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E-Survey of Road users' Attitudes



Driver fatigue

ESRA2 Thematic report Nr. 4

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Driver fatigue

ESRA2 Thematic report Nr. 4

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List of Abbreviations

Country codes

AT	Austria
AU	Australia
BE	Belgium
CA	Canada
CH	Switzerland
CZ	Czech Republic
DE	Germany
DK	Denmark
EG	Egypt
EL	Greece
ES	Spain
FI	Finland
FR	France
HU	Hungary
IE	Ireland
IL	Israel
IN	India
IT	Italy
JP	Japan
KE	Kenya
KR	Republic of Korea
MA	Morocco
NG	Nigeria
NL	Netherlands
PL	Poland
PT	Portugal
RS	Serbia
SE	Sweden
SI	Slovenia
UK	United Kingdom
US	United States
ZA	South Africa

Other abbreviations

ESRA	E-Survey of Road Users' Attitudes
EU	European Union
ICW	Individual country weight used in ESRA2
IPSOS	Institut de Publique Sondage d'Opinion Secteur
OR	Odds Ratio
OSA	Obstructive sleep apnoea

Executive Summary

Objective and methodology

ESRA (E-Survey of Road users' Attitudes) is a joint initiative of road safety institutes, research centres, public services, and private sponsors from all over the world. The aim is to collect and analyse comparable data on road safety performance, in particular road safety culture and behaviour of road users. The ESRA data are used as a basis for a large set of road safety indicators. These provide scientific evidence for policy making at national and international levels.

Vias institute in Brussels (Belgium) initiated and coordinates ESRA, in cooperation with eleven core group partners (BASt, BFU, CTL, IATSS, IFSTTAR, ITS, KFV, NTUA, PRP, SWOV, TIRF). At the heart of ESRA is a jointly developed questionnaire survey, which is translated into national language versions. The themes covered include self-declared behaviour, attitudes and opinions on unsafe traffic behaviour, enforcement experiences and support for policy measures. The survey addresses different road safety topics (e.g. driving under the influence of alcohol, drugs and medicines, speeding, distraction) and targets car occupants, motorcycle and moped drivers, cyclists and pedestrians.

The present report is based on the second edition of this global survey, which was conducted in 2018 (ESRA2_2018). In total this survey collected data from more than 35.000 road users across 32 countries. An overview of the ESRA initiative and the project-results is available on: www.esranet.eu.

This thematic ESRA report on driving fatigue describes the rate of self-declared fatigued driving, the personal acceptability of fatigued driving, and the perception of driving fatigue as an accident cause amongst road users in 32 countries. It includes comparisons amongst the participating countries as well as results in relation to age and gender.

Key results

Below for each research question the major findings are presented.

What is the prevalence of fatigued driving? And what are differences?

- In most countries one fifth to one quarter of car drivers report to have driven while having trouble keeping eyes open in the past 30 days.
- In Europe, North America and Africa, self-declared fatigued driving rates are (considerably) higher for male drivers than for female drivers.
- In Europe and North America, the self-declared fatigued driving rates tend to decrease with increasing age, in Asia-Oceania and in Africa this age pattern is not found (or even reversed).

What is the personal acceptability of fatigued driving? And what are differences?

- In all participating countries worldwide less than 3% of road users find fatigued driving personally acceptable showing that road users personal norms reject this behaviour.
- In Europe, North America and Asia-Oceania, the personal acceptability of fatigued driving is (slightly) higher among the younger age groups. Surprisingly, in Africa the personal acceptability is highest (15% amongst the oldest age group).
- The gender differences in personal acceptability of fatigued driving are quite small.

What is the perception of fatigued driving as accident cause? And what are differences?

- In all countries worldwide a large majority of road users perceive tired driving as a frequent cause of accidents.

- European road users most frequently perceive tired driving as a frequent crash cause (74%), with lower rates reported amongst road users in North America (69%), Africa (64%) and Asia-Oceania (53%).
- In Europe and North America, the perception of tired driving as a frequent crash cause is more prevalent among older age groups (55-64; 65+) than younger age group whereas this age pattern is not found in Asia-Oceania and Africa.

What factors are related to the personal acceptability of fatigued driving? And to the perception of fatigued driving as accident cause?

- The most important variables that explain the differences in answers to personal acceptability of fatigued driving are: age, education level and personal involvement in accidents.
- The most important variables that explain differences in answers to perception of fatigued driving as crash cause are age, gender and frequency of car use.

What factors are related to self-declared fatigued driving?

- Drivers who feel that it is acceptable to drive being so sleepy that you have trouble keeping your eyes open are 6.5 times more likely to drive when they are tired
- Compared to male drivers, the odds of driving when tired for women are reduced by 47%.
- Compared to drivers aged 55+, the odds of driving when tired are increased by 30% for drivers aged between 18 to 34 years, and by 8% for drivers aged 35 to 54 years
- Compared to drivers with a Master's degree or higher, the odds of self-declared fatigued driving decrease by 51% for drivers with secondary education level, by 46% for drivers with a bachelor's degree or similar and by 50% for drivers with primary education level or lower
- Drivers who think it is acceptable to drive being so sleepy that you have trouble keeping your eyes open are 6.5 times more likely to drive while tired.
- Drivers who believe that fatigued driving is the cause of a road crash involving car frequently have a 40% reduced odds of self-declared fatigued driving
- Drivers who live in urban areas have a 29% decreased odds of self-declared fatigued driving compared to drivers who live in semi-urban and rural areas.
- In Europe, drivers in Austria, Finland and Greece have the highest odds ratios for self-declared fatigued driving (OR 1.5 to 1.9).
- In Europe, drivers in Italy, Serbia and United Kingdom have the lowest odds ratios for self-declared fatigued driving (OR 0.6 - 0.7).
- Outside Europe, drivers in Japan, Republic of South Korea and Egypt have higher odds ratios than the reference category for driving while tired (OR 1.7 to 2.0).

Key recommendations

- The self-report data in ESRA2 on fatigued driving confirm data from other sources that fatigued driving is one of the major problems for road safety worldwide. The high prevalence of self-declared fatigue driving warrants serious attention of road safety policy makers.
- To prevent driving fatigue attention should be payed to create further measures in the fields of legislation, road infrastructure, education and campaigns, the implementation of safety culture and fatigue management programs in companies.
- Within a company context, studies have shown that an active safety culture and fatigue management are the best measures to address professional driver fatigue. The safety culture should also be a 'just culture' where drivers can be open about problems of driving fatigue without fear of sanctions.

- Awareness-raising campaigns on fatigued driving should provide helpful and clear instructions how to prevent the problem and how to react to the problem in a real situation.
- Drivers can be advised to familiarise themselves with fatigue detection systems in their vehicles and to take warning signals by these systems seriously. However, prime responsibility for prevention of driver fatigue rests with the driver herself and drowsiness detection systems are only a (less than perfect) aid for keeping this responsibility.
- Besides education and campaigns and safety culture programs, the implementation of rumble strips on major roadways (motorways and rural roads) is a proven safety measure against fatigued driving.

The ESRA initiative has demonstrated the feasibility and the added value of joint data collection on road safety performance by partner organizations all over the world. The intention is to repeat this initiative on a triennial basis, retaining a core set of questions in every wave. In this way, ESRA produces consistent and comparable road safety performance indicators that can serve as an input for national road safety policies and for international monitoring systems on road safety performance.

1 Introduction

Worldwide, and also in European countries, driving fatigue is a major road safety problem (Bioulac et al., 2017; Gonçalves, 2015; European Commission, 2015). In the literature the concepts of driver "fatigue", "drowsiness" and "sleepiness" are often used interchangeably. Fatigue refers to the tiredness experienced as a result of mental or physical effort (e.g. from driving for a long time) which can be overcome by ceasing the fatiguing activity (Talbot & Filtness, 2017). Sleepiness can be defined as the physiological pressure to fall asleep (e.g. from poor sleep quality, reduced sleep duration or time of day effects) which can only be overcome by sleeping or physiological influence such as with caffeine (Talbot & Filtness, 2017).

Driving fatigue is a major factor in a large proportion of road crashes (range 10-20%) (European Commission, 2015). Several studies (European Commission, 2015) suggest that driving fatigue is associated with increased crash risk. A person who drives after being awake for 17 hours has a risk of crashing equivalent to being at the level of 0.05 blood alcohol concentration (i.e. twice the normal risk). The increased risk often results from a combination of biological, lifestyle-related and work-related factors (European Commission, 2015).

Amongst young drivers, driving while fatigued is quite common due to lifestyle factors. Adolescents need more sleep than adults; fatigue may affect youngsters more than adults. Most professional drivers and shift workers have to cope with fatigued driving on a frequent basis due to work-related factors. About half of all professional drivers have less than normal sleep time before a long-distance trip (European Commission, 2015). In Europe, three previous surveys on driving fatigue have been conducted since 2010 (Gonçalves et al., 2015; IPSOS, 2018; ESRA1-, Trigoso et al., 2016).

Different research methods, such as crash analysis, naturalistic driving, meta-analysis, confirm the hazards of fatigued driving. Based on an US crash analysis, Teft (2014) estimated that 13% of crashes in which a person was hospitalized, and 21% of crashes in which a person was killed involved a drowsy driver. Dingus et al. (2016) studied a database of road traffic accidents that were observed during a large-scale naturalistic driving study. The researchers compared video extracts of driver behaviour 20 seconds prior to crashes and a matched sample of other driving periods for the same driver that did not result in a crash. They found that fatigue was associated with an increased crash risk of OR = 3.4 (Odds Ratio). A meta-analysis of 17 studies (10 cross-sectional, 6 case control and 1 cohort study) indicates a 2.5 higher crash risk (OR = 2.51) due to sleepiness at the wheel (Bouliac et al., 2017).

In various driving simulation studies, it has been established that fatigue leads to a deterioration of driving performance manifesting itself in slower reaction time, diminished steering performance, reduced ability to keep sufficient headway and increased tendency to mentally withdraw from the driving task (European Commission, 2015). The withdrawal of attention and cognitive processing capacity from the driving task is not a conscious, well-planned decision but a semi-autonomic mental process of which drivers may only be dimly aware. Drivers may try to compensate for the influence of fatigue for instance by increasing the task demands (e.g. driving faster so that a 'new' sensation of driving raises adrenaline and attention levels) or by lowering them (e.g. increasing the safety margins by slowing down or using longer headways). However, both evidence from crash investigations and from observations of (fatigued) driving performance in simulation research indicate that the problem of driver fatigue cannot be sufficiently compensated for by behavioural. Compensatory strategies are not sufficient to remove all excess risk, manifesting itself in decreased driving performance and in real-life crashes (European Commission, 2015).

The most important general factors that cause fatigue are lack of sleep, bad quality sleep and sleep demands induced by the internal clock (European Commission, 2015). Besides these general factors, prolonged driving (time-on-task) can increase driver fatigue especially when drivers do not take sufficient rest breaks. For specific groups of drivers, e.g. professional drivers, these general factors often play a more persistent role due to long or irregular work schedules. A small part of the general population (3-5%) has to cope with obstructive sleep apnoea, a sleeping disorder which contributes to above average sleepiness (European Commission, 2015). A frequently occurring sleep disorder is Obstructive Sleep Apnoea (OSA) that causes the muscles and tissue in the airway to collapse during sleep and causes the airway to be blocked. Such sleep disturbance episodes can cause patient to partially wake multiple times from sleep resulting in sleep deprivation and feelings of sleepiness during

the day. According to the Talbot & Filtness (2016) review on studies on obstructive sleep apnea a car driver with untreated OSA is 2-3 times more likely to be involved in an accident; for truck drivers with untreated OSA the risk is potentially even higher.

