Analysis of occupational accidents during the chainsaws use in Andalucía

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ARTICLE INFO

Keywords:
Chainsaw
Occupational accidents
Safety
Injured workers
Forestry
Agriculture

ABSTRACT

The chainsaw is one of the most dangerous pieces of work equipment in the field of occupational health and safety. Analysis of occupational accidents involving chainsaws is scant. The aim of this study is to provide a faithful description of registered occupational accidents related to the chainsaw in the Andalusian region of Spain. In total, 373 accidents were studied, and in which characteristics of the injured person, enterprise, workplace and sequence of the event were studied. It was determined that the injured victim tended to be a male worker between 30 and 59 years old from the forestry or agricultural sector. Typically, the accident took place in the month of February or March. As for the characteristics of the accident, normally it occurred in forestry or agricultural areas during associated tasks, with the loss of control of the chainsaw, leading to contact with the blades, causing open wounds to the leg, knee or fingers. A specific feature in Andalusia is the influence of the use of the chainsaw in olive tree pruning and in the task of preventing forest fires. It is important to develop an international training standard and apply it to any worker who uses the chainsaw. The manufacturers of chainsaws should be involved in the prevention of accidents at work while using their devices, in terms of safe use to prevent the loss of control of the chainsaw, and in promoting the mandatory use of personal protective equipment to reduce or eliminate injuries caused by cuts, especially to the upper extremities.

1. Introduction

Good occupational health and safety policy depends on knowledge of the causes of accidents (Williamson and Feyer, 1998). Studies and analysis of occupational accidents provide accurate knowledge of the environment and personal circumstances surrounding the accident, making it possible to predict similar events and implement preventive strategies (Bird, 1990; Gatfield, 1999; Thompson et al., 1998). These studies can be of great help for personnel training, working methods and selection of protective equipment (Rikhardsson and Impgaard, 2004; Camino et al., 2008), including which day and the length of the working day, or rest time (Lilley et al., 2002).

Due to the high mechanization of agricultural and forestry farms, the use of hand-held machines and the number of related accidents has increased. Accidents with hand-held machines are the most common in the agricultural sector (Kogler et al, 2015). Their use has spread to other groups of workers, and the people who operate them are subject to various risks of injury. In human–machine interaction, it is humans who produce the greatest number of accidents. Careless maintenance and improper handling and operation pose a high risk of injury to operators. In Andalusia, the accident research institute analyzes and investigates occupational accidents and proposes preventive measures.

The chainsaw is one of the most efficient and productive portable power tools used in the industry but it can also be one of the most dangerous in the field of occupational health and safety (OSHA, 2018). The chainsaw is especially important in the forestry sector where it is frequently used as working equipment (OSHA, 2014). Typical manual operations in forestry work are: felling, limbing, bucking, yarding and log loading and transporting (Cabeças, 2007). In the first three operations the chainsaw is typically used. In fact, in semi-mechanized logging operations, a great majority of accidents are caused by chainsaws, above all in the logging phase (Albizu et al., 2010; Nieuwenhuis and Lyons, 2002; Neely and Wilhelmson, 2006; Shaffer and Milburn, 1999; Axelsson, 1998; Peters, 1991). Nevertheless, most of the research is focused

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on injuries or accidents in the forestry sector in general or in some of the phases mentioned, but it does not focus directly on the chainsaw. Thus, several investigations have been carried out in different countries such as United States focused on logging injures and fatal accidents (Myers and Fosbroke, 1994) or in characterization of logging injures (Lefort et al., 2003). Also in this country, Wilmsen et al. (2015) carried out a study of occupational injuries and illnesses, medical treatment and general working conditions for forestry workers. In Ireland, Nieuwenhuis and Lyons (2002) examined the severity of accidents in forestry harvesting. In Sweden, Thelin (2002) analyzed the accident risk in farm work, and Lindroos and Burström (2010) studied the type of accidents that occurred in private forests. In China, logging fatalities and non-fatal injuries were reported by Wang et al, (2003). In New Zealand, Bentley et al., (2005) and Parker and Ashby (2005) focused their study on job safety analysis of the chainsaw during logging operations in the forestry sector. In Spain, Gorgues and Guiu (2010) performed statistical analysis of accidents in the forestry sector within the context of an evaluation and implementation project of chainsaw operator certification. Likewise, Albizu-Urionabarretxea et al. (2013) reviewed the main labor risks and safety and conditions of forestry work and Ambrosio et al (2001) analyzed work security and health and safety in forestry harvesting. In Austria, Tsioras et al (2014) analyzed the wood harvesting accidents in forestry enterprises. In Turkey, the occupational accidents in logging workers were studied by Enez et al., (2014) and Melemez (2015) focused on fatal occupational accidents. In Italy, Laschi et al., 2016) analyzed workplace accidents during forestry operations in public companies. In Central Europe, Allman et al., (2017) focused a study on yarding accidents in the forestry sector, while Cabeças (2007) focused on health and safety problems of logging throughout the Europe Union. Finally, only one study, (Robb and Cocking, 2014), was found that focuses on chainsaw-related fatalities and accidents and the European trend; although this study only focuses on the arboriculture and forestry sector.

However, the fact that the forestry sector is not the only sector where the chainsaw is used as work equipment should also be taken into account. Thereby, the chainsaw is also used in the agricultural sector such as olive and other tree pruning, together with other sectors such as gardening, construction and emergency situations. Therefore, an analysis of the research focused on the use of the chainsaw beyond the forestry sector, that is, regardless of the scope in which it is used, was carried out and two main types of studies were identified. Firstly, there were some studies focused on the injuries, especially fatalities, caused by the chainsaw. Though, they are based on case studies and analyzed from a medical perspective (Haynes et al., 1980; Fernie et al., 1994; Brown, 1995; Reuhl and Bratzke, 1999; Koehler et al., 2004). Secondly, few studies that focus on chainsaw accidents both in the workplace and in the domestic environment were found.

Cividino et al. (2013) based their research on web-based news items published between 2007 and 2012 related to fatal and non-fatal accidents in Italy, involving people who were using chainsaws. On the whole, 336 cases were collected over a 5-year period. The research by Hammig and Jones (2015), who examined emergency department visits related to chainsaws in the United States between 2009 and 2013, is particularly interesting.

Apart from that, no study has been found that focuses on the analysis of fatal and non-fatal injuries produced while the chainsaw is used in the workplace, regardless of the sector to which the worker belongs. For this reason, this study aims to provide an accurate analysis and description of chainsaw occupational accidents recorded in Andalusia, Spain. We have selected the region of Andalusia in Spain, with a total surface area of 87,268 km^2, of which half are devoted to agriculture, with a high incidence of olive cultivation and forests, and where the chainsaw is normally used as work equipment, to be a significant place for our study. Formed by 8 provinces and a population of more than 8 million, Andalusia is, in geographical and demographic terms, larger than countries such as Belgium, Denmark, Austria and Switzerland. Agriculture is the main source of employment in half of Andalusia's municipalities. Olive cultivation accounts for 1.5 million hectares, 80% of national production and 30% of world production. In addition, Andalusia has around 4.8 million hectares of forests, of which 1.2 million hectares are also used for extensive agricultural purposes, such as the "*dehesas*" (meadowland).

2. Data and methodology

In order to achieve the proposed objective, the set of accidents reported in Andalusia during the period from January 2009 to December 2016 has been analyzed, with the portable chainsaw being one of the agents involved, the material agent associated with a specific physical activity[1] or the term used in the accident description. Chainsaw[2] is the term with which it is known according to the code system used by the Delt@ electronic system for the notification of occupational accidents in Spain (Ministerio de Empleo y Seguridad Social, 2015), and according to the European Statistics on Accidents at Work (ESAW) at European Commission (2013).

The data has been provided by the Department of Labor of the Regional Government of Andalusia, and extracted from the official accident report forms presented in Spain. In total, information on 373 accidents was provided.

However, as the records included descriptions of victims and witnesses, these were examined and records that were not relevant to our study were deleted. Thus, 38 accidents that had been erroneously included were eliminated; 29 of these accidents which occurred while working with hand-held non-powered tools, such as hand saws or axes; and 9 accidents involving other power saws, such as circular saws, miter saws, power string trimmers or band saws. Thus, of the 411 reported accidents, only 373 were finally analyzed.

In addition, data on all occupational accidents registered in Andalusia in 2019 have also been used in this study. These data have been obtained from the Institute of Statistics and Cartography of the Regional Government of Andalusia and have been used to establish comparisons with the trend of chainsaw accidents in some sections such as age, type of contract, month of the accident, day of the week, hour or working day timetable.

As a complement to the descriptive statistical analysis, which was the aim of this study, an inferential analysis was carried out in order to enhance knowledge about the occupational accidents studied. For this purpose, the Pearson Chi-Square test was applied. The variables that were included in the analysis were pre-treated to reduce the number of groups or classes, which was initially quite high. Thus, those with the highest absolute frequencies were kept and the rest were grouped into the class "others". Subsequently, the existence or otherwise of a significant statistical association between different variables was analyzed.

Specifically, in order to choose the type of test to be used in the inferential analysis, the variables were first tested for normality by applying the Kolmogorov-Smirnov test or the Shapiro-Wilk test depending on the sample size. These tests indicated that the distributions of the variables were non-parametric. Since the variables were qualitative, non-parametric and had multiple response categories, the Chi-square statistic was applied to test the association between two variables. For this purpose, tests were performed between different pairs of variables that had previously undergone normality tests, verifying their non-normal distribution. Cases where a significant association was found between two of these variables were included in the inference results.

2.1. Accidents data

In Spain, the employer is obliged to notify the labor authority of any

[1] Describe what the victim was doing when the accident happened.
[2] Code 07.01.04.01

damage to the health of the workers in his service that has occurred in the course of their work, i.e. occupational accidents and occupational diseases. With regard to occupational accidents, Table 1 summarizes how they are reported, who is responsible for reporting them and what deadlines exist for reporting them, depending on the type of accident.

Therefore, in Spain, information on accidents with sick leave or their relapses with sick leave is reported by means of the accident report (Delt@ report).

2.2. Classifying analyzed variables

The Competent Labor Authority in Andalusia has collaborated in this research by providing the disaggregated information obtained from the accident reports (Delt@ report). The aim of this research was to describe accidents in Andalusia in which the chainsaw was being used, i.e. in which the chainsaw was used as work equipment. Thus, in order to study accidents related to the use of chainsaws in the workplace, regardless of the sector or the worker's occupation, the present research was designed starting by defining the criteria for filtering the data recorded from the accident reports. Thus, the criterion for filtering the data was to select all accidents in which the chainsaw appears coded as the material agent of the physical activity. Once this filtering had been carried out, possible errors were detected in the reporting of the code of the chainsaw as the material agent of the physical activity in the accident reports, and the criterion was extended to include accidents in which the word "chainsaw" appears in the description of the accident. The Competent Labor Authority in Andalusia provided the researchers with information on reported accidents that met this criterion.

Subsequently, those variables that could be of interest for the development of the research were selected in order to describe the recorded chainsaw accidents. The data was organized as shown in Table 2.

The economic activity of the company was presented in accordance with the National Classification of Economic Activities (NACE) and the European code system; while the worker's occupation was defined using the International Standard Classification of Occupations 08 (ISCO-08) at International Labour Organization (2012) and the National Job Classification System of Spain (CNO-2011). On the other hand, variables with an asterisk were defined using the European Statistics on Accidents at

Table 1
Summary of information on which accidents must be reported through the system in Spain. (Elaborated from ISTAS, 2021).

What accidents are reported?	How is it reported?	When are they reported?	Who reports them?
Serious, very serious, fatal or multiple occupational accident (more than four persons)	Urgent notification of the accident report (Delt@ report)	24 h in case of serious, very serious, fatal or multiple accidents (more than 4 persons), except for In-itinere accidents	Employer
Accident at work with sick leave (other than serious, very serious, fatal or multiple accidents) or relapse with sick leave	Accident report (Delt@ report)	5 working days from the date on which the accident or sick leave occurred	Employer
Accidents at work without sick leave	List of accidents at work occurring without medical leave	Monthly within the first 5 working days of each month	Employer
Discharges or deaths of injured persons	List of discharges or deaths of injured persons	Monthly by the 10th of the following month	Managing or collaborating entity

Table 2
Variables used in the analysis of chainsaw accidents and fatalities.

