

A Multi-year Analysis of Traffic Accidents Involving Agricultural Tractors

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The agricultural sector in Spain is responsible for a high rate of accidents every year, and many of them are traffic accidents. Tractors are a relatively rare sight on roads, meaning that the incidence of accidents involving these vehicles is relatively low, however, an above-average number of people are seriously injured or killed as a result of such accidents. Tractors are considered responsible for the majority of the occupational accidents in agriculture. Moreover, tractor overturns stand out as the principal cause of fatal accidents mainly because those accidents involved tractors without rollover protective structures (ROPS). Despite the obligation for all tractors of having a protective structure, the incidence rate of accidents with sick leave followed a rising line in the last ten years. Thus, in this study an analysis of the data of traffic accidents involving agricultural tractors in Spain, during the 2004-2013 period, is developed in order to identify the main risk factors that influence them. Official data from the "Statistical Yearbook of Accidents" published annually were used. A total of 2892 accidents were analysed. The results obtained showed that the incidence rate of both accidents and deaths were lower in accidents involving tractors than in general ones, but the consequences were more severe. In addition, the majority of accidents producing victims happened in interurban roads involving two or more vehicles. Defects in the lighting and brake systems were identified as risk of producing an accident. In the majority of the cases, the driver was the only victim of the crash. The total number of victims showed a decreasing tendency while the fatality index remained constant. The age of driver was reported to directly influence the number of accidents, with a high proportion of drivers over 45 years old. The main offences committed by drivers were related to inadequate speed and distracted driving. As much as possible we put our findings in an international context.

1. Introduction

Traffic accidents are nowadays one of the main problems in both developed and emerging countries and their management stands as a major concern for each administration (Alizadeh et al., 2014). In order to reduce the number of fatalities and injuries of road traffic accidents, strategic plans are being followed in many parts of the world proving good results (Evans, 2003). However, in general terms it seems that no specific procedures to reduce accidents involving tractors are being taken into consideration. In a study carried out by Behl et al. (2011), in Germany, it was identified that despite the number of accidents involving agricultural vehicles was low, the rate of killed and seriously injured was above average national numbers.

Therefore, it is necessary to analyse specific data of tractor-related traffic accidents by disaggregating and comparing them to the general data of traffic accidents. The incidence rate of tractor-related accidents is often hidden in statistics of general traffic accidents. Jaarsma and De Vries (2014) while analysing crashes involving agricultural vehicles in The Netherlands found that many national statistics cover tractor-related road accidents including them in a general category of "other vehicles". In addition, sometimes there is a lack of information regarding the causes and consequences of these accidents.

Other researchers worldwide have also highlighted this concern over the consequences of tractor-related accidents. Nevertheless, very little research has been reported regarding tractor traffic accidents in southern European countries considering these have a large agricultural base and a high fleet of tractors, which

increases their presence on both interurban and urban highways rising consequently the probability of being involved in an accident. In this respect, a study about tractor usage time in Spain established that around 20% of total usage time of a tractor is dedicated to transport (MAPA, 2006). In a study of accident rates in the agricultural sector in Spain, Arana et al. (2010) highlighted that almost 8% of the fatality accidents were due to traffic crashes.

For these reasons, the aim of this study is to analyse the data of traffic accidents that are gathered annually in the official statistical Yearbook developed by the Spanish National Department of Traffic (Dirección General de Tráfico, DGT); focusing on tractor involving ones and identifying their main causes. The results of this study are placed as much as possible in an international context.

2. Materials and methods

This study analysed road traffic accidents involving agricultural tractor vehicles that occurred in Spain in a time span of 10 years (2004-2013). Official data from the “Statistical Yearbook of Accidents” (*Anuario Estadístico de Accidentes*) published annually by the Spanish National Department of Traffic (*Dirección General de tráfico*, DGT) dependent on the Ministry of the Interior of Spain (*Ministerio del Interior*) were used (DGT, 2016). A total number of 2892 accidents were reported in the period under study. In these Yearbooks, in addition to data of general accidents, data corresponding to agricultural tractors are detailed, which were analysed in this study. From 2014 on, in these Yearbooks, the category agricultural tractors as such disappeared and was included into the category “other vehicles”. For this reason, we have analysed accidents until 2014.

3. Results and discussion

3.1 Traffic accidents and victim rates

Figure 1 shows the number of accidents and deaths per every 10000 vehicles in the fleet, respectively, and, figure 2 shows the number of victims killed and those with serious or minor injuries per every 1000 accidents. The total fleet of vehicles in Spain was comprised of about 70% of cars, 16% of trucks, 9% of motorbikes and 5% of tractors.

