An Overview of Agricultural Injuries in Florida from 2015-2019

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HIGHLIGHTS

- We identified 48 fatal and 187 non-fatal agricultural injuries in Florida from 2015-2019.
- Vehicles and environmental sources were the two leading injury sources.
- Using multiple data sources helped us understand the at-risk populations.

ABSTRACT. *The purpose of this study was to examine and describe fatal and non-fatal agricultural injuries documented in Florida. We used Occupational Safety and Health Administration (OSHA) data and AgInjuryNews.org (AIN) data from 2015 through 2019 to identify 48 fatal and 187 non-fatal injuries during the five-year study period, with 86% (40 fatal, 175 non-fatal) of these injuries being occupational. A total of 101 (43%) people were injured as a result of transportation incidents. Major injury sources were vehicles (46%) and environmental sources (heat, lightning, etc.) (14%). Using AIN data, we identified risks for youth under the age of 18 and for individuals age 65 and older. This study suggests the need for additional injury surveillance efforts to gather demographic information to identify at-risk populations.*

Keywords. *Agriculture, Fatal, Injury, Surveillance, Transportation.*

Workers in agriculture are exposed to a wide range of occupational and environmental health hazards. The 2019 Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) and Survey of Occupational Injuries and Illnesses (SOII) data suggest that the agriculture, forestry, and fishing (AgFF) sector is the most hazardous industrial sector in the U.S., with a work-related fatality rate of 23.1 per 100,000 full-time equivalents (FTEs) and a non-fatal injury rate of 5.2 per 100 full-time hired workers (BLS, 2021a, 2021b).

In Florida, workers in the AgFF sector have been identified as having a high fatality rate. In 2018, the state's annual AgFF sector-related fatality rate was 17.8 deaths per 100,000 FTEs (BLS, 2021c). Non-fatal occupational injury data are provided by SOII for most U.S. states, but no data are available for Florida (BLS, 2020d). Few studies have specifically addressed fatal and non-fatal agricultural injuries in Florida. Liller et al. (2000) analyzed fatalities on Florida farms from 1989 to 1998 using death certificates and

Submitted for review on 18 February 2021 as manuscript number JASH 14533; approved for publication as a Research Article by the Ergonomics, Safety, & Health Community of ASABE on 27 April 2021.

identified 193 unintentional injury deaths over this ten-year period. Their study revealed that the most common injury source was machinery, which included farm tractors. Their study also identified 20 suicides and 17 homicides.

Florida has 47,400 farms producing nearly 300 different commodities on 9.7 million acres of land (USDA-NASS, 2019a). According to the Florida data in the 2017 Census of Agriculture, 12,207 farms use hired labor, and 88% of them employ fewer than ten workers (USDA-NASS, 2019b). Because of Florida's unique climate, agricultural work takes place 12 months of the year. A wide variety of Florida's specialty crops depend heavily on manual labor throughout the year. For example, one hectare of strawberry production requires almost 1,980 hours of manual labor (1,420 hours for harvest-specific tasks) (Roka and Guan, 2018). Every year, it is estimated that 150,000 to 200,000 migrant and seasonal farmworkers travel to Florida to work (Roka and Guan, 2018). Seasonal and migrant farmworkers follow the crop cycles. The number of seasonal and migrant farmworkers reaches its maximum from January through March and begins to decline in April (Roka and Guan, 2018). Another critical feature of farm employment in Florida is its "at-will" basis, meaning that employers have no obligations to offer the same job or rehire the same worker from one day to the next (Roka and Guan, 2018). At-will employment may prevent growers from investing in the training and development of their workforce, which may include health and safety training.

The purpose of this study was to examine and describe fatal and non-fatal injuries across Florida's agricultural industry, which at the time of this writing had not been done for more than 20 years. We expect that this analysis will illuminate the underlying causes of such injuries to better inform future safety and health interventions.

