Analysis of the average duration of sick leave due to electrical contact in the primary, secondary and tertiary sectors in Spain (2013-2019)

Abstract

The analysis of the economic impact of occupational health and safety has been side-lined for many years. Various studies have acknowledged the importance of analysing the seriousness of accidents on the basis of the number of working days lost due to injuries sustained in such accidents in different economic sectors. In this longitudinal comparative study, we analyse the average duration of sick leave associated with 4,098,520 accidents that occurred in Spain between 2013 and 2019, and more specifically with 5,724 accidents involving direct and indirect electrical contact. Based on the number of lost workdays, the relationship between the seriousness of electrical accidents and the economic sectors where they occur is explored via contingency tables in which statistical Chi-square value (χ2) was calculated. The main results obtained show that the average duration of sick leave shows an upward year-on-year trend in all three economic sectors. In addition, accidents due to direct and indirect electrical contact occur in all sectors, and the injuries produced in this type of accident are more severe than those produced in the sum of all accidents in Spain. Our figures show that the longest duration of sick leave occurs in the primary sector, followed by the tertiary and the secondary sectors. These results should prompt the competent authorisites to require businesses to maintain the equipment and facilities in good order, and to introduce effective supervision programmes that guarantee compliance with the measures enforced and reduce the serious consequences of electrical accidents.

Keywords

Electrical accidents; primary, secondary and tertiary sectors; occupational health and safety; seriousness; lost workdays; Duration of Sick Leave

1. Introduction

The economic effect of occupational accidents can no doubt seem alarming when reading some estimates [1,2,3]. The International Labor Organization determined that 4% of global gross domestic product (GDP) is lost due to occupational accidents and diseases [4]. In Europe, Eurostat [5] determined that occupational accidents cost €55 billion in 2000, 88% of which was due to lost working time. One of the largest Spanish unions determined that the cost of work-related accidents in Spain in 2002 amounted to €11.988 billion, equivalent to 1.72% of GDP [6]. The results of a study performed in 2012 by Mutua Universal were also discouraging, revealing that occupational accidents in Spain cost close to €20 billion in 2007 and close to €14 billion in 2011 [7]. The apparent downward year-on-year trend in these costs is deceptive when we consider that these years coincide with the economic crisis that severely impacted the number of active workers [8]. In fact, 568,360 occupational accidents were reported in Spain in 2011 with a cost per accident of €24,594 - equivalent to 27% more than the estimated cost in 2007.

Awareness and interest in the economic aspects of occupational health and safety have been side-lined for many years [9]. Furthermore, accident investigation reports make little effort to analyse costs per accident [10], and the economic cost of accidents is barely perceptible in corporate balance sheets [11]. This might be due to the complexity of determining and specifically evaluating the losses associated with occupational accidents [12-15], an analysis that requires several different variables to be taken into consideration in order to arrive at an accurate estimation of the cost involved. Mossink and De Greef [16] suggest using a group of variables classified according to three stakeholders: the worker, society, and the company. In Spain, the National Institute of Occupational Safety, Health and Welfare at Work [17] also classifies the human and economic burden of occupational accidents in terms of these three stakeholder groups.

The INSST [17] also adds another series of costs that may remain more or less hidden for the company itself, such as time lost by colleagues, interference in production, loss of productivity, etc.

Indicators that can eliminate or minimise subjectivity are needed to limit this complexity and obtain results that can help prioritize the measure to be introduced in the different scenarios that may arise. These indicators, moreover, must be highly representative of the costs of the accident [13].

Given that different studies [7,18,19] have shown that most costs derived from occupational accidents are associated with production losses, and these costs are directly proportional to the number of days of sick leave, the average duration of sick leave is most probably the best indicator on which to base an analysis of the economic cost of occupational accidents.

For the Member States of the European Union, Directive 89/391/EEC [20] defined the concept of an accident at work as any bodily injury sustained by a worker as a result of or arising out of work performed for hire. In addition, in Spain the seriousness of occupational accidents must be determined in a medical report issued by the doctor treating the injured person. This notification is made in compliance with the mandate of the European Statistics on Accidents at Work (ESAW) [21], which was transposed into Spanish law through Order TAS/2926/2002. In terms of severity, accidents can be classified as slight, severe, very severe or fatal. The accident clasification depending on the seriousness of the injuries and expected period of recovery. These four degrees of seriousness are: 1) Slight accident: when the injuries produced are not expected to leave any type of sequelae. Also known in some countries as minor incidents. 2) Severe accident: when the injuries produced do not endanger the worker's life or are not incapacitating. 3) Very severe accident: when injuries occur that can cause permanent functional or organic alterations or endanger the worker's life. 4) Fatal accident: when the accident causes the death of the worker.

Nevertheless, the objectivity and value of the medical diagnosis that determines the seriousness or severity of an accident can vary due to the heterogeneity of the consequence and the different characteristics of each patient. Furthermore, studies have shown that seriousness is underestimated between 3.5 and 13 fold with respect to reality [13,22]. This could be due to both the rigidity of prevailing classification systems and other worker-related moral factors. For example, “moral risk” arises from the insurance benefits received as a result of an occupational accident, and can lead to malingering on the part of the worker in order to extend the period of sick leave [22-26]. Castillo-Rosa *et al.* [27], however, observed a significant relationship between the consequences of electrical accidents and the characteristics of the injured worker, such as age, sex, seniority, nationality and occupation. However, the objectivity and value of the medical diagnosis that determines the seriousness or severity of an accident can vary due to the heterogeneity of the consequence and the different characteristics of each patient.

Therefore, a more robust indicator than slight, severe, very severe or fatal is needed to ensure objectivity when evaluating an occupational accident. For this purpose, authors such as Durán [28] recommend implementing a system whereby the seriousness of the accident is re-qualified when the worker is declared fit to return to work.

As shown above, assessing the seriousness of occupational accidents on the basis of the injuries suffered by a worker greatly affects the cost of this type of incident. It is considered a suitable indicator [29], and has been used in several studies [18,30-33].

The seriousness of an accident is defined as the number of workdays lost as a result of the incident [34]. Likewise, according to the dictionary of technical and scientific terminology, the seriousness of an accident is defined as “The number of worker days lost due to a disabling accident per thousand worker-hours of exposure” [35].

