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Severity of occupational agricultural accidents in Spain, 2013–2018[1]

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ABSTRACT

The objective of this paper is to understand the causes of work accidents in Spain in the agricultural sector, and to propose possible plans and actions to improve the sector's accident rates in the future. The paper analyses the complete pool of accidents in Spain from 2013 to 2018. Fourteen variables are studied, with the influence of each relating to accident severity, divided into three types (light, serious, and fatal). The analysis is based on a total of 158,166 accidents. Results show that the severity of the accident is related to age, gender, nationality, economic activity, company staff, length of service, location of accident, deviation, injury, days of absence, day of the week, injury, and region of Spain. This sector produces a high rate of serious accidents compared to all other sectors, employs the most foreign workers, and uses heavy machinery at work that also serves as a means of transport. We offer conclusions and future lines of research to improve worker safety and also help regulators. These results provide information that should be of use for both companies and regulators, to increase the safety of agricultural activities. This study analyzes accidents in the agriculture sector in Spain in the period between 2013 and 2018, therefore conclusions may be different when other countries of the European Union or of the rest of the world are considered.

1. Introduction

In the context of occupational health and safety, the term 'agriculture' is generally used to include all activities related to workplace safety in the agriculture sector. Agriculture, therefore, refers to all activities related to agricultural products, animal husbandry and livestock, including aquaculture and agroforestry (INSST, 2019). In our study we would like to limit the definition of agriculture to all activities directly related to cultivation and primary processing, as there is a lack of understanding about the specificities of this industry, which entails other types of considerations regarding the diversity of the workforce in terms of origin and gender. We are interested in all agricultural companies regardless of their size (Pyykkönen and Aherin, 2012).

The structure of farms in Spain is relatively small: 51% have less than 5 Ha land, and only 11% have more than 50 Ha. The average area is 25 Ha per farm, a figure well below the average 90 Ha of farms in the United Kingdom or 62 Ha in France (PC, 2019). Spain produces a high proportion of fruit and vegetable crops, which tend to need significantly less cultivated agricultural area than, for example, cereals.

The small aggregate size of Spanish farms is also reflected in the number of people who work on them. 93% of farms in Spain are owned by one person and most of these farms (91%) are family operated, which includes the owner of the farm, the spouse and other family members (INE, 2017). In addition, 69% of salaried workers do not work full time in this activity, but rather combine it with other activities (INE, 2017).

Agriculture is one of the sectors with the highest accident rates. It is unique in having a high percentage of temporary workers (García-Arroyo and Osca, 2020), and family members frequently collaborate. Agricultural activity is also notable for its diversity of tasks, many working with heavy machinery (Rondelli et al., 2018). Phytosanitary products and other chemical substances are widely used (Rezaei et al., 2019). The work itself is highly demanding in terms of physical effort and strength, and usually performed in extreme environmental conditions, with isolation in the workplace and a low level of training (Holte and Follo, 2018). All of this entails a wide variety of occupational hazards to which agricultural workers are exposed and which frequently result in occupational accidents (Valero and Abril, 2016).

According to the estimates of the International Labour Organization (ILO), the agricultural sector employs around 1.3 billion workers worldwide, representing half of the global workforce. Likewise, at least 170,000 agricultural workers die at work each year, which means that workers in the agricultural industry are twice as likely to die at work

[1] In the pdf proof, there are a differents spaces without text, it should be adjusted to avoid it. Thanks!!!

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compared to workers in other production industries (ILO, 2015).

In the European Union (EU-28), according to 2017 data, 12.8% of fatal accidents correspond to the agriculture sector (EUROSTAT, 2017). In addition, agricultural workers also suffer serious non-fatal injuries, the most common relating to animals, machinery, and falls (Rautiainen et al., 2004; Svendsen et al., 2014; Rondelli et al., 2018).

Given the global nature of the agricultural industry, the literature studying the accident rate includes research from several different countries. These countries include Spain (Arana et al., 2010), Italy (Zambon et al., 2018), Norway (Svendsen et al., 2014), Great Britain (Solomon, 2002), Finland (Karttunen and Rautiainen, 2013), India (Kumar and Dewangan, 2009), and the United States (Patel et al., 2017).

In Spain, according to 2018 data from the Ministry of Labour, Migrations and Social Security or MTMSS (INSST, 2019), agriculture is the third highest sector in terms of incidence rate (workplace accidents causing days lost, during working hours, per 100,000 workers). Specifically, the figure is 5,297.9, very close to the value for heavy industry (5,536.5) and somewhat further from the value for the construction industry (7,982.7), which ranks highest for workplace accidents in Spain. Although tractors cause more than 70% of accidents in Spain (Arana et al., 2010; Rondelli et al., 2018), 19% of which are serious and 21% fatal, it has been noted in some studies that the causal chain is different for fatal and non-fatal injuries (Salminen et al., 1992; Kica and Rosenman, 2020), which requires a deeper understanding of the variables associated with these accidents.

The detailed analysis of accidents, both fatal and non-fatal, requires the study of the influence of different variables relating to injury severity. There are several research studies in this area (Rorat et al., 2005; Moradhaseli et al., 2017), and some of them provide details on age (Goldcamp et al., 2004), gender (Momose and Suenaga, 2015; Fontaneda et al., 2019) or the nationality of the worker (García-Arroyo and Osca, 2020), among others.

This frame of reference has led to the selection of a set of variables influencing accident rates in the agricultural sector and, more specifically, the severity of these accidents. These variables have been categorized in five groups that are explained in this article: (a) personal, (b) company, (c) material, (d) temporal, and (e) geographical, following the categorization used in Camino-López et al. (2008).

This work aims to assess the relationship between these groups of variables and accident severity to help identify the appropriate prevention, control and mitigation actions. We hope to gain a better understanding of the accidents suffered by workers in the agricultural industry, so that measures and strategies can be designed that will reduce accident rates in the sector, and to determine the priority of such measures, whether quantitative (number of accidents) or qualitative (severity of the accident). The following sections include methodology, results, discussion, and conclusions outlining the proposals that we believe could usefully guide agricultural policymakers and companies.

