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Fatal Tractor Accidents in the Agricultural Sector in Spain during the Past Decade

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Abstract: Currently, there is a discrepancy between the number of occupational accidents in the agricultural sector reported by Spanish governmental sources and those actually occurring in general. This is mainly due to the official definition of 'occupational accident' in the current regulations. In order to be able to analyse all fatal accidents involving tractors, other sources of information must therefore be used. In this study, we have collected the news published in different media during the period 2010–2019. Statistical models that take into account the spatial and temporal dependence of the data were used to estimate the rates of fatal accidents in the provinces of Spain using the Bayesian inference technique INLA (Integrated Nested Laplace Approximation). The results obtained showed that the total number of fatal accidents in that period was 644. The crude rates of fatal accidents per province ranged from 0 to 223.5 fatal accidents per 100,000 registered tractors. In addition, the overall rate for Spain as a whole was 6.87 fatal accidents per 100,000 tractors. As in other EU countries, it was found that the regions with the highest number of accidents were also related to steep terrain, to an older tractor fleet and to horticultural crops and vineyards.

Keywords: agricultural fatalities; ROPS; rollover; spatial-temporal analysis; Bayesian models; tractor power

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1. Introduction

In Spain, both agricultural and construction sectors are those with the highest occupational accident rates. However, since the appearance of Law 31/1995 on the prevention of occupational risks (transposition of European Directive 89/391/EEC), the agricultural sector is the only sector that has not improved this rate that continues increasing [1,2]. Possible causes could include the family structure of farms, the small size of farms [3], the high percentage of temporary workers [4] and the frequent collaboration of family members in farm-related tasks. Farming is also characterised by the diversity of tasks, many of them involving heavy machinery [5]. Moreover, the use of plant protection products and other chemicals is widespread [6]. The work itself is very demanding in terms of physical effort and strength, and is often carried out in extreme environmental conditions, with isolation at the workplace combined with a low level of training among workers [7]. This leads to a wide variety of occupational hazards to which agricultural workers are exposed and which often result in occupational accidents [8].

However, what happen when people who do not fit into the legal definition of a worker suffer the accident? These accidents are not considered "accidents at work" and, therefore, are not included in the official statistics and data of the INSST (National Institute for Health and Safety at Work). This is usually the case for many accidents suffered by retired people, children under 16 years of age, collaborating family members, etc., who are not linked to the work activity as defined in the legislation [1]. According to Arana et al. [9]

out of 388 fatal accidents involving agricultural machinery in Spain during the years 2004–2008, only 61.85% of them were of an official nature. Elderly people were the most at risk, followed by children and people outside the agricultural sector. Most of the fatalities were due to the rollover of tractors without protective structures.

In the work carried out by Arnal [2] on accidents in the agricultural sector in the decade 2004 to 2013, it was indicated that Galicia was the Autonomous Community where most accidents were recorded, with 603, followed by Andalucía, Aragón, Castilla-León and Valencia that exceed 200 accidents reported in the press. Of all accidents including machinery, 69% of them involved tractors, being the tractor rollover the most frequent one (30% of the total). Of these rollover accidents, 71% were fatal. Regarding the tractors involved in those accidents reported in the press, 32.8% were more than 10 years old, 5.3% were less than 10 years old and the age of the rest was unknown.

Very similar results were recorded in the report produced by the MAPFRE Foundation [10] in this same sector. In this case, the period studied ranged between 2010 and 2019. In that period, the media reported 1172 news of people died on the farm. However, according to the official records on occupational accidents of the INSST, there were only 473 deaths (40% of those published). Similar rate was obtained by [9]. Therefore, to analyse the reality of the accident rate in the agricultural sector in depth, all accidents that occur while carrying out agricultural tasks should be considered, both those involving workers and those involving people that according to the official definition cannot be considered agricultural workers. Regarding the cause of death, of the 1172 cases of fatal accidents analysed, tractor rollover was responsible of 595 deaths (59%). The profile of the deceased was that of a male over 60 years of age (54% of cases). Regarding the characteristics of the tractor involved in the rollover, in 91% of the cases, it did not have a rollover protection structure or, if it did, it was folded down.

Specifically, tractor rollover accidents have been the subject of specific analysis in the work carried out by the Instituto de Seguridad y Salud Laboral de la Región de Murcia (Institute for Occupational Health and Safety of the Region of Murcia) [11]. In this case, the study focused on the period from October 2005 to December 2007. It analysed 21 tractor rollover accidents, 14 of which resulted in death. Among the conclusions drawn, it was found that 38% of the tractors involved in the accidents had a power of 29 to 67 kW, 43% had less than 29 kW and the power of the rest was unknown. Regarding the age of the damaged tractors, 43% were more than 20 years old. In five cases, the tractor was over 30 years old. Of the 21 cases, eight tractors were fitted with an arc-type protective structure, seven of which were approved but it was lowered at the time of the accident, and 1 tractor had a handmade protective structure which was not approved but was not lowered at the time of accident, resulting in a minor one.