Methods

Agricultural injury surveillance is stubbornly complex and difficult to track for many subcategories of workers, including youth, unpaid volunteers, migrant workers, undocumented immigrants, and those working in agriculture as secondary occupations (Weichelt et al., 2021). Researchers are often tasked with compiling data from multiple sources in order to piece together a complete picture of the injury burden for a specific state or region. Three such supplemental sources are the OSHA Severe Injury Database, the OSHA Integrated Management Information System (IMIS), and AgInjuryNews.org (AIN); these three datasets were used in this study. The five-year timeframe from 2015 to 2019 is believed to be large enough to capture and describe a representative sample of agricultural injuries in Florida.

Employee fatalities in the U.S. must be reported by the employer to OSHA within eight hours, with certain exceptions. After OSHA completes an investigation into a work-related incident that resulted in a fatality or three or more injuries, a Fatality and Catastrophe Investigation Summary (OSHA Form 170) is completed and then submitted to the Integrated Management Information System (IMIS) (DOL, 2020a). OSHA Form 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 using a description, abstract, keyword, occupation code, industry code, OSHA office, and event date (DOL, 2020b). We used an industry

code to obtain fatal cases for the 2015-2019 period. The industry code is based on the North American Industry Classification System (NAICS). The NAICS system starts with broad, two-digit industry codes (e.g., 11 = agriculture, forestry, fishing, and hunting). Three-digit codes provide further subsectors (e.g., 112 = animal production and aquaculture), and four-digit codes are the most focused groups that describe the relevant businesses (e.g., 1121 = cattle ranching and farming). The IMIS database was searched for NAICS code 11. The search was filtered for Region 4 from the OSHA office section. OSHA has ten regional offices, and Florida is included in Region 4 (DOL, 2020c). 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" tab. Details were requested for all incidents produced by the database searches along with the inspection reports.

Descriptions of each incident were reviewed, and only Florida cases were entered into a spreadsheet by calendar year. These cases included the OSHA inspection number, date of injury, NAICS industry code, a narrative description of the injury event, the 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 (BLS, 2020e). We used the 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 the OSHA severe injury database (DOL, 2020d). 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 January 2015. The severe injury database provides information describing the incident, the name and address of the establishment where the incident occurred, and an industry code based on NAICS. Each case is coded according to OIICS codes for the nature of the injury, body part, injury source, and event and exposure. The OSHA severe injury database was filtered for NAICS code 11 and to include "Florida" in the analyses.

The third data source was AgInjuryNews.org (AIN), a web-based collection of U.S. agricultural injury and fatality reports maintained by the National Farm Medicine Center of the Marshfield Clinic Research Institute (Weichelt and Gorucu, 2019; AIN, 2020). The AIN dataset is available through a web-based system that provides interactive searches of publicly available injury data, most often derived from news media, obituaries, social media (e.g., Facebook, Twitter, and GoFundMe), and police reports (Gorucu et al., 2019). The Marshfield Clinic Research Institute's IRB has reviewed and exempted the AIN methods for collection and storage of injury data on AgInjuryNews.org. To keep the search terms relevant with advances in technology in the agriculture industry, the AIN data collection team periodically reviews and revises the agricultural terminology and inclusion criteria (Weichelt et al., 2018).

Trained coders coded the AIN cases according to the Farm and Agricultural Injury Classification (FAIC) codes and OIICS codes, achieving substantial levels of agreement (kappa = 0.70 to 0.92) (Gorucu et al., 2020). The AIN dataset was filtered by state (Florida), and the data were exported for review. The FAIC codes were used to classify farm and agriculturally related fatalities and injuries consistently and accurately as either occupational or non-occupational from the perspective of production agriculture (farming or ranching) (ASABE, 2020; Gorucu et al., 2020). The AIN cases were also coded for nature,

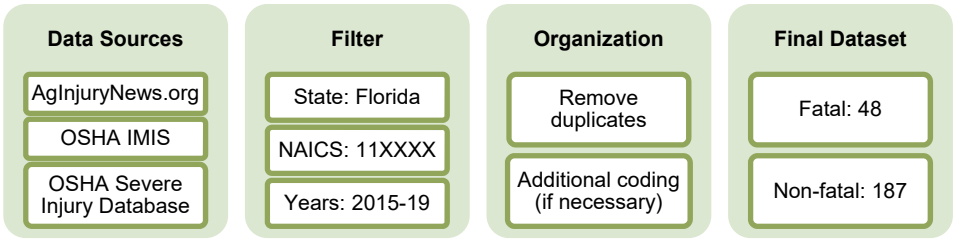

Figure 1. Data acquisition flow diagram.

body part, injury source, secondary injury source, and event/exposure categories according to OIICS version 2.01 (BLS, 2020e). Figure 1 shows the flow diagram for data acquisition.