Driver fatigue countermeasures may be directed at drivers, transport companies, road operators or vehicle manufacturers (European Commission, 2015). Drivers may learn how to prevent and mitigate driver fatigue by campaigns. Transport companies can introduce special policies to educate drivers and management about the problem (European Commission, 2015). Roads can be marked with edging or centre lines that provide audio-tactile feedback when crossed (rumble strips). Also, the legislation concerning working and resting hours may be further improved and vehicles can be equipped with fatigue detection devices (European Commission, 2015).

1.1 Survey research

Survey research world-wide suggests that over half of all private drivers drive while being fatigued or drowsy at least once a year (European Commission, 2015). Whereas in some surveys the question on driver fatigue is stated in general terms (e.g. driving while you were very tired or too tired), the ESRA2 survey uses a fatigue question with a clear, recognisable behavioural criterion "…drive when you were so sleepy that you had trouble keeping your eyes open" (See also Section 3.3).

In Europe, a driver fatigue survey in 2013 including over 12.000 questionnaires from nineteen countries indicated that the average prevalence of falling asleep at the wheel in the previous two years was 17%. After adjustment for individual characteristics, falling asleep behind the wheel was more frequent in the Netherlands and Austria, followed by Belgium, Portugal, Poland and France. Lower odds were found in Croatia, Slovenia and Italy. Frequencies were similar to the mean sample in the remaining nine countries. The main predictors of falling asleep at the wheel included male gender, high amount of driving exposure and elevated risk for OSAS (Gonçalves et al., 2015).

In 2015, the ESRA1 survey in seventeen European countries obtained the following findings on fatigued driving (Trigoso et al., 2016):

- More than half of the European drivers (60%) reported to have driven at least once when they were actually too tired to drive during the last year.

- Most of the drivers who reported tiredness (84%) said that that they had stopped and taken a break when they felt too tired to drive.

- Driving when tired was more prevalent among men and younger drivers; a high educational level, a frequent driving (kilometres per year), and a high acceptability increased the likelihood of driving when too tired; on the other hand, the increase of the risk perception decreased the likelihood of driving when fatigued.

In 2018, a survey in eleven European countries (France, Germany, Belgium, Spain, Great Britain, Italy, Sweden, Greece, Poland, Slovakia, Netherlands; at least 1,000 drivers interviewed in each country) indicated that over the last few years (IPSOS, 2018):

- 44% of all drivers felt very tired but continued driving because they felt they had to

- 26% of all drivers had been on the verge of falling asleep behind the wheel

- 16% of all drivers had experienced crossing into an emergency lane due to drowsiness

- 9% of Europeans have had – or have almost had – an accident as a result of dozing off

The ESRA2 survey asks questions on frequency and personal acceptability of fatigued driving and on the perception of fatigued driving as a crash cause. In this chapter we will take a look at how road users in different regions, countries, age and gender groups, differ in self-declared fatigued driving, in personal acceptability of fatigued driving and in the perception of fatigued driving as a crash cause.

The ESRA2 findings are used to answer the following research questions:

- What is the prevalence of self-declared fatigued driving?
- What are the differences in self-declared fatigued driving between countries, gender and age groups?

- What is the level of self-declared personal acceptability of fatigued driving?
- What are the differences in self-declared personal acceptability of fatigued driving between countries, gender and age groups?
- How common is the perception of fatigued driving as a frequent cause of crashes?
- Which factors are related to the prevalence of self-declared fatigued driving, to the level of self-declared personal acceptability of fatigued driving and to the perception of fatigued driving as a crash cause?

2 Methodology

ESRA (E-Survey of Road users' Attitudes) is a joint initiative of road safety institutes, research centres, public services, and private sponsors from all over the world. The aim is to collect and analyse comparable data on road safety performance, in particular road safety culture and behaviour of road users. The ESRA data are used as a basis for a large set of road safety indicators. These provide scientific evidence for policy making at national and international levels.

ESRA data is collected through online panel surveys, using a representative sample of the national adult populations in each participating country (at least N = 1000 per country). At the heart of this survey is a jointly developed questionnaire, which is translated into national language versions. The themes covered include self-declared behaviour, attitudes and opinions on unsafe traffic behaviour, enforcement experiences and support for policy measures. The survey addresses different road safety topics (e.g. driving under the influence of alcohol, drugs and medicines, speeding, distraction) and targets car occupants, motorcycle and moped drivers, cyclists and pedestrians. The present report is based on the second edition of this global survey, which was conducted in 2018 (ESRA2_2018). In total this survey collected data from more than 35 000 road users across 32 countries.

The participating countries in ESRA2_2018 were:

- Europe: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Portugal, Serbia, Slovenia, Spain, Sweden, Switzerland, United Kingdom;
- America: Canada, USA;
- Asia and Oceania: Australia, India, Israel, Japan, Republic of Korea;
- Africa: Egypt, Kenya, Morocco, Nigeria, South Afrika.

Vias institute in Brussels (Belgium) initiated and coordinates ESRA, in cooperation with eleven core group partners (BASt (Germany), BFU (Switzerland), CTL (Italy), IATSS (Japan), IFSTTAR (France), ITS (Poland), KFV (Austria), NTUA (Greece), PRP (Portugal), SWOV (the Netherlands), TIRF (Canada)). The common results of the ESRA2_2018 survey will be published in a Main Report, a Methodology Report and at least fifteen Thematic Reports (Table 1). Furthermore, 32 country fact sheets were produced, in which national key results are compared to a regional mean (benchmark) and scientific articles, national reports and many conference presentations are currently in progress. An overview of the results and news on the ESRA initiative is available on: www.esranet.eu

Table 1: ESRA2 Thematic Reports

Driving under influence	Child restraint systems	Cyclists
Speeding	Unsafety feeling & risk perception	Moped drivers & motorcyclists
Distraction (mobile phone use)	Enforcement	Young road users
Fatigue	Vehicle automation	Elderly road users
Seat belt	Pedestrians	Gender aspects

The present report summarizes the ESRA2_2018-results with respect to driver fatigue. An overview of the data collection method and the sample per country can be found in (Meesmann & Torfs, 2019. ESRA2 methodology).

Note that a weighting of the data was applied to the descriptive analyses. This weighting took into account small corrections with respect to national representativeness of the sample based on gender and six age groups: 18-24y, 25-34y, 35-44y, 45-54y, 55-64y, 65y+; based on population statistics from United Nations data (United Nations Statistics Division, 2019). For the regions, the weighting also took into account the relative size of the population of each country within the total set of countries from this region. SPSS 25.0 and R 3.6.0 was used for the descriptive results of this report. In the advanced analyses, SPSS 25.0 was used for the logistic regression and R 3.5.3 (RStudio Version 1.1.463) for the Random Forest Analyses.

3 Results

3.1 Descriptieve analysis

This section presents the descriptive statistics on questions about driver fatigue. The ESRA2 questions on driving fatigue concern the following:

- self-declared fatigued driving in the past 30 days (Section 3.1.1),
- the personal acceptability of fatigued driving (Section 3.1.2), and
- the perception of fatigued driving as an accident cause (Section 3.1.3).

In each ESRA country about 1000 road users participated in the survey, among which about 800 car drivers (precise sample sizes are presented in Appendix 3). Please note that in the African countries a lower percentage of people has access to and use the internet (in Kenya and Nigeria less than 30%). Within the African countries the numbers of 65+ respondents who answered the ESRA2 survey were quite low (with the exception of South Africa), so that the answers of this particular age group in African countries cannot be considered to be representative.

People aged 65+ who answered the questionnaire must be a very specific group.

For each topic, the results are presented in a similar way: first the basic results per country in a table, then the results are further split out in various graphs first by global region (and country), then by age, and by gender.

Statistical tests of differences between regions, gender and age groups have been performed and are reported in Appendix 4. Given the rather large sample sizes of the region, gender and age groups, nearly all regional, gender and age group differences described in this chapter were statistically significant at $p < 0.01$. Besides statistical significance also the effect sizes of the tested differences were reported in Appendix 4. Nearly all effect sizes ranged from "small" to "medium".

3.1.1 Self-declared driving while tired

Table 2 presents the results on self-declared fatigued driving of car drivers.

Table 2: Self-declared fatigued driving by car drivers (Over the last 30 days, how often did you as a car driver drive when you were so sleepy that you had trouble keeping your eyes open)

Country	Never (1)	At least once (2-5)
Australia	83,0%	17,0%
Austria	68,2%	31,8%
Belgium	75,6%	24,4%
Canada	78,0%	22,0%
Czech Republic	78,1%	21,9%
Denmark	75,9%	24,1%
Egypt	68,7%	31,3%
Finland	71,2%	28,8%
France	81,5%	18,5%
Germany	76,5%	23,5%
Greece	74,4%	25,6%
Hungary	79,7%	20,3%
India	78,1%	21,9%
Ireland	76,1%	23,9%
Israel	73,5%	26,5%
Italy	85,8%	14,2%
Japan	66,8%	33,2%
Kenya	82,2%	17,8%
Morocco	77,6%	22,4%
Netherlands	78,4%	21,6%
Nigeria	82,3%	17,7%
Poland	80,4%	19,6%
Portugal	79,8%	20,2%
Republic of Korea	70,1%	29,9%
Serbia	86,1%	13,9%
Slovenia	79,2%	20,8%
South Africa	77,5%	22,5%
Spain	79,3%	20,7%
Sweden	75,7%	24,3%
Switzerland	81,0%	19,0%
United Kingdom	84,7%	15,3%
United States	78,1%	21,9%

As can be seen in the Table 2, the percentage of car drivers who confess to fatigued driving in the past 30 days varies for many countries between 19% to 25%. Car drivers, in Austria, Japan, Republic of Korea and Egypt, have the highest rates of self-declared fatigued driving (rates varying between 30% to 33%), and car drivers in Serbia UK, Italy and Australia the lowest (rates varying between 14% to 17%).