INFORMATION	VARIABLES
ENTERPRISE	Economic Activity
WORKER	Occupation
	Age, Sex and Nationality
	Employment Status and type of contract
DATE OF ACCIDENT	Year
	Month
	Day of the week
	Time of day
	Hour of work
WORKING CONDITIONS	Working Environment*
WORKPLACE	Working Process*
	Usual Work Tasks
SEQUENCE OF EVENTS	Specific Physical Activity*
	Material Agent associated with the Specific Physical Activity
	Deviation*
	Material Agent associated with the Deviation
	Contact-Mode of Injury*
	Material Agent associated with the Contact-Mode of Injury
VICTIM	Severity of the accident
	Type of Injury*
	Part of Body Injured*

* This variable uses the ESAW code.

Table 3
Coding of variables in pre-treatment before inferential analysis.

Variable	Coding of the variable in pre-treatment
Economic activity	Crop and animal production, hunting and related service activities
	Forestry and logging
	Public administration and defence; compulsory social security
	Others
Age of the victim	Between 20 and 29 years
	Between 30 and 39 years
	Between 40 and 49 years
	Between 50 and 59 years
	60 years or older
Day of the week	Monday; Tuesday; Wednesday; Thursday; Friday; Saturday; Sunday
Month	January; February; March; April; May; June; July; August; September; October; November; December;
Deviation	Breakage, bursting, splitting, slipping, fall, collapse of Material Agent
	Loss of control (total or partial) of machine, means of transport or handling equipment, hand-held tool, object, animal
	Slipping - Stumbling and falling - Fall of persons
	Body movement without any physical stress (generally leading to an external injury)
	Body movement under or with physical stress (generally leading to an internal injury)
	Others
Type of Injury	Wounds and superficial injuries
	Bone Fracture
	Dislocations, sprains and strains
	Others
Part of body injured	Head, not further specified
	Neck, inclusive spine and vertebra in the neck
	Back, including spine and vertebra in the back
	Upper Extremities, not further specified
	Lower Extremities, not further specified
	Others
Severity of the accident	Fatal; Serious; Minor
Type of contract	Employee with a temporary job
	Employee with a permanent job
Assessment of the risk leading to the accident	Risk included in the risk assessment
	Risk not included in the risk assessment

Table 4
Reported chainsaw accident by economic activity (CODE NACE-2009).

Code	Economic Activity	Absolute frequency	Relative frequency (%)
A	**AGRICULTURE, FORESTRY AND FISHING**	**258**	**69.2**
1	Crop and animal production, hunting and related service activities	**152**	**40.7**
01.1	Growing of non-perennial crops	34	9.1
01.2	Growing of perennial crops	93	24.9
01.4	Animal production	3	0.8
01.5	Mixed farming	14	3.8
01.6	Agricultural support activities and post-harvest crop activities	8	2.1
2	Forestry and logging	**105**	**28.2**
02.1	Silviculture and other forestry activities	61	16.4
02.2	Logging	10	2.7
02.3	Gathering of wild growing non-wood products	2	0.5
02.4	Forestry support services	32	8.6
3	Fishing and aquaculture	**1**	**0.3**
03.2	Aquaculture	1	0.3
C	**MANUFACTURING**	**8**	**2.2**
10	Manufacture of food products	**1**	**0.3**
10.4	Manufacture of vegetable and animal oils and fats	1	0.3
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	**5**	**1.3**
16.1	Sawmilling and planning of wood	3	0.8
16.2	Manufacture of products of wood, cork, straw and plaiting materials	2	0.5
17	Manufacture of paper and paper products	**1**	**0.3**
17.2	Manufacture of articles of paper and paperboard	1	0.3
33	Repair and installation of machinery and equipment	**1**	**0.3**
33.1	Repair of fabricated metal products, machinery and equipment	1	0.3
F	**CONSTRUCTION**	**16**	**4.3**
41	Construction of buildings	**6**	**1.5**
41.2	Construction of residential and non-residential buildings	6	1.5
42	Civil engineering	**2**	**0.6**
42.1	Construction of roads and railways	1	0.3
42.9	Construction of other civil engineering projects	1	0.3
43	Specialised construction activities	**8**	**2.2**
43.1	Demolition and site preparation	4	1.1
43.2	Electrical, plumbing and other construction installation activities	1	0.3
43.3	Building completion and finishing	1	0.3
43.9	Other specialised construction activities	2	0.5
N	**ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES**	**14**	**3.8**
81	Building services and landscape activities	**13**	**3.5**
81.3	Landscape service activities	13	3,5
82	Office administrative, office support and other business support activities	**1**	**0.3**
82.9	Business support service activities n. e.c.	1	0.3
O	**PUBLIC ADM. & DEFENCE, COMPULSORY SOCIAL SECURITY**	**51**	**13.6**
84	Public administration and defence	**51**	**13.6**
84.1	Adm. of the State and the economic and social policy of the community	40	10.7
84.2	Provision of services to the community as a whole	11	2.9
S	**OTHER SERVICE ACTIVITIES**	**6**	**1.6**
94	Activities of membership organisations	**4**	**1.1**
94.9	Activities of other membership organisations	4	1.1
96	Other personal service activities	**2**	**0.5**
96.0	Other personal service activities	2	0.5
———	**OTHER FAMILIES OF ECONOMIC ACTIVITIES WITH A RELATIVE FREQUENCY OF LESS THAN 1%: E,G,H,I,J,L,M,P,R,T**	**20**	**5.3**
	TOTAL	**373**	**100**

Work (ESAW) code system. In addition, the material agent was classified in more detail using the 8-digit system developed by Communication and Information Resource Centre Administrator (CIRCA). Thus, the first 4 digits of the material agent variable are the same as those used by ESAW, and the last 4 digits provide more detailed information. In addition to these variables presented, a further one included in the accident reports was analyzed to indicate whether the risk that led to the chainsaw accident had been included in the risk assessment or had not been included before the accident occurred.

It is important to clarify that the figures showing the distribution of accidents according to age (Fig. 1), type of contract (Fig. 2), month (Fig. 5), day of week (Fig. 6), time of accident (Fig. 7) and working day timetable (Fig. 8) compare chainsaw accidents with occupational accidents in general, i.e. all occupational accidents that occurred in Andalusia in 2019, including chainsaw accidents.

After collection and examination, the data was tabulated and statistically analyzed by computer, using the EXCEL software package and SPSS Statistics v25.

2.3. *Pre-treatment of variables*

The variables provided by the Labor Authority, as shown in Table 2, were already coded according to standardized classifications such as NACE, ISCO or ESAW, therefore for the descriptive statistical analysis they were used with their original coding, i.e. no pre-treatment of the variables was carried out. Some of these variables could have a wide range of values. For example, in the case of economic activity there were also a large number of different codes depending on the economic activity of the enterprise (see Statistical classification of economic activities in the European Community). For this reason, in order to present the results in tables in an appropriate way avoiding extensive tables, the results of those codes with a low frequency were grouped at the end of the table, just to present the data and not for the analysis. Specifically, in Table 4, economic activities with a relative frequency of less than 1% were grouped together at the end of the table. Similarly, in Tables 5, 8, 9, 10, 10, 12, 13, 14, 15, 17 and 18, codes with a relative frequency of less than 1% were grouped at the end of the table.

For inferential analysis, pre-treatment of the data was necessary because many of the variables had too many possible codes or categories. For other variables such as day of week, month, severity, type of contract and assessment of the risk leading to the accident, preprocessing was not necessary. In the case of the age of the victim, ranges were established. The remaining variables were initially coded to include a large number of possible codes according to the classifications established in the European Statistics on Accidents at Work (ESAW). In these cases, in order to reduce the large number of categories, the variables were grouped into families or classes. These classes or families were established according to the European Statistics on Accidents at Work (ESAW) code groups. In addition, if there were several code groups with very low frequencies, these code groups were included together in the category “other”. For example, in the type of injury codes “011 -

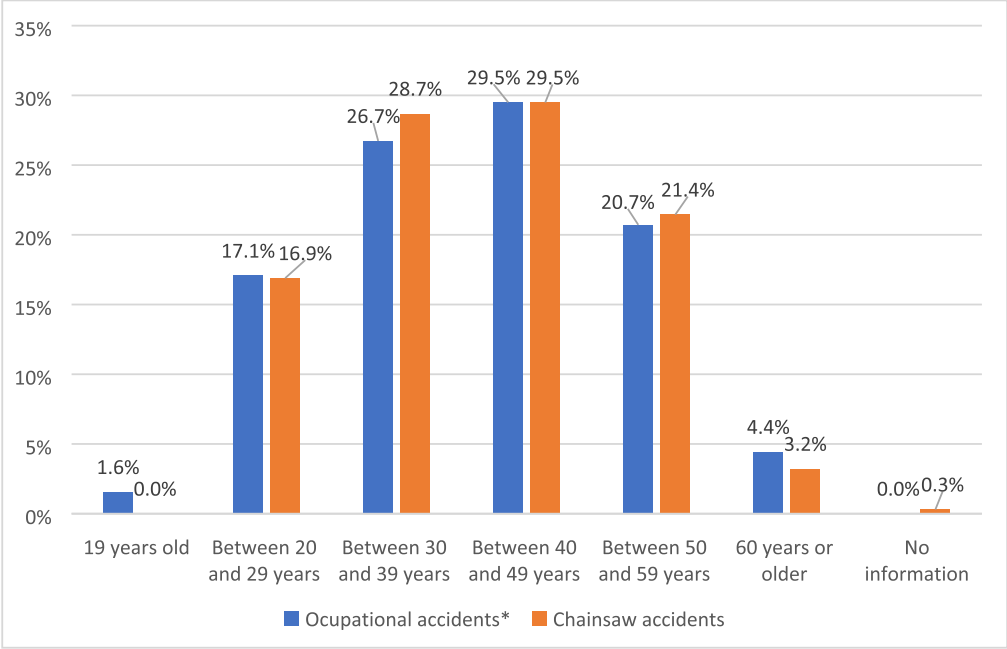


Fig. 1. Age group of workers involved in chainsaw accidents (2009–16) and in occupational accidents in Andalusia (2019). *Occupational accidents refer to all occupational accidents that occurred in 2019 in Andalusia, including chainsaw accidents.

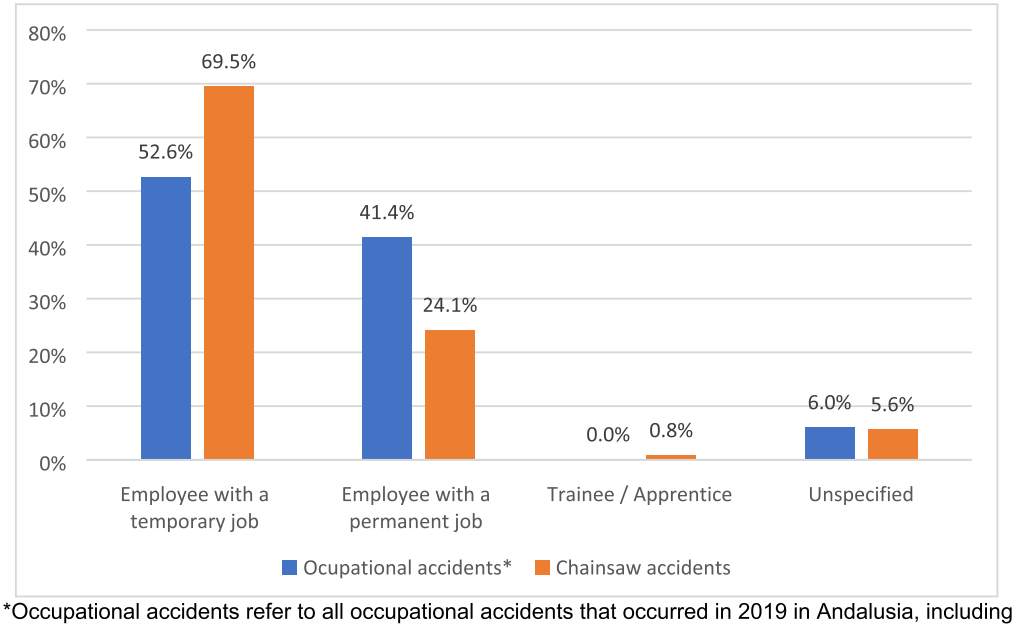


Fig. 2. Distribution of injured workers by type of contract. *Occupational accidents refer to all occupational accidents that occurred in 2019 in Andalusia, including chainsaw accidents.

