

Fatigue among HGV drivers in Norway and Greece: examining the influence of national road safety culture

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Abstract

Fatigue is a risk factor involved in 10-25% of all road crashes. The aim of the present study is to examine factors influencing fatigue among HGV drivers in Norway and Greece, focusing especially on the role of national road safety culture. The study is based on survey data (N=201) and qualitative interviews (N=18) with HGV drivers in Norway and Greece. As previous studies indicate higher levels of aggression and conflicts in the Greek National RSC, we hypothesize that this will be related to higher levels of fatigue among the Greek drivers, as the National RSC is more exhausting. Results from logistic regression analyses support our hypothesis, indicating a relationship between National RSC and fatigue, controlled for the several key variables (e.g. work pressure, driving hours, type of transport). This conclusion is also supported by the results of the qualitative interviews, where Greek drivers report of an exhausting traffic environment, involving aggression and conflicts.

Keywords: *Driver fatigue, National road safety culture; road safety behaviours, Norway, Greece, heavy goods vehicle drivers.*

1. Introduction

1.1 Background and aims

Fatigue has been found to contribute to a substantial share of accidents involving professional drivers in road transport, and its detrimental effect on vigilance is a potential threat to safety (Sagberg et al., 2004). The implications of severe sleepiness for transport operator performance can be as serious as those caused by high alcohol levels (Dawson & Reid, 1997; Williamson & Feyer, 2000).

Studies have for instance reported that fatigue is a risk factor involved in 10-25 % of all road crashes. International research shows that between 36 and 64 % of professional drivers report having fallen asleep behind the wheel one time or another (Sagberg & Bjørnskau 2004). The share is higher among professional drivers than among private drivers (23-52%), as the former drive longer distances (Sagberg & Bjørnskau 2004). Sleep-related crashes are on the average more serious than crashes caused by other factors, due to the fact that they often occur under conditions of relatively high speed (e.g., rural roads with little traffic). The most frequent sleep-related crash type is driving off the road. In order to be able to implement measures to control this important risk factor, it is crucial to develop knowledge about the factors influencing driver fatigue.

There is a vast research literature on tiredness, drowsiness, fatigue and sleepiness, and these terms are often used interchangeably. Because of its undoubted importance in serious transport accidents, many researchers have narrowed their operationalization of fatigue to the concept of sleepiness, some arguing that it is by far the most important contributor to fatigue-related accidents (Dawson & McCulloch, 2005). Other scholars highlight additional aspects of fatigue, in addition to sleepiness, e.g. local physical fatigue, e.g. in a skeletal muscle, general physical fatigue, mental fatigue induced by a long-lasting high mental workload, or “central nervous system” fatigue, normally referred to as sleepiness (Phillips et al 2015).

These different aspects of fatigue indicate that driver fatigue may have a range of different causes, which may be related to different outcomes. The experience of fatigue itself has several dimensions, with fatigued people reporting that they are cognitively, emotionally or physically tired to different extents. The most frequently identified causes of HGV driver fatigue that have been identified in previous research are drivers’ (old) age, sleep history, long working hours, limited resting opportunities, type of transport (e.g. long distance transport), time pressure, pay structures, customer demands, stress induced by the work activities and the traffic environment (e.g. monotonous or stressful environment) (Nordbakke 2004; Moe 2006; Jackson et al 2011).

In this study, we contribute to the line of research examining the influence of the work activities and the traffic environment on (mental) fatigue, by focusing specifically on the influence of national road safety culture. Previous studies indicate that some traffic safety cultures may be more exhaustive to drive in than others, e.g. due to the nature of the interaction between road users. Studies comparing road safety behaviours in northern and southern European countries have found higher prevalence of aggressive violations (e.g. become angered and indicate hostility to other road users, e.g. by following them, sounding the horn to indicate annoyance) in the southern European countries (Warner et al 2011, Özkan et al 2013). These types of aggressive violations are related to accident involvement (Warner et al 2011). Nævestad et al (2019) conclude that the Greek national RCS is characterized by a higher level of aggressive violations. They define (RSC) as shared patterns of behaviour, shared norms prescribing certain road safety behaviours and thus shared expectations regarding the behaviours of others.