Age and lack of safety structures (ROPS) are factors in almost all fatal accidents. Therefore, knowledge of the characteristics of the tractor fleet is important when studying this problem. The Ministerio de Agricultura, Pesca y Alimentación (MAPA—Ministry of Agriculture, Fisheries and Food) [12] carried out an analysis of the national tractor fleet 2005-2006 which can help to understand the situation in Spain. Thus, the distribution of tractors according to their age can be seen in Table 1.

Table 1. Percentage of tractors by age [12].

Age of the Tractors	% Tractors
>20	40
16–20	15
11–15	12
6–10	18
<5	15

The average age of tractors in Spain was 16.3 years. However, there were big differences from one region to another, with the País Vasco having the oldest tractors, and Andalucía and the Valencian Community having the youngest fleet.

The average power of tractors was 55.5 kW. The highest average power was found in Murcia (71.7 kW), followed by Castilla-León and Navarra (66.4 kW) and the lowest average power was found in the Islas Baleares (33.5 kW). Logically, there was a relationship between age and power: tractors older than 20 years had less average power (46.5 kW) compared to those of lesser age (<5 years) with 70.6 kW average power.

As for whether or not the tractor had a rollover protective structure (ROPS), which as previously mentioned it is directly related to the mortality rate in tractor rollovers, 31.7% of tractors did not have a ROPS [12]. This translates into about 300,000 tractors without ROPS in Spain. Another worrying fact is that of the 68.3% of tractors that had a ROPS, 5.5% did not have it approved. In terms of geographical distribution, 86% of tractors in Andalucía and Cantabria had a ROPS compared to the País Vasco and Asturias (29.4% and 43.8%, respectively). Here it can also be seen that the more modern the tractor, the higher the percentage of them with an approved ROP structure (90.6%), compared with those over 20 years old, where only 35% had one. Moreover, the more powerful the tractor, the higher the frequency of the presence of an approved ROP structure. Specifically, 93.4% of tractors with power ratings between 82 and 96 kW had it.

Therefore, if we analyse in detail the accident rate of the tractor together with the characteristics of the fleet (age, power, presence of ROPS. . .) we could be able to take the appropriate measures to reduce the high accident rates in the field. Both factors should be analysed in parallel, as previous studies have already hypothesised that the two of them are related. Given that the analysis of the tractor fleet revealed the existing geographical differences, in this work we propose to carry out a study that will allow us to obtain comparable results, in order to be able to take appropriate decisions in the field of risk prevention.

In most of the investigations carried out on tractor rollovers, different data analysis techniques are used without taking into account their spatial distribution, i.e., whether or not there is a geographical dependence in the occurrence of accidents is not studied. Although in some cases a study of the temporal evolution is carried out, in no case are the spatio-temporally events related. However, other studies have carried out a spatio-temporal analysis of the data. Thus, in a study on the effect of selected variables on the injury severity of both at-fault and non-fault drivers of highway vehicles in North Carolina, proportional odds models were used [13]. The proportional odds model is a class of generalised linear models used to model the dependence of an ordinal response on discrete or continuous covariates. This model assumes the effect of the dependent variables being identical across all variable categories.

Similarly, in the research on the use and understanding of safety signs on agricultural machinery, a survey was conducted at the National Exhibition of Agricultural Mechanisation held in the Piedmont Region, Italy [14]. Almost 400 surveys were distributed to random individuals with a response rate of 80%. Unanswered or wrongly answered questions were scored as 0 and partially correct or correct questions were scored as 1. They were then subjected to a Multiple Correspondence Analysis (MCA) and a Latent Class Analysis (LCA). Subsequently, a hierarchical regression analysis was used to investigate the skills that predicted the probability of belonging to these classes. Descriptive analysis and LCA were performed using SPSS and MPLUS statistical software while R software and the FactoMineR package were used for MCA.

In another study conducted in Iran [15] on tractor accidents and safety on farms, authors also used exploratory factor analysis using SPSS to identify the factors underlying tractor drivers' perceptions of safety issues. Blazquez et al. [16], statistically processed data on cargo truck accidents on Route 5 in Chile, to establish black spots on these roads. To do so, they used spatial statistical methods such as Moran's I-indicator, Getis-Ord Gel local spatial statistics and spatial co-occurrence analysis of groups of crashes with high attribute values (hot spots). Finally, another traffic study was conducted in Poland [17], in which Polish cities were ranked according to the level of traffic accidents, and their level of safety was determined with the use of multidimensional statistical analysis. It was necessary to ensure comparability by using normalisation or standardisation, such as the zero unitarisation method, which allowed for comparison between objects.

With this background, the objectives of the present study were:

- To analyse the spatial and spatio-temporal distribution of fatal accidents in Spain, involving an agricultural tractor, in order to identify those areas, at state level, with the highest risk.
- To relate the occurrence of fatal accidents with the characteristics of the tractor fleet in the corresponding provinces, in the period 2010–2019, in Spain.

