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Injuries and Fatalities Related to Skid Steers: 2015–2020 †

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Abstract: Skid steers are versatile self-propelled machines that are regularly used in a variety of recreational applications and occupational industries. They can be hazardous for both operators and bystanders. The purpose of this paper is to describe patterns of skid steer injuries in the US from 2015 to 2020. Data were obtained from Occupational Safety and Health Administration (OSHA) accident reports and the severe injury database. Agriculture-related incidents were obtained from AgInjuryNews. The study identified 312 skid steer-related injuries (2015–2020) in OSHA, with an additional 68 agricultural injuries identified using AIN. Construction, administrative and waste management, and agriculture industries were the top three industries with the highest number of injuries. Bystander workers experienced a higher number of injuries than operators. Contact with the machine was the most prevalent and more fatal than the other injury events. Agricultural skid steer injuries involved a broad age range of victims, from very young children to adults. These findings emphasize the need for improved safety engineering and clear safety guidelines for skid steer operators and those who are around skid steers. With the increased prevalence of skid steers across industries, it is imperative to have cohesive and comprehensive safety regulations, guidelines, and policy enforcement.

Keywords: bystander; injury; skid steer; vehicle

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1. Introduction

A skid steer is a versatile self-propelled machine. They are available with tracks or wheels and are used in various industries from construction to agriculture [1,2]. Skid steers are often equipped with safety features to prevent injuries and improper operation of skid steer loaders [3,4]. In a report by CDC, skid steer-related fatalities and surveillance information of similar incidents that occurred from 1980–1995 were evaluated [4]. After evaluating the surveillance data, the study concluded that those protective safety measures can be easily bypassed, making it more likely for accidents to occur [4]. Skid steers have seen an increase in sales and utilization across industries over the last five years and this is projected to continue to rise into the 2030s, increasing exposure and opportunity for injuries [5,6].

US DOL reported 100 incidents between 1997 and 2007. The study found that 20% of the injuries and fatalities were the direct result of the operator bypassing the built-in safety features available in the skid steer. The study concluded that properly maintained safety equipment and proper use of machinery as per safety guidelines are essential in preventing injuries and fatalities [7]. Similarly, Moore and Pratt evaluated skid steer safety configurations, as well as common issues related to their operation [3]. The study points out that the two common types of skid steers (front entry loaders and side entry loaders)

each present a risk when safety procedures are bypassed. This is because of the small size of skid steers, which require operators to sit very close to the active movement of loader arms and attachments. The study concluded that employers and workers likely do not understand the hazards associated with operating skid steers [3].

In a study of news media reports by Weichelt and Bendixsen, skid steer-related incidents involving youth in agriculture were reviewed [8]. Data were collected through AgInjuryNews.org, a web-based dataset that collects and disseminates publicly available injury reports (e.g., news media and obituaries) about agricultural-related incidences [8]. The report describes a false sense of safety in relation to agricultural machinery, coupled with under-surveillance of youth-related injuries resulting in high numbers of skid steer injuries and deaths every year to young children. The study found very little evidence of safety interventions in skid steer operations and called for increased research to evaluate the complexities of those injuries and fatalities.

The objective of this article is to expand upon the current literature, by identifying and describing the main causes leading to serious occupational and nonoccupational injuries and fatal accidents involving skid steers, with an additional emphasis on agricultural cases.

2. Materials and Methods

Data sources for this study were the OSHA Severe Injury Database, OSHA Integrated Management Information System (IMIS), and AgInjuryNews.org for agricultural-related skid steer injuries. The timeframe of 1 January 2015–31 December 2020 was believed to be large enough to capture and describe a representative sample of U.S. skid steer incidents.

2.1. OSHA Dataset

The incident reports in the OSHA database covered fatal and serious incidents only; information on injuries, such as minor cuts and minor fractures, were therefore not available or included in this analysis. Worker fatalities in the U.S. must be reported by the employer to OSHA within eight hours, with certain exceptions [9]. After OSHA completes an investigation into a work-related incident that results in fatalities or three or more injuries, a fatality and catastrophe investigation summary (OSHA 170 form) is completed and then submitted to the Integrated Management Information System (IMIS) [10]. The OSHA 170 includes an abstract summarizing the injury incident and information about the victim and employer, as well as any violations of OSHA standards and accompanying citations and penalties. The IMIS summaries provide descriptions of injury events, as well as information on injury dates and locations, industry, and the victim's occupation, age, and gender.