In the present study, we examine whether differences in RSC also may have repercussion for drivers’ fatigue, more specifically, we examine whether an RSC with a high level of aggression and conflicts among drivers is more exhaustive to drive in, creating a higher level of fatigue. The relationship between national RSC and fatigue has never been examined before in previous research, and the present study therefore contributes to the research on fatigue by also providing information about the importance of the road environment and the road user interaction for fatigue, or more specifically the importance of national RSC for fatigue.

The aim of the present study is to examine the factors influencing fatigue among HGV drivers in Norway and Greece, focusing especially on the role of national road safety culture.

We compare drivers in Norway and Greece, as we know from previous research that the RSCs in these countries differ when it comes to the level of aggressive violations (Nævestad et al 2019). Norway and Greece were selected for comparison by Nævestad et al (2019a) since the road safety status in the two countries differ significantly. Norway had the lowest road mortality rate in Europe with 20 road deaths per million inhabitants in 2017, and the lowest road death

risk (ETSC 2018). In comparison, the mortality rate in Greece in 2017 was 69 road deaths per million inhabitants, which was well above the EU average of 50 (ETSC 2018).

1.2 Previous research

1.2.1 What is fatigue?

Based on Phillips et al (2015), we define fatigue as a suboptimal psychophysiological condition caused by exertion. The degree and dimensional character of the condition depends on the form, dynamics and context of exertion. The context of exertion is described by the value and meaning of performance to the individual; rest and sleep history; circadian effects; psychosocial factors spanning work and home life; individual traits; diet; health, fitness and other individual states; and environmental conditions. The fatigue condition results in changes in strategies or resource use such that original levels of mental processing or physical activity are maintained or reduced.

1.2.2 Factors influencing fatigue

Age Nordbakke (2004) finds that the risk of falling asleep behind the wheel decreased with increasing age for professional drivers. She concludes that more work experience seems to enable professional drivers to become aware of fatigue, and deal with it effectively. Interestingly, on the other hand, Moe (2006) found that the more experience bus drivers had, the more exhausted and tired they reported to be. One explanation may be that even though older drivers are more tired, they are better at preventing tiredness from affecting driving performance.

Sleep history. Occupational factors are thought to be a predictor of daytime sleepiness, insomnia and sleep duration, which suggests that the organisation can influence driver fatigue by helping determine sleep history (Kronholm et al., 2006). In the analysis by Ursin et al. (2009), it was found that professional drivers in Norway slept less than leaders (in different occupations) and service workers. Rise times, but not bedtimes, were also earlier for drivers than for service workers and leaders. Twenty-four per cent of drivers, versus only seven per cent of leaders, had less than six hours sleep on a normal weekday night.

Type of transport (and road environment). Nordbakke (2004) found that the risk of falling asleep behind the wheel (at any time in career) was higher for long distance drivers (42 per cent) than for local transport drivers (34 per cent). Reports of falling asleep behind the wheel were also higher for HGV drivers (44 per cent) than for bus drivers (31 per cent). This may be due to the monotonous nature of driving that the HGV drivers in the sample were exposed to, since 83 per cent of the bus drivers drove local transport. A British literature study asserts that dangerous levels of fatigue are produced by driving goods vehicles on monotonous inter urban roads that provide fewer stimuli to the driver, as they are more likely to be driven when the effects of sleepiness are most severe, and driven by male drivers who are more likely to suffer from obstructive sleep apnea (Jackson et al., 2011: 41).