We identified 153 agricultural injury cases from the OSHA data and 90 agricultural injury cases from the AIN data. All datasets were combined into a single spreadsheet and checked for duplicates. There were eight matching cases between AIN and OSHA. After removing the duplicates, there were 48 fatal and 187 non-fatal agricultural injuries. The cases from OSHA were coded for FAIC by the first author. Descriptive statistics, including frequency and percent distributions, were calculated in SPSS version 26.0 (IBM, 2019).

Results

A total of 235 agricultural injuries (48 fatal and 187 non-fatal) were identified for the years 2015-2019 in Florida. The number of injuries ranged from a high of 82 injuries in 2017, to a low of 25 injuries in 2015. Monthly distribution of the injuries is shown in figure 2. The highest number of injuries occurred in April, while the lowest was in July and August. The distribution of the injuries by Florida county is shown in figure 3. As shown on the map, injuries were heavily concentrated in south Florida over the study period.

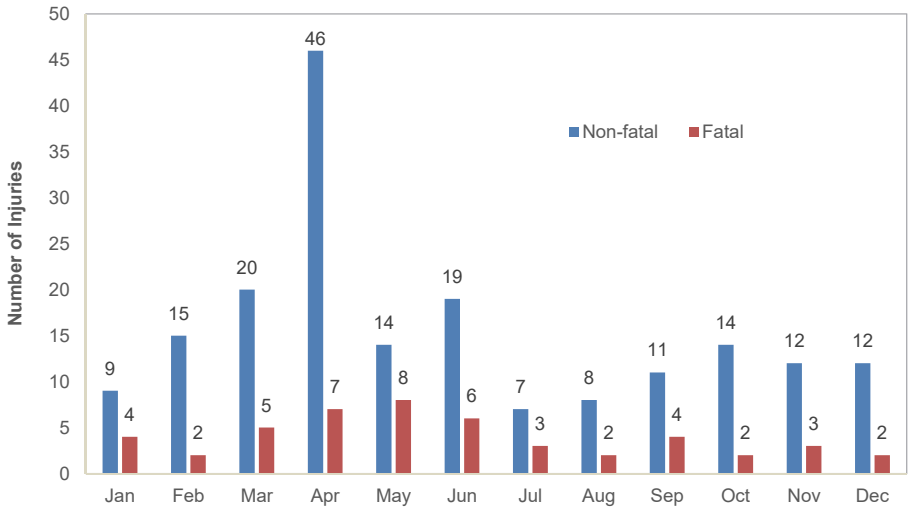

Figure 2. Monthly distribution of agricultural injuries in Florida, 2015-2019.

