FATIGUE, SLEEPINESS AND, SLEEP DISORDERS

WHAT IMPACT ON ROAD SAFETY?

AN ANALYSIS OF THE PORTUGUESE REALITY.

2025

PUBLICATION DATA

Title: Fatigue, Sleepiness and, Sleep Disorders. What impact on Road Safety? An analysis of the Portuguese reality.

Objective: Generate knowledge about the phenomenon of fatigue, sleepiness, and sleep disorders in driving in the national context, assessing the penetration and impact on driving. Highlight the need to implement measures to reduce driving in such situations, contributing to a reduction in road crashes.

Methodology: Online questionnaires, collected between the 3rd and 10th of December 2024, completed by 1002 drivers of passenger cars or goods vehicles, who have driven at least a few days per month in the 12 months preceding data collection, in Portugal.

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Publication date: March 2025

ISBN: 978-972-98080-9-8

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EXECUTIVE SUMMARY

Driver fatigue and drowsiness are highly significant risk factors, comparable to driving under the influence of alcohol, speeding, and distraction, contributing to a considerable percentage of serious and fatal crashes, but with less awareness and without prevention campaigns with a national impact.

Although some international studies address fatigue and drowsy driving, their prevalence and impact can vary significantly across countries due to cultural, social, economic, and legislative differences. It is therefore crucial to obtain specific data on the Portuguese context to fully understand the scale of the problem at the national level.

The international *E-Survey of Road Users' Attitudes* (ESRA, 2023) revealed that 18.4% of Portuguese drivers admitted to having driven in the previous month while so sleepy they had difficulty keeping their eyes open. Although alarming, this finding does not provide a comprehensive picture of fatigued driving in Portugal, highlighting the need for a more in-depth national study to better understand this serious issue and inform awareness-raising and preventive actions.

This study investigates the prevalence and impact of sleep disorders, fatigue, and drowsiness while driving in Portugal, using data from a questionnaire completed by 1,002 Portuguese drivers.

Key Results

- **Sleep Disorders:** Approximately 1 in 4 drivers experiences excessive sleepiness, and 1 in 5 is at high risk of suffering from sleep apnoea. One in 10 drivers reported having been diagnosed with a sleep disorder, with insomnia (53%) and sleep apnoea (41%) being the most common. Despite these prevalences, awareness remains low: around 20% of drivers reported not recognising any of the sleep disorders presented and not knowing the main symptoms of sleep apnoea.

- **Fatigue and Drowsiness while driving:** More than half of drivers reported having driven for over two hours without stopping (65%) and having driven while feeling excessively tired (58%) at least once in the previous 12 months. Around 1 in 3 admitted to driving while extremely sleepy, and 9.4% even reported having fallen asleep at the wheel. These behaviours are more prevalent among drivers with excessive sleepiness, those at high risk of sleep apnoea, individuals with sleep disorders, student workers, shift workers, professional drivers, and those who drive at night or in the early hours (midnight to 6 a.m.).

- **Measures to Combat Fatigue and Drowsiness:** Most drivers resort to ineffective measures when they feel sleepy or fatigued. Although stopping for a nap was correctly identified by 82.5% of drivers as one of the most effective countermeasures, only 11.2% actually used this strategy.

- **Attitudes and Risk Perception:** Most drivers acknowledge the risks of driving while fatigued, agreeing that one should not drive when sleepy and recognising that sleepiness increases crash risk. Nevertheless, 9.6% admitted they would still continue driving even when sleepy, and 18.4% believed they were capable of driving safely despite feeling tired.

- **Crashes and near misses:** 8.4% of drivers reported having had at least one crash, and 44.9% reported a near miss in the previous 12 months. Fatigue, tiredness, or sleepiness accounted for 29.7% of accidents and 20.9% of near misses, most occurred during the night or early morning hours. Crashes or near misses related to fatigue or sleepiness are more frequent among drivers aged 18–24, drivers with excessive sleepiness, a high risk of obstructive sleep apnoea, existing sleep disorders, student workers, professional drivers, and those who drive at night or in the early morning (between midnight and 6 a.m.). Increased exposure to driving (more kilometres or hours behind the wheel), extreme sleepiness, fatigue, or driving for more than two hours without a break are also associated with crashes or near misses.

This study highlights the urgent need to address fatigued and drowsy driving in Portugal. The high prevalence of sleep disorders, combined with the frequency of fatigued driving and the number of fatigue-related crashes, calls for coordinated efforts to raise awareness, educate, and support drivers.

Key Recommendations

The following recommendations are based not only on the findings of this study, but also on European Commission recommendations:

- **Raise awareness of sleep disorders** (20% of drivers are unaware of them), their impact on driving, and the importance of receiving appropriate treatment. Individuals who frequently feel tired or sleepy should consult a healthcare professional.

- **Develop awareness campaigns** to highlight the risks of driving while fatigued or sleepy, providing clear and practical guidance on prevention strategies and how to respond in real-life situations.

- Integrate **information about the risks of fatigued and drowsy driving into educational programmes** and driver training curricula**.**

- For professional drivers, **employers should actively promote awareness of the dangers of fatigue and sleepiness, as well as the impact of sleep disorders on driving performance.** Working hours should be structured to comply with driving time and rest regulations, with mechanisms in place to ensure these rules are respected.

1.INTRODUCTION

Sleep Disorders

Sleep disorders are a set of clinical conditions that affect the duration, continuity and/or depth of sleep with a consequent alteration in its quality, directly impacting the individual's ability to adequately perform their functions during wakefulness. These disorders can manifest themselves in various ways, such as difficulty falling asleep or staying asleep, frequent awakenings during the night, excessive sleepiness during the day or unusual behaviour during sleep, and can often contribute to the occurrence and/or worsening of other health problems.

There are different types of sleep disorders, each with specific characteristics and causes and, according to the International Classification of Sleep Disorders (ICSD), they can be classified into 6 categories: insomnia; sleep-disordered breathing, such as sleep apnoea; central hypersomnia disorders, such as narcolepsy; sleep-wake circadian rhythm disorders; parasomnias and sleep-related movement disorders, such as restless legs syndrome. It is estimated that around 10% of the adult population suffers from the most common disorders, which are: chronic insomnia (3 times a week for at least 3 months) and a further 20% from occasional insomnia [1] and that obstructive sleep apnoea, due to interruptions in breathing during sleep, affects around 950,000 people in Portugal, aged between 30 and 69 years [2]. Other less common disorders, such as narcolepsy and restless legs syndrome, also contribute to a high prevalence of sleep disorders overall. Narcolepsy is a neurological disorder, while restless legs syndrome is a movement disorder that causes an uncontrollable urge to move the legs during sleep.

The causes of sleep disorders can be varied, including genetic factors, lifestyle, medical and psychological conditions, and proper diagnosis and treatment are essential to ensure quality sleep and prevent long-term complications. One of the main symptoms and consequences of sleep disorders is excessive daytime sleepiness, characterised by a persistent feeling of tiredness/fatigue and sleepiness during the day, which can lead to difficulties concentrating and an increased risk of accidents, especially when driving.

Driver Fatigue and Drowsiness

Fatigue while driving is considered one of the most significant risk factors in traffic, alongside drink-driving, speeding, and distraction. It is estimated that fatigue while driving contributes to approximately 15% to 20% of serious crashes - with higher percentages in crashes involving heavy vehicles and fatal crashes occurring on motorways [3].

Data from the *2023 E-Survey of Road Users' Attitudes* (ESRA) show that around 1 in 5 drivers across 22 European countries reported having driven in the previous month while feeling so sleepy that they had difficulty keeping their eyes open (18.4% in Portugal). This behaviour is more prevalent among drivers aged up to 34 years (approximately 26%) [4]. According to a report by the European Transport Workers' Federation, based on a 2021 survey of around 3,000 lorry drivers, 60% of heavy goods vehicle drivers and 66% of heavy passenger vehicle drivers regularly drive while feeling tired. Around 1 in 3 heavy goods vehicle drivers and 1 in 4 heavy passenger vehicle drivers reported having fallen asleep at the wheel at least once in the previous 12 months [5].

The most significant general causes of fatigue include lack of sleep, poor-quality sleep, sleep disorders (e.g. sleep apnoea or narcolepsy), and sleep needs regulated by the biological clock [3]. Driving for long periods can exacerbate driver fatigue, especially when drivers do not take sufficient breaks to rest. These factors often have a more persistent impact among specific groups of drivers - such as professional drivers or shift workers, - due to long or irregular working hours. Another high-risk group is young drivers, for whom fatigue is often linked to lifestyle factors [3].

Fatigue leads to a deterioration in driving performance, which is mainly manifested through longer reaction times and a tendency to mentally disengage from the driving task. Drivers may attempt to compensate for fatigue by increasing the demands of the driving task (e.g. driving faster to stimulate alertness through adrenaline) or by reducing them (e.g. increasing following distance or slowing down). However, evidence from crash studies and driving performance simulations indicates that driver fatigue cannot be adequately compensated for through behavioural strategies alone [3].

Several studies suggest that driving while fatigued is associated with a significantly increased risk of road accidents. For example, in a video analysis study comparing the behaviour of drivers in the 20 seconds before a crash with non-crash periods, researchers concluded that fatigue was associated with a 3.4 times higher risk of an accident [6]. A meta-analysis of 17 studies estimated that fatigue while driving increases the risk of an accident by 2.5 times [7].

Measures to combat driver fatigue should target drivers, road infrastructure, and vehicles [3]. Drivers should be informed — through media campaigns and driver training — about the causes, effects, and warning signs of fatigue, as well as strategies to reduce its impact.

For professional drivers, employers should organise working schedules in a way that ensures compliance with driving and rest time regulations, and proactively monitor their observance. Regarding infrastructure, the European Commission recommends the provision of appropriate rest areas and facilities along roads to allow drivers to recuperate, thereby reducing fatigue-related driving. The implementation of longitudinal rumble strips — which alert drivers through sound and vibration when the vehicle veers towards the edge of the carriageway — can help reduce fatigue-related accidents [3,8]. In terms of vehicles, systems such as forward collision warning and lane departure warning can also help mitigate the consequences of fatigued driving [3].

Objectives

This study aims to generate knowledge about this phenomenon in the national context, given the importance of the topic of fatigue, sleepiness, and sleep disorders to driving, as well as the lack of available data in Portugal. The responses to a questionnaire collected from a sample of 1,002 Portuguese drivers were analysed for this purpose. In addition to understanding the extent of the problem, the study aims to propose measures to reduce driving while fatigued or sleepy, thereby contributing to a reduction in road crashes.

The objectives of the study are to:

- Assess levels of sleepiness (Epworth Scale), the risk of sleep apnoea (Berlin Questionnaire), and the prevalence of sleep disorders (self-reported) among Portuguese drivers;
- Analyse drivers' knowledge of sleep disorders and the symptoms of sleep apnoea;
- Assess the frequency of driving while fatigued, tired, or sleepy (self-declared);
- Assess attitudes and risk perceptions associated with driving while fatigued, tired, or sleepy;
- Identify factors associated with excessive sleepiness, high risk of sleep apnoea, and sleep disorders;
- Identify factors associated with driving and the risk of crashes or near misses caused by fatigue, tiredness, or sleepiness;
- Propose measures to reduce the incidence of driving while fatigued, tired, or sleepy.

2. METHODOLOGY

This study was based on a questionnaire targeting drivers travelling in Portugal. The questionnaire was completed by drivers through an online panel, ensuring both geographical and demographic representativeness.

Population, sample, and data collection

The target population consisted of drivers of passenger cars or goods vehicles who had driven at least a few days per month during the 12 months prior to data collection.
The sample was stratified by NUTS II region, gender, and age group. The stratification was based on data from the Instituto da Mobilidade e dos Transportes (IMT) [Institute for Mobility and Transport] based on the number of valid driving licences in Portugal. The distribution of the sample by NUTS II region was as follows: Alentejo (n = 64, 6.4%), Algarve (n = 48, 4.8%), Lisbon (n = 274, 27.3%), Central Portugal (n = 220, 22.0%), Northern Portugal (n = 349, 34.8%), Azores (n = 24, 2.4%) e Madeira (n = 23, 2.3%). Stratification by gender and age group (18–24, 25–34, 35–44, 45–54, 55–64, 65+ years) ensured a distribution proportional to the composition of the Portuguese driving population, according to IMT data.

Data collection took place between 3 and 10 December 2024. The median time to complete the questionnaire was 10.0 minutes (1st Quartile = 8.9; 3rd Quartile = 13.2). A total of 1002 valid responses were obtained from drivers of passenger cars or goods vehicles, ensuring a maximum sampling error of 3.1% with a 95% confidence level.

Questionnaire

The questionnaire was jointly developed by Prevenção Rodoviária Portuguesa [Portuguese Road Safety Association] (PRP) and VitalAire. In addition to socio-demographic information, professional activity, and driving habits, the questionnaire included items on sleep disorders as well as fatigue and drowsiness while driving: self-reported behaviour, attitudes, risk perception, and involvement in road crashes or near misses.

The Epworth Sleepiness Scale was used to assess levels of sleepiness. The scale consists of 8 items rated on a 4-point Likert scale, with scores allowing classification into normal (0–9 points), mild to moderate excessive (10–15 points), or severe excessive sleepiness (16–24 points). [9] More information is provided in Annex A4 (Sleepiness Assessment – Epworth Sleepiness Scale).

The Berlin Questionnaire was used to assess the risk of obstructive sleep apnoea. This 10-item instrument, validated for the Portuguese population, classifies individuals as being at low or high risk for the condition. [10] More information about the questionnaire and the classification method is available in Annex A5 (Risk of Obstructive Sleep Apnoea – Berlin Questionnaire).

Statistical analysis

The report includes a descriptive analysis of the data, presenting absolute and relative frequencies (%) for each questionnaire item. Associations between variables were also examined. In addition to presenting cross-tabulations, the Chi-square test of independence was used to assess statistical significance. A significance level of 5% was applied.

Sample characterisation

The sample included 1002 car drivers, mostly men (55.1%), who had driven at least a few days per month in the previous 12 months. The drivers were aged between 18 and 83, with an average age of 46.6 years. There was a predominance of drivers with a secondary education or less (59.2%) and those who were married or in a civil partnership (60.6%).

In terms of employment status, the majority were either employed or self-employed (75.3%), worked between 35 and 40 hours per week (79.2%), worked during the daytime (78.2%) and had two days off per week (85.0%).

Around one in four drivers used a car for work purposes (24.5%), while the remaining 75.5% drove only for commuting or personal use. Most participants drove a car for less than 10 hours per week (67.6%) and had driven fewer than 15,000 kilometres in the previous year (73.3%).