Work pressure and working conditions. Pressure to carry on driving while tired is an important influencing factor found in previous research. When it comes to why professional

drivers exert themselves in the face of increasing fatigue, and violate hours of work regulations, factors found to be most important were: pressure from management (49 per cent) and an aspiration to follow time schedules (44 per cent) (Nordbakke 2004: 61). Interestingly, Anund, Kecklund and Åkerstedt (2011) also cited time pressure as a reason why drivers do not stop driving even when they are sleepy. Other studies of professional driver fatigue have focused on more indirect causes, such as time pressure, pay structures, customer/consumer demands, loading or delivery queues, inadequate drivers numbers, poor shift schedule planning and management (Jackson et al., 2011). In a study of bus drivers, Moe (2006), also found stress related to harassment and passenger trouble, time pressure and a demand for high concentration levels, and higher stress loads in winter than summer to be important factors influencing fatigue.

National Road Safety Culture. The above-mentioned studies indicate the importance of type of transport and road environment and work pressure and working conditions for driver fatigue. Previous studies indicate that some traffic safety cultures may be more exhaustive to drive in than others, e.g. due to the nature of the interaction between road users. Warner et al. (2011) compare safety behaviours among private drivers in Finland, Sweden, Turkey, and Greece (each with N = 200). The study identifies nine key DBQ items that drivers from different countries rate differently. Warner et al. (2011) found a higher prevalence of aggressive violations (e.g., become angered and indicate hostility, sound the horn to indicate annoyance) and ordinary violations (pull too far out of a junction) in Greece and Turkey than in Sweden and Finland. Özkan et al. (2013) compare DBQ items in six countries: Finland, Great Britain, Greece, Iran, The Netherlands, and Turkey (each with N = 240). One of the main results from this study is that that Greek drivers reported to commit aggressive violations more often than other nationalities, especially behaviours indicating their annoyance and hostility to other road users. Nævestad et al (2019a) also found similar differences comparing the level of aggressive road user behaviours among private and professional drivers in Norway and Greece. They also found a relationship between aggressive road user behaviours and national road safety culture.

In this study, we follow their definition of RSC as shared patterns of behaviour, shared norms prescribing certain road safety behaviours, and thus shared expectations regarding the behaviours of others. Operationalizing RSC partly as descriptive norms, which refer to individuals' perceptions of what other people actually do (Cialdini 1990), we may refer to the mechanism mediating between safety culture (shared norms and expectations) and safety behaviours as "subtle social pressures" (Cialdini 1990). Descriptive norms may influence behaviour by providing information about what is normal (Cialdini 1990). It is also important to note that descriptive norms can also influence behaviour through the false consensus bias, in which individuals overestimate the prevalence of risky behaviour among their peers in order to justify their own behavior.

2. Methods

2.1 The Safe Culture project

The study was conducted within the research project "Safety culture in private and professional transport: examining its influence on behaviours and implications for interventions",

undertaken by the Institute of Transport Economics of Norway (TOI) in cooperation with the National Technical University of Athens (NTUA). Results from this project focusing on professional and private drivers in Norway and Greece have been presented in Nævestad et al (2019a) and only on bus drivers in Nævestad et al (2019b).

2.2 *Quantitative survey*

2.2.1 *Recruitment of respondents and sample*

Two surveys among professional HGV drivers from seven companies in Norway (and a group of drivers from unknown companies) and two companies in Greece were undertaken (total N=201). To have comparable companies in the two countries, the recruitment of companies was based on the following criteria: 1) The vast majority (i.e. minimum 90 %) of HGV drivers in each company should be of the main nationality (Norwegian or Greek), 2) Recruited drivers should include a mixture of drivers involved in long distance transport and distribution transport. In addition, a share of the Norwegian drivers was involved in transport of dangerous goods. We initially planned to recruit a similar group in Greece, but this was not possible.

2.2.2 *Survey themes*

Working conditions with safety implications: drivers' experiences with customer time pressure that may compromise safety, payment types (e.g., bonus for efficiency), management focus on driving style, and seat belt use.

Safety behaviours: Seven questions including questions taken from the DBQ and based on the results of previous research (Warner et al, 2011). The chosen DBQ questions were those who Scandinavian and Southern European drivers scored significantly different on, and which were related to accident involvement (Warner et al 2011).