The IMIS online database is searchable by using description, abstract, keyword, occupation code, industry code, OSHA, office, and event dates [11]. We searched the database using the terms "skid steer", "skid loader", and "bobcat". The search produced lists of injury events with report IDs, event dates, and event descriptions. IMIS allows users to access investigation summaries with descriptive information for specific incidents by clicking on a "Get Detail" Table. Details were obtained for all incidents produced by the database searches and the inspection reports.

Descriptions of each incident were reviewed and only cases involving skid steer as either the primary or secondary injury source were entered into a spreadsheet by calendar year. These included the OSHA inspection number, date of injury, North American Industry Classification System (NAICS) code, a narrative description of the injury event, type of injury, and the employee's occupation, age, and gender. In addition to the existing variables, cases were coded according to the Occupational Injury and Illness Classification System (OIICS), version 2.01 [12]. The authors used investigation summary information to classify each case according to the source of injury and the event or exposure associated with the injury.

We also used data from an OSHA severe injury database [13]. OSHA currently requires employers to report all severe work-related injuries, defined as an amputation, in-patient hospitalization, or loss of an eye, but this requirement did not exist prior to 1 January 2015.

With the exception of a few state-based programs, OSHA does not require reporting for agricultural operations employing fewer than 11 nonfamily workers. The severe injury database provides information describing the incident, the name and address of the establishment where it happened, and an industry code based on NAICS. Each case is coded according to Occupational Injury and Illness Classification (OIICS) codes for nature, body part, injury source, and event and exposure.

Additional data elements were recorded in the accident investigation by OSHA: environmental risk factors, and human risk factors, which correspond to unsafe human acts [14]. OSHA defines 18 categories of environmental risk factors which describe the physical factors, such as working surface/facility, layout condition, and illumination. There are 20 human-related risk factors that correspond to unsafe human acts, such as misjudgment of hazardous situations or no PPE used [14]. Environmental and human-related risk factor data were available for all fatal incidents but for only 52 nonfatal incidents. After merging fatal and nonfatal incidents, there were 87 fatal and 225 nonfatal injuries within the OSHA dataset.

2.2. AgInjuryNews Dataset

To expand upon the aforementioned occupational injury data, we analyzed the available AgInjuryNews dataset. AgInjuryNews is a collection of publicly available injury reports, primarily sourced from news media, obituaries, social media, etc. The system includes agricultural, fishing, and forestry-related reports from the U.S. and Canada. Limitations and data collection methods of AgInjuryNews data are well-described elsewhere [15,16]. The authors exported a subset of the dataset—those coded specifically as self-propelled "skid steer" involving injuries that occurred in the U.S.

Injuries are coded and double-reviewed using OIICS coding schemes. Occupational work-relatedness was determined by using the Farm and Agricultural Injury Classification (FAIC) code (American Society of Agricultural and Biological Engineers—ASAE S575.1) [17]. Victims are coded by age and gender, as well as their role as operator, passenger, bystander, or other. In this study, only three cases overlapped between AIN and OSHA. Overlapping cases were determined by comparing several key variables, such as date of injury, injury location (city and state), and victim demographics. Additionally, the description of injuries was used to identify overlapping cases.

2.3. Analysis

The Statistical Package for the Social Sciences (SPSS) for Windows (IBM SPSS Version 27, Armonk, NY, USA) was used to analyze the data [18]. Univariate statistics (i.e., frequency distributions) were used to describe the characteristics of fatal and nonfatal injuries. The relationships among variables for fatal and nonfatal injuries were determined by Chi-square (χ^2) tests. Tableau data visualization software (Tableau Desktop; Tableau Software, Seattle, WA, USA) was used to create maps showing the number of injuries in the different states across the U.S.