2. Methodology

In Spain, all injuries that occur to workers as a result of their work are defined as occupational accidents. Since 2003, the National Institute of Occupational Safety and Health (INSST) of Spain's Ministry of Labor, Migration and Social Security (MTMSS) has used online forms to gather all such accidents that result in one or more working days lost, using a specific report form for each accident which is stored individually.

This accident report contains the company information (size, activity) and the data of the injured worker (gender, age, seniority, nationality). In addition, there are data on the injured body part, the deviation that caused the accident, and the day of the week. Finally, the report notes all workdays lost due to the accident.

For this study, the MTMSS provided the anonymized data of all occupational accidents in the Spanish agriculture industry as defined by the Classification of Economic Activities in the European Community (EUROSTAT, 2008). During the years studied (2013 to 2018) no changes were made to this classification. Although reporting is mandatory in Spain, it is possible that some accident cases were not been notified (Arana et al., 2010). As a complementary analysis in Spain, health authorities have an obligation to diagnose the severity of each occupational accident. For this purpose, the severity of an accident can be classified into three different levels: light accident, serious accident, and fatal accident.

The design of this study was also based on previous work on accident analysis by Camino-López et al. (2008) and López-Arquillos et al. (2012) for the construction industry, which we translate and adapt to agriculture in Spain. We first choose the variables and then classify them into groups to assess the relationship between all the variables and the severity of each accident according to those variables.

2.1. Data

We selected all accidents that resulted in one or more workdays lost, occurring in Spain over the period 2013 to 2018. We took the data from the reports companies sent to the Ministry of Employment and Social Security.

There was a total of 3,420,087 reported accidents in Spain during this period, 158,166 of which were in the agriculture industry (NACE codes included are 011, 012, 0,13, 015, and 016, as we also report below). Of the accidents analyzed for the agricultural sector between 2013 and 18, 156,065 accidents (98.67%) are classified as light accidents, 1,828 (1.16%) as serious, and finally, 273 accidents (0.17%) as fatal.

A work accident is light when the injury caused to the worker is not classified as serious and does not involve any disability, or if this occurs, it lasts less than 30 days.

At the level of frequency incidence, it is important to show the information in the form of total (AR_{total}) and fatal (AR_{fatal}) accident rates. The definition of these accident rates is as follows:

$$AR_{total} = \frac{number\ of\ accidents\ with\ sick\ leave \times 10^5}{average\ number\ of\ exposed\ workers} \quad (1)$$

$$AR_{fatal} = \frac{number\ of\ fatal\ accidents \times 10^5}{average\ number\ of\ exposed\ workers} \quad (2)$$

2.2. Variables analyzed

The variables are categorized into five groups that are explained in detail below: (a) personal, (b) company, (c) material, (d) temporal, and (e) geographic (Camino-López et al. 2008). The variables chosen are presented, grouped in the proposed categories, in Table 1.

Personal variables (a) include the characteristics of the injured worker: gender, age, nationality and length of service of the injured worker. Company variables (b) include the branch of activity (NACE),

Table 1
Summary of variables.

Variable group	Variable
Personal (a)	Age Gender Country of origin Length of service
Business (b)	National Classification of Economic Activities (NACE) Company Staff Location of accident
Material (c)	Deviation Injury
Temporal (d)	Day of the week Days of abscense
Geographic (e)	Region of Spain

the size of the company and the location of the accident. Material variables (c) include aspects that are unique to the accident, such as how it happened, and the type of injury suffered. Temporal variables (d) refer to the moment when the accident took place (day of the week and time of day) and the duration of the sick leave. The geographic variable (e) used in this study describes the severity of accidents according to the geographical area where they occurred; in the case of Spain, we consider the regions that Spain is divided into.

We have considered Agriculture activities based on the classification established in the National Institute of Occupational Safety and Health (INSST, 2019) under the category of "Agriculture", and specifically choosing the following ones, presented in Table 2.

2.3. Statistical analysis

The statistical package used for the analysis is the Stata version16/MP. The study of the relationship between severity and the rest of the variables was carried out using contingency tables in which the value of the chi-square statistic ($\chi 2$) was calculated, to test the hypothesis of independence of severity with respect to the variables (Camino-López et al. 2008; López-Arquillos et al., 2012). This statistic shows the possible influence of the different values of the variables studied on severity.

To understand specifically which of the cells of the contingency table are relevant, we use the corrected standardized residuals comparing the expected frequency and the observed frequency. Corrected standardized residuals (csr) are shown in the analysis tables marked with an asterisk (*) where their absolute value is less than 1.96, which, as a result, do not reach a statistical significance of 95%, so to reject the hypothesis of independence of the variables. For those values that are greater than 1.96 in absolute value, we can reject the existence of a random influence for the variables related to severity, so we can consider that the influence is not random, meaning that dependence of the variables exists, and therefore, we can reject the hypothesis of independence of the variables. We report this using a (*) in all the Tables of the study, besides the value of the variables.

Accident rates were obtained by dividing the number of accidents in the category studied by the total number of accidents. Therefore, the total accident rate (TAR) was obtained by dividing the number of total accidents in the category studied by the number of total accidents analyzed. The light accident rate (LAR) was obtained by dividing the number of light accidents in the category studied by the total number of light accidents. The serious accident rate (SAR) was obtained by dividing the number of serious accidents in the category studied by the number of total serious accidents. Finally, the fatal accident rate (FAR) was obtained by dividing the number of fatal accidents in the category studied by the total number of fatal accidents.

The nature of the data used allows us to study and compare groups of accidents in the agriculture sector that have already occurred. Therefore, the rates obtained are not the typical incidence rates calculated using the ratio between accidents and workers at risk, because workers at risk for each category is a figure that is not available. But our data allow us to compare different severities correctly, thus showing the probability that of an accident in that specific category being light, serious, or fatal.

Table 2
Agriculture activities.