National RSC index. In addition to drawing inferences about national RSC based on national shared patterns of behaviour (among private and professional drivers), we also measure national RSC as descriptive norms (Cialdini et al 1990), reflecting drivers' perceptions of what other drivers in our country do. The survey includes 9 questions on expectations to other road users (cf. Table 2). Seven of these reflect those used for respondents' own behavior. Five answer alternatives ranged between 1 (none-very few) and 5 (almost all/all).

Sector transport safety culture: Six questions were constructed for this survey, but they are influenced by previous research on framework conditions for transport safety in road, sea and air transport (e.g. Bjørnskau & Longva, 2009; Nævestad, Phillips & Elvebakk 2015).

Fatigue. Fatigue is measured by means of the question: «In the course of the last three months, have you fallen asleep (or dozed off for a moment) while driving a heavy goods vehicle?».

Accident involvement. We also report results for one question on respondents' crash involvement while driving in the last two years, with four answer alternatives: 1) no, 2) yes involving property damage, 3) yes, involving personal injuries, 4) yes, involving fatal injuries.

2.2.3 *Analysis*

When comparing the mean scores of different groups, we use one-way Anova tests, which compare whether the mean scores are equal (the null hypothesis) or (significantly) different.

We use hierarchical, logistic regression analyses, where independent variables are included in successive steps to examine factors influencing whether respondents have fallen asleep or dozed off while driving a heavy vehicle at work, in the last three months or not. The most basic independent variables are included first, then the other independent variables are included. Of course, we cannot conclude about causality, as this is a cross-sectional and correlational study. We nevertheless use the term predict when we describe the regression analyses.

2.2 Qualitative interviews

Ten HGV drivers from Greece and eight HGV drivers from Norway were interviewed. The purpose of the qualitative interviews was to invite interviewees to present their views on and illustrate the themes and questions in the quantitative survey with concrete examples. A central purpose was to provide additional and contextual information about national road safety culture, road user interaction, fatigue, working conditions, and work pressure. We conducted qualitative interviews to get rich descriptions of these issues. We used a semi structured interview guide. Analyzing the interviews, we compared drivers' statements on different themes within and across countries, to look for common patterns.

3. Results

3.1 Description of the sample in the quantitative survey

The majority of drivers in the survey were aged between 36 and 55 years old. However, the share of drivers between 26-35 years old was over twice as high in Norway as in Greece, while there were more Greek drivers aged 46-55 years (Table 1). The majority of the drivers have a professional experience of more than 16 years.

Table 1: Distribution of professional HGV drivers per nationality and age

Nationality	Driver's age					Total
	<26	26-35	36-45	46-55	56+	
Norwegian	3 %	25 %	31 %	34 %	8 %	101
Greek	0 %	12 %	31 %	48 %	9 %	100
Total	2 %	19 %	31 %	41 %	9 %	201

In total, about a third of the survey participants are usually driving long distance (NO: 17%, GR:52%), followed by a combination of long distance and distribution (NO:35%, GR:24%), distribution transport (NO:12%, GR:24%) The shares of long-distance transport (three times higher) and distribution transport (two times higher) are far higher in the Greek sample. In the Norwegian sample, 37% of the respondents drive dangerous goods. There are no dangerous goods drivers in the Greek sample.

The mean number or thousand km driven during the last two years by professional Greek HGV drivers is 155 000 km. The corresponding number for Norwegian drivers was 154 000. While 34% of the Greek HGV drivers reported that they own their own vehicle, only 3 % of the Norwegian drivers reported so. Accordingly, 27 % of the Greek drivers reported to be self-employed, while only 3% of the Norwegian were self-employed. 92% of the Norwegian drivers held a permanent position, while 68% of the Greek drivers did.

