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Commuting accidents of Spanish professional drivers: when occupational risk exceeds the workplace

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Background. Work traffic accidents are an issue both in Spain and all over the world, and specific evidence on commuting accidents is scarce. Even though both industrial safety and welfare have been improved during the last decades, the commuting accidents rate is growing worldwide. *Purpose*. The aim of this study was to examine and describe the characteristics of commuting traffic crashes of Spanish professional drivers. *Materials and methods*. For this cross-sectional study, commuting accidents suffered by drivers during the last 12 years were analyzed. Crossed and heatmap-based analyses were performed in order to establish patterns and driver-based differences among commuting crashes. *Results*. Commuting crashes' features were found to be associated with demographic and job-related variables of professional drivers. Drivers' gender, time slots (peak/off-peak hours) and the specific hour of the event explained different trends in accident severity and characteristics. *Conclusions*. The results of this study suggest that commuting accidents involving professional drivers differ in demographic and situational issues from general and on-duty professional drivers' traffic crashes. Also, since in Spain commuting crashes are occupational accidents, more numerous and better actions should be taken in this regard, especially considering the association of professional drivers' accidents with fatigue and shift-working.

Keywords: commuting accidents; professional drivers; driver features; working conditions; traffic crashes; traffic injuries

1. Introduction

Commuting accidents can be understood as accidents occurring during the displacement to/from work, which result in death or personal injuries [1]. During recent decades, the evidence has shown that commuting accidents are, to a large extent, road traffic crashes [2]. This fact is objective considering that, worldwide, most workers go to work using the road, both as passengers of a private or public transportation means or driving their own vehicles [1].

Although workplace causalities are decreasing, as a consequence of different regulations and improvements in industrial safety, work-related commuting accidents seem to show a growing tendency in many countries, including Spain. It is estimated that, in the European Union (EU), there are more than 200 million active workers, and about 50,000 million commuting trips take place every year [3]. In Spain alone, during the year 2018 almost 70,000 occupational traffic crashes took place, 3.7% more than in 2017, and most of them (around 51,000) happened while the victims were commuting to/from the working place. Regarding numbers, these accidents left 146 deceased and 82,133 injured workers as a result, 1022 of them suffering severe injuries. Meanwhile, different factors related to both working conditions and transportation dynamics seem to suggest that this trend may continue to increase during the next years [4]. Following an applied perspective, the task of reducing the number of work injuries largely depends on the available knowledge of their causal factors and dynamics.

However, until now only few studies have explored the factors associated with commuting traffic accidents in professional drivers. In addition, much of the available evidence comes from small-scale research studies based on convenience samples, whose results are restricted to transport companies or specific occupational subgroups (e.g., bus or truck drivers); therefore, external validity is considerably limited, considering the specificity and lack of heterogeneity of working conditions.

In this regard, it is worth mentioning that the case of commuting accidents of professional drivers is certainly special, if we bear in mind that it implies the occurrence of a traffic accident taking place before or after a working schedule which already consists of driving a motor vehicle. Regarding this, the empirical evidence has stated different factors potentially modulating and increasing the crash risk, such as fatigue, driving stress and overstimulation due to traffic-related elements as a consequence of prolonged driving taking place during the work-shift.

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1.1. Holding the risk: fatigue and health problems in professional driving

Since rest and recovery are closely related to job performance [5,6], fatigue and sleep problems are considered relevant risk factors for job-related causalities and injuries [7]. Concretely, fatigue has been described by several studies as a highly prevalent problem among different occupational groups, including professional drivers [8–10].

Also, fatigue and inadequate rest have been linked with negative consequences for physical health, including musculoskeletal problems and decreased strength [11,12], increased mortality, cardiovascular problems [13], diabetes and obesity [10]. In the field of mental health, the fatigue of workers has been closely related to emotional alterations [14] and higher rates of work stress and burnout [15]. On the other hand, work-related fatigue has been associated with reduced rates of attention/recurrent distractions [11] and lower job satisfaction [16]. Furthermore, and also regarding what concerns the occupational field, fatigue has been empirically linked to a substantial increase of absenteeism and sick-leave [17,18], poor job performance and elevated rates of occupational accidents [7].