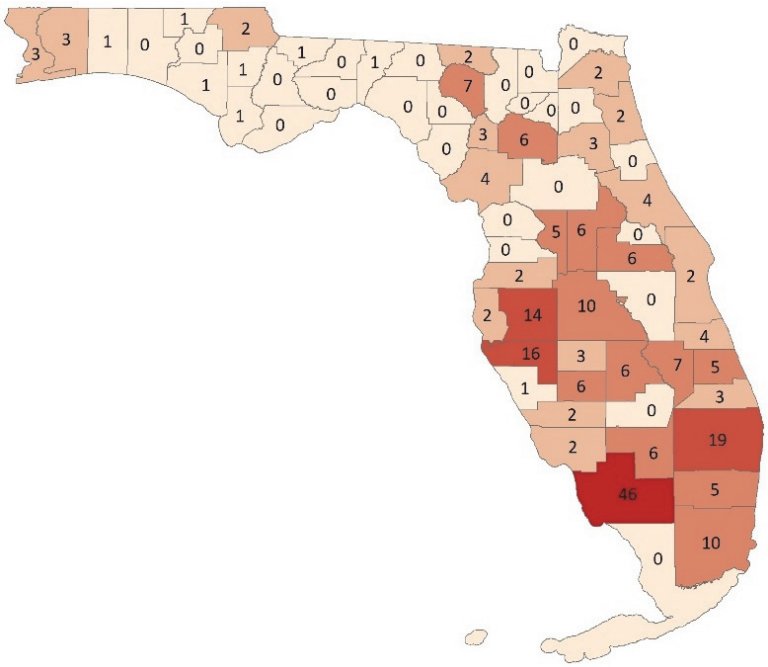

Figure 3. Numbers of agricultural injuries in Florida counties, 2015-2019.

Age, gender, industry of employment, and occupation were the only demographic characteristics coded in OSHA and AIN for the identified cases. Age was only populated for 81 cases (34%), and gender was only populated for 91 cases (39%), with 17 cases for females and 74 cases for males out of the 235 cases. Using this incomplete data, the average age was 43 years for fatal injuries and 37 years old for non-fatal injuries. Ten incidents resulted in multiple victim injuries.

Injuries by Industry Subsector and FAIC

Table 1 lists the cases grouped by their three-digit NAICS industry subsector and four-digit industry group as coded in IMIS. Crop production workers (NAICS 111) and workers in support activities for agriculture (NAICS 1151 and 1152) had the highest numbers of fatal and non-fatal injuries. Regarding the industry groups, most of the injured workers were involved in fruit and tree nut farming, followed by vegetable and melon farming, and then greenhouse, nursery, and floriculture production (table 1). Within NAICS 115, 97% of the injured workers were working in support activities for crop production as contracted laborers (data not shown).

Of the 235 injuries, 85% were occupational (FAIC-1 through FAIC-4) (table 2). Almost 20% of the occupational injuries were fatal. There were 23 non-workers (9.2%) injured in an agriculture-related incident (FAIC-5 through FAIC-9: non-occupational). Twelve of these victims were under the age of 18. The majority of non-occupational injuries occurred as a result of roadway hazards with agricultural vehicles (FAIC-9). These cases included occupants of other vehicles. Other non-occupational injuries occurred during an activity involving agricultural equipment, tools, and products (FAIC-6).

Table 1. Injuries by NAICS industry subsector and industry group.

NAICS Industry Subsector and Industry Group	Fatal (n = 48)	Non-Fatal (n = 187)	Total (n = 235)
111 - Crop production	18	72	90 (38.3%)
1111 - Oilseed and grain farming	0	2	2
1112 - Vegetable and melon farming	6	16	22
1113 - Fruit and tree nut farming	4	27	31
1114 - Greenhouse, nursery, and floriculture	3	15	18
1119 - Other crop farming	5	12	17
112 - Animal production	1	19	20 (8.5%)
1121 - Cattle ranching and farming	1	10	11
1123 - Poultry and egg production	0	4	4
1124 - Sheep and goat farming	0	1	1
1125 - Aquaculture	0	1	1
1129 - Other animal production	0	3	3
115 - Support activities for agriculture and forestry	10	27	37 (15.7%)
1151 - Support activities for crop production	10	26	36
1152 - Support activities for animal production	-	1	1
Unknown industry	19	66	88 (37.4%)

Table 2. Injuries by FAIC classification code.

FAIC Classification Code	Fatal (n = 48)	Non-Fatal (n = 187)	Total (n = 235)
Occupational	37	163	200 (85.1%)
FAIC-1: Farm/ranch production work	25	132	157
FAIC-4: Support activities for agriculture and forestry	12	31	46
Non-occupational	5	18	23 (9.8%)
FAIC-6: Farm/ranch hazard exposure, non-workers: Equipment, tools, objects, and products	5	4	9
FAIC-7: Farm/ranch hazard exposure, non-workers: Structures and landscape	-	1	1
FAIC-9: Farm/ranch hazard exposure: Roadways	-	13	13
FAIC-10: Undeterminable	6	6	12 (5.1%)

OIICS categories for the nature of the injury and body part injured could be coded for 126 and 155 cases, respectively. Fractures (n = 38) were the most prevalent injury, followed by heat-related injuries (n = 22). Twenty employees had amputations of fingers or fingertips, and one employee suffered an arm amputation. In terms of body part injured, 52 injuries involved body systems, which were coded for drownings, heat-related injuries, electrocutions, and poisonings. Other body parts most typically affected included the upper extremities (20%), lower extremities (14%), and trunk (14%) (data not shown).