3.2 National road safety culture

3.2.1 Quantitative results

An exploratory factor analysis (EFA) was conducted in order to examine the underlying factor structure of the items measuring national transport safety culture. The tests indicated that the items and the data were suitable for factor analysis. Bartlett's test of sphericity (approx. Chi-square) was 872.280 ($p < ,001$). The Kaiser–Meyer–Olkin's measure of sampling adequacy showed a value of 0,806. The Eigenvalues and the scree plot indicated a two-factor solution. The two first components had an Eigenvalue higher than 1, which explained a total of 65 % of the variance. We used a principal component analysis (PCA) with Oblimin rotation, where we set the number of factors to two and the cutoff values of the factor loadings at 0,3. This produced the following result.

Table 2: Factor analysis results - national culture scale

Item “When driving in my country, I expect the following behaviour from other drivers: (Answer alternatives: 1 (none-very few) and 5 (almost all/all)).	Aggression/ Violations	Compliance/ politeness
That they sound their horn to indicate their annoyance to another road user	0,812	
That they become angered by a certain type of driver and indicate their hostility by whatever means they can	0,790	
That they overtake a slow driver on the inside	0,786	
That they drive when they suspect they might be over the legal blood alcohol limit	0,771	
That they disregard the speed limit on a motor way road	0,728	
That they drive without using a seatbelt	0,720	
That they disregard the speed limit on a residential road	0,717	
That they respect and follow traffic rules		0,907
That they are polite to other road users		0,879

We made a sum score index, based on these seven items loading on the Aggression/violations index (min: 7, max: 35). (Cronbach’s Alpha: .875). The mean score of the Norwegian HGV drivers on the index was 15.5 points, while the mean score of the Greek HGV drivers on the index was 17.9 points. The difference between the two scores was statistically significant ($P < 0,001$). This indicates that the Greek HGV drivers expect higher levels of aggression and violations from other drivers in their country than the Norwegian drivers.

We also made an index measuring aggressive road safety behaviours, comprised of three DBQ items: “Sound your horn to indicate your annoyance to another road user”, “Become angered by a certain type of driver and indicate your hostility by whatever means you can”, “Pull out of a junction so far that the driver with right of way has to stop and let you out” (min: 3, max 21: points), and results indicate significantly higher ($P < 0,01$) scores among the Greek HGV drivers

(5.8 points) than the Norwegian HGV drivers (4.7 points), indicating that the former are more aggressive in traffic

3.2.2 Results from the qualitative interviews

In line with the quantitative results, Greek HGV drivers mentioned that it is common in Greece to signal anger and irritation in traffic. They said that drivers often face lack of politeness: inappropriate nonverbal gestures, obscene verbal behavior, honking and even fights, and that this is relatively common in traffic in Greece. All drivers reported the occurrence of incidents, sometimes on a daily basis. They also perceived that this was getting worse due to the financial crisis; that Greek drivers have become more tense in the last few years of the financial crisis and that it makes them easier to “explode” in traffic. The HGV drivers believe that they have specific responsibility towards the other road users as they drive a heavy vehicle, so they have to keep an eye on them. They pointed out a crucial differentiation which is the fact that they drive for a living while “all other drivers are just out on the streets” but they are not professional drivers. Especially during the last years of the financial crisis, nerves are uptight, so all drivers explode much more easily while driving.

None of the Norwegian HGV drivers expected other drivers to be rude or angry in general, like the Greek HGV drivers. However, they often experienced that other drivers get irritated and do not understand the limits of driving an HGV. When asked about what behaviours they perceived as rude in traffic, the respondents mentioned too narrow distance when overtaking trucks, slamming the brakes in order to hinder you from overtaking them, too low speed, not respecting the duty to yield right-of-way, not adjusting the speed according to conditions, etc. When asked about whether they got irritated or angry when driving HGVs, most of the Norwegian HGV drivers answered yes. They said for instance that they were annoyed by private motorists who did not understand that heavy vehicles’ need speed to reach the top of a hill, the need of more space to manoeuvre, and have to receive extra leeway during winter conditions. A lack of using flashers was also a common factor of annoyance. However, most drivers did not show that they were angry, and if they did, they signaled this annoyance by flashing their lights or, on rare occasions, using the horn.