1.2. Shift work: increasing the risk of commuting crashes

Different empirical studies have systematically shown how fatigued drivers are more prone to perform risky road behaviors and, subsequently, to suffer traffic crashes, than those reporting adequate periods of rest and sleep [9,19–21]. Focusing on the specific field of professional driving, work-related fatigue is largely elicited by shift work; this means being engaged in non-standard working hours [22]. In this regard, and bearing in mind the nature of transport dynamics, these unfavorable conditions largely depend on, e.g., peak and off-peak hours, meteorological conditions and unexpected demands: professional drivers constitute one of the workforces in which shift work is more prevalent worldwide [21].

Shift work and long working hours not only decrease job performance [5], but also consequently increase the risk of industrial accidents: Ryu et al. [23] have shown that shift-workers may present up to 2.7 times more probability of suffering work injuries.

Furthermore, shift work may enhance the problematic transition between acute and chronic fatigue through the alteration of circadian rhythms and resting periods [2], the prolonged exposure to high job demands being summed with insufficient resting cycles; this may result in chronic symptomatology that is difficult to treat [14]. Also, as several symptoms linked to work-related fatigue of shift-workers are usually pharmacologically treated [24], the driving task could be severally impaired as a consequence of the effects or side-effects of pharmacological products, thus increasing even more the risk of suffering traffic crashes during commuting trips [25,26].

1.3. Demographic differences in commuting accidents

While commuting accidents constitute a current problem for the occupational health of all workers, different studies have examined key differences regarding the demographic features of road users who suffer this kind of crash. In brief, the evidence suggests that, although gender (being a male driver) remains a powerful predictor of commuting accidents, social phenomena such as the growing number of women employees and/or drivers have substantially modified the features of commuting crashes in Europe [27].

Also, the age of the driver largely explains differences in risk perception, risk-taking, overconfidence and risky road behaviors such as infringing traffic norms while driving, with young drivers being those who tend to present riskier driving profiles [28]. On the other hand, work injuries have been found to affect and rebound more severely in the case of older people, considering factors such as their higher fragility and passive vulnerability, typical of later life stages [29]. Furthermore, work-related accidents of professional drivers have proven to be associated with differences in both working conditions and psychosocial factors at work, such as monotonous and repetitive tasks, time pressure, work stress or job strain under the Karasek's [30] demand–control approach, social support [31], interaction with other road users, night shifts during which on-trip visibility is highly reduced and adverse weather conditions [32].

Nevertheless, several gaps still need to be filled in this regard. While the scientific literature has recently addressed with more rigorousness and broadness the public health problem of occupational accidents suffered by professional drivers, the scope looks quite reduced to the mere study of on-duty crashes (between the beginning and the ending of the work schedule), especially if we keep in mind several factors such as the difficulty of researching events occurring outside the work environment and the always challenging problem of under-reporting, mostly in the case of near-misses and minor incidents, i.e., underestimated events that could easily have resulted in accidents of greater severity.

1.4. Objective of the study

Responding to these gaps in the literature on road and occupational safety, the aim of this study was to examine the characteristics of 588,997 communing traffic crashes involving Spanish professional drivers. It is expected that the results of the research will be useful to establish priorities and intervention strategies focused on reducing the fatality and morbidity associated with commuting accidents in this vulnerable occupational group.

2. Methods and materials

2.1. Data and case selection ('sample')

The data were collected from the full electronic declaration of injured workers (DELTA) database, obtained from the Ministry of Labor, Migration and Social Security of Spain. The DELTA database summarizes a total of 588,997 commuting traffic crashes involving professional drivers aged between 18 and 82 years (age range) during the 12-year period 2005–2016. In Spain, data on traffic accidents with victims are collected by police officers who arrive at the place of the accident, using a structured questionnaire that investigates the possible determinants (environmental, mechanical and individual) of the traffic crash.