2. Materials and Methods

2.1. Basic Data

Given that the official data from the INSST only includes occupational accidents but does not record all accidents related to agricultural tractors, the data on these accidents were collected from the information gathered in the media between 2010 and 2019. Most of this information was obtained through alerts in web search engines. It should also be noted that the Agrarian Mechatronics research group has professional contacts in all the Autonomous Communities of Spain, and thanks to this, many of the news recorded correspond to personal communications of news that have appeared in the written press. Therefore, there has been a significant amount of data curation to avoid replication and to have as much information as possible on each accident. The information collected for each accident included the date, location, age of the accident victim, the outcome and the factors involved, among others. Location was related to provinces or to Autonomous Communities, which may include one or several provinces, as this is the administrative organization in Spain. Figures S1 and S2 show the maps of Spain with its administrative division to Autonomous Communities and to provinces, respectively. Information on the topography performed in the different Spanish regions can be found in [18].

In this paper we have compared the fatal accident rates for each province and year, defined as the number of accidents per 100,000 tractors registered in the census. To do this, information on the tractor fleet for that period was needed. This information was obtained from the Official Register of Agricultural Machinery (ROMA) and the analysis of the tractor fleet [12] of the Ministry of Agriculture, Fisheries and Food (MAPA). The variables used from the census were: maker, model, date of registration, power, province, municipality, state, and UNE 68051 code.

The information for the spatial representation of the data was provided by the Spatial Statistics Group of UPNA and consisted of a map of the provinces of Spain with the correction of the position of the Islas Canarias. It was a geospatial vector file (shapefile format) with associated information including the name and code of the provinces, as well as the surface area and other spatial characteristics of interest. The codes of each province necessary to be able to associate the accidents to each area were obtained from the website of the National Institute of Statistics (INE, 2020).

2.2. Statistical Analysis

In order to estimate the underlying spatial and spatio-temporal distribution of tractor accident rates, statistical Bayesian models were used to smooth the crude rates by borrowing information from spatial and temporal neighbours. This allowed us to carry out a more in-depth study of which areas had a higher than expected level of accidents (by computing Bayesian posterior exceedance probabilities) and whether there was any kind of temporal relationship between these accidents. Moreover, this analysis permitted us to identify common factors that exist in the different geographical areas (tractor power, mountainous areas…) and that may justify a higher number of fatal accidents. Moreover, it also allowed us to calculate whether the probability of an accident occurring at present is higher or lower than expected according to the data collected in the period 2010–2019. An example of this statistical analysis is described in [19].

For this purpose, the interactive web application SSTCDapp [19] was used, a Shiny application for the analysis of spatial and spatio-temporal count data developed by the Spatial Statistics Research Group of the UPNA (https://emi-sstcdapp.unavarra.es/Login/ accessed on 1 June 2022). SSTCDapp provides a simple user interface for the analysis and estimation of spatial and spatio-temporal count data, allowing to fit a wide variety of space-time models using the approximate Bayesian inference technique known as INLA (Integrated Nested Laplace Approximation) [20]. The application allows users to upload their data and associated cartography, to generate graphs and tables for the descriptive analysis of the raw risks or rates, to adjust different statistical models that allow smoothing the risks or rates in space and time, and finally, to analyse the results obtained through maps and specific temporal evolutions of the regions of interest. Unlike other software used for the analysis of count data, SSTCDapp facilitates the fitting of complex statistical models to non-expert users without the need to install any software on their own computers, as all calculations are made on a powerful remote server. The application is built using the Shiny package of the R statistical software, while model fitting and inference are carried out through the R-INLA package (https://www.r-inla.org/ accessed on 1 June 2022).

To smooth the crude fatal accident rates for each province and year, spatio-temporal models including conditional autoregressive (CAR) prior distributions for the spatially structured random effect and first-order random walk prior distributions for the temporally structured random effect were considered. In addition, the four different types of interactions originally proposed by Knorr-Held [21] were considered as prior distributions for the spatio-temporal random effects of the model. These interactions allowed the spatio-temporal effects to be completely independent (Type I), structured in time but not in space (Type II), structured in space but not in time (Type III) or completely structured in space and time (Type IV). Once the different models were adjusted, the SSTCDapp application provided different Bayesian model selection criteria such as the Deviance Information Criterion (DIC), the Watanabe-Akaike information criterion (WAIC) or the Logarithmic-Score. For further details, see [19] and the references therein.

In our analysis, although the differences between the possible spatio-temporal interactions according to these criteria were small, the one with a completely structured interaction effect in both space and time dimensions was chosen as the best model.

3. Results

3.1. Analysis of Fatal Accidents

The total number of fatal accidents in the agricultural sector reported by the media in the decade 2010–2019 was 644, which was almost 65 per year for this cause alone. The raw accident data can provide us a misleading picture of what was happening, as we did not link these accidents to the population of tractors likely to be involved in an accident in each area. In other words, the number of accidents recorded were not directly comparable as the total number of tractors in each area was not taken into account.

The crude rates of fatal tractor accidents for each province and year varied between 0 and 223.5 fatal accidents per 100,000 tractors registered in ROMA, with mean and median values of 7.83 and 5.37, respectively. The overall rate for Spain as a whole was 6.87 fatal accidents per 100,000 tractors.