Superficial injuries", "012 - Open wounds" and "019 - Other types of wounds and superficial injuries" were included in the category "Wounds and superficial injuries" which includes codes 010 to 019. The final coding of the variables used for the pre-treatment prior to the inferential analysis is presented in Table 3.

3. Results and discussion

3.1. Enterprise

3.1.1. Economic activity

The accidents analyzed are found in 16 of the 21 economic activity

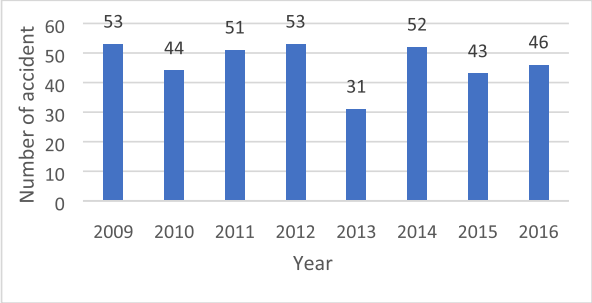


Fig. 3. Annual Distribution of accidents.

groups included in the NACE European code system. As can be seen in Table 4, most accidents occurred in the agriculture, forestry and fisheries sectors, mainly in plant and animal production, hunting and related services and forestry and logging and - to a much lesser extent - other sectors including those such as public administration and defense and compulsory social security. In particular, 40.8% of accidents occurred in the agricultural sector, of which 24.9% were in pruning activities for perennial crops.

3.2. *Worker*

3.2.1. *Occupation*

In the ranking of the occupations with the highest ratio of chainsaw accidents, the top three positions are related to occupations in the

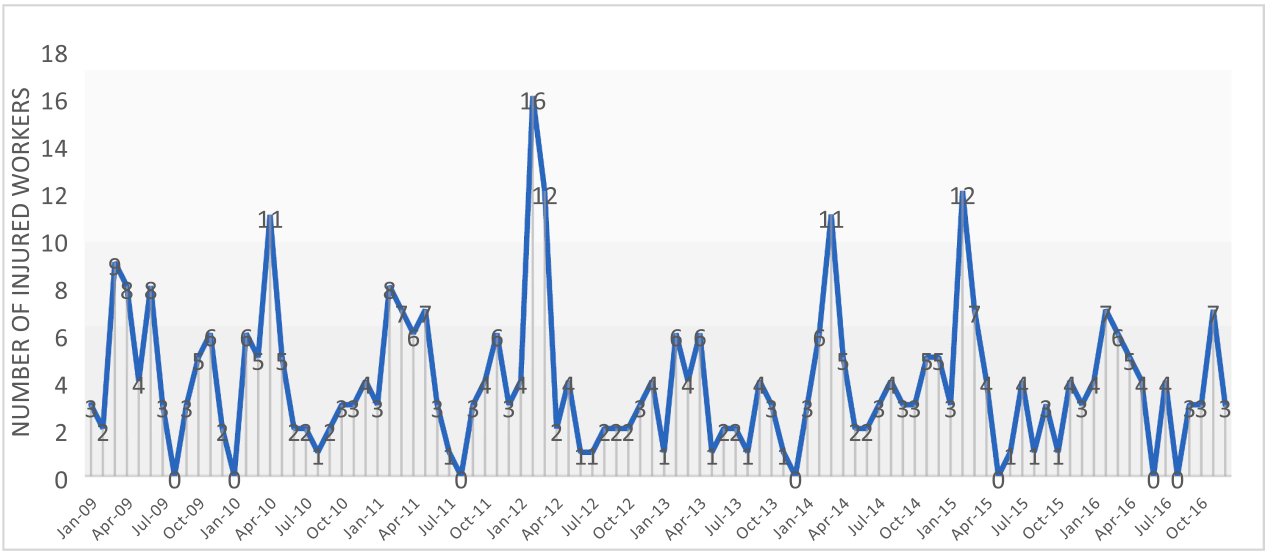


Fig. 4. Chainsaw Accidents in Andalusia between January 2009 and December 2016. *Occupational accidents refer to all occupational accidents that occurred in 2019 in Andalusia, including chainsaw accidents.

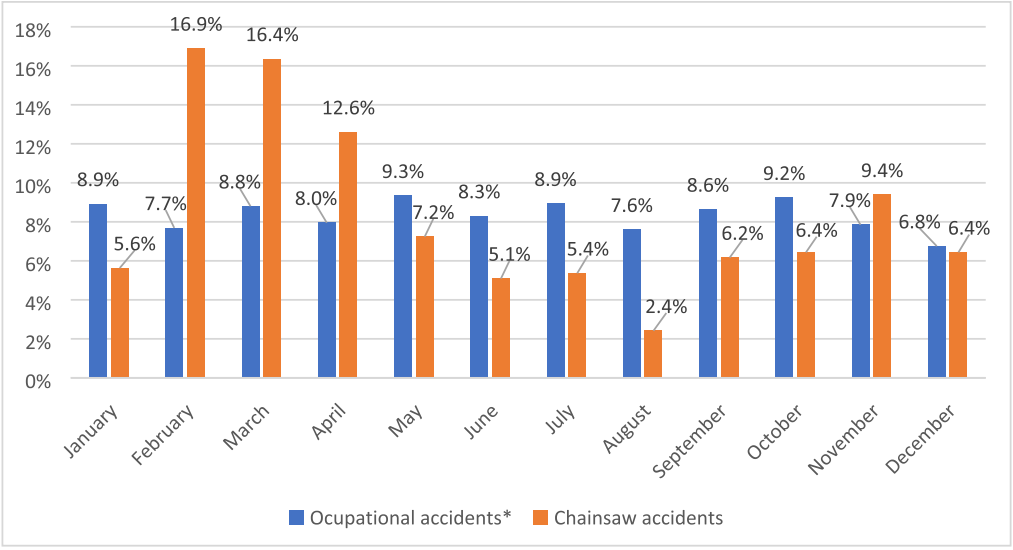


Fig. 5. Distribution of accidents according to the month in which the accident takes place. *Occupational accidents refer to all occupational accidents that occurred in 2019 in Andalusia, including chainsaw accidents.

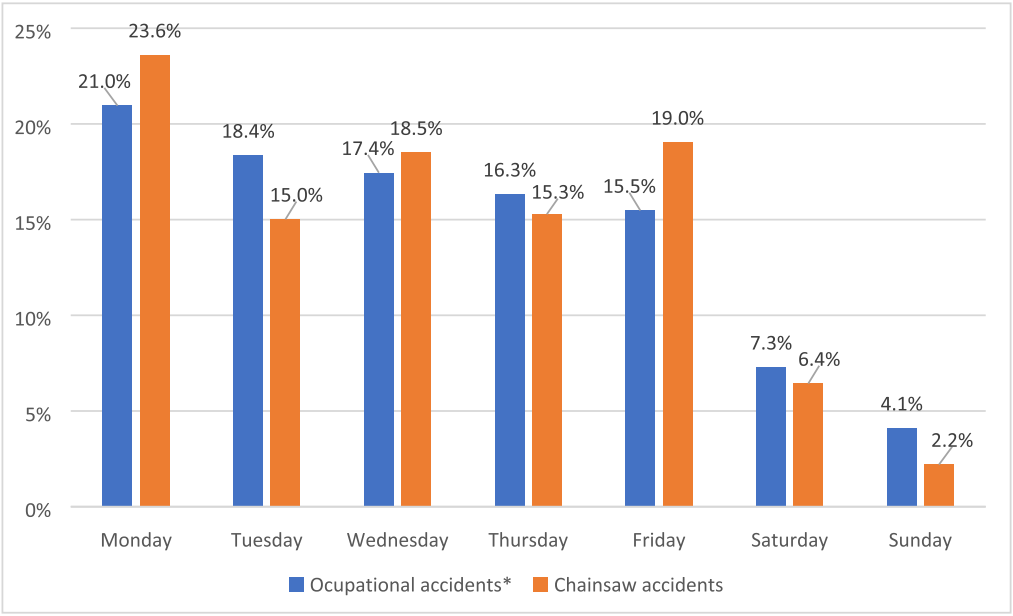


Fig. 6. Distribution of accidents according to the day of the week in which the accident takes place. *Occupational accidents refer to all occupational accidents that occurred in 2019 in Andalusia, including chainsaw accidents.

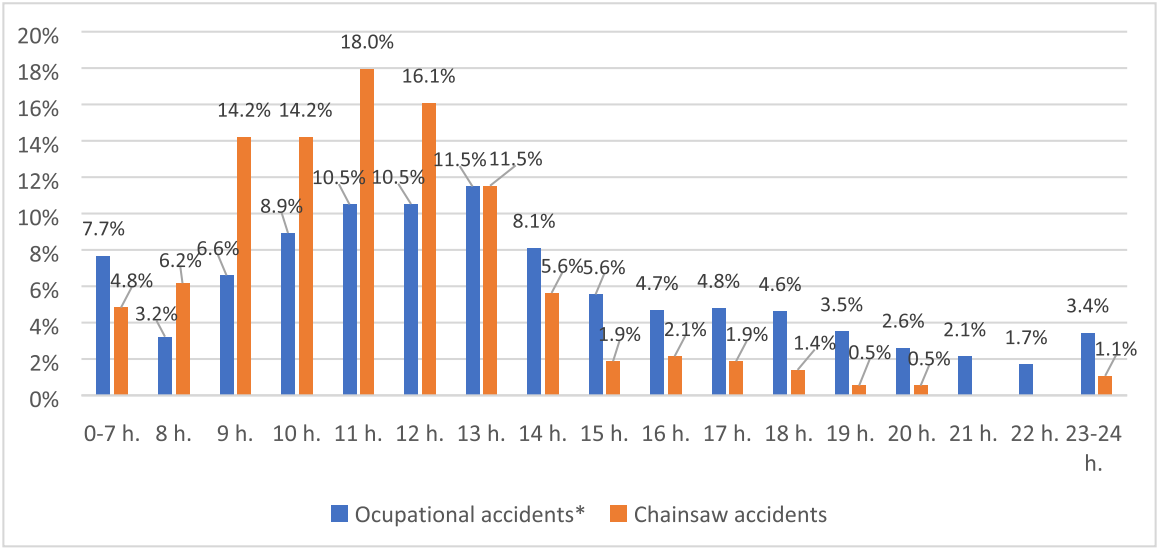
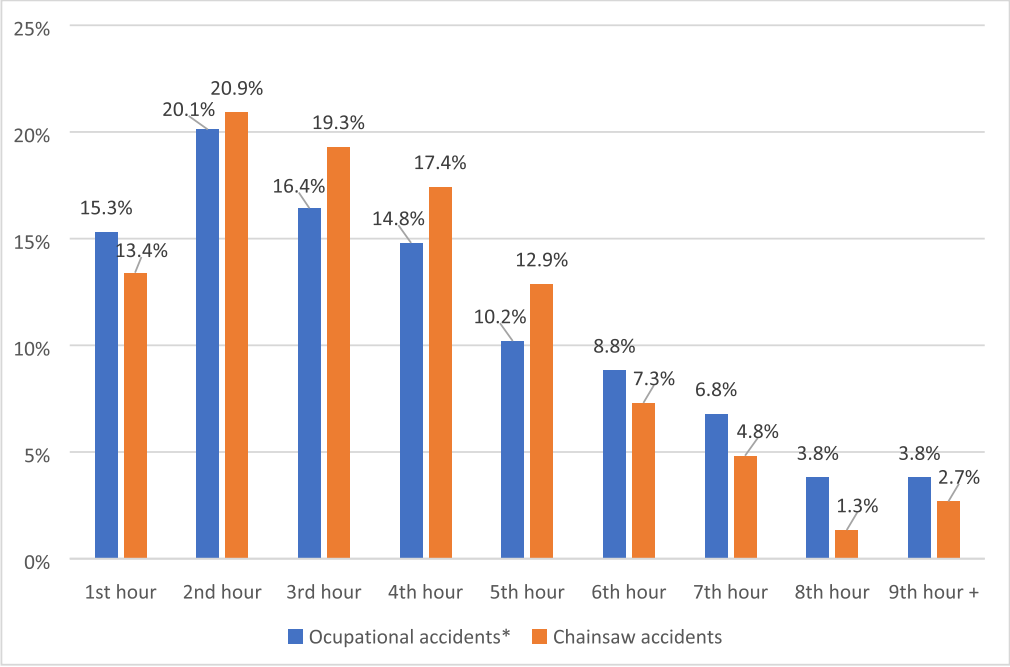


