Investigating the Rates, Severity and Affecting Factors of Accidents Related to Agricultural Tractors and Grain Combine Harvesters in Ilam Province of Iran

J. Allahnouri[1], A. Marzban[1*], M. Ghasemi-Nejad-Raeini[1], M. Rahnama[1], M. Savari[2]

1- Department of Agricultural Machinery and Mechanization Engineering, Faculty of Agricultural Engineering and Rural Development, Agricultural Sciences and Natural Resources University of Khuzestan, Molla Sani, Iran
2- Department of Agricultural Extension and Education, Faculty of Agricultural Engineering and Rural Development, Agricultural Sciences and Natural Resources University of Khuzestan, Molla Sani, Iran
(*- Corresponding Author Email: afshinmarzban@asnrukh.ac.ir)
https://doi.org/10.22067/jam.2025.91786.1336

Abstract

Agriculture is the most prominent industry in developing countries and also ranks as one of the most dangerous professions. Tractors and grain combine harvesters are two of the main self-propelled agricultural machines. Agricultural machines, despite their irreplaceable role in increasing productivity, contribute significantly to agricultural accidents. This study was conducted to investigate the current rates and severity of accidents and human casualties related to agricultural tractors and grain combine harvesters in Ilam province, Iran. Evaluations were conducted using data from the years 2019-2023.Over these five years, the accident frequency for agricultural combines and tractors was 61 and 43, respectively, indicating a statistically significant difference. Among the tractor drivers in this research, the most frequent accidents occurred due to the power take-off shaft (P.T.O.), helices, and feeding rollers. Among combine drivers, accidents were most common at the shear points of the machine (cutter bars, gears, etc.). This research evaluated the factors affecting field accidents related to tractors and combines and estimated the accident rates. Accident rates, including AFR (Accident Frequency Rate), ASR (Accident Severity Rate), FIR (Fatal Incident Rate), and FSI (Frequent Severity Index), were calculated. The rates of AFR, ASR, FIR, and FSI were 25.84, 45.82, 1.66, and 1.066% for combine harvesters, and 5.60, 12.63, 4.44, and 0.262% for tractor accidents, respectively. The nonfatal rate for combine harvesters was 6445 per 100,000, and for agricultural tractors, it was 4334 per 100,000. Tractor accidents had a higher fatality rate than combine harvesters, with 445 fatalities per 100,000 for tractors compared to 333 per 100,000 for combine harvesters.

Keywords: Accident survey, Accident indices, Accident factors, Combine, Operator safety, Tractor

Introduction

The occurrence of incidents in agricultural occupations is inevitable. Identifying the factors affecting the incidence of accidents can help reduce accidents among farmers (Moradhaseli, Farhadian, Abbasi & Ghofranipour, 2017). Work-related stress is one of the most important variables affecting productivity, resulting from the interaction of environmental factors, work capacity, and excessive work, and it affects health and performance (Karimi *et al.*, 2024). According to global reports, harmful accidents resulting from work activities cause 150,000 work injuries and 1,400 deaths annually in Iran (Abbasi Balochkhaneh, Ghotbi Ravandi, Golkhani, Baes's mat & Hasan pour Sodre Jani, 2016). An accident is an unforeseen and unexpected event that causes injury (International Labour Organization, 2011). In order to prevent injuries to tractor operators during agricultural operations, and for them to be able to maintain adequate reaction time, the tractor users should drive less than 8 hours during the work-day (Mohammadi, Kheiralipour, Ghamary, Jahan Bakhshi & Shahidi, 2023). One of the most important debates in agricultural mechanization is the issue of human safety when working with machines, which has become a prominent topic in ergonomics science today (Gholami, Kalantari & Rajabi Vandechli, 2017).

Occupational diseases related to workplaces are typically explained as disorders or illnesses that negatively affect work productivity (Hamalainen, Takala & Kiat, 2017). Despite the use of unsafe implements in tractors

compared to other machines, tractors are still used for agricultural activities and transportation on farms (Kasar, Comer pay, Ilhan, Eroğlu, & Deniz, 2023). Recently, attention to health, efficiency, and safety in the workplace has increased. Agriculture is one of the human work activities with the highest risk indices (Cecchini, Bedini, Musetti, Marino, & Stasi, 2018). Mechanization has increased agricultural productivity and made work easier. However, it has also increased accidents and injuries when operators and farmers work with agricultural machinery (Shikha & Chaudhari, 2016). The importance of safety in agricultural activities is promoted by the development of standard rules related to professional work and equipment safety (Fargnoli, Lombardi, Haber, & Puri, 2018). Tractors are a main source of agricultural injuries, particularly those caused by overturning. To prevent accidents due to overturning, rollover protective structures are provided with tractors (Singh, Tewari, & Hota, 2023). Approximately 337 million job accidents occur annually, with occupational injuries and accidents in agriculture occurring for various reasons (Sarkar, Vinay, Raj, Maiti, & Mitra, 2018).

Accidents usually occur as a result of a combination of accumulated problems, such as machine breakdowns, operator interventions, and human error. Studies have identified agriculture as one of the most dangerous jobs in the world (Pawlak, Nowakowicz-Debek, Wlazlo, Maksym, & Sasakova, 2017). The main causes of agricultural machinery accidents are slipping, falling, crush points, and pinch points. Crushing of operators (35%), improper control of the machine during agricultural activities (28.7%), and breakdowns, injuries, or overturning (19.5%) are the most common accident causal factors (Gite, Tiwari, & Khadatkar,2010). Operators are exposed to erosion factors and work injuries while driving. Due to a lack of proper maintenance and service, insufficient management, and non-standard driving, farmers are at risk of injuries (Quendler *et al.*, 2014). Agricultural activities cannot be performed without the use of modern agricultural machinery. The performance of grain combine harvesters depends on factors such as operator skill, distractions, and errors (Du, Dorneich, Steward & Mackenzie, 2016). Moments of error while driving are common and can sometimes have significant consequences. In fact, accidents involving agricultural tractors are the leading cause of work-related deaths in the agricultural industry in many countries (Jun, 2014). Agriculture is one of the most dangerous job sectors for farmers, operators, and workers. Therefore, decisions aimed at improving safety in agricultural workplaces need to take into account the behavior of farmers, operators, workers, and related factors (Damalas, Koutroubas, & Abdollahzadeh, 2019). Accidents in agriculture occur due to neglecting safety factors, lack of knowledge and education, and poor design of agricultural machinery and equipment. Approximately half of the world's population is employed in the agricultural sector, which fulfills the basic needs of their lives through agricultural activities (Maisyaroh, Widianto, & Fibriansari, 2022). Physiological factors during work activities are one of the challenges of occupational health. The force of gravity affects human health at work. Therefore, the mechanization of work can prevent work hazards (Hayati, Marzban, & Asoodar, 2022).

The most significant cause of death in this sector is injuries caused by accidents. The available information on the use of protective equipment in tractors is scarce, and when operators do have access to this equipment, they frequently employ it in an unsafe manner. (Antunes, Cordeiro, & Teixeira, 2018). Studies show that tractors are involved in 14% of agricultural accidents, and fatal accidents related to agricultural machines are 8 times more common than those involving other types of machines (Murphy *et al.*, 2010). Tractors are known to be the leading cause of occupational accidents in agricultural operations. Tractor overturns are the primary cause of fatal accidents, especially when tractors are used without protective structures

(Arnal, López-Maestre Salas, Arazuri, Mangado, & Jaren, 2017). Many factors contribute to the increase in fatal tractor accidents, including operator error, tractor technical issues, and environmental conditions related to agricultural activities. To reduce accidents, these factors must be addressed (Ehlers & Field, 2017). Based on incidents in some countries, despite the relatively low number of agricultural machine accidents, the rate of severe injuries and fatalities is higher than the global average (Mayrhofer, Quendler, & Boxberger, 2013).