The time evolution of crude rates during the study period, as well as posterior mean estimates of year-specific rates (commonly referred to as temporal pattern) are depicted in Figure 1. Although the tractor fatal accident rates seemed to have a slightly decreasing trend during the first half to the analysis period (years 2010–2014), the estimated rates remained constant during the next years. As can be seen in Figure 1, the 95% credible intervals of the estimated rates contained almost all values of year-specific crude rates.

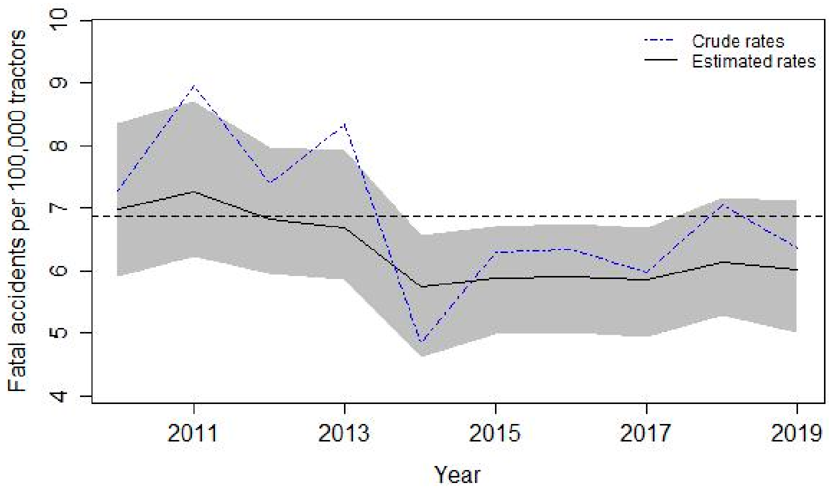

Figure 1. Temporal evolution of year-specific tractor fatal accident crude rates (blue dashed line) and estimated rates (black solid line) with 95% credible intervals bands (shaded area). The overall rate for Spain (black dashed line) is also included as a reference value.

Figure 2 shows the maps with posterior mean estimates of the province-specific rates (commonly referred to as the spatial pattern) and posterior exceedance probabilities of that rates being higher than the overall rate for Spain during the period of analysis. The maps show how the provinces of Alicante, Cantabria and Pontevedra had higher estimated rates than the rest of the communities. The regions with the lowest tractor fatality rates were the provinces of Cádiz, Sevilla, Ciudad Real, Toledo, Cuenca, Girona, Palencia, Valladolid and Zamora. Looking at the probability of these rates exceeding the national average rate, the provinces with the highest average rate were joined by most of the bordering provinces. The same occurred for the lowest rates.

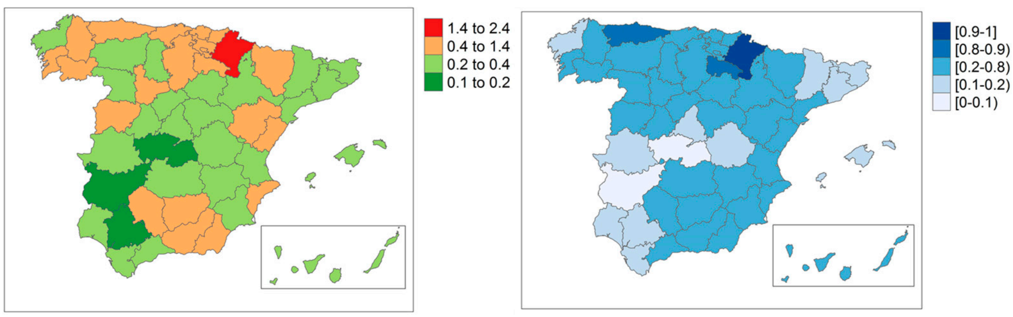

Figure 2. Province-specific rates of tractor fatalities. Posterior mean estimates (**left**) and posterior exceedance probabilities of that rates being higher than the overall rate for Spain (**right**).

This fact confirms that the agriculture practices carried out in the different agricultural areas are closely related, regardless of the province. In neighbouring areas, the customs, the machinery and the type of work in the fields are often very similar. On many occasions, it seems that the orography and the size of the plots increase the risk of a tractor rollover; while on others, where the orography may apparently be more favourable, the type of farm (crops) may be responsible for an increased risk of an accident due to rollover (lowered safety arches for working in permanent crops).

Figure 3 shows the maps with the posterior mean estimates of fatal tractor accidents, while Figure 4 shows the posterior exceedance probabilities of these rates being higher than the overall rate for Spain, for each province and year. It can be seen (Figure 3) that the same areas always had the highest accident rates throughout the period analysed. In the northern area, in the period 2010–2013, Galicia had the highest accident rate, as did the Mediterranean provinces, with Alicante standing out. In the second period (2014–2019), Asturias was highlighted, and the rates decreased in Galicia. Guipúzcoa (País Vasco) remained with high rates throughout the period analysed, as did Alicante, although the latter went reducing its accident rate.