More detailed data regarding the sample's characteristics are available in Tables A1, A2, and A3 in the Annex.

3. RESULTS

3.1. Sleep Disorders

The results obtained based on the Epworth Sleepiness Scale showed that 73.9% of drivers were classified as having normal/common sleepiness, 22.7% as having mild/moderate excessive sleepiness, and 3.5% as having severe excessive sleepiness (Figure 1 and Tables A4 and A5 in the Annex).

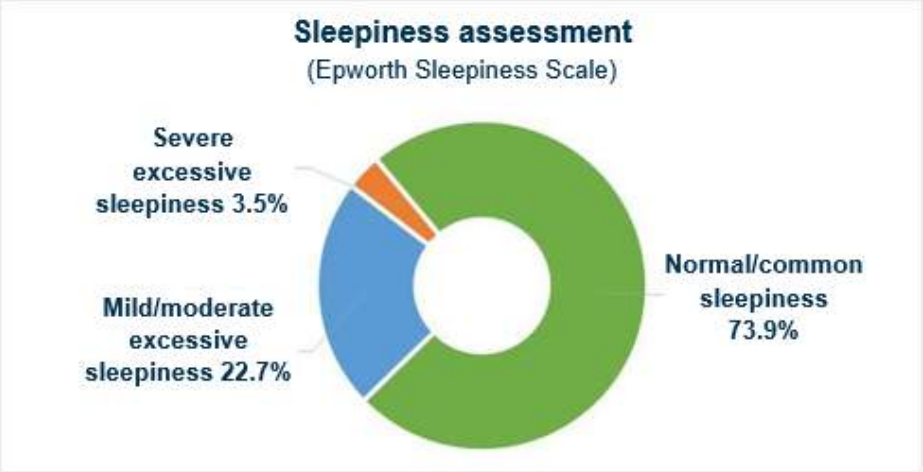

Figure 1. Sleepiness assessment using the Epworth Sleepiness Scale (N = 1002)

Regarding the risk of suffering from sleep apnoea, assessed through the Berlin Questionnaire, approximately 1 in 5 drivers were classified as high risk (20.6%) (Figure 2 and Tables A6 and A7 in the Annex).

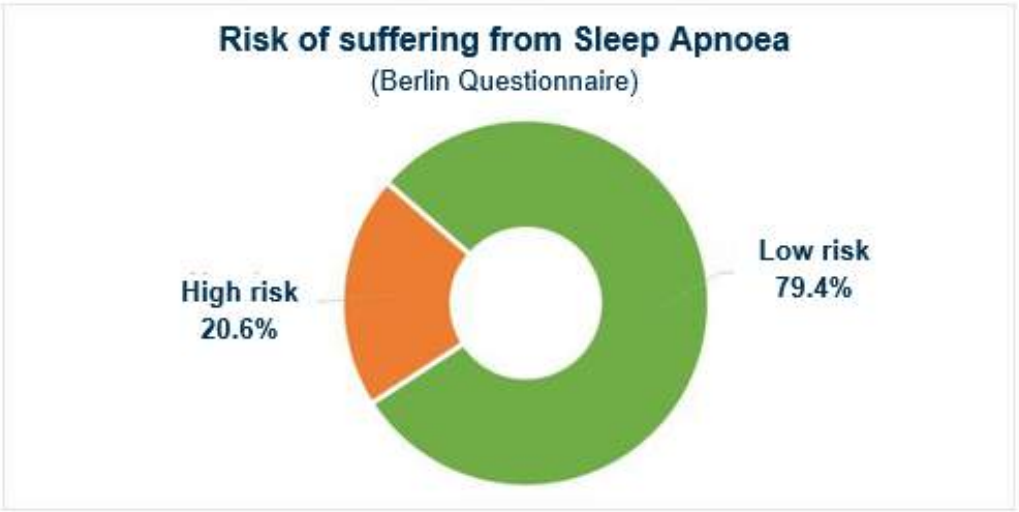

Figure 2. Risk of sleep apnoea (Berlin Questionnaire) (N = 1002)

Approximately 1 in 10 drivers (10.7%) reported having been diagnosed with a sleep disorder. Among these, the majority stated they had been diagnosed with insomnia (53.3%) or sleep apnoea (41.1%). Considering the total number of drivers, the estimated prevalence of insomnia was 5.7%, sleep apnoea 4.4%, and restless legs syndrome 0.8% (Figure 3 and Table A8 in the Annex).

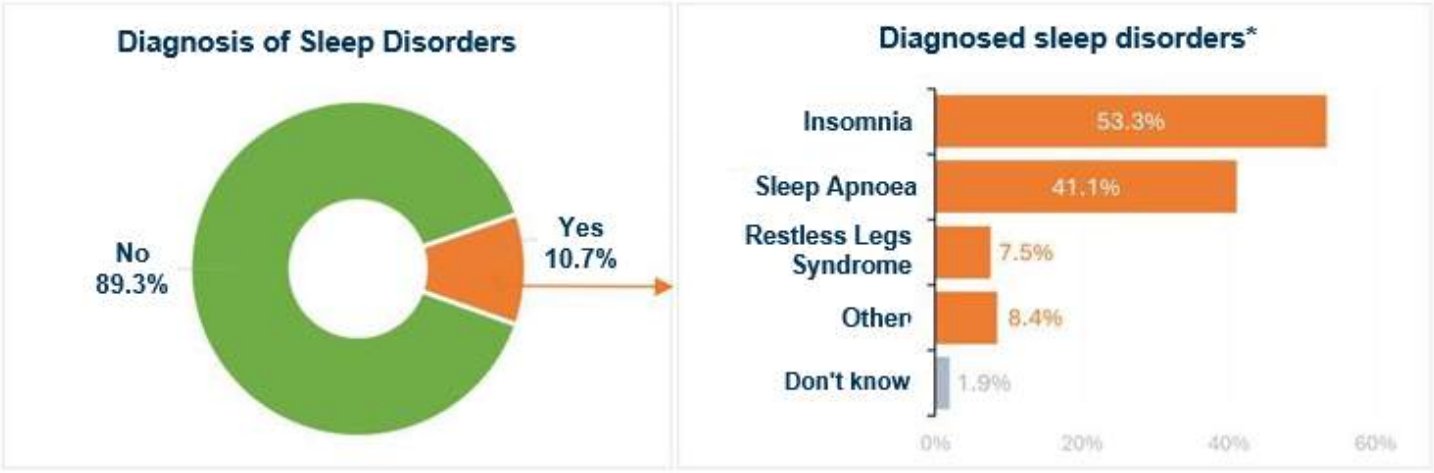

Figure 3. Diagnosis of sleep disorders (self-reported) (N = 1002)
(*Among those diagnosed with a sleep disorder (N = 107); more than one diagnosis could be indicated)

The use of therapies to treat sleep disorders was reported by 11.4% of drivers. Most of these drivers reported taking medication to sleep (60.2%); 21.2% reported having changed their sleep habits/routines, 17.8% used continuous positive airway pressure (CPAP) devices, and 5.9% reported using other therapies. Considering the total sample, 7.1% of drivers took medication to sleep and 2.1% used CPAP (Figure 4 and Table A8 in the Annexes).

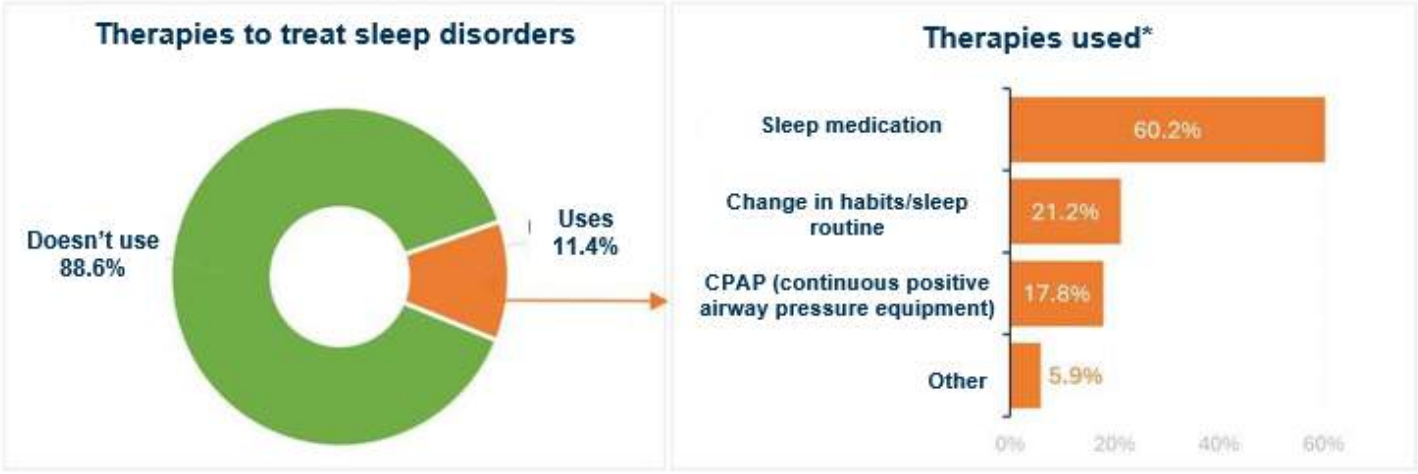

Figure 4. Use of therapies to treat sleep disorders (self-reported) (N = 1002)
(*Among those using therapies (N = 107); more than one therapy could be indicated)

Among the sleep disorders presented, most respondents were familiar with insomnia (74.8%) and sleep apnoea (65.7%), but only 23.1% were familiar with restless legs syndrome and 13.8% with narcolepsy. It should be noted that almost 1 in 5 drivers (18.9%) stated they were not familiar with any of the presented sleep disorders (Figure 5 and Table A9 in the Annexes).

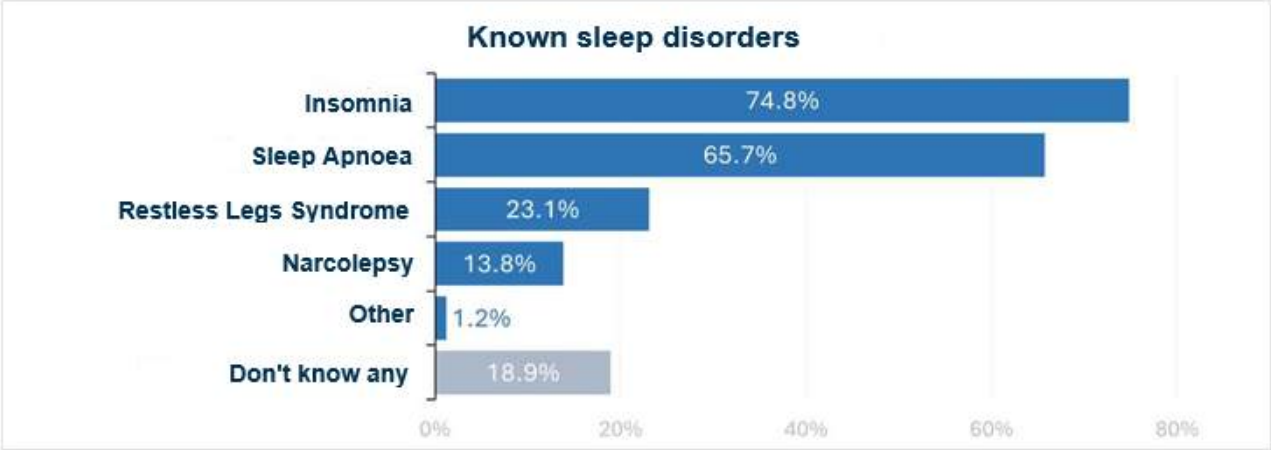

Figure 5. Awareness of sleep disorders
('Which of the following sleep disorders are you familiar with?' – more than one option could be indicated) (N = 1002)

Regarding the identification of the main symptoms of sleep apnoea, the most commonly reported symptom was interrupted breathing during sleep (64.5%). The remaining symptoms were mentioned by fewer than half of the drivers. Approximately 1 in 5 drivers stated they could not identify the main symptoms of sleep apnoea (Figure 6 and Table A9 in the Annexes).

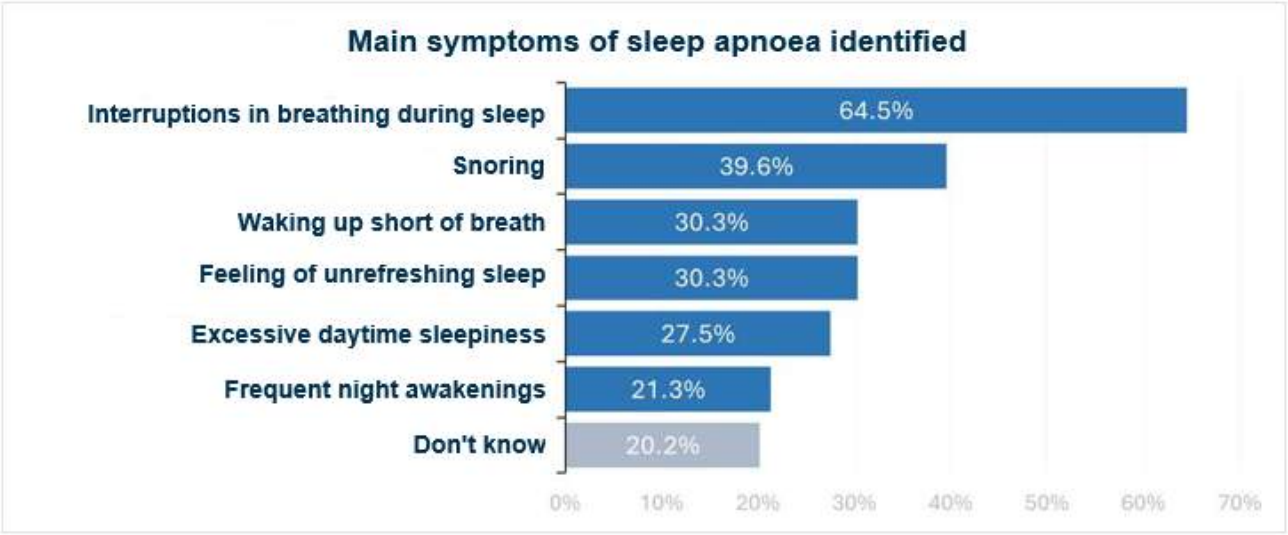

Figure 6. Identification of main symptoms of sleep apnoea
('Can you identify the main symptoms of sleep apnoea?' – more than one option could be indicated) (N = 1002)

3.2. Driver Fatigue and Drowsiness

More than half of the drivers reported having driven for more than 2 hours without a break (65.0%) and while feeling too tired/fatigued (58.0%) at least once in the past 12 months. Around 1 in 3 (33.4%) stated they had driven while so sleepy that they had difficulty keeping their eyes open, and 9.4% admitted to having fallen asleep at the wheel (see Figure 6 and Table A10 in the Annex).

