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Livestock Vehicle Accidents in Spain: Causes, Consequences, and Effects on Animal Welfare

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Abstract

Livestock vehicle accidents are rare but involve significant economic, human, and nonhuman farm animal losses. This study obtained information on the characteristics of accidents, the animals involved, and injuries to humans from newspaper reports about livestock vehicle accidents in Spain from January 2000 to December 2008. Most accidents involved pig transport (57%), followed by bovine (30%), poultry (8%), and sheep (5%). Driver mortality was not high (6%), and most accidents (76%) involved only the livestock vehicle, which often was overturned (64%) on a straight road transect (51%). Multivariate analysis of the data suggests 2 types of accidents, depending on the species transported. In the first cluster, 95.3% of the cases involved pig transport with articulated vehicles (60.5%). In the second cluster, 94.4% of the accidents involved small vehicles used for cattle transport (44.4%). The results of this study indicate that the characteristics of livestock vehicle accidents vary according to species. One of the main causes of accidents appears to be driver fatigue, which may be due to several factors such as intense workdays, poorly designed route plans, or high levels of pressure from companies.

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Livestock vehicle accidents are rare but involve significant economic, human, and nonhuman farm animal losses. This study obtained information on the characteristics of accidents, the animals involved, and injuries to humans from newspaper reports about livestock vehicle accidents in Spain from January 2000 to December 2008. Most accidents involved pig transport (57%), followed by bovine (30%), poultry (8%), and sheep (5%). Driver mortality was not high (6%), and most accidents (76%) involved only the livestock vehicle, which often was overturned (64%) on a straight road transect (51%). Multivariate analysis of the data suggests 2 types of accidents, depending on the species transported. In the first cluster, 95.3% of the cases involved pig transport with articulated vehicles (60.5%). In the second cluster, 94.4% of the accidents involved small vehicles used for cattle transport (44.4%). The results of this study indicate that the characteristics of livestock vehicle accidents vary according to species. One of the main causes of accidents appears to be driver fatigue, which may be due to several factors such as intense workdays, poorly designed route plans, or high levels of pressure from companies.

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transport of livestock animals is an important component of meat production; however, it may have important negative impacts on animal welfare and the environment (Ljungberg, Gebresenbet, & Aradom, 2007**41**). Ljungberg, D., Gebresenbet, G. and Aradom, S. 2007. Logistics chain of animal transport and abattoir operations. *Biosystems Engineering*, 96: 267–277. [CrossRef], [Web of Science ®]

View all references. Approximately 663 million animals on the farm (600 million poultry, 40 million pigs, 20 million sheep, 2.5 million cattle, 1.5 million goats, and 30,000 horses) are transported to abattoirs in Spain per year (Spanish Ministry of Agriculture, Fisheries and Food [MAPA], 2009). This strategic activity requires appropriate planning and infrastructure (Miranda-de la Lama et al., 2009) to avoid accidents and maintain high standards of animal welfare. Little is known about the characteristics of livestock accidents despite the fact that the current tendency is for the total number of journeys per year to increase. This is partly due to the decrease in the number of abattoirs (now fewer, larger, and more specialized), which increases transport time and distance (Ljungberg et al., 2007**41**). Ljungberg, D., Gebresenbet, G. and Aradom, S. 2007. Logistics chain of animal transport and abattoir operations. *Biosystems Engineering*, 96: 267–277. [CrossRef], [Web of Science ®]

View all references; Villarroel et al., 2001**57**. Villarroel, M., María, G. A., Sierra, I., Sañudo, C., García-Belengué, S. and Gebresenbet, G. 2001. Critical points in the transport of cattle to slaughter in Spain that may compromise the animals' welfare. *Veterinary Record*, 149: 173–176. [CrossRef], [PubMed], [Web of Science ®], [CISA]

View all references.