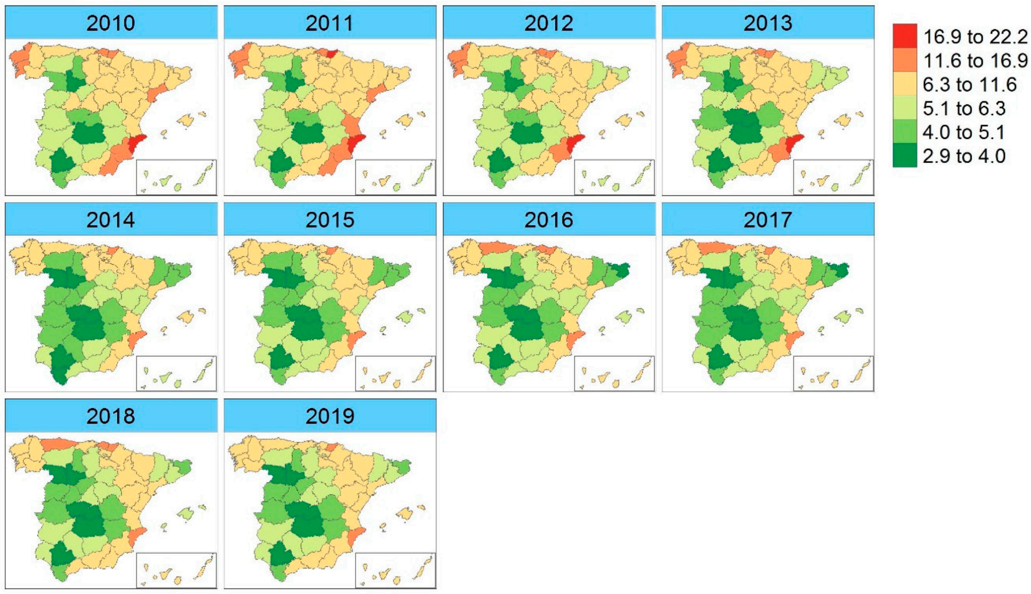

Figure 3. Maps showing the posterior mean estimates of tractor fatality rates per province and year.

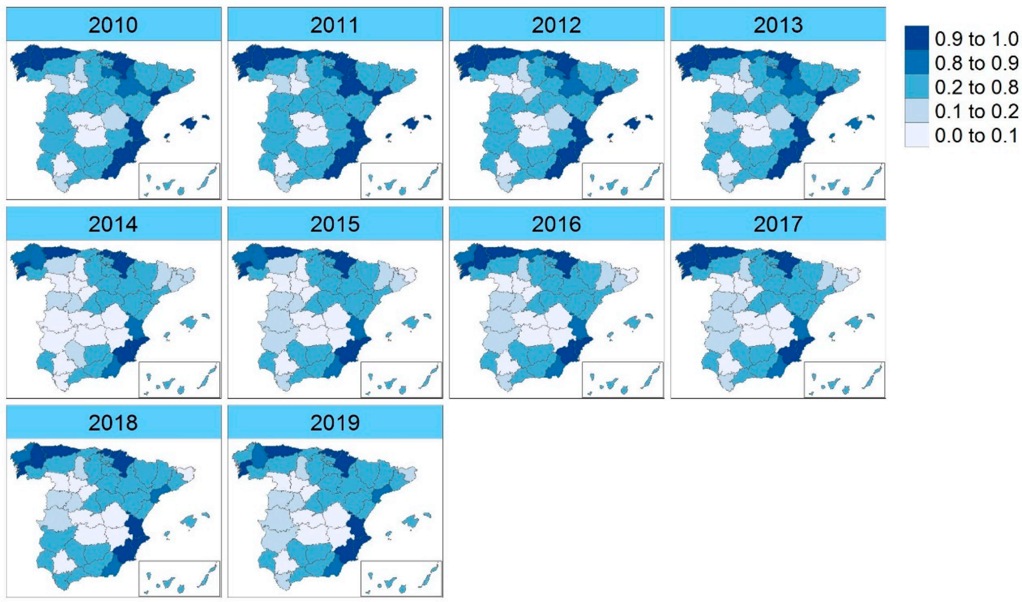

Figure 4. Maps showing the posterior exceedance probabilities of tractor fatality rates being higher than the overall rate for Spain, per province and year.

With regard to the probability of tractor fatalities being higher than the national average, it can be seen in Figure 4 that once again the provinces of the Cantabrian coast and the Mediterranean had the highest probabilities, while the central provinces and Andalucía had the lowest probability of accidents compared to the national average. This difference may be due to the fact that in Castilla-León, Castilla-La Mancha, Aragón, Extremadura and western Andalucía, the plots are in general more regular, larger [22], with less slope (Figure S3), and dedicated to extensive crops.