There are few studies about combine accidents in the world. In one study, 60 accidents were evaluated, and according to research reports, 10 people were killed and 40 people were trapped and injured due to falling from combine harvester (Health & Safety Executive, 2012). Another study examined road and farm accidents related to combine harvesters, investigating 194 accidents with 228 victims (61 dead and 167 injured). Of these, 116 accidents (59.8%) happened on farms, while 78 (40.2%) occurred in road traffic. Two very important types of accidents were farm fires and drivers' bodies getting stuck in the pinch points of the combine machine, accounting for 41.4% and 25.9% of the accidents, respectively (Keskin & Şekerli, 2018). Research on agricultural accidents is crucial for minimizing these incidents, as numerous tragic and fatal accidents related to farming activities take place each year. (Cividino, Pergher, Zucchi Atti, & Gubiani, 2018). Agricultural tractors, being integral to agricultural activities, pose serious risks related to injuries, especially due to side overturns or rear overturns (Abubakar, Ahmad, & Akande, 2010). Agricultural activity in Iranian farms is characterized by a high level of mechanization, where farm tractors are used extensively. Farm machinery is often large and slow-moving. Although the number of tractor-related injuries is increasing, the safety of Iranian farm tractors had not been documented before (Houshyar & Houshyar, 2018). There is no comprehensive concept of the health status of Iranian farmers and the work-related injuries affecting them (Ghafari, Cheraghi, & Dusti Irani, 2017). A study showed that participation in occupational health and safety training courses had the greatest effect (80%) on reducing agricultural occupational injuries among farmers in Ilam province. Other influential factors included education level (69%), farmers' income (68%), safety knowledge (67%), history of farming activity (64%), farm area (60%), and farmers' age (59%) (Parak, Pour Saeed, Eshraghi Samani, & Chaharsoghi Amin, 2021).

Materials and Methods

To carry out this study, the first stage involved investigating the issues related to accidents and safety during working with agricultural machines. The effective factors in the occurrence of tractor and combine accidents (mechanical, human, environmental factors, etc.) were identified in Ilam province, located in the west of Iran. Data were collected through field studies over a period of 5 years, focusing on incidents involving the owners and operators of combines and tractors. Using questionnaires and interviews, insight were gathered from tractor and combine operators, organized based on an analytical framework focusing on human, environmental, and mechanical factors for each incident, The questionnaires encompassed a range of topics., including personal traits (three questions), professional characteristics (three questions), accidents details (five questions), attitude towards safety (twenty questions), attitude towards health (sixteen questions), level of access to safety information (seven questions), risk tolerance (sixteen questions) and knowledge about safety practices (twenty questions). Additionally, questions related to factors affecting the accident (twenty-two questions) and questions related to measures to prevent accidents (fifteen questions) were included. Statistical data analysis was done using SPSS software, Friedman's test was used to rank accidents related to tractors and combine harvesters, and T-test mean comparison method was used to compare accidents in two groups of combine and tractor

operators.

Related statistics, information from questionnaires, and the accident experiences of grain combine harvester and tractor operators were examined. The number of fatal and non-fatal accidents in Ilam province was also collected. The accident frequency and severity of agricultural accidents and injuries were assessed through direct surveys of agricultural operators of tractors and combines. The effective factors influencing accidents involving agricultural combines and tractors were analyzed using SPSS software.

Ilam province is located in the west of the Zagros Mountain range and borders Khuzestan province to the south, Lorestan province to the east, and Kermanshah province to the north. It also shares a 425-kilometer border with Iraq to the west. The province comprises 12 cities, 29 districts, 27 towns, 54 villages, and 750 inhabited villages (Sadat Haeri *et al.*, 2019). Covering an area of 20,164 square kilometers, it represents approximately 1.2 percent of the country's total area and includes 336,000 hectares of agricultural land. The total number of tractors and combines in Ilam province is 6,130 and 163, respectively (Anonymous, 2023). Fig. 1 shows the area under study.

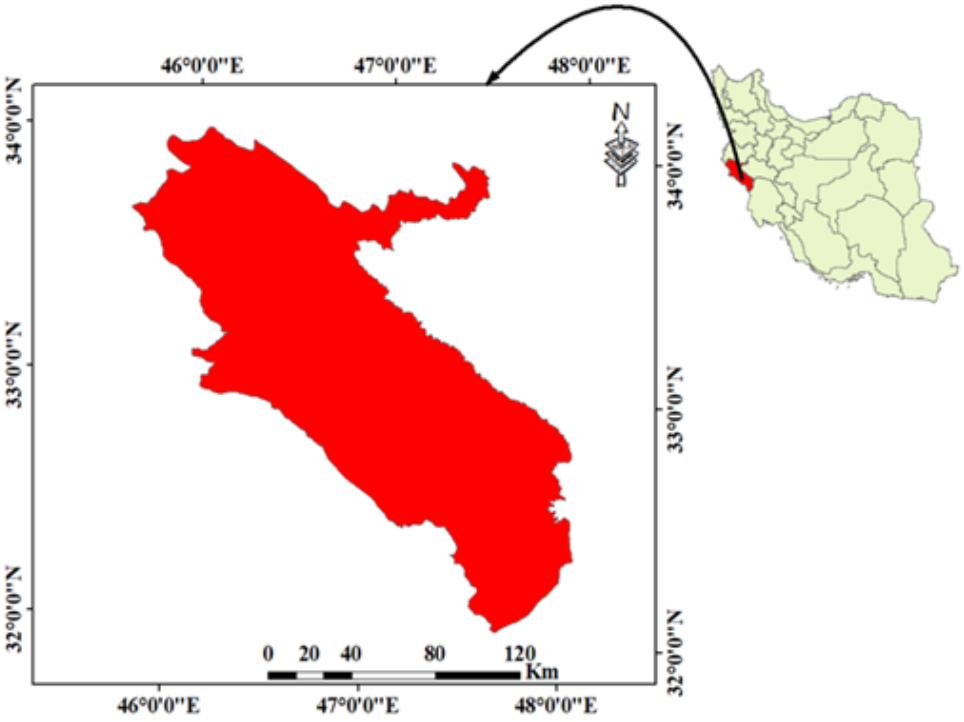

Fig. 1. Map of the Ilam province in Iran

Statistical population and sampling method

The sample size for this research was estimated using Cochran's formula; sample sizes for tractor and combine operators were both 180 people. (Cochran, 1977). The sampling was done using a multi-stage method and three townships of Dehloran, Abdanan and Darrehshahr were selected according to geographical conditions, topography, cultivated area, and the number of tractors and combines. Aforementioned townships include about 50% of the agricultural lands of Ilam province, and then, based on the population size in each township, the sample percentage was calculated.

$$n = \frac{\frac{z^2 pq}{d^2}}{1 + \frac{1}{N}\left[\frac{z^2 pq}{d^2} - 1\right]} \quad (1)$$

where:

N: statistical sample size

N: the size of the statistical population

z: value of normal variable with a confidence level of 1- α

p: percentage containing the desired attribute

q: the ratio not containing the desired attribute

Validity and reliability of research tools

To assess the reliability of the research tool, Cronbach's alpha coefficients were used. Cronbach's alpha is a classic standard for measuring reliability and is a suitable measure for evaluating internal consistency. Internal consistency refers to the degree of correlation between factors and the related questions. A Cronbach's alpha value greater than 0.6 indicates acceptable reliability (Taber, 2018).

Table 1- Validity and reliability of research tools with Cronbach's alpha coefficient

Variable name	Number of questions	Cronbach's alpha
Attitude toward safety in agriculture	20	0.839
Attitude toward health	16	0.755
The level of information accessibility	7	0.700
Risk tolerance	16	0.666
Knowledge about safety	22	0.762
Factors affecting the accident	7	0.943
Impact of various actions increasing accidents	15	0.651

Because Cronbach's alpha values are greater than 0.7, so the questionnaire has adequate reliability.