Fig. 7. Distribution of accidents according the time of accident. *Occupational accidents refer to all occupational accidents that occurred in 2019 in Andalusia, including chainsaw accidents.

agricultural and forestry sectors and they represent more than half of the total (Table 5). Specifically, agricultural laborers accounted for more than a third of the accidents with forestry workers some way behind this. Market gardeners and crop growers also account for as many accidents as forestry workers. Workers included in this group are skilled workers in agricultural activities, so they are included in the agricultural sector. In addition, there are other occupations in lower positions that could be linked to these sectors, meaning that the total percentage could be a little higher. These results demonstrate that the sectors in Andalusia where most occupational chainsaw accidents reported are the forestry and agricultural and sectors. However, it is can also be seen that almost a quarter of workers who have occupations outside these sectors, for example fire-fighters, are in fourth position in the ranking. This may be due to the fire prevention tasks that these workers perform. Also, construction and mining workers appear in the ranking but with fewer accidents, although there are other occupations included in the rest that could be linked to this sector.

3.2.2. Age, gender and nationality

Regarding chainsaw accidents, the average age of the injured



*Occupational accidents refer to all occupational accidents that occurred in 2019 in Andalusia, including chainsaw accidents

Fig. 8. Distribution of accidents according to the working day timetable.

Table 5
Reported chainsaw accident by worker occupation.

CODE ISCO-08	Worker Occupation	Absolute frequency	Relative frequency (%)
921	Agricultural laborers	135	36.2
611	Market gardeners and crop growers	75	20.1
621	Forestry and related workers	74	19.8
541	Protective services workers: Fire-fighters	27	7.2
613	Mixed crop and animal producers	10	2.7
931	Mining and construction laborers	9	2.4
834	Mobile plant operators	7	1.9
711	Building frame and related trades workers	6	1.6
962	Others elementary workers	6	1.6
911	Domestic, hotel - office cleaners - assistants	4	1.1
932	Manufacturing laborers	4	1.1
–	Others groups with relative frequency of less than 1% (131, 312, 515, 712, 741, 751, 752, 832, 933, 952, 961)	8	4.3
	Total	**373**	**100**

Table 6
Distribution of injured workers by Social Security category.

Employment Status	Absolute frequency	Relative frequency
Private sector employee	297	79.6
Public sector employee	55	14.8
Self-employed	21	5.6
Total	**373**	**100**

workers was 40.9, with more than half of them being aged between 30 and 49 (see Fig. 1). There were very few workers over 60 years old. Fig. 1 shows that the distribution of chainsaw accidents by age group of workers is similar to occupational accidents in Andalusia in general.

Table 7
Distribution of injured workers by type of contract.

Type of Contract	Absolute frequency	Relative frequency
Full-time	336	90.1
Part-time	6	1.6
Unspecified	28	7.5
Trainee / Apprentice	3	0.8
Total	**373**	**100**

Table 8
Distribution of accidents by working environment.

Code	Working Environment	Absolute frequency	Relative frequency (%)
034	Forestry zone	134	36.0
033	Farming area - tree or bush crop	122	32.7
032	Farming area - ground crop	24	6.4
061	Area permanently open to public thoroughfare	19	5.1
036	Garden, park, botanical garden, zoological garden	18	4.8
011	Production area, factory, workshop	12	3.2
072	Communal parts of a building, annexes, private family garden	6	1.6
049	Other group 040 type Working Environments not listed above	5	1.3
012	Maintenance area, repair workshop	4	1.1
022	Construction site - building being demolished, repaired, maintained	4	1.1
031	Animal breeding places	4	1.1
–	Other working environments with relative frequency of less than 1% (013, 021, 029, 039, 042, 044, 051, 059, 069, 071, 089, 092, 999)	21	5.6
	Total	**373**	**100**

Table 9
Distribution of accidents by Working Process.

Code	Working Process	Absolute frequency	Relative frequency (%)
34	Forestry type work	181	48.5
31	Agricultural type work - working the land	67	18.0
32	Agricultural type work - with vegetables, horticultural	41	11.0
39	Other group 30 type Working Processes not listed above	22	5.9
11	Production, manufacturing, processing – all types	22	5.9
52	Maintenance, repair, tuning, adjustment	19	5.1
59	Other group 50 type Working Processes not listed	5	1.3
24	Renovation, repair, aggregation, maintenance - of all types of buildings	4	1.1
–	Other Working Process with relative frequency of less than 1% (00, 22, 29, 35, 41, 51, 99)	12	3.2
	Total	**373**	**100**

Table 10
Distribution of accidents by specific physical activity.

Code	Specific Physical Activity	Absolute frequency	Relative frequency (%)
22	Working with hand-held tools – motorized	243	65.2
13	Monitoring the machine, operating or driving the machine	33	8.8
21	Working with hand-held tools - manual	29	7.8
41	Manually taking hold of, grasping, seizing, holding, placing - on a horizontal level	19	5.1
19	Other group 10 type Specific Physical Activities not listed above	14	3.8
11	Starting the machine, stopping the machine	6	1.6
42	Tying, binding, tearing off, undoing, squeezing, unscrewing, screwing, turning	6	1.6
67	Movements on the spot	6	1.6
61	Walking, running, going up, going down, etc.	5	1.3
–	Others with relative frequency of less than 1% (29, 49, 51, 52, 69, 70)	12	3.2
	Total	**373**	**100**

Table 11
Distribution of accidents by the material agent associated with the specific physical activity.

Code	Material Agent associated with the Specific Physical Activity	Absolute frequency	Relative frequency (%)
07.01.04.01	Portable chainsaws	275	73.7
06.01.01.02	Log saws	72	19.3
10.12.07.00	Chainsaw	24	6.5
10.12.07.01	Circular chain saw, fixed chain saw	2	0.5
	Total	**373**	**100**

As for gender, in Andalusia this type of work is essentially carried out by male workers and, in fact, all the injured workers were men. In terms of the nationality of the injured workers, almost all were Spanish (94.6%).

Table 12
Distribution of accidents by deviation.

Code	Deviation	Absolute frequency	Relative frequency (%)
43	Loss of control (total or partial) - of hand-held tool (motorized or not) or of the material being worked by the tool	105	28.2
64	Uncoordinated movements, spurious or untimely actions	31	8.3
41	Loss of control (total or partial) - of machine (including unexpected start-up) or of the material being worked by the machine	28	7.5
52	Slipping - Stumbling and falling - Fall of person - on the same level	27	7.2
33	Slip, fall, collapse of Material Agent - from above (falling on the victim)	21	5.6
74	Twisting, turning	18	4.8
35	Slip, fall, collapse of material agent - on same level	18	4.8
71	Lifting, carrying, standing up	17	4.6
44	Loss of control (total or partial) - of object (being carried, moved, handled, etc.)	17	4.6
72	Pushing, pulling	13	3.5
0	No information	8	2.1
51	Fall of person - to a lower level	8	2.1
99	Other Deviations not listed above in this classification.	8	2.1
32	Breakage, bursting - causing splinters (wood, glass, metal, stone, plastic, others)	7	1.9
79	Other group 70 type Deviations not listed above	7	1.9
39	Other group 30 type Deviations not listed above	6	1.6
24	Powdery - fume emission, dust emission, particles	5	1.3
75	Treading badly, twisting leg or ankle, slipping without falling	5	1.3
69	Other known deviation from group 60 but not mentioned above	4	1.1
–	Other Deviation with relative frequency of less than 1% (19, 21, 22, 34, 45, 59, 61, 62, 63, 73, 84)	20	5.3
	Total	**373**	**100**

3.2.3. *Employment status*

The study shows that almost all injured workers were employees, mostly in the private sector (Table 6).

On the other hand, the results show that around two thirds of injured workers were employees with a temporary contract (Fig. 2), with occupational accidents being close to half of all temporary workers, while almost a quarter were employees with permanent contracts.

In addition, the majority of the injured workers had full-time contracts (Table 7). The codes of the Spanish Guide to the Social Security focus on the type of contract and a code is not included for the self-employed. For this reason, in the case of injured self-employed workers, the type of contract was not specified. Finally, job seniority was not included in the available information.

3.3. *Date of accident*

3.3.1. *Annual accidents and trends*

A similar number of accidents occurred in 2009, 2011, 2012 and 2014 (Fig. 3), in which about 53 workers were injured.

The trend is constant, with a slight decrease in recent years (Fig. 4).

3.3.2. *Month*

Generally, there is stability in the number of monthly occupational accidents in Andalusia. However, regarding chainsaw accidents most of them occurred in February, March and April, while the fewest occurred

Table 13
Distribution of accidents by material agent associated with the deviation.

Code	Material Agent of Deviation	Absolute frequency	Relative frequency (%)
07.01.04.01	Portable chainsaws	155	41.6
06.01.01.02	Saw for trunks	52	13.9
18.01.01.00	Branches, trunks…	40	10.7
00.01.00.00	No material agent	28	7.5
01.02.02.00	Farmland (fields, meadows…)	20	5.4
10.12.07.00	Chainsaw	15	4.0
00.02.00.00	No information	9	2.4
18.01.00.00	Trees, plants, crops	7	1.9
99.00.00.00	Other material agents not listed in this classification	6	1.6
07.01.00.00	Mechanical hand tools for sawing	5	1.3
08.01.00.00	Hand tools, without specification of power	4	1.1
09.99.00.00	Other known portable or mobile machines and equipment in group 09 but not listed above	4	1.1
19.03.03.00	Vegetable remains	4	1.1
–	Other Agent Material of Deviation with relative frequency of less than 1% (14.05.00.00, 07.02.00.00, 14.05.01.00, 01.02.00.00, 10.12.07.01, 20.02.00.00, 08.02.00.00, 07.01.99.00, 20.99.00.00, 14.06.00.00, 01.02.01.02, 04.01.04.01, 18.06.00.00, 07.02.03.00, 18.02.05.06, 06.02.00.00, 11.03.01.04)	24	6.4
	Total	**373**	**100**

Table 14
Distribution of accidents by contact-mode of Injury.

Code	Contact-Mode of Injury	Absolute frequency	Relative frequency (%)
51	Contact with sharp Material Agent (knife, blade etc.)	151	40.5
71	Physical stress - on the musculoskeletal system	62	16.6
42	Struck - by falling object	41	11.0
59	Other group 50 type Contacts -Modes of Injury not listed above	20	5.3
31	Vertical motion, crash on or against (resulting from a fall)	19	5.1
52	Contact with pointed Material Agent (nail, sharp tool etc.)	17	4.6
41	Struck - by flying object	15	4.0
32	Horizontal motion, crash on or against	13	3.5
43	Struck - by swinging object	10	2.7
44	Struck - by rotating, moving, transported object, including vehicles	6	1.6
49	Other group 40 type Contacts -Modes of Injury not listed above	4	1.1
–	Others with relative frequency of less than 1% (16, 39, 45, 53, 63, 99, 00)	15	4.0
	Total	**373**	**100**

in June, July, August and January (Fig. 5).