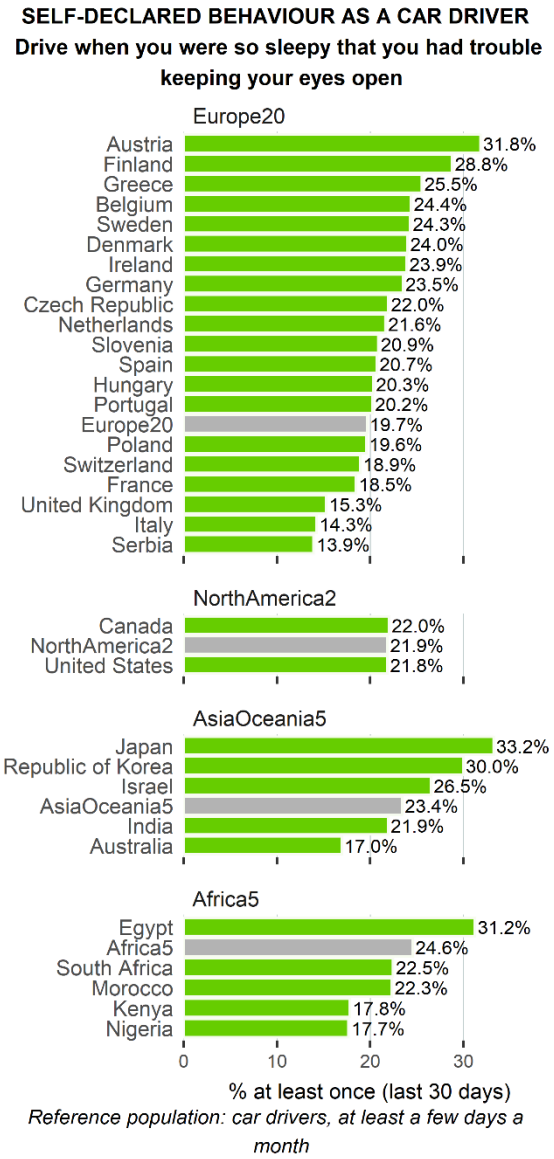
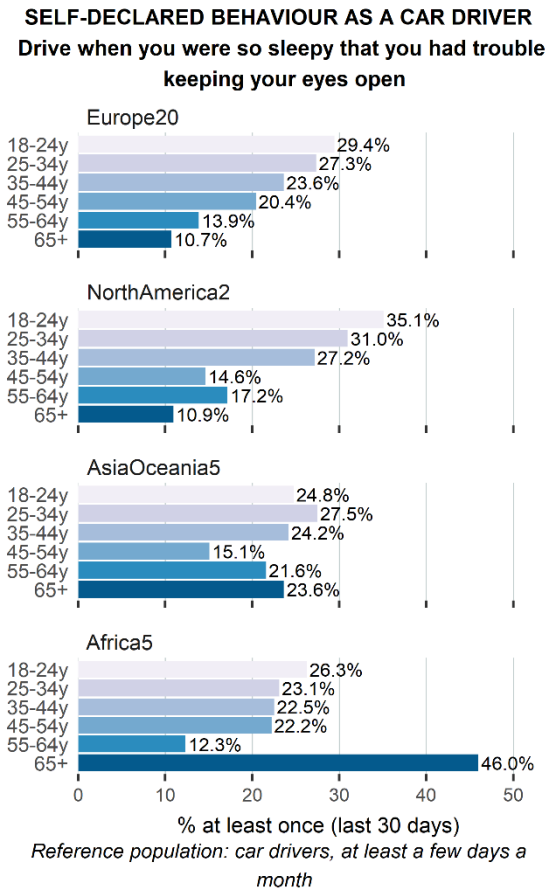


Figure 1 presents the results of car drivers for self-declared fatigued driving in the past 30 days per global region and country. The self-declared fatigued driving in past 30 days varies from 20% in Europe to 25% in Africa. The rates of self-declared fatigued driving are in between for North American (22%) and Asia-Oceania (23%). Within each of the three regions Europe, Africa, and Asia-Oceania, the self-declared fatigued driving rates vary between 17% or slightly less to about 31-33%.

In Europe, Austrian (32%) and Finnish drivers (29%) report the highest rates of fatigued driving, whereas drivers in UK (15%), Italy (14%), Serbia (14%) report the lowest rates. In Asia-Oceania, Japanese drivers most frequently report fatigued driving (33%) and Australian drivers least frequently (17%). In Africa Egyptian drivers more frequently report fatigued driving (31%) than drivers in Kenya and Nigeria (both 18%).

Figure 1: Self-declared fatigued driving by car drivers per region (% of car drivers that did it at least once… in the past 30 days).

In Figure 2 the self-declared fatigued driving rates are presented for different age groups in the four world regions.

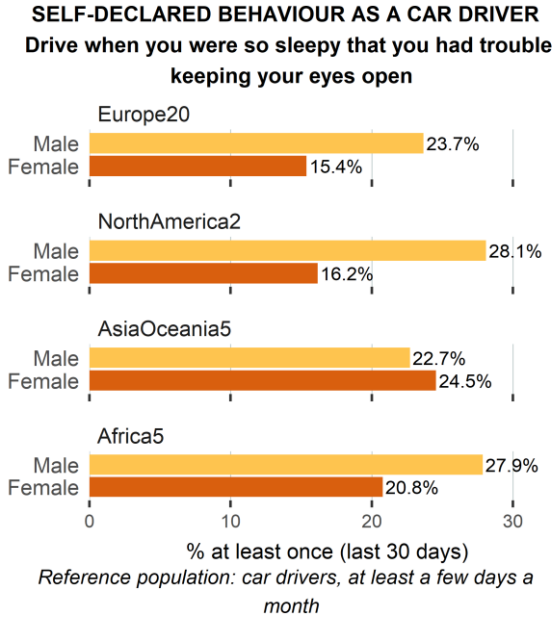


As can be seen in Figure 2 in Europe and North America the self-declared fatigued driving rates tend to decrease with increasing age. The highest rates are found amongst the youngest car drivers, age 18 to 24 (29% to 35%); the lowest rates among the oldest (65+) age group of car drivers (11%).

However, in Asia-Oceania, self-declared fatigued driving rates are not much different between young and older age groups, and surprisingly in Africa the self-declared fatigued driving rates are the highest for the oldest age group. In Africa, nearly half (46%) of car drivers aged 65+ profess to fatigued driving in the past 30 days. As mentioned in section 3.1, the answers of 65+ African respondents are not considered as being representative due to low numbers of respondents.

Figure 2: Self-declared fatigued driving by car drivers per region (% of car drivers that did it at least once … in the past 30 days).

Figure 3 presents self-declared fatigued driving rates by car drivers for region and gender.



As can be seen in Figure 3, in Europe, North America and Africa, self-declared fatigued driving rates are (considerably) higher for male drivers (24% to 28%) than for female drivers (15% to 21%). In Asia-Oceania, the rates for male and female drivers are similar (23%, 24%).

Figure 3: Self-declared fatigued driving by car driver per region and gender (% of car drivers that did it at least once … in the past 30 days).

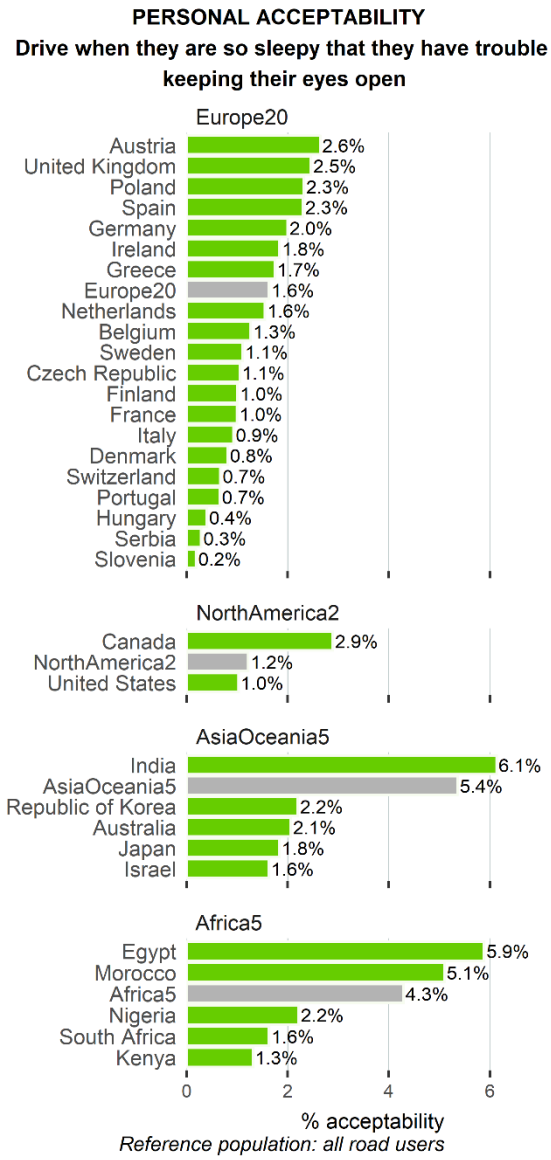
3.1.2 Personal acceptability of driving while tired

Table 3 presents the results on how acceptable road users find fatigued driving. The results in this table show that in most countries only one to two percent of all road users find fatigued driving acceptable. The highest rates of acceptability are reported in India (6%), Egypt (6%) and Morocco (5%).

Table 3: Self-declared personal acceptability of fatigued driving by all road users (How acceptable do you, personally, feel it is for a car driver to drive when they're so sleepy that they have trouble keeping their eyes open?)

Country	unacceptable/neutral (1-3)	acceptable (4-5)
Australia	97,9%	2,1%
Austria	97,3%	2,7%
Belgium	98,7%	1,3%
Canada	97,1%	2,9%
Czech Republic	99,0%	1,0%
Denmark	99,2%	0,8%
Egypt	94,1%	5,9%
Finland	99,0%	1,0%
France	99,0%	1,0%
Germany	98,0%	2,0%
Greece	98,2%	1,8%
Hungary	99,6%	0,4%
India	93,9%	6,1%
Ireland	98,2%	1,8%
Israel	98,4%	1,6%
Italy	99,1%	0,9%
Japan	98,2%	1,8%
Kenya	98,7%	1,3%
Morocco	94,9%	5,1%
Netherlands	98,5%	1,5%
Nigeria	97,8%	2,2%
Poland	97,7%	2,3%
Portugal	99,3%	0,7%
Republic of Korea	97,8%	2,2%
Serbia	99,7%	0,3%
Slovenia	99,8%	0,2%
South Africa	98,3%	1,7%
Spain	97,7%	2,3%
Sweden	98,9%	1,1%
Switzerland	99,3%	0,7%
United Kingdom	97,5%	2,5%
United States	99,0%	1,0%

The region and country results concerning personal acceptability of fatigued driving are presented in Figure 4.

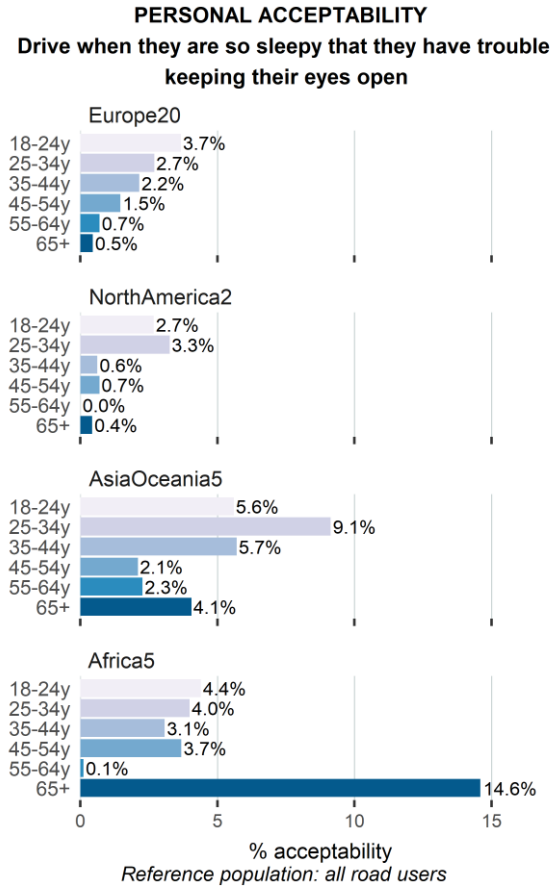


As can be seen in Figure 4, the rates of road users who find that fatigued driving is acceptable are quite low in each world region, with on average less than 2% road users in Europe and North America, and less than 6% of road users in Africa and Asia-Oceania.

As noted earlier, the three countries with the highest rates of personal acceptability of fatigued driving are India (6%), Egypt (6%) and Morocco (6%).

Figure 4: Personal acceptability of fatigued driving among all road users by region and country ("How acceptable do you, personally, feel it is for a CAR DRIVER to drive when they're so sleepy that they have trouble keeping their eyes open?")

Personal acceptability of fatigued driving is further spilt out by region and age group in Figure 5.