3.3 Fatigue and factors influencing fatigue

As noted, fatigue is measured by means of the question: «In the course of the last three months, have you fallen asleep (or dozed off for a moment) while driving a heavy vehicle at work?”. Six percent of the Norwegian HGV drivers answered yes to this question, while 24% of the Greek HGV drivers answered yes.

The different importance of fatigue in the two countries was also reflected in the qualitative interviews. Fatigue, sleepiness and overtiredness on long-distance trips were considered very important issues in the interviews with the Greek HGV drivers. When it comes to falling asleep or feeling fatigued, the Greek HGV drivers who were interviewed reported that it is common to feel tired but, contrary to past decades and old habits, they said that they park somewhere in order to take a power nap. Some of the interviewees mentioned that they have fallen asleep after a heavy schedule, driving throughout the country for many hours, but that they managed to wake up immediately and not to lose control of the vehicle. Afterwards, they stopped in a parking place to sleep.

In Table 3, we examine factors influencing respondents' answers to the question "In the course of the last three months, have you fallen asleep (or dozed off for a moment) while driving a heavy goods vehicle?" (0=No, 1=Yes). Odds ratios are presented.

Table 3: Logistic regression. Dependent variable: "In the course of the last three months, have you fallen asleep (or dozed off for a moment) while driving a heavy goods vehicle?" (0=No, 1=Yes). Odds ratios.

	Mod.1	Mod.2	Mod.3	Mod.4	Mod.5	Mod.6	Mod.7	Mod.8	Mod.9
Age group	1.009	1.003	1.021	1.020	1.017	1.000	1.027	1.029	.965
Mileage		1.003	1.004	1.004	1.004	1.003	1.003	1.002	1.002
Aggressive violations			1.209**	1.208**	1.209**	1.211*	1.247**	1.194*	1.193*
Work pressure				1.003	1.006	.966	.963	.830	.709
Work hours					.971	.973	.971	.974	1.032
Type of transport (Long distance =0, Other=1)						.424*	.412*	.360*	.584
Commission pay (=0, other=1)							2.239	1.732	2.419
National RSC								1.121*	1.091*
Norwegian nationality (=1, Gree= 0)									.214*
Nagelkerke R ²	.000	.012	.073	.073	.074	.108	.122	.203	.254

*p < 0,05 , **p < 0,01.

The first main result of the table is that aggressive violations contributes significantly and positively to falling asleep. This means that HGV drivers who score higher on the aggressive violations index, or in other words report to be involved in more aggressive violations (i.e. signaling irritation and annoyance to other drivers), have higher odds of falling asleep behind the wheel. This applies also when we control for national RSC in Model 8 and nationality in Model 9. We have seen that there is a close relationship between the HGV drivers' own aggressive violations, and the level of aggression and violations that they attribute to other drivers in their countries (i.e. their national RSC).

The second main result is that national road safety culture contributes significantly and positively to falling asleep. This means that HGV drivers who attribute higher levels of aggression and violations to other drivers in their country have higher odds of falling asleep behind the wheel. This is in line with our key hypothesis.

The third main result is that Norwegian nationality contributes significantly and negatively to falling asleep. This means that Norwegian HGV drivers have lower odds of falling asleep behind the wheel than the Greek drivers. The contribution of nationality applies also when controlling for national RSC, which indicates that there are more national differences influencing fatigue among the studied HGV drivers than we measure by means of our variable national RSC.

The fourth main result of the table is that type of transport (i.e. other than long distance) contributes significantly and negatively to falling asleep. This means that HGV drivers who do not drive long distance have lower odds of falling asleep behind the wheel than those who drive long distance. Long distance ceases to contribute significantly when the nationality variable is included, indicating a relationship between Greek nationality and long distance. However, although our national sampled are biased when it comes to type of transport, we still see a significant relationship between fatigue and national RSC, also when we control for type of transport.