3.3.3. Day of week

While occupational accidents in Andalusia decreased during the week, Mondays and Fridays were the days of the week with the highest number of chainsaw accidents (Fig. 6).

Table 15
Distribution of accidents by material agent associated with the contact-mode of injury.

Code	Material Agent of Contact-Mode of Injury	Absolute frequency	Relative frequency (%)
07.01.04.01	Portable chainsaws	167	44.8
06.01.01.02	Log saw	51	13.7
18.01.01.00	Branches, trunks…	43	11.5
10.12.07.00	Chainsaw	18	4.9
00.01.00.00	No material agent	15	4.0
01.02.02.00	Farmland (fields, meadows, etc.)	11	2.9
07.01.00.00	Mechanical hand tools - for sawing	11	2.9
18.01.00.00	Trees, plants, crops	8	2.1
14.05.00.00	Particles, dust, fragments, chips, splinters and the like	6	1.6
99.00.00.00	Other material agents who are not cited in this classification	6	1.6
19.03.03.00	Vegetable remains	5	1.3
00.02.00.00	No information	4	1.1
08.01.00.00	Manual tools, without motor specification, for sawing	4	1.1
14.05.01.00	Fragments, chips, splinters, broken glass	4	1.1
–	Other Agent Material of Contact-Mode of Injury with relative frequency of less than 1 (01.02.00.00, 01.02.01.01, 01.02.01.06, 06.02.03.00, 07.01.04.00, 07.01.99.00, 07.02.00.00, 07.02.03.00, 08.02.00.00, 08.99.00.00, 10.12.07.01, 10.18.99.00, 14.01.03.00, 14.06.00.00, 20.99.00.00)	20	5.4
	Total	**373**	**100**

Table 16
Distribution of accidents by severity.

Severity of accident	Absolute frequency	Relative frequency (%)
Fatal	0	0
Serious	9	2.4
Minor	364	97.6
Total	**373**	**100**

Table 17
Distribution of accidents by type of injury.

Code	Deviation Type of injury	Absolute frequency	Relative frequency (%)
012	Open wounds	166	44.5
011	Superficial injuries	60	16.1
032	Sprains and strains	39	10.5
019	Other types of wounds and superficial injuries	34	9.1
039	Other types of dislocations sprains and strains	24	6.4
021	Closed fractures	13	3.5
031	Dislocations	9	2.4
052	Internal injuries	8	2.1
022	Open fractures	5	1.3
029	Other types of bone fractures	4	1.1
120	Multiple injuries	4	1.1
–	Other Contact-Mode of Injury with relative frequency of less than 1% (000, 051, 059, 999)	7	1.9
	Total	**373**	**100**

3.3.4. Time of the day

The time of day when the accidents occurred (Fig. 7), three quarters of the accidents took place between 9:00 and 13:00 (74%), with a peak

Table 18
Distribution of accidents by part of body.

Code	Description of Part Injured	Absolute Frequency	Relative frequency (%)
54	Finger(s)	71	19
62	Leg, including knee	66	17.7
52	Arm, including elbow	37	9.9
53	Hand	36	9.7
31	Back, including spine and vertebra in the back	25	6.7
64	Foot	22	5.9
13	Eye(s)	20	5.4
51	Shoulder and shoulder joints	16	4.3
63	Ankle	11	2.9
12	Facial area	8	2.1
65	Toe(s)	8	2.1
21	Neck, inclusive spine and vertebra in the neck	7	1.9
41	Rib cage, ribs including joints and shoulder blades	7	1.9
59	Upper extremities, other parts not mentioned above	5	1.3
49	Torso, other parts not mentioned above	4	1.1
55	Wrist	4	1.1
69	Lower Extremities, other parts not mentioned above	4	1.1
–	Other Part of body injured with relative frequency of less than 1% (11, 14, 19, 29, 39, 42, 43, 61, 68,78)	22	5.9
	Total	**373**	**100**

at 11:00 am. As seen in Fig. 7, distribution by time of day in occupational accidents differs significantly from chainsaw accidents in Andalusia.

More than half the accidents (Fig. 8) occurred during the second, third or fourth hour of work (57.6%). As we can see in the figure, the third, fourth and fifth working hours show a small difference in respect to occupational accidents in Andalusia.

3.4. Working conditions

3.4.1. Working environment

Three quarters of accident rates (Table 8) occur in working environments related to forestry or agricultural areas (75%). Thus, more than one third of accidents occurred in farm areas (39.1%), out of which the majority was in tree or bush crop areas; with the other third of the accidents occurring in forestry zones.

3.5. Workplace

3.5.1. Working Process

Working processes related to the forestry and agricultural sectors (Table 9) occupy the top positions (77.5%), although, clearly, forestry related work ranks first, accounting for more than half the accidents under analysis. Following this, agricultural tasks was the second working area that most appeared in the accidents studied (29%).

3.5.2. Usual work tasks

Although the information provided by the labor authorities did not include the ESAW code for the workstation variable, it did show whether the work task performed by the injured worker at the time of the accident was his usual work task or not. We found that 96% of the injured workers were performing their usual work tasks. Additionally, another relevant fact was that in 67.6% of the accidents, the risk that gave rise to the accident was included in the risk assessment. In contrast, in 32.4% of the cases the risk was not assessed even though the worker may have been doing his/her usual work task.

3.6. Sequence of events

In this section, Sequence of Events and its most common causes, it has not been possible to make comparisons with other studies because most of them do not include information on the sequence of events, and those that do refer to the forestry sector in general.

3.6.1. Specific physical activity

Most accidents occurred while the injured worker was working with hand-held motorized power tools or chainsaws (Table 10). In addition, there were some accidents that occurred while the injured worker was monitoring, operating or driving, starting or stopping the machine and other, group 10 (13.2%).

3.6.2. Material agent associated with the specific physical activity

It should be clarified that the accidents that were studied either cited chainsaws as the material agent associated with the specific physical activity or else the term “chainsaw” was included in the description of the accident. In all other cases, chainsaw appeared in the description of the accident, but not specifically as the material agent. It is important to note that there are other material agents that can lead to confusion or error such as “Log saws” which belong to the group “Hand tools, not powered - not specified” or “Chainsaw” which belong to the group “Machines and equipment – fixed”. If the descriptions of this groups are observed it is found that it would not be correct to include the chainsaw in these groups because it is both powered and portable. Given the above, these accident reports were probably not properly filled in, since it was clear from the description of the accident that a chainsaw was being used. For this reason, in Table 11 the chainsaw (Portable chainsaw) does not appear as a material agent in all cases. In these cases, the description was checked to verify that the accident was caused by the chainsaw, as mentioned above.

3.6.3. Deviation

Although the results show that there were many different deviations, the most frequent was the loss of control of the chainsaw (Table 12). The second-most common deviation is for other body movements under or with physical stress.

3.6.4. Material agent associated with the deviation

This section is similar to that previously discussed in Section 3.6.2. Portable chainsaw appeared in Table 13 as the material agent of the deviation in almost half of the accidents. Other material agents such a saw for trunks and chainsaws were found. These last material agents have probably been assigned the wrong codes and “Portable chainsaw” should have been used instead. The person who filled out the accident report may have been confused by the similarity of the words and lack of clarity of the concepts.

3.6.5. Contact-Mode of injury

The most frequent contact-mode of injury was the contact with sharp material agents; this was followed by the physical stress on the musculoskeletal system (Table 14).

3.6.6. Material agent associated to the Contact-Mode of injury

In the same way as in the previous material agents studied, the portable chainsaw appeared in about 50% of the accidents (Table 15). Similarly, log saw and chainsaw were found to be the material agent. As indicated above, these codes may have been wrongly assigned and the material agent was probably a “Portable chainsaw”, which added up to 63.3%.

3.7. Victim

3.7.1. Severity of accident

It was noted that there were zero fatal accidents and nine serious

accidents (Table 16).

3.7.2. Type of injury

Almost half of the workers had open wounds followed by superficial injures (Table 17).

3.7.3. Part of body injured

As for the parts of the body that were injured, many different codes were entered and none of them accounted for over 20% of the total (Table 18). However, when the groups of injured body parts were studied, it was found that more than three quarters of the accidents (76.7%) fell into two groups: upper extremities (45.3%) and lower extremities (31.4%). Specifically, the most commonly injured parts of the body were fingers and legs, including the knee.

3.8. Inferential analysis

In relation to the inferential analysis, the significant statistical association between different variables was studied. A summary of the most relevant results is presented in the Table 19. On the one hand, we analyzed whether different variables such as severity of the accident, month, day of the week, deviation, type of injury or part of body injured were associated with the economic activity of the enterprise. The results of Pearson's chi-square test indicated that some of them had a statistically significant association with economic activity. These variables were month of accident ($p = .000$), deviation ($p = .002$), type of injury ($p = .009$), part of body injured ($p = .002$). In addition, another available variable was included in the analysis which indicated whether the risk had been assessed prior to the accident or whether the risk that led to the accident was not considered in the risk assessment. This variable also showed a statistically significant association with the economic activity of the enterprise ($p = .002$). In the case of severity ($p = .504$) or day of the week ($p = .327$), there was no significant association with the economic activity of the enterprise.

On the other hand, other combinations of variables were analyzed although not as many statistically significant associations were obtained as in the case of economic activity. Therefore, other results could be highlighted, such as that type of injury ($p = .000$), part of body injured ($p = .014$) or month of the accident ($p = .005$) are associated with the type of contract. It was also found that type of contract ($p = .007$) is associated with the age of the worker.

Finally, it can also be noted that severity ($p = .507$), day of the week ($p = .079$) or deviation ($p = .652$) were not statistically significantly associated with the above-mentioned variable "assessment of the risk that caused the accident" on whether the risk had been previously assessed before the accident occurred.

Table 19
Main results of the inferential analysis.

Independent variable	Dependent variable	Pearsońs chi-square (p-value)
Economic activity	Month of accident	0.000
	Deviation	0.002
	Type of injury	0.009
	Part of the body injured	0.002
	Assessment of the risk leading to the accident	0.002
	Severity	0.504
	Day of the week	0.327
Type of contract	Type of injury	0.000
	Part of the body injured	0.014
	Month of the accident	0.005
Age of the worker	Type of contract	0.007
Assessment of the risk leading to the accident	Severity	0.507
	Day of the week	0.079
	Deviation	0.652

4. Discussion

4.1. Economic activity and worker

Analysis of the results of the accidents related to chainsaw in Andalusia indicates that within the agricultural and forestry sectors, the agricultural sector becomes very important. In particular, 24.9% of the chainsaw accidents were in pruning activities for perennial crops. This indicates that in Andalusia the majority of chainsaw accidents occur in perennial crop pruning activities in the agricultural sector. This circumstance could be explained by the fact that in Andalusia, the cultivation of the olive tree, a perennial crop, represents 30% of the agricultural area, with just over 1.52 million hectares (Consejería de Agricultura, Pesca y Desarrollo Rural, 2015).

In relation to workers, the average age of the injured workers is similar to the findings of Tsioras et al. (2014) who studied 1077 accidents associated with wood harvesting activities in Austria from 2000 to 2009, who determined an average of age of 40.1. They also found that half of the workers between 36 and 50 years old, in our case 47.2% of the workers, are between those ages. Laschi et al. (2016) have also shown similar results in their study on forestry operations in an alpine context, with the majority of workers injured aged between 31 and 50 years. In addition, very few workers were over 60 years old. This can possibly be explained by the relationship between physical workload and ageing, considering that a progressive decline in physical abilities has consistently been reported (De Zwart et al., 1996; Fraade-Blanar et al., 2017) and the relationship between job characteristics and retirement, which indicates that high physical demand was statistically related to early retirement (Belbase et al., 2015). Plus, the fact that physical workload in these jobs is high, due to the weight of the chainsaw among other factors.