Large vehicle accidents are associated with a series of factors that include driver effects, vehicle type, and road conditions (Joshua & Garber, 1992**36**). Joshua, S. C. and Garber, N. J. 1992. A causal analysis of large vehicle accidents through fault-tree analysis. *Risk Analysis*, 12: 173–187. [CrossRef], [Web of Science ®], [CISA]

View all references. Important driver-risk factors include age, alcohol consumption (Loeb & Clarke, 2007**40**). Loeb, P. and Clarke, W. 2007. The determinants of truck accidents. *Transportation Research Part E: Logistics and Transportation Review*, 43: 442–452. [CrossRef], [Web of Science ®]

View all references, fatigue, chronic health problems (Häkkinen & Summala, 2001), imprudence, distraction (Hanowski, Pérez, & Dingus, 2005**53**). Hanowski, R. J., Pérez, M. and Dingus, T. A. 2005. Driver distraction in long-haul truck drivers: Transportation research part F. *Traffic Psychology and Behaviour*, 8: 441–458. [CrossRef], [Web of Science ®]

View all references, and lack of training and knowledge of how to transport livestock properly (Schwartzkopf-Genswein, Haley, Church, Woods, & O'Byrne, 2008**50**). Schwartzkopf-Genswein, K. S., Haley, D. B., Church, S., Woods, J. and O'Byrne, T. 2008. An education and training programme for livestock transporters in Canada. *Veterinaria Italiana*, 44: 273–283. [PubMed]

View all references.

In the case of vehicles, some of the most important aspects associated with accidents include mechanical failures, problems with weight balance between the vehicle and the trailer (Braver et al., 1997**3**). Braver, E., Zador, P., Thum, D., Mitter, E., Herbert, M., Baum, H. and Vilardo, F. 1997. Tractor-trailer crashes in Indiana: A case-control study of the role of truck configuration. *Accident Analysis & Prevention*, 29: 79–96. [CrossRef], [PubMed], [Web of Science ®], [CISA]

View all references, design defects (Dwyer & Wheeler, 1987**20**). Dwyer, M. J. and Wheeler, J. A. 1987. Preliminary results from the on-farm evaluation of an experimental farm transport vehicle. *Journal of Agricultural Engineering*, 38: 15–26. [CrossRef]

View all references, and the total weight and relative weight of the vehicle (Björnstig, Björnstig, & Eriksson, 2008). Finally, climate conditions (Hijar, Carrillo, Flores, Anaya, & López, 2000), topography, and road design can also increase the incidence of accidents in certain transects (Miaou & Lum, 1993**43**). Miaou, S. and Lum, H. 1993. Modeling vehicle, accidents and highway geometric design relationships. *Accident Analysis & Prevention*, 25: 689–709. [CrossRef], [PubMed], [Web of Science ®], [CISA]

View all references. The Spanish Transport Ministry (DGT; Dirección General de Tráfico) has identified road transects where accidents are more probable. These are known as accident concentration zones (ACZ) or “black zones,” where three or more accidents (with victims) have occurred within 1 year along a transect of less than 100 m. Starting in 2005, 776 ACZ were identified and marked in Spain for DGT (2007).

During an accident involving a livestock vehicle, a high level of coordination is required between police, firemen, drivers, owners, and veterinary services (Casper, Dora, Formey, & Lundin, 1995**5**). Casper, J., Dora, R., Formey, W. and Lundin, C. S. 1995. Animal emergency preparedness and disaster plans: MDA CN 91–95. *Journal of Equine Veterinary Science*, 15: 191–194. [CrossRef], [Web of Science ®]

View all references. Accidents also have an effect on animal welfare, company income, logistics, and the public image of the industry. In Australia, the United States, and Canada, several studies have been carried out to elaborate specific action protocols (National Transport Commission, 2006; Woods & Grandin, 2008**59**). Woods, J. and Grandin, T. 2008. Fatigue: A major cause of commercial livestock truck accidents. *Veterinaria Italiana*, 44: 259–262. [PubMed]

View all references. In Europe and, especially in Spain, there is little information about the causes and consequences of these types of accidents. The goal of this work is to analyze the factors that contribute to the livestock vehicle accidents in Spain, the damage caused, and the effect of that damage on the animals transported.