3. Results

3.1. Results from the OSHA Dataset

We included a total of 312 injuries (85 fatalities and 227 severe nonfatal injuries). Demographic information was available only for some of the victims. Victim sex was available only for 225 cases and most victims (99%, 222 of 225) were male. Age information was available for 141 victims and ages ranged from 17 to 77 years old with a mean age of 42.5 years. Skid steer incidents occurred in many different industry sectors (Table 1). Construction industry workers had the highest number of skid steer injuries over the study period. These incidents occurred in 44 states and Texas, Florida, and California had the highest number of cases reported (Figure 1).

Table 1. Industrial sectors and numbers of fatal and nonfatal injuries.

Industrial Sector (NAICS 2-Digit Code)	Fatal (n = 87)	Nonfatal (n = 225)	Total (n = 312)
Construction (23)	30	112	142
Administrative and Support/Waste Management (56)	15	32	47
Agriculture, Forestry, and Fishing (11)	11	8	19
Wholesale Trade (42)	9	8	17
Wood Product Manufacturing (32)	5	5	10
Real Estate and Rental and Leasing (53)	5	4	9
Mining (21)	1	8	9
Other Services (81)	2	7	9
Professional, Scientific, and Technical Services (54)	2	7	9
Transportation and Warehousing (48)	2	6	8
Manufacturing (31)	1	5	6
Primary Metal Manufacturing (33)	1	6	7
Utilities (22)	1	5	6
Others [1]	2	12	14

[1] Others include warehousing and storage; retail trade; accommodation and food services; arts, entertainment and recreation; postal service; public administration; sporting goods; hobby; musical instruments; education; health care; and bookstores.

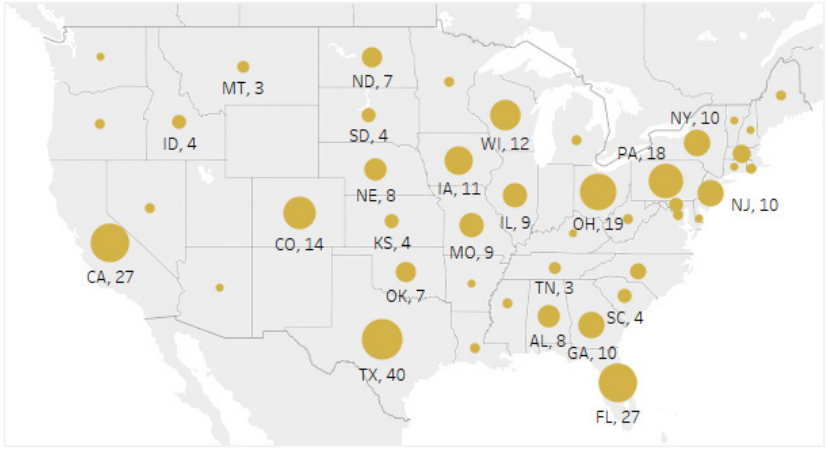

Figure 1. Locations of skid steer-related fatalities and severe injuries, 2015–2020 (Magnitude of circles are proportional to the number of injuries).

The yearly number of skid steer injuries from the OSHA dataset (fatal and nonfatal) and BLS-CFOI (fatal) are shown in Figure 2. BLS-CFOI data were extracted from the Census of Fatal Occupational Injuries database using their one-screen data search [19]. Since we did not have access to the CFOI microdata, we could not determine exactly how many overlapping cases were between CFOI and OSHA fatal cases. However, we assumed that all of the OSHA cases were included in the CFOI data since CFOI includes all fatal work injuries, regardless of whether the victim was working in a job covered by the OSHA. Further discussion is provided in the Discussion section.

Table 2 provides summary results broken down by nature of injury and body parts injured. Fatal injuries mostly resulted from crushing injuries to the head, chest, and multiple body parts (n = 30); asphyxiations, strangulations, and suffocations (n = 9); and multiple traumatic injuries (n = 8) (Table 2). Fatal injuries mostly involved multiple body parts, body systems, head and neck, and trunk. For nonfatal injuries, fractures were the most prevalent type of injury, followed by amputations. The lower extremities (i.e., feet, ankles, legs) were the most vulnerable to a nonfatal injury followed by upper extremities (mostly fingers). Amputations were to the fingers (n = 17), fingertips (n = 7), legs (n = 4), feet (n = 2), and toe (n = 1).