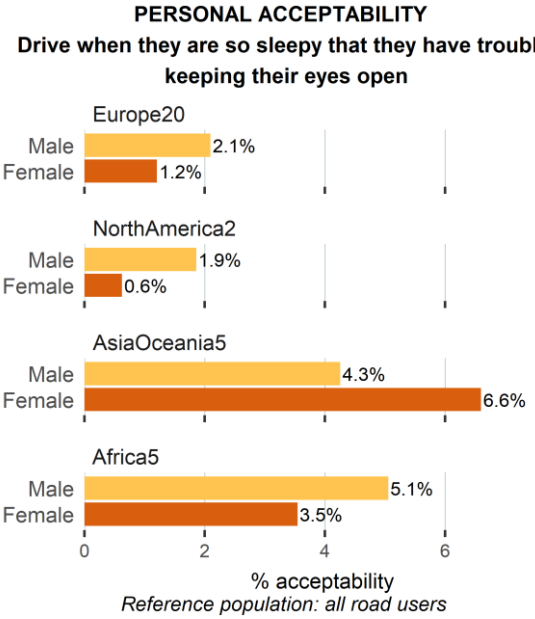


As can be seen in Figure 5, in Europe, North America and Asia-Oceania, the personal acceptability of fatigued driving is (slightly) higher among the younger aged car drivers than among older age groups. The difference between age groups is, however, only a few percentage points.

In contrast to these findings, in Africa, surprisingly, the personal acceptability of fatigued driving is far higher (15%) for the oldest age group (65+) road users than for the younger age groups of road users (18-24 years: 4%; 25-34 years: 4%). However, the answers of 65+ group cannot be regarded as representative.

Figure 5: Personal acceptability of fatigued driving among all road users by region and age group ("How acceptable do you, personally, feel it is for a car driver to drive when they're so sleepy that they have trouble keeping their eyes open?)

In Figure 6 personal acceptability of fatigued driving is split out for region and gender.



As can be seen in Figure 6, in the four world regions, the gender differences in personal acceptability of fatigued driving are quite small (1 to 3 percentage points difference).

Figure 6: Personal acceptability of fatigued driving among all road users by region and gender ("How acceptable do you, personally, feel it is for a car driver to drive when they're so sleepy that they have trouble keeping their eyes open?)

3.1.3 Perception of fatigued driving as an accident cause

The country results of the perception of fatigued driving as a frequent accident cause are presented in Table 4. In most countries a large majority of road users (between 70% and 85%) perceive fatigued driving to be a frequent cause of crashes with car drivers involved. In contrast, in a few countries a much smaller percentage of road users has this perception (Republic of Korea: 33%; Japan: 40%; India: 55%; Morocco: 58%).

Table 4: Self-declared perception of fatigued driving as crash cause among all road users ("How often do you think 'driving while tired' is the cause of a road crash involving a car?")

Country	not that often/not frequently (1-3)	often/frequently (4-6)
Australia	18,3%	81,7%
Austria	24,0%	76,0%
Belgium	27,3%	72,7%
Canada	27,3%	72,7%
Czech Republic	15,5%	84,5%
Denmark	31,4%	68,6%
Egypt	38,7%	61,3%
Finland	18,7%	81,3%
France	29,0%	71,0%
Germany	24,1%	75,9%
Greece	29,4%	70,6%
Hungary	19,3%	80,7%
India	45,3%	54,7%
Ireland	37,9%	62,1%
Israel	18,5%	81,5%
Italy	29,8%	70,2%
Japan	59,5%	40,5%
Kenya	16,7%	83,3%
Morocco	41,5%	58,5%
Netherlands	28,8%	71,2%
Nigeria	23,7%	76,3%
Poland	23,3%	76,7%
Portugal	19,6%	80,4%
Republic of Korea	66,7%	33,3%
Serbia	19,1%	80,9%
Slovenia	26,9%	73,1%
South Africa	30,8%	69,2%
Spain	25,0%	75,0%
Sweden	23,3%	76,7%
Switzerland	27,2%	72,8%
United Kingdom	24,4%	75,6%
United States	31,6%	68,4%

Figure 7 presents region and country results of the question on how often fatigued or tired driving is perceived to be a frequent road crash cause.

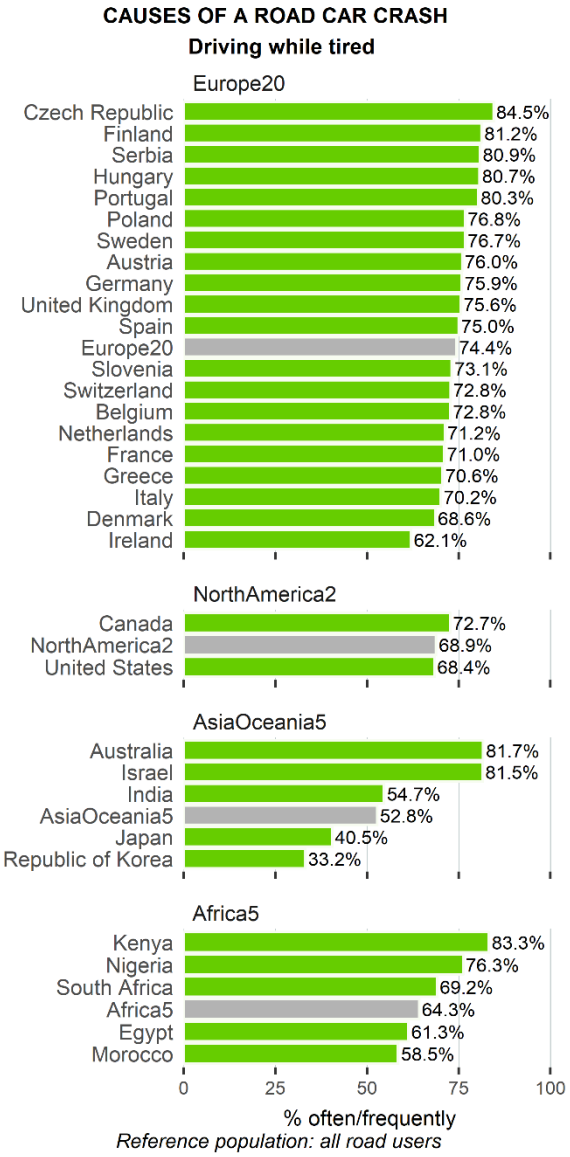
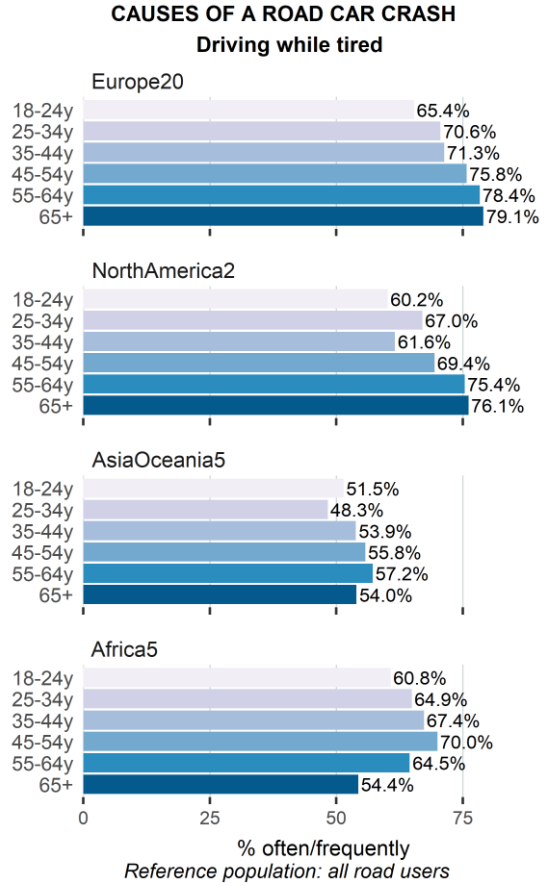


Figure 7 shows that European road users most commonly perceive tired driving as a frequent crash cause (74%), with lower rates being reported amongst road users in North America (69%), Africa (64%) and Asia-Oceania (53%).

Figure 7: Perception of fatigued driving as accident cause among all road users by region and country ("How often do you think 'driving while tired' is the cause of a road crash involving a car?")

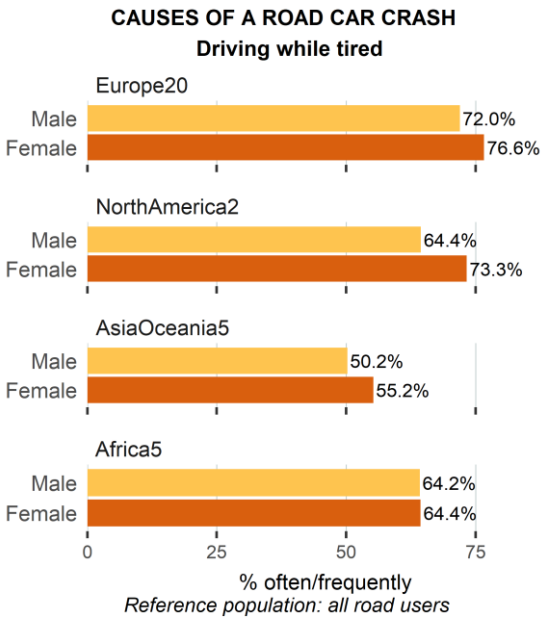
The results concerning the perception of tired driving as a crash cause are further split out for region and age group in figure 8.



As can be seen in Figure 8, in both regions, Europe and North America, the perception of tired driving as a frequent crash cause is more prevalent among older age groups (55-64; 65+) than younger age groups, with differences in the range of 10 to 15 percentage points. In Asia-Oceania the differences between age groups are small and there is no clear trend in these differences. In Africa, surprisingly, the perception of tired driving as a frequent crash cause is less prevalent amongst the oldest age group (54%) than amongst younger age groups (61-70%).

Figure 8: Perception of fatigued driving as accident cause among all road users by region and age group ("How often do you think 'driving while tired' is the cause of a road crash involving a car?")

Figure 9 presents results on the perception of fatigued driving as accident cause per world region and gender.



As can be seen in Figure 9, with respect to perception of tired driving as frequent crash cause, female and male road users in Africa do not differ, and female and male road users differ only modestly in Europe and Asia-Oceania (with females 4 to 5 percentage points lower rates).

In North America the difference between female and male road users is more substantial, with 64% of female road users perceiving tired driving as a frequent crash cause versus 73% male road users.

Figure 9: Perception of fatigued driving as accident cause by region and gender ("How often do you think 'driving while tired' is the cause of a road crash involving a car?")

3.2 Advanced analyses

In this section, first it will be examined which contributing factors are important for the questions on the personal acceptability of fatigued driving, and on the perception of driving fatigue as accident cause (Section 3.2.1). Random forest analyses are used to outline any critical contributing factors to respondent answers on these questions. Second, binary logistic regression is used to develop a statistical model to investigate the association between explanatory variables and the self-declared behaviour of driving when drivers are so sleepy that they had trouble keeping their eyes open over the last 30 days (Section 3.2.2.).

The statistical model examines the answers of car drivers and the dependent variable, self-declared fatigued driving ('driving when you are so tired that you have trouble keeping your eyes open in the past 30 days'), takes two values (0-never and 1-at least once of experiencing fatigue). The explanatory variables in the model include socio-demographic information (age, gender, education), personal acceptability of fatigued driving, perception of fatigued driving as accident cause, and the level of urbanisation. All variables were entered simultaneously in the regression model and after several attempts with different combinations of independent variables the most appropriate model was chosen. Odds ratios (and the respective 95% Confidence Intervals) are used to measure the strength of association between the variables.