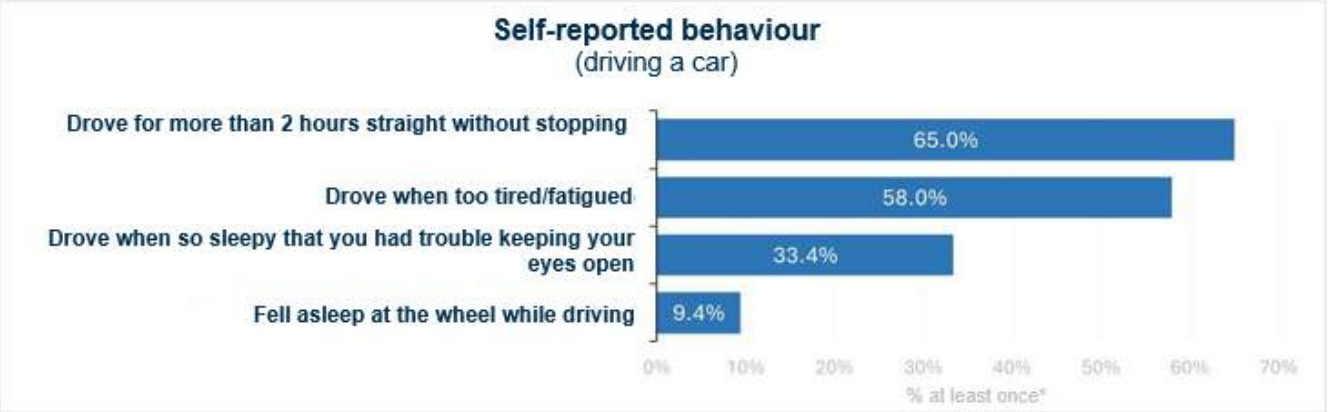

Figure 7. Self-reported behaviour – driving a passenger car
('During the past 12 months, as a car driver, how often have you...?' *Percentage of "at least once" – answers 2 to 5 on a 5-point scale, from 1 = "never" to 5 = "(almost) always") (N = 1002).

Among the drivers who reported having driven while tired/fatigued or sleepy in the past 12 months, the most frequently mentioned countermeasures were: opening the windows or turning on the air conditioning (40.8%), stopping to eat, stretch, or relax without dozing off/sleeping (34.6%), turning up the volume on the radio/sound system (34.3%), consuming caffeine or taking caffeine tablets (28.9%), and talking to passengers (25.2%) – all reported by more than 1 in 4 drivers.

It is worth noting that the most effective measures were adopted by fewer drivers: stopping for a nap (11.2%) and asking a passenger to take over driving duties (13.0%) – although this option is not always feasible (e.g., when travelling alone) (see Figure 8 and Table A11 in the Annex).

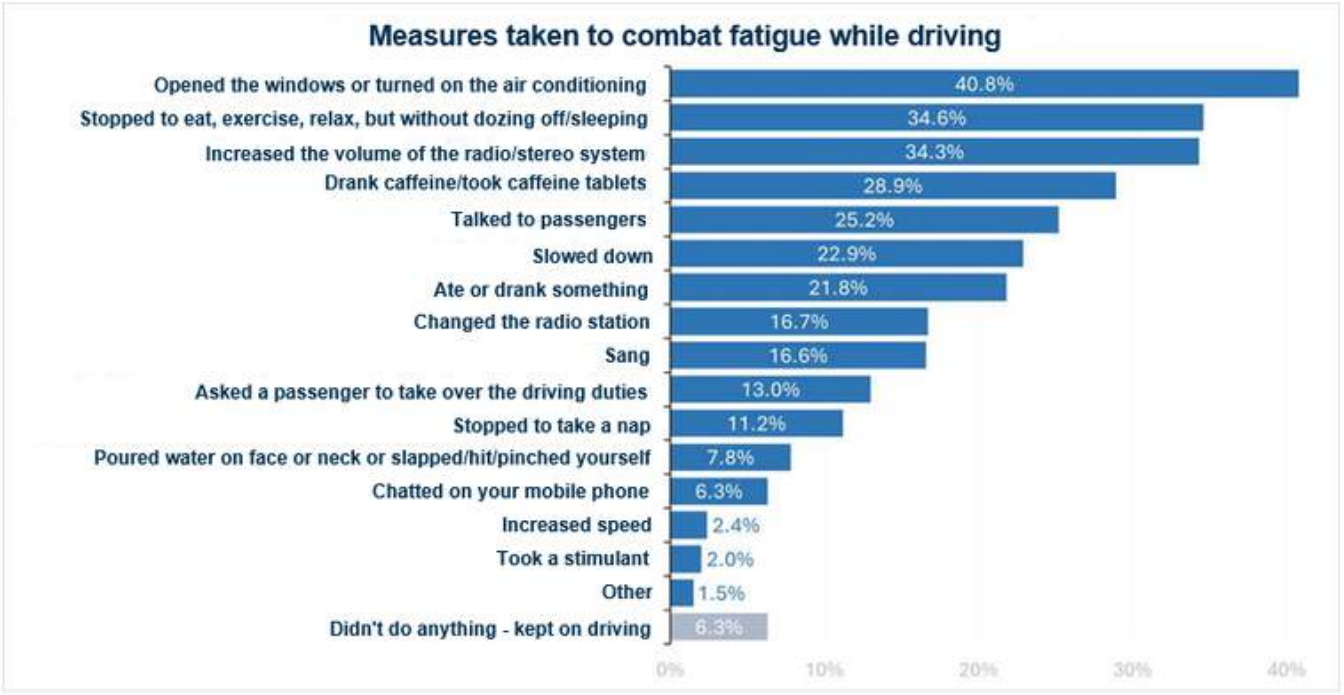

Figure 8. Measures taken to combat fatigue while driving
('In the past 12 months, when you felt sleepy/tired/fatigued while driving, which of the following measures did you take? (you may select more than one option)') (N = 615 drivers who, in the previous 12 months, had driven while so sleepy that they had difficulty keeping their eyes open or while too tired/fatigued).

Although only a small number of drivers reported using them, "asking a passenger to take over driving duties" (rated as effective by 86.5%) and "stopping for a nap" (82.5%) were considered as the most effective strategies to combat fatigue while driving. Conversely, some measures perceived as less effective were mentioned by a significant proportion of drivers, such as talking to passengers (55.8%), opening windows or turning on the air conditioning (35.4%), eating or drinking something (34.1%), turning up the radio/sound system (30.6%), or singing (30.3%) – all reported by more than 30% of drivers. Riskier behaviours were also mentioned, such as talking on a mobile phone (18.1%) or increasing speed (5.6%) (see Figure 9 and Table A12 in the Annex).

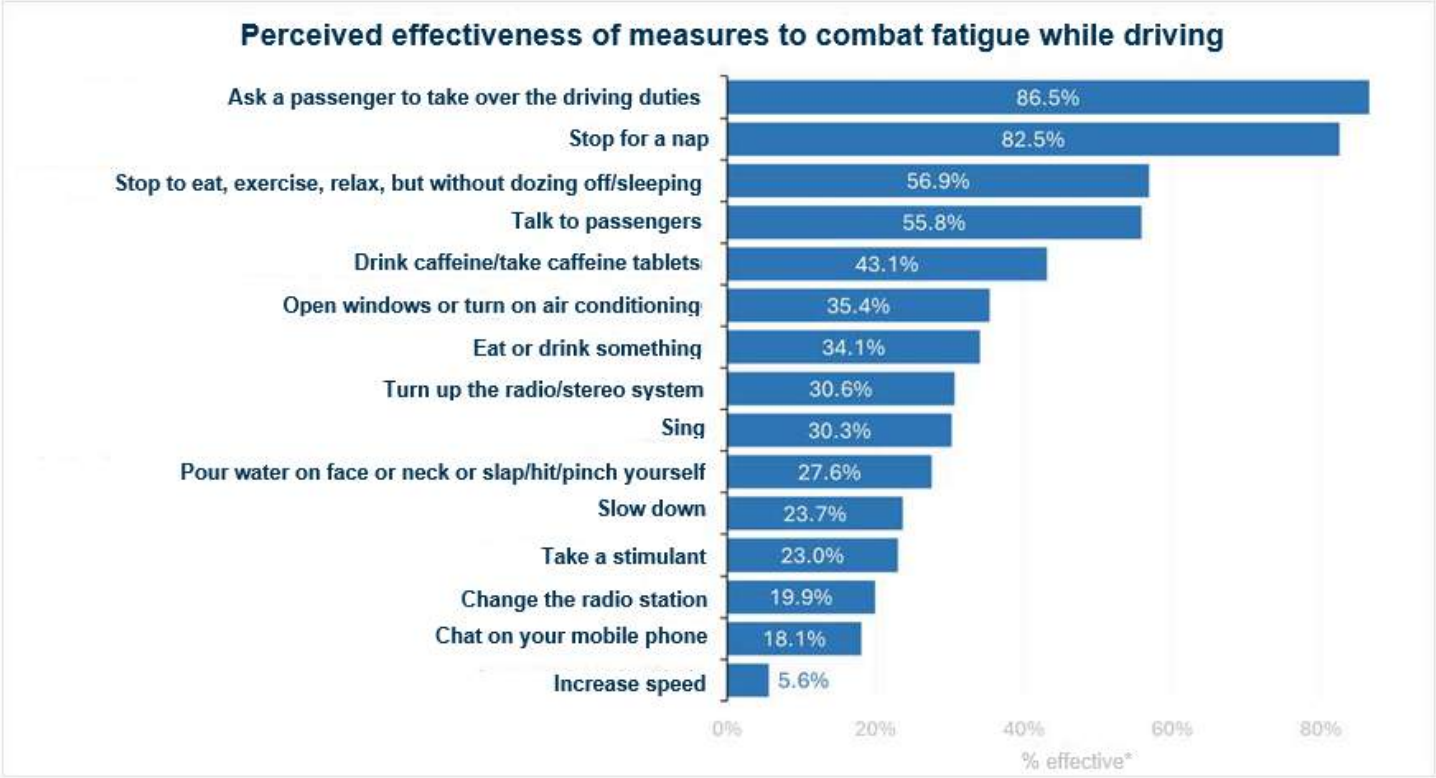

Figure 9. Perceived effectiveness of measures to combat fatigue while driving
('For each of the following measures, indicate on a scale from 1 [not effective] to 5 [very effective] how effective you think they are in combating fatigue/sleepiness while driving.' *Percentage of "effective" – responses 4 and 5 on the 5-point scale) (N = 1002).

Regarding attitudes towards driving while tired/fatigued/sleepy (see Table 1 and Tables A13, A14, and A15 in the Annex), most drivers agreed that they should not drive when they feel sleepy (86.9%) and that the risk of a crash increases when driving while sleepy (91.4%). In line with this, most drivers disagreed with statements such as "I continue driving even if I feel sleepy" (72.8%) and "I can drive safely even when I'm tired/fatigued" (54.1%). However, 9.6% admitted that they would continue driving even when sleepy, and 18.4% considered themselves capable of driving safely while tired/fatigued. The results also reveal a low level of acceptance for driving when so sleepy that it is hard to keep one's eyes open (considered acceptable by only 5.2%) and a high risk perception associated with driving while tired/fatigued (80.5%) and while sleepy (90.6%).

Table 1. Attitudes, personal acceptability and risk perception of driving while tired/fatigued/sleepy (N = 1002).

Attitudes (1)	Disagree (1-2)	Neutral (3)	Agree (4-5)
When I feel sleepy, I should not drive a vehicle	5.4%	7.8%	86.9%
Even if I feel sleepy while driving, I will continue to drive	72.8%	17.6%	9.6%
If I feel sleepy while driving, the risk of an crash increases	3.1%	5.5%	91.4%
I can drive safely when I feel tired/fatigued	54.1%	27.5%	18.4%
Personal Acceptability (2)	**Unacceptable (1-2)**	**Neutral (3)**	**Acceptable (4-5)**
How acceptable do you personally think it is for a car driver to drive when they are so sleepy that they have difficulty keeping their eyes open?	87.9%	6.9%	5.2%
Risk Perception (3)	**Not Risky (1-2)**	**Neutral (3)**	**Risky (4-5)**
Driving when tired/fatigued	4.2%	15.3%	80.5%
Driving when feeling sleepy	3.7%	5.8%	90.6%

(1) "To what extent do you agree with each of the following statements?" – 5-point response scale, from 1 = "disagree" to 5 = "agree".; (2) 5-point response scale, from 1 = 'unacceptable' to 5 'acceptable'; (3) 'How risky do you consider it to be?' - 5-point response scale, from 1 = 'not at all risky' to 5 'very risky'.

Out of the 1002 drivers in the sample, 8.4% reported having had at least one road crash as a car driver. Tiredness/fatigue (20.2%) and sleepiness (9.5%) were reported as the cause of the most recent crash by 29.7% of drivers who had experienced a road crash. These results indicate that 2.5% of the drivers in the sample had at least one road crash due to tiredness/fatigue or sleepiness. The majority of such crashes occurred at night (36.0%) and in the early hours of the morning (20.0%) (see Figure 10 and Table A16 in the Annex).

44.9% of drivers reported having experienced at least one near miss (i.e., a situation in which a collision was narrowly avoided) in the previous 12 months – 20.9% of these were attributed to tiredness/fatigue or sleepiness. These findings indicate that 9.4% of the drivers in the sample experienced at least one near miss on the road due to tiredness/fatigue or sleepiness. As with crashes, the majority of near misses attributed to tiredness/fatigue or sleepiness occurred at night (44.7%) and in the early morning (10.6%) (see Figure 10 and Table A17 in the Annex).