In Figure 1, both in the rate of accidents and deaths, it was observed that the agricultural tractor rates were below the general ones. Despite this, Figure 1 shows that while the general rate fell in the decade considered from an approximate value of 36 to 29; the rate of agricultural tractors remained quite stable and even rose slightly. In the case of the death rate, the decrease produced in tractors was much less significant than that in the general rate since, at the beginning of the decade, there was a difference of 1.30 points between both rates, but at the end of it that difference was reduced to 0.36 points.

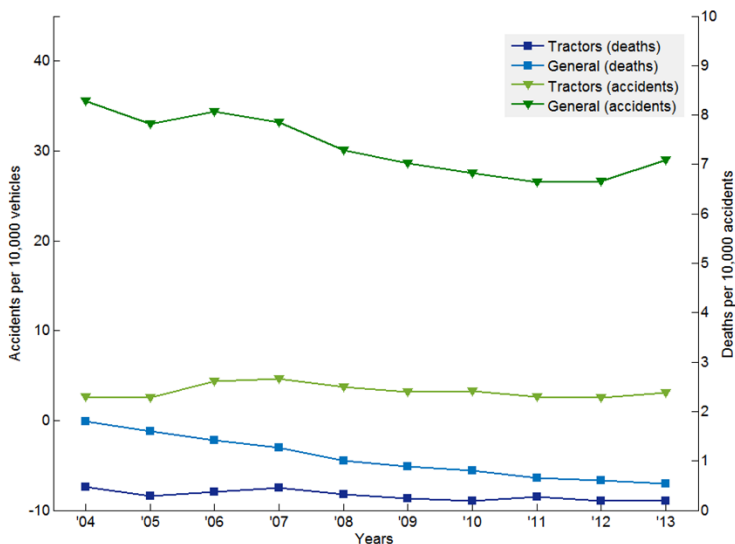


Figure 1: Rate of accidents and deaths per every 10000 vehicles in the fleet in the 2004-2013 period.

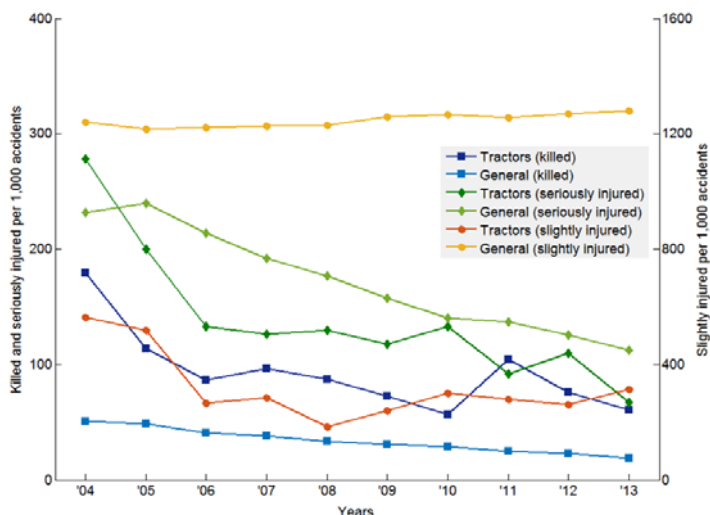


Figure 2: Rate of killed, seriously injured and slightly injured per every 1000 accidents in the 2004-2013 period.

In Figure 2, it is curious to see how the values of the rates vary according to the seriousness of the victims. The agricultural tractor rate of killed was above the rate of general accidents, while the rates of seriously injured decreased in parallel, and, the rate of slightly injured in general accidents was much higher than that of tractors. Surprisingly, it can be seen that in 2010 and 2012, the rate of seriously injured in general accidents was about the same that in tractor-related ones, even though, the number of tractors in the fleet was about 33 times less the general one. Therefore, according to these results, it seems that the severity of the victims is greater in accidents in which agricultural tractors intervene than in the rest of the accidents. This result is in accordance with a report published by Behl et al. (2011) of tractor-related crashes in Germany in which authors reported that the rate of killed and seriously injured were above the average one.

3.2 Vehicles involved

From 2004 to 2013, there were 3320 vehicles involved in tractor-related traffic accidents with victims (DGT, 2016). From those, the 23% (763) of accidents involved only one vehicle, while the 77% (2557) left occurred between two or more vehicles. So, the majority of accidents are produced between an agricultural tractor and a non-agricultural vehicle. Khorashadi et al. (2005) studied traffic accidents in California that involved not only tractors but large trucks during the 1997-2000 period, and, they also reported that the majority of accidents occurred between two or more vehicles, with a percentage of 90.3% over 9.7% cases involving only one vehicle.