The bibliography referring to the study of the existing relationship between the numbers of workdays lost after the occupational accident and the seriousness of the same is evaluated in investigations carried out in several countries. In the United States, the study by Cheadle et al. [36] shows that companies with more workers have fewer lost working days after an accident. In Spain the work of Fontaneda et al. [37] show that a better knowledge of accident-related sick leave helps to make decisions to shorten their duration. In Italy, an inverse relationship was noted between the size of the firm and the duration of sick leave in all industrial sectors thanks to the published study by Fabiano, Curro, and Pastorino [38]. In contrast, in South Korea, a large company had a lengthier duration of sick leave for employees experiencing back pain or lumbago [39].

For the purposes of this study, therefore, we will use the number of worker days lost as a result of the accident as an indicator of seriousness, since it is evident that, aside from fatal accidents, the more days needed to recover, the more serious the accident [25,37].

The main objective of this study is to determine the impact and seriousness of occupational accidents in different economic sectors. Given the seriousness of injuries caused by accidents due to electrical contact [40-43], we have included this type of accident in our analysis in order to verify whether its consequences are the same or equivalent in different economic sectors.

This study will contribute useful information that stakeholders can use as a basis for formulating their strategies and guiding their efforts towards limiting the serious consequences of electrical accidents.

2. Methodology

2.1 Data sources

This analysis of the seriousness of occupational accidents due to electrical contact produced in Spain is based on the database maintained by the Ministry of Labour, Migration and Social Security, in which a total of 4,098,520 accidents were registered between 2013 and 2019 (see Table 1).

Table 1. Classification of accidents by economic sector and year.

YEAR	ECONOMIC SECTOR			TOTALS
	PRIMARY	SECONDARY	TERTIARY	
2013	29.858	141.509	317.965	489.332
2014	32.841	146.728	334.708	514.277
2015	35.341	162.377	356.912	554.630
2016	36.282	174.918	381.900	593.100
2017	38.959	190.301	394.773	624.033
2018	38.730	205.454	400.538	644.722
2019	40.498	227.950	409.978	678.426
TOTAL	**252.509**	**1.249.237**	**2.596.774**	**4.098.520**

These data have been extracted from "Delt@", a communication system that registers notifications of work-related accidents in Spain in accordance with Order TAS/2926, dated 21 November 2002 (Ministry of Labour and Social Affairs) [44]. This information has been adapted to the guidelines of Directive 89/391/EEC [20] in order to standardise the processing of data related to work-related accidents in EU member states.

According to the harmonised procedure in the ESAW methodology [45], the source of hazards of the accidents analysed is any deviation due to an electrical problem resulting in contact with a normal or abnormally live element. These sources cause direct electrical contact or indirect electrical contact. We used the "deviation" variable included in accident reports uploaded to Delt@ to restrict our search to accidents due to direct or indirect electrical contact reported in the different economic sectors in Spain. This gave us a total of 5,724 accidents (see Table 2).

Then, using the CNAE (National Classification of Economic Activities) code on the accident report that identifies the economic activity of the company where the accident occurred (equivalent to NACE or ISIC), the accidents were classified as primary, secondary or tertiary [46] (see Tables 1 and 2). Finally, given that the occupational health authorities in Spain must diagnose the seriousness of each accident using medical criteria based on the degree of injury and the estimated length of recovery, the accidents extracted from the database were distributed by seriousness, as shown in Table 3.

Table 2. Classification of electrical accidents by economic sector and year.

	PRIMARY			SECONDARY			TERTIARY			
YEAR	**TOTAL**	**INDIRECT**	**DIRECT**	**TOTAL**	**INDIRECT**	**DIRECT**	**TOTAL**	**INDIRECT**	**DIRECT**	**TOTALS**
2013	18	8	10	369	208	174	365	213	145	752
2014	28	19	9	364	188	176	329	189	140	721
2015	18	8	10	382	201	181	358	203	155	758
2016	17	10	7	418	244	174	374	215	159	809
2017	22	12	10	418	223	195	388	248	140	828
2018	27	19	8	490	267	223	384	230	154	901
2019	25	14	11	572	343	229	358	212	146	955
TOTAL	**155**	**90**	**65**	**3.013**	**1.674**	**1.339**	**2.556**	**1.510**	**1.046**	**5.724**

Table 3. Classification of electrical accidents by economic sector, year and seriousness.

	SLIGHT				SEVERE				FATAL				
YEAR	**1º**	**2º**	**3º**	**TOTAL**	**1º**	**2º**	**3º**	**TOTAL**	**1º**	**2º**	**3º**	**TOTAL**	**TOTALS**
2013	15	349	345	709	2	15	17	34	1	5	3	9	752
2014	24	339	322	685	4	16	6	26	0	9	1	10	721
2015	17	353	351	721	0	18	7	25	1	11	0	12	758
2016	14	405	367	786	0	12	5	17	3	1	2	6	809
2017	19	399	384	802	2	19	4	25	1	0	0	1	828
2018	23	468	379	870	3	18	4	25	1	4	1	6	901
2019	22	551	347	920	2	17	7	26	1	4	4	9	955
TOTAL	**134**	**2864**	**2495**	**5493**	**13**	**115**	**50**	**178**	**8**	**34**	**11**	**53**	**5724**

2.2. Study design

We performed a longitudinal study to determine the evolution of the seriousness of workplace accidents in Spain over the study period (2013 to 2019). For this purpose, we followed Azadeh-Fard *et al*. [35] and Fontaneda *et al.* [37] and calculated the Average Duration of Sick Leave (ADSL) index as the quotient between lost workdays and the number of occupational accidents produced between 2013 and 2019 in the context analysed [47].

In order to determine the influence of this indicator on the primary, secondary and tertiary economic sectors, we analysed on the one hand, the seriousness of the accident (slight and severe accidents) and on the other, the type of accident (total number of accidents, electrical accidents, accidents due to direct electrical contact and accidents due to indirect electrical contact).

It is important to note that the number of lost workdays shown in the Ministry of Labour, Migration and Social Security databases does not include the impact of fatal accidents on the duration of sick leave. Therefore, in order to determine the impact on the total number of accidents analysed in each category, we determined that a fatal accident is equivalent to 6,000 lost workdays, based on the provisions of the Ministry of Labour Order of 16 January 1940 (BOE of 29 January 1040) [48].