MATERIAL AND METHODS

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We obtained information about livestock accidents based on newspaper reports in Spain between January 2000 and December 2008. The reports were found using the cybermetrics method with appropriate Boolean operators; filters (Jenkins, 2004**35**. Jenkins, M. 2004. Evaluation of methodological search filters—a review. *Health Information and Libraries Journal*, 21: 148–163. [CrossRef], [PubMed]
View all references; Woods & Grandin, 2008**59**. Woods, J. and Grandin, T. 2008. Fatigue: A major cause of commercial livestock truck accidents. *Veterinaria Italiana*, 44: 259–262. [PubMed]
View all references); and content-analysis techniques (Chapman, 1998**7**. Chapman, S. 1998. "Content analysis." In *Handbook of public health methods* Edited by: Kerr, C., Taylor, R. and Heard, G. 483–490. Sydney, , Australia: McGraw-Hill.

View all references), including 22 digital libraries from the most important local and national newspapers. The terms for the searches included: [accidents, overturning, collision, vehicle, livestock, bovine, pigs, goats, horse, sheep, poultry=(Spain)] in all possible combinations. The same procedure was also used with search engines such as Google, Yahoo, Altavista, Ask, and Alltheweb.

Databases

The reports were placed in a database using the relational system for data management (Microsoft Office Access). For a report to be included in the database, the report had to be from a newspaper, provide date and location, and contain at least 90% of the information required on location of the accident, characteristics, animals involved, and human injury. For location, we denoted the hour of day, autonomous community (first-level geopolitical division of Spain), motorway and kilometre, and whether it was in an ACC (DGT, 2008b). The main characteristics of the accident included the type of transect (straight line, curve, roundabout, bridge, slope, or detour), cause of the accident (overtaking, frontal collision, lateral collision, rear collision, or mechanical failure), and the type of vehicle (small, rigid, or articulated). Regarding animal welfare, we denoted species (porcine, bovine, ovine, or poultry), approximate number of animals transported dead and slaughtered *in situ*, and number of animals on the road after the accident. Finally, information on human injury included driver condition (unharmed, injured, and dead) and other people (injured, dead).

Statistical Analysis

A descriptive analysis (averages, percentages, and frequencies) was performed using the data from 76 accidents (out of 86 total) that involved pigs, cattle, poultry, or sheep. For accidents that involved pigs and cattle, which represented 88% of all accidents ($n = 66$), we also performed a chi-square and Kruskal-Wallis and Mann-Whitney test—due to the nonparametric character of the variables and the information used (Glantz, 2006²⁷; Glantz, S. A. 2006. *Bioestadística [Biostatistics]*, 6th ed. New York, NY: McGraw-Hill..

View all references) – crossing several variables (type of transeuse of the accident, and type of vehicle). This was done to better understand the nature of the accidents and the results from the multivariate analysis. In addition, to identify the relation between several variables – such as cause of the accidents and species and vehicle type – we used two multivariate statistical techniques: the multiple correspondence analysis and cluster analysis. The former was used to obtain a graphical representation of the interrelations among variables; the former was used to classify the accidents according to their degree of relation. SPSS 14.0 was used to analyze the data. The multiple correspondence analyses provide a multidimensional representation of the different categories of nominal type variables. First we developed a chi-square test to analyze the interrelation among accident cause, species, and vehicle. The normalization method used was that of the principal variables; the criteria of convergence established was 0.00001. To accept the final model, we used as the criteria a total inertia explained by the new dimensions close to or above 0.8, which is considered acceptable (Uriel & Aldas, 2005:55; Uriel, E. and Aldas, J. 2005. *Análisis multivariante aplicado* [Applied multivariate statistical analysis] Madrid, . Spain: Thomson Editors.,

Later, we developed a cluster analysis to classify the observations in groups that are homogeneous with respect to the variables used to characterize them, as different as possible between groups. The two-step clustering method was used (Hair, Anderson, Tatham, & Black, 1999a). Hair, J., Anderson, R., Tatham, R. and Black, W. 1999. *Análisis multivariante [Multivariate data analysis]*, 5th ed. Madrid, Spain: Prentice Hall Iberia..

View all references). Once established, clusters were characterized by taking into account some of the variables on accident characteristics and animal welfare.

RESULTS

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General Description of the Accidents

Approximately 57% of all livestock accidents analyzed ($n = 76$) involved pigs; 30%, cattle; 8%, poultry; and 5%, sheep (no other species were mentioned). The average number of accidents reported per year in Spain was 9.5, with more accidents in 2006, 2007, and 2008 (62% of the total) and fewer in 2002 (3%). The distribution of accidents per day of the week was Monday (21%), Tuesday (16%), Wednesday (13%), Thursday (19%), Friday (17%), Saturday (5%), and Sunday (9%). The geographic distribution of the accidents is presented in Table 1.