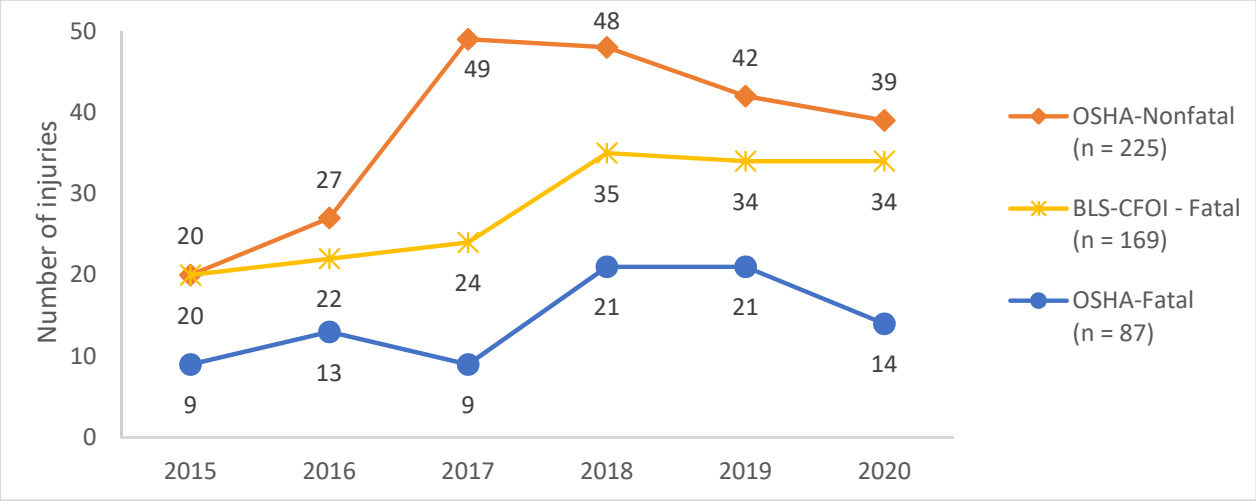

Figure 2. Fatal and nonfatal skid steer injuries by year.

Table 2. Summary of injury cases by nature of the injury and injured body parts.

Variables	Fatal (*n* = 87)	Nonfatal (*n* = 225)	Total (*n* = 312)
Nature of injury			
Fractures	5 (5.7%)	117 (52.0%)	122 (39.1%)
Crushing injuries	30 (34.5%)	16 (7.1%)	46 (14.7%)
Amputations	-	31 (13.8%)	31 (9.9%)
Multiple traumatic injuries	8 (9.2%)	6 (2.7%)	14 (4.5%)
Soreness, pain, hurt-nonspecified injury	-	11 (4.9%)	11 (3.5%)
Asphyxiations, strangulations, suffocations	9 (10.3%)	-	9 (2.9%)
Bruise/Contusion/Abrasion	3 (3.4%)	6 (2.7%)	9 (2.9%)
Others [1]	10 (11.5%)	-	10 (3.2%)
Nonclassifiable	22 (25.3%)	38 (16.9%)	60 (19.2%)
Body part			
Lower extremities	4 (4.7%)	115 (50.7%)	119 (38.1%)
Upper extremities	3 (3.5%)	44 (19.4%)	47 (15.1%)
Multiple body parts	23 (27.1%)	22 (9.7%)	45 (14.4%)
Trunk	14 (16.5%)	22 (9.7%)	36 (11.5%)
Head and neck	14 (16.5%)	16 (7.0%)	30 (9.6%)
Body systems	17 (20.0%)	-	17 (5.4%)
Nonclassifiable	10 (11.8%)	8 (3.5%)	18 (5.8%)

[1] Other nature categories include avulsions; enucleations; concussions; cuts, lacerations; dislocation of joints, electrocution, electric shock; hernias due to traumatic incidents, etc.