3.2.1 Factors that affect the personal acceptability of fatigued driving

In this section, Random Forest analyses are used to provide insight on the importance of variables on driver fatigue. A Random Forest is a classifier including a collection of tree-structured classifiers {h(x, Θk), k = 1,…}, where the {Θk} are independent identically distributed random vectors and each tree casts a unit vote for the most popular class as input x (Breiman, 2001). When Random Forests are trained the algorithm tracks how often each descriptor is used by the trees of the forest and how many of the data points are affected by the decision within a tree. This information can be compiled into a characteristic number which reflects the importance of a variable. In this report, the Random Forest Analysis is used to determine the variable importance rankings when examining the personal acceptability of fatigued driving. The variable importance as indicated by the Random Forest models is a helpful indicator to define which variables are significant for fatigue acceptability. However, the magnitude of the effect and the sign of each variable are not identified.

Figure 10 shows the results of variable importance when examining the personal acceptability of driving when car drivers are so sleepy that they have trouble keeping their eyes open. This figure was produced as an output of the Random Forest analysis. Variables to the right of the dashed red vertical line are identified to be significant in an ascending order. This line is set at the value of the lowest important variable. From the figure, it can be observed that the most important factors are age, educational level and the frequency of past involvement in road crashes in which at least one injured person had to be hospitalized followed by gender. It should be noted that the x-axis represents the relative importance of each variable. All variables whose importance is negative or zero are non-significant and they can be excluded from further exploration; it should be also noted that variable importance should be interpreted as a relative ranking of predictors, since the absolute values of importance scores should not be interpreted or compared over different studies (Strobl et al., 2009a; 2009b).

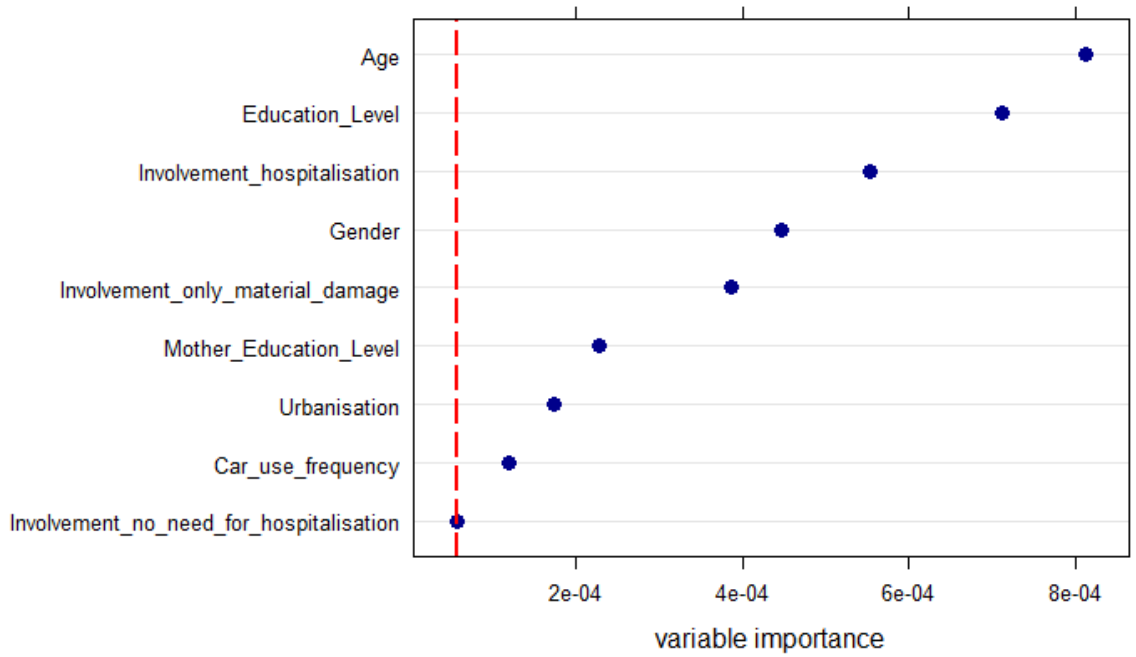


Figure 10: Variable importance ranking from Random Forest Analysis ("How acceptable do you, personally, feel it is for a car drivers to drive when they're so sleepy that they have trouble keeping their eyes open?)

3.2.2 Factors that affect the perception of fatigued driving as accident cause

Figure 11 - also produced by the Random Forest analysis - presents the results of variable importance when examining the frequency with which respondents think that driving while tired is the cause of a road crash involving a car. The three most important factors are age, frequency of car use, and gender followed by the frequency of involvement in road crashes (in which at least one injured person had to be taken in hospital).

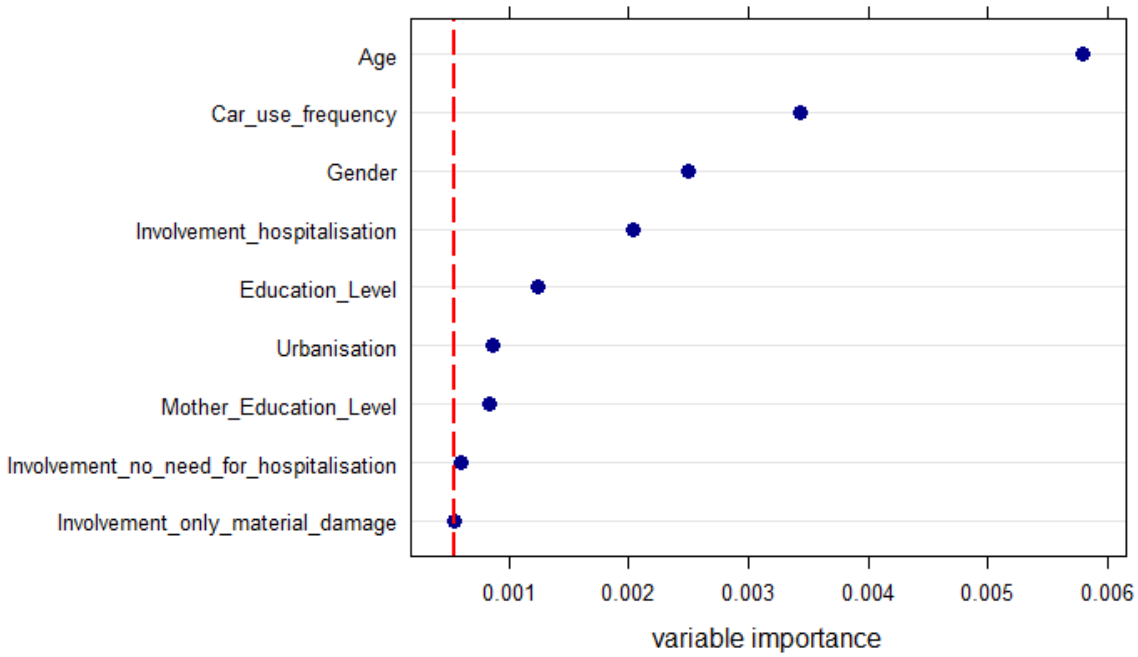


Figure 11: Variable importance ranking from Random Forest Analysis ("How often do you driving while tired is the cause of a road crash involving a car?")

3.2.3 Factors that affect the self-declared fatigued driving

Table 5 shows the results of the logistic regression model for driving while tired. The dependent variable is the item of the questionnaire "Over the last 30 days, how often did you as a car driver drive when you were so sleepy that you had trouble keeping your eyes open?". The variable was coded as 0=never and 1=at least once.

The odds of driving when tired for women, in comparison with men, decrease by 47% (OR=0.53). In other words, women are less likely to report that they drive when they are too tired.

When comparing with the drivers aged 55+, the odds of driving when tired increase by 30% (OR=1.30) for drivers aged 18 to 34, and by 8% (OR=1.08) for drivers aged 35 to 54.

The odds of driving when tired for drivers with primary education level or lower, in comparison with drivers with a Master's degree or higher, decrease by 50% (OR=0.50). Comparing with drivers with a Master's degree or higher, the odds of driving when tired decrease by 51% (OR=0.49) for drivers with secondary education level, and by 46% (OR=0.54) for drivers with a bachelor's degree or similar.

Drivers who feel that it is acceptable to drive being so sleepy that they have trouble keeping their eyes open are 6.53 times more likely to drive when they are tired.

The odds are significantly lower for those who believe that driving while tired is the cause of a road crash involving car frequently (OR=0.60).

When comparing with the drivers who live in semi-urban and rural areas, the odds of driving when tired decrease by 29% (OR=0.71) for drivers who live in urban areas.

Table 5: Logistic regression model for driving while tired.

Dependent variable: "Over the last 30 days, how often did you as a car driver drive when you were so sleepy that you had trouble keeping your eyes open?" (0=never; 1=at least once)	
Factors (reference category)	Odds Ratio (CI 95%)
Gender (Ref. male)	
Female	0.53** (0.50-0.56)
Age group (Ref. 55+)	
(18-34 yrs.)	1.30** (1.21-1.39)
(35-54 yrs.)	1.08* (1.01-1.15)
Educational level (Ref. Master's degree or higher)	
Primary education or none	0.50** (0.43-0.59)
Secondary education	0.49** (0.46-0.53)
Bachelor's degree or similar	0.54** (0.51-0.58)
Personal acceptability (Ref. unacceptable/neutral)	
Driving when you have trouble keeping the eyes open (acceptable)	6.53** (5.34-7.97)
Risk perception (Ref. not that often)	
Driving while tired is the cause of a road crash involving a car(often)	0.60** (0.56-0.63)
Urbanisation (Ref. semi-urban and rural)	
Urban	0.71** (0.67-0.75)

*Notes: *p<0.05, **p<0.01*

Table 6 shows the odds ratio for each country derived from the logistic regression model for self-declared driving while tired. In this model, Poland was chosen as the reference category because Poland was the country with a descriptive answer frequency on the self-declared fatigued driving question that was closest to the European average (see Figure 1). Regarding European countries, Austria, Finland and Greece have the highest odds ratios for self-declared fatigued driving (OR 1.5 to 1.9). On the other hand, Italy, Serbia and United Kingdom are the countries where car drivers are less likely to profess to fatigued driving (OR 0.6 - 0.7). Outside Europe, Japan, Republic of South Korea and Egypt have higher odds ratios than the reference category for driving while tired (OR 1.7 to 2.0).

Table 6: Logistic regression model for driving while tired, country effects.

Dependent variable: "Over the last 30 days, how often did you as a CAR DRIVER drive when you were so sleepy that you had trouble keeping your eyes open?" (0=never; 1=at least once)	
Factors (reference category)	Odds Ratio (CI 95%)
Constant	0.24**
Austria	1.90** (1.51-2.38)
Belgium	1.31* (1.06-1.63)
Switzerland	0.96 (0.74-1.23)
Germany	1.26* (1.01-1.57)
Denmark	1.30* (1.01-1.66)
Greece	1.53** (1.21-1.94)
Spain	1.11 (0.87-1.43)
Finland	1.65** (1.29-2.11)
France	0.93 (0.72-1.20)
Ireland	1.32* (1.04-1.69)
Italy	0.67** (0.52-0.88)
Netherlands	1.12 (0.86-1.44)
Poland	1 (Reference)
Portugal	1.07 (0.83-1.37)
Sweden	1.32* (1.02-1.69)
Slovenia	1.13 (0.89-1.45)
United Kingdom	0.73* (0.55-0.96)
Canada	1.13 (0.88-1.45)
Czech Republic	1.15 (0.88-1.50)
Hungary	1.05 (0.81-1.36)
Israel	1.48* (1.16-1.88)
Republic South Korea	1.83** (1.44-2.32)
USA	1.12 (0.88-1.44)
Australia	0.82 (0.63-1.07)
Serbia	0.71* (0.54-0.93)
Japan	2.04** (1.59-2.61)
India	1.13 (0.88-1.46)
Egypt	1.76** (1.37-2.27)
Kenia	0.95 (0.72-1.24)
Nigeria	0.98 (0.75-1.27)
Morocco	1.13 (0.87-1.47)
South Africa	1.14 (0.89-1.46)

*Notes: *p<0.05, **p<0.01*

3.3 Comparison with other findings

In the ESRA2 survey three questions concern fatigued driving. As we will explain in more detail below, only one of these three questions was asked in an identical format in ESRA1 and two questions were changed between ESRA1 and ESRA2 (see Table 7).