About 63% of the drivers involved in livestock accidents were unharmed, 31% were injured, and 6% died ($n = 4$ drivers); 24 people were injured. About 76% of the accidents involved only the livestock vehicle, 17% were collisions with cars, and 7% involved other vehicles. In the case of collisions with cars and vehicles, 18% involved at least 1 injured person and 13% involved at least 1 death. In the case of the occupants of cars and other vehicles, 41 died and 83 were injured.

Click to view table

TABLE 1 Livestock Vehicle Accidents Reported in Spain in 17 Different Autonomous Communities

Regarding other accident characteristics, 51% occurred along a straight transect, 30% on curves or roundabouts, 9% on bridges or slopes, and 9% on detours. There was no significant relationship ($p > .05$) between livestock accidents and ACZ (Figure 1). Among the causes of the accidents, 64% were overturnings; 26%, collisions; 6%, mechanical failures; and 4%, animal falling out of the vehicle. Regarding vehicle type, 48% involved rigid vehicles; 32%, articulated; 15%, small vehicles; and 3%, light vehicles.

Multivariate Analysis

The correspondence analysis provided a two-dimensional solution shown in Table 2. The adjustment to the model is considered significant because it explains almost 100% of the total variance. Figure 2 shows the centroids of the points in the categories of the variables included in the correspondence analysis. The position of the centroids indicates that, in the case of the cattle, more accidents involved small vehicles. In the case of the pigs, accidents with articulated and rigid vehicles were more related with overturnings. The results of the correspondence analysis are confirmed by the cluster analysis. This type of analysis suggests that there are two types of accidents, depending on the species transported (Table 3).

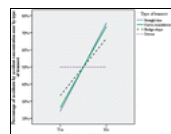


FIGURE 1 Relationship between road type and accident concentration zones as defined by the Spanish Transport Ministry. (Figure available in color online.)

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The first cluster contains 95.3% of accidents with pigs. When comparing the correspondence and cluster analyses, there appears to be a relation between pig transport accidents with articulated and rigid vehicles that overturned. Among those accidents, 60.5% and 39.5% involved articulated and rigid vehicles, respectively, associated with 72.1% overturnings during the day (88.4%). In 79.5% of the cases, the animals survived the accident and were found wandering freely on the motorway. Approximately 22% of the animals died, and 2% were injured and slaughtered in situ.

Click to view table

TABLE 2 Model Summary of the Multiple Correspondence Analyses

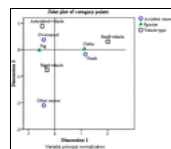


FIGURE 2 Graphic representation of the multiple correspondence analysis. (Figure available in color online.)

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In the second cluster, 94.4% of the accidents involved cattle, 44.4% with small vehicles, followed by articulated (33.3%) and rigid (22.2%). The cause was either overturning or collision in almost equal proportion and equally distributed during the day or night. In 20.5% of those accidents, there were animals wandering freely on the motorway, 12.2% mortality, and 14.7% animals injured and slaughtered on-site.

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Accidents involving loaded livestock vehicles can be a serious problem in the meat production chain—causing economic, animal, and even human loss. In addition, they also have an important impact in the media and affect the image of the industry for consumers. In Europe, little is known about the characteristics of these accidents. Thus, our study provides an important advancement step in understanding their determining factors and in providing information that can be used to generate specific protocols of action.

Click to view table

TABLE 3 Summary of Accident Characterization After Cluster Analysis Based on Species, Accident Characteristics, and Animal Welfare

Livestock vehicle accidents in Spain involved the four main species produced in Spain for meat (MAPA, 2009). Most of the accidents (80%) occurred in vehicles carrying pigs or cattle, as observed by Woods and Grandin (2008) **59**. Woods, J. and Grandin, T. 2008. Fatigue: A major cause of commercial livestock truck accidents. *Veterinaria Italiana* , 44: 259–262.