Activity description	NACE Code
Non-perennial crops	011
Perennial crops	012
Plant propagation	013
Agricultural production combined with livestock production	015
Support activities for agriculture, livestock and post-harvest preparation	016

3. Results

The agriculture sector in Spain has the third worst workplace accident rate, representing 4.62% of all accidents during the period 2013–2018, after the construction and industrial sectors. Table 3 shows total, AR_{total} (Eq. (1)), and fatal accident rate, AR_{fatal} (Eq. (2)) for the Spanish accident rate as a whole from 2013 to 2018, and separately for the agriculture sector.

Therefore, the intention of this paper is to obtain information about the "how", "who", "when", "where" and "with" of serious or fatal accidents (Camino-López et al. 2008).

3.1. Personal variables

Statistically, in the agricultural sector, men have had more accidents, and once happened, these are more serious, compared to women. In Spain during the period 2013–18, of the total accidents, a total of 115,774 (80.25%) were suffered by men while women suffered a total of 28,491 accidents (19.75%). When serious accidents are analyzed, the percentage of accidents suffered by women falls to 14.98%, and if fatalities are studied, the percentage falls further, to 1.41% (only 3 fatal accidents).

Table 4 shows the influence of the age of the worker involved in the accident with respect to severity. Results highlight maximum severity in the 30–49 age range, representing 55.71% of total accidents. Severity of accidents increases with age, with the 40–59 range showing a SAR of 60.37% and a FAR of 64.73%.

Nationality is also a relevant aspect in the analysis of the accident rate for agriculture. Of the total accidents analyzed in the agricultural sector from 2013 to 2018 in Spain (144,265), 26.30% (37,938 accidents) were suffered by foreign workers. Taking into account the total number of accidents in the agriculture sector (144,265), the countries of origin of accident victims were Morocco (16,231 accidents, 11.25%), Romania (9,675 accidents, 6.71%) and Ecuador (4,663 accidents, 3.23%).

Work experience is a relevant element in accident rates as it reflects the set of skills and knowledge that the worker has acquired due to having worked in a certain job. Table 5 shows the effect of workers' experience on the severity of accidents.

3.2. Company variables

The activity of organizations is a relevant aspect in the study of accidents in agriculture. Using the Classification of economic activities in the European Community -NACE- (EUROSTAT, 2008), the agriculture sector in Spain in the 2013–18 period includes various activities, and in this study, we have included those with the greatest impact on accident rates, which we summarize in Table 2.

Table 6 shows that the distribution of accidents is concentrated in activities 011 "Non-perennial crops" and 012 "Perennial crops" which represent 37.29% and 44.62% of the total accidents in agriculture, so jointly representing 81.91%. Activities 015 "Agricultural production combined with livestock production" (TAR 8.01%) and 016 "Support activities for agriculture, livestock and post-harvest preparation" (TAR 9.08%) are at a distance but with significant accident rates as well.

Table 7 compares the severity of the accident with the size of the company. Company size is among the relevant elements in the definition of the occupational risk prevention model applied. This aspect can influence the accident rate of a company and the severity of the accidents which occur there.

Not all accidents that occur in the agriculture sector occur in the usual workplace; sometimes accidents occur when workers move between sites or between different areas of their usual work location. Table 8 includes the severity of agricultural sector accidents as a function of the location of the accident.

Table 3
Accidents in Agriculture compared to all sectors, 2013–2018 in Spain.

	2013	2014	2015	2016	2017	2018	TOTAL
All sectors							
Total number of workers	2,31,90,000	2,29,55,000	2,29,22,000	2,28,23,000	2,27,42,000	2,28,07,000	13,74,39,000
Total number of accidents	4,89,329	5,14,274	5,54,630	5,93,099	6,24,033	6,44,722	34,20,087
Total number of Fatal Accidents	558	580	629	693	699	729	3,888
Total Accident Rate	2,110.09	2,240.36	2,419.64	2,598.69	2,743.97	2,826.86	2,488.44
Fatal Accident Rate	2.41	2.53	2.74	3.04	3.07	3.20	2.83
Agriculture							
Total number of workers	10,11,000	10,01,000	9,90,000	10,17,000	10,34,000	10,03,000	60,56,000
Total number of accidents	21,739	24,279	26,274	27,075	29,612	29,187	1,58,166
Total number of Fatal Accidents	36	41	48	49	43	56	273
Total Accident Rate	2,150.25	2,425.47	2,653.94	2,662.24	2,863.83	2,909.97	2,611.72
Fatal Accident Rate	3.56	4.10	4.85	4.82	4.16	5.58	4.51

Table 4
Total accidents in Spanish agriculture comparing age and severity (2013–2018).

Chi-Squared	783.92							
	df = 18	Sig = 0.000						
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Fatalities**	
	N=	1,44,265	N=	1,42,437	N=	1,615	N=	213
Age	Number	**TAR%**	Number	**LAR%**	Number	**SAR%**	Number	**FAR%**
<16	133	**0.09%**	132	**0.09%**	1	**0.06%**	0	**0.00%**
16–19	3,161	**2.19%**	3,151	**2.21%**	9	**0.56%**	1	**0.47%**
20–24	12,992	**9.01%**	12,936	**9.08%**	53	**3.28%**	3	**1.41%**
25–29	16,657	**11.55%**	16,559	**11.63%**	93	**5.76%**	5	**2.35%**
30–39	41,107	**28.49%**	40,776	**28.63%**	305	**18.89%**	26	**12.21%**
40–49	39,270	**27.22%**	38,733	**27.19%**	480	**29.72%**	57	**26.76%**
50–59	25,191	**17.46%**	24,615	**17.28%**	495	**30.65%**	81	**38.03%**
60–64	5,471	**3.79%**	5,259	**3.69%**	173	**10.71%**	39	**18.31%**
65–70	239	**0.17%**	232	**0.16%**	6	**0.37%**	1	**0.47%**
>70	44	**0.03%**	44	**0.03%**	0	**0.00%**	0	**0.00%**

*: Corrected Standardised Resicuals < 1.96 in absolute value.

Table 5
Total accidents in Spanish agriculture comparing lenght of service and severity (2013–2018).