2.2. Ethics

To carry out this study, the Social Science in Health Research Ethics Committee of the University of Valencia was consulted, certifying that our research – linked to the project entitled 'training, occupational psychosocial factors, health and safety of professional drivers' – responded to the general ethical principles currently relevant to research in social sciences, and certifying its accordance with the Declaration of Helsinki. This issued a favorable opinion to carry out the study (IRB approval number H1535548125595). Personal and/or confidential data were not used for this study.

2.3. Statistical analysis (data processing)

Descriptive analyses (frequencies and percentages) were performed first, in order to analyze the basic features of commuting accidents involving professional drivers. The correlational bivariate analysis (Pearson correlation) was used to establish measures of association between numeric study variables. Furthermore, χ^2 independence tests (with differential significance level criteria for $p < 0.05$, $p < 0.01$ and $p < 0.001$) were carried out to compare categorical factors. Finally, a heatmap analysis was used for studying the time distribution of: (a) the overall traffic crashes suffered by professional drivers; (b) the commuting crashes; (c) the fatalities in commuting crashes. Statistical analyses were carried out using SPSS version 24.0.

3. Results

Firstly, descriptive results of the data are presented. Regarding gender, a total of 315,121 (53.5%) of these accidents were suffered by male drivers and 273,876 (46.5%) by female drivers. Regarding crash severity, 574,528 (97.4%) of the commuting crashes were considered mild (simple), 11,617 (2.1%) serious, 755 (0.1%) very serious and 2097 (0.4%) fatal (including fatal victims). The mean age of professional drivers involved in commuting accidents was 34.97 (*SD* 10.45) years. Regarding their tenure at the current job, the mean time was 4.19 (*SD* 6.22) years; 8.5% of them had spent less than 1 month in their current position, 32.6% less than 1 year, 21.3% between 1 and 3 years, and 37.6% more than 3 years. As regards the type of accident, all of the analyzed crashes corresponded to commuting (*in itinere*) events, i.e., on the way from or to the workplace [33].

3.1. Correlational analysis

The Pearson' association coefficients (bivariate correlations) are presented in Table 1. In this regard, significant associations were found between demographic factors, work-related factors and commuting crash-related features. Specifically, the professional drivers' age and work tenure (years of service) were positively and significantly associated with the length of sick leave, and negatively correlated to the number of victims involved in crashes. On the other hand, more severe commuting crashes tended to involve drivers working in smaller companies, represent more sick-leave days for the driver and, also, involve a greater amount of road users. Finally, it is worth mentioning that more severe commuting crashes were negatively associated with the age and work tenure of professional drivers; in other words, the more limited the drivers' experience, the more severe the commuting crash suffered.

3.2. Gender comparisons

The cross-analysis of categorical variables revealed key gender-based differences regarding the characteristics of the commuting crashes suffered by professional drivers. Firstly, commuting crashes showed a tendency for higher severity among male drivers ($X_{(3)}{}^2 = 2819.98$; $p < 0.001$). Secondly, regarding injuries derived from commuting accidents, male drivers were significantly more prone than women to be involved in commuting crashes involving hospitalized victims ($X_{(1)}{}^2 = 4115.16$; $p < 0.001$). Thirdly, and as regards the time slot in which commuting accidents take place, male drivers were significantly more prone to suffer commuting accidents during the night than their female counterparts, but female drivers tended to report higher rates of commuting crashes during daylight hours ($X_{(1)}{}^2 = 3144.73$; $p < 0.001$). Specific frequencies and proportions are presented in Table 2.

3.3. Fatal commuting crashes in peak vs off-peak hours

Commuting accidents not only present significant differences when compared according to the individual features of professional drivers, but also when traffic flows are considered a potential modulator of crash severity. In addition to the fact that 51.51% of commuting accidents occur during peak hours (see Table 3), χ^2 analysis revealed that the severity of commuting crashes is significantly higher

Table 1. Bivariate (Pearson) correlations between demographic, work and crash severity-related features.