View all references. One possible reason is that these species are larger and may cause sudden shifts in weight balance on the vehicle (Gade & Chistensen, 1998). Gade, P. B. and Chistensen, L. 1998. Effect of different stocking densities during transport on the welfare and meat quality in Danish slaughter pigs. *Meat Science*, 48: 237–247.

View all references; Kent, 1997³⁷. Kent, J. E. 1997. Stress in transported sheep. *Comparative Haematology International*, 7: 163–166.

View all references). Moreover, rapid acceleration or sudden braking can easily cause these large animals to lose their balance (Department of Local Government and Regional Development, 2003; Gebresenbet & Eriksson, 1998²⁶. Gebresenbet, G. and Eriksson, B. 1998. *Effect of transport and handling on animal welfare, meat quality and environment with special emphasis on tied cows: Report 233*. Uppsala, Sweden: Swedish Agricultural Sciences..

View all references). The center of gravity for a livestock trailer is different from other freight hauled commercially. Different trailer designs will also have different centers of gravity (pothely trailer vs. a straight trailer; Canadian Livestock Transporters, 2009). In addition, livestock can move around in the trailer or lean on curves, which shifts weight distribution and makes a rollover more likely (Rhode Island Division of Motor Vehicles, 2008). Also, drivers may be under stress to fulfill their timetable in porcine and bovine production systems (Villarrol et al., 2001⁵⁷, Villarrol, M., María, G. A., Sierra, I., Sañudo, C., García-Belenguer, S. and Gebresenbet, G. 2001. Critical points in the transport of cattle to slaughter in Spain that may compromise the animals' welfare. *Veterinary Record*, 149: 173–176.

View all references). Fewer accidents in poultry may be a direct result of the well-organized logistics and integrated organization of this industry (Van Horne & Achterbosch, 2008⁵⁶. Van Horne, P. L. M. and Achterbosch, T. J. 2008. Animal welfare in poultry production systems: Impact of EU standards on world trade. *World's Poultry Science Journal* , 64: 40–52.

View all references). In the case of sheep, the low number of accidents could be because journeys are more local and shorter as a direct result of geographic brand names that are tied to specific regions (Miranda-de la Lama et al., 2009; Sañudo, Sanchez, & Alfonso, 1998).

Most accidents were concentrated in the last 3 years of the study (62%), which can be associated with an increase in the demand for meat observed in recent years. In southern Europe, the trend is to follow a diet with more meat and less traditional Mediterranean cuisine (Colmenero, 2000b; Colmenero, F. J. 2000. Relevant factors in strategies for fat reduction in meat products. *Trends in Food Science and Technology* . 11: 56–66.

View all references; Di Giuseppe et al., 2008**15**. Di Giuseppe, R., Bonanni, A., Olivieri, M., Di Castelnuovo, A., Donati, M. B., De Gaetano, G. and Iacoviello, L. 2008. Adherence to Mediterranean diet and anthropometric and metabolic parameters in an observational study in the 'Alto Molise' region: The MOLI-SAL project. *Nutrition, Metabolism & Cardiovascular Diseases*. 18: 415–421.

View all references; Krystallis & Arvanitovannis, 2006**38**. Krystallis, A. and Arvanitovannis, I. S. 2006. Investigating the concept of meat quality from the consumers' perspective: The case of Greece. *Meat Science*, 72: 164–176.

View all references). However, another possible reason for this finding is that one of the major sources for local and regional news in recent years is online news websites (Del Águila-Obra, Padilla-Meléndez, & Serarols-Tarrés, 2007; Lee & Leung, 2008). Lee, P. and Leung, L. 2008, Assessing the displacement effects of the Internet. *Telematics and Informatics*, 25: 145–155.

View all references). In terms of the distribution of accidents throughout the week, most accidents occurred on Monday to Friday (86%), in line with previous observations of a greater amount of activity in commercial abattoirs on those days (Villarrol et al., 2001⁵⁷; Villarrol, M., María, G. A, Sierra, I., Sañudo, C., García-Belenguier, S. and Gebresenbet, G. 2001. Critical points in the transport of cattle to slaughter in Spain that may compromise the animals' welfare. *Veterinary Record*, 149: 173–176.