The most common injury event types were transportation incidents (n = 104, 43.0%), contact with objects or equipment (n = 46, 19.6%), exposure to harmful substances and environments (n = 46, 19.6%), and falls, slips, or trips (n = 25, 10.6%) (table 3). Half of the transportation incidents occurred on roadways. All pedestrian vehicular injuries were to bystanders struck by a vehicle in a non-roadway area. Almost all of the injuries to non-workers occurred as transportation incidents (data not shown). Non-workers were bystanders, other vehicle occupants in roadway incidents, or occupants of a vehicle in non-roadway incidents, i.e., recreational vehicle users or extra riders.

Most incidents involving contact with objects or equipment were “struck by” injuries. Examples of these injuries include “ran over by a tractor left in reverse gear”, “struck by a falling trailer while trying to connect it to the tractor”, or “struck by a freely rolling log”.

Table 3. Event/exposure types of fatal and non-fatal injuries.

Event/Exposure	Fatal (n = 48)	Non-Fatal (n = 187)	Total (n = 235)
Transportation (n = 101, 43.0%)			
Roadway incidents involving motorized land vehicle	8	44	52
Non-roadway incidents involving motorized land vehicles	12	14	26
Pedestrian vehicular incidents	9	7	16
Animal and other non-motorized transportation incidents	1	4	5
Rail vehicle incidents	1	1	2
Contact with objects and equipment (n = 46, 19.6%)			
Struck by object or equipment	3	21	24
Caught in or compressed by equipment or objects	0	18	18
Struck against object or equipment	0	2	2
Contact with object and equipment, unspecified and n.e.c.	0	2	2
Exposure to harmful substances and environments (n = 46, 19.6%)			
Exposure to temperature extremes	5	18	23
Exposure to electricity	6	13	19
Exposure to other harmful substances	0	4	4
Falls, slips, or trips (n = 25, 10.6%)			
Falls to lower level	1	17	18
Falls on same level	0	6	6
Slip or trip without fall	0	1	1
Others (n = 17, 7.2%)			
Animal and insect related incidents	1	9	10
Non classifiable and others	1	6	7

The second most common contact injury was “caught in” injuries. Examples include “when working around a conveyor, employee’s glove was caught in the conveyor, which pulled his arm, resulting it being amputated”, and “employee’s pant leg was caught by an auger, and the employee suffered two broken legs, requiring hospitalization”.

The “exposure to harmful substances or environment” category accounted for 46 injuries. Eleven employees were killed by injuries related to environmental heat exposure, electrocution due to ladders touching power lines, and lightning. Seventeen employees were hospitalized for heat-related illnesses.

Of the 25 falls, slips, or trips, the most frequent events were falls to a lower level, followed by falls on the same level. The most frequent incidents involving a fall to a lower level were falls from ladders, non-moving trucks, and platforms.

In terms of injury sources, most injuries were caused by vehicles (46.4%; e.g., trucks, tractors, off-road vehicles, etc.), followed by environmental sources (13.6%, e.g., heat, lightning, etc.) and machinery (10.6%, e.g., agricultural machinery, conveyors, loaders, etc.). Other injury sources were persons, plants, and animals (8.9%; e.g., livestock, logs, tree limbs, etc.) and tools, instruments, and equipment (8.5%; e.g., ladders, hand tools).

Comparisons of AIN and OSHA Data

The OSHA and AIN data were compared for the demographics of the injured victims and the injury source and event/exposure categories (table 4). In terms of the injury severity and gender of the victims, no significant differences were found. The AIN data included non-occupational agricultural injuries to non-workers, as well as family members and self-employed farmers. All victims under the age of 18 and 91% (10 of 11) of victims in the 65 and older age group were identified in the AIN data ($p < 0.001$). In terms of injury source and event/exposure, the OSHA data had larger proportions for each category except

Table 4. Comparison of results by data sources.