Chi-Squared	749.74							
	df = 14	Sig = 0.000						
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Fatalities**	
	N=	1,44,265	N=	1,42,437	N=	1,615	N=	213
Length of service	Number	**TAR%**	Number	**LAR%**	Number	**SAR%**	Number	**FAR%**
< 1 month	43,385	**30.07%**	42,917	**30.13%**	411	**25.45%**	57	**26.76%**
1–3 months	38,053	**26.38%**	37,769	**26.52%**	255	**15.79%**	29	**13.62%**
4–12 months	24,215	**16.79%**	24,007	**16.85%**	181	**11.21%**	27	**12.68%**
1–2 years	6,858	**4.75%**	6,771	**4.75%**	77	**4.77%**	10	**4.69%**
3–4 years	7,262	**5.03%**	7,171	**5.03%**	80	**4.95%**	11	**5.16%**
5–10 years	12,387	**8.59%**	12,120	**8.51%**	231	**14.30%**	36	**16.90%**
11–30 years	10,527	**7.30%**	10,190	**7.15%**	306	**18.95%**	31	**14.55%**
> 30 years	1,578	**1.09%**	1,492	**1.05%**	74	**4.58%**	12	**5.63%**

*: Corrected Standardised Resicuals < 1.96 in absolute value.

Table 6
Total accidents in Spanish agriculture comparing NACE and severity (2013–2018).

Chi-Squared	435.63								
	df = 8	Sig = 0.000							
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Fatalities**		
	N=	144,265	N=	142,437	N=	1615	N=	213	
Activity description (NACE Code)	Number	**TAR%**	Number	**LAR%**	Number	**SAR%**	Number	**FAR%**	
Non-perennial crops (011)	52,894	**37.29%**	52,265	**36.69%**	539	**33.37%**	90	**42.25%**	
Perennial crops (012)	64,893	**44.62%**	64,239	**45.10%**	577	**35.73%**	77	**36.15%**	
Plant propagation (013)	1,390	**1.00%**	1,379	**0.97%**	10	**0.62%**	1	**0.47%**	*
Agricultural production combined with livestock production (015)	11,911	**8.01%**	11,525	**8.09%**	358	**22.17%**	28	**13.15%**	
Support activities for agriculture, livestock and post-harvest preparation (016)	13,177	**9.08%**	13,029	**9.15%**	131	**8.11%**	17	**7.98%**	

*: Corrected Standardised Resicuals < 1.96 in absolute value.

Table 7
Total accidents in Spanish agriculture comparing staff and severity (2013–2018).

Chi-Squared	874.73 df = 14 Sig = 0.000								
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Fatalities**		
Company staff	N= Number	144,265 **TAR%**	N= Number	142,437 **LAR%**	N= Number	1615 **SAR%**	N= Number	213 FAR%	
<5 workers	41,880	**29.03%**	40,833	**28.67%**	942	**58.33%**	105	**49.30%**	
5–10 workers	14,512	**10.06%**	14,298	**10.04%**	186	**11.52%**	28	**13.15%**	
11_25 workers	18,915	**13.11%**	18,684	**13.12%**	207	**12.82%**	24	**11.27%**	
26–50 workers	13,683	**9.48%**	13,576	**9.53%**	87	**5.39%**	20	**9.39%**	*
51–100 workers	13,426	**9.31%**	13,357	**9.38%**	61	**3.78%**	8	**3.76%**	*
101–250 workers	17,346	**12.02%**	17,270	**12.12%**	63	**3.90%**	13	**6.10%**	
251–500 workers	12,331	**8.55%**	12,284	**8.62%**	40	**2.48%**	7	**3.29%**	
> 500 workers	12,172	**8.44%**	12,135	**8.52%**	29	**1.80%**	8	**3.76%**	

*: Corrected Standardised Resicuals < 1.96 in absolute value.

Table 8
Total accidents in Spanish agriculture comparing location of the accident and severity (2013–2018).

Chi-Squared	789.46 df = 4 Sig = 0.000							
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Fatalities**	
Location of accident	N= Number	144,265 **TAR%**	N= Number	142,437 **LAR%**	N= Number	1615 **SAR%**	N= Number	213 **FAR%**
Habitual worksite	135,827	**94.15%**	134,256	**94.26%**	1,422	**88.05%**	149	**69.95%**
On the way from worksite-worksite	2345	**1.63%**	2,209	**1.55%**	87	**5.39%**	49	**23.00%**
Non-habitual worksite	6,093	**4.22%**	5,972	**4.19%**	106	**6.56%**	15	**7.04%**

*: Corrected Standardised Resicuals < 1.96 in absolute value.

3.3. Material variables

The type of accident has been frequently studied in the literature (Melchior & Ruviaro, 2019). Table 9 shows the aggregate data of the deviations that have been the cause of the various accidents that occurred in the 2013–2018 period in the agriculture sector. The classification of the deviations follows the methodology of European Statistics on Accidents at Work, or ESAW (EUROSTAT, 2013).

Table 10 shows the aggregate data for injuries derived from the various accidents that occurred in the 2013–2018 period in the agriculture sector. Injuries are categorized according to ESAW (EUROSTAT, 2013).

3.4. Temporal variables

Table 11 shows lost workdays due to accident according to severity. Most fatal accidents involve an absence of one day (FAR of 64.79%) or one to seven days (FAR of 31.46%). This is because cases of instantaneous death, or death on the same day as the accident, are registered as one day of absence in the database; in the rest of the cases, the difference between the day of the accident and the day of death is recorded. The data presented do not include relapses from previous accidents that require a new sick leave period.

Table 12 presents the accident rate data according to the day of the week. It shows that Monday is the day of the week with the most total accidents (TAR 20.35%) at every level of severity.

Table 9
Total accidents in Spanish agriculture comparing deviation and severity (2013–2018).