Injuries by the event or exposure categories, environmental factors, and human factors are given in Table 3. Event or exposure is defined as "the manner in which the injury or illness was produced or inflicted" [20]. Fatal skid steer-related injuries mostly resulted from contact with objects or equipment, accounting for 55% of all fatalities, followed by transportation incidents (44% of fatal cases). Nonfatal injuries mostly resulted from transportation incidents (49% of all nonfatal cases), followed by contact injuries (Table 3).

The frequency distributions of the environmental factors were cross tabulated with the degree of injury (Table 3). Environmental and human factor categories were available for 78% (66 of 85) of fatal injuries but only for 23% (52 of 227) of the nonfatal injuries.

Almost 46% of the fatal incidents were related to material-handling equipment or method. This was followed by pinch point action. Misjudgment of the hazardous situation (32%), position inappropriate for the task (10%), insufficient/lack/written work practice (9%), equipment inappropriate for operation (7%), and safety devices removed/inoperative

(6%), and were leading human factor categories for the injuries. The "other" category for environmental and human-related risk factors includes no further details.

Table 3. The event/exposure, environmental, and human factors.

Variables	Fatal (n = 87)	Nonfatal (n = 225)	Total (n = 312)
Event ($\chi 2$ = 10.211, p = 0.037)			
Contact with objects and equipment	47 (55.3%)	94 (41.8%)	141 (45.2%)
Transportation incidents	37 (43.5%)	110 (48.9%)	147 (48.2%)
Falls	-	17 (7.6%)	17 (5.6%)
Others [1]	3 (3.5%)	4 (1.8%)	7 (2.3%)
Environmental-related risk factors [2]			
Materials handling equipment/method	30 (45.5%)	24 (46.2%)	54 (45.8%)
Pinch point action	9 (13.6%)	4 (7.7%)	13 (11.0%)
Overhead moving/falling object	6 (9.1%)	3 (5.8%)	9 (7.6%)
Work surface/facility layout conditions	4 (6.1%)	5 (9.6%)	9 (7.6%)
Weather	-	3 (5.8%)	3 (2.5%)
Catch point/Puncture action	2 (3.0%)	1 (1.9%)	3 (2.5%)
Shear point action	2 (3.0%)	-	2 (1.7%)
Flying object action	-	1 (1.9%)	1 (0.8%)
Illumination	1 (1.5%)	-	1 (0.8%)
Sound level	1 (1.5%)	-	1 (0.8%)
Other	11 (16.7%)	11 (21.2%)	22 (18.6%)
Human-related risk factor [2]			
Misjudgment, hazard situation	21 (31.8%)	17 (32.7%)	38 (32.2%)
Position inappropriate for the task	5 (7.6%)	7 (13.5%)	12 (10.2%)
Insufficient/lack of written work practice	7 (10.6%)	3 (5.8%)	10 (8.5%)
Equipment inappropriate for the operation	3 (4.5%)	5 (9.6%)	8 (6.8%)
Safety devices removed/inoperable	7 (10.6%)	-	7 (5.9%)
Malfunction in securing/warning operation	2 (3.0%)	1 (1.9%)	3 (2.5%)
Defective equipment in use	1 (1.5%)	0 (0.0%)	1 (0.8%)
Inappropriate material handling	-	1 (1.9%)	1 (0.8%)
Lockout/tagout procedure malfunction	1 (1.5%)	-	1 (0.8%)
Material-handling procedure—inappropriate	-	1 (1.9%)	1 (0.8%)
Perception malfunction, task environment	-	1 (1.9%)	1 (0.8%)
Other	19 (28.8%)	16 (30.8%)	35 (29.7%)

[1] Other event category includes nonclassifiable cases and exposure to harmful substances and environment. [2] Unknown environmental and human-related cases are not included in the percentages.

3.2. Injuries by the Employee Role and Activity

General work activity and employee's role were identified from the injury narratives (Table 4). We categorized the victims as operators, on-site bystander employees, and others. Below, injuries under each category are explained in detail. Overall, the severity of the incidents depended on what activity was being conducted at the time of the incident (χ^2 = 20.542, p = 0.015). The proportion of fatal outcomes was significantly higher for the employees who were performing maintenance and repairs.