In the ESRA1 study, the self-declared fatigued driving was studied by asking respondent the following questions: 1. 'In the past 12 months, as a road user, how often did you realise that you were actually too tired to drive?' and 2. "In the past 12 months, as a road user, how often did you stop and take a break because you were too tired to drive'. For the ESRA2 study, it was decided to use a new question as indicator for fatigued driving "Over the last 30 days, how often did you as a car driver drive when you were so sleepy that you had trouble keeping your eyes open". The new question focuses on behaviour in the past 30 days (instead of past 12 months) since it can be expected that memory effects or bias plays a lesser role when a shorter, more recent time period is asked to be remembered. Also, the new question specifically mentions "…trouble keeping eyes open .." as a defining element of fatigued driving instead of the more general phrase "…too tired to drive …". These changes in question make it impossible to reliably and soundly compare ESRA-findings over time.

We also observe here that the ESRA2 question on self-declared fatigued driving is different from the question in two other European surveys. A survey on sleepiness at the wheel conducted in 2013 in 19 European countries by Gonçalves et al. (2015) used the question: "During the last 2 years – have you fallen asleep at the wheel?". The IPSOS survey (IPSOS, 2018) asked the following question: "Do you ever take the wheel in the following situations? …When you are feeling very tired". In the first survey a rather long time period is mentioned (last 2 years) which may increase errors of recall. In the IPSOS survey the formulation "When you are feeling very tired" is more general than the specific formulation used in ESRA2.

In the ESRA1 study, the question the perception of accident causes was studied by the following question: "In your opinion, how many road traffic accidents are caused by each of the following factors? Estimate a percentage of accidents for each factor. In other words, how many accidents out of 100 were caused by the following factors." In ESRA2 this question was changed into: "How often do you think each of the following factors is the cause of a road crash involving a car?"

The results in Table 7 from different surveys on fatigued driving indicate the following:

- Irrespective of whether the time frame is 30 days, 2 years or a few years, there are about one fifth (17%, 20%) to one quarter (26%) of European car drivers who profess to have driven while (nearly) dozing off.

- Whereas the personal acceptability of fatigued driving is very low in the two ESRA-surveys, the IPSOS survey with a different wording of the acceptability issue shows that although 69% of drivers think it is something you must never do, 31% of driver thinks that it can be done (if careful and if you can avoid falling asleep). Clearly, as with many other issues acceptability is partly dependent upon how the question and answer alternatives are framed.

- The three surveys ESRA1, ESRA2, and IPSOS indicate that fatigued driving is seen as an important cause of accidents. According to the IPSOS survey, the perception of fatigued driving as an accident cause is especially strong when car drivers consider fatal accidents on motorways (40% consider drowsiness the main cause) rather than fatal accidents on roads in general (8% consider drowsiness as main cause).

Table 7: Comparison fatigued driving questions ESRA1 and ESRA2

Subject	ESRA1question	ESRA2question	Gonçalves et al., 2015	IPSOS, 2014, 2018
Participating countries	EU 17: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Poland, Portugal, Slovenia, Spain, Sweden, Switzerland, Netherlands, United Kingdom	EU 20: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Serbia, Slovenia, Spain, Sweden, Switzerland, United Kingdom	EU 19: Austria, Belgium, Croatia, Estonia, France, Germany Greece Iceland, Italy, Lithuania, Netherlands, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Turkey	EU 10: Belgium, France, Germany, GB, Greece, Italy, Netherlands, Poland, Spain, Sweden
Self-declared fatigued driving	"In the past 12 months, as a road user, how often did you…?' '...realise that you were actually too tired to drive" Europe-17: 60%	"Over the last 30 days, how often did you as a CAR DRIVER…drive when you were so sleepy that you had trouble keeping your eyes open)" Europe 20: 20%.	During the last 2 years – have you fallen asleep at the wheel?" Europe-19: 17%	IPSOS 2018: More specifically, over the last few years, have you run into any of the following problems while driving? Had the impression that you dozed off at the wheel for a few seconds Europe-10: 26% feel they may have dozed off for a few seconds while driving
Personal acceptability	"How acceptable do you, personally, feel it is for a driver to…? drive when they're so sleepy that they have trouble keeping their eyes open" Europe-17 3.5%	"How acceptable do you, personally, feel it is for a driver to…? drive when they're so sleepy that they have trouble keeping their eyes open" Europe-20: 1.6%	-	IPSOS 2014: When you think about driving while tired, which of the following statements best reflects your attitude? - It's something you must never do (69%) - You can do it if you're extremely careful (25%) - You can do it because there are ways to avoid falling asleep (6%)
Perception accident cause	"how many accidents out of 100 were caused by the following factors" Europe-17: 20.4%	"In your opinion, how many road traffic accidents are caused by each of the following factors?" Europe-20: 74%	-	IPSOS 2018: "What in your opinion are the principal causes of fatal accidents in your country on motorways?" Europe-10: 36% identify drowsiness as one of the main causes of fatalities on motorways

3.4 Limitations of the data

In general, self-report data are vulnerable to a number of biases. Common biases are (Choi & Pak, 2005; Krosnick and Presser, 2010):

- desirability bias – the tendency of respondents to provide answers which present a favourable image of themselves, e.g. individuals may over-report good behaviour or under-report bad, or undesirable behaviour

- bias through misunderstanding of questions (e.g. questions with difficult words, long questions)

- recall error - unintentional faulty answers due to memory errors

In the ESRA2 survey the main question about driver fatigue ("Over the last 30 days, how often did you as a car driver drive when you were so sleepy that you had trouble keeping your eyes open?") provides a clear behavioural criterion (having trouble keeping eyes open) and refers to a recent time period. In view of this we expect that problems with understanding the question and recall errors may be very modest. Given the fact that a rather large percentage of respondents had no problems indicating that they had experienced fatigued driving in the past 30 days, we also think that social desirability bias may have played a minor role.

Although the logistic regression analysis identifies a number of explanatory variables that predict the self-declared fatigue driving, the associations between explanatory and dependent variables are correlational and the causal direction of influence between variables is not indicated by the analysis.

4 Summary and discussion

Major findings

Below for each research question the major findings are described.

What is the prevalence of fatigued driving? And what are differences?

- In most countries one fifth to one quarter of car drivers report to have driven while having trouble keeping eyes open in the past 30 days.
- In Europe, North America and Africa, self-declared fatigued driving rates are (considerably) higher for male drivers than for female drivers.
- In Europe and North America, the self-declared fatigued driving rates tend to decrease with increasing age, in Asia-Oceania and in Africa this age pattern is not found (or even reversed).

What is the personal acceptability of fatigued driving? And what are differences?

- In all participating countries worldwide less than 3% of road users find fatigued driving personally acceptable showing that road users personal norms reject this behaviour.
- In Europe, North America and Asia-Oceania, the personal acceptability of fatigued driving is (slightly) higher among the younger age groups. Surprisingly, in Africa the personal acceptability is highest (15% amongst the oldest age group).
- The gender differences in personal acceptability of fatigued driving are quite small.

What is the perception of fatigued driving as accident cause? And what are differences?

- In all countries worldwide a large majority of road users perceive tired driving as a frequent cause of accidents.
- European road users most frequently perceive tired driving as a frequent crash cause (74%), with lower rates reported amongst road users in North America (69%), Africa (64%) and Asia-Oceania (53%).
- In Europe and North America, the perception of tired driving as a frequent crash cause is more prevalent among older age groups (55-64; 65+) than younger age group whereas this age pattern is not found in Asia-Oceania and Africa.

What factors are related to the personal acceptability of fatigued driving? And to the perception of fatigued driving as accident cause?

- The most important variables that explain the differences in answers to personal acceptability of fatigued driving are: age, education level and personal involvement in accidents.
- The most important variables that explain differences in answers to perception of fatigued driving as crash cause are age, gender and frequency of car use.

What factors are related to self-declared fatigued driving?

- Drivers who feel that it is acceptable to drive being so sleepy that you have trouble keeping your eyes open are 6.5 times more likely to drive when they are tired
- Compared to male drivers, the odds of driving when tired for women are reduced by 47%.
- Compared to drivers aged 55+, the odds of driving when tired are increased by 30% for drivers aged between 18 to 34 years, and by 8% for drivers aged 35 to 54 years

- Compared to drivers with a Master's degree or higher, the odds of self-declared fatigued driving decrease by 51% for drivers with secondary education level, by 46% for drivers with a bachelor's degree or similar and by 50% for drivers with primary education level or lower
- Drivers who think it is acceptable to drive being so sleepy that you have trouble keeping your eyes open are 6.5 times more likely to drive while tired.
- Drivers who believe that fatigued driving is the cause of a road crash involving car frequently have a 40% reduced odds of self-declared fatigued driving
- Drivers who live in urban areas have a 29% decreased odds of self-declared fatigued driving compared to drivers who live in semi-urban and rural areas.
- In Europe, drivers in Austria, Finland and Greece have the highest odds ratios for self-declared fatigued driving (OR 1.5 to 1.9).
- In Europe, drivers in Italy, Serbia and United Kingdom have the lowest odds ratios for self-declared fatigued driving (OR 0.6 - 0.7).
- Outside Europe, drivers in Japan, Republic of South Korea and Egypt have higher odds ratios than the reference category for driving while tired (OR 1.7 to 2.0).

Discussion

In earlier European surveys on fatigued driving it was found that it is a frequently occurring traffic behaviour among car drivers that affects nearly half to over half of all car drivers (Gonçalves et al., 2015; Trigoso et al., 2016; IPSOS, 2018). In these surveys the respondents were asked to recall personal events of fatigue driving in the past year or two years. The present ESRA2 survey focused on fatigued driving within the time frame of the past month (30 days) in order to minimise recall error. The assumption being that recall of personal events in the past 30 days is likely to be more accurate than events in the past year or years.

Even with a far shorter time reference of 30 days on average one in five car drivers in Europe reports to have driven at least once while having trouble keeping eyes open. Of course, this a worrying statistic for road safety. In North America, Asia-Oceania and Africa, the rate of self-declared fatigued driving is even slightly higher (22% to 25%).

It is not surprising that self-declared fatigued driving is especially high in some countries which are known for their stern work ethic such as Japan and Republic of Korea. In these countries, the rather high rates of self-reported fatigued driving may reflect objective conditions that lead to high driving fatigue. It is less clear why among European countries Austria ranks highest in term of self-declared fatigued driving. In another survey Austria ranks second among European countries in terms of odds of falling asleep behind the wheel (Gonçalves et al., 2015). It should be kept in mind that self-reports may not only reflect objective driver behaviour but may also reflect how much drivers are concerned with or pay attention to some personal behaviour. It could be that Austrian drivers do not actually engage more frequently in fatigued driving than drivers in other European countries but are more alert to it and more honest or open about it.

Although apparently fatigued driving occurs rather frequently, the percentage of road users (including all modes, not only car drivers) who find this behaviour personally acceptable is quite low. Only in three countries (India, Morocco, Egypt) slightly more than 5% of road users reported to be accepting this behaviour. In all other countries of the ESRA2 survey the acceptance rates for this behaviour were very low, from almost 0% acceptance to about 2.5% of road users who have some acceptance.