Chi-Squared		4.2e + 03 df = 94 Sig = 0.000						
		Total Accidents		**Light Accidents**		**Serious Accidents**		**Fatalities**	
Description	Deviation code	N= Number	144,265 **TAR%**	N= Number	142,437 **LAR%**	N= Number	1615 **SAR%**	N= Number	213 **FAR%**
Deviation due to electrical problem, explosion, fire	10	807	**0.56%**	772	**0.54%**	29	**1.80%**	6	**2.82%**
Deviation due to overflow, tipping, leakage, spillage, emanation	20	1,938	**1.34%**	1,911	**1.34%**	26	**1.61%**	1	**0.47%**
Breaking, bursting, sliding, falling, collapsing, of material agents	30	8,216	**5.70%**	8,013	**5.63%**	189	**11.70%**	9	**4.23%**
Loss of total or partial control of work equipment or materials	40	19,525	**13.53%**	19,145	**13.44%**	317	**19.63%**	63	**29.58%**
Fall of people. Slip or trip with fall	50	32,225	**22.34%**	31,681	**22.24%**	528	**32.69%**	16	**7.51%**
Movement of the body without added physical effort	60	28,724	**19.91%**	28,536	**20.03%**	182	**11.27%**	6	**2.82%**
Movement of the body as a result of or with physical effort	70	42,344	**29.35%**	42,219	**29.64%**	124	**7.68%**	1	**0.47%**
Surprise, fear, violence, aggression, threat, presence	80	2,267	**1.57%**	2,201	**1.55%**	63	**3.90%**	3	**1.41%**
Another deviation	99	4,014	**2.78%**	3,840	**2.70%**	71	**4.40%**	103	**48.36%**
No information	000	4,205	**2.91%**	4,119	**2.89%**	86	**5.33%**	0	**0.00%**

*: Corrected Standardised Resicuals < 1.96 in absolute value.

Table 10
Total accidents in Spanish agriculture comparing injury and severity (2013–2018).

Chi-Squared		3.9e + 04 df = 28 Sig = 0.000								
		Total Accidents		**Light Accidents**		**Serious Accidents**		**Fatalities**		
Description	Injury code	N= Number	144,265 **TAR%**	N= Number	142,437 **LAR%**	N= Number	1615 **SAR%**	N= Number	213 **FAR%**	
Unkown injury	0	2,555	**1.77%**	2,532	**1.78%**	23	**1.42%**	0	**0.00%**	*
Superficial wounds and injuries	10	48,271	**33.46%**	48,102	**33.77%**	168	**10.40%**	1	**0.47%**	
Bone crushing	20	11,914	**8.26%**	11,125	**7.81%**	787	**48.73%**	2	**0.94%**	
Dislocations, sprains and strains	30	66,102	**45.82%**	65,970	**46.32%**	132	**8.17%**	0	**0.00%**	*
Amputations	40	484	**0.34%**	382	**0.27%**	100	**6.19%**	2	**0.94%**	
Concussions and internal lesions	50	8,460	**5.86%**	8,302	**5.83%**	124	**7.68%**	34	**15.96%**	
Burns, scalds and frostbite	60	713	**0.49%**	680	**0.48%**	31	**1.92%**	2	**0.94%**	
Poisonings and infections	70	249	**0.17%**	242	**0.17%**	6	**0.37%**	1	**0.47%**	
Drowning and asphyxiation	80	36	**0.02%**	30	**0.02%**	0	**0.00%**	6	**2.82%**	
Effects of noise, vibration and pressure	90	67	**0.05%**	67	**0.05%**	0	**0.00%**	0	**0.00%**	*
Extreme temperature effects	100	67	**0.05%**	58	**0.04%**	8	**0.50%**	1	**0.47%**	
Psychic trauma, traumatic shock	110	481	**0.33%**	469	**0.33%**	8	**0.50%**	4	**1.88%**	
Multiple lesions	120	1,343	**0.93%**	1,177	**0.83%**	107	**6.63%**	59	**27.70%**	
Heart attacks, strokes, and other non-traumatic diseases	130	245	**0.17%**	66	**0.05%**	78	**4.83%**	101	**47.42%**	
Other injuries	999	3,278	**2.27%**	3,235	**2.27%**	43	**2.66%**	0	**0.00%**	

*: Corrected Standardised Resicuals < 1.96 in absolute value.

Table 11
Total accidents in Spanish agriculture comparing days of absence and severity (2013–2018).

Chi-Squared	1.1e + 05 df = 14 Sig = 0.000								
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Fatalities**		
Abscence	N= Number	144,265 **TAR%**	N= Number	142,437 **LAR%**	N= Number	1615 **SAR%**	N= Number	213 **FAR%**	
1 day	138	**0.10%**	0	**0.00%**	0	**0.00%**	138	**64.79%**	
2–7 days	31,091	**21.55%**	31,005	**21.77%**	19	**1.18%**	67	**31.46%**	
8–15 days	40,995	**28.42%**	40,975	**28.77%**	18	**1.11%**	2	**0.94%**	
16–30 days	31,887	**22.10%**	31,821	**22.34%**	64	**3.96%**	2	**0.94%**	
1–3 months	28,740	**19.92%**	28,414	**19.95%**	324	**20.06%**	2	**0.94%**	
4–6 months	10,198	**7.07%**	9,274	**6.51%**	922	**57.09%**	2	**0.94%**	
7–12 months	952	**0.66%**	753	**0.53%**	199	**12.32%**	0	**0.00%**	*
> 1 year	264	**0.18%**	195	**0.14%**	69	**4.27%**	0	**0.00%**	*

*: Corrected Standardised Resicuals < 1.96 in absolute value.

Table 12
Total accidents in Spanish agriculture comparing day of the week and severity (2013–2018).

Chi-Squared	52.27 df = 12 Sig = 0.000							
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Fatalities**	
Day of the week	N= Number	144,265 **TAR%**	N= Number	142,437 **LAR%**	N= Number	1615 **SAR%**	N= Number	213 **FAR%**
Monday	29,362	**20.35%**	29,007	**20.36%**	309	**19.13%**	46	**21.60%**
Tuesday	25,709	**17.82%**	25,396	**17.83%**	276	**17.09%**	37	**17.37%**
Wednesday	25,098	**17.40%**	24,813	**17.42%**	257	**15.91%**	28	**13.15%**
Thursday	23,500	**16.29%**	23,208	**16.29%**	259	**16.04%**	33	**15.49%**
Friday	22,760	**15.78%**	22,485	**15.79%**	237	**14.67%**	38	**17.84%**
Saturday	13,414	**9.30%**	13,205	**9.27%**	190	**11.76%**	19	**8.92%**
Sunday	4,422	**3.07%**	4,323	**3.04%**	87	**5.39%**	12	**5.63%**

*: Corrected Standardised Resicuals < 1.96 in absolute value

3.5. Geographic variable

Table 13 collects information on the accident rate and severity in the different regions of Spain.