[\[CrossRef\]](#), [\[PubMed\]](#), [\[Web of Science ®\]](#), [\[CSA\]](#)
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Most of the drivers involved in accidents were unharmed, with very few deaths. This agrees with the information provided by the DGI and the Spanish Transport and Communications Federation (FCI; Federación de Comunicación y Transporte). They estimate that mortality in accidents for lorry drivers is close to 10% (DGT, 2008a; FCI, 2000). It is important to underline that, even though driver mortality was low, livestock vehicle accidents provoke a comparatively high mortality in the occupants of the vehicle. This is because the passengers are not common road users, the possibility of getting injured or dying in a collision with livestock vehicles is relatively high. This is because passenger car occupants may be exposed to extremely high deceleration forces in collisions with heavy vehicles (Björnstén et al. 2008; Chang & Mannering, 1999b; Chang, L. Y. and Mannering, F. 1999. Analysis of injury severity and vehicle occupancy in truck- and non-truck-involved accidents. *Accident Analysis & Prevention*, 31: 579–592.

[\[CrossRef\]](#), [\[PubMed\]](#), [\[Web of Science®\]](#), [\[CSA\]](#)
View all references).

Because few accidents occurred in ACZ, it would appear that the causes of livestock vehicle accidents are different from other traffic accidents. More than half the accidents we analyzed involved an overturned vehicle on a straight road transect, suggesting the causes are more related to the driver or the vehicle or to animal movement in the vehicle.

The multiple types of livestock transport vehicles can be categorized into two types: pig transport (Cluster 1); the other, cattle transport (Cluster 2). This may be due to the different transport logistics of each species. In pigs, transport is mostly managed by integrated companies with a high level of logistic control (Simons & Taylor, 2007⁵¹; Simons, D. and Taylor, D. 2007. Lean thinking in the UK red meat industry: A systems and contingency approach. *International Journal of Production Economics* v. 106, 70–81.

View all references). However, the sector is highly competitive; drivers may be under high pressure, which can increase fatigue or accidents (Cockram et al., 2004¹⁰. Cockram, M. S., Baxter, E. M., Smith, L. A., Bell, S., Howard, C. M., Prescot, R. J. and Mitchell, M. A. 2004. Effect of driver behaviour, driving events and road type on the stability and resting behaviour of sheep in transit. *Animal Science*, 79: 165–176.

[View all references](#); Woods & Grandin, 2008**59**. Woods, J. and Grandin, T. 2008. Fatigue: A major cause of commercial livestock truck accidents. *Veterinaria Italiana* , 44: 259–262.

View all references). In cattle, drivers tend to be freelance and under less pressure and logistic control (Ljungberg et al., 2007**41**. Ljungberg, D., Gebresenbet, G. and Aradom, S. 2007. Logistics chain of animal transport and abattoir operations.

Biosystems Engineering , 96: 267–277. [CrossRef], [Web of Science ®]
View all references; Swanson & Morrow-Tesch, 2001**54**. Swanson, J. C. and Morrow-Tesch, J. 2001. Cattle transport: Historical, research, and future perspectives. *Journal Animal Science* , 79: E102–E109.