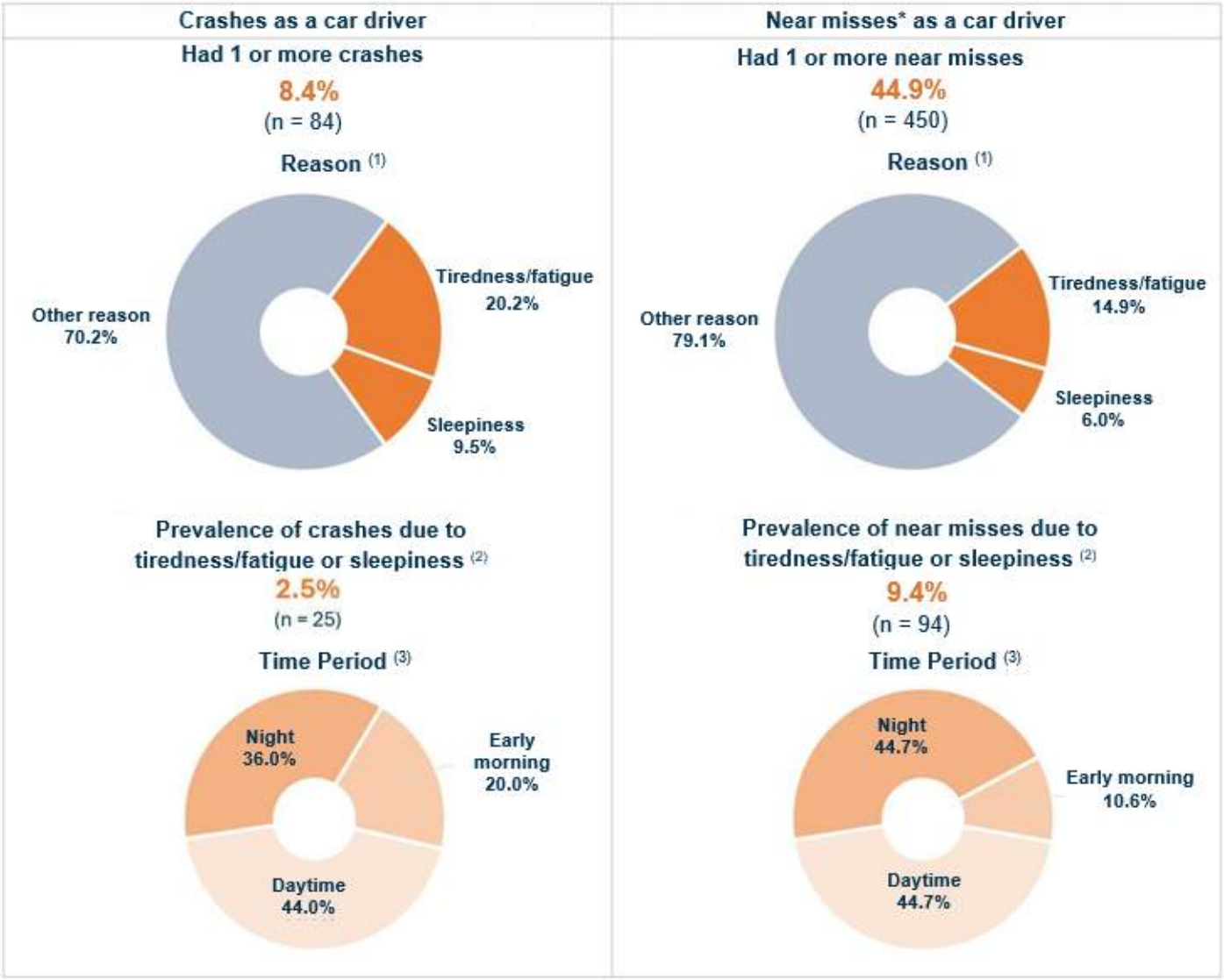

Figure 10. Involvement in crashes and near misses as a car driver in the previous 12 months (N = 1002).
(1) among drivers who have crashes/near misses; (2) prevalence in the total sample; (3) distribution of crashes/near misses due to tiredness/fatigue or sleepiness; * 'near misses' means being on the verge of having a crash, which was avoided.

3.3. Association between variables

This section presents the results of the analysis of factors associated with sleepiness, risk of sleep apnoea, and diagnosed sleep disorders, as well as their relationship with risky driving behaviour and involvement in road crashes or near misses. Socio-demographic, occupational, and driving-related variables were analysed. The main findings are highlighted below – detailed results of all the associations studied are available in Tables A18 to A20 in the Annex.

3.3.1. Factors associated with sleepiness, risk of sleep apnoea, and sleep disorders

The percentages of drivers with excessive sleepiness (as measured by the Epworth Sleepiness Scale) across different socio-demographic, occupational, and driving-related variables are presented in Figure 11. Only variables showing statistically significant associations ($p < 0.05$) are discussed here (see Table A18 in the Annex for more information).

The results indicate that excessive sleepiness is more prevalent among younger drivers and decreases progressively with age – it is 2.6 times higher among drivers aged 18–24 (39.2%) compared to those aged 65 and over (14.9%).

Occupational status also affects the prevalence of excessive sleepiness, being higher among working students (41.2%) and students (37.0%), while the lowest prevalence is observed among retired individuals (14.1%). The number of hours worked per week is also a relevant factor, with the highest prevalence recorded among those working more than 40 hours per week (33.8%), and the lowest among those working less than 35 hours (18.1%). Additionally, drivers who use a vehicle as part of their job show a higher prevalence of excessive sleepiness (31.0%) than those who do not (24.6%). There is also a clear relationship between excessive sleepiness and driving during early morning hours (midnight to 6 a.m.), with prevalence increasing in line with the percentage of kilometres driven during this time frame. Specifically, the prevalence nearly doubles among drivers who drive 10% or more of their total kilometres between midnight and 6 a.m. (approx. 36%) compared to those who do not drive during those hours (18.8%).

No statistically significant differences were found in the prevalence of excessive sleepiness by gender or by working hours arrangements (see Table A18 – Annex).

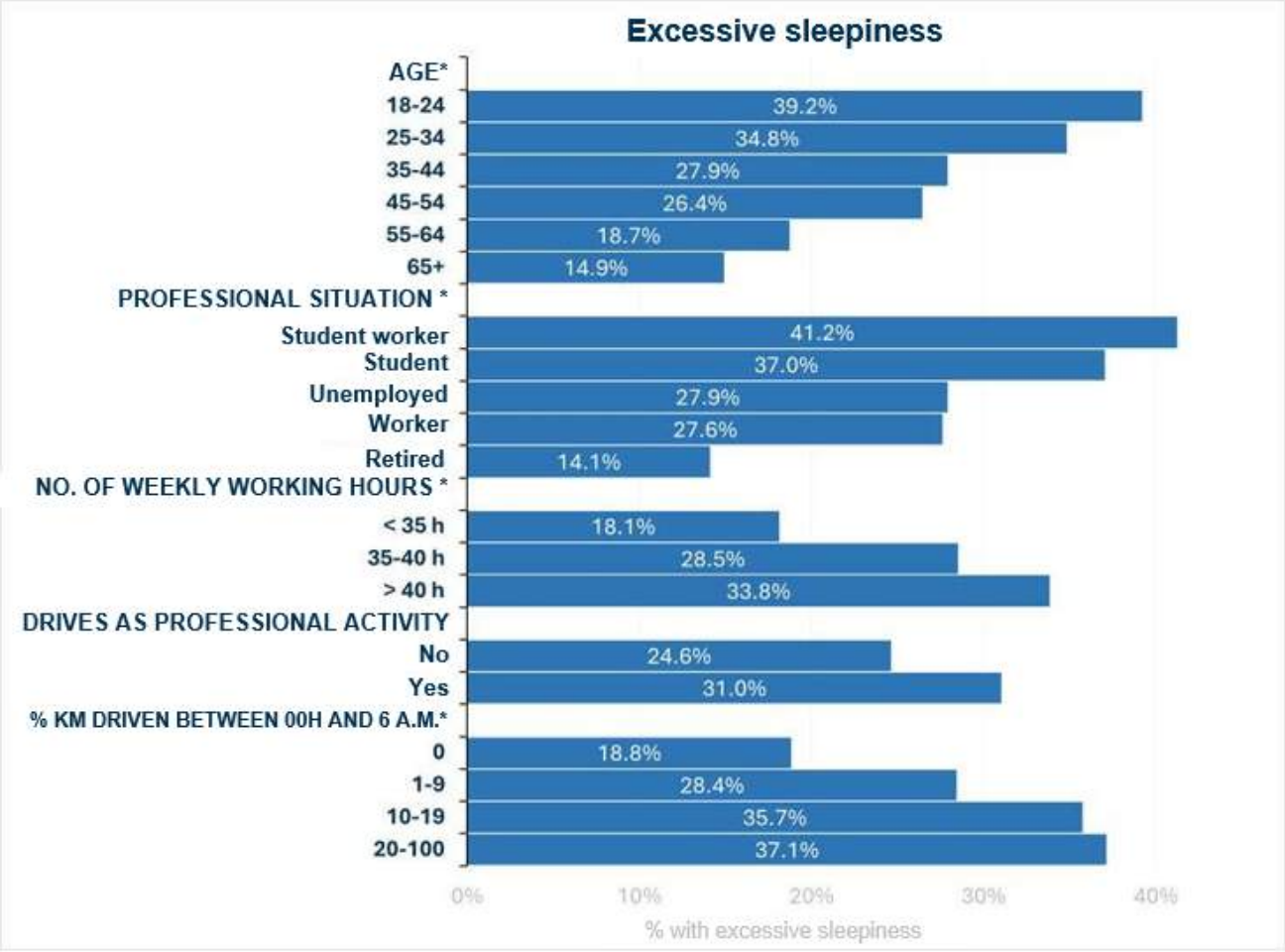

Figure 11. Percentage of drivers with excessive sleepiness

(Epworth Sleepiness Scale: mild/moderate/severe excessive sleepiness), by socio-demographic, professional, and car driving data (*p<0.05 in the Chi-square test of independence).

Figure 12 shows the percentage of drivers with a high risk of sleep apnoea, as assessed by the Berlin Questionnaire, broken down by gender and age group.

There is a statistically significant association between age and risk of sleep apnoea ($p < 0.001$), with the prevalence increasing progressively with age. Specifically, the prevalence is 4.2 times higher among drivers aged 65 and over (26.9%) than among those aged 18–24 (6.3%).

The prevalence of drivers at high risk of sleep apnoea does not differ significantly between women (19.2%) and men (21.6%) ($p > 0.05$), and it does not vary significantly across occupational or driving-related variables (Table A18 – Annex).

Results regarding the association between high risk of sleep apnoea and other variables are presented in Table A18, along with findings on self-reported sleep disorder diagnoses.

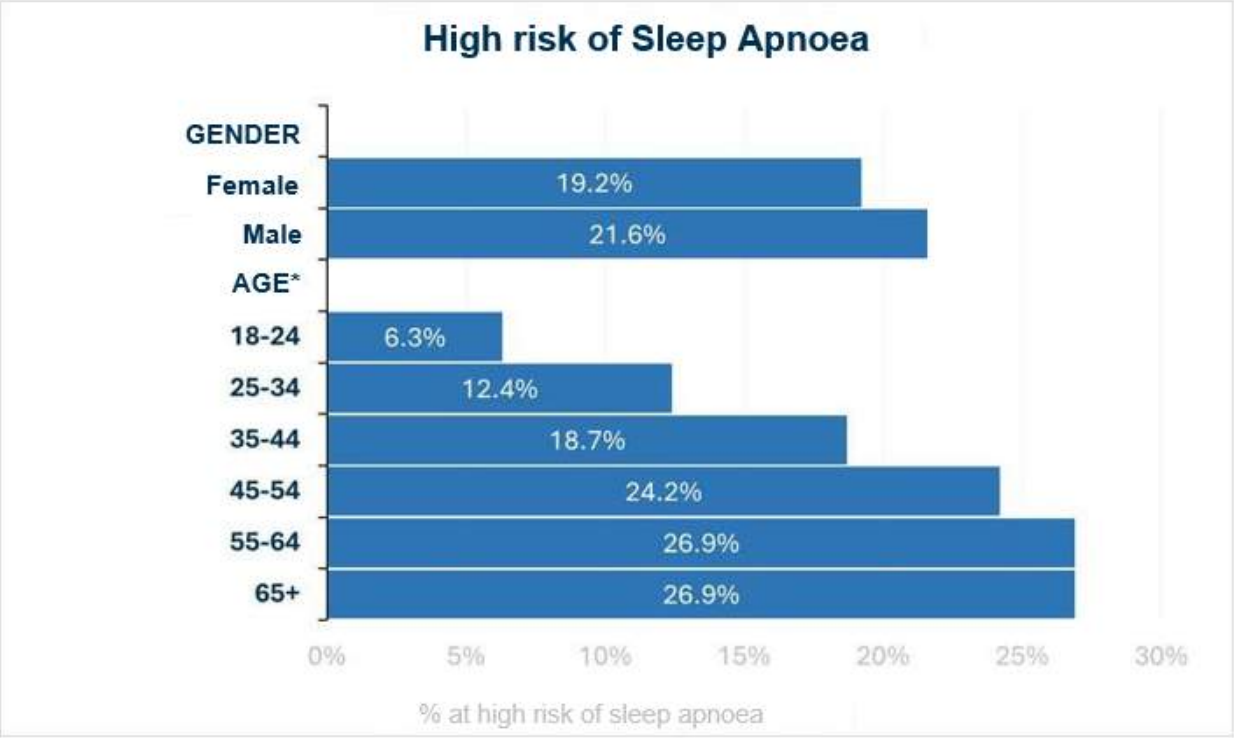

Figure 12. Percentage of drivers at high risk of sleep apnoea (Berlin questionnaire), by gender and age (*$p<0.001$ in Chi-square test of independence; $p > 0.05$ in association with gender).

3.3.2. Factors associated with self-reported driving behaviour when tired, sleepy or fatigued

Figures 13 and 14 present the main findings regarding the factors associated with the self-reported behaviours "Drove when so sleepy that it was difficult to keep eyes open" and "Fell asleep at the wheel while driving". Table A19 in the Annex provides the results of the associations between these behaviours and other variables, including the remaining two behaviours assessed in the questionnaire: "Drove when too tired/fatigued" and "Drove for more than 2 hours without stopping".

Figure 13 shows that the percentage of drivers who reported having driven while so sleepy that they had difficulty keeping their eyes open at least once in the previous 12 months increases with the severity of sleepiness: 25.0% among drivers with normal levels of sleepiness, 54.6% among those with mild/moderate excessive sleepiness, and 74.3% among drivers with severe excessive sleepiness. The behaviour was also more frequent among drivers at high risk of sleep apnoea (43.7% vs. 30.8% among drivers at low risk), and among those with a diagnosed sleep disorder (43.9% vs. 32.2% without diagnosis). Notably, drivers with severe excessive sleepiness were almost three times more likely to report this behaviour than those with normal sleepiness (74.3% vs. 25.0%).