We also calculated the percentage variance from the first to the last year of analysis in order to determine the range of variation of the indicator used and the mean of the percentage variance for each variable considered. Thus, comparing the values of our ADSL index as an indicator of the seriousness of the accidents analysed with the accidents occurring at the national level in the different economic sectors studied allowed us to determine the effect of the seriousness of occupational electrical accidents in this study.

2.3. Statistical Analysis

Next, for the accidents included in this study, a statistical analysis was carried out in order to demonstrate the existence of a relationship between the seriousness of accidents of electrical origin and the economic sectors in which they occur based on the number of lost workdays as a result of the accident suffered by the worker. To this end, tests of independence were applied in order to demonstrate this [27,33].

For this analysis, contingency tables were prepared and the statistical Chi-square value ($\chi 2$) was calculated in order to accept or reject the null hypothesis of independence. This statistic associated with a significance level $p<0.05$ allows us to verify with a confidence level of 95% the relationship of dependence between the variables analysed. To facilitate the description of the sample, information has been added on the number of lost workdays due to accidents (N) as a percentage of the total of the variable it represents. Also, in the description of the results, together with the values of the statistically significant frequencies, corrected standardised residuals (csr) are shown with the understanding that, for a confidence level of 95% or 99%, absolute values higher than 1.96 or 2.58 confirm beyond chance the impact of the categories considered on the relationship of the dependence of the variables analysed.

SPSS Statistics vs.25 (Statistical Package for the Social Sciences) was used to process and analyse the data.

3. Results

3.1 Evolution of the average duration of sick leave (ADSL) for the total number of accidents produced in Spain (2013-2019)

Total slight accidents

Using the criteria described in the foregoing section, the analysis of the evolution of the ADSL due to slight accidents occurring in Spain during the study period shows that the highest year-on-year ADSL for this type of accident is observed in the primary sector (32,56), followed by the tertiary sector (30,76) and the secondary sector (29,88).

Comparing the ADSL in each economic sector, it is interesting to note that the indicator only falls below the national average in the secondary sector (-2,32%). The ADSL in the tertiary sector, meanwhile, is slightly above the national average (+0,52%), but the year-on-year ADSL in the primary sector is far above the national average (+6,42%).

Total severe accidents

The analysis of the evolution of the ADSL due to serious accidents occurring in Spain during the study period shows that the highest year-on-year ADSL for this type of accident is observed in the secondary sector (154,96), followed by the primary sector (143,40) and the tertiary sector (139,45).

In this case, comparing the ADSL in each economic sector, it is interesting to note that the indicator only exceeds the national average in the secondary sector (+5,36%), while the ADSL in the tertiary sector shows a similar percentage below the national average (-3,35%), with a very slightly above percentage below the national average in the primary sector (+0,16%).

Total accidents (slight, severe and fatal)

The analysis of the evolution of the ADSL due to all accidents occurring in Spain during the study period, including the impact of fatal accidents using the criteria described in the Methodology section, shows that the highest year-on-year ADSL is observed in the primary sector (46,63), followed by the secondary sector (38,62) and the tertiary sector (36,99).

Comparing the ADSL in each economic sector, it is interesting to note that the indicator only falls below the national average in the tertiary sector (-2,87%). The secondary sector shows considerable improvement, passing from an above average ADSL (+2,57%) in 2013 to a very slightly above average ADSL in 2019 (+0,91%). The results from the primary sector are particularly disappointing, being well above the national average (+22,57%). Considering the results of the analysis of minor and serious accidents, it is clear that fatal accidents severely effect the ADSL in the primary sector.

Regarding the evolution of the ADSL during the study period, Figure 1 shows, since 2014, a steady year-on-year trend in all sectors, regardless of the seriousness of the accident. Interestingly, the ADSL in the primary sector is far above the ADSL in the secondary and tertiary sectors, which are practically aligned.

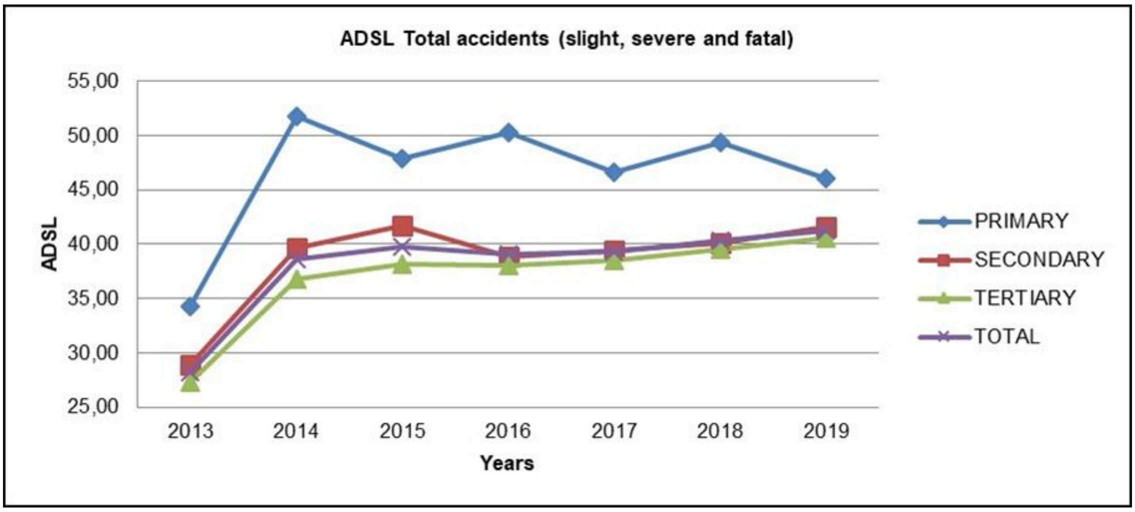

Fig. 1. Evolution of ADSL in the different sectors with respect to the national total.

Percentage evolution of average duration of sick leave in Spain

Based on the ADSL for accidents occurring in Spain by sector over the study period, Table 4 shows that the indicator increased in the final year of analysis, 2019, compared to the first year of analysis, 2013.

Table 4. Increase in ADSL due to accidents from 2013 to 2019.

Type of accident	PRIMARY	SECONDARY	TERTIARY	TOTALS
Increase (%) ADSL Slight	58.07%	56.00%	60.23%	58.46%
Increase (%) ADSL Severe	424.25%	525.96%	454.56%	474.74%
Increase (%) ADSL Total	34.21%	44.01%	48.70%	46.38%

These data show an upward trend in the ADSL in all sectors, especially with regard to severe accidents.