Finally, and surprisingly, none of the work-related variables: work pressure, working hours, or commission pay contributes significantly. It should also be mentioned that we did not find a statistically significant relationship between organisational safety culture and fatigue, or self-employed driver and fatigue.

4. Discussion

4.1 Four times higher levels of fatigue among Greek HGV drivers

The aim of the present study was to examine factors influencing fatigue among HGV drivers in Norway and Greece, focusing especially on the role of national road safety culture. Six percent of the Norwegian HGV drivers answered yes to this question, while 24% of the Greek HGV drivers answered yes. Thus, we see that the share of fatigue is four times higher in the Greek sample than the Norwegian. The different importance of fatigue was also reflected in the qualitative interviews.

4.2 The National RSC in Greece is characterized by higher levels of aggression/violations

Quantitative results indicate that Greek HGV drivers expect higher levels of aggression and violations from other drivers in their country than the Norwegian HGV drivers, and that they have higher levels of aggressive violations. We attribute this to differences in national road safety culture; what is expected and considered “normal” in traffic. The qualitative interviews also indicate differences in national RSC: while it is common in Greece to signal anger and irritation in traffic, this is not viewed as common in Norway. The irritation experienced by Norwegian HGV drivers was more related to other drivers’ lacking understanding of the needs of heavy vehicles in traffic. These results are in line with previous research, indicating higher levels of aggressive violations in southern European countries than Northern European countries (Warner et al 2011; Özkan et al 2013).

4.3 The National RSC in Greece is related to higher levels of fatigue

As the mentioned previous studies (Warner et al 2011; Özkan et al 2013) indicate higher levels of aggression and conflicts in the Greek National RSC, we hypothesized that this will be related to higher levels of fatigue among the Greek drivers, as we expected higher levels of aggression and conflicts to be more exhausting. Results from the logistic regression analyses supported our hypothesis, indicating a relationship between national RSC and fatigue, controlled for the several key variables (e.g. work pressure, driving hours, type of transport). This conclusion was also supported by the results of the qualitative interviews, where Greek drivers reported of road safety culture that is relatively exhaustive, requiring a considerable amount of energy (cf.

Nævestad et al 2019a). The relationship between national RSC and fatigue has never been examined before in previous research, and the present study therefore contributes to the research on fatigue by also providing information about the importance of the road user interaction for fatigue, or more specifically the importance of national RSC for fatigue.

Previous research indicates, however, a relationship between working activities, driving environment and fatigue. The previous studies have especially found a relationship between monotony (lacking stimuli) and fatigue for long distance drivers (Nordbakke 2004; Jackson et al 2011). Other studies indicate that too much stimuli and challenging working conditions also may lead to fatigue, e.g. Moe's (2006) study of bus drivers, which found that stress related to harassment and passenger trouble, time pressure and a demand for high concentration levels were related to higher levels of fatigue. It seems that our results are comparable to those of Moe (2006), indicating that the higher level of aggression and conflicts in the Greek RSC could involve a higher mental workload for the Greek HGV drivers, and subsequently higher levels of fatigue. While Moe (2006) found that bus drivers become fatigued through negative interactions with passengers, we have found that HGV drivers' become fatigued through interaction with other drivers.

4.5 Work-related variables do not contribute significantly to fatigue

Previous studies indicate that work-related variables are related to HGV driver fatigue, e.g. pressure from management and an aspiration to follow time schedules (Nordbakke 2004; Anund, Kecklund and Åkerstedt 2011; Jackson et al 2011). Other studies of professional driver fatigue also indicate the influence of pay structures, customer/consumer demands, loading or delivery queues, inadequate drivers numbers, poor shift schedule planning and management (Jackson et al., 2011). However, to our surprise, none of the work-related variables that we included in the multivariate analysis of factors influencing fatigue, e.g. work pressure, working hours, or commission pay, contributed significantly. We have that long-distance transport contributes significantly in the multivariate analyses, as expected based on previous research, but that national RSC nevertheless contributes significantly to fatigue when controlling for long distance transport.