The differences are even more pronounced regarding falling asleep at the wheel: the proportion of drivers who reported falling asleep while driving at least once in the previous 12 months was 6.2 times higher among those with severe excessive sleepiness (31.4%) compared to those with normal sleepiness (5.1%). This behaviour was also more frequent among drivers at high risk of sleep apnoea (15.5% vs. 7.8% at low risk) and among drivers diagnosed with sleep disorders (18.7% vs. 8.3%) (see Figure 13).

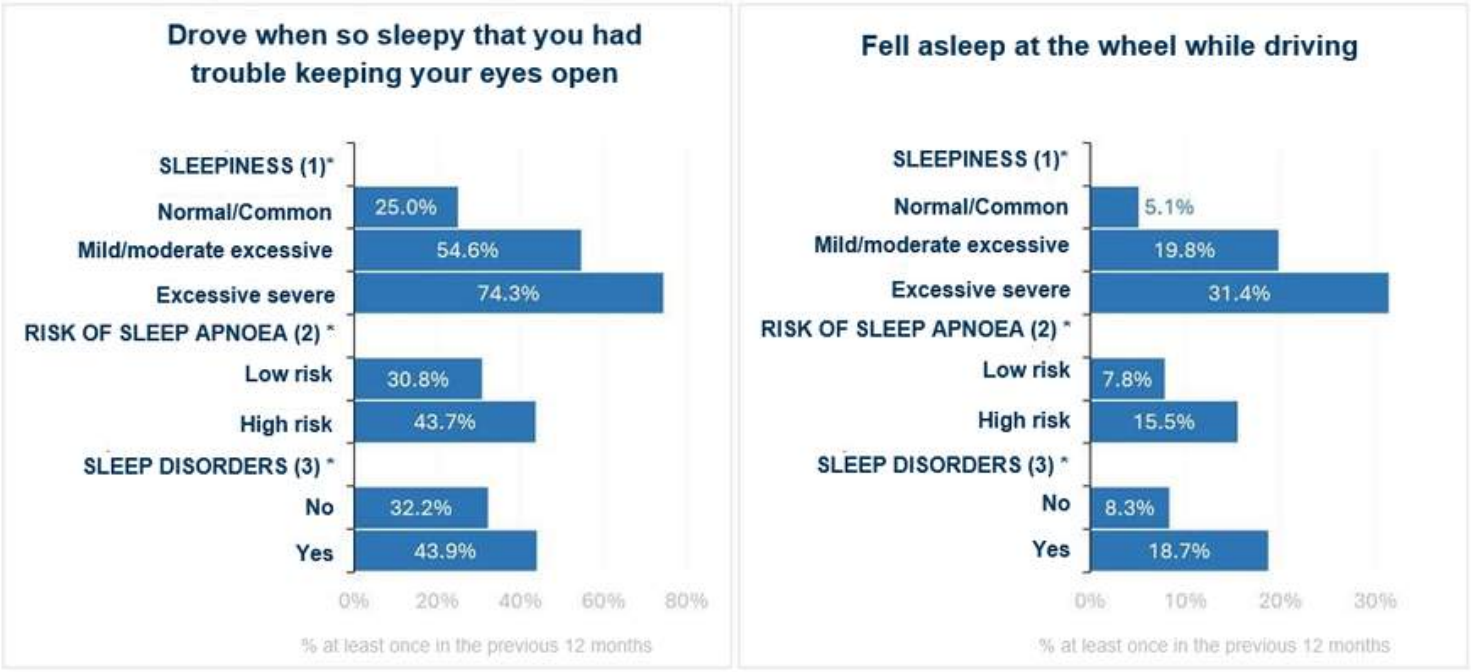

Figure 13. Percentage of drivers who reported having driven when they were so sleepy that they had difficulty keeping their eyes open and having fallen asleep at the wheel while driving
(at least once in the previous 12 months), by classification of sleepiness ((1) Epworth Sleepiness Scale), risk of Sleep Apnoea ((2) Berlin Questionnaire) and self-reported diagnosis of sleep disorders ((3) (* $p < 0.05$ in the Chi-square test of independence).

Concerning professional activity variables (Figure 14), the highest rates of both behaviours were observed among drivers who drive as part of their job: 51.8% of these drivers reported driving while so sleepy that they had difficulty keeping their eyes open (nearly double the rate of other drivers: 27.5%), and 18.8% reported having fallen asleep at the wheel (almost three times more than other drivers: 6.3%). It is also noteworthy that 30.0% of drivers who work night or evening shifts reported having fallen asleep while driving, approximately three times higher than among those working rotating shifts (11.9%) or daytime shifts (9.8%). The findings also point to a higher prevalence of these behaviours among student workers.

Driving in the early hours of the morning is associated with a higher prevalence of both types of behaviours, with the likelihood increasing alongside the percentage of kilometres driven between midnight and 6 a.m.

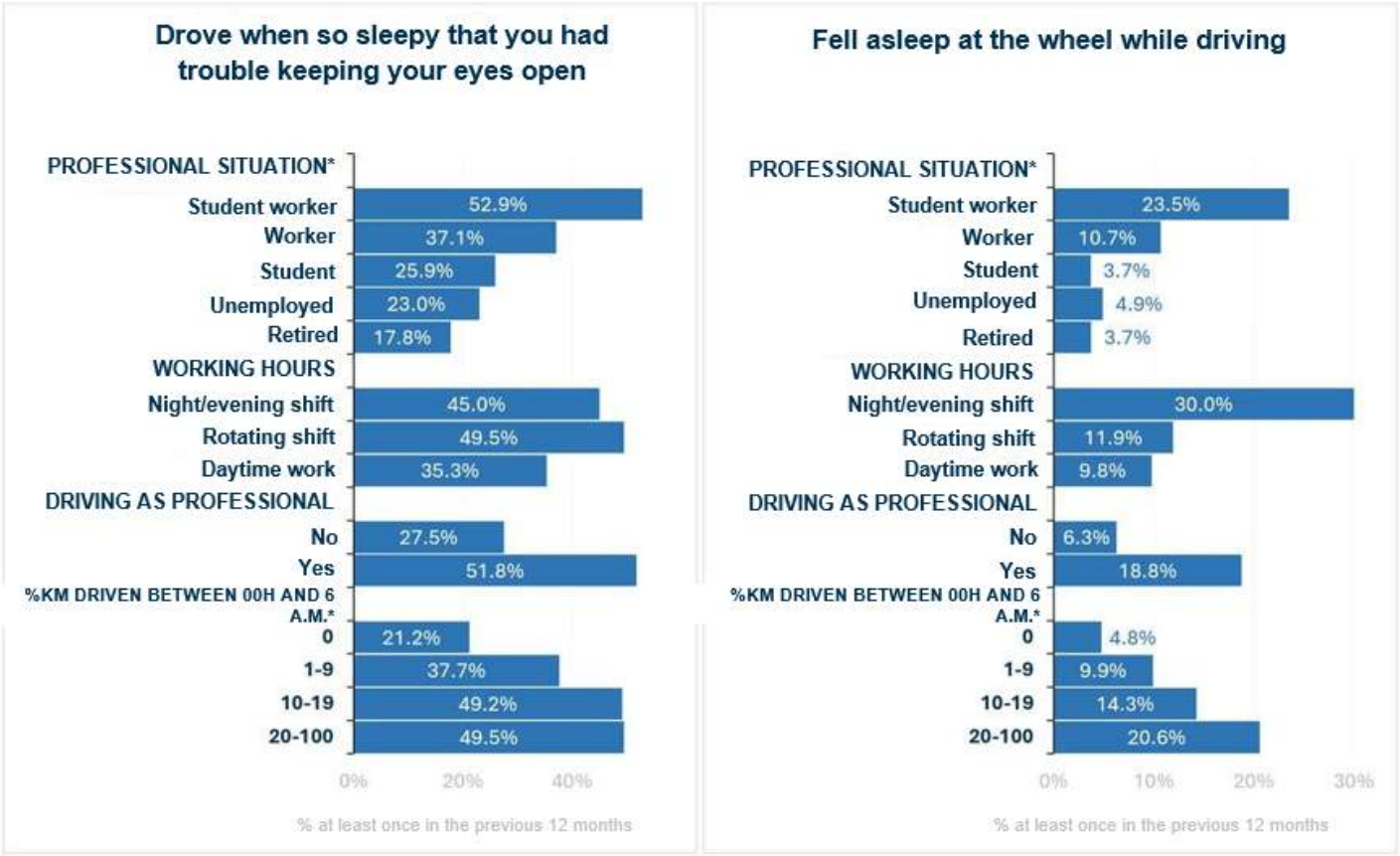

Figure 14. Percentage of drivers who reported having driven when they were so sleepy that they had difficulty keeping their eyes open, and having fallen asleep at the wheel while driving
(at least once in the previous 12 months), by data on professional activity and driving during the night/early morning (*p<0.05 in the Chi-squared test of independence; p > 0.05 in cases without *).

Other results, presented in Table A18 of the Annex, show that risk perception and attitudes towards driving while tired, fatigued or sleepy significantly influence self-reported behaviour. For example, drivers who consider it risky to drive while sleepy are less likely to report having driven when so sleepy that they had difficulty keeping their eyes open (31.0% vs. 56.8% among those who do not consider it risky), or having fallen asleep while driving (7.3% vs. 29.5%).

Regarding attitudes, drivers who consider it acceptable to drive when so sleepy that they have difficulty keeping their eyes open, or who believe they are capable of driving safely while tired or fatigued, are more likely to report both behaviours: driving while extremely sleepy and falling asleep at the wheel.

3.3.3. Factors associated with road crashes or near misses due to fatigue, tiredness or sleepiness

Figures 15 to 17 present the main findings regarding factors associated with self-reported involvement in road crashes or near misses attributed to fatigue, tiredness or sleepiness. More detailed information on the analyses performed, along with additional results, is available in Table A20 of the Annex.

The data in Figure 15 show that the risk of having experienced a road crash or near miss due to fatigue, tiredness or sleepiness in the previous 12 months is three times higher among drivers with excessive sleepiness (20.0%) than among those with normal sleepiness (6.5%). The risk is also elevated among drivers at high risk of sleep apnoea (13.6% vs. 9.0% in low-risk drivers), and among those diagnosed with sleep disorders (15.9% vs. 9.3% in drivers without such diagnoses).

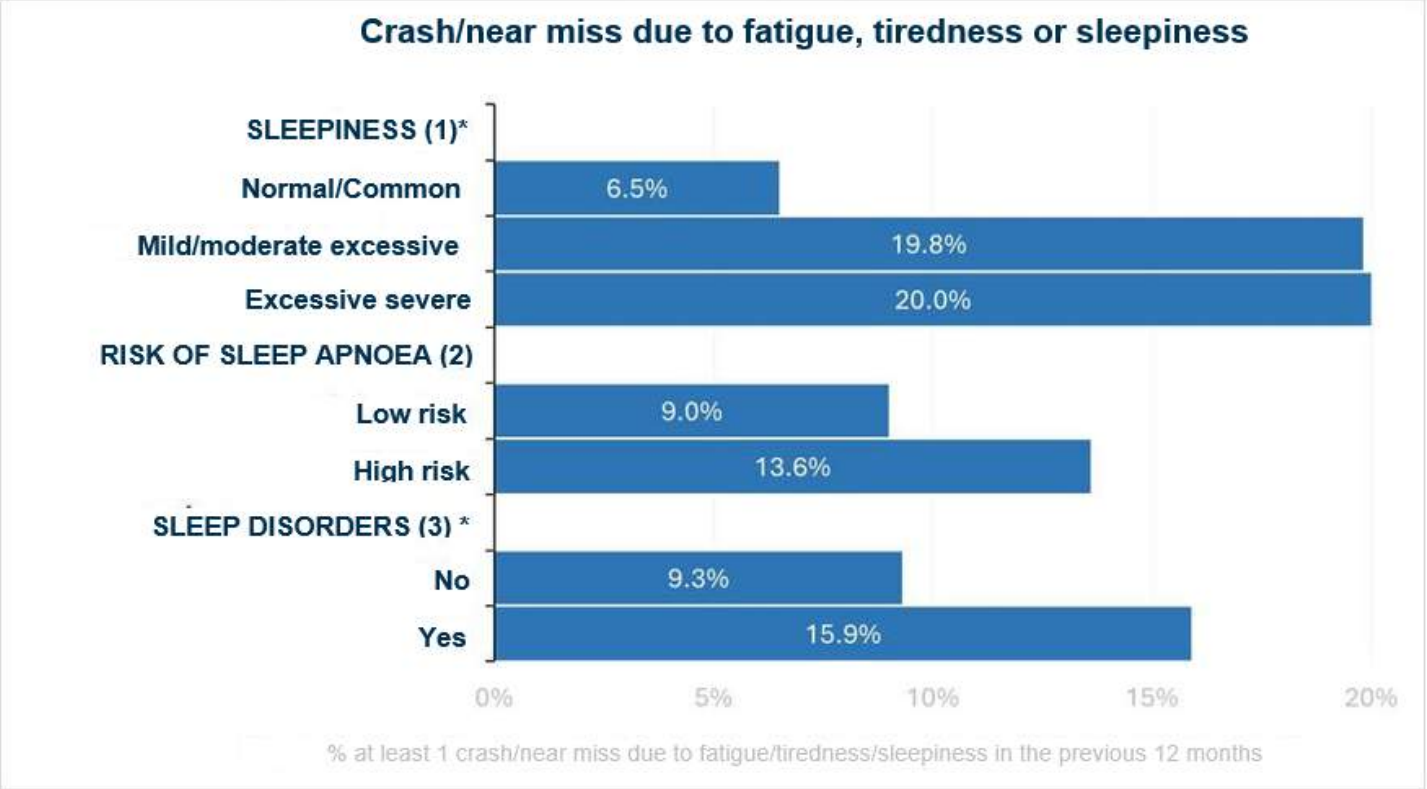

Figure 15. Percentage of drivers who reported having had at least 1 traffic accident/near miss due to fatigue/tiredness/sleepiness in the previous 12 months by classification of sleepiness ((1) Epworth Sleepiness Scale), risk of sleep apnoea ((2) Berlin Questionnaire) and diagnosis of sleep disorders ((3) self-reported) (*p<0.05 in the Chi-square test of independence; p = 0.052 in association with the risk of sleep apnoea).

Regarding the professional activity variables (Figure 16), the percentage of drivers who drive as part of their job and who reported road crashes or near misses attributed to fatigue, tiredness or sleepiness (19.2%) is 2.7 times higher than among those who do not (7.0%). Student workers (23.5%) and students (18.5%) reported the highest rates of crashes/near misses, followed by employed workers (10.7%), unemployed individuals (8.2%), and retired persons (3.7%).

