2	0.3	Seat broke	1	0.2			
Not following policy	2	0.3	Tripped over tractor	1	0.2	Tractor conditions		
Fell asleep driving tractor	1	0.2	Steering wheel fell off	1	0.2	Slippery steps	7	1.1
Riding in tractor bucket	1	0.2						

A notable proportion (21%) of tractor-related injury claims were associated with tractor mounting or dismounting. Ten percent of injury claims were associated with the worker falling, jumping, or slipping off a tractor. Fifty percent of mounting/dismounting injuries were to the ankle or knee. Our finding that a high percentage of injury claims was associated with tractor mounting or dismounting was consistent with previous research.^{15,16} Lee and colleagues⁹ reported over 40% of tractor-related injuries occurred while mounting or dismounting a tractor, and Carlson and colleagues⁸ reported 33.1% of tractor-related injuries were attributed to the same activity. Notable proportions of agricultural injuries have also been linked to falls from tractors.^{9,17,18} The need to further investigate tractor design and safety, especially relevant to tractor mounting and dismounting has been

discussed previously^{3,8,9} and our findings support this need. The American Society of Agricultural Engineers (ASAE) has developed a series of voluntary safety standards (ASAE S318.10) for the design, manufacture, and use of agricultural machinery. Regarding the mounting and dismounting of a tractor, all agricultural equipment should have steps and handholds that make it easy for the operator to get on or off the tractor safely. The height of the first tractor step should not be more than 27 inches off the ground, and the distance between steps should be between 12 and 16 inches. Steps should be at least 10 inches wide. All steps should have a slip-resistant surface and should be kept free of oil, grease, mud, and other debris.¹⁹ These design specifications for the mounting and dismounting of a tractor may not accommodate the current population of

operators and should be reevaluated using an updated anthropometric database reflective of the population of tractor users/operators.

Future research should address not only the percentage of tractors in operation that meet these recommended standards, but also if these recommendations provide the necessary protection against tractor mounting or dismounting injuries. Tractor operators have reported a problem of tractor steps being high above the ground, which contributed to mounting and dismounting injuries.⁹ Another factor to be considered is step visibility. Poor step visibility may contribute to improper foot placement, which may result in slips or falls. This is especially relevant for older tractor operators whose age-related changes in visual acuity, contrast sensitivity, visual field, and depth perception may increase the risk for falls. A human factor analysis of tractor step visibility is warranted.

The present study also determined a quarter of tractor-related injuries involved strain (i.e., overexertion) injury mechanisms, and over 15% of event descriptions were associated with tractor maintenance or repair. Maintenance and repair activities involve lifting heavy objects such as tractor tires or machinery, increasing the risk for overexertion injuries. In the present study, over a third of event descriptions involving tractor maintenance involved overexertion type injuries, and lifting various objects was associated with 17.0% of these injuries. Farm owners or tractor operators are often alone when performing maintenance on a tractor and may not have the opportunity to recruit other workers for assistance when lifting heavy objects. Lifting aids such as mechanical hoists can be used for lifting heavy objects such as tractor parts or tires, reducing the physical burden on the worker. Reducing the physical demand associated with lifting reduces the risk for overexertion injury. The remaining maintenance-related injury claims involved other types of injuries including burns, lacerations, foreign objects in the eye, contusions, and punctures. Several claims involved radiator burns, lacerations due to coming in contact with sharp tractor part edges, hydraulic fluid spraying in the eyes, dropped tools on body parts, hands getting

caught in moving parts, and flying tractor parts and tools. Results from the present study demonstrated tractor-maintenance tasks present many opportunities for worker injury. Additional avenues for tractor-maintenance injury abatement include personal protective equipment, proper machine guarding, safety and maintenance training, shop cleanliness, and adequate staffing levels.

Several authors reported that the physical and financial burdens of nonfatal tractor-related injuries are substantial when measured by health care costs/and or lost productivity.^{3,8,9,20} The present study demonstrated over a quarter of Colorado hired workers missed a minimum of 3 calendar work-days as a result of a tractor-related injury. A closer examination of high-cost tractor-related claims (e.g., claims in the 75 percentile of total cost) revealed a higher proportion of injuries to the spine/back (16.8%) as compared to all tractor-related injuries involving the spine/back (13.6%). Fractures represented 18.0% of high-cost tractor-related injuries as compared to only 8.7% of all tractor-related injuries. In addition, contusions represented 15.5% of high-cost tractor-related injuries as compared to 25.2% of all tractor-related injuries. These findings suggested injury claims involving the spine/back and fractures are more costly, whereas injury claims involving contusions are less costly. Claim costs associated with tractor-overturn injuries were higher than tractor-related injury claims in general. The mean medical plus indemnity claim cost for tractor overturn claims was 3.4 times higher than that of tractor-related claims. The higher claim cost for overturn claims was driven by higher indemnity costs, which was 4.9 times higher than tractor-related indemnity costs. These results suggest tractor-overturn injuries are more serious in nature and result in more lost-time.

Limitations

The data utilized in this study were collected and maintained for industrial insurance purposes rather than epidemiological occupational injury research. The possible misclassification of claim information was not assessed due to

restriction in access to First Report of Injury documents for the purposes of claimant confidentiality. As a result, the possibility of misclassification of claims data exists.

Indemnity cost data would not take into account disability among workers who did not satisfy the state waiting period for wage replacement benefits. Therefore, our results likely underestimate indemnity expenses experienced by those injured in a tractor-related event. Medical and indemnity costs did not encompass all dimensions of financial burden due to injury. Burden also included indirect costs such as lost productivity, increased absenteeism, higher employee turnover, and recruitment of replacement workers.

In the present study, narrative descriptions of injury events were analyzed using the agent-host-environment epidemiological model. Narrative descriptions were dependent on information accuracy, detail, and completeness provided in the First Report of Injury of each injury claim. Therefore, narrative descriptions were subject to information bias, which was not able to be controlled in the present study. Other factors that may play a role in tractor-related injuries that were not captured in the present study included tractor age, proper tractor maintenance, operator age and experience, proper use of tractors, tractor modifications, worker hurry, stress, fatigue, and staffing levels.

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