Accident rate:

Accident frequency rate (AFR) represents the number of different incidents leading to loss of working time that occurred in a specific period (monthly-yearly) per one million working hours as follow (SIGHI, 2006):

$$AFR=\frac{\text{number of accidents} \times 1000000}{\text{total useful hours of workers}} \quad (2)$$

Accident severity rate (ASR) represents the number of lost working days for every 1000 working hours. The entire organization had this amount of production stoppage days (Akanbi, Charles Owaba, & Olley, 2009):

$$ASR=\frac{\text{days lost due to the accidnt} \times 1000}{\text{total number of hours the worker at the same time}} \quad (3)$$

FIR represents the number of accidents per 1000 working hours per the total number of employees:

$$FIR=\frac{\text{number of deaths} \times 1000}{\text{number of workers}} \quad (4)$$

FSI represents frequent severity index, is calculated according to the following formula:

$$FSI=\sqrt{\frac{FIR \times ASR}{1000}} \quad (5)$$

Results and Discussion

Table 2 shows that all respondents were male, with a total of 360 participants consisting of with a total of 360 participants consisting of 180 combine harvester operators and 180 tractor operators. According to the findings, 69.7 percent of the sample size has primary education, that shows combine and tractor operators do not have higher education.

Table 2- Characteristics of respondents at the working area

Variable	Characteristics	Frequency	Percentage
Gender	**Male**	**360**	**100**

Age	21-30 years	62	17.2
	31-40 years	91	25.3
	41-50 years	104	28.9
	51-60 years	74	20.55
	61-70 years	29	8.05
Education	Primary Education	251	69.72
	Diploma	97	26.9
	Associate degree	8	2.2
	Bachelor	3	0.8
	Other qualification	1	0.3
Working experience	1-6 years	33	9.2
	7-10 years	77	21.4
	10-15 years	135	37.5
	16-20 years	78	21.7
	More than 20	37	10.3
Type of work	Tractor operators	180	50
	Combine operators	180	50

Table 3 shows the number of different accidents involving combine machines over a 5-year period. Although between 2020 and 2023 we have a reduction in accidents and injuries, significant accidents and injuries are still observed and measures should be implemented to prevent accidents involving combine machines. According to the results of (Ceylan, 2012) for the years 2004 to 2010, although there is a serious reduction in the number of accidents in Turkey, there is no significant change in the number of permanent incapacities. Until 2009 for mining, metal and construction sectors, there was no improvement in the number of permanent incapacities as a result of accidents, but in 2009, a remarkable decrease can be seen in these three sectors. However, in 2010, the permanent incapacity number in the metal sector became more than the average value of the last seven years in Turkey. Additionally, Table 3 presents the accident information related to tractor. Results shows that the number of tractor-related accidents during this period is significant, and basic measures are needed to prevent and reduce tractor accidents. According to Volkov ski, Chalo ska, and Grad (2018), 30.5% of agricultural accidents were due to farm machinery, 34.2% were related to hand tools, and 35.3% were caused by other sources, such as environmental factors, etc. The highest number of accidents was related to tractors (31%), P.T.O (14%) and sprayer (4%). In these agricultural machinery accidents, 5.6 percent of the accidents were fatal, while 94.4%, the remaining percentage, were non-fatal. Also, Park *et al.* (1990) analyzed the causes of fatal tractor accidents, revealing that an average of 9.4 people die each year, with a peak of 27 fatalities (57.45%) attributed to violations of traffic signs and regulations. As a result of poor psycho-physical conditions, pedestrians and second party errors with 12 cases (25.53%), and technical malfunction of the vehicle with 8 cases (17.02%) individuals were killed.

Table 3- Number of combines and tractors accident types in the study during 2019-2023 period

Machine	Year	Killed	Seriously injured	minor injury	Completely injured/dead
Combine	2019	1	8	8	17
	2020	1	12	5	18
	2021	1	6	4	11
	2022	0	4	3	7
	2023	0	4	4	8
	Total	3	34	24	61
	%	4.91	55.73	39.34	100
Tractor	2019	1	5	6	12
	2020	1	4	4	9

2021	0	4	4	8
2022	1	2	5	8
2023	1	1	4	6
Total	4	16	23	43
%	9.30	37.20	53.48	100

Fig. 2 shows the typical accidents gathered by the authors involving tractors and combines in the study, during 2023 and 2024 years, at the working area.

Fig. 2. Typical tractors and combines accidents (images provided by authors)

Combines and tractors accident

Result of investigating the number of non-fatal accidents related to agricultural combines and tractors during five years in the current study revealed that the number of accidents involving combines were more frequent than those involving tractors (Fig.3). The accident rate was 6445 per 100,000 for combine harvesters and 4334 per 100,000 for agriculture tractors. This can be due to the difference in the technical and complicated structure of combines compared to agricultural tractors, the type of harvesting operation, and human error. researches related to the Estonian Labor Inspectorate shows that, there were 785 non-fatal accidents (NFA) per 100,000 agricultural workers, while the rate in Eurostat was more than twice as high (1914 per 100,000) (Dimitrovski, 2013). Finland and Sweden, with the same agricultural structures, had different NFA rates: Finland 5,331 and Sweden 554 per 100,000 workers. These examples illustrate the large variation in agricultural accident statistics due to: farm structure, and the type of agricultural machinery that is used by farmers. This study aligns with the findings of Merisalu, Lepala., Jakob, and Rautiainen (2019), indicating that the total number of non-fatal workplace accidents in the EU-27 saw a reduction of 39,818 incidents between 2017 and 2020. Also, according to Mitrev ska, Mitrevski, and Kulevska (2023), accidents in the agricultural sector are critical due to multiple contributing factors, and preventing agricultural accidents can save lives and provide a safer working

environment.

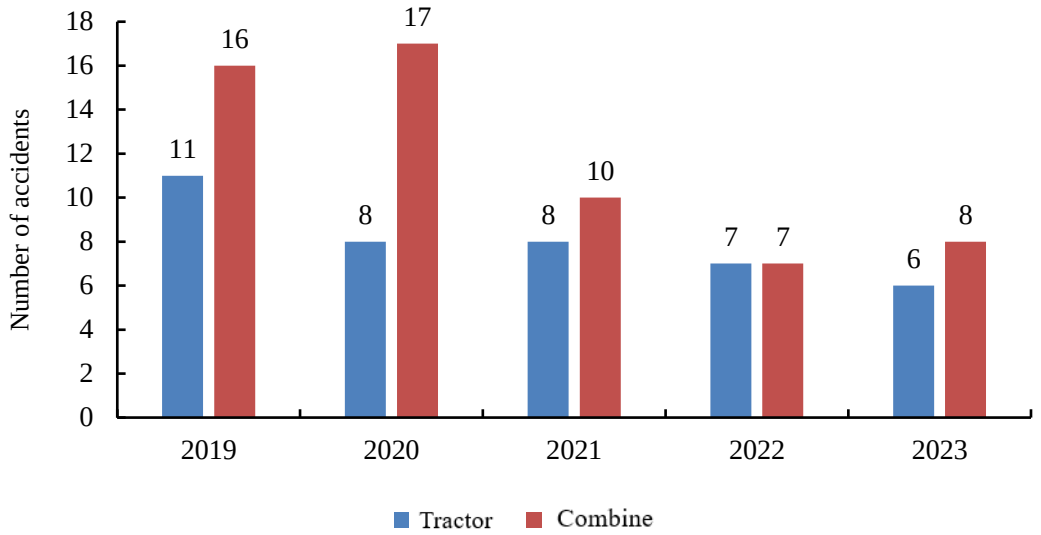

Fig. 3. Number of non-fatal accidents 2019-2023

Figure 4 illustrates the investigation of fatal accidents related to tractor and combine operators. The number of fatal tractor accidents was higher than that of combine accidents (445 per 100,000, for tractors and 333 per 100,000 for combine harvesters in Ilam province). This discrepancy is likely due to the special working conditions, the mechanical structure of tractors, and the excessive fatigue experienced by tractor operators. Also, the continuous use of agricultural tractors during all seasons and the seasonal use of combine harvesters. From 2019 to 2023, the number of fatal accidents related to tractors and combines decreased. According to Health and Safety Authority (2021), between 2017 and 2020, the incidence rates of both non-fatal and fatal accidents at work decreased.in 2019, the EU-27 Member States saw the lowest recorded incidence rates for non-fatal and fatal accidents, standing at 1,447.3 per 100,000 employed individuals for non-fatal incidents and 4.44 per 100,000 employed individuals for fatal accidents.