3.2 Evolution of the average duration of sick leave due to electrical accidents in Spain (2013-2019)

Slight electrical accidents

Using the criteria described in the Methodology section, the analysis of the evolution of the ADSL due to slight electrical accidents in Spain during the study period shows that the highest year-on-year ADSL for this type of accident is observed in the primary sector (29,33), followed by the tertiary sector (26,48) and the secondary sector (24,71). This order of prevalence coincides with the order established previously in the analysis of the total number of accidents occurring nationwide.

Comparing the ADSL due to electrical accidents in each economic sector, it is interesting to note that the indicator only falls below the national average in the secondary sector (-3,66%), The same trend was observed in the analysis of all accidents nationwide (-2,32%). The ADSL in the primary sector is above the national average (+10,74%), somewhat higher than that observed in the analysis of the total accidents nationwide (+6,42%), but it is particularly striking to note that the year-on-year ADSL in the tertiary sector is above the national average (+3,12%) and six times higher than the total number of accidents nationwide (+0,52%).

Severe electrical accidents

The analysis of the evolution of the ADSL due to severe electrical accidents in Spain during the study period shows that the highest year-on-year ADSL for this type of accident is observed in the secondary sector (114,51), followed by the tertiary sector (98,55) and the primary sector (85,23).

Comparing the ADSL in each economic sector, it is interesting to note that the indicator falls below the national average in the tertiary sector (-5,97%), two times higher than a figure than the total number of accidents nationwide (-3.35%). Also that the ADSL in the secondary sector is below to the national average (-1,79%), and far lower than the ADSL for all severe accidents (+5,36%). However, the results of the analysis of severe electrical accidents in the primary sector shows a percentage below the national ADSL (-1,86%) and far from the ADSL observed in the analysis of all severe accidents shown above (+0,16%). These results are evidence of the major impact of electrical accidents on the primary sector.

Total electrical accidents (slight, severe and fatal)

The analysis of the evolution of the ADSL due to all electrical accidents in Spain during the study period, including the impact of fatal accidents using the criteria described in the Methodology section, shows that the highest ADSL is observed in the primary sector (353,62), followed by the secondary sector (98,72), and the tertiary sector (53,45), with significantly lower values.

Comparing the ADSL in each economic sector, it is interesting to note that year-on-year the indicator only falls far below the national average in the tertiary sector (-31,49%). This was previously observed in the tertiary sector in the analysis of the total number of accidents nationwide (-2,87%). In this case, however, the ADSL in the secondary sector is above the national average (+8,19%). Regarding the primary sector, the results are again discouraging, with figures far above the national average (+403,60%) and up to seventeen times higher than the total number of accidents (+22,57%). These results clearly show the major impact of electrical accidents on all productive sectors in general, and on the primary sector in particular.

Regarding the evolution of the ADSL during the study period, Figure 2 shows a steady year-on-year trend in both the secondary and tertiary sectors, regardless of the seriousness of the accident. However, the ADSL due to electrical accidents in the primary sector shows an unstable trend overall, but with values far above those obtained in the other sectors.

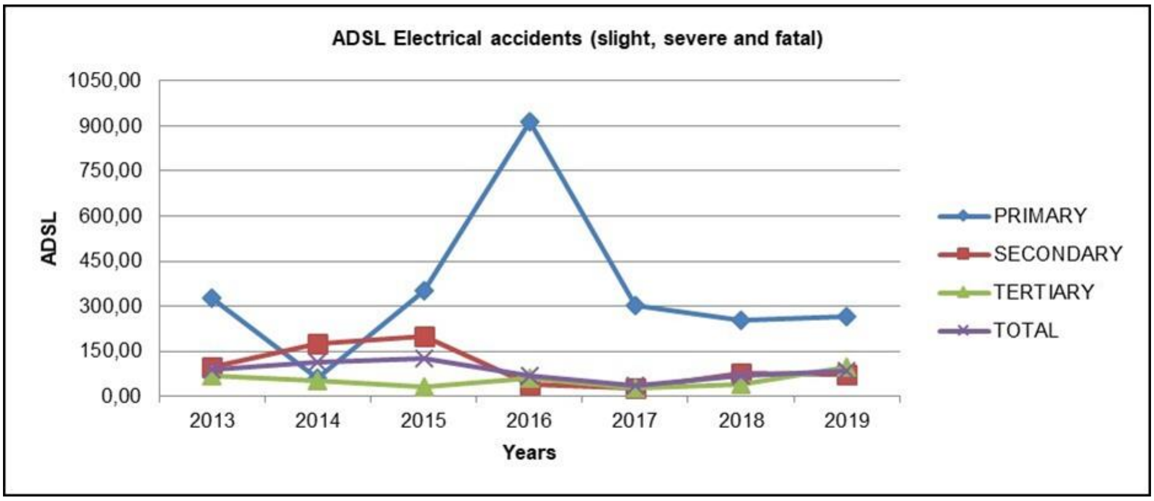

Fig. 2. Evolution of the ADSL of the total number of electrical accidents in the different sectors with respect to the national total.

3.3 Evolution of the average duration of sick leave for accidents due to indirect electrical contact in Spain (2013-2019)

Slight accidents due to indirect electrical contact

Using the criteria described in the Methodology section, the analysis of the evolution of the ADSL due to slight accidents due to indirect electrical contact in Spain during the study period shows that the highest year-on-year ADSL for this type of accident is observed in the primary sector (31,90), followed by the tertiary sector (27,15) and the secondary sector (23,60). This order of prevalence coincides with that established previously in the analysis of the total number of electrical accidents nationwide. In this case, however, indirect electrical contact has a greater impact on the ADSL, since in the previous analysis the ADSL was 29,33 in the primary sector, 26,48 in the tertiary sector and 24,71 in the secondary sector.

Comparing the ADSL for accidents due to indirect electrical contact in each economic sector, it is interesting to note that the indicator only falls below the national average in the secondary sector (-7,02%). The same trend was observed in the analysis of all slight accidents nationwide (-2,32%) and all slight electrical accidents (-3,66%). The ADSL in the tertiary sector, however, is slightly above the national average (+6,84%), somewhat higher than that observed in the analysis of all slight accidents nationwide (+0,52%) and slightly below the total number of slight electrical accidents (+3,12%). Once again, the results show that the ADSL for slight accidents due to indirect electrical contact in the primary sector is far above the national average (+20,74%) and three times higher than the total number of slight accidents nationwide (+6,42%).