The results also indicate that the risk of a crash or near miss due to fatigue, tiredness or sleepiness increases proportionally with the percentage of kilometres driven during the night or early morning. Drivers who report driving 10 kilometres or more between midnight and 6 a.m. have a risk that is four times higher than those who never drive during that period (18.3%–19.6% vs. 4.1%). The risk also rises with weekly driving time, reaching 24.6% among those who drive more than 20 hours per week — again, four times higher than among drivers who drive less than 5 hours per week (6.2%).

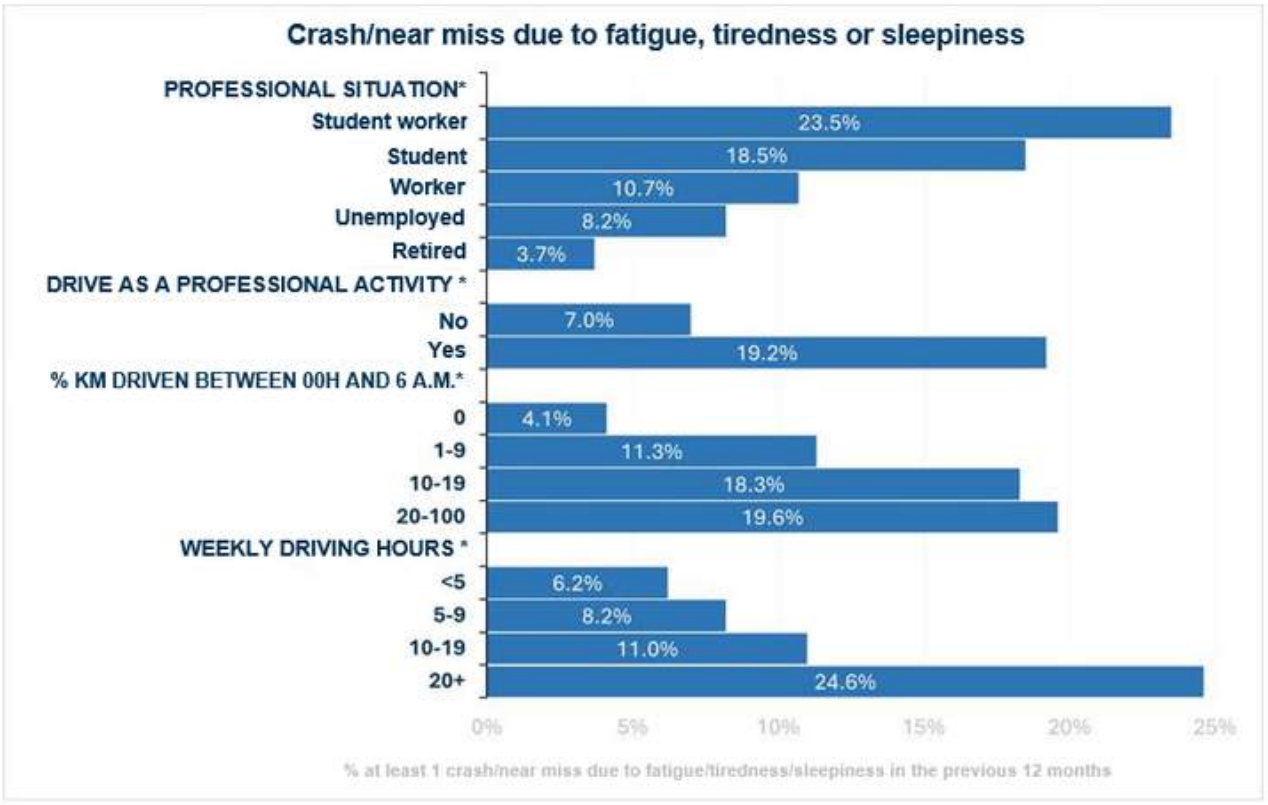

Figure 16. Percentage of drivers who reported having had at least 1 traffic accident/near miss due to fatigue/tiredness/sleepiness in the previous 12 months, by professional and driving data (*p<0.05 in the Chi-square test of independence).

Figure 17 further shows that drivers who report engaging in risky driving behaviours have a significantly higher likelihood of being involved in a fatigue-related crash or near miss than those who do not: "Drove when so sleepy that it was difficult to keep eyes open" – 22.7% vs. 3.6%, "Drove when too tired/fatigued" – 16.4% vs. 1.2%, and "Drove for more than 2 hours straight without stopping" – 12.9% vs. 4.6%.

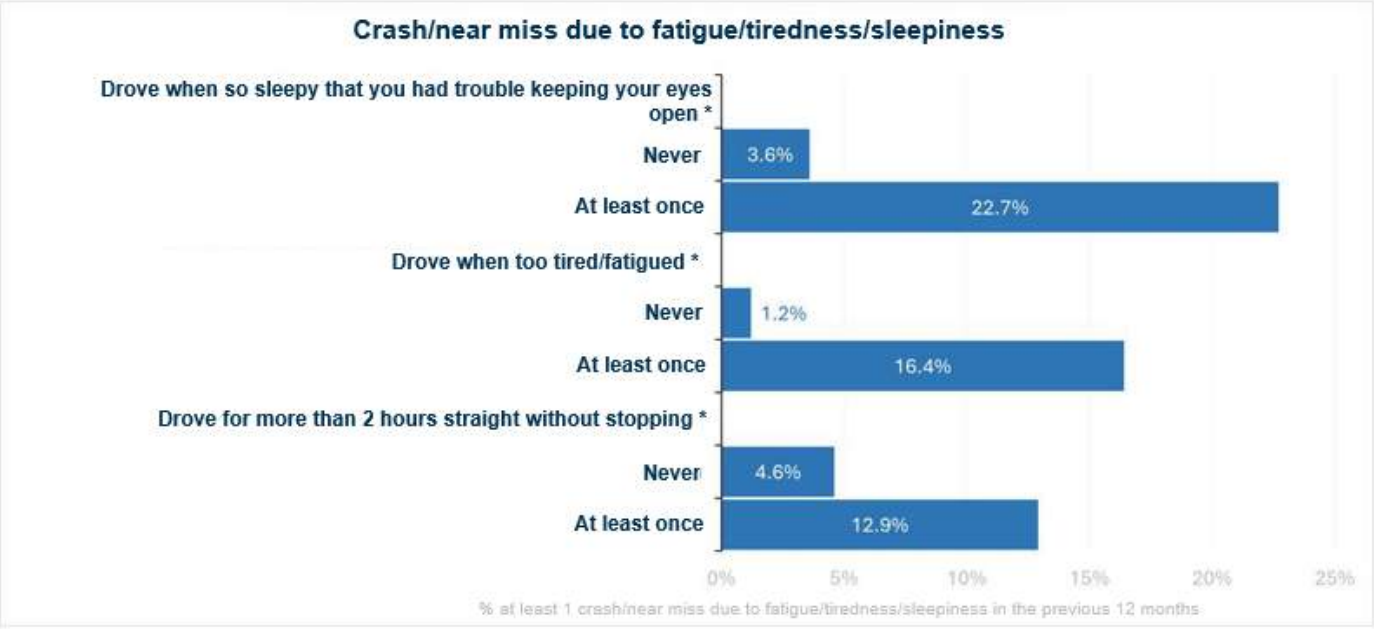

Figure 17. Percentage of drivers who reported having had at least 1 crash/near miss due to fatigue/tiredness/sleepiness in the previous 12 months, by self-reported behaviour in the previous 12 months (*p<0.001 in the Chi-square test of independence).

It should also be noted that the prevalence of crashes or near misses due to fatigue, tiredness or sleepiness is higher among younger drivers — 19.0% in drivers aged 18 to 24 years — and decreases steadily with age, falling to less than 4% among drivers aged 55 and over (Table A20 in the Annex).

4. CONCLUSIONS

The findings of this study reveal a concerning prevalence of sleep disorders among the Portuguese driving population, with insomnia and sleep apnoea being the most commonly reported conditions. A significant proportion of individuals also report driving while feeling tired, sleepy or fatigued.

Moreover, concerning attitudes towards drowsy driving were observed. Many drivers believe they can drive safely despite being tired, or choose to continue driving even when feeling sleepy. These attitudes, combined with the ineffective countermeasures most drivers resort to, often lead to extreme sleepiness and falling asleep at the wheel, significantly increasing the risk of fatigue-related road crashes.

A considerable number of drivers reported being involved in road crashes or near misses attributed to fatigue, tiredness, or sleepiness, underlining the serious consequences of this issue. Most of these incidents occur at night or during the early hours of the morning. The results show a significantly higher risk of such events among drivers with excessive sleepiness, those at high risk of sleep apnoea, and individuals with diagnosed sleep disorders.

The study also identified specific high-risk groups, including student workers, professional drivers, and those who regularly drive between midnight and 6 a.m.. Furthermore, drivers who admitted to risky behaviours, such as driving when tired or fatigued, or driving for more than two hours without taking a break, were also more likely to be involved in road crashes or near misses.

These findings underscore the urgent need to develop and implement prevention and awareness campaigns focused on the dangers of drowsy driving. Such initiatives should aim to raise awareness of sleep disorders and their impact on driving safety; encourage diagnosis and treatment of these conditions; promote healthy sleep habits and safe driving practices, especially among high-risk groups; and inform the public about the ineffectiveness of common myths and strategies used to combat sleepiness at the wheel.

Ultimately, promoting a road safety culture that does not tolerate driving while sleepy is essential to reducing the number of fatigue-related road crashes.

5. RECOMMENDATIONS

The following recommendations are based not only on the results of this study, but also on the recommendations of the European Commission [3], which highlight the need to address driver fatigue through three main pillars: drivers, road infrastructure, and vehicles. These recommendations aim to increase driver awareness of the risks associated with fatigue, improve road conditions to facilitate adequate breaks and rest, and promote the implementation of in-vehicle technologies that help prevent fatigue-related crashes

Focus on drivers

- Increase awareness of sleep disorders (around 20% of drivers are unaware of them) their impact on driving, and the importance of proper treatment. Drivers who experience frequent tiredness and drowsiness should consult a healthcare professional;
- Develop awareness campaigns to warn about the risks of fatigue and drowsiness while driving, providing clear and practical guidance on how to prevent them and how to react in real situations;
- Include information on the dangers of driving while fatigued and drowsy in educational programmes and driver licensing training;
- Inform drivers about the importance of fatigue and drowsiness detection systems in vehicles, explaining their correct use and the need to take system alerts seriously.

In the case of professional drivers:

  - Raise employers' awareness of the importance of implementing road safety plans that address the risks of fatigue and drowsiness while driving;
  - Employers should schedule working hours in a way that ensures compliance with driving time and rest period regulations, actively monitoring and enforcing adherence.

Focus on infrastructure

- Install rumble strips on major roads (motorways and national roads);
- Develop public rest areas along road networks, with secure parking facilities, allowing drivers to rest safely.

Focus on vehicles

- Provide incentives for the purchase of vehicles equipped with Advanced Driver Assistance Systems (ADAS);
- Promote the development of affordable solutions for detecting and preventing fatigue and drowsiness in vehicles.

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Annex

A1. Socio-demographic data

Table A1. Socio-demographic data (N = 1002).

		n	%
Gender	Female	447	44.6
	Male	552	55.1
	Other	3	0.3
Age (years)	18-24	79	7.9
	25-34	161	16.1
	35-44	219	21.9
	45-54	227	22.7
	55-64	182	18.2
	65+	134	13.4
	Minimum - maximum: 18 - 83 Mean (Standard Deviation): 46.6 (14.5)		
Level of education	1st Cycle	4	0.4
	2nd Cycle	9	0.9
	3rd Cycle	54	5.4
	Secondary Education	526	52.5
	University Degree	291	29.0
	Master's Degree	101	10.1
	Doctorate	17	1.7
Marital Status	Single	269	26.8
	Married	447	44.6
	Civil partnership	160	16.0
	Widowed	17	1.7
	Separated/divorced	104	10.4
	Other	5	0.5

A2. Professional activity

Table A2. Professional activity (N = 1002).

		n	%
Professional status	Employee	632	63.1
	Self-employed	122	12.2
	Student worker	17	1.7
	Student	27	2.7
	Unemployed	61	6.1
	Retired	135	13.5
	Other	8	0.8
Number of working hours weekly*	< 35 hours	83	10.8
	35-40 hours	611	
	> 40 hours	77	10.0
	Minimum - maximum: 4 - 70 Mean (Standard Deviation): 37.8 (7.3)		
Working hours arrangement*	Daytime shift (e.g. 8 a.m. - 5 p.m. or 9 a.m. - 6 p.m.)	603	78.2
	Night shift (mostly at night, for example, 10 p.m. - 6 a.m. or midnight - 8 a.m.)	12	1.6
	Back shift (work starts in the late afternoon and goes into the night, e.g. 2 p.m. - 10 p.m. or 4 p.m. - midnight)	28	3.6
	Rotating shift (workers alternate between day shifts, back and night shifts)	109	14.1
	Other	19	2.5
Days off per week*	0 -1 day	77	10.0
	2 days	655	85.0
	3 - 5 days	39	5.1
	Minimum - maximum: 0 - 5 Mean (Standard Deviation): 1.97 (0.53)		
Driving a vehicle as a professional activity	Yes, mainly transports other person(s) (e.g. taxi, bus, ...)	40	4.0
	Yes, mainly transports goods (e.g. truck, post office, food delivery, ...)	49	4.9
	Yes, mainly transports myself (e.g. visiting patients, salesperson, ...)	156	15.6
	No, drive a car only for commuting or for personal reasons	757	

* among respondents working as employees, self-employed or student workers (N = 771).

A3. Driving a car

Table A3. Driving (N = 1002).

		n	%
How often have you driven a passenger car Or a light goods vehicle in the previous 12 months	At least 4 days per week	771	76.9
	From 1 to 3 days per week	166	16.6
	A few days a month	65	6.5
Hours of driving a car in a normal week	< 5	337	33.6
	5-9	341	34.0
	10-14	154	15.4
	15-19	56	5.6
	20-24	49	4.9
	25-29	17	1.7
	30+	48	4.8
	Mean (Standard Deviation): 8.7 (9.0) Median: 6.0		
Approximate number of kilometres driven a car in the previous 12 months	< 5000	419	41.8
	5000 - 9999	136	13.6
	10000-14999	179	17.9
	15000-19999	81	8.1
	20000-24999	75	7.5
	25000-29999	29	2.9
	30000+	83	8.3
	Mean (Standard Deviation): 11877.422674.8 Median: 6000.0		
Approximate percentage of kilometres usually driven from midnight to 6 a.m.	0	416	41.5
	1-9	363	36.2
	10-19	126	12.6
	20-49	61	6.1
	50-100	36	3.6
	Mean (Standard Deviation): 6.614.6 Median: 1.0		

A4. Sleepiness assessment (Epworth Sleepiness Scale)

Table A4. Epworth Sleepiness Scale - frequencies of answers to each item (N = 1002).