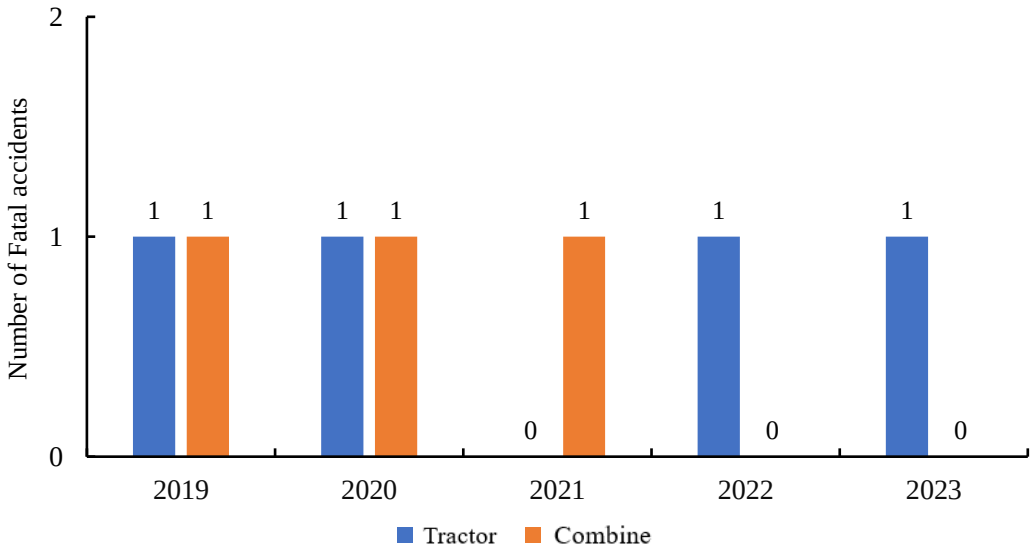

Fig. 4. Number of fatal accidents during 2019-2023

Figure 5 presents an analysis of data concerning the factors contributing to accidents involving tractors and combines. The result indicates that in the tractor operator group, the most common hazards arise from components such as the power Take-Off (P.T.O) shaft, helices and feeding rollers. In contrast, for the combine operator group, the areas with the highest frequency of incidents are the shear points of the Machin, including cutter bars and gears. According to similar studies (Chio, Kim, & Jung, 2024), most types of accidents in agricultural machines happen due to human errors. Therefore, investigating related causes and preventing operators from driving when tired as well as resting after long work can reduce accidents related to human factors. The main causes of accidents were insufficient management, inappropriate work conditions, and insufficient training. Factors causing injury in agricultural areas have been influenced by several factors. There are threat factors, capability factors, and vulnerability factors that have been proven capable of causing injury.

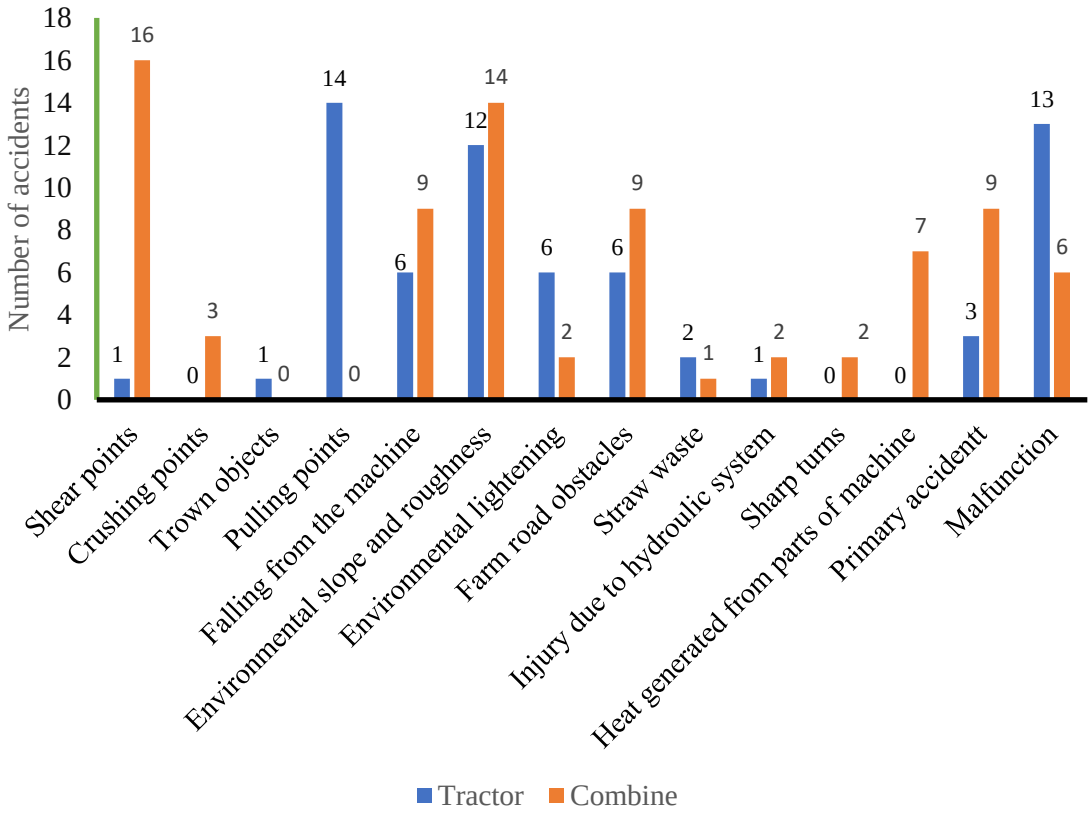

Fig. 5. Factors affecting the occurrence of accidents

According to the findings, tractor drivers ranked fatigue from long working hours (average rating of 4.169), unfavorable environmental conditions such as mountain roads and steep slopes (average rating of 4.167), and driver negligence and distraction (average rating of 4.158) as the top three contributing factors to accidents. Similarly, combine drivers ranked negligence and distraction (average rating of 4.442), adverse environmental conditions (average rating of 4.389), and fatigue from long working hours (average rating of 4.294) as the most significant factors. Tone and Irwin (2021), identified steep slopes, sharp curves, and road conditions (e.g., farm roads and access routes)

as primary contributors to accidents. Studies on agricultural work accidents and farmer safety promotion have highlighted uneven or slippery floors, lack of lightening, narrow spaces, and ground obstacles as major causes. Agricultural machinery accidents were found to occur more frequently while moving on farm roads compared to stationary indoor work. These results align with the findings in Table (4). Additionally, a comparison of the average factors affecting accidents for combine and tractor drivers was performed using an independent samples t-test, as shown in Table (5). Since the significance value of the t-test was less than 0.05, this indicates a significant difference in the average values of these factors between the two groups.