Severe accidents due to indirect electrical contact

The analysis of the evolution of the ADSL for severe accidents due to indirect electrical contact in Spain during the study period shows that the highest year-on-year ADSL for this type of accident is observed in the secondary sector (143,58), followed by the tertiary sector (64,96) and the primary sector (54,43). However, in the previous analysis of total electrical accidents nationwide, the ADSL in the primary sector was higher than the other sectors, mainly because this type of accident did not occur in several of the years studied. This means that severe electrical accidents in the primary sector are mainly caused by direct contact, and indirect contact has less importance.

Comparing the ADSL in each economic sector, it is interesting to note that it falls far below the national average in both the tertiary (-37,61%) and primary (-66,59%) sectors. It is also striking that the ADSL in the secondary sector is very close to the national average (+8,30%), and similar to the ADSL for all severe accidents nationwide (+5,36%). These results show that severe accidents due to indirect electrical contact have little impact on the primary sector and more on the secondary sector.

Regarding the evolution of the ADSL for severe accidents due to indirect electrical contact during the study period, Figure 3 shows an overall upward trend, with certain stability since 2014 only observed in the secondary sector. However, the primary and tertiary sectors show an unstable trend that is indicative, as mentioned above, of the lower impact of this type of accident in both sectors. It should be noted that severe electrical accidents due to indirect electrical contact in the primary sector have not occurred in several of the study years, specifically in 2015, 2016, 2017 and 2018. This means that serious accidents of electrical origin in the primary sector are mainly caused by direct contacts, with indirect contacts having less weight in this case.

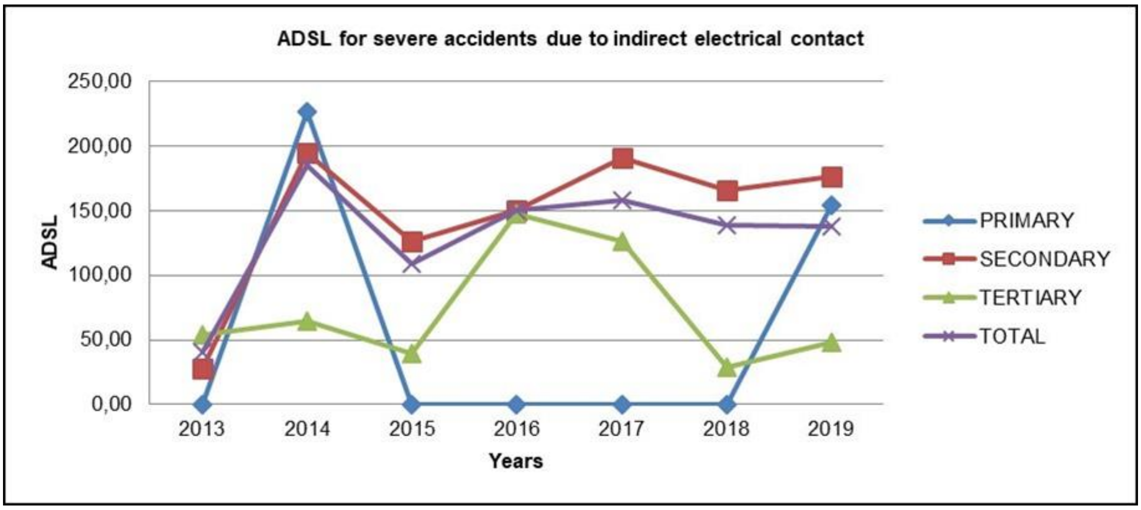

Fig. 3. Evolution of the ADSL for severe accidents due to indirect electrical contact in the different sectors with respect to the national total.

Total accidents due to indirect electrical contact (slight, severe and fatal)

The analysis of the evolution of the ADSL for all accidents due to indirect electrical contact in Spain during the study period, including the impact of fatal accidents using the criteria described in the Methodology section, shows that the highest ADSL is observed in the primary sector (264,76), followed by the secondary sector (49,90), and the tertiary sector (43,67) with significantly lower values.

Comparing the ADSL in each economic sector, it is interesting to note that year-on-year the indicator only falls far below the national average in the tertiary sector (-11,32%), and is close to the national average in the secondary sector (-5,64%). In the primary sector the results are again alarming, being far above the national average (+360,66 %), and 126 times higher than the total number of accidents in the primary sector (+22,57%), and being very equal with the total number of electrical accidents in the primary sector (+430,60%). These results show the major impact of fatal accidents due to indirect electrical contact in the primary sector.

Regarding the evolution of the ADSL for electrical accident during the study period, Figure 4 shows a steady year-on-year trend in both the secondary and tertiary sectors, regardless of the seriousness of the accident. However, the ADSL for accidents due to indirect electrical contact in the primary sector is almost always far above those obtained in the other sectors.

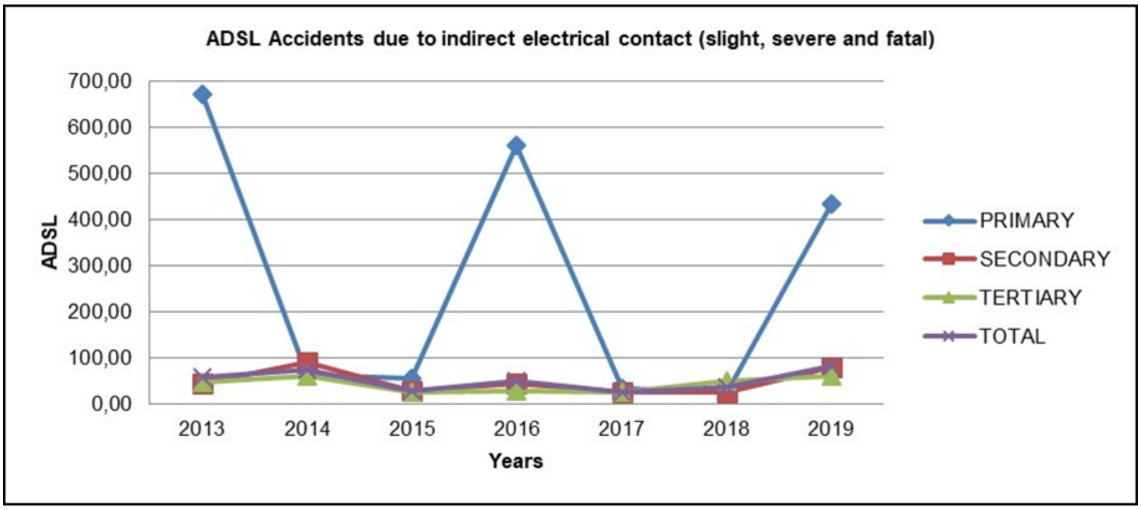

Fig. 4. Evolution of the ADSL for total accidents due to indirect electrical contact in the different sectors with respect to the national total.