4. Discussion

With respect to the accident rate data presented in Table 13, the data provided by official bodies can be considered an undercount, as it can happen that a high percentage of accidents are not reported to the official body; during the 2004–2008 period, one estimation considers that only 61.85% of total fatal accidents in the agricultural sector in Spain were reported (Arana et al., 2010). This underreporting is motivated by the type of worker who is in agriculture: often without a residence permit (Rubiales-Gutiérrez et al., 2010), or belonging to the family itself in family-operated farms (PC, 2019); groups that often are not registered as workers in the agricultural sector and do not report their accidents.

Table 13
Total accidents in Spanish agriculture comparing region of Spain and severity (2013–2018).

Chi-Squared	1.1e + 03 df = 34 Sig = 0.000								
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Fatalities**		
Climatic zone	N= Number	144,265 **TAR%**	N= Number	142,437 **LAR%**	N= Number	1615 **SAR%**	N= Number	213 **FAR%**	
Andalusia	53,487	**37.08%**	52,801	**37.07%**	623	**38.58%**	63	**29.58%**	
Aragon	3,812	**2.64%**	3,760	**2.64%**	37	**2.29%**	15	**7.04%**	
Asturias	346	**0.24%**	329	**0.23%**	17	**1.05%**	0	**0.00%**	*
Cantabria	150	**0.10%**	143	**0.10%**	6	**0.37%**	1	**0.47%**	
Castilla la Mancha	9,773	**6.77%**	9,630	**6.76%**	127	**7.86%**	16	**7.51%**	
Castilla Leon	5,976	**4.14%**	5,820	**4.09%**	135	**8.36%**	21	**9.86%**	
Catalunya	6,412	**4.44%**	6,319	**4.44%**	80	**4.95%**	13	**6.10%**	
Ceuta	2	**0.00%**	2	**0.00%**	0	**0.00%**	0	**0.00%**	*
Madrid	886	**0.61%**	878	**0.62%**	7	**0.43%**	1	**0.47%**	
Valencia	18,617	**12.90%**	18,530	**13.01%**	70	**4.33%**	17	**7.98%**	
Extremadura	13,731	**9.52%**	13,502	**9.48%**	212	**13.13%**	17	**7.98%**	
Galicia	2,267	**1.57%**	2,114	**1.48%**	149	**9.23%**	4	**1.88%**	
Islas Baleares	5,561	**3.85%**	5,506	**3.87%**	48	**2.97%**	7	**3.29%**	
La Rioja	1,257	**0.87%**	1,223	**0.86%**	26	**1.61%**	8	**3.76%**	
Meillla	1	**0.00%**	1	**0.00%**	0	**0.00%**	0	**0.00%**	*
Navarra	1,734	**1.20%**	1,720	**1.21%**	10	**0.62%**	4	**1.88%**	
Pais Vasco	818	**0.57%**	799	**0.56%**	15	**0.93%**	4	**1.88%**	
Murcia	19,435	**13.47%**	19,360	**13.59%**	53	**3.28%**	22	**10.33%**	

*: Corrected Standardised Resicuals < 1.96 in absolute value.

4.1. Personal variables

For the total of analyzed accidents in the agriculture sector, 19.75% (28,491 accidents) affected women and 80.25% (115,774 accidents) affected men, compared to total accidents across all sectors, where the figures are 34% women and 66% men (INE, 2017). Analysing this information together with sector occupation data for men and women (INE, 2017) shows that the agricultural sector is heavily male-dominated (Alamgir et al., 2009). This greater frequency and severity of accidents for men also relates to the type of work carried out in agriculture, often with a greater physical burden. Likewise, the farming model in Spain (PC, 2019) may be the reason for fewer accidents suffered by women being reported (McCoy et al., 2002). Regarding serious accidents, the results can help to affirm that accidents suffered by men tend to have more serious consequences than those suffered by women (Momose and Suenaga, 2015).

Regarding the age of the injured worker (see Table 4), younger cohorts have fewer accidents and mostly of lower severity, which is even more evident in the case of serious accidents. This aspect had already been observed in previous studies (Goldcamp et al., 2004), and our study confirms their results. The agriculture sector workforce comprises mainly middle-aged workers, meaning that there is a very little representation of young workers. Most serious accidents can be associated with the use of tractors, especially for middle-aged workers (Arana et al., 2010; Di Nocera et al., 2018; Rondelli et al., 2018).

The percentage of accidents involving foreign workers in the agricultural sector (26.30%) is well above the rest of the sectors where accidents suffered by foreign workers account for around 10% of all accidents (INE, 2016). This situation shows the precariousness of the agricultural sector and the low stability of the workforce, especially in seasonal crops (vineyards, olive trees, fruit, etc.), an element that favors high accident rates.

Continuing with nationality, the severity level for foreign workers in the agriculture sector presents a SAR of 15.60%, and a FAR of 23.00%, and importantly, there is a notably higher incidence of fatalities for foreign workers compared to Spanish nationals.

Lack of experience is one of the causes frequently cited as generating the highest accident rates in different sectors (Cattledge et al., 1996; Bande and López-Mourelo, 2015).

73.24% of accidents in agriculture in the period 2013–2018 involved workers with less than one year of experience in the company, although this data does not necessarily correspond to a lack of working experience, given the high level of temporary employment in the sector, especially in companies with few workers, which also explains the high accident rate in companies with less than five workers. This percentage decreases when considering the fatal accidents of this group of workers, with a FAR of 53.06% (and deaths within less than a month at 26.76%). Therefore, it can be concluded that the accidents that occur are less serious.