Table 4- Ranking of factors affecting accidents related to tractors and combines

Factors	Tractor operator		Combine operator	
Machine worn out	7	3.414	6	3.694
Unfamiliarity with the operation of the machine	6	3.536	7	3.672
Existence of unfavorable environmental conditions (mountainous roads, steep slopes, etc.)	2	4.389	2	4.167
Non-standard equipment and machinery	4	4.172	5	4.061
Insufficient physical ability of the driver	5	3.753	4	4.078
Fatigue from prolonged work	3	4.294	1	4.169
Driver's negligence and distraction	1	4.442	3	4.158
Friedman test results	X^2 = 114.680 Sig = 0.000		X^2 = 46.975 Sig = 0.000	

Table 5- Comparison of the average factors affecting accidents related to combine and tractor drivers

Variable name	Machine type	Number	Average	Standard deviation	Sig	t
Machine worn out	Tractor	180	478.0	977.0	602.0	0.523
	Combine	180	428.0	833.0		
Lack of familiarity with the operation of the machine	Tractor	180	511.0	948.0	0.953	0.059
	Combine	180	506.0	836.0		
Existence of unfavorable environmental conditions (mountainous roads, steep slopes, etc.)	Tractor	180	75.0	176.1	0.114	-1.58
	Combine	180	956.0	285.1		
Non-standard equipment and machinery	Tractor	180	711.0	08.1	0.221	1.226
	Combine	180	856.0	154.1		
Insufficient physical ability of the driver	Tractor	180	706.0	132.1	0.388	0.865
	Combine	180	611.0	93.0		
Fatigue from prolonged work	Tractor	180	0.767	1.158	0.274	-1.09
	Combine	180	0.906	1.245		
Friedman test results	Tractor	180	0.783	1.178	0.086	1.72–
	Combine	180	0.011	1.329		

Table 6 shows the total number of working hours lost due to injuries resulting from accidents involving combine and tractor operators over five years in Ilam province. The injuries are categorized, and the number of hours lost is proportional to the type of injury, providing the total working days lost due to combine and tractor-related incidents during this period. According to Khosravi, Hashemi Nazari, Dehghani Fard, and Jabari (2007), the total number of reported fatal accidents was 9 in 2004 and 6 in 2005, resulting in the loss of

67,500 working days in 2004 and 45,000 working days in 2005. With approximately 21,000 workers during these years, this corresponds to 43 deaths per 100,000 workers in 2004 and 26 deaths per 100,000 in 2005. Esmaeili, Vazirineghad, and Shahrokhi (2008), reported that 92.9% of the victims were men, with the most common injuries affecting the legs (35.7%) and hands (25.7%).

Table 6- Number of days lost due to disability related to combine and tractor operators

Combine							
Year	**Killed (hour)**		**Seriously injured (hour)**		**Minor injury (hour)**		**Total (hour)**
	Number of killed	**Hour**	**Body limb**	**Hour**	**Body limb**	**Hour**	
2019	1	48000	Arm amputation	36000	Two fingers	6000	**42000**
					Forearm	36000	
					Finger cut	9600	**141600**
					Disability	48000	
					Toe	2400	**2400**
			Hand amputation	24000	Two fingers	6000	**30000**
					Three fingers	9600	**9600**
2020	1	48000	Foot amputation	24000	Finger cut	9600	**69600**
					Forearm	36000	
			Leg amputation	36000	Toe	2400	**86400**
2021	0	0	Hand amputation	24000	Three fingers	9600	**33600**
			Wrist amputation	24000	Finger cut	7200	**115200**
			Disability	48000	Forearm	36000	
2022	1	48000	Hand amputation	24000	Finger cut	14400	**38400**
			Wrist amputation	24000	Two fingers	6000	**162000**
			Disability	48000	Forearm	36000	
2023	0	0	Arm amputation	36000	Finger cut	14400	**134400**
			Disability	48000	Forearm	36000	

Tractor							
Year	**Killed (hour)**		**Seriously injured (hour)**		**Minor injury (hour)**		**Total (hour)**
	Number of killed	**Hour**	**Body limb**	**Hour**	**Body limb**	**Hour**	
2019	2	96000	Hand amputation	24000	Toe	2400	**74400**
			Disability	48000			
			Arm amputation	36000	Finger cut	2400	**38400**
			Foot amputation	24000	Two fingers	6000	**126000**
			Disability	48000	Three fingers	9600	**57600**
2020	1	48000	Leg amputation	36000	Toe	2400	**38400**
			Hand amputation	24000	Two fingers	6000	**78000**
			Foot amputation	24000	Finger cut	2400	**2400**
					Three fingers	9600	**33600**
2021	0	0	Arm amputation	36000	Finger cut	2400	**38400**
			Disability	48000	Toe	2400	**50400**
					Finger cut	2400	**2400**
2022	1	48000	Hand amputation	24000	Finger cut	2400	**74400**
			Foot amputation	24000	Toe	2400	**26400**
			Leg amputation	36000	Finger cut	2400	**38400**
2023	1	48000	Foot amputation	24000			**72000**
			Hand amputation	24000			**24000**

Table 7 shows the accident indices, including AFR, ASR, FIR and FSI for various accidents related to working with agricultural combines and tractors during five years. It is for the first time that these indices are used for agricultural machinery accidents in the country of Iran. It was determined that, among the indices, the FSI and ASR index for combine

and tractor operators, and AFR for combine operators were higher than the standard (The acceptable level of safety performance for FSI is less than 0.1 and for ASR it is less than 1 and for AFR it is between 0 and 10) By observing the safety principles while working with tractors and agricultural combines, these indices should be brought to the standard. One study result revealed that, during the five years period of 2008 to 2012, in accidents involving tractors, on average 9.4 people die per year, and the largest number of 27 (57.45%) people died tragically due to noncompliance with safety alert symbols and regulations (Lohan, Singh, & Kumar, 2022). The study by Halvani *et al.* (2010) in Yazd province in 2014 found that the frequency of the incident was 5.6. The FIR indices during five years were below the standard level (0-10), which means that per 200,000 working hours, the number of incidents was within the standard.

Table 7- AFR, ASR, FIR and FSI rates for combine and tractor operators in Ilam Province during 2019-2023 years

Machine	Year	AFR	ASR	FIR	FSI
Combine	2019	36.016	59.74	2.77	1.46
	2020	38.13	41.31	2.77	1.25
	2021	23.30	39.40	2.77	0.958
	2022	14.83	53.072	0	0.887
	2023	16.95	35.59	0	0.776
	Mean	25.84	45.82	1.66	1.066
Tractor	2019	7.82	24.15	5.55	0.435
	2020	5.86	12.41	5.55	0.270
	2021	5.21	7.43	5.55	0.196
	2022	5.21	8.21	0	0.206
	2023	3.91	10.95	5.55	0.207
	Mean	5.60	12.63	4.44	0.262

Conclusion

Accidents related to tractors, combines, and agricultural machines are known as one of the serious problems in the agricultural sector. These accidents primarily arise from the unique design and operational methods of these machines. The most important factors affecting accidents are overturns, falling from agriculture machinery, human errors, traffic road accidents and insufficient training related to safety. According to the results of this study, non-fatal accidents related to agricultural combines and tractors from 2019 to 2023 indicated that the number of accidents involving agricultural combines was higher than those involving agricultural tractors. The accident rate for combine harvesters was 6445 per 100,000, while for agricultural tractors, it was 4333 per 100,000. This is due to the complicated structure of combine harvester machines and farm work conditions. However, the number of fatal tractor accidents was higher than that of combines (445 per 100,000 for tractors and 333 per 100,000 for combine harvesters in Ilam province). This is attributed to the special working conditions of tractors, their mechanical structure, excessive fatigue of tractor operators, and the lack of rollover protection structures (ROPS). According to Ghafari *et al.* (2017), agricultural work in Iran is fraught with risks, leading to numerous fatalities. For instance, a study covering various years noted 39 fatal injuries recorded in agriculture, forestry, hunting, and fishing between 2011 and 2016. According to research in Spain, the total number of fatal accidents between 2010 and 2019 was 644. The rate of fatal accidents per province was between 0 and 223.5 fatal accidents per 100,000 registered tractors. Furthermore, the overall rate for Spain was 6.87 fatal accidents per 100,000 tractors. It was found that the highest number of accidents happened in the areas with high land slope, also the worn-out fleet of tractors and the use of old tractors were the main causes of accidents (Jaren *et al.*, 2022). A comparison between Ilam province in Iran and