3.2. Analysis of the Tractor Fleet by Autonomous Communities

As indicated in the Introduction section, the characteristics of the tractors were one of the main factors in the fatal accidents. Therefore, it was necessary to analyse the type of tractors of each Autonomous Community (AACC) using official data. ROMA provided us information on the registrations made each year by AACC. This information reflected the agricultural machinery market in general and tractors in particular.

Table 2 shows the number of new tractors registered in each of the Autonomous Regions, by power range in kW.

Table 2. Number of tractors registered in the period 2012–2019, by power ranges and Autonomous Regions.

AACC	POWER (kW)					
	≤30	30.1–50	50.1–70	70.1–90	90.1–110	>110
Andalucía	2075	1478	3489	9710	3343	1288
Aragón	391	247	1088	1564	898	2518
Asturias	97	122	333	297	170	91
Baleares	550	384	332	334	109	52
Canarias	327	185	126	115	21	0
Cantabria	29	26	104	178	106	91
Castilla-León	470	282	739	1769	1933	5113
Castilla—La Mancha	353	204	1662	3882	1719	2328
Cataluña	767	632	2168	2021	865	1479
Valencia	393	472	2147	1463	398	180
Extremadura	360	437	1640	2245	842	715
Galicia	972	1,413	1119	846	680	749
Madrid	88	26	75	107	88	163
Murcia	122	257	1226	1538	578	526
Navarra	85	109	177	483	280	735
País Vasco	154	256	294	435	135	248
Rioja	15	80	277	973	128	157

As it can be seen in Table 2, power was analysed according to six ranges: 30 kW, 30.1–50 kW, 50.1–70 kW, 70.1–90 kW, 90.1–110 kW and >110 kW. These power ranges used were the same as those in the annual reports of the Ministry of Agriculture, Fisheries and Food. However, it should be taken into account that although in this work we analysed the period 2010–2019, in the case of power, the years 2010 and 2011 were not used because they did not have the same classification range and thus, were not comparable. By Autonomous Community, Table 2 shows that Andalucía was the one with the highest number of new tractors registered in the 70.1–90 kW power range, with almost half of its new tractors (45.41%) in that range. Similarly, in Castilla-La Mancha this type of tractor was the most purchased. However, Castilla-León was the autonomous community that bought the most powerful tractors (49.61%), with power ratings over 110 kW, followed by Aragón (37.55%). This higher power along with a lower accident rate could be explained by the fact that more powerful tractors have a higher price, and this tends to lead to the incorporation of more and better safety measures because they represent an affordable percentage of the price. In smaller, lower priced tractors, the percentage of the price that the extra safety measures represent is high and this means that sometimes they are not chosen.

On the other hand, the Islas Canarias and the Islas Baleares purchased the least powerful tractors. Galicia, one of the Autonomous Regions with the highest accident rate, was the region where the power of new tractors purchased was rather low, with the 50.1–70 kW range accounting for the highest number of tractors. Moreover, in this Autonomous Community, in addition to having an ageing, small, underpowered tractor fleet with few safety measures, there is also the circumstance of a very irregular orography and the small size of farms. The combination of these factors could be responsible for the high accident rate. Figure 5 shows the average number of tractors registered in the ROMA in the selected period analysed. There were some AACC with high market of tractors, as Andalucía (167,947 tractors), Galicia (160,515.6), Castilla-Leon (152,570), Castilla-La Mancha (146,173) and Cataluña (111,055); and others with a lower one, as Canarias (4242), Cantabria (8598) or Madrid (11,994).

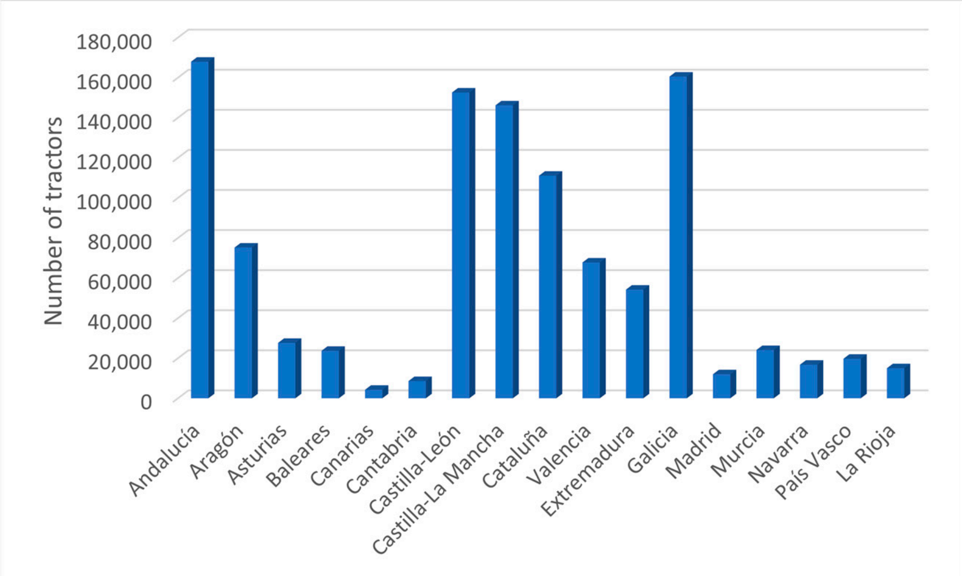

Figure 5. Average number of tractors registered in the ROMA in the period 2010-2019, by Autonomous Community.