3.4 Evolution of the average duration of sick leave for accidents due to direct electrical contact in Spain (2013-2019)

Slight accidents due to direct electrical contact

Using the criteria described in the Methodology section, the analysis of the evolution of the ADSL for slight accidents due to direct electrical contact in Spain during the study period shows that the highest year-on-year ADSL for this type of accident is observed in the primary sector (26,78), followed by the secondary sector (2624) and the tertiary sector (24,41).

Comparing the ADSL for accidents due to direct electrical contact in each economic sector, it is interesting to note that the indicator is above the national average in the primary sector (+1,90%) and in the secondary sector (+1,03%). On the other hand, the teritiary sector (-5,18%) present a lower average duration of leave. This result shows how slight accidents due to direct contact in the secondary sector have an average duration of sick leave above all slight accidents nationwide (-2.32%), also above the total of slight electrical accidents (-3.66%) and well above slight accidents due to indirect electrical contact (-7.02%).

Severe accidents due to direct electrical contact

The analysis of the evolution of the ADSL for severe accidents due to direct electrical contact in Spain during the study period shows that the highest ADSL for this type of accident is observed in the tertiary sector (120,69), followed by the secondary sector (103,16) and the primary sector (71,26).

Comparing the ADSL in each economic sector, it is interesting to note that the indicator falls below the national average in the primary sector (-36,81%) and the secondary sector (-7,34%). However, the ADSL in the tertiary sector presents a very considerable positive percentage deviation (+11.68%). These results show the major impact of severe accidents due to direct electrical contact in the tertiary sector.

Total accidents due to direct electrical contact (slight, severe and fatal)

The analysis of the evolution of the ADSL for all accidents due to direct electrical contact in Spain during the study period, including the impact of fatal accidents using the criteria described in the Methodology section, shows that the highest ADSL is observed in the primary sector very broad (477,19), followed by the secondary sector (151,43), and the tertiary sector (66,90).

Comparing the ADSL in each economic sector, it is interesting to note that the indicator only falls far below the national average in the tertiary sector (-34,53%), and is close to the national average in the secondary sector (+1,50%). Regarding the primary sector, the results are again far above the national average (+417,77%) and 18 times higher than the total number of accidents in the primary sector (+22,57%).

Regarding the evolution of the ADSL for electrical accidents during the study period, Figure 5 shows a steady year-on-year trend in both the secondary and tertiary sectors. However, the ADSL for accidents due to direct electrical contact in the primary sector shows an unstable trend with clear ups and downs.

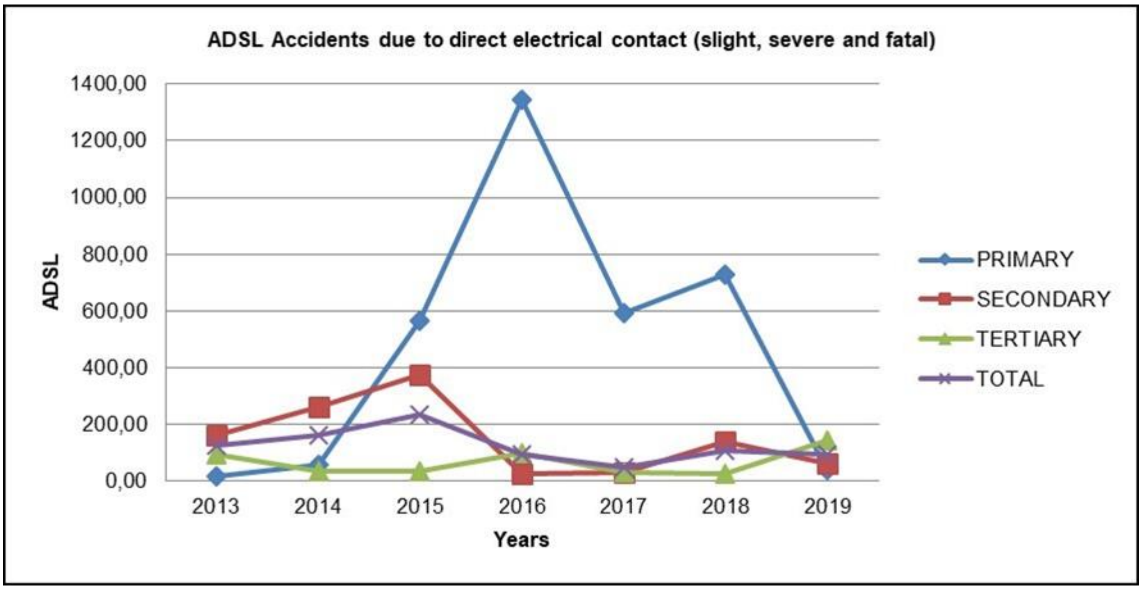

Fig. 5. Evolution of the ADSL for total accidents due to direct electrical contact in the different sectors with respect to the national total.

3.5 Comparative analysis of average duration of sick leave by economic sector

Slight accidents

The comparative analysis of the ADSL for slight accidents over the study period shows that the primary sector (32,26) exceeds the secondary sector (29,88), the tertiary sector (30,76) and the national average (30,60). These differences are greater in the case of electrical accidents (29,33) and even more so in the case of accidents due to indirect electrical contact (31,90).

The tertiary sector is prevalent in the ADSL, although in this case the impact of electrical accidents falls below the average value of the total number of accidents except for those due to direct electrical contact, with little difference in terms of direct (24,41) or indirect (27,15) electrical contact.

The same is true of the secondary sector, insofar as the impact of electrical accidents falls below the average value of the total number of accidents, with little difference in terms of direct (26,24) or indirect (27,15) electrical contact.