	AIN (n = 90)	OSHA (n = 153)	Chi-Squared Results
Severity			
Fatal	24 (26.7%)	31 (20.3%)	1.328
Non-fatal	66 (73.3%)	122 (79.7%)	(df = 1, p = 0.249)
Gender[a]			
Female	12 (23.5%)	7 (14.6%)	1.276
Male	39 (76.5%)	41 (85.4%)	(df = 1, p = 0.259)
Age[a]			
Under 18	12 (29.3%)	-	30.883
18-64	19 (46.3%)	47 (97.9%)	(df = 2, p < 0.0001)
65 and older	10 (24.4%)	1 (2.1%)	
Source			
Machinery	2 (2.3%)	23 (18.0%)	56.417
Persons, plants, animals	4 (4.6%)	18 (14.1%)	(df = 4, p < 0.0001)
Parts and materials	2 (2.3%)	20 (15.6%)	
Vehicles	72 (82.8%)	40 (31.3%)	
Other sources	7 (8.0%)	27 (21.1%)	
Event/exposure			
Transportation	69 (80.2%)	35 (25.2%)	68.367
Falls, slips, trips	2 (2.3%)	23 (16.5%)	(df = 3, p < 0.0001)
Exposure to harmful substances or environments	12 (14.0%)	38 (27.3%)	
Contact with object and equipment	3 (3.5%)	43 (30.9%)	

[a] Missing variables were not included in percentages and chi-squared calculations.

the "vehicle" and "transportation" categories, which were represented in higher proportions in the AIN data.

Discussion

This is the first study to investigate agricultural injuries in Florida since 2000; no other studies on the topic were identified in the peer-reviewed literature. Our goal was to use OSHA and AgInjuryNews.org data to explore the epidemiology of injuries. Similar to the other U.S. states, crop production-related injuries and fatalities occurred with the greatest frequency in Florida, with relatively fewer injuries and fatalities in animal production.

Unlike many other U.S. states (Weichelt and Gorucu, 2019; Gorucu and Michael, 2020), the monthly distribution of agricultural injuries in Florida is more evenly distributed. The lowest numbers of injuries were in July and August. Most cases occurred in April, which was related to a roadway accident involving a bus carrying 60 farmworkers, 34 of whom were injured as a result.

Agricultural exposures create hazardous situations not only for the workers but also for non-workers who are living on or visiting farms, as well as for motor vehicle occupants who share the roads with farm equipment. In our analysis, we found that occupational injuries accounted for higher proportions of all agricultural injuries (85%) in Florida compared to the proportions reported for other U.S. states. For example, the proportion of occupational farm fatalities was 56% in Pennsylvania from 2000 through 2012, and the non-occupational proportion was 44% (Gorucu, et al., 2015). The difference between these results might be explained by methodological differences, the number of data sources used, or demographic differences (e.g., the Pennsylvania Anabaptist population versus migrant/seasonal farmworkers in Florida). The Pennsylvania database for farm fatalities uses multiple data sources, such as death certificates, police and coroner reports, a newspaper

and media clipping service, and county agricultural and extension educators. Additional data sources may be needed to identify non-occupational fatalities and injuries in Florida.

The two most common injury events in our datasets were transportation incidents (43%) and contact with objects or equipment (20%), which is consistent with other studies (Gorucu et al., 2015; Weichelt and Gorucu, 2019). The leading injury source in our study was vehicles (46%). Vehicles were reported to be the leading injury sources in many other studies (Scott and Dalton, 2020; Weichelt and Gorucu, 2019). Vehicles, including trucks, tractors, and off-road vehicles (including ATVs and UTV side-by-sides) are hazardous not only for operators but also for passengers and bystanders. Vehicle-sourced incidents involved transportation, contact by, and fall-related injuries. In a study by Gorucu et al. (2021), injury types in terms of source and event/exposure reported in SOII, which has the same limitations as OSHA, were found to be different from what their study revealed based on emergency department records. From 2015 to 2019, national SOII data reported "floors, walkways, ground surfaces" as the leading injury source, followed by "person, injured or ill worker" (i.e., worker motion or position) and "vehicles" (Gorucu et al., 2021).