4.6 Is the relationship between national RSC and fatigue a spurious relationship?

We see a relationship between National RSC and fatigue when controlling for several key variables, but there may be variables that we have not controlled for that generate systematic differences between the different groups. It is, however, hard to imagine which variables this could be, as we control for work pressure, hours at work, age, mileage, long distance transport, commission pay. We do however not control for sleep patterns and sleep history (Kronholm et al 2009; Ursin et al 2009), activities outside work, additional jobs etc. Additionally, respondents' answer to some questions could also be due to different national baselines (e.g. what does time pressure that may compromise safety mean in Norway versus Greece?) (Nævestad et al 2017). Another unmeasured variable could be different national cultures of understanding and dealing with fatigue among professional drivers in Norway versus Greece; i.e. is fatigue accepted and perceived as "part of the job" among drivers in Greece to a higher extent than in Norway? The interview results points to a culture accepting fatigue among professional drivers, at least previously in Greece. This is an important issue for future research.

Another important issue for future research, is whether high levels of fatigue may increase aggressive violations among drivers.

4.7 Methodological limitations and issues for future research

The first main methodological weakness of the present study is the relatively small samples of respondents: we have only 201 HGV drivers in total from the two countries. Thus, we recommend that future studies examining further the themes that we discuss here, include larger samples of HGV drivers. This is required to establish robust conclusions. Our conclusions about the national RSCs in the studied countries are however in accordance with previous studies, indicating the validity of the conclusions (Warner et al 2011; Özkan et al 2013).

Another potential challenge related to the small sample is the issue of representativity. With the low number of respondents, it is reasonable to ask whether they actually are representative for their own sector. Unfortunately, it is impossible to calculate response rates, due to the method of survey distribution. It is important to note that we complement the quantitative data with rich qualitative interview data, supporting our results.

The second main methodological weakness of the study is the differences between the national samples. There is a three times higher share of long-distance drivers in the Greek sample than the Norwegian, and there are 37 % dangerous goods drivers. We know, based on previous research that long-distance driving is related to fatigue outcomes (Nordbakke 2004), and this is also reflected in our study. Long distance transport has a share of 24% who have fallen asleep, while it is 3% for distribution (and 11% for dangerous goods). That is why we control for long distance transport in the multivariate analysis, and national RSC still contributes significantly. Moreover, the share of distribution drivers (with the lowest fatigue prevalence) was twice as high in the Greek sample than the Norwegian. Additionally, when we compare the prevalence of falling asleep in the different types of transport, the share answering yes is far higher for Greek drivers in all the categories, indicating that nationality is a more important variable than type of transport. Although numbers are small in these subcategories, we see a clear tendency across the different types of transport, of higher levels of fatigue in the Greek sample. A share of six percent of the Norwegian long-distance drivers had fallen asleep or dozed off, compared to 29 % of the Greek long-distance drivers. Comparing the combined long-distance/distribution category, corresponding shares were, 3% and 35%, i.e. ten times higher, while it was 0% and 4% for distribution transport.

We also control for distance travelled in these analyses. Additionally, we saw that the travelled distance was the same for Norwegian and Greek drivers. Finally, it should also be mentioned that we have not been able to measure several key variables, e.g. sleep history and sleep patterns (Kronholm et al 2009; Ursin et al 2009).

5. Conclusion

As previous studies indicate higher levels of aggression and conflicts in the Greek National RSC, we hypothesized that this will be related to higher levels of fatigue among the Greek HGV drivers, as the National RSC is more exhausting. Our results indicated a four times higher level of fatigue among the Greek HGV drivers than the Norwegian, and that the Greek national RSC is characterized by a higher level of aggression, conflicts and violations. Results from logistic

regression analyses support our hypothesis, indicating a relationship between National RSC and fatigue, controlled for the several key variables (e.g. work pressure, driving hours, type of transport). This conclusion is also supported by the results of the qualitative interviews, where Greek drivers report of an exhausting traffic environment.

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