			1	2	3	4	5	6
1	Age (years)	σ	1	0.475**	0.038**	0.118**	−0.011**	0.067**
		p	–	0.000	0.000	0.000	0.000	0.000
2	Work tenure (months)	σ	–	1	0.007**	0.057**	−0.047**	0.088**
		p	–	–	0.000	0.000	0.000	0.000
3	Crash severity (level)	σ	–	–	1	0.189**	0.028**	−0.010**
		p	–	–	–	0.000	0.000	0.000
4	Sick leave (days)	σ	–	–	–	1	0.003*	0.004**
		p	–	–	–	–	0.013	0.001
5	Involved people (number of victims)	σ	–	–	–	–	1	−0.021**
		p	–	–	–	–	–	0.000
6	Size of the company (number of workers)	σ	–	–	–	–	–	1
		p	–	–	–	–	–	–

*Correlation significant at 0.05 level (two-tailed).
**Correlation significant at 0.01 level (two-tailed).
Note: σ = Pearson's correlation coefficient; p = two-tailed.

Table 2. Gender-based comparisons for commuting crash features.

			Gender		
Feature	Value	Item	Female	Male	Total
Crash severity	Mild	*N*	270,267	304,261	574,528
		%	98.7	96.6	97.5
	Serious	*N*	3029	8588	11,617
		%	1.1	2.7	2.0
	Very serious	*N*	205	550	755
		%	0.1	0.2	0.1
	Fatal	*N*	375	1722	2097
		%	0.1	0.5	0.4
	Total	*N*	273,876	315,121	588,997
		%	100	100	100
Requiring hospitalization	No	*N*	263,788	291,195	554,983
		%	96.3	92.4	94.2
	Yes	*N*	10,088	23,926	34,014
		%	3.7	7.6	5.8
	Total	*N*	273,876	315,121	588,997
		%	100	100	100
Time slot	Daylight	*N*	214,537	226,839	441,376
		%	78.3	72.0	74.9
	Night	*N*	59,339	88,282	147,621
		%	21.7	28.0	25.1
	Total	*N*	273,876	315,121	588,997
		%	100	100	100

Note: *N* = absolute frequency; % = relative percentage (within gender value).

Table 3. Time (peak/off-peak) comparisons for commuting crash severity.

			Time interval		
Variable	Value	Item	Non-fatal	Fatal	Total
Crash injuries	Off-peak	*N*	284533	892	285,425
		%	99.7	0.3	100
	Peak	*N*	302,367	1205	303,572
		%	99.6	0.4	100
	Total	*N*	586,900	2097	588,997
		%	100	100	100

Notes: *N* = absolute frequency; % = relative percentage (within gender value).

during peak hours ($X_{(1)}^2 = 26.14$; $p < 0.001$), when compared to those accidents taking place during off-peak time slots.

3.4. *Trends in professional drivers' crashes, commuting crashes and severity by time of the day*

The heatmap analysis allowed us to identify frequency-based trends in the hourly distribution of traffic crashes suffered by professional drivers. In the first moment, and regardless of their typology, the crashes involving professional drivers registered in Spain were analyzed, finding an unvarying tendency to increase over 5% through a single cluster (cluster 1a) located between 08:00 and 19:59. Frequency of accidents by night mostly oscillated between 1 and 3% in the interval 20:00–00:00 and between 0 and 1% in the interval 00:01–04:59.

As regards commuting crashes of professional drivers, two frequency-based clusters were identified: the first (cluster 2a), ranging between 7.4 and 14% of commuting crashes, was established between 07:00 and 09:59; the second cluster (cluster 2b), that ranges between 5.2 and 10.4% crashes per hour, was established in the time lapse from 13:00 to 15:59.

Finally, and regarding severe commuting accidents involving fatal victims, the tendency slightly varies from the frequency-based distribution of commuting crashes, analyzed regardless of their severity (see Figure 1). Three clusters were found: a first cluster (cluster 3a), located from 07:00 to 08:59, ranged between 12.9 and 14.3% of fatal accidents. A second group of highly frequent commuting crashes (cluster 3b) was found in the interval 14:00–15:59, and grouped between 6.5 and 7.5% of them. The last cluster (cluster 3c) ranged between 19:00 and 19:59, and grouped 6.7% of the total number of fatal commuting crashes registered.