Likewise, the gender result is in line with the study by Hammig and Jones (2015) that analyzed all chainsaw related injuries treated in hospital emergency rooms in the United States from 2009 to 2013. They found that 95.1% of the patients were male. Similar results were found by Lindroos and Burström (2010) when analyzing accidents in Swedish forestry between 1996 and 2001. The nationality of the injured workers was Spanish, coinciding with Albizu et al. (2010), who reported predominantly workers of Spanish nationality in forestry harvesting in Spain

On the other hand, although the present study shows that almost all injured workers were employees, it seems likely that the accidents of self-employed workers are not reported. The Spanish National Commission on Health and Safety at Work emphasizes that one of the difficulties in obtaining reliable data on forestry accidents is the underreporting of accidents, given the large number of self-employed workers (Comisión Nacional de Seguridad y Salud en el Trabajo, 2006). Robb & Cocking (2014) reported that, in Spain, 80% of chainsaw operators are self-employed and paid on piecework. Something similar also occurs in the agricultural sector. It has been found that companies where chainsaw workers are registered are mainly in the agricultural and forestry sectors. Hence, this could be one of the reasons why the percentage of self-employed workers injured is so low.

Another characteristic of the tasks using the chainsaw at work is the temporary or seasonal nature. This leads to an increase in temporary work linked to these tasks. In fact, if we compare the injured workers with a temporary job in Andalusia with the chainsaw injured workers with a temporary job, we obtain that the proportion of injured temporary workers in the chainsaw case is higher than in Andalusia. Specifically, the injured workers with a temporary job are usually around 50 % in Andalusia, while our results indicate that around two thirds of the chainsaw injured workers were employed on a temporary contract (see Fig. 2).

In the same area as those reported by Servicio Público de Empleo Estatal (2015) which indicated that most of the new contracts in 2014 in forestry (73%) were for a Specific Project or Service. This indicates the

existence of traffic flows of workers in this occupation due to their temporary character or seasonal nature. Albizu et al. (2010), reported similar results.

4.2. Date of accident

Distribution of chainsaw accidents suggest seasonality and contrast with the stability of the occupational accidents in Andalusia (see Fig. 5). This seasonality is mainly due to two facts. Firstly, the olive trees that produce olive oil, as is the case in most of Andalusia, are pruned in February, March and April. Secondly, in Andalusia, the Administration carries out forest fire prevention work in the medium-risk months (from 1 to 31 May and from 16 to 31 October) and in the low-risk months (from 1 January to 30 April and from 1 November to 31 December). All of that could explain the high percentage of accidents in February, March and April. Similarly, in the high-risk months, i.e. from 1 June to 15 October, efforts are focused on extinguishing fires, and the burning of vegetation and agricultural and forestry residues, as well as off-road vehicle traffic, are prohibited. Both prohibitions are limited to forestry land and its areas of influence, i.e. non-forestry land (agricultural and urban) within 400 m of the forest. During the summer months, farmers are not allowed to burn pruning waste and, as a result, forestry and agricultural work with chainsaws is considerably reduced. This explains the decrease in accidents observed in the graph during the summer months.

Moreover, as mentioned above, this seasonality could also explain the high number of temporary workers involved in accidents in relation to permanent workers. In this sense, it was also found that the month of the accident depends on the type of contract. In fact, an in-depth analysis of the data shows that the months with the highest number of injured temporary workers are February, March and April, with 47, 41 and 35 injured workers respectively, while the average for the rest of the months is 15.1. It is also in these months that the highest number of injured permanent workers was recorded, but in smaller numbers, 13, 12 and 8 respectively, while the average for the rest of the months is 6.3.

In addition, Albizu-Urionabarrenetxea et al. (2013), who studied the forestry sector in Spain, also pointed out the strong seasonality of the sector and noted fall and spring as the seasons with higher accident rates. In addition, Cividino et al. (2013) reported a reduction in accidents in the summer, although they found that the months with the highest number of accidents were January to April. Italy and Spain are the two leading producers of olive oil in the world, although production in Spain is between 2 and 1.22 times higher than in Italy depending on the year (Castillo, 2012). Tsioras et al. (2014) also found February and March as the highest accident rates in Austria. On the contrary, Hammig and Jones (2015) obtained different results in the United States, with the summer season having the highest accident rate. In added value, the significant association found between month and economic activity; and month and type of contract, supports the results obtained in the descriptive analysis and what was mentioned in the previous paragraphs. That is, the higher number of accidents in the months of January and February is associated with greater agricultural activity and a higher number of temporary contracts. This could be explained by the pruning of olive groves and fire prevention work in Andalusia.

On the other hand, in Andalusia, occupational accidents (as a whole) tend to oscillate throughout the week, whilst the results of this study suggest that Mondays and Fridays are the days of the week with the highest number of chainsaw accidents (see Fig. 6), which coincides with studies by Jacke, (1989), Cividino et al. (2013), Tsioras et al., (2014), Robb and Cocking (2014) and Laschi et al., (2016). These peaks are consistent with the so-called "Monday morning blues, Friday afternoon syndrome". That is, the cycle of a work week can cause, on one side, poor concentration and a tendency to rush work on Friday afternoons, and, on the other hand, a lack of motivation on Monday mornings after the weekend (Bryson & Forth, 2007; Robb et al., 2014). In contrast, Albizu-Urionabarrenetxea et al. (2013) found higher accident rates on Wednesdays (20%) and Thursdays (25%). Although our study recorded similar rates for Wednesday (18.5%). Perhaps this difference can be explained considering that their studies only included forestry workers and the present study includes any worker who uses the chainsaw, that is, agricultural and other sectors workers are also included. In contrast, accidents decreased significantly at weekends, which can be explained by the reduction in work on those days, especially on Sundays.

In terms of time of the day, the available accident information only provides integer values for the time of day it occurred, without indicating the minutes. Distribution of chainsaw accidents according the time differs significantly to occupational accidents in Andalusia (see Fig. 7). Most accidents took place between 9 am and 1 pm, with a peak at 11 am. This same peak was reported by other authors (Tsioras et al., 2014; Bentley et al.; 2005; Wettmann, 2005; Fischer, 1991; Stadlmann, 1991). Contrary to what other authors indicate (Camino et al. 2011; Bentley et al., 2005; Kirk, 1996; Parker and Ashby, 2005) a peak is reported in the second hour with a drop during ensuing ones. According to these authors, factors such as fatigue, dehydration or food intake could lead to a loss of attention towards the end of the work shift, which promoted a higher number of accidents. Furthermore, third, fourth and fifth working hours show a small difference with respect to occupational accidents in Andalusia (see Fig. 8). A future analysis must therefore be made of this data, obtaining more information, specifically, on meal times and breaks, this could help to understand this difference. In addition, according to Allman et al. (2017), working in the afternoon was less hazardous than in the morning and pre-noon, recording fewer accidents.

Finally, it should also be noted that most of the injured workers were performing their usual work tasks. This implies that the worker must receive appropriate specific training. However, in the case of the chainsaw, there are no specific regulations, so the worker often does not have enough training. It is therefore necessary to develop a European training standard as proposed by Robb and Cocking (2014).

4.3. Sequence of events

In Sections 3.6.2, 3.6.4 and 3.6.6 on the material agent of the physical activity, deviation or contact-mode of injury respectively, it was noted that errors were detected in the coding of the chainsaw as material agent, as there were several similar categories that were confused in accident reports such as Log saws, Portable chainsaws, Chainsaw, Circular chain saw or Saw for trunks. In this regard, numerous studies have reported that errors are common when filling in and/or coding accident reports (Jacinto et al., 2016; Molinero-Ruiz et al., 2015, Salguero-Caparros et al., 2015). There are different reasons that could explain these errors. Nevertheless, measures should be developed to ensure that the person completing the reports, whether an administrative or a technician, has the necessary knowledge to complete the report properly.

On the other hand, in relation to the deviation, the loss of control of chainsaw was the most frequent type of deviation which is consistent with the fact that kickback was the most common and poses the greatest hazard, according to Koehler et al. (2004). By contrast, according to other authors (Allman et al., 2017; Laschi et al., 2016; Tsioras et al., 2014) the worker's fall or slip and falling objects, such as trees or logs, are the most frequent actions that caused accidents in different forestry operations. Consequently, these same events or deviations have been found in this study, that is, slipping, stumbling and falling or "Fall of persons, and Breakage", bursting, splitting, slipping, fall, collapse of Material Agent, adding up to a total of 23.2%, compared with 22.2% to loss of control. In addition, the significant association observed between the type of injury and economic activity; and the type of injury and type of contract, confirm the results obtained in the descriptive analysis. In other words, minor injuries caused by loss of control of the chainsaw are related to greater agricultural activity and to a greater number of temporary contracts. Aspects that again suggest olive grove pruning and fire

prevention work.

Regarding the contact-mode of injury, the contact with sharp material agent, probably due to contact with the blade of the chainsaw, was the most frequent. This was followed by the physical stress on the musculoskeletal system, since continuous effort lifting the chainsaw can lead to this type of injury, due to its weight. In third place were accidents in which the injured worker was struck by falling object, by flying object, or by a swinging object, which add up to 17.7%. These results obtained are similar to those found by Albizu et al. (2010) in forestry holdings in Castile and León (Spain).

4.4. Victim

If we focus in the severity of chainsaw accidents, none were fatal. This can be explained if one takes into account that deaths while operating chainsaw are extremely rare (Koehler et al., 2004). Nine accidents were serious (2.4%). As can be seen in Table 20, seven were forestry or agricultural workers with a temporary contract for project and service (77.7%). This could indicate that employees with a temporary contract suffered more serious accidents, than workers with other types of contracts such as permanent ones who did not record any serious accidents in the period studied. In relation to the deviation and its associated material agent, the most frequent were the fall or slip due to branches, trunks, tress or farmland, which could point out the importance of the work environment in this type of tasks, as it can lead to serious accidents. There were also some accidents, in a smaller proportion, due to loss of control of the chainsaw. In relation to the sequence of accident events, the most frequent deviation was falling or slipping due to branches, trunks, tress or farmland resulting in fractures and multiple injuries. This could point to the importance of the working environment when a worker is performing tasks with the chainsaw, as it can lead to serious accidents. There were also some accidents, to a lesser extent, due to loss of control of the chainsaw resulting in open wounds on legs and feet due to contact with the chainsaw blade.

Table 20
Specific characteristics of serious* chainsaw accidents (N = 9).

Variable	Categories	No. of accidents (relative frequency)
Worker occupation	Forestry	5 (55.5%)
	Agricultural	2 (22.2%)
	Others	2 (22.2%)
Type of contract	Temporary job	7 (77.7%)
	Permanent job	2 (22.2%)
Deviation	Fall, slipping	6 (66.6%)
	Loss of control of chainsaw	3 (33.3%)
Material Agent associated with the Deviation	Branches, trees	6 (66.6%)
	Chainsaw	3 (33.3%)
Type of injures	Fractures	6 (66.6%)
	Open wounds	3 (33.3%)

* In Spain, the seriousness of an accident at work is estimated by the doctors of the Mutual Insurance Companies or the Public Health System according to the duration of the temporary incapacity and the foreseeable consequences and incapacity (see Orden TAS/2026/2002 available at: https://www.boe.es/buscar/pdf/2002/BOE-A-2002–22650-consolidado.pdf). It should be noted that there are no regulatory criteria for classifying the seriousness of injuries resulting from accidents at work, although the categories of minor, serious or fatal injuries are established as an occupational contingency of the social security system. In this sense, there is *an Instruction 104/2001 on relations of Temporary Incapacity with the Public Prosecutor's Office* which *"considers "serious accident" to be a serious anatomical or functional loss of a serious nature, which will foreseeably give rise to sequelae for the physical integrity or health of the affected worker, and which will foreseeably lead, in due course, to the granting of a benefit for permanent incapacity in any of its degrees, or the application of the scale for non-disabling permanent injuries, except for simple scars"*. (More information is available at: https://www.osalan.euskadi.eus/images/congreso/s94-ponencia_eladio_gonzalez_osalancongreso.pdf).