It is interesting to observe that workers with more experience present the opposite trend in accident severity. Specifically, those with over a year's work experience account for 26.76% of all accidents, but with a FAR of 46.94%. In terms of variance in rates, the best FAR rate compared to TAR (TAR-FAR) is found for the group of workers with experience of less than one year (TAR-FAR = 26.30%), the situation being especially positive for workers with 1–3 months' experience (12.76%). This is contrary to what is observed for workers with more than one year of experience (TAR-FAR = -26.30%) and especially workers with 5–10 years' experience (-8.31%) and 11–30 years' experience (-7.25%). This situation could be due to over-confidence among the most experienced workers, which can lead to carelessness; moreover, more experienced workers usually work more with tractors, an aspect that is directly related to more serious accidents and a high percentage of fatal accidents.

Workers with little experience (less than one year) show a higher percentage of all accidents. This fact shows how hiring with safety and experience in mind leads to a decrease in the number of accidents. In contrast, comparing severity through FAR-TAR, we observe that the most experienced workers suffer more serious or fatal accidents. A longer time working in the sector should imply more training and experience in the work being carried out, and consequently, fewer serious accidents. However, the results do not correspond to this idea, due to more experienced workers underestimating their risks. Another associated factor is the use of heavy machinery, in this case tractors, which has been considered one of the basic elements for higher mortality rates in the agricultural sector (Arana et al., 2010; Di Nocera et al., 2018; Rondelli et al., 2018).

4.2. Company variables

The analysis of the severity of accidents by economic activity remains (see Table 6) closely aligned with the respective TAR, but with a

tendency to increased severity in the specific activity of Code 015, "Agricultural production combined with livestock production", which presents a TAR 8.01% but a SAR of 22.17%, and a FAR of 13.15%, showing that there is a specific incidence of livestock activities in the increasing percentage of more serious accidents.

With respect to the size of the company, comparing the different rates, we can observe that companies with fewer than 5 workers accumulate the majority of accidents (TAR 29.03%) and that the severity of the accidents is higher, with SAR at 58.33% and FAR at 49.30%. This situation is strongly associated with the business operation model, sometimes a family business, with few workers, that is one of the main characteristics of Spanish agriculture (INE, 2017).

In contrast, with 5 workers or more there is a homogeneous distribution of accidents, occurring in all cases and presenting, in general terms, lower severity of accidents. The largest companies (with 251–500 or over 500 workers) present a TAR of 8.55% and 8.44% and a FAR of 3.29% and 3.76% respectively, showing that accidents occurring in agricultural concerns with higher number of workers are less serious.

However, these data are only for accidents that have occurred and do not take into account the number of people employed in these companies, and therefore can be misleading. A large company has been shown to be associated with better levels of safety than a small one (Salminen et al., 1993; Fabiano et al., 2004). A significant trend towards higher mortality is established with smaller company sizes in the studied mortality figures; this situation may be due to greater pressure from the Labor Authority and the implementation of more safety measures by the employer.

Considering the results of Table 8, a high percentage of analyzed accidents occurred in the usual workplace (TAR of 94.15%), but their mortality rate was considerably lower (FAR of 69.95%). Accident rates in non-habitual workplaces represent 4.22 % of total accidents, although their severity is greater for these cases (SAR of 4.19% and FAR of 7.04%).

It is important to note that the high FAR in the sector, especially in the usual workplace, corresponds to the use of heavy machinery (tractors), even more so if we consider accidents that occur during displacement between two workplaces, which is usually by tractor. This analysis suggests the importance of establishing preventive action plans that could maximize tractor safety (Arnal et al., 2017; Rondelli et al., 2018; Kim et al., 2019).

4.3. Material variables

With respect to the accidents and their severity (see Table 9), in the case of agriculture, the main type of accident analyzed occurs due to overturning during the handling of heavy machinery (tractor), since these accidents are more serious (Arana et al., 2010; Valero and Abril, 2016) and relate to older and more experienced workers, who are usually the workers that use tractors (Goldcamp et al., 2004; Arana et al., 2010).

The category of "complete or partial loss of control for the working equipment or materials" (80) in Table 9 includes accidents caused by the "loss (total or partial) of control of the means of transport or cargo (with or without motor)" (code 42), representing 1.63% of total accidents, with severity levels at 5.70% for SAR and 23.47% for FAR (with 50 fatal accidents). According to the study by Arana et al. (2010), not all fatal accidents associated with tractor use are reported, establishing that in the period 2004–2008 only 61.88% of the total of such accidents occurring in Spain were officially registered. Thus the final numbers can be expected to be underestimated in this sector due to the type of worker, as sometimes their lack of formal employment contracts means that accidents suffered are not reported (Rubiales-Gutiérrez et al., 2010; PC, 2019).

This deviation should receive special attention and should be reduced as far as possible with preventive measures, training of workers and use of safety equipment. There are several studies on how to improve the intrinsic safety conditions of this machinery (Rondelli et al., 2018; Di Nocera et al., 2018; Kim et al., 2019).

Other deviations to highlight in terms of the total number of accidents correspond to falls by a "person at the same level" (code 52) with TAR of 15.14%, "uncoordinated movements" (code 64) with TAR of 15.46% and "lift, transport, hoist" (code 71) with TAR of 15.46%, but with much lower severity rates in all three cases; fatal accidents (FAR) values are 2.35%, 0.47%, and 0%, respectively.

Additionally, it should be noted that in Spain accidents caused by non-traumatic diseases (myocardial infarction, cerebral hemorrhage, etc.) are considered workplace accidents unless there is evidence to consider otherwise.

With respect to the type of injury suffered (see Table 10), superficial wounds and injuries (code 010) and dislocations, sprains, and strains (code 030) are 79.28% of the TAR, data that directly correlate with a LAR of 80.09%. This group of accidents presents an impact in terms of severity that is barely significant (SAR of 18.57% and FAR 0.47%) in line with other sectors studied (López-Arquillos et al., 2012).