4. Discussion

The objective of this study was to examine the characteristics of commuting traffic crashes suffered by Spanish professional drivers. Based on the analysis of the available records, it was possible to identify key facts and factors characterizing commuting crashes and their severity. Overall, commuting crashes involving professional drivers have both similarities and differences with on-duty accidents, and some driver-related features seem to explain differential risks for what concerns their severity and consequences.

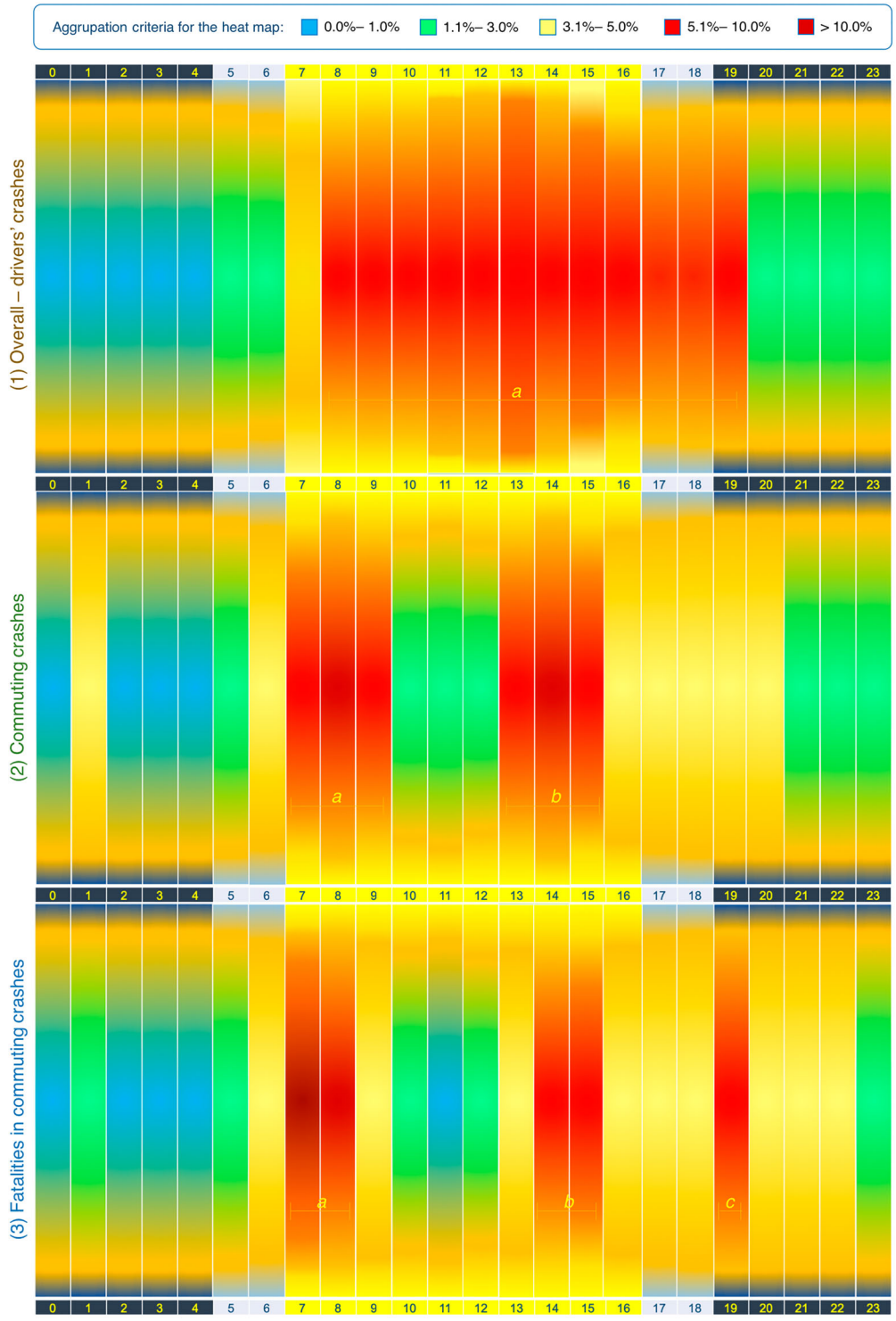
4.1. *Drivers' features, crash severity and gender disparities*