Figure 3 shows the number of vehicles involved in accidents with victims according to the type of highway itemised per year from 2004 to 2013, inclusive. It can be seen that the rate of accidents involving one vehicle remained stable over the period studied, while accidents involving two or more vehicles decreased notably, in spite of the slight rise in 2013. From the total of the vehicles involved in accidents with victims during the period under study, 88% (2925) happened on interurban highways and only 12% (395) on urban ones. This is not surprising since tractors do not generally circulate inside towns.

Figure 3 also evidences the drop in the number of vehicles implicated in accidents occurring on interurban highways, which, in 2012, represented nearly half of those in 2004. In the case of urban highways, as the number of vehicles involved was considerably lesser, so the reduction in them was lower.

Taking into account the total of accidents, the number of vehicles involved in fatal accidents is shown in Table 1. Of the total of vehicles involved in accidents with victims during the period studied, 11.72% (389) of them were involved in fatal accidents; and from those, the majority happened in interurban highways (84.06%).

Another important aspect to analyse is the state of the vehicles involved in accidents producing victims. According to Wei and Lovegrove (2012), the main responsible for most of crashes are either the driver, the vehicle or the road. With respect to agricultural tractors, the main faults found on them are also shown in Table 1. It is revealed that 92.8% of vehicles did not apparently exhibit any fault. From the 7.28% left, the most common fault reported was that of "faulty rear lights". As an example of this problematic, Cole et al. (2009), while studying the safety status of farm tractors in 4 rural Kentucky countries, realised that only 40.9% out of 149 vehicles analysed possessed properly and undamaged lighting equipment. The second most recurrent defect found in this study was "faulty brakes". In a study performed by Jones and Stein (1989) "brake defects"

was reported as the most common type of fault in tractor-related crashes, present in 56% of the total accidents, followed by “steering defect” found in 21% of them.

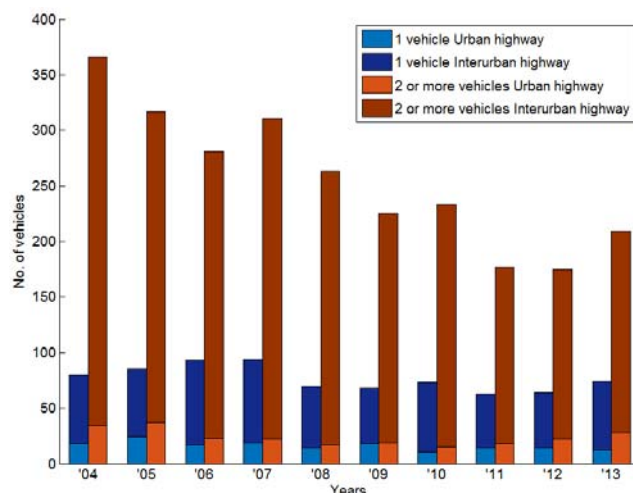


Figure 3: Vehicles involved in accidents with victims grouped by type of highway from 2004 to 2013, inclusive.

Table 1: Number of vehicles involved in accidents producing victims and their state from 2004 to 2013, inclusive.

Vehicles involved	Interurban highways	Urban highways	TOTAL
In the total of accidents with victims	2925	395	3320
In the total of fatal accidents	327	62	389
Fault			
Without apparent faults	2735	345	3080
Heavily worn tyres	4	1	5
Tyre puncture or burst	1	0	1
Loss of wheel	3	0	3
Faulty rear lights	30	2	32
Faulty brakes	8	2	10
Broken or defective steering	4	0	4
Overload	2	2	4
Unevenly distributed load	2	0	2
Other faults	36	8	44
Unknown reasons	100	35	135
TOTAL VEHICLES	2925	395	3320

3.3 Victims of traffic accidents with agricultural tractors

From 10 years of observation, it was found that 17% (263) of the total accidents were fatal, 25.3% (390) resulted in seriously injured victims and 57.7% (890) in slightly injured ones (Table 2). It can also be seen in Table 2 that most of the victims occurred in accidents on interurban highways. On average, in Spain, 85.5% (225) of the total number of fatalities, 87.2% (340) of the seriously injured victims, and 84% (753) of those slightly injured were registered outside urban areas. In addition, it should be mentioned that the majority of victims in all the cases were drivers (82.6%, 1275).

Figure 4 represents the number of victims in traffic accidents involving agricultural tractors. It seems that lines of trend were clearly in descent in all the cases. During those years, the proportion of fatal accidents in Spain decreased by 57.5%. The evolution of the fatality index (FI) in agricultural tractor accidents comparing to the total of accidents with victims during the period 2004-2013 is also shown in Figure 4. The FI is defined as the

percentage of the number of dead over the number of total victims. As it can be seen, the average FI in Spain is very high since, while the general total of accidents dropped from 3.31% to 1.33%, the mean FI in agricultural tractor accidents was approximately 17% along the period studied. The FI rates of general accidents were between 10 and 20 times lower the rates of agricultural tractors, suggesting that a crash with an agricultural tractor is in general much more severe. This affirmation is in accordance with Costello et al. (2009) who stated that an accident with an agricultural vehicle is in general about 5 times more likely to result in a fatality than an accident with a non-agricultural vehicle.