View all references). Cattle drivers do not tend to participate in training or safety programs provided by large companies (Schwartzkopf-Genswein et al., 2008**50**. Schwartzkopf-Genswein, K. S., Haley, D. B., Church, S., Woods, J. and O’Byrne, T. 2008. An education and training programme for livestock transporters in Canada. *Veterinaria Italiana* , 44: 273–283. [PubMed]
View all references).
That most accidents involved pigs may also be a reflection of the importance of pig production in Spain, with more journeys per day than other species (Gracia & Albisu, 1998**28**. Gracia, A. and Albisu, L. M. 1998. The demand for meat and fish in Spain: Urban and rural areas. *Agricultural Economics* , 19: 359–366. [CrossRef], [Web of Science ®]
View all references). In the last 2 decades, pig production has increased considerably on a national level, and Spain is now the second largest pig producer in the European Union (Oliveira, Guitián, & Yus, 2007**47**. Oliveira, J., Guitián, F. J. and Yus, E. 2007. Effect of introducing piglets from farrow-to-finish breeding farms into all-in all-out fattening batches in Spain on productive parameters and economic profit. *Preventive Veterinary Medicine* , 80: 243–256. [CrossRef], [PubMed], [Web of Science ®]
View all references). This growth has implied a stratification of the production chain, where weaned piglets are sent to farms for fattening. Recently, most piglets are imported from central Europe, which increases long-distance transport (Martínez-López, Perez, De la Torre, & Sánchez-Vizcaino Rodríguez, 2008).
Accidents with vehicles carrying pigs were more frequent during the day and, in cattle, occurred throughout the day or night. This may be because loading times for pigs are usually longer and normally occur at only one farm (Martínez-López et al., 2008; Warriss, 2003**58**. Warriss, P. D. 2003. Optimal lairage times and conditions for slaughter pigs: A review. *Veterinary Record* , 153: 170–176. [CrossRef], [PubMed], [Web of Science ®], [CSA]
View all references), making the whole process more systematic and linked with certain hours of the day, usually beginning early morning (personal observation). In Spain, 80% of the road accidents occurred between 6h00 and 0h00 (DGT, 2009). In France, Charbotel, Martin, Gadegbeku, and Chiron (2003) found that 87% of the accidents occurred between 4h00 and 18h00. Night accidents were more dangerous—probably because it is more difficult to handle the traffic and the animals. Our results do not allow us to know whether the accidents studied were due to excess speed. However, speeding is a major road safety problem throughout Europe (European Transport Safety Council, 1995). Several studies have concluded that accident frequency increases with mean speed of traffic (Elvik & Vaa, 2004**21**. Elvik, R. and Vaa, T. 2004. *Costs and benefits: The handbook of road safety measures*. Oxford, , UK: Elsevier Science..

View all references). It is important to underline that livestock vehicles support enormous weights, which helps to make them unstable and more difficult to maneuver. Both of those problems become worse at high speed. However, speeding may be more probable in smaller vehicles because they are more versatile and easier to drive than articulated vehicles. This suggests that excess speed in small vehicles carrying bovine could be a cause of the accidents reported in Cluster 2. The most important determining factor in controlling vehicle speed (the driver) can be improved through training. Vehicle operators who have implemented speed-reduction policies have found benefits such as improved fuel consumption and reduced wear and tear on top of the desired reduction in accidents (Murray & Whiteing, 1995**45**. Murray, W. and Whiteing, T. 1995. Reducing commercial vehicle accidents through accident databases. *Logistics Information Management* , 3: 22–29. [CrossRef]
View all references).

Fatigue has been suggested as one of the main causes of livestock vehicle accidents. Woods and Grandin (2008)**59**. Woods, J. and Grandin, T. 2008. Fatigue: A major cause of commercial livestock truck accidents. *Veterinaria Italiana* , 44: 259–262. [PubMed]
View all references found that 59% of all accidents occurred between 12h00 and 6h00 in Canada and the United States and that driver fatigue was the main cause. Nonetheless, Häkkinen, and Summala (2001) found that accidents were associated with day driving, young drivers, and chronic health problems in older drivers and not always prolonged transport during the night. According to our results, fatigue appears to play a role but not just associated with night driving, as argued by Woods and Grandin. Driver fatigue can also be associated with other factors such as intense schedules, poorly designed routes, and high levels of pressure by companies. Thus, driver fatigue is associated not only with lack of sleep but also with stress (Cockram et al., 2004**10**. Cockram, M. S., Baxter, E. M., Smith, L. A., Bell, S., Howard, C. M., Prescott, R. J. and Mitchell, M. A. 2004. Effect of driver behaviour, driving events and road type on the stability and resting behaviour of sheep in transit. *Animal Science* , 79: 165–176.