Before analysing the general situation of the tractors market in Spain, it is important to introduce the issue of the change of ownerships. This was also subject to registration in the various agricultural machinery registers, and this practice is much more frequent than the purchase of a new tractor. For this type of registration, the age of the tractor is of interest, as it gives an idea of how modern or old the machinery that changes ownership is. Table 3 and Figure 6 group together all the changes of ownership of tractors in the period 2010–2019 that occurred in Spain (data disaggregated by AACC are not shown). It was observed that the change of ownership of tractors older than 20 years was the most frequent (55.80%) compared to the change of ownership of tractors between 3 and 5 years old (3.48%).

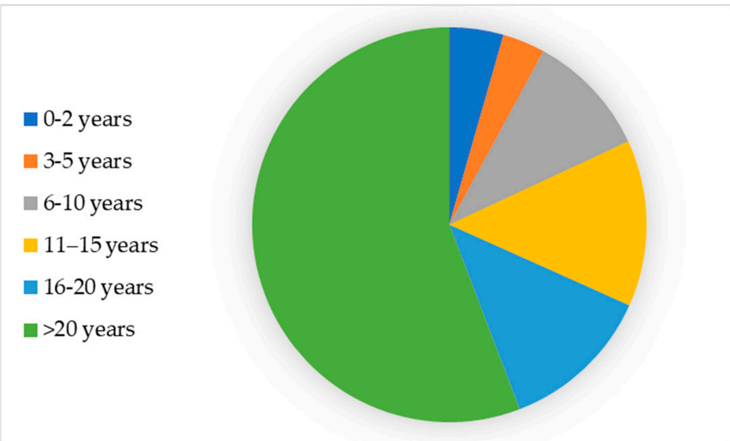

Figure 6. Distribution of tractors changing ownership according to age.

Table 3. Total number of tractors registered in the period 2012–2019, by age range.

Age					
0–2	**3–5**	**6–10**	**11–15**	**16–20**	**>20**
11,644 4.44%	9126 3.48%	26,604 10.16%	35,672 13.62%	32,743 12.50%	146,170 55.80%

Once all the information is available, it is possible to describe the whole characteristics of the set of tractors by AACC and the most likely relationship with fatal accidents.

First, it is noteworthy that Galicia had an average number of tractors registered in the period 2010–2019 similar to Andalucía (Figure 5) and above the rest of the Autonomous Regions. Galicia was one of the Autonomous Regions with the highest number of tractors, and tended to change ownership (there is more market) of older tractors than in other Autonomous Regions. In 2019, Galicia registered 1036 changes of ownership, which were of tractors over 40 years old (which is not authorised since the entry into force of Royal Decree 448/2020). This may be an explanation for its higher probability of fatal accidents.

The reason for this repeated occurrence in this community could be the subject of a more in-depth study of this market. Although the combination of several factors such as the high cost of new tractors together with the low profitability of farms, their size, the simple mechanics of old tractors as opposed to the complicated breakdowns of modern tractors, and the fact that there is a market for old tractors, could explain the abundance of this type of tractors.

Continuing with other regions, Navarre was one of the Autonomous Communities with the highest probability of fatal accidents. The fleet of tractors in Navarre was not excessively large compared to other Autonomous Communities, however, the power of new tractors registered in the period 2012–2019 was, for the most part (39.33%), over 110 kW. With regard to the age of the tractors that change ownership, as in all the Autonomous Communities, tractors over 20 years old stood out in the majority of transactions. In Navarre, therefore, the purchase of tractors tended to correspond to high power tractors and transfers of ownership to older tractors, which may explain the results obtained in Section 3.1.

Asturias and Murcia, with a similar number of tractors, slightly more in Asturias, were also two communities with a high probability of fatal accidents. They shared, as with the other Autonomous Communities, the transactions of older tractors, but in terms of power in the purchase of tractors, the largest number were in the power ranges of 50.1–70 and 70.1–90 kW, not being particularly high powers.

The same occurred in the País Vasco, Valencia and Tarragona (in Cataluña). They had a high probability of fatal accidents while the power of newly registered tractors was not among the highest.

La Rioja, Cantabria and Aragón, specifically the province of Zaragoza, also had a high probability, although somewhat lower than the previous communities did. In La Rioja, mainly new tractors of low power (70.1–90 kW) were purchased, representing 59.69% of new registrations. In Cantabria, which was one of the communities with the smallest machinery fleet, the power groups most purchased were those of 50.1–70 kW and 90.1–110 kW. In Aragon, although not all its provinces had the same probability of fatal accident risk, most of the new tractors registered were in the highest power range, i.e., >110 kW (37.55%). In terms of the age of the tractors changing ownership, in all of them, the oldest group, those over 20 years old, was close to or exceeded 50% of the registrations.