Severe accidents

The comparative analysis of the ADSL for severe accidents over the study period shows that the secondary sector (154,96) exceeds the primary sector (143,40), the tertiary sector (139,45) and the national average (145,14). However, in the case of electrical accidents, the ADSL is greater in the secondary sector (114,51) than the tertiary (98,55) and primary (85,23) sectors. These differences are even more significant in the case of accidents due to direct electrical contact.

However, it is interesting to note that the ADSL for accidents due to indirect electrical contact is again higher in the secondary sector than all other sectors.

Total accidents (slight, severe and fatal)

Finally, the comparative analysis of the ADSL for total accidents over the study period (slight, severe and fatal) (see Figure 6) shows that the primary sector (46,23) again exceeds the secondary sector (38,23), the tertiary sector (36,96) and the national average (38,07).

These differences are far greater in the case of electrical accidents (353,62) and even more so in the case of accidents due to direct electrical contact (477,19).

The tertiary sector is prevalent in the ADSL, although in this case the impact of electrical accidents falls below the average value of the total number of accidents, with major differences in terms of direct (66,90) and indirect (43,67) electrical contact.

The same is true of the secondary sector, insofar as electrical accidents have greater impact than the average value of the total number of accidents, with major differences in terms of direct (151,43) and indirect (49,90) electrical contact.

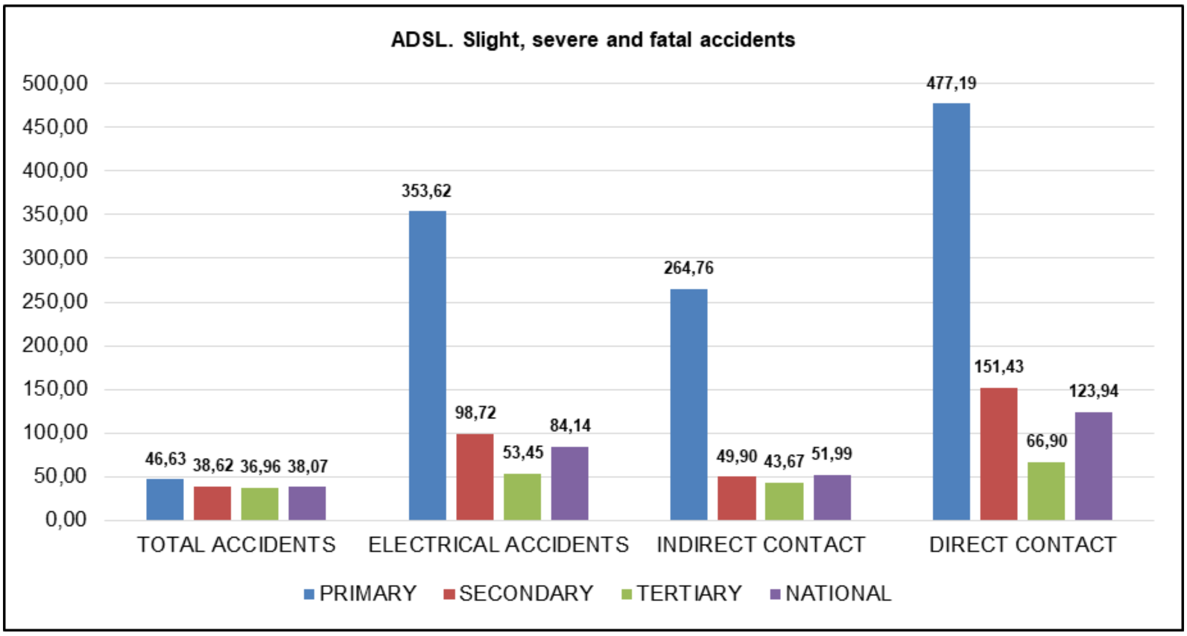

Fig. 6. Comparative analysis of the ADSL in total accidents.

3.6 Correlation Analysis between electrical accident severity and the economic sectors

The classification of the electrical accidents analysed according to the economic sector (primary, secondary and tertiary) in which they occurred and according to their severity yields the results shown in Table 5. The results obtained show the special relevance of electrical accidents in terms of the number of lost workdays as a result of the accident suffered. These results become more acute in the case of fatal accidents, which account for 66.30% of the total number of lost workdays, reaching 89.11% in the case of the primary sector. It should be remembered that one fatal accident is equivalent to 6,000 lost workdays.

Table 5. Seriousness of accidents due to direct electrical contact and indirect electrical contact versus total number of electrical accidents by economic sector and severity in Spain according to number of lost workdays (2013-2019).

Sector	Seriousness	Total electrical accidents		Indirect electrical contact			Direct electrical contact		
				$\chi2$= 552,283	df=4	Sig=0,000	$\chi2$= 476,564	df=4	Sig=0,000
		N	A(%)	N	B(%)	B/A	N	C(%)	C/A
Global	Slight	141517	29,50%	81735	47,38%	1,60	59782	19,46%	0,65
	Severe	20101	4,20%	6761	3,91%	0,93	13340	4,34%	1,03
	Fatal	318000	66,30%	84000	48,69%	0,73	234000	76,20%	1,14
Primary	Slight	4124	7,65%	2788**	13,03%	1,70	1336	4,11%	0,53
	Severe	1737	3,22%	608	2,84%	0,88	1129**	3,47%	1,07
	Fatal	48000	89,11%	18000	84,13%	0,94	30000**	92,40%	1,03
Secondary	Slight	71373	24,68%	38573**	45,03%	1,82	32800	16,12%	0,65
	Severe	13754	4,75%	5083*	5,93%	1,24	8671*	4,26%	0,89
	Fatal	204000	70,55%	42000	49,03%	0,69	162000	79,62%	1,12
Tertiary	Slight	66020	48,32%	40374	61,70%	1,27	25646**	36,02%	0,74
	Severe	4610	3,37%	1070	1,63%	0,48	3540	4,97%	1,47
	Fatal	66000	48,30%	24000	36,67%	0,75	42000	59%	1,22

Note: N: number of lost workdays; A: % total electrical accidents; B: % accidents by indirect electrical contact; C: % accidents by direct electrical contact; *CSR > 1.96; **CSR >2.58

Likewise, when direct and indirect electrical contact accidents are analysed taking into account the economic sector in which they occur and compared with the total number of electrical accidents at national level, the differences in the severity of the consequences of the accident in terms of number of lost workdays are even greater in the primary and secondary sectors. The results show a statistically significant relationship between the seriousness of electrical accidents and the economic sector in which they occur. This relationship is verified both in the analysis of the set of electrical accidents due to indirect contact ($\chi2$=552,283; Sig=0,000; df=4) and direct electrical contact ($\chi2$=476,565; Sig=0,000; df=4). Among them, electrical accidents due to indirect contact with minor consequences in the secondary sector stand out, as their percentage is multiplied by 1.82 (csr: 4.3), and even multiplied by 1.70 among slight accidents in the primary sector (csr: 2.2). It is also noteworthy that electrical accidents due to direct contact with severe consequences occur in a higher proportion in the tertiary sector, multiplying by 1.47. These results also show that accidents due to indirect electrical contact are more serious in the primary and secondary sectors, with accidents due to direct electrical contact being more serious in the tertiary sector.