If these results are compared with the results of other studies focusing on accidents in the forestry sector (Albizu et al., 2010; Lindroos and Burström, 2010; Enez et al., 2014; Tsioras et al., 2014, Laschi et al., 2016, Allman et al., 2017), the most common types of injuries are the same: contusions, wounds, dislocations or sprain and fractures. Nevertheless, the percentages, and therefore, ranking order varies from study to study, such as Lindroos and Burström (2010), who included dental damage as the most frequent types of injury.

According to our results, different studies of accidents in the forestry sector (Albizu et al., 2010; Lindroos and Burström, 2010; Tsioras et al., 2014; Robb & Cocking, 2014; Hammig and Jones, 2015; Laschi et al., 2016, Allman et al., 2017) have noted that the parts of the body most frequently affected by injuries are the upper and lower extremities. Inferential analysis results show that both economic activity and type of contract are significantly associated with the injured body part. This suggests that in the agricultural and forestry sector they do not use the personal protective equipment for the extremities, such as anti-cut gloves, jackets, trousers, bibs and boots for chainsaws.

4.5. The standard occupational accident

The characteristics that involve the accidents with chainsaws registered in Andalusia between January 2009 and December 2016 suggest that the injured victims tended to be a male worker from the forestry or agricultural sector. They were aged between 30 and 59, were employed in the private sector and had been hired under a full-time contract to carry out a specific project or offer a specific service, with a temporary job. There are about 46 accidents a year. Typically, the accident took place within the second or third hour of work, between 10.00 am and midday, on a Monday, in the month of February and March. Normally it occurred in forestry or agricultural areas during forestry or agricultural tasks, working with the portable chainsaw, with the (total or partial) loss of control of the chainsaw, leading to contact with the blades and causing open wounds to the leg (including the knee) or fingers. It should be noted that there was no fatal accident, so it can be concluded that these accidents are usually of a minor nature. The results highlight a factor specific to Andalusia, which is that in addition to accidents with chainsaws in the prevention of forest fires, there are also, and at a similar level, accidents of workers who carry out seasonal pruning of olive trees. Fig. 9 represents the sequence of events and the most common causes, i.e. working with chainsaw, which is cause of the deviation due to loss of control, where contact with the cutting edge of the chainsaw producing the injury.

4.6. Preventive measures

Taking into consideration the results obtained on chainsaw accidents, as well as the information available from other related studies, a set of preventive measures can be established in order to avoid and reduce chainsaw accidents. On the one hand, before using the chainsaw at work, workers must receive clear instructions on the use of hand-held machines, with special attention to their risks, and must be trained on site. It is also necessary to ensure that workers are aware of the importance of a tidy and clean working environment to avoid branches, logs or other objects that could cause injury. Similarly, given the frequency of accidents and injuries to chainsaw operators (Robb et al., 2014), it is essential to promote and enforce the use of personal protective equipment to reduce or eliminate injuries caused by cuts to any part of the body, especially the upper extremities. The worker's perception of risk is a key element in preventive measures (Albizu-Urionabarrenetxea et al., 2013), therefore it is essential that workers are aware of the risks associated with the chainsaw. According to Salminen et al. (1999) the physical fitness and personality of the worker influence the accident rate, so personal behavior plays a key role in the risk potential (Meléndez, 2015). For this reason, proper worker selection is important, focusing on those workers who have specific training in chainsaw use

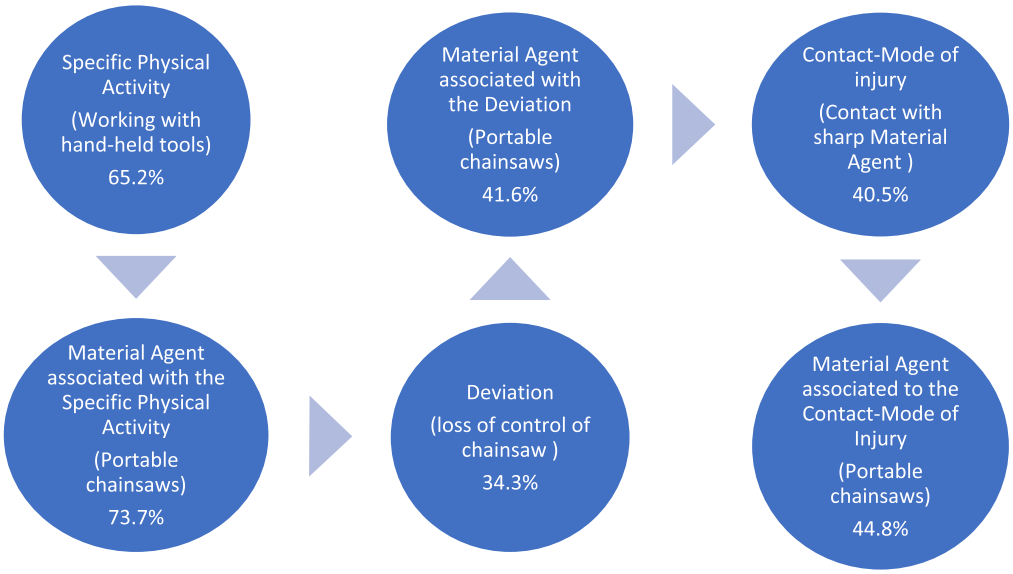


Fig. 9. Sequence of events and its most common cause.

and occupational health and safety. Also, promoting organizational measures that encourage rest and concentration could also help to reduce accidents. In fact, longer lunch breaks and task rotation were considered as recommended preventive measures. (Østensvik et al., 2008).

On the other hand, other actors need to be involved in developing measures to promote the safe use of chainsaws. The labor authority can have an important role in this issue. In this way, information from studies similar to this one could be used to develop specific policies and campaigns to address specific problems. For example, the promotion and development of specific training programs for that temporary workers (Fabiano et al., 2008). In addition, the authority could regulate mandatory training for the use of the chainsaw at work that guarantees the appropriate knowledge and skills of the worker. Likewise, the manufacturers of chainsaws should be involved in the prevention of accidents at work using their devices, especially in the safe use that would prevent the loss of control of the chainsaw. They can encourage the development of demonstrations and explanatory workshops, as well as the development of appropriate graphic materials in manuals, which should include safety measures.

5. Limitations

During this study, it has been observed that there is a significant lack of studies focused on occupational accidents related to chainsaws. All the studies mentioned refer to the forestry sector or to chainsaw-related injuries in general, i.e., including both home and work injuries. Indeed, there are no scientific studies that focus solely on occupational chainsaw injuries, making it difficult to make comparisons or to determine the general characteristics of these injuries and the circumstances in which they occur. But the most important limitation is that there are a significant number of self-employed workers or paid on piecework (80%), and even workers not registered in social security, who do not report accidents. This is due, as mentioned above (Robb & Cocking, 2014), to the seasonal nature of chainsaw work and the fact that most workers belong to the forestry and agricultural sectors. Likewise, The Spanish National Commission on Health and Safety at Work emphasizes that one of the difficulties in obtaining reliable data on forestry accidents is the underreporting of accidents, given the large number of self-employed workers (National Health and Safety at Work Commission, 2006).

Inconsistencies have also been observed that point to errors in the completion of accident reports, perhaps due to a lack of training or because the person completing them is not responsible for this task. For example, in some accidents the code assigned to the material agent did not correspond to the correct code on the chainsaw. However, in the accident description, the chainsaw was identified as the material agent.

Finally, non-public access to information and the local nature of the study add to the limitations raised. The scope of this study is limited to the region of Andalusia. Indeed, it would be advisable to extend the study to a national level in order to find out the characteristics of chainsaw-related accidents at work in Spain and worldwide. Comparisons could even be made between regions to detect which of these records the largest number of accidents.

6. Conclusion

This paper has been a first step in the analysis of occupational accidents with chainsaws but it is necessary to continue to further elaborate this research. First of all, by obtaining more information about chainsaw operators, followed by the development of specific preventive measures which allow for improving the health and safety of these workers, in order to reduce or eliminate chainsaw accidents. Although the chainsaw is one of the most dangerous pieces of work equipment, there are few specific regulations on its use at work and the training of chainsaw operators. Consequently, it would be advisable to develop an international standard for the training of these workers. To do this, it will be necessary to study what training these workers are currently receiving and what their main shortcomings are, taking into account high numbers of employee with a temporary job and seasonality. It is also necessary to promote and oblige the use of personal protective equipment to reduce or eliminate injuries caused by cuts to any part of the body, especially in the upper extremities. Also, the manufacturers of chainsaws should be involved in the prevention of accidents at work when using their devices, especially in the safe use that would prevent the loss of control of the chainsaw.

In addition, the results show that around 30% of injured workers related to the chainsaw in Andalusia did not belong to the forestry or agricultural sector. This fact emphasizes the importance of not only developing a training standard, but also applying it to any worker who uses the chainsaw independently of the sector in which they work. Until now the problem has been studied essentially in the forestry and agricultural sector. Therefore, it can be concluded that in order to regulate

the problem it is necessary to start by defining which workers are considered chainsaw operators. The ideal would be to consider any worker who uses the chainsaw at work regardless of the time or frequency of use, given the high risk of this work equipment.

Finally, the errors detected when filling in accident reports are highlighted. Therefore, the person in charge of filling in the accident report should be trained in order to improve the quality of the information recorded on accidents. Likewise, it would also be desirable to establish mechanisms to help self-employed workers to report their accidents, preventing this information from being lost. In fact, since 2019 in Spain it is compulsory for all self-employed to do so.

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.

Acknowledgements

We acknowledge the support of the Regional Government of Andalusia for the information provided. Also, we thank the support of ABA International and European Union Erasmus + program, especially the project "Vocational Education & Training Standards in Agriculture, Forestry & Environmental Safety at Heights" (Vet-Safety), in which the present study is included. We are grateful for the support provided by University of Malaga. All of them have made our research possible.

References

Albizu, P.M., Tolosana, E., Ulecia, J., Fernández, M., 2010. Diagnóstico de la seguridad en los aprovechamientos forestales a partir de registros empresariales, bases de datos oficiales y muestreos de campo. Propuestas de actuación. For. Syst. 19 (2), 221–233.

Albizu-Urionabarrenetxea, P.M., Tolosana-Esteban, E., Roman-Jordan, E., 2013. Safety and health in forest harvesting operations. Diagnosis and preventive actions. A review. For. Syst. 22 (3), 392–400. https://doi.org/10.5424/fs/2013223-02714.

Allman, M., Jankovský, M., Allmanová, Z., Ferenčík, M., Messingerová, V., Vlčková, M., Stoilov, S., 2017. Work accidents during cable yarding operations in Central Europe 2006–2014. For. Syst. 26 (1), 011.

Ambrosio, Y., Tolosana, E., Vignote, S., Garasa, M., 2001. Análisis de la seguridad y salud laboral en los aprovechamientos forestales de cortas de clara en España. Revista Chapingo. Serie ciencias forestales y del ambiente 7, 55–65.

Axelsson, S.Å., 1998. The mechanization of logging operations in Sweden and its effect on occupational safety and health. J. For. Eng. 9 (2), 25–31.

Belbase, A., Sanzenbacher, G., Gillis, C.M., 2015. Does age-related decline in ability correspond with retirement age?. Center for Retirement Research at Boston College. http://crr.bc.edu/wp-content/uploads/2015/09/wp_2015-24.pdf.

Bentley, T.A., Parker, R.J., Ashby, L., 2005. Understanding felling safety in the New Zealand forest industry. Appl. Ergon. 36 (2), 165–175.

Bird, F.E., 1990. Liderazgo Práctico en el Control de Pérdidas. Internacional Loss Control Institute, Longanwille.

Brown, A.F.T., 1995. Chainsaw penetrating neck injury. Retrieved from J. Accid. Emerg. Med. 12, 134–137. http://emj.bmj.com/content/emermed/12/2/134.full.pdf.