'How likely are you to nod off or fall asleep in the following situations, in contrast to feeling just tired?'	**0. no probability of nodding off**	**1. slight probability of nodding off**	**2. moderate probability of nodding off**	**3. Strong probability of nodding off**
Sitting and reading	34.2%	41.7%	17.9%	6.2%
Watching TV	15.6%	39.3%	28.3%	16.8%
Sitting inactive in a public place (e.g. waiting room, cinema or meeting)	59.2%	29.3%	8.9%	2.6%
As a passenger in a car for one hour or more without stopping	42.2%	34.4%	16.7%	6.7%
Lying down in the afternoon when circumstances permit	14.6%	30.9%	32.5%	22.0%
Sitting down talking to someone	80.3%	14.2%	4.6%	0.9%
Sitting quietly after a lunch without drinking alcohol	35.1%	39.8%	17.4%	7.7%
At the wheel, stopped in traffic for a few minutes	81.3%	13.2%	4.6%	0.9%

Sleepiness assessment

Classified according to '*Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep. 1SS1 Dec;14(c):540-5. PMID: 17S8888' [https://doi.org/10.10S3/sleep/14.c.540]*.

Table A5. Sleepiness assessment (Epworth Sleepiness Scale) (N = 1002)

Assessment	**n**	**%**
Normal/common sleepiness (0-9 points)	740	73.9
Mild/moderate excessive sleepiness (10-15 points)	227	22.7
Severe excessive sleepiness (16-24 points)	35	3.5
Scale score (sum of 8 item scores) Minimum - maximum: 0 - 24 Mean (standard deviation): 7.0 (4.2)		

A5. Risk of suffering from Sleep Apnoea (Berlin Questionnaire)

Table A6. Berlin questionnaire - frequencies of answers to each item (N = 1002).

Questions		n	%
CATEGORY 1			
1. Do you snore?	a. Yes	416	41.5
	b. No	443	44.2
	c. I don't know	143	14.3
If you snore (answer 'Yes' in question 1)			
2. Is your snoring: *	a. Slightly louder than your breathing	297	71.4
	b. As loud as when you speak	80	19.2
	c. Louder than when speaking	20	4.8
	d. So loud that it can be heard in other rooms of the house	19	4.6
3. How often do you snore? *	a. Almost every day	192	46.2
	b. 3-4 times a week	94	22.6
	c. 1-2 times a week	100	24.0
	d. 1-2 times a month	17	4.1
	e. Never or almost never	13	3.1
4. Has your snoring ever bothered other people? *	a. Yes	252	60.6
	b. No	97	23.3
	c. I don't know	67	16.1
5. Has someone noticed you stopped breathing during sleep?	a. Almost every day	30	7.2
	b. 3-4 times a week	21	5.0
	c. 1-2 times a week	35	8.4
	d. 1-2 times a month	26	6.3
	e. Never or almost never	304	73.1
CATEGORY 2			
6. How often do you feel tired or fatigued after a night's sleep?	a. Almost every day	121	12.1
	b. 3-4 times a week	121	12.1
	c. 1-2 times a week	294	29.3
	d. 1-2 times a month	203	20.3
	e. Never or almost never	263	26.2
7. During the day, do you feel tired, fatigued or unable to cope?	a. Almost every day	86	8.6
	b. 3-4 times a week	120	12.0
	c. 1-2 times a week	234	23.4
	d. 1-2 times a month	271	27.0
	e. Never or almost never	291	29.0
8. Have you ever nodded off or fallen asleep while you were driving?	a. Yes	174	17.4
	b. No	828	82.6
If the answer is 'Yes' in question 8			
G. How often does this happen? **	a. Almost every day	1	0.6
	b. 3-4 times a week	3	1.7
	c. 1-2 times a week	8	4.6
	d. 1-2 times a month	34	19.5
	e. Never or almost never	128	73.6
CATEGORY 3			
10. Do you have high blood pressure?	a. Yes	184	18.4
	b. No	760	75.8
	c. I don't know	58	5.8

* N = 416 who answered 'Yes' to question 1; N = 174 who answered 'Yes' to question 8.

Prevalence of risk of suffering from sleep apnoea

Classification according to: '*A.P. Vaz, M. Drummond, P. Caetano Mota, M. Severo, J. Almeida, J. Carlos Winck. Translation of the Berlin Questionnaire into Portuguese and its application in the identification of OSAS in a sleep respiratory pathology consultation. Revista Portuguesa de Pneumologia, Volume 17, Issue 2, 2011, Pages 5S-c5, ISSN 0873-215S*' [https://www.journalpulmonology.org/en-pdf-S0873215911700150]:

Berlin Questionnaire score (Instructions on the last page of the article):

- **Category 1**: items 1, 2, 3, 4 and 5
  - Item 1 - if the answer was yes - 1 point
  - Item 2 - if the answer was c or d - 1 point
  - Item 3 - if the answer was a or b - 1 point
  - Item 4 - if the answer was a - 1 point
  - Item 5 - if the answer was a or b - 2 points

Category 1 is positive if the score is greater than or equal to 2 points

- **Category 2**: items 6, 7 and 8 (item 9 to be considered separately)
  - Item 6 - if the answer was a or b - 1 point
  - Item 7 - if the answer was a or b - 1 point
  - Item 8 - if the answer was a - 1 point

Category 2 is positive if the score is greater than or equal to 2 points

- **Category 3** is positive if the answer to item 10 is yes or if the patient's body mass index (BMI) is greater than 30 kg/m^2.

Patient at **high risk** for OSAS: two or more categories with a positive score.
Patient at **low risk** for OSAS: no or only one category with a positive score.

Table A7. Prevalence of risk of suffering from Sleep Apnoea (Berlin Questionnaire) (N = 1002).

Classification	n	%
Low risk	796	79.4
High risk	206	20.6

A6. Diagnosed sleep disorders and therapies used

Table A8. Prevalence of diagnosed sleep disorders and therapies used (N = 1002).

		n	%	Prevalence[(a)]
Sleep disorders diagnosed				
You have been diagnosed with a sleep disorder	Yes	107	10.7	**10.7%**
	No	895	89.3	
What sleep disorder was diagnosed? *	Sleep Apnoea	44	41.1	**4.4%**
	Insomnia	57	53.3	**5.7%**
	Restless Legs Syndrome	8	7.5	**0.8%**
	Other	7	8.4	**0.9%**
	Don't know	2	1.9	
Therapies used				
You use a therapy to treat a sleep disorder	Yes	114	11.4	**11.4%**
	No	888	88.6	
Therapy used **	CPAP (continuous positive airway pressure equipment)	21	17.8	**2.1%**
	Medicines for sleeping	71	60.2	**7.1%**
	Change of habits/sleep routine	25	21.2	**2.5%**
	Other	7	5.9	**0.7%**
Have you ever used any therapy for sleep disorders***	Yes	93	10.5	
	Never	791	89.5	

* among those diagnosed with some sleep disorder (N = 107) - could indicate more than one option; ** among those using therapy to treat sleep disorders (N = 114) - could indicate more than one option; *** among those not using therapy to treat sleep disorders (N = 888) - could indicate more than one option; **** among those already using therapy to treat sleep disorders (N = 93); [(a)] number of disorders/therapies divided by total sample size (N = 1002).

A7. Awareness of sleep-related diseases

Table A9. Awareness of sleep-related diseases (N = 1002).

		n	%
'Of the following sleep disorders, which do you know about?' *	Sleep Apnoea	658	65.7
	Insomnia	749	74.8
	Restless Legs Syndrome	231	23.1
	Narcolepsy	138	13.8
	Other	12	1.2
	Don't know any	189	18.9
'Do you know how to identify the main Symptoms of Sleep Apnoea?' *	Snoring	397	39.6
	Breathing interruptions during sleep	646	64.5
	Frequent night awakenings	213	21.3
	Excessive daytime sleepiness	276	27.5
	Waking up short of breath	304	30.3
	Feeling of unrefreshing sleep	304	30.3
	Don't know	202	20.2

* could indicate more than one option: 'Select all that apply'.

A8. Self-reported behaviour - driving a car

Table A10. Self-reported behaviour - driving a car (N = 1002).

'During the last 12 months, how often have you driven a car?'	1. never	2	3	4	5. (almost) always	At least 1 time*
Drove when so sleepy, that you had trouble keeping your eyes open	66.6%	21.8%	8.2%	3.1%	0.4%	33.4%
Drove when too tired/fatigued	42.0%	33.0%	16.9%	6.7%	1.4%	58.0%
Fell asleep at the wheel while driving	90.6%	5.2%	2.5%	1.4%	0.3%	9.4%
Drove for more than 2 hours straight without stopping	35.0%	23.9%	20.4%	11.4%	9.4%	65.0%

* percentage of 2 to 5 answers on the 5-point scale, from 1 = 'never' to 5 '(almost) always'.

AG. Measures to combat driving fatigue

Self-reported

Table A11. Measures to combat driving fatigue - **self-reported** (N = 615*).

Measures **	%
Opened the windows or turned on the air conditioning	40.8%
Stopped to eat, exercise, relax, but without nodding off/sleeping	34.6%
Increased the volume of the radio/stereo system	34.3%
Drank caffeine/took caffeine tablets	28.9%
Talked to passengers	25.2%
Slowed down	22.9%
Ate or drank something	21.8%
Changed the radio station	16.7%
Sang	16.6%
Asked a passenger to take over the driving duties	13.0%
Stopped to take a nap	11.2%
Poured water on face or neck or slapped/hit/pinched yourself	7.8%
Chatted on your mobile phone	6.3%
Increased speed	2.4%
Took a stimulant	2.0%
Other	1.5%
Didn't do anything - kept driving	6.3%

Question: 'In the last 12 months when you felt sleepy/tired/fatigued while driving a car, which of the following measures have you taken?' N = 615 drivers who in the previous 12 months drove when they were so sleepy that they had difficulty keeping their eyes open or who drove when they were too tired/fatigued (drivers who answered 2 to 5 in the first two questions of self-reported behaviour); **could indicate more than one measure.

Perception of efficacy

Table A12. Measures to combat driving fatigue - **perception of efficacy** (N = 1002).

Measures	1. not at all effective	2	3	4	5. very effective	Effective*
Ask a passenger to take over the driving duties	2.20%	2.10%	9.20%	15.10%	71.50%	86.50%
Stop for a nap	1.90%	3.30%	12.30%	22.90%	59.70%	82.50%
Stop to eat, exercise, relax, but without nodding off/sleeping	6.40%	11.60%	25.10%	29.10%	27.70%	56.90%
Talk to passengers	3.70%	9.90%	30.60%	33.30%	22.50%	55.80%
Drink caffeine/take caffeine tablets	10.00%	15.10%	31.80%	28.40%	14.70%	43.10%
Open windows or turn on air conditioning	10.90%	18.20%	35.50%	23.40%	12.10%	35.40%
Eat or drink something	12.60%	19.90%	33.40%	23.80%	10.40%	34.10%
Turn up the radio/stereo system	15.20%	19.60%	34.60%	21.20%	9.50%	30.60%
Sing	15.80%	20.60%	33.30%	20.60%	9.80%	30.30%
Pour water on face or neck or slap/hit/pinch yourself	16.90%	22.50%	33.00%	19.10%	8.60%	27.60%
Slow down	29.80%	21.10%	25.40%	12.80%	10.90%	23.70%
Take a stimulant	22.40%	20.90%	33.80%	16.40%	6.60%	23.00%
Change the radio station	27.10%	23.30%	29.70%	15.10%	4.80%	19.90%
Chat on your mobile phone	43.90%	17.60%	20.50%	12.40%	5.70%	18.10%
Increase speed	68.70%	14.40%	11.40%	4.00%	1.60%	5.60%

Question: 'For each of the following measures indicate on a scale from 1 [not effective] to 5 [very effective] how effective they are to combat fatigue/sleepiness while driving?'; *percentage of 4 and 5 answers of the 5-point scale, from 1 = 'not effective' to 5 'very effective'.

A10. Attitudes towards tiredness/fatigue/sleepiness when driving a car

Acceptability

Table A13. Acceptability of driving a car while fatigued (N = 1002).

	1. unacceptable	2	3	4	5. acceptable	Acceptable *
How acceptable do you personally think it is for a car driver to drive when they are so sleepy that they have difficulty keeping their eyes open?	75.0%	12.9%	6.9%	3.4%	1.8%	5.2%

* percentage of 4 and 5 answers on the 5-point scale, from 1 = 'unacceptable' to 5 'acceptable'.

Attitudes

Table A14. Attitudes towards driving while tired/fatigued/sleepy (N = 1002).

Statements	1. disagree	2	3	4	5. Agree	Agrees*
When I feel sleepy, I should not drive a vehicle	2.4%	3.0%	7.8%	16.2%	70.7%	86.8%
Even if I feel sleepy while I'm driving, I'll continue driving	47.8%	25.0%	17.6%	6.7%	2.9%	9.6%
If I feel sleepy while driving, the risk of having an crash increases	1.7%	1.4%	5.5%	11.6%	79.8%	91.4%
I can drive safely when I feel tired/fatigued	29.8%	24.3%	27.5%	13.8%	4.6%	18.4%

Question: 'To what extent do you agree with each of the following statements?'; *percentage of answers 4 and 5 on the 5-point scale, from 1 = 'disagree' to 5 'agree'.

A11. Perceived risk of driving a car while tired/fatigued/sleepy

Table A15. Attitudes towards driving while tired/fatigued/sleepy (N = 1002).

Statements	1. not at all risky	2	3	4	5. very risky	Risky*
Driving when tired/fatigued	1.2%	3.0%	15.3%	31.1%	49.4%	80.5%
Driving when feeling sleepy	1.6%	2.1%	5.8%	17.3%	73.3%	90.5%

Question: 'How risky do you consider:'; * percentage of answers 4 and 5 on the 5-point scale, from 1 = 'not at all risky' to 5 'very risky'.