Spain provinces shows that Ilam province has a higher accident rate. The elevated incidence of accidents tied to tractor and combine operators in this study, particularly when compared to Spain, can be attributed to substandard conditions of agricultural roads in Ilam. Additionally, the prevalence of agricultural vehicles on public and farm roads, especially at night during peak working seasons significantly contributes to the high accident rates observed in I lam. The lack of proper training and awareness among agricultural machine operators, the significant gap between local practices and international standards and the absence of safety culture in the agricultural sector in the studied Ilam province, combined with advancements in agriculture and the standard design of machinery in Spain, could be major factors contributing to the differing accident rates in Ilam province and Spain. The similar results of research in Chaharmahal and Bakhtiari province, Iran, also showed that the human factor with an average ranking of 4.85 and the machine malfunction with an average ranking of 3.91, environment with an average rank of 3.51 and sharp turns of the road with an average rank of 2.78 were the most important accident factors related to agricultural machinery (Omidi Arjanki, Javadiyan & Tabashir, 2022). The results of this research matched our research. Their results also show that other provinces in Iran also suffered from accidents related to agricultural machinery and necessary preventive measures should be taken in this field. Among the types of farm accidents related to combine harvesters and agricultural tractors, incidents involving the power take-off shaft, helices, feeding rollers, and shear points (cutter bars, gears, etc.) were most frequent. Attachments used with tractors and combine harvesters, such as blades, mowers, rotary cutters, scrapers, forks, rakes, and towed parts like grain carts, cutter bars, and trailers, also contributed to accidents. Safety education and maintenance of these devices can prevent accidents related to tractors and combines (Karimi & Fakhri, 2021). Ranking the factors affecting tractor accidents in this study indicated that, fatigue from prolonged work (average rating of 4.169), unfavorable environmental conditions (average rating of 4.167), and driver negligence and distraction (average rating of 4.158) were the top three factors. For combine drivers, negligence and distraction (average rating of 4.442), adverse environmental conditions (average rating of 4.389), and fatigue from long-term work (average rating of 4.294) were ranked highest. Agricultural activities are time-sensitive, requiring farmers to work long hours, especially during planting and harvesting seasons, which can lead to stress, fatigue, and increased accident risk (Edwards & Sherlock, 2021). A t-test comparison of the average factors affecting accidents for combine and tractor drivers showed that unfavorable environmental conditions, non-standard equipment and machinery, and fatigue from long-term work significantly affected accidents related to combine harvesters and tractors. The number of days lost due to disability related to combine and tractor operators was 108,150 and 96,900 days, respectively. This indicates that farm accidents related to combine harvesters are more frequent than those involving agricultural tractors. After calculating the accident indices, the means of AFR, ASR, FIR, and FSI over the last five years were 25.84%, 45.82%, 1.66%, and 1.066 for combine operators, and 5.602%, 12.63%, 4.44%, and 0.262 for tractor operators, respectively. Among the indices, the FSI and ASR for combine and tractor operators, and AFR for combine operators, were higher than the standard. The acceptable levels of safety performance are: FSI less than 0.1, ASR less than 1, and AFR between 0 and 10. By observing safety principles while working with tractors and agricultural combines, these indices should be brought to standard levels. One study showed that the frequency-severity index (FSI) over six years, except for 2013 and 2016, was less than the standard, indicating appropriate protection in those years (Kors, 2019). In 2013, the FIR index was significantly worse than in 2012. The results of

this study show that accident indices in agricultural machinery (combine and tractor) were higher than those in industry activities, despite certain conditions and management in industrial factories in Iran. This finding related to combine harvesters and agricultural tractors shows that, observing safety principles while working with tractors and agricultural combines is crucial. This research analyzed accidents related to agricultural combines and tractors. Among the accident-causing factors, operator distraction, unsafe environmental conditions, unsafe farm roads, personal and operator errors, and machine malfunctions, especially in combine harvesters, were the main causes of agricultural machine accidents in Ilam province. Comparing the accident indices of combines and tractors, combines had a higher mean accident frequency, which is statistically significant due to their more complicated mechanisms and the time-sensitive nature of the harvesting season.

Suggestions

Although in this study, for the first time, the accident indices used in industry and factories were applied in the evaluation of agricultural accidents, it seems that due to the difference in the nature of agriculture and industry, there is a need to adjust the indices for agricultural purposes. It is suggested that, at the level of the province and the country, a database system of statistics of agricultural accidents should be considered in order to provide the possibility of evaluation and planning regarding the improvement of the safety of working with agricultural machines. Investigations showed that tractors and combines do not have an appropriate level of safety appliances and devices, so it is suggested that these affairs be taken into consideration during technical inspections.

It is recommended to improve road infrastructures, steep turns, and steep hills in cooperation with the national Agricultural Jihad Organization to prevent and reduce accidents in farms. Use Roll-Over Protective Structures (ROPS) and cabins for operator protection and install protective shields on PTO systems and rotating parts in order to reduce and prevent accidents related to crush and shear points.

Acknowledgments

We are grateful to the Research Deputy of Agricultural Sciences and Natural Resources University of Khuzestan.

Authors Contribution

J. Allahnouri: Data collection, Data analsis, Writing the manuscript

A. Marzban: Conceptualization, Supervision, Management, Methodology, Review and editing

M. Ghasemi Nejad Raeini: Supervision, Review and editing

M. Rahnama: Methodology, Software services

M. Savari: Statistical analysis, Validation

References

1. Abbasi Balochkhaneh, F., Ghotbi Ravandi, M. R., Golkhani, F., Baes mat, S., & Hasan pour Sodre Jani, Z. (2016). Determining the most important hazards in the cement industry. *Health Education and Health Promotion (HEHP)*, *4*(3), 3-11. https://hehp.modares.ac.ir/article-5-9277-en.pdf
2. Abubakar, M. S., Ahmad, D., & Akande, F. B. (2010). A review of farm tractor overturning accidents and safety. *Pertanika Journal of Science and Technology*, *18*(2), 377-385. https://www.researchgate.net/publication/268042049_A_Review_of_Farm_Tractor_Overturning_Accidents_and_Safety
3. Akanbi, O. G., Charles-Owaba, O. E., & Olley, A. (2009). Human factors in traffic accidents in Lagos, Nigeria. *Disaster Prevention and Management: An International Journal*, *18*(4), 397-409. https://doi.org/10.1108/09653560910984456

4. Anonymous. (2023). Ilam Province Agricultural Jihad Organization. *Department of Mechanized Technologies.* (in Persian).
5. Antunes, S. M., Cordeiro, C., & Teixeira, H. M. (2018). Analysis of fatal accidents with tractors in the Centre of Portugal: Ten years analysis. *Forensic Science International, 287*, 74-80. https://doi.org/10.1016/j.forsciint.2018.03.048
6. Arnal, P., López-Maestre Salas, A., Arazuri, S., Mangado, J. M., & Jaren, C. (2017). A multi-year analysis of traffic accidents involving agricultural tractors. *Chemical Engineering Transactions, 58*, 88-93. https://doi.org/10.3303/CET1758019
7. Cecchini, M., Bedini, R., Mosetti, D., Marino, S., & Stasi, S. (2018). Safety knowledge and changing behavior in agricultural workers: An assessment model applied in central Italy. *Safety and Health at Work, 9*(2), 164-171. https://doi.org/10.1016/j.shaw.2017.07.009
8. Ceylan, H. (2012). Analysis of occupational accidents according to the sectors in Turkey. *Gazi University Journal of Science, 25*(4), 909-918. https://dergipark.org.tr/tr/download/article-file/83575
9. Chio, W., Kim, K., & Jung, W. (2024). A Mini Review (PRISMA) on causes of incidents and injuries occurring in agricultural workplaces. *Journal of Agriculture, 14*(4), 514. https://doi.org/10.3390/agriculture14040514
10. Cividino, S. R. S., Pergher, G., Zucchi Atti, N., & Gubiani, R. (2018). Agricultural health and safety survey in Friuli Venezia Giulia. *Agriculture, 8*(1), 9. https://doi.org/10.3390/agriculture8010009
11. Cochran, W. G. (1977). *Sampling techniques*. (3rd ed.). Wiley.
12. Damalas, C. A., Koutroubas, S. D., & Abdollahzadeh, G. (2019). Drivers of personal safety in agriculture: A case study with pesticide operators. *Agriculture, 9*(2), 34. https://doi.org/10.3390/agriculture9020034
13. Dimitrovski, Z. (2013). Fatal consequences in traffic accidents with tractors in the agriculture of Republic of Macedonia. *Machines, Technologies, Materials.* https://eprints.ugd.edu.mk/id/eprint/9670
14. Du, Y., Dorneich, M. C., Steward, B. L., & Mackenzie, C. A. (2016). A Bayesian-influence model for error probability analysis of combine operations in harvesting. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 60*(1), 1414-1418. https://doi.org/10.1177/1541931213601325
15. Edwards, J. P., & Sherlock, K. (2021). Opportunities for improving the safety of dairy parlor workers. *Journal of Dairy Science, 104*, 419-430. https://doi.org/10.3168/jds.2020-18954
16. Ehlers, S. G., & Field, W. E. (2017). Injury/fatality-causing incidents involving the rearward movement of agricultural machinery: Types, causes, and preventive measures. *Safety, 3*(1), 8. https://doi.org/10.3390/safety3010008
17. Esmaeili, A., Vazirineghad, R., & Shahrokhi, F. (2008). A one-year study of accidents caused by work in farmers who have seen an accident and referred to the centers Healthcare of Bam city. *Scientific, Specialized Quarterly Journal of Occupational Medicine, 1*(1), 42-46. (in Persian). http://tkj.ssu.ac.ir/article-1-28-en.html
18. Fargnoli, M., Lombardi, M., Haber, N., & Puri, D. (2018). The impact of human error in the use of agricultural tractors: Case study research in vineyard cultivation in Italy. *Agriculture, 8*(6), 82-102. https://doi.org/10.3390/agriculture8060082
19. Ghafari, M., Cheraghi, Z., & Dusti Irani, A. (2017). Occupational risk factors among Iranian farmworkers: A review of the available evidence. *Epidemiology and Health, 39*, e2017027. https://doi.org/10.4178/epih.e2017027
20. Gholami, H., Kalantari, D., & Rajabi Vandechli, M. (2017). Ergonomic evaluation of vibrations of a rototiller with new blade. *Journal of Agricultural Machinery, 7*(2), 491-502. (In Persian with English abstract). https://doi.org/10.22067/jam.v7i2.56061