Bryson, A., Forth, J., 2007. Are there day of the week productivity effects? London School of Economics (MHRLdp004). Retrieved from http://cep.lse.ac.uk/pubs/download/mhrldp0004.pdf.

Cabeças, J.M., 2007. An approach to health and safety in E.U. forestry operations – Hazards and preventive measures. Enterprise Work Innov. Stud. 3, 13–34.

Camino, M.A., Ritzel, D.O., Fontaneda, I., Gonzalez-Alcantara, O.J., 2008. Construction industry accidents in Spain. J. Saf. Res. 39 (5), 497–507. https://doi.org/10.1016/j.jsr.2008.07.006.

Camino-Lopez, M.A., Fontaneda, I., Gonzalez-Alcantara, O.J., Ritzel, D.O., 2011. The special severity of occupational accidents in the afternoon: "The lunch effect". Accid. Anal. Prev. 43 (3), 1104–1116. https://doi.org/10.1016/j.aap.2010.12.019.

Castillo, M., 2012. La cultura del olivo. Aspectos distintivos en el cultivo del olivar entre la región de Umbría (Italia) y la provincia de Sevilla. Espacio y Tiempo 26, 75–101.

Cividino, S.R.S., Gubiani, R., Pergher, G., Dell'Antonia, D., Maroncelli, E., 2013. Accident investigation related to the use of chainsaw. Journal of. Agric. Eng. 44 (2s) https://doi.org/10.4081/jae.2013.(s1):e137.

Comisión Nacional de Seguridad y Salud en el Trabajo, 2006. Trabajos Forestales http://www.insht.es/InshtWeb/Contenidos/Instituto/Comision/GruposTrabajo/forestales_jun2006.pdf.

Consejería de Agricultura, Pesca y Desarrollo Rural, 2015. Plan Director del Olivar Andaluz. Junta de Andalucía.

de Zwart, B.C.H., Frings-Dresen, M.H.W., van Dijk, F.J.H., 1996. Physical workload and the ageing worker: a review of the literature. Int. Arch. Occup. Environ. Health 68 (1), 1–12.

Enez, K., Topbas, M., Acar, H.H., 2014. An evaluation of the occupational accidents among logging workers within the boundaries of Trabzon Forestry Directorate, Turkey. Int. J. Ind. Ergon. 44 (5), 621–628.

European Commission, 2013. European Statistics on Accidents at Work (ESAW). Ed. Methodologies & Working papers, Eurostat.

Fabiano, B., Currò, F., Reverberi, A.P., Pastorino, R., 2008. A statistical study on temporary work and occupational accidents: specific risk factors and risk management strategies. Saf. Sci. 46 (3), 535–544.

Fernie, C.G.M., Gibson, I.H., Newton, F., 1994. Chainsaw deaths: accident, suicide or murder? J. Clin. Forensic Med. 1 (2), 109–112. https://doi.org/10.1016/1353-1131(94)90010-8.

Fischer, M., 1991. Unfallursachenforschung als Grundlage fur die Unfallverhutung (cause analysis of accidents as basis for accident prevention). Diplomarbeit am Institut fur Forsttechnik. Universitat fur Bodenkultur, Wien, p. 38.

Fraade-Blanar, L.A., Sears, J.M., Chan, K.C.G., Thompson, H.J., Crane, P.K., Ebel, B.E., 2017. Relating older workers' injuries to the mismatch between physical ability and job demands. J. Occup. Environ. Med. 59 (2), 212–221.

Gatfield, D., 1999. Can cognitive science improve the training of industrial process operators? J. Saf. Res. 30 (2), 133–142.

Gorgues, A.C., Guiu, R.F., 2010. Statistical analysis of accidents in the forestry sector in Spain (Leonardo Project Report No. 2). Retrieved from http://www.adam-europe.eu/prj/5126/prd/14/2/ACCIDENTS%20IN%20THE%20FORESTRY%20SECTOR%20%20%20%20%20%20IN%20SPAIN-2010%20v_2_.pdf.

Hammig, B., Jones, C., 2015. Epidemiology of chain saw related injuries, United States: 2009 through 2013. Adv. Emergency Med. 2015.

Haynes, C.D., Webb, W.A., Fenno, C.R., 1980. Chain saw injuries: review of 330 cases. J. Trauma Acute Care Surg. 20 (9), 772–776.

International Labour Organization, 2012. International Standard Classification of Occupations: ISCO-08. Ed. ILO, Geneve. Available in: ilo.org/wcmsp5/groups/public/—dgreports/—dcomm/—publ/documents/publication/wcms_172572.pdf.

ISTAS, 2021. Notificación de accidentes de trabajo y Enfermedades profesionales. Instituto Sindical de Trabajo, Ambiente y Salud. Available on 28 January 2021 at https://istas.net/salud-laboral/actividades-preventivas/notificacion-de-accidentes-de-trabajo-y-enfermedades.

Jacinto, C., Santos, F.P., Guedes Soares, C., Silva, S.A., 2016. Assessing the coding reliability of work accidents statistical data: How coders make a difference. J. Saf. Res. 59, 9–21.

Jacke, H., 1989. Die Unfallhäufigkeit im Wochenverlauf (accident frequency along the week days). Allg. Forst Zeitschrift 48, 1276–1281.

Kirk, P., 1996. Reducing the impact of fatigue on forest workers. Liro Report 21 (3).

Koehler, S.A., Luckasevic, T.M., Rozin, L., Shakir, A., Ladham, S., Omalu, B., Dominick, J., Wecht, C.H., 2004. Death by chainsaw: fatal kickback injuries to the neck. J. Forensic Sci. 49 (2), 1–6. https://doi.org/10.1520/JFS2003276.

Kogler, R., Quendler, E., Boxberger, J., 2015. Analysis of occupational accidents with agricultural machinery in the period 2008–2010 in Austria. Saf. Sci. 72, 319–328. https://doi.org/10.1016/j.ssci.2014.10.004.

Laschi, A., Marchi, E., Foderi, C., Neri, F., 2016. Identifying causes, dynamics and consequences of work accidents in forest operations in an alpine context. Saf. Sci. 89, 28–35.

Lefort Jr, A.J., De Hoop, C.F., Pine, J.C., Marx, B.D., 2003. Characteristics of injuries in the logging industry of Louisiana, USA: 1986 to 1998. Int. J. For. Eng. 14 (2), 75–89.

Lilley, R., Feyer, A.-M., Kirk, P., Gander, P., 2002. A survey of forest workers in New Zealand: do hours of work, rest, and recovery play a role in accidents and injury? J. Saf. Res. 33 (1), 53–71.

Lindroos, O., Burström, L., 2010. Accident rates and types among self-employed private forest owners. Accid. Anal. Prev. 42 (6), 1729–1735. https://doi.org/10.1016/j.aap.2010.04.013.

Melemez, K., 2015. Risk factor analysis of fatal forest harvesting accidents: a case study in Turkey. Saf. Sci. 79, 369–378. https://doi.org/10.1016/j.ssci.2015.07.004.

Ministerio de Empleo y Seguridad Social, 2015. Sistema Delt@. Guía de cumplimentación del parte de accidente de trabajo (PAT). Ed. Subdirección General de Estadística, Secretaría General Técnica.

Molinero-Ruiz, E., Pitarque, S., Fondevila-McDonald, Y., Martin-Bustamante, M., 2015. How reliable and valid is the coding of the variables of the European Statistics on Accidents at Work (ESAW)? A need to improve preventive public policies. Saf. Sci. 79, 72–79.

Myers, J.R., Fosbroke, D.E., 1994. Logging fatalities in the United States by region, cause of death, and other factors—1980 through 1988. J. Saf. Res. 25 (2), 97–105.

Neely, G., Wilhelmson, E., 2006. Self-reported incidents, accidents, and use of protective gear among small-scale forestry workers in Sweden. Saf. Sci. 44 (8), 723–732.

Nieuwenhuis, M., Lyons, M., 2002. Health and safety issues and perceptions of forest harvesting contractors in Ireland. Int. J. For. Eng. 13 (2), 69–76.

Østensvik, T., Veiersted, K.B., Cuchet, E., Nilsen, P., Hanse, J.J., Carlzon, C., Winkel, J., 2008. A search for risk factors of upper extremity disorders among forest machine operators: a comparison between France and Norway. Int. J. Ind. Ergon. 38, 1017–1027.

OSHA, 2014. E-fact 29. Occupational safety and health in Europe's forestry industry. file:///Users/aalt/Downloads/E-fact_29_-_Occupational_safety_and_health_in_Europes_forestry_industry.pdf.

OSHA, 2018. Fact Sheet. Working Safely with Chain Saws. https://www.osha.gov/OshDoc/data_Hurricane_Facts/chainsaws.pdf.

Parker, R., Ashby, L., 2005. Chainsaw related injuries. COHFE Report Volume 6 No 1. ISSN 1174-1234.

Peters, P.A., 1991. Chainsaw felling fatal accidents. Trans. ASAE 34 (6), 2600–2608.

Reuhl, J., Bratzke, H., 1999. Death caused by a chain saw – homicide, suicide or accident? A case report with a literature review (with 11 illustrations). Forensic Sci. Int. 105 (1), 45–59.
Rikhardsson, P.M., Impgaard, M., 2004. Corporate cost of occupational accidents: an activity-based analysis. Accid. Anal. Prev. 36 (2), 173–182.
Robb, W., Cocking, J., 2014. Review of European chainsaw fatalities, accidents and trends. Arboricult. J. 36 (2), 103–126. https://doi.org/10.1080/03071375.2014.913944.
Salminen, S., Klen, T., Ojanen, K., 1999. Risk taking and accident frequency among Finnish forestry workers. Saf. Sci. 33, 143–153.
Salguero-Caparros, F., Suarez-Cebador, M., Rubio-Romero, J.C., 2015. Analysis of investigation reports on occupational accidents. Saf. Sci. 72, 329–336.
Servicio Público de Empleo Estatal. Observatorio de las ocupaciones, 2015. Los perfiles de la oferta de empleo 2015. Ed. Servicio Público de Empleo Estatal, Madrid. http://www.sepe.es/contenidos/que_es_el_sepe/publicaciones/publicaciones.html.
Shaffer, R.M., Milburn, J.S., 1999. Injuries on feller-buncher/grapple skidder logging operations in the Southeastern United States. For. Prod. J. 49 (7/8), 24.
Stadlmann, H., 1991. Motorsägen – Unfallanalyse 1990/91 (Chainsaws – Analysis of Accidents 1990/91). SVB, Wien, p. 16.
Thelin, A., 2002. Fatal accidents in Swedish farming and forestry, 1988–1997. Saf. Sci. 40 (6), 501–517. https://doi.org/10.1016/S0925-7535(01)00017-0.
Thompson, Richard C., Hilton, Thomas F., Witt, L.A., 1998. Where the safety rubber meets the shop floor: a confirmatory model of management influence on workplace safety. J. Saf. Res. 29 (1), 15–24.
Tsioras, P.A., Rottensteiner, C., Stampfer, K., 2014. Wood harvesting accidents in the Austrian State Forest Enterprise 2000–2009. Saf. Sci. 62, 400–408. https://doi.org/10.1016/j.ssci.2013.09.016.
Wang, Jingxin, Bell, Jennifer L., Grushecky, Shawn T., 2003. Logging injuries for a 10-year period in Jilin Province of the People's Republic of China. J. Saf. Res. 34 (3), 273–279.
Wettmann, O., 2005. Berufsunfaelle in Forstbetrieben 2003 (Occupational Accidents in Forest Enterprises for the Year 2003). SUVA, Luzern, p. 26.
Wilmsen, Carl, Bush, Diane, Barton-Antonio, Dinorah, 2015. Working in the Shadows: Safety and Health in Forestry Services in Southern Oregon. J. Forest. 113 (3), 315–324.
Williamson, Ann, Feyer, Anne-Marie, 1998. The causes of electrical fatalities at work. J. Saf. Res. 29 (3), 187–196.