The low acceptance of fatigued driving seems to suggest that most road users are aware of the risk or danger that is associated with this type of behaviour. This is also evident from the answers on the perception of fatigued driving as an accident cause. Nearly three-quarters (74%) of European road users perceive tired driving as a frequent accident cause, with somewhat lower rates in North America (69%), Africa (64%) and Asia-Oceania (53%). Although the personal acceptability of fatigued driving was found to be very low in the ESRA2 and ESRA1-surveys, the IPSOS 2014-survey - with a different wording for acceptability - shows that although 69% of drivers think it is something you must never do, 31% of driver think that it can be done (if careful and if you can avoid falling asleep). Clearly, as with

many other issues acceptability is partly dependent upon how question and answer alternatives are framed.

Looking at gender and age differences in the fatigued driving questions, young drivers and male drivers were more like to confess to fatigued driving. In general, the age and gender differences tend to be similar in the different world regions. As an intriguing exception to this, drivers aged 65 or older in Africa reported far higher fatigued driving, larger personal acceptability of fatigued driving and lower perceptions of fatigue as accident cause than younger African drivers. These differences were rather large and opposite in direction to those in other regions. Further ESRA2 results in other domains may perhaps shed further light on these results.

The main conclusion from the present results seems to be that despite a low acceptance and high risk perception concerning fatigued driving, there is still a far too high percentage of car drivers, in Europe and in other world regions, who seem not to be able to prevent or adequately react to the problem of fatigued driving. It is important to note that car drivers seem not to be able to prevent this behaviour even though they may have strong personal norms and reject this type of behaviour. Therefore, it is recommended that campaigns provide car drivers with behavioural advice that may assist in prevention of this behaviour.

Presently, there are several possibilities of preventing fatigue-related crashes. Both non-professional drivers as well as professional drivers and their employers should be aware of the causes of fatigue and its road safety effects. Haulage companies can make this part of a Fatigue Management programme (European Commission, 2015).

Within professional companies, safety culture should stimulate ways to encourage professional drivers to recognise the early signs of driving fatigue and to take timely action (European Commission, 2015; Anund et al., 2015). Within this context, Anund et al. (2015) stress the importance of a 'just culture': this refers to a just and forgiving response to vehicle operators' self-report of incidents and fatigue. The absence of a just culture will conceal risk.

Automatic in-vehicle detection and warning systems may be possibilities for the future (European Commission, 2015). In recent years, automobile companies have installed driver assistance technologies in vehicles for driver assistance, including fatigue detection and warning (Sikander & Anwar, 2018). Also, third party companies are producing fatigue detection devices. In the field of driver fatigue detection, continuous research is being performed and several approaches show promising results in constrained laboratory environments. Nevertheless, much progress is required before this technology can perform well and accurately under real-driving conditions (Sikander & Anwar, 2018).

One of the problems for generating reliable and accurate fatigue detection systems is the large individual variation in neurobehavioral and cognitive performance (Jacobé de Naurois et al., 2018). In car driving tasks there is large inter-individual variation in driving behaviour and eye behaviour. Individuals' patterns of fatigue or drowsiness evolution over time can differ, and for a given self-declared drowsiness level, markers such as eye blink duration also vary considerably between individuals (Jacobé de Naurois et al., 2018). Thus, there is a need to consider drivers' traits or profiles to calibrate systems for the detection and prediction of drowsiness (Jacobé de Naurois et al., 2017).

Since a number of modern cars are equipped with fatigue detection systems it should be recommended that drivers take the effort to familiarise themselves with the operation of these systems and that they take warning signals by these systems seriously. At the same time, it should be communicated to drivers that drowsiness detection systems are only an aid in driver fatigue prevention, that these systems are not yet completely reliable, and that driver fatigue prevention is first and foremost a responsibility of the driver herself.

Closing remarks

The initial aim of ESRA was to develop a system for gathering reliable and comparable information about people's attitudes towards road safety in a number of European countries. This objective has been achieved and the initial expectations have even been exceeded. ESRA has become a global initiative which already conducted surveys in 46 countries across six continents. The outputs of the ESRA project have become building blocks of national and international road safety monitoring systems.

The ESRA project has also demonstrated the feasibility and the added value of joint data collection on road safety attitudes and performance by partner organizations in a large number of countries. The intention is to repeat this initiative on a triennial basis, retaining a core set of questions in every wave allowing the development of time series of road safety performance indicators.

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Appendix 1: ESRA2_2018 Questionnaire

Introduction

In this questionnaire, we ask you some questions about your experience with, and your attitudes towards traffic and road safety. When responding to a question, please answer in relation to the traffic and road safety situation in [COUNTRY]. There are no right or wrong answers; what matters is your own experience and perception. Thank you for your contribution!

Socio-demographic information

Q1) In which country do you live? _____

Q2) Are you ... male – female – other (only in country who officially recognizes another gender)

Q3a) In which year were you born? Dropdown menu

Q3b) In which month were you born? Dropdown menu

Q4_1) What is the highest qualification or educational certificate that you have obtained? none - primary education - secondary education - bachelor's degree or similar - master's degree or higher

Q4_2) What is the highest qualification or educational certificate that your mother has obtained? none - primary education - secondary education - bachelor's degree or similar - master's degree or higher - I don't know

Q5a) Which of the following terms best describes your current professional occupation? white collar or office worker (excluding executive)/employee (public or private sector) →Q5b - blue collar or manual worker/worker →Q5b - executive →Q5b - self-employed/independent professional →Q5b - currently no professional occupation →Q5c

Q5b) Do you have to drive or ride a vehicle for work? (Please indicate the job category that is most appropriate for you) yes, I work as a taxi, bus, truck driver, … - yes, I work as a courier, mailman, visiting patients, food delivery, salesperson, … - no

Q5c) You stated that you currently have no professional occupation. Which of the following terms best describes your current situation? I am … a student - unemployed, looking for a job – retired - not fit to work - a stay-at-home spouse or parent - other

Q6) What is the postal code of the municipality in which you live? _____

Q7) In which region do you live? Drop down menu

Q8a) How far do you live from the nearest bus stop, light rail stop, or metro/underground station? less than 500 metres → Q8b - between 500 metres and 1 kilometre → Q8b - more than 1 kilometre → skip Q8b

Q8b) What is the frequency of your nearest bus stop, light rail stop, or metro/underground station? at least 3 times per hour - 1 or 2 times per hour - less than 1 time per hour

Mobility & exposure

Q9) Do you have a car driving licence or permit (including learner's permit)? yes - no

Q10) During the past 12 months, how often did you use each of the following transport modes in [country]? How often did you ...? at least 4 days a week - 1 to 3 days a week - a few days a month - a few days a year - never
Items (random): walk minimum 100m (pedestrian; including jogging, inline skate, skateboard, …) - cycle (non-electric) - cycle on an electric bicycle/e-bike/pedelec - drive a moped (≤ 50 cc or ≤ 4 kW; non-electric - drive a motorcycle (> 50 cc and > 4 kW non-electric) - drive an electric moped (≤ 4 kW) - drive an electric motorcycle (> 4 kW) - drive a powered personal transport device such as an electric step, hoverboard, solowheel,… - drive a car (non-electric or non-hybrid) - drive a taxi - drive a bus as a driver - drive a truck/lorry - drive a hybrid or electric car - take a taxi or use a ride-hail service (e.g. Uber, Lyft) - take the train - take the bus - take the

tram/streetcar - take the subway - take the aeroplane - take a ship/boat or ferry - be a passenger in a car - use another transport mode

Q11) Over the last 30 days, have you transported a child (<18 years of age) in a car? yes - no
Items: below 150cm - above 150cm

Self-declared safe and unsafe behaviour in traffic

Q12_1a) Over the last 12 months, how often did you as a CAR DRIVER …?
You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.
Binary variable for all items: at least once (2-5) - never (1)
Items (random):

- drive after drinking alcohol
- drive faster than the speed limit outside built-up areas (but not on motorways/freeways)
- read a text message or email while driving

Q12_1b) Over the last 30 days, how often did you as a CAR DRIVER …?
You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.
Binary variable for all items: at least once (2-5) - never (1)
Items (random):

- drive when you may have been over the legal limit for drinking and driving
- drive after drinking alcohol
- drive 1 hour after using drugs (other than medication)
- drive after taking medication that carries a warning that it may influence your driving ability
- drive faster than the speed limit inside built-up areas
- drive faster than the speed limit outside built-up areas (but not on motorways/freeways)
- drive faster than the speed limit on motorways/freeways
- drive without wearing your seatbelt
- transport children under 150cm without using child restraint systems (e.g. child safety seat, cushion)
- transport children over 150cm without wearing their seatbelts
- talk on a hand-held mobile phone while driving
- talk on a hands-free mobile phone while driving
- read a text message/email or check social media (e.g. Facebook, twitter, etc.) while driving
- drive when you were so sleepy that you had trouble keeping your eyes open

Q12_2) Over the last 30 days, how often did you as a CAR PASSENGER …? You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.
Binary variable for all items: at least once (2-5) - never (1)
Item:

- travel without wearing your seatbelt in the back seat

Q12_3) Over the last 30 days, how often did you as a MOPED DRIVER OR MOTORCYCLIST …? You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.
Binary variable for all items: at least once (2-5) - never (1)
Items (random):

- ride when you may have been over the legal limit for drinking and driving
- ride faster than the speed limit outside built-up areas (but not on motorways/freeways)
- ride a moped or motorcycle without a helmet
- read a text message/email or check social media (e.g. Facebook, twitter, etc.) while riding a moped or motorcycle

Q12_4) Over the last 30 days, how often did you as a CYCLIST …? You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.
Binary variable for all items: at least once (2-5) - never (1)
Items (random):

- cycle when you think you may have had too much to drink
- cycle without a helmet
- cycle while listening to music through headphones
- read a text message/email or check social media (e.g. Facebook, twitter, etc.) while cycling

- cycle on the road next to the cycle lane

Q12_5) Over the last 30 days, how often did you as a PEDESTRIAN …? You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.
Binary variable for all items: at least once (2-5) - never (1)
Items (random):

- listen to music through headphones as a pedestrian while walking in the streets
- read a text message/email or check social media (e.g. Facebook, twitter, etc.) while walking in the streets
- cross the road when a pedestrian light is red
- cross the road at places other than at a nearby (distance less than 30m) pedestrian crossing

Acceptability of safe and unsafe traffic behaviour

Q13_1) Where you live, how acceptable would most other people say it is for a CAR DRIVER to….? You can indicate your answer on a scale from 1 to 5, where 1 is "unacceptable" and 5 is "acceptable". The numbers in between can be used to refine your response.
Binary variable: acceptable (4-5) – unacceptable/neutral (1-3)
Items (random):

- drive when he/she may be over the legal limit for drinking and driving
- drive 1 hour after using drugs (other than medication)
- drive faster than the speed limit outside built-up areas (but not on motorways/freeways)
- not wear a seatbelt while driving
- transport children in the car without securing them (child's car seat, seatbelt, etc.)
- talk on a hand-held mobile phone while driving
- read a text message/email or check social media (e.g. Facebook, twitter, etc.) while driving

Q14_1) How acceptable do you, personally, feel it is for a CAR DRIVER to…? You can indicate your answer on a scale from 1 to 5, where 1 is "unacceptable" and 5 is "acceptable". The numbers in between can be used to refine your response.
Binary variable: acceptable (4-5) – unacceptable/neutral (1-3)
Items (random)

- drive when he/she may be over the legal limit for drinking and driving
- drive 1 hour after using drugs (other than medication)
- drive after taking a medication that may influence the ability to drive
- drive faster than the speed limit inside built-up areas
- drive faster than the speed limit outside built-up areas (but not on motorways/freeways)
- drive faster than the speed limit on motorways/freeways
- not wear a seatbelt while driving
- transport children in the car without securing them (child's car seat, seatbelt, etc.)
- talk on a hand-held mobile phone while driving
- talk on a hand-free mobile phone while driving
- read a text message/email or check social media (e.g. Facebook, twitter, etc.) while driving
- drive when they're so sleepy that they have trouble keeping their eyes open

Attitudes towards safe and unsafe behaviour in traffic

Q15) To what extent do you agree with each of the following statements? You can indicate your answer on a scale from 1 to 5, where 1 is "disagree" and 5 is "agree". The numbers in between can be used to refine your response.
Binary variable: agree (4-5) – disagree/neutral (1-3)
Items (random):
Normative believes & subjective norms (including injunctive norms from Q13)

- Most of my friends would drive after having drunk alcohol.
- Most of my friends would drive 20 km/h over the speed limit in a residential area.