21. Gite, L. P., Tiwari, P. S., & Khadatkar, A. (2010). Farm machinery accidents in Indian agriculture. In *Proceedings of International Ergonomics Conference, HWWE 2009* (Vol. 1, pp. 283-290). University of Calcutta. https://www.researchgate.net/publication/262457121
22. Halvani, G. H., Fallah, H., Barkhordari, A., Khoskdaman, R., Behjat, M., & Koohi, F. (2010). A Survey of causes work related accidents in workplaces covered by Social Security Organization of Yazd in 2005. *Iran Occupational Health, 7*(39). https://www.sid.ir/paper/129161/en
23. Hamalainen, P., Takala, J., & Kiat, T. B. (2017). *Global estimates of occupational accidents and work-related illnesses 2017*. Workplace Safety and Health Institute.
24. Hayati, A., Marzban, A., & Asoodar, M. A. (2022). Workplace and gravity: Two mechanized cow milking systems compared for human physiological strains. *Journal of Agricultural Machinery, 12*(1), 21-32. https://doi.org/10.22067/jam.2020.58607.0
25. Health and Safety Executive. (2012). *Safe use of combine harvesters* (AIS6 rev2). Retrieved from https://www.hse.gov.uk/pubns/ais6.htm
26. Houshyar, M., & Houshyar, E. (2018). Tractor safety and related injuries in Iranian farms. *Safety Science, 103*, 88-93. https://doi.org/10.1016/j.ssci.2017.11.0
27. Health and Safety Authority. (2021). *Farm Safety Action Plan* 2021-2024https://www.hsa.ie/eng/publications_and_forms/publications/agriculture_and_forestry/farm-safety-action-plan-2021-2024.pdf.
28. International Labour Organization. (2011). *Safety and health in agriculture: Code of practice*. International Labour Organization. https://www.ilo.org/publications/safety-and-health-agriculture-code-practice
29. Jaren, I., Ibarrola, A., Mangado, T., Adin, A., Amal, A., López-Maestre Salas, A., Rios, A., & Arazuri, S. (2022). Fatal tractor accidents in the agricultural sector in Spain during the past decade. *Agronomy, 12*(7), 1694. https://doi.org/10.3390/agronomy12071694
30. Jun, L. J. (2014). The improvement on agricultural machinery safety using wireless sensing system and stability control algorithm. *Sensors & Transducers, 178*(9), 88-93. http://www.sensorsportal.com
31. Karimi, K., & Fakhri, A. (2021). Farm vehicle crashes on U.S. public roads: A review paper. *Journal of Safety Science and Technology, 1*(2), 34-54. https://doi.org/10.4236/ojsst.2021.112004
32. Karimi, M., Sahragard, A., Rahimi Pordanjani, T., Mohammadi, A., Cousins, R., & Mo Karami, H. (2024). Development and validation of a model for predicting productivity based on psychosocial factors in administrative staff: The mediating role of physical and mental health. *Health Education and Health Promotion, 12*(2), 291-298. https://doi.org/10.58209/hehp.12.2.291
33. Kasar, O., Comer Pay, E., İlhan, B., Eroğlu, O., & Deniz, T. (2023). An analysis of injuries due to tractor accidents: A ten-year retrospective study. *Kırıkkale Universities Tıp Fakültesi Dergisi, 25*(3), 472-481. https://doi.org/10.24938/kutfd.1356720
34. Keskin, M., & Şekerli, Y. E. (2018). An evaluation of combine harvester accidents in Turkey. *Journal of Agricultural Faculty of Mustafa Kemal University, 23*(2), 137-147. https://www.researchgate.net/publication/329913129
35. Khosravi, J., Hashemi Nazari, S., Dehghani Fard, S., & Jabari, K. (2007). Investigating accidents caused by work leading to death among workers working in companies, the contracting of urban services and green spaces of Tehran Municipality in 2004 and 2005. *Scientific Journal of Forensic Medicine, 13*(2), 68-77. (in Persian).
36. Kors, B. (2019). Investigating indicators of safety performance monitoring and analysis of occupational accidents in the Golestan Link Cement Factory. *The Fourth Specialized Conference of Tehran Cement Industrial Group*. (in Persian). https://Tehrancement.co.ir