Regarding job experience, we found that 44.3% of fatal commuting crashes were suffered by professional drivers with 10 years or less of work tenure. In accordance with this, occupational safety-related studies dealing with different occupational groups have already stated that job experience appears to play a protective role [31,34,35]. Nevertheless, the correlational analysis has shown that, talking about accidents that are not necessarily fatal but mostly involve injured victims, the longer the work tenure, the more severe the commuting accidents and the longer the sick leave periods of involved professional drivers tend to be. In this regard, commuting crash severity is also modulated by demographic factors. Through the cross-analyses, this study established gender-based differences in the severity of commuting crashes. Both in the case of crash severity and in the number of hospitalized victims as a result of the crash, males were significantly more prone to present this adverse outcome once suffering a commuting accident. These results were consistent with other studies addressing gender differences in commuting factors, whose findings describe, overall, a major risk or probability of suffering occupational-related injuries – including commuting crashes – for male workers in almost all of the productive sectors [27]. However, in the light of recent evidence on this rising phenomenon that in 2018 involved almost 70,000 Spanish workers [4,36], commuting crashes suffered by female professional drivers cannot be underestimated. It captures our attention that about one out of six (17.9%) commuting accidents of professional drivers are suffered by women, while the participation of female workers represents only a small proportion of the active working population in the transport industry. In brief, and although gender disparity is progressively decreasing, in most countries male drivers constitute more than 90% of the active workforce [37,38].

4.2. *Time of the crash, particularities of commuting accidents and the high fatigue risk*

This study has shown that commuting accidents substantially differ from overall (including on-duty) traffic crashes suffered by professional drivers. As has been established by means of the heatmap analysis used to test time slots and severity of crashes of professional drivers, on the one hand the overall number of crashes involving them is almost uniformly distributed between 08:00 and 19:59 (cluster 1a), while commuting accidents are highly clustered in two different time clusters: 07:00–09:59 (cluster 2a) and 13:00–15:59 (cluster 2b).

Furthermore, commuting crashes involving fatal victims are clearly located in three hourly clusters: 07:00–08:59 (cluster 3a), 14:00–15:59 (cluster 3b) and 19:00–19:59 (cluster 3c). It is striking that, although morning off-peak hours involve higher traffic flows, compared to cluster 1a, clusters 2a and 3a present a higher concentration of, respectively, commuting crashes and fatal commuting crashes (starting 1 h before cluster 1a), a set of facts that allows us to hypothesize the potential presence of



Hour of day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
(1) All crashes (%)	0.9	0.6	0.6	0.5	0.6	1.1	1.9	4.1	6.1	6.8	6.7	7.6	7.9	8.2	7.2	5.9	5.8	5.7	6.0	5.5	4.2	2.9	1.9	1.3
(2) Commuting crashes (%)	0.7	3.9	0.6	0.5	0.6	1.5	3.3	9.9	14.0	7.4	2.6	1.5	1.9	5.2	10.4	9.7	4.8	3.3	4.3	4.6	3.4	2.4	2.5	1.2
(3) Commuting fatalities (%)	0.8	3.0	0.7	0.7	0.8	2.0	6.2	14.3	12.9	4.8	1.6	1.0	1.3	3.8	6.5	7.5	4.8	3.5	4.2	6.7	4.3	3.1	3.5	1.9

Figure 1. Hourly distribution of the overall number of crashes of professional drivers (PDs) in Spain (top, cluster 1a), commuting crashes (middle, clusters 2a and 2b) and fatalities in commuting crashes involving professional drivers (bottom, clusters 3a, 3b and 3c). Note: The full color version of this figure is available online.

inadequate rest and recovery, very close to what Zuzewicz et al. [39] found when working with Polish professional drivers. In accordance with what we have stated, this last topic has been addressed by several studies focusing on problems such as inadequate sleep or complete lack of sleep before morning shifts as potential predictors of risky driving behaviors [9], or as impairments to the driving performance and/or predictors of traffic causalities among professional drivers [40–42]. In this regard, e.g., the Transport Accident Commission [43] recommends an average amount of 8 h of good-quality sleep as a safe measure for driving.