View all references; Gustafsson, 1997**30**. Gustafsson, B. 1997. The health and safety of workers in a confined animal system. *Livestock Production Science* , 49: 191–202. [CrossRef]
View all references).
In Cluster 1, most accidents involved rigid vehicles; in Cluster 2, most involved small vehicles. Probably this is because most cattle transport in Spain involves small companies with one to two vehicles that are smaller in size than pig-transport vehicles (Villarroel et al., 2001**57**. Villarroel, M., María, G. A., Sierra, I., Sañudo, C., García-Belenguer, S. and Gebresenbet, G. 2001. Critical points in the transport of cattle to slaughter in Spain that may compromise the animals’ welfare. *Veterinary Record* , 149: 173–176. [CrossRef], [PubMed], [Web of Science ®], [CSA]
View all references). Smaller vehicles are more prone to sudden braking or changes in speed (Gras et al., 2006**29**. Gras, E. M., Sullman, J. M., Cunill, M., Planes, M., Aymerich, M. and Font-Mayolas, S. 2006. Spanish drivers and their aberrant driving behaviours. *Transportation Research Part F: Traffic Psychology and Behaviour* , 9: 129–137. [Web of Science ®]
View all references), which is also reflected in our results. Most accidents that involved collisions also involved smaller vehicles and cattle (Cluster 2) in contrast to pigs (Cluster 1), where most accidents involved overturned vehicles. However, many vehicles overturned in both clusters, which confirms the hypothesis that driver fatigue is one of the main causes of accidents.

The high proportion of animals who remain on the road after an accident involving pigs (>70%) has important implications for road safety. Although quite large, these animals may be difficult to see or avoid (short legs and compact body), which underlines the need to develop protocols to contain animals after accidents. In Cluster 2, more animals were slaughtered on site, which suggests a certain amount of suffering for cattle, although this procedure was often carried out to avoid risks to other vehicles. If procedures could be developed to contain animals more effectively after an accident, we may be able to decrease the levels of mortality on the road.
Livestock vehicle accidents require the joint training of multidisciplinary teams to help decrease confusion and attend to victims efficiently (Emergency Management Institute, 2008). However, these situations are usually unexpected, and effective action is not always possible (Cooper & Cooper, 2007**12**. Cooper, J. E. and Cooper, M. 2007. *Introduction to veterinary and comparative forensic medicine*. Oxford, , UK: Blackwell.. [CrossRef]
View all references). The characteristics of the load will affect the type of emergency action because the animals who survive are excited, injured, and difficult to contain and attend. As a result, livestock vehicle accidents can generate important effects in the media and often underline the lack of training of emergency personnel, which also degrades the image of the industry. In recent years, many organizations (European Federation of Veterinarians) have proposed reducing journey times for livestock—this being a critical point for animal welfare (Appleby, Cussen, Garces, Lambert, & Turner, 2008**1**. Appleby, M. C., Cussen, V., Garces, L., Lambert, L. A. and Turner, J. 2008. *Long distance transport and welfare of farm animals* Wallingford, , UK: CABI.. [CrossRef]
View all references; Cockram, 2007**9**. Cockram, M. S. 2007. Criteria and potential reasons for maximum journey times for farm animals destined for slaughter. *Applied Animal Behaviour Science* , 106: 234–243. [CrossRef], [Web of Science ®]
View all references; Speer, Slack, & Troyer, 2001**53**. Speer, N. C., Slack, G. and Troyer, E. 2001. Economic factors associated with livestock transportation. *Journal Animal Science* , 79: E166–E170.

View all references). Nonetheless, there is a growing tendency to decrease the number of abattoirs and increase transport time (Villarroel et al., 2001**57**. Villarroel, M., María, G. A., Sierra, I., Sañudo, C., García-Belenguer, S. and Gebresenbet, G. 2001. Critical points in the transport of cattle to slaughter in Spain that may compromise the animals’ welfare. *Veterinary Record* , 149: 173–176. [CrossRef], [PubMed], [Web of Science ®], [CSA]
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CONCLUSIONS AND IMPLICATIONS

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The results of this study indicate that the characteristics of livestock vehicle accidents vary according to species. Prevention and rescue protocols should be developed to take this into account. One of the main causes of accidents is driver fatigue, which is due to several factors such as intense workdays, poorly designed route plans, or high levels of pressure from companies. Thus, the industry should take actions to establish the work conditions of these drivers, with special references to rest times and driver shifts. To prevent accidents and control their consequences, appropriate programs should be developed to train drivers and emergency staff, emphasizing the handling of animals undergoing stress, pain, and suffering. All that should be oriented to minimize the consequences of accidents for animal welfare and improve human safety.

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Notes

^aMann-Whitney test.
^{*}*p* ≤ .05.
^{**}*p* ≤ .01.

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