Jaarsma and De Vries (2014) reported an average FI value of 7.6 in The Netherlands for the 2006-2010 period, which is approximately less than half the average value in Spain (FI: 17) for the same period. However, it should be noted that former authors studied the number of accidents involving not only tractors but also all kind of agricultural vehicles including combines and seeders. In this respect, in a study accomplished by Akdur et al. (2010) in Turkey, authors realised that tractors were the most common machine causing injuries (46%), while harvesters and seeders accounted for a total of 8.1% and 5.4%, respectively. Mayrhofer et al. (2013) also pointed out that tractors were responsible for most of the injuries and fatalities in farm accidents in Austria.

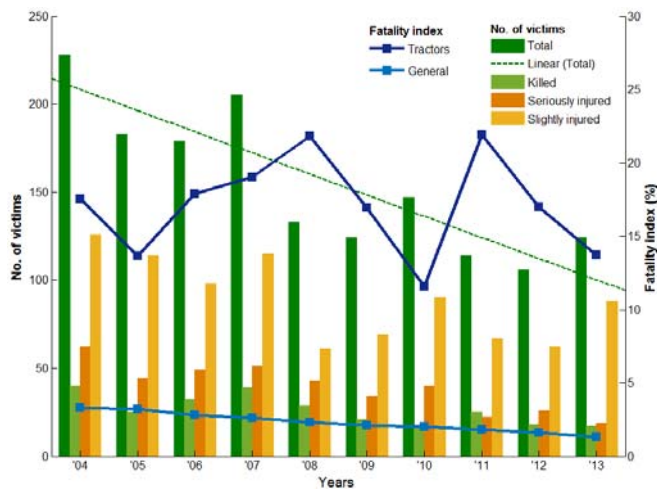


Figure 4: Number of victims in agricultural tractor traffic accidents each year and fatality index in agricultural tractor accidents and in the total from 2004 to 2013, inclusive.

Table 2: Number of occupants and victims of accidents according to their seriousness, condition, and type of highway from 2004 to 2013, inclusive.

Seriousness	Highways	Condition	TOTAL
Killed (Total: 263)	Interurban	Drivers	206
		Passengers	19
	Urban	Drivers	36
Seriously injured (Total: 390)	Interurban	Drivers	280
		Passengers	60
	Urban	Drivers	33
Minor injured (Total: 890)	Interurban	Passengers	17
		Drivers	651
	Urban	Passengers	102
Total victims	Interurban	Drivers	69
		Passengers	68
	Urban	Occupant	1543
Occupants (Total: 3,582)	Interurban	Occupant	3105
	Urban	Occupant	477

3.4 Offences of drivers involved in agricultural tractor accidents with victims

When analysing the offences committed by the drivers, these are divided into two sections, one referring to speed and the other to the rest of offences. The highest rate corresponds to those drivers who have not committed any speed offence, representing 84% of the total. The greatest incidence in the offences known is that of inappropriate speed (3.05%), with a testimonial 0.12%, when the established speed is exceeded. Chen and Chen (2011) reported "exceeding speed limit" as responsible for 1.45% of accidents in the State of Illinois while "exceeding safe speed for conditions" accounted for another 1.44%. Furthermore, there is a greater significance in a slow speed, representing a 0.55% over the total, an inherent characteristic of agricultural tractors, which, by law, have their speed limited in most cases to 40 km/h or to 25 km/h if they have a trailer or are towing machinery. Besides this, most of the speed offences (88.3%) were committed on interurban highways. Regarding the rest of offences, nearly half the drivers (46%) did not commit any offence. The most significant offence committed was "distracted or inattentive driving" accounting for 26.8%, followed by "incorrect turning" (23.2%). These two offences signify together 50% of the total. The two offences following them in importance are "skipping the stop sign", with 8.4%, and "failing to respect the rule of priority" with 7.3%. "Driving on wrong side" accounted for 0.06% of total offences committed by drivers. Chen and Chen (2011) reported this same offence in 0.7% of accidents and "improper lane usage" in 2.63% whereas in our study "drift to the opposite lane" accounted for 1.98% of the total.

4. Conclusions

The analysis of traffic accidents elaborated in this study provides information about the accident and victim rates, the vehicles involved, the condition of the victims and the main offences committed, in a time span covering one decade. This information is essential to understand the main risk factors influencing tractor-related crashes. The results provided could be used to design prevention measures in order to reduce the number of tractor-related traffic accidents as well as to minimise their consequences.

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