Multiple injuries (code 120) are the most common injury type, involving a 6.63% SAR and a 27.70% FAR, although they only account for 0.93% of all accidents. The second most present injury type is concussion and internal injuries (code 050), which represent 5.86% of all accidents, but also with notable severity rates, 7.68% SAR and 15.96% FAR. These types of injuries are related to the type of accident that occurs in the agriculture sector (handling of heavy machinery) and accidents that occur when traveling to the workplace or on the way home.

Special attention should be paid to heart attacks, stroke, and other non-traumatic diseases (code 130), since they represented only 245 of the 144,265 total accidents (0.17%), but 101 of the 213 deaths (47.42%). The increase in the FAR value with respect to the TAR value is especially high in this group. This information would be clearly different in the case of considering accidents that occurred while commuting from home to work and vice versa, which would entail a substantial change in the proportion of accidents of different severity.

4.4. Temporal variables

Table 11 includes the information of the number of days lost due to the accident, with respect to the severity of the accident. Most of the total accidents have a duration of up to 3 months in lost workdays, basically for light accidents (LAR of 92.09%), and the percentage of these with a maximum duration of one month have a LAR of 72.88%. It should also be noted that light accidents sometimes last longer than a few days because their actual recovery time is longer than initially expected (López-Arquillos et al., 2012).

The most serious accidents focus on periods of absence between 1 month and 1 year, with SAR 89.47%. If considering only the interval of absence from 3 to 12 months, SAR is 69.41 %

Mondays are the weekdays with most accidents (see Table 12). This fact, called the "Monday effect", is partly because some of the accidents that occur on weekends are not reported until Monday, the first working day of the week, due to the worker's social benefits in relation to the insurance company (Campolieti and Hyatt, 2006; López-Arquillos et al., 2012; Butler et al., 2013). This aspect relates directly to the number of clearly light accidents reported on Saturday (TAR 9.30%) and Sunday (TAR 3.07%), compared to Tuesday to Friday where the number of total accidents remains approximately constant.

Light (LAR) and serious accidents (SAR) show a good correspondence with respect to the total accidents (TAR), but in the case of the fatal accidents (FAR) rates, they decrease from Monday to Wednesday and increase again from Wednesday to Friday, an effect that has also been observed in other sectors such as construction (López-Arquillos et al., 2012).

4.5. Geographic variable

Table 13 confirms that the accident severity distribution is not the same in all Spanish regions. The highest number of accidents is mainly centered in the southern (Andalusia) and eastern (Valencia and Murcia) areas of Spain, areas characterized by more labor-intensive agriculture and a greater presence of immigrant workers. There is a certain percentage decrease between the value calculated by subtracting the fatal accident rate from the total accident rate (% TAR-% FAR), which in the case of Andalusia is 7.50%; however, the value of these decreases is lower for the cases of Valencia and Murcia, 4.92% and 3.14%, respectively.

Fewer of accidents occur in the cereal growing regions: Castilla-La Mancha, Castilla y León, and Extremadura, where the use of machinery is higher for agricultural tasks. In this case, the TAR-FAR differences are −0.74% in the case of Castilla-La Mancha and −5.54% for Castilla y León. Again, this higher mortality can be attributed to the use of machinery.

5. Conclusions

Accidents in the agriculture sector are worth studying, as the rate is high (it is one of the sectors with the most accidents) and the sector's characteristics mean that these high accident levels persist over time, with little improvement.

After examining the sector, we find high levels of immigrant labor, poor working conditions, and high potential risks due to the nature of the work: the use of heavy machinery, dangerous materials, and in general hard physical work outdoors, often in the form of precarious employment. This leads to the conclusion that as this sector is more precarious and people working in it are less likely to organize and claim their rights, the need to study the specific reasons for accidents is truly compelling as a matter of social justice, and will help to establish government and company policies to bring the levels of workplace safety found in other sectors.

A closer study of this sector helps us understand other aspects to be addressed in terms of continuous training. The findings suggest that there is an issue with workers who tend to overestimate their ability to perform their jobs as they get older. As a consequence of this, they underestimate the dangers involved and take more risks, leading to more serious accidents. These findings show the need to increase other ways of making workers aware of the dangers, and suggest that government bodies should oblige companies to train workers exposed to this overconfidence.

5.1. Implications for the industry and government

Identifying the main variables present in agricultural accidents is the first step towards reducing accidents and minimizing their consequences.

The conclusions of this work can be used to design prevention measures to be established in the situations found to lead to the most serious accidents. These conclusions also offer some guidance for designing training plans and improving the information that should be available about the risks to which agricultural workers are exposed.

The role of the Labor Administration must be especially sensitive in this sector, the third in Spain in terms of the number of accidents, but the first in terms of severity, including mortality from occupational accidents. The establishment of specific action plans and an increase in ad-hoc inspections in this sector is a factor that would reduce accidents, once specific measures are established.

Finally, an important element is the analysis of the possible under-reporting of accidents, which according to some studies is high, and could even be hiding the situation of workers in precarious work, especially foreigners. If 27.02% of workers in the sector are non-nationals, and accidents are under-reported, this figure can be expected to increase, creating a vicious circle of precarity that is unjust and should be denounced.

5.2. Limitations

This study analyzes accidents in the agriculture sector in Spain in the period 2013–2018, but its conclusions may be different in other countries of the European Union or in the rest of the world. The MTMSS Workplace Accident Registry system gathers the total number of reported accidents, but it may be that some have not been reported, and therefore have not been considered in this study.

Only accidents that have led to at least one lost workday have been considered, which means that accidents without a personal injury are not analyzed in this study. Similarly, we analyze the severity of accidents once they have occurred, but not the probability of their occurrence. The nature of the data used allows us to study and compare groups of accidents in the agriculture sector that have already occurred, to show the probability of an accident in that specific category being light, serious, or fatal.

5.3. Future research

There is a need for future research to include a detailed study of some of the variables for a more precise focus on their influence on the severity of agricultural accidents.

Given its relevance in terms of accident rates, it is important to study the immigrant group that works in agriculture, as well as the type of hiring system and contracting, which presents interesting effects for a differentiated study comparing it to the other productive sectors.

Although accidents occurring in the handling of heavy machinery have been studied by various authors, a detailed analysis is required, given their high severity and mortality.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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