Table 4. Categorization of skid steer injury incident types by the role of the employee.

	Variables	Fatal (n = 87)	Nonfatal (n = 225)	Total (n = 312)
On-site (n = 193, 61.9%)	Working (bystander) employee	36 (41.4%)	101 (44.9%)	137 (43.9%)
	Performing maintenance/repair	17 (19.5%)	23 (10,2%)	40 (12.8%)
	Mounting/dismounting attachments	-	16 (7.1%)	16 (5.1%)
Operator (n = 99, 31.7%)	Operating skid steer	21 (24.1%)	60 (26.7%)	81 (26.0%)
	Operator entering/exiting	1 (1.1%)	8 (3.6%)	9 (2.9%)
	Operator out/troubleshooting	6 (6.9%)	3 (1.3%)	9 (2.9%)
Other (n = 20, 6.4%)	Passenger (riding in/standing on the bucket)	3 (3.4%)	7 (3.1%)	10 (3.2%)
	Training other employees, other vehicle operators, or unknown roles	3 (3.4%)	7 (3.1%)	10 (3.2%)
	Passenger (riding in/standing on the bucket)	3 (3.4%)	7 (3.1%)	10 (3.2%)

Most of the injuries were to the on-site employees (n = 193, 62%) as they were injured when they were working in close proximity to the skid steer at the time of the incident. Most of the on-site employees were bystander employees. Other on-site employees were injured most often when they were performing maintenance or repairs and mounting or dismounting skid steer attachments. On-site employees were struck by skid steer backing up or moving forward, struck by skid steer, or struck by a falling object from the skid steer, crushed/pinned within the skid steer assembly, and killed as a result of falls. A few examples of bystander injury reports are given below:

> *" . . . , an employee was bending over to pick something up, when he was struck by a skid steer loader. The employee was killed from crushing injuries"*.
>
> (https://www.osha.gov/pls/imis/establishment.inspection_detail?id=1233538.015 (accessed on 30 January 2021)).
>
> *" . . . , an employee was walking across the work site and was struck by a steel column that was falling off the skid steer forks. The employee suffered a fractured skull and broken neck which resulted in his death"*.
>
> (https://www.osha.gov/pls/imis/establishment.inspection_detail?id=1295475.015 (accessed on 30 January 2021)).
>
> *" . . . , an employee was standing next to a skid steer loader when the tracks ran over the employee's left leg and fractured it. The employee was hospitalized"*. (*example from the severe injury database*)
>
> *" . . . , an employee was doing some landscaping work and was planting oak trees using a skid steer. The employee was walking alongside the steer, tripped, and fell into its path. The employee amputated his right hand's pinky when it was caught underneath it and was hospitalized"*. (*example from the severe injury database*)

Employees performing maintenance and repairs were injured when they entered the hazardous zone of the skid steer, either as a result of being struck by skid steer attachments or caught in or compressed by the skid steer arms. The following report is an example incident that occurred during maintenance/repair:

> *" . . . , two employees were installing a new control valve on a skid steer. While they were located beneath the bucket of the vehicle, it suddenly came down and struck them. Both employees were killed"*.
>
> (https://www.osha.gov/pls/imis/establishment.inspection_detail?id=1386974.015 (accessed on 30 January 2021)).

A total of 99 (32%) skid steer operators were fatally or nonfatally injured. When we looked closely at the activity being conducted at the time of the incident, we found that operators were either operating the skid steer or entering/exiting the skid steer, or when the operator was troubleshooting outside the skid steer. The event categories for the operator injuries were nonroadway incidents, such as rollover or falling from the moving vehicle; struck by a skid steer while troubleshooting; caught in or compressed by a skid steer; and falls, slip, or trip (8%, 8 of 97). Two examples of operator injuries are given below:

> *" . . . , an employee was installing helical piers to secure a foundation on a new construction site. The employee was outside the skid steer (track loader) cab. The equipment was on. A hydraulic hose that operates the skid steer helical pier driver attachment was wrapped around the right joystick of the skid steer causing the lift arms of the skid steer to activate and lower. The employee was caught between the lift arms and the cab of the track loader and is killed"*. (https://www.osha.gov/pls/imis/establishment.inspection_detail?id=1305725.015 (accessed on 30 January 2021)).
>
> *" . . . , Employee #1 was operating a John Deere 640 Skid Steer, pulling logs from a ravine in the woods. The skid steer shifted sideways and flipped over, rolling down the hill. Employee #1 was not provided a seat belt, so when the skid steer flipped over,*

the employee was thrown from the cab. Employee #1 was crushed under the weight of the skid steer in the roll-over. He sustained head injuries and a crushed chest and was killed". (https://www.osha.gov/pls/imis/establishment.inspection_detail?id=1087541.015 (accessed on 30 January 2021)).

There were 20 other employees injured when they were training other employees, operating other vehicles, or as a passenger riding in/standing on the bucket. These injuries involved falls, caught-in, struck by, and nonroadway incidents. An example from the severe injury database is given below:

" . . . *an employee was on a skid steer bucket when his leg was caught between the bucket and the track of the skid steer. His leg was amputated from the knee down*". (*Example from the severe injury database*).

3.3. Agricultural Skid Steer Injuries from AgInjuryNews.org

Over the study period from 2015 to 2020, there were 68 injuries (48 fatal, 20 nonfatal) reported in AIN. The highest number of agricultural incidents were in the years 2018 and 2019, each with 15 victims. In terms of victim demographics, most of the victims were male (88%) (Table 5). Victim ages ranged between 1 and 89 years old. Youth victim ages ranged between 1 and 14 years; 58% (14 of 24) were under 5 years old and 83% (20 of 24) were under 10 years old at the time of the incident (mean age 5.1 years). Adult victim ages ranged from 19 to 89 years old and the mean age was 51.3 years.

Table 5. Characteristics of injuries for agricultural skid steer injuries from news media.

Variables		Fatal (n = 48)	Nonfatal (n = 20)	Total (n = 68)
Sex *	Female	5 (10%)	3 (18%)	8 (12%)
	Male	43 (90%)	14 (82%)	57 (88%)
Age	Under 18	18 (39%)	6 (30%)	24 (36%)
	18 and older	30 (61%)	14 (70%)	44 (64%)
Role *	Bystander	13 (30%)	5 (26%)	18 (27%)
	Operator	22 (50%)	9 (47%)	31 (49%)
	Passenger	5 (11%)	4 (26%)	9 (16%)
	Other	4 (9%)	1 (5%)	5 (8%)

* Unknown data were not included in the percentages.

There were 31 operators (27 skid steer and 4 other vehicle drivers) injured in incidents related to skid steers. All skid steer operators were adult operators except one victim who was 14 years old at the time of the incident. Operator injuries were mostly nonroadway transportation incidents that occurred in an agricultural work site such as a barn, manure storage, etc.

Bystander victims were mostly youth under 18 (72%, 13 of 18). Almost 85% (11 of 13) of the youth bystanders were fatally injured. More than 60% of the bystander youth (8 of 13) were under 5 years old. There were five adult bystanders (18 and older age group) and most of these adult victims were working at the time of the incident (80%).

Passenger victims were mostly (89%, 8 of 9) under 18 years old. These victims were mostly children on the operators' laps (n = 4) and riding in the skid steer bucket (n = 3). There was one additional youth victim injured after their passenger vehicle collided with a skid steer driven by a 10-year-old on the roadway. Half of the passenger injuries were fatal.

Injuries were also analyzed by occupational work-relatedness and age categories. Occupational work-relatedness could not be determined for five adult victims and one youth victim, and these incidents were excluded from the percentage calculations. Almost 90% (35 of 39) of adult victims and 21% (5 of 23) of youth victims were working at the time of the incident. Seventeen youth victims were either nonworking bystanders or non-working passengers. An additional five other vehicle occupants were injured in collisions with skid steers.

4. Discussion

In this study, we investigated the fatal and nonfatal skid steer-related incidents in the U.S. We determined that the majority of the victims were on-site bystander employees. Several examples were presented to illustrate and understand the circumstances of skid steer incidents. The study also presents the agricultural-related skid steer incidents. Youth under 18 accounted for more than one-third of the agricultural incidents.