Nevertheless, in the case of professional drivers, the compliance with hours-of-service regulations is usually impaired by different factors [7], such as shift-working [20,21,44], sleep disorders [19,24] and irregular circadian rhythms that may be potentially altered, among other factors, by prolonged fluctuating shifts, fatigue and excessive awake periods [13,42].

These outcomes also suggest the need for developing adequate occupational measures for the management of fatigue, stress and adverse working conditions derived from infrastructural and traffic conditions, and other factors that may potentially appear during commuting trips. In other studies, which also address traffic crashes of professional drivers, it has been highlighted that there is a need to improve road training, fatigue monitoring and enhancement of sleep and inter-shift resting periods [39,45,46], especially considering that, in the case of professional drivers, commuting trips represent very closely an extension of the already demanding driving task.

5. Conclusions

The results of this study allowed us to establish that commuting accidents substantially differ from overall (including on-duty) traffic crashes suffered by drivers. A high proportion (44%) of commuting crashes were suffered by drivers with less than 10 years of tenure, thus highlighting the importance of job experience and training as protective factors.

Two critical hourly clusters for commuting crashes were identified: one ranged between 07:00 and 09:59, and the other between 13:00 and 15:00. Also, fatal commuting crashes occurring during peak hours were slightly more frequent than those suffered during off-peak time slots.

Regarding gender differences, results showed that commuting accidents suffered by male drivers tend to be more severe than those reported by females.

6. Practical implications

Although in Spain commuting crashes are already legislated as occupational accidents (which is already a great step forward for the protection of workers), more numerous and better actions should be taken in this regard, especially considering the association of professional drivers' accidents with highly prevalent phenomena such as fatigue and shift work. In this regard, the outcomes of this study allow us to propose three main scenarios for future actions, in order to reduce communing crashes within this type of workforce.

Firstly, it is worth considering specific factors linked to the work environment of professional driving. This article remarked on the role of, e.g., time pressure and fatigue as potential enhancers of commuting accidents. In this regard, measures such as schedule flexibility and adequate rest/recovery periods between trips have shown, in the past, a certain effectiveness in reducing on-duty accidents. However, the habit of 'having a break' and other similar practices are rarely carried out at the end of the workday, i.e., before commuting from work. Thus, we suggest that brief resting periods at the end of the work schedule – before the last driving shift – could be implemented as well.

Secondly, on the other hand, we saw from the heatmap how a large amount of commuting crashes (including a high proportion of the most severe ones) happen during the displacement to work. Our findings and the theoretical background followed in the study suggest that, apart from the high levels of fatigue that transport workers are prone to develop during the workday, insufficient recovery could be an important issue to address through occupational health strategies.

Finally, companies should be encouraged to extend their occupational prevention plans in what concerns the commuting trips of workers [27], offering friendly alternatives and benefits (e.g., shuttle services, collaborative commuting, replacement drivers for cases of sickness or excessive fatigue) and providing training to strengthen the drivers' awareness on potential risks and decision-making, thus enhancing their ability to cope with such situations (e.g., 'am I in a good condition to drive for 1 h more after 8 h of service?'), as preventive ways of contributing to the decrease of commuting crashes.

7. Limitations of the study and further research

Although our sample size was considerably large, and all statistical parameters were accurately and positively tested during the treatment of data, some specific issues should be listed as potential sources of bias.

Firstly, research on traffic accident severity based on police reports may be biased by under-reporting problems. In particular, it has been found that, in many cases, police officers do not record full information about the accident when they perceive that the situation is of little consequence [47,48].

However, the under-reporting of information is much less frequent in accidents involving fatal injuries. In this regard, Elvik and Mysen [49] found 97% concordance

between police and hospital reports of fatal traffic accidents in Norway. On the other hand, the lack of occupational data for the professional drivers (e.g., seniority, driving experience, previous accidents and infractions) limits knowledge on the predictors of work traffic accidents.

Finally, naturalistic studies based on detailed observation protocols could shed light on work traffic accident factors that have been barely researched, such as driving performance, concentration, fatigue and decision-making under adverse and risk-related conditions.

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