The other regions did not show such a high probability of fatal accidents. Andalucía (except Almeria), Madrid and Cataluña (except Tarragona) had an average probability of fatal tractor accidents. In these regions, the new tractors registered were not very powerful. Andalucía registered barely 6% of its new tractors in the >110 kW group, with the bulk being in the 70.1–90 kW range (45.41%). Madrid did not register many new tractors, but it did place them in the high power group. In Cataluña, on the other hand, they preferred two power groups, 50.1–70 kW and 70.1–90 kW. With regard to the age of registered tractors, Andalucía had a lower percentage of tractors over 20 years old (41.06%) than other regions.

Castilla-La Mancha, Castilla-León and Extremadura were communities with a low probability of tractor fatal accidents. Castilla-León bought the most powerful tractors and both Castilla-La Mancha and Castilla-León had a large fleet of machinery. The age of tractors older than 20 years that change ownership in all three cases exceeded 50%.

Finally, the Islas Canarias and the Islas Baleares were communities both with very low-powered tractors and in the Islas Canarias the change of ownership of tractors was mainly in the 6–10-year age group. The Islas Baleares followed the trend of the other regions.

4. Discussion

As mentioned before, according to Arana et al. [9] the main cause of death in the agricultural sector was the tractor. Moreover, tractor rollover and traffic accidents [23] are among the main causes, although there are large differences between the different provinces, as has become evident in this work. Such differences among provinces were also found in a work carried out by Cecchini et al. [24] regarding work accidents in agriculture in Italy.

As in our study, in the work of Baraza et al. [25], the accident rates for the agricultural sector as a whole between 2013 and 2018 were very high and more or less maintained over time. This study also analysed the accident rate by Autonomous Community, but in this case, they used the fatal accident rate as the number of fatal accidents in each community divided by the number of total fatal accidents. They agreed with the work presented here that the geographical distribution of accidents was not the same in all Spanish regions. The highest number of accidents was found in Andalucía, Valencia and Murcia. In their case, they justified it by a more labour-intensive agriculture and a greater presence of immigrant workers. They also agreed on lower rates in Castilla-La Mancha, Extremadura and Castilla-León, where cereal farming or highly extensive crops predominate.

In the work presented by Faccinetti et al. [26] on fatal accidents due to tractor rollover in Italy, they analysed, among other aspects, geographical differences. In their case, they also had a high incidence that was maintained over time, with a downward trend since 2013, as in our study. The regions with the highest number of accidents were also related to steep terrain, to an older tractor fleet and to horticultural crops and vineyards.

5. Conclusions

In this study, with the objective of relating the probability of occurrence of fatal accidents in which the tractor is present as an agricultural machine, we collected the information appeared in the media between 2010 and 2019. According to the information obtained regarding the machinery registrations carried out in that period in Spain, using the ratios of new registered tractor with power and change of ownership with age, we can conclude, for each of the Autonomous Communities, that:

- Galicia was an Autonomous Region with a high probability of fatal accidents, which may be due to its large fleet of tractors, especially low-powered tractors, and to the high rate of registrations of change of ownership of old tractors, the highest among all the Autonomous Regions.
- Navarre was one of the Autonomous Regions with a high probability of fatal accidents. Despite the fact that the majority of new tractor registrations were for tractors with a power of over 110 kW, most of the changes of ownership were for tractors over 20 years old and other factors such as the type of structure of the farms or the orography would justify this high probability.
- Asturias, País Vasco, Tarragona (in Cataluña), Valencia and Murcia, with a high probability of fatal accidents, did not stand out for their purchase of powerful new tractors, but maintained the general trend of transfers of older tractors.
- Cantabria and La Rioja, with a somewhat lower accident probability than the previous communities, also purchased new tractors of medium power.

- Andalucía and Cataluña, in most of their provinces, had an average probability of fatal tractor accidents. The purchase of new tractors in these regions corresponded to medium horsepower. Andalucía registers proportionally fewer old tractors than other regions.
- Castilla-La Mancha, Castilla-León and Extremadura were regions with a low probability of tractor accidents. In the case of Castilla-León, the relationship between low accident probability and less powerful new tractors did not hold true, since it was the region registering the highest percentage of new high-powered tractors and, likewise, the change of ownership was mainly of older tractors.
- In the islands, the relationship between low accident probability and registration of low-powered tractors was fulfilled, and in the Islas Canarias in particular, hardly any old tractors were registered. The Islas Baleares, which had a somewhat higher accident probability than the Islas Canarias, registered mostly older tractors.

In general, in Spain, there is a relationship between the probability of fatal accidents and the power of the tractors registered, except in Castilla-León, where there was clearly no such relationship.

Furthermore, it is important to train farmers in the way they work, the type of machinery they use on their farms, the type of tractor, etc., in accordance with the different agricultural areas, as there is a tendency for accident rates to be similar in neighbouring provinces.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agronomy12071694/s1. Figure S1: map of Spain divided into its autonomous communities. Figure S2: map of Spain divided into its provinces. Figure S3: map of slopes (%) of Spain.

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