4. Discussion

According to the results obtained, it is determined that the average duration of sick leave has steadily increased in all 3 economic sectors in recent years. The question remains whether this situation is due to “moral risk” or malingering on the part of the worker to prolong his or her sick leave [25], or whether, despite the year-on-year reduction in the number of accidents, those that occur are more serious for some reason, thus prolonging the duration of sick leave [35]. In this sense, as argued by Kim *et al*. [49] creating a culture of prevention in occupational safety and health both in theory and in practice, would decrease the incidence of occupational injuries and diseases associated with industrialization.

The results also clearly show the major impact of electrical accidents on the seriousness of occupational accidents. This situation has been already reported in several studies that have shown the greater severity of the consequences derived from electrical accidents [40, 42, 50-52].

In terms of accidents due to electrical contact, the results show that the type of contact [50, 53] affects the ADSL in different economic sectors [1], insofar as accidents due to direct electrical contact have a greater impact on the tertiary sector. This has been confirmed by other authors, who have reported that accidents due to direct electrical contact are associated with a higher percentage of severe or fatal accidents [53-55], resulting in more prolonged sick leave than those caused by indirect contact. However, the results obtained in the primary sector are striking, insofar as the percentage of fatal accidents caused by indirect contact (58% of cases) is much higher than accidents caused by direct contact (42% of cases). This could be due to the health and safety shortcomings [56] found in some primary sector workplaces, where the lack certain safety features increases indirect electrical contact and the likelihood of this type of accident.

Comparing accidents within sectors, the results from the analysis of the primary sector are interesting: although it is associated with fewer accidents, the ones that occur are more severe than in other sectors. Is this because the activities involved in this sector are more traditional and involve more risky procedures? Is it because health and safety management is less stringent in this sector? Is it because workers are less qualified? Is it because businesses in this sector use more archaic technologies with fewer safety measures? Is it because primary sector workplaces tend to be located far from hospitals or healthcare centres, thus delaying the treatment of injured workers? Many questions probably remain unasked, but the evidence shows that stakeholders must make every effort to mitigate and control the adverse conditions of primary sector workers. Likewise, and as Ichikawa [52] argues, in order to reduce the number of electrical accidents in the workplace, it is essential to continue and improvement of preventive measures and safety training following electrical accidents.

5. Conclusions

The objective of this study has been to analyze the impact and seriousness of occupational accidents due to electrical contact in the different economic sectors on the basis of the number of working days lost due to injuries sustained in such accidents.

Therefore, the main conclusions drawn from our results are:

- The average duration of sick leave shows an upward trend in both slight and severe accidents in the last few years studied. This compels us to ask why accidents are becoming more severe, a question that can only be answered once surveillance and monitoring systems have been put in place.

- The considerable differences in the duration of sick leave in the different economic sectors, particularly the primary sector, begs the question of whether this is due to human or organizational factors. If it is due to human factors, then workplace monitoring needs to be strengthened in order to improve the working environment and processes. If it is due to organizational factors, then procedures need to be improved.

- Accidents due to direct electrical contact have a greater impact on the ADSL in the tertiary sector, with accidents classified as severe being up to 1.47 times higher than in other sectors. This means that effective protection measures against this type of risk are needed, such as the use of double or reinforced insulation in all equipment, training, and information about specific electrical risk such as live one work, etc.

- Accidents due to indirect electrical contact have a greater impact on the ADSL in the primary sector, where for accidents qualified as fatal they are up to 1.70 times higher than in the secondary and tertiary sectors. This means that effective protection measures against this type of risk are needed, such as the use of circuit breakers, equipotential networks, non-conducting work environments, use of double insulated conductors, etc.

- Fatal electrical accidents considerably increase the ADSL for occupational accidents in all economic sectors, particularly the primary sector, and there is a pressing need to improve the effectiveness of protection measures against electrical contacts. These results should prompt the competent authorities to require businesses maintain their equipment and facilities in good order, and introduce effective supervision programmes that guarantee compliance with the measures enforced and reduce the serious consequences of electrical accidents.

5.1. Practical applications

Taking into account the findings of the current work, the following practical applications are exposed, namely:

Electrical risks have a major impact on the duration of sick leave in all economic sectors, depending on their particular characteristics. This is why it is so important to implement training, information systems, and signage, and tailor these elements to the different operational resources used, and to introduce organizational mechanisms that facilitate supervision and guarantee health and safety in all jobs. It is therefore the effective combination of technical and organisational solutions that reduces the risk of electrical accidents.

The use of the Average Duration of Sick Leave (ADSL) indicator is very favourable in view of the high representativeness of accident costs, and may even minimise subjectivity in the evaluation of severity of the accident. Clearly, more days of absence implies that the accident is more serious and due to its proportionality, its costs are higher.

5.2. Limitations

In relation to the above conclusions, the limitations of this study must be taken into account. Firstly, the geographical scope of the analysis carried out corresponds to Spain, which limits the generalization of the results to other countries. Secondly, the period of analysis is limited to 2013-2019, according to the database provided by the Ministry of Labour, Migration and Social Security of the Government of Spain. Thirdly, the impossibility of accessing information on the costs associated with occupational accidents such as wages, medical care, compensation, etc., prevents us from accurately estimating and quantifying the costs of the accidents under study.

5.3. Future research

The study, once concluded, gives rise to the consideration of the following future lines of research. On the one hand, to investigate whether there are personal factors that affect this type of accident and to check whether there is a direct relationship. On the other hand, to complete the results obtained with a description of the work activities in each of the economic sectors. Also, to objectively determine the costs of accidents at work beyond the number of lost workdays. And finally, to investigate the suitability of systems, devices and measures for protect against electrical hazards in various work areas.

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