A12. Traffic crashs

Table A16. Road crashes as a car driver (N = 1002).

		n	%	Prevalence[(a)]
Have you had a crash in the previous 12 months	No	918	91.6	
	Yes	84	8.4	**8.4%**
Some of the crashes were caused by: *	Tiredness/fatigue	17	20.2	**2.5%**
	Sleepiness	8	9.5	
	Other reason	59	70.2	
In relation to the most recent crash caused by tiredness/fatigue or sleepiness:				
At what time of day did it occur? **	Daytime	11	44.0	
	Night	9	36.0	
	Early morning	5	20.0	
What was the purpose of the trip? **	Home - work/school travel	6	24.0	
	Work/school - home travel	5	20.0	
	Work-related travel	10	40.0	
	Leisure travel	4	16.0	
	Other reason	-	-	

* among those who had at least one crash (N = 84); ** among those who had at least one crash caused by tiredness/fatigue or sleepiness (N = 25); [(a)] number of crashes divided by total drivers (N = 1002).

Table A17. Near-miss as a car driver (N = 1002).

		n	%	Prevalence[(a)]
Had a near miss in the last 12 months	No	552	55.1	
	Yes	450	44.9	**44.9%**
Some of the near misses were caused by: *	Tiredness/fatigue	67	14.9	**9.4%**
	Sleepiness	27	6.0	
	Other reason	356	79.1	
In relation to the most recent near miss caused by tiredness/fatigue or sleepiness:				

At what time of the day did it occur? **	Daytime	42	44.7
	Night	42	44.7
	Early morning	10	10.6
What was the purpose of the trip? **	Home - work/school travel	25	26.6
	Work/school - home travel	18	19.1
	Work-related travel	23	24.5
	Leisure travel	24	25.5
	Other reason	4	4.3

* among those who had at least one near miss (N = 450); ** among those who had at least one near miss caused by tiredness/fatigue or sleepiness (N = 94); [a] number of crashs divided by total drivers (N = 1002).

A13. Factors associated with sleepiness, risk of sleep apnoea and sleep disorder diagnoses

Table A18. Factors associated with sleepiness, risk of sleep apnoea and sleep disorder diagnoses

		N	Excessive sleepiness [1]	High risk of Sleep Apnoea [2]	Diagnosis of sleep disorders [3]
Gender	Female	447	26.8%	19.2%	11.9%
	Male	552	25.5%	21.6%	9.4%
	p		*0.641*	*0.367*	*0.212*
Age	18-24	79	39.2%	6.3%	7.6%
	25-34	161	34.8%	12.4%	9.3%
	35-44	219	27.9%	18.7%	8.2%
	45-54	227	26.4%	24.2%	10.6%
	55-64	182	18.7%	26.9%	12.1%
	65+	134	14.9%	26.9%	16.4%
	p		***<0.001***	***<0.001***	*0.186*
Professional status	Worker	754	27.6%	21.0%	9.7%
	Student worker	17	41.2%	23.5%	11.8%
	Student	27	37.0%	3.7%	11.1%
	Unemployed	61	27.9%	18.0%	9.8%
	Retired	135	14.1%	23.0%	15.6%
	p		***0.005***	*0.234*	*0.373*
Number of hours of weekly work	< 35 hours	83	18.1%	16.9%	10.8%
	35-40 hours	611	28.5%	20.5%	9.3%
	> 40 hours	77	33.8%	29.9%	11.7%
	p		***0.026***	*0.100*	*0.754*
Working hours arrangements	Daytime work	603	27.7%	21.9%	10.3%
	Night/evening shift	40	32.5%	17.5%	12.5%
	Rotating shift	109	30.3%	18.3%	6.4%
	p		*0.717*	*0.597*	*0.389*
Drive in your professional activity	No	757	24.6%	19.7%	11.1%
	Yes	245	31.0%	23.3%	9.4%
	p		***0.046***	*0.228*	*0.452*
Percentage of kilometres driven between midnight and 6 a.m.	0	416	18.8%	20.0%	12.7%
	1-9	363	28.4%	20.1%	8.5%
	10-19	126	35.7%	23.0%	6.3%
	20-100	97	37.1%	21.6%	15.5%
	p		***<0.001***	*0.879*	*0.088*

[1] Epworth Sleepiness Scale - percentage of drivers with excessive sleepiness (mild/moderate/severe); [2] Berlin questionnaire - percentage of drivers with high risk of Sleep Apnoea; [3] Percentage of drivers who have been diagnosed with some type of sleep disorder (self-reported); p - significance value of the Chi-square test of independence - highlighted in bold are cases where association is statistically significant with a significance level of 5% ($p < 0.05$).

A14. Factors associated with self-reported driving behaviour when tired, sleepy or fatigued

Table A19. Factors associated with self-reported driving behaviour when tired, sleepy or fatigued

			Self-reported behaviour (% at least once in the previous 12 months)			
		N	Drove when was so sleepy that had difficulty to keep your eyes open	Drove when was too tired/fatigued	Fell asleep at the wheel while driving	Drove more than 2 hours without stopping
Gender	Female	447	29.8%	57.0%	8.9%	52.8%
	Male	552	36.4%	58.9%	9.8%	74.8%
	p		***0.027***	*0.560*	*0.653*	***<0.001***
Age	18-24	79	48.1%	69.6%	10.1%	67.1%
	25-34	161	50.9%	72.7%	12.4%	70.2%
	35-44	219	37.9%	63.9%	12.3%	72.6%
	45-54	227	29.1%	58.6%	11.0%	67.8%
	55-64	182	22.5%	47.8%	3.3%	53.3%
	65+	134	18.7%	36.6%	6.0%	56.0%
	p		***<0.001***	***<0.001***	***0.013***	***<0.001***
Professional status	Worker	754	37.1%	62.9%	10.7%	68.0%
	Student worker	17	52.9%	76.5%	23.5%	70.6%
	Student	27	25.9%	59.3%	3.7%	40.7%
	Unemployed	61	23.0%	39.3%	4.9%	59.0%
	Retired	135	17.8%	37.0%	3.7%	55.6%
	p		***<0.001***	***<0.001***	***0.011***	***0.002***
Number of hours of weekly work	< 35 hours	83	31.3%	59.0%	12.0%	59.0%
	35-40 hours	611	37.5%	63.7%	10.3%	68.7%
	> 40 hours	77	44.2%	63.6%	15.6%	72.7%
	p		*0.246*	*0.711*	*0.361*	*0.134*
Working hours arrangements	Daytime work	603	35.3%	61.9%	9.8%	67.3%
	Night/evening shift	40	45.0%	60.0%	30.0%	62.5%
	Rotating shift	109	49.5%	73.4%	11.9%	77.1%
	p		***0.012***	*0.064*	***<0.001***	*0.093*
Drive in professional activity professional activity	No	757	27.5%	53.4%	6.3%	59.6%
	Yes	245	51.8%	72.2%	18.8%	81.6%
	p		***<0.001***	***<0.001***	***<0.001***	***<0.001***
Driving hours in a normal week	<5	337	26.4%	50.4%	9.5%	55.2%
	5-9	341	32.8%	59.2%	7.6%	64.2%
	10-19	210	39.5%	62.4%	9.0%	74.3%
	20+	114	44.7%	68.4%	14.9%	78.9%
	p		***0.001***	***0.002***	*0.146*	***<0.001***
Kilometres driven in the last year	< 5000	419	27.7%	49.9%	11.2%	58.0%
	5000 - 9999	136	27.9%	55.9%	6.6%	56.6%
	10000-14999	179	31.8%	57.5%	7.8%	67.6%
	15000-24999	156	41.0%	68.6%	4.5%	78.8%
	25000+	112	53.6%	76.8%	15.2%	77.7%
	p		***<0.001***	***<0.001***	***0.016***	***<0.001***
Percentage of km of driving between mid night and 6 a.m.	0	416	21.2%	42.5%	4.8%	52.4%
	1-9	363	37.7%	66.7%	9.9%	71.9%
	10-19	126	49.2%	73.0%	14.3%	81.7%
	20-100	97	49.5%	72.2%	20.6%	71.1%
	p		***<0.001***	***<0.001***	***<0.001***	***<0.001***
Assessment of sleepiness [1]	Normal/Common	740	25.0%	49.9%	5.1%	61.4%
	Mild/moderate excessive	227	54.6%	80.6%	19.8%	75.3%
	Excessive severe	35	74.3%	82.9%	31.4%	74.3%
	p		***<0.001***	***<0.001***	***<0.001***	***<0.001***
Risk of Sleep Apnoea[2]	Low risk	796	30.8%	55.0%	7.8%	62.4%
	High risk	206	43.7%	69.4%	15.5%	74.8%
	p		***<0.001***	***<0.001***	***0.001***	***0.001***
Diagnosis of sleep disorders [3]	No	895	32.2%	56.8%	8.3%	64.9%
	Yes	107	43.9%	68.2%	18.7%	65.4%
	p		***0.015***	***0.023***	***<0.001***	*0.918*
Risk Perception						
Driving when you are tired/fatigued	Not risky/neutral	195	42.1%	72.3%	11.8%	71.8%
	Risky	807	31.4%	54.5%	8.8%	63.3%
	p		***0.004***	***<0.001***	*0.198*	***0.026***
	Not risky/neutral	95	56.8%	68.4%	29.5%	75.8%

Driving when you are sleepy	Risky	907	31.0%	56.9%	7.3%	63.8%
	p		***<0.001***	***0.030***	***<0.001***	***0.020***
Attitudes						
Driving when so sleepy that it is difficult to keep your eyes open	Unacceptable/neutral	950	31.7%	56.8%	7.8%	63.5%
	Acceptable	52	65.4%	78.8%	38.5%	92.3%
	p		***<0.001***	***0.002***	***<0.001***	***<0.001***
When I feel sleepy, I don't drive a vehicle	Disagrees/neutral	132	50.0%	72.7%	24.2%	69.7%
	Agrees	870	30.9%	55.7%	7.1%	64.3%
	p		***<0.001***	***<0.001***	***<0.001***	*0.222*
Even if I feel sleepy while driving, I will continue to drive	Disagrees/neutral	906	30.5%	56.2%	7.8%	64.3%
	Agrees	96	61.5%	75.0%	24.0%	70.8%
	p		***<0.001***	***<0.001***	***<0.001***	*0.205*
If I feel sleepy while driving, the risk of having a crash increases	Disagrees/neutral	86	52.3%	64.0%	20.9%	69.8%
	Agrees	916	31.7%	57.4%	8.3%	64.5%
	p		***<0.001***	*0.241*	***<0.001***	*0.329*
I'm able to drive safely when feeling tired/fatigued	Disagrees/neutral	818	30.4%	55.5%	8.3%	63.8%
	Agrees	184	46.7%	69.0%	14.1%	70.1%
	p		***<0.001***	***0.001***	***0.014***	*0.106*

[1]Epworth Sleepiness Scale; [2] Berlin Questionnaire; [3] self-reported; p - significance value of the Chi-squared test of independence - cases where the association is statistically significant at a significance level of 5% ($p < 0.05$) are highlighted in bold.

A15. Factors associated with road crashes/near misses due to fatigue, tiredness or sleepiness

Table A20. Factors associated with road crashes/near misses due to fatigue, tiredness or sleepiness

		N	Had at least one crash or near miss due to fatigue, tiredness or sleepiness	*p*
Gender	Female	447	8.9%	*0.314*
	Male	552	10.9%	
Age	18-24	79	19.0%	***<0.001***
	25-34	161	13.7%	
	35-44	219	13.7%	
	45-54	227	10.6%	
	55-64	182	2.2%	
	65+	134	3.7%	
Professional status	Worker	754	10.7%	***0.016***
	Student worker	17	23.5%	
	Student	27	18.5%	
	Unemployed	61	8.2%	
	Retired	135	3.7%	
Number of weekly working hours	< 35 hours	83	8.4%	*0.092*
	35-40 hours	611	10.5%	
	> 40 hours	77	18.2%	
Working hours arrangements	Daytime work	603	10.3%	*0.259*
	Night/evening shift	40	12.5%	
	Rotating shift	109	15.6%	
Drive as a professional activity	No	757	7.0%	***<0.001***
	Yes	245	19.2%	
Driving hours in a normal week	<5	337	6.2%	***<0.001***
	5-9	341	8.2%	
	10-19	210	11.0%	
	20+	114	24.6%	
Kilometres driven in the last year	< 5000	419	10.0%	***0.005***
	5000 - 9999	136	3.7%	
	10000-14999	179	8.4%	
	15000-24999	156	11.5%	
	25000+	112	17.9%	
Percentage of driving km between midnight and 6 a.m.	0	416	4.1%	***<0.001***
	1-9	363	11.3%	
	10-19	126	18.3%	
	20-100	97	19.6%	
Sleepiness assessment [1]	Normal/Common	740	6.5%	***<0.001***
	Mild/moderate excessive	227	19.8%	
	Excessive severe	35	20.0%	
Risk of suffering from Sleep Apnoea [2]	Low risk	796	9.0%	*0.052*
	High risk	206	13.6%	
Diagnosis of sleep disorders [3]	No	895	9.3%	***0.031***
	Yes	107	15.9%	

Self-reported behaviour				
Drove when so sleepy, you had trouble keeping your eyes open	Never	667	3.6%	<***0.001***
	At least once	335	22.7%	
Drove when too tired/fatigued	Never	421	1.2%	<***0.001***
	At least once	581	16.4%	
Fell asleep at the wheel while driving	Never	908	7.0%	<***0.001***
	At least once	94	38.3%	
Drove for more than 2 hours straight without stopping	Never	351	4.6%	<***0.001***
	At least once	651	12.9%	
Risk Perception				
Driving when tired/fatigued	Not risky/neutral	195	11.8%	*0.346*
	Risky	807	9.5%	
Driving when feeling sleepy	Not risky/neutral	95	15.8%	***0.047***
	Risky	907	9.4%	
Attitudes				
Driving when so sleepy you have trouble keeping your eyes open	Unacceptable/neutral	950	9.7%	*0.182*
	Acceptable	52	15.4%	
When I feel sleepy, I should not drive a vehicle	Disagrees/neutral	132	15.2%	***0.033***
	Agrees	870	9.2%	
Even if I feel sleepy while driving, I will continue to drive	Disagrees/neutral	906	9.7%	*0.386*
	Agrees	96	12.5%	
If I feel sleepy while driving, the risk of a crash increases	Disagrees/neutral	86	14.0%	*0.199*
	Agrees	916	9.6%	
I can drive safely when I feel tired/fatigued	Disagrees/neutral	818	9.4%	*0.207*
	Agrees	184	12.5%	

[(1)]Epworth Sleepiness Scale; [(2)] Berlin Questionnaire; [(3)] self-reported; p - significance value of the Chi-squared test of independence - cases where the association is statistically significant at a significance level of 5% ($p < 0.05$) are highlighted in bold.

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2025

ISBN 978-972-98080-9-8