Occupational skid steer-related hazards pose a persistent risk to workers, especially in the construction, administrative and support waste management, agriculture, forestry, and fishing industries. More than forty percent of fatal and nonfatal injuries were bystander employees being either struck or crushed by a skid steer, and skid steer operators accounted for roughly one-third of injuries. Other workers were injured while performing maintenance or repairs, mounting or dismounting skid steer attachments, riding in or standing on the skid steer bucket, and training other employees.

BLS-CFOI reported 169 skid steer-related fatalities in the same study period [19]. Given the scope of work across both programs, the OSHA dataset will always represent only a portion of the BLS-CFOI reports. Further data from the BLS-CFOI showed that there were 61 fatalities in the agriculture, forestry, and fishing industry in the same time period accounting for 36% of all skid steer-related fatalities reported by CFOI [21]. Additionally, the BLS-CFOI data do not capture all fatalities occurring in industrial settings, only those victims working at the time of the incident, missing nonworking bystanders, and a significant portion of youth farm-related fatalities [8,16].

Our analysis was primarily based on OSHA data which include only deaths from those states where OSHA conducted inspections. There are some known limitations with the dataset, specifically that OSHA does not include/inspect those self-employed, or any operations that employ fewer than 11 nonfamily workers. However, OSHA case report data are still quite useful in understanding the injury circumstances relating to occupational skid steer incidents.

Similar hazards and injury types as described herein were reported elsewhere in the literature. Interestingly, we continue to see an increase in skid steer-related occupational fatalities and a concerning number of fatalities involving working and nonworking bystanders. Even though we did not have information on operator visibility, many of these incidents are undoubtedly related to the limitations to operator visibility while in these machines. Bystander workers need to ensure a safe distance from the operating machinery and remove nonsafety-related earbuds/headphones while working in proximity to these machines; in addition, high-visibility vests and PPE should always be worn on the worksite.

The number of young children's deaths related to skid steers is concerning. We cannot overstate how important it is that young children not be present in an active work environment, especially when machinery, such as skid steers, is in operation. When assigning youth to certain agricultural tasks, such as machinery operation on farms, parents and supervisors are recommended to use Agricultural Youth Work Guidelines, the latest generation of the North American Guidelines for Children's Agricultural Tasks (NAGCAT). These guidelines provide recommendations based on an understanding of childhood growth and development for appropriate tasks for youth [22]. Considering the number of on-foot employee injuries and fatalities, there is a need for further engineering improvements to these machines; moreover, there is a need for improved safety of the work environment, as evidenced by the data. Operators need to continue to be fully aware of their surroundings, coworkers, and the limitations of the viewing areas surrounding the machine. Backup alarms and innovative sensors would be helpful, as would cameras, allowing the operator to view the hard-to-see areas around the machine. Finally, because many on-foot employees are in close proximity to the skid steer, rigorous organizational policies and their enforcement, are required to supplement improved engineering safety standards in order to reduce injuries.

Our research is subject to certain limitations. The data used in this study are somewhat limited in part because they come from secondary data using self-reports from industry

participants. The actual number of severe injuries is not known and could be much higher. Additionally, AgInjuryNews.org data are only for agricultural-related injuries reported in news media. The characteristics of injuries and victims in other industries or home improvement projects in news media may be different to our findings.

Future studies may be needed to better understand the risks for young, inexperienced, or foreign-born workers. Other news media searchers can be used for nonagricultural skid steer injuries and fatalities for self-employed individuals and small operations that are not covered by OSHA. Additional research is needed to assess the prevalence and utility of safety devices such as backup alarms, sensors, rear-back camera systems, and so on.

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Institutional Review Board Statement: No human subjects were involved in this research. Since the OSHA data are publicly available and de-identified, this study is exempt from our Institutional Review Board. Additionally, the AgInjuryNews initiative is considered exempt for review by the Marshfield Clinic Research Institute's Institutional Review Board.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study can be obtained from AgInjuryNews.org, https://www.osha.gov/pls/imis/accidentsearch.html (accessed on 30 January 2021), and https://www.osha.gov/severeinjury (accessed on 30 January 2021).

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