Florida has unique hazards for agricultural workers, such as environmental heat and lightning. Environmental hazards were the second most common injury source (14%) in our study. Workers in construction and agriculture were the two most common labor groups facing environmental heat-related fatalities in the U.S. between 2014 and 2016 (Roelofs, 2018). High temperatures and extreme weather events are projected to increase in frequency, duration, and variability with ongoing climate change (Roelofs, 2018). To protect workers from heat-related illnesses, the health impacts of climate change should be acknowledged for interventions (Roelofs, 2018; Levy and Roelofs, 2019; Hesketh et al., 2020).

Study Limitations

Similar to most agricultural injury surveillance projects, there are limitations with the datasets. The limitations of the AIN dataset, and of other datasets that use media reports, are well-documented in recent literature (New-Aaron et al., 2019; Weichelt and Gorucu, 2019; Gorucu et al., 2019; Weichelt et al., 2019a).

Victim demographics is another limitation of the datasets. Although migrant and seasonal farmworkers represent a substantial portion of the agricultural workforce in Florida, we could not identify the numbers of injuries and fatalities for these populations. Neither of the data sources used in this study included race or ethnic origin variables. Similarly, we had incomplete gender and age information; thus, we could not identify the at-risk populations in these domains. Future research using additional data sources is needed to assess the impact of farm injuries on migrant and seasonal farmworkers as well as on different age groups. Matching fatal cases with death certificates may help researchers gather additional details, including decedent demographics.

Another limitation is the inclusion criteria of the data sources. Florida OSHA captures injury data from employers who employ eleven or more non-family workers on an agricultural operation. Thus, we expect that workplace injuries on smaller operations are not fully represented within this dataset. Furthermore, the OSHA reports do not capture non-worker injuries, such as a person traveling on a public roadway who collides with agricultural equipment, or a toddler run over by a farm tractor or skid steer. While AIN includes cases that fit those two examples, not all cases are reported in public news outlets (e.g., obituaries and news reports) and therefore may not be captured in the database.

These limitations are common concerns frequently described in the literature by injury surveillance teams for more than 30 years (Gunderson et al., 1990; Purschwitz and Field, 1990; Stallones, 1990; Weichelt et al., 2019b; Kica and Rosenman, 2020; Weichelt et al., 2020). However, the data sources used to compile and analyze cases from this study's time period helped us to better understand the traumatic injuries and fatalities in Florida agriculture.

Conclusions

Similar to the other U.S. states, agricultural injuries in Florida resulted from a wide variety of sources and events. Vehicles and transportation incidents were the most common injury sources and injury events, respectively. Educational training efforts should focus on preventing vehicular transportation injuries on both worksites and roadways. Back-up cameras and back-up alarms should be used on worksites to prevent bystander injuries. Additionally, efforts should focus on preventing environmental heat and lightning-related injuries. The University of Florida Institute of Food and Agricultural Sciences (IFAS) offers bilingual training for farm labor supervisors on agricultural safety and health topics, including safe transportation and driving, pesticide safety, heat stress prevention, and agricultural equipment safety. When delivering the training, educators must be aware of the different working conditions and tasks performed by the workers.

This study identified and described an overview of the traumatic injuries and fatalities in Florida agriculture and also pointed out several gaps, consistently described in the peer-reviewed literature. Research efforts should focus on identifying the demographics of the injured victims using multiple data sources. Finally, we recommend continued collaborative discussion and strategic planning for the funding of and implementation of a national agricultural injury surveillance system.

Acknowledgements

Funding support was provided through the Southeastern Coastal Center for Agricultural Health and Safety via CDC/NIOSH (Grant No. U54 OH011230), the National Farm Medicine Center, the Marshfield Clinic Research Institute, the Dean Emanuel Endowment, and the National Children's Center for Rural and Agricultural Health and Safety via CDC/NIOSH (Grant No. U54 OH009568).

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