Behaviour believe & attitudes

- For short trips, one can risk driving under the influence of alcohol.
- I have to drive fast; otherwise, I have the impression of losing time.
- Respecting speed limits is boring or dull.
- For short trips, it is not really necessary to use the appropriate child restraint.
- I use a mobile phone while driving, because I always want to be available.
- To save time, I often use a mobile phone while driving.

Perceived behaviour control (here: self-efficacy)

- I trust myself to drive after having a glass of alcohol.
- I have the ability to drive when I am a little drunk after a party
- I am able to drive after drinking a large amount of alcohol (e.g. half a liter of wine).
- I trust myself when I drive significantly faster than the speed limit.
- I am able to drive fast through a sharp curve.
- I trust myself when I check my messages on the mobile phone while driving.
- I have the ability to write a message on the mobile phone while driving.
- I am able to talk on a hand-held mobile phone while driving.

Habits

- I often drive after drinking alcohol.
- Even when I am a little drunk after a party, I drive.
- It sometimes happens that I drive after consuming a large amount of alcohol (e.g. a liter of beer or half a liter of wine).
- I often drive faster than the speed limit.
- I like to drive in a sporty fast manner through a sharp curve.
- It happens sometimes that I write a message on the mobile phone while driving.
- I often talk on a hand-held mobile phone while driving.
- I often check my messages on the mobile phone while driving.

Intentions

- I will do my best not to drive after drinking alcohol in the next 30 days.
- I will do my best to respect speed limits in the next 30 days.
- I will do my best not to use my mobile phone while driving in the next 30 days.

Quality control items

- Indicate number 1 on the answering scale.
- Indicate number 4 on the answering scale.

Subjective safety & risk perception

Q16) How safe or unsafe do you feel when using the following transport modes in [country]? You can indicate your answer on a scale from 0 to 10, where 0 is "very unsafe" and 10 is "very safe". The numbers in between can be used to refine your response.
Items (random) = Items indicated by the respondent in Q10 are displayed.

Q17) How often do you think each of the following factors is the cause of a road crash involving a car? You can indicate your answer on a scale from 1 to 6, where 1 is "never" and 6 is "(almost) always". The numbers in between can be used to refine your response.
Binary variable: often/frequently (4-6) - not that often/not frequently (1-3)
Items (random)

- driving after drinking alcohol
- driving after taking drugs (other than medication)
- driving faster than the speed limit
- using a hand-held mobile phone while driving
- using a hands-free mobile phone while driving
- inattentiveness or day-dreaming while driving
- driving while tired

Support for policy measures

Q18) Do you oppose or support a legal obligation to …? You can indicate your answer on a scale from 1 to 5, where 1 is "oppose" and 5 is "support". The numbers in between can be used to refine your response.
Binary variable: support (4-5) – oppose/neutral (1-3)
Items (random)

- install an alcohol "interlock" for drivers who have been caught drunk driving on more than one occasion (technology that won't let the car start if the driver's alcohol level is over the legal limit)
- have zero tolerance for alcohol (0,0 ‰) for novice drivers (licence obtained less than 2 years)
- have zero tolerance for alcohol (0,0 ‰) for all drivers
- install Intelligent Speed Assistance (ISA) in new cars (which automatically limits the maximum speed of the vehicle and can be turned off manually)
- install Dynamic Speed Warning signs (traffic control devices that are programmed to provide a message to drivers exceeding a certain speed threshold)
- have a seatbelt reminder system for the front and back seats in new cars
- require all cyclists to wear a helmet
- require cyclists under the age of 12 to wear a helmet
- require all moped drivers and motorcyclists to wear a helmet

- require pedestrians to wear reflective material when walking in the streets in the dark
- require cyclists to wear reflective material when cycling in the dark
- require moped drivers and motorcyclists to wear reflective material when driving in the dark
- have zero tolerance for using any type of mobile phone while driving (hand-held or hands-free) for all drivers
- not using headphones (or earbuds) while walking in the streets
- not using headphones (or earbuds) while riding a bicycle

Q19_1) What do you think about the current traffic rules and penalties in your country for driving or riding under the influence of alcohol? agree – disagree
Items:

- The traffic rules should be stricter.
- The traffic rules are not being checked sufficiently.
- The penalties are too severe.

Q19_2) What do you think about the current traffic rules and penalties in your country for driving or riding faster than the speed limit? agree – disagree
Items: Q19_1

Q19_3) What do you think about the current traffic rules and penalties in your country for using a mobile phone while driving or riding? agree – disagree
Items: Q19_1

Enforcement

Q20_1) On a typical journey, how likely is it that you (as a CAR DRIVER) will be checked by the police for… You can indicate your answer on a scale from 1 to 7, where 1 is "very unlikely" and 7 is "very likely". The numbers in between can be used to refine your response.
Binary variable: likely (5-7) – unlikely/neutral (1-4)
Items (random)

- … alcohol, in other words, being subjected to a Breathalyser test
- … the use of illegal drugs
- … respecting the speed limits (including checks by a police car with a camera, fixed cameras, mobile cameras, and section control systems)
- … wearing your seatbelt
- … the use of hand-held mobile phone to talk or text while driving

Q21_1) In the past 12 months, how many times have you been checked by the police for using alcohol while DRIVING A CAR (i.e., being subjected to a Breathalyser test)? never – 1 time – at least 2 times - I prefer not to respond to this question
Binary variable: at least once - never (removing "I prefer not to respond to this Q)

Q22_1) In the past 12 months, how many times have you been checked by the police for the use of drugs (other than medication) while DRIVING A CAR? never – 1 time – at least 2 times - I prefer not to respond to this question
Binary variable: at least once - never (removing "I prefer not to respond to this Q)

Involvement in road crashes

Introduction: The following questions focus on road crashes. With road crashes, we mean any collision involving at least one road vehicle (e.g., car, motorcycle, or bicycle) in motion on a public or private road to which the public has right of access. Furthermore, these crashes result in material damage, injury, or death. Collisions include those between road vehicles, road vehicles and pedestrians, road vehicles and animals or fixed obstacles, road and rail vehicles, and one road vehicle alone.

Q23_1a) In the past 12 months, how many times have you personally been involved in road crashes in which you or somebody else had to be taken to the hospital? ___ times (number; max. 10) if 0 → Q23_2a; if >0 → Q23_1b → Q23_2a
Binary variable: at least once - never

Q23_1b) Please indicate the transport modes you were using at the time of these crashes.
Items indicated by the respondent in Q10 are displayed; Threshold = 'at least a few days a year'.
Number to be indicated after each transport mode; note the sum should be equal to the number indicated in Q23_1a

Q23_2a) In the past 12 months, how many times have you personally been involved in road crashes with only minor injuries (no need for hospitalisation) for you or other people? ___ times (number; max. 10) if 0 → Q23_3a; if >0 → Q23_2b → Q23_3a
Binary variable: at least once - never

Q23_2b) = Q23_1b

Q23_3a) In the past 12 months, how many times have you personally been involved in road crashes with only material damage?
___ times (number; max. number 10) if 0 → skip Q23_3b; if >0 → Q23_3b → next Q
Binary variable: at least once - never

Q23_3b) = Q23_1b

Vehicle automation

I2) Introduction: The following questions focus on your opinion about automated passenger cars. We talk about two different levels of vehicle automation:
Semi-automated passenger cars: Drivers can choose to have the vehicle control all critical driving functions, including monitoring the road, steering, and accelerating or braking in certain traffic and environmental conditions. These vehicles will monitor roadways and prompt drivers when they need to resume control of the vehicle.
Fully-automated passenger cars: The vehicle controls all critical driving functions and monitoring all traffic situations. Drivers do not take control of the vehicle at any time.

Q24) How interested would you be in using the following types of automated passenger car? You can indicate your answer on a scale from 1 to 7, where 1 is "not at all interested" and 7 is "very interested". The numbers in between can be used to refine your response.
Binary variable: interested (5-7) - not interested/neutral (1-4)
Items:

- semi-automated passenger car
- fully-automated passenger car

Q25_1) How likely do you think it is that the following benefits will occur if everyone would use a semi-automated passenger car? You can indicate your answer on a scale from 1 to 7, where 1 is "very unlikely" and 7 is "very likely". The numbers in between can be used to refine your response.
Binary variable: likely (5-7) – unlikely/neutral (1-4)
Items (random):

- fewer crashes
- reduced severity of crash
- less traffic congestion
- shorter travel time
- lower vehicle emissions
- better fuel economy
- time for functional activities, not related to driving (e.g. working)
- time for recreative activities, not related to driving (e.g. reading, sleeping, eating)

Q25_2) How likely do you think it is that the following benefits will occur if everyone would use a fully-automated passenger car? You can indicate your answer on a scale from 1 to 7, where 1 is "very unlikely" and 7 is "very likely". The numbers in between can be used to refine your response.
Items (random) = Q25_1

Bonus question to be filled in by national partner

Q26) .....? You can indicate your answer on a scale from 1 to 5, where 1 is "…." and 5 is "….". The numbers in between can be used to refine your response.
Items (random; 4 items)

Q27) .....? You can indicate your answer on a scale from 1 to 5, where 1 is "…." and 5 is "….". The numbers in between can be used to refine your response.
Items (random; 4 items)

Social desirability scale

Introduction: The survey is almost finished. The following questions have nothing to do with road safety, but they are important background information. There are no good or bad answers.

Q28) To what extent are the following statements true? You can indicate your answer on a scale from 1 to 5, where 1 is "very untrue" and 5 is "very true". The numbers in between can be used to refine your response.
Items (random):

- I always respect the highway code, even if the risk of getting caught is very low.
- I would still respect speed limits at all times, even if there were no police checks.
- I have never driven through a traffic light that had just turned red.
- I do not care what other drivers think about me.
- I always remain calm and rational in traffic. (if needed pop-up: rational = non-emotional)
- I am always confident of how to react in traffic situations.

Appendix 2: ESRA2 weights

The following weights are used to calculate representative means on national and regional level. They are based on UN population statistics (United Nations Statistics Division, 2019). The weighting took into account small corrections with respect to national representativeness of the sample based on gender and six age groups (18-24y, 25-34y, 35-44y, 45-54y, 55-64y, 65y+). For the regions, the weighting also took into account the population size of each country in the total set of countries from this region.

Individual country weight	Individual country weight is a weighting factor based on the gender*6 age groups (18-24y, 25-34y, 35-44y, 45-54y, 55-64y, 65y) distribution in a country as retrieved from the UN population statistics.
Europe20 weight	European weighting factor based on all 20 European countries participating in