37. Lohan, S. K., Singh, P., & Kumar, S. (2022). Agricultural work-related fatalities and injuries in Punjab (India). *Injury Prevention, 28*(5), 459-464. https://doi.org/10.1136/injuryprev-2022-044566
38. Maisyaroh, A., Widianto, E. P., & Fibriansari, R. D. (2022). Determinants of injury in agricultural area. Nurse and Health. *Journal Keperawatan, 11*(1), 22-33.
39. Mayrhofer, H., Quendler, E., & Boxberger, J. (2013). Occupational incidents with self-propelled machinery in Austrian agriculture. *Journal of Agromedicine, 18*(4), 359-367. https://doi.org/10.1080/1059924X.2013.827997
40. Merisalu, E., Lepala, L., Jakob, M., & Rautiainen, R. H. (2019). Variation in Eurostat and national statistics of accidents in agriculture. *Agronomy Research, 17*(5), 1969-1983. https://doi.org/10.15159/AR.19.190
41. Mitrev ska, C., Mitrevski, V., & Kulevska, F. (2023). Statistical indicators for accidents at work in agriculture activity. *Journal on Processing and Energy in Agriculture, 27*(1), 22-24. https://doi.org/10.5937/jpea27-43287
42. Mohammadi, A., Kheiralipour, K., Ghamary, B., Jahan Bakhshi, A., & Shahidi, R. (2023). Predicting whole-body vibration-based on linear regression models and determining permissible exposure time of tractor operator. *Journal of Agricultural Machinery, 13*(2), 227-237. (in Persian with English abstract). https://doi.org/10.22067/jam.2021.73589.1071
43. Moradhaseli, S., Farhadian, H., Abbasi, E., & Ghofranipour, F. (2017). Factors affecting the incidence of occupational accidents among farmers. *Health Education and Health Promotion, 5*(1), 39-56. https://hehp.modares.ac.ir/article-5-866-en.html
44. Murphy, D. J., Myers, J., McKenzie Jr, E. A., Cavaletto, R., May, J., & Sorensen, J. (2010). Tractors and rollover protection in the United States. *Journal of Agromedicine, 15*(3), 249-263. https://doi.org/10.1080/1059924X.2010.484309
45. Omidi Arjanki, M., Javadiyan, R., & Tabashir, A. (2022). Investigating the causes of agricultural vehicle accidents studied in Chaharmahal and Bakhtiari province. *Child and Adolescent Social Injuries Journal*. (in Persian). https://www.noormags.ir/view/fa/articlepage/2165417
46. Parak, F., Pour Saeed, A., Eshraghi Samani, R., & Chaharsoghi Amin, H. (2021). Analyzing factors affecting reduction of agricultural occupational injuries among gardeners of Ilam Province. Ilam Branch, Islamic Azad University. (in Persian). https://doi.org/10.22034/iaeej.2021.248956.1558
47. Park, N. J., Kang, C. H., Oh, I. S., Lee, Y. B., Jung, H., & Park, W. K. (1990). Survey on farm work accidents of farm machinery: Analysis on the accidents of combine harvester. *Journal of Research Reports of the Rural Development Administration, Farm Management, Agricultural Engineering and Sericulture, 32*(1), 24-32.
48. Pawlak, H., Nowakowicz-Dębek, B., Wlazło, M., Maksym, P., & Sasakova, N. (2017). Farmers' awareness in the field of occupational safety and health in sustainable management. In *Proceedings of the X International Scientific Symposium "Farm Machinery and Processes Management in Sustainable Agriculture"* (pp. 54-63). Lublin, Poland. https://doi.org/10.24326/fmpmsa.2017.54
49. Quendler, E. R., Kogler, H., Mayrhofer, S., Ebner, S., Gross, L., TechNet, A., ... & Boxberger, J. (2014). *Identification Neuer Technologies Zur Vermeidung von Arbeitsunfällen im Umfeld von Fahrzeugen, Maschinen und Geräten in der Land- und Forstwirtschaft*. IKA. https://www.dafne.at/dafne_plus_homepage/index.p
50. Sadat Haeri, Z., Bagherian, S. Kh., Bahrami, P., Tarjeman, Z., Karmi, Z., Karimi, M., Moradi, Y., Moradbaigi, A., & Mirzai, A. (2019). Statistical Yearbook of Ilam Province. Ilam Province Management and Planning Organization. pp. 171-172. (in Persian).
51. Sarkar, S., Vinay, S., Raj, R., Maiti, J., & Mitra, P. (2018). Application of optimized machine

learning techniques for prediction of occupational accidents. *Computers and Operations Research, 106*, 210-224. https://doi.org/10.1016/j.cor.2018.02.021

52. Shikha, V., & Chaudhari, S. (2016). Highlights from the literature on risk assessment techniques adopted in the mining industry: A review of past contributions, recent developments and future scope. *International Journal of Mining Science and Technology, 26*(4), 691-702. https://doi.org/10.1016/j.ijmst.2016.05.023
53. Social Insurance and General Health Insurance (SIGHI) Law, Law number: 5510, Gazette number: 26200 (2006). Retrieved from: https://natlex.ilo.org/dyn/natlex2/r/natlex/fe/details?p3_isn=74711
54. Singh, G., Tewari, V. K., & Hota, S. (2023). Agricultural accidents and ergonomic intervention in agricultural machinery design in India. *Agricultural Engineering International: CIGR Journal*, *25*(4), 137-146. https://cigrjournal.org/index.php/Ejounral/article/view/6039
55. Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education, 48*, 1273-1296. https://doi.org/10.1007/s11165-016-9602-2
56. Tone, I. R., & Irwin, A. (2021). Safety in the field: Assessing the impact of stress and fatigue on situation awareness in Irish and British farmers. In *Proceedings of the 21st Congress of the International Ergonomics Association (IEA 2021)* (pp. 274-283). Springer. https://doi.org/10.1007/978-3-030-74608-7_35
57. Volkovski, T., Chaloska, J., & Grad, M. P. (2018). *Annual report for fatalities, injuries, and accidents at work*. Macedonian Occupational Safety and Health Association. Retrieved from: https://webapps.ilo.org/static/english/protection/safework/cis/about/mtg2009/macedonia.pdf

بررسی نرخ و شدت حوادث مربوط به تراکتورهای کشاورزی و کمباین‌های غلات و عوامل مؤثر بر آن در استان ایلام

جلال اله نوری[۱]، افشین مرزبان[۱*]، محمود قاسمی نژاد رائینی[۱]، مجید رهنما[۱]، مسلم سواری[۲]

تاریخ دریافت: ۱۴۰۳/۱۱/۰۶
تاریخ پذیرش: ۱۴۰۳/۱۲/۱۳

چکیده

کشاورزی یک صنعت غالب در کشورهای در حال توسعه است و در رتبه خطرناک‌ترین مشاغل قرار می‌گیرد. تراکتورها و ماشین‌های برداشت غلات از ماشین‌های کشاورزی خودگردان هستند که علی‌رغم نقش بی‌بدیل‌شان در افزایش بهره‌وری، سهم قابل‌توجهی در حوادث دارند. این حوادث هزینه‌های زیادی را به‌همراه دارد و بهره‌وری را کاهش می‌دهد. این مطالعه به‌منظور بررسی میزان و شدت حوادث و تلفات انسانی و عوامل موثر بر حوادث مزرعه‌ای مربوط به تراکتورها و کمباین‌های کشاورزی در استان ایلام با استفاده از داده‌های مربوط به سال‌های ۱۴۰۲-۱۳۹۸ انجام شد. فراوانی حوادث تراکتورها و کمباین‌ها در مطالعه انجام‌شده، به‌ترتیب ۶۱ و ۴۳ بود که نشان‌دهنده‌ی اختلاف آماری معنی‌داری است. در این تحقیق در بین رانندگان تراکتور بیشترین حوادث ناشی از محور (P.T.O.)، هلیس و غلتک‌های تغذیه و در بین رانندگان کمباین، رایج‌ترین حوادث مربوط به نقاط برشی ماشین (شانه برش، چرخ‌دنده‌ها و غیره) بود. نرخ حوادث از جمله AFR (نرخ فرکانس حادثه)، ASR (نرخ شدت حادثه)، FIR (نرخ حادثه مرگبار) و FSI (شاخص شدت تکرار حادثه) محاسبه شد. میزان AFR، ASR، FIR و FSI به‌ترتیب ۲۵/۸۴، ۴۵/۸۲، ۱/۶۶ و ۱/۰۶۶ برای کمباین‌ها و ۵/۶۰، ۱۲/۶۳، ۴/۴۴و ۰/۲۶۲ درصد برای حوادث تراکتور بوده است. نرخ حوادث غیرمرگبار برای رانندگان کمباین‌ها ۶۴۴۵ در هر ۱۰۰۰۰۰ و برای رانندگان تراکتورها ۴۳۳۴ در هر ۱۰۰۰۰۰ بود، با این حال، تعداد حوادث کشنده تراکتور بیشتر از کمباین‌ها بود (۴۴۵ و ۳۳۰ در هر ۱۰۰۰۰۰ دستگاه).

واژه‌های کلیدی: ایمنی اپراتور، تراکتور، شاخص‌های حوادث، عوامل حادثه، کمباین

۱- گروه مکانیزاسیون و ماشین‌های کشاورزی، دانشکده مهندسی زراعی و عمران توسعه روستایی، دانشگاه علوم کشاورزی و منابع طبیعی خوزستان، ملاثانی اهواز، اهواز، ایران
۲- گروه ترویج و آموزش کشاورزی، دانشکده مهندسی زراعی و عمران توسعه روستایی، دانشگاه علوم کشاورزی و منابع طبیعی خوزستان، ملاثانی اهواز، اهواز، ایران
(*- نویسنده مسئول: Email: afshinmarzban@asnrukh.ac.ir)

https://doi.org/10.22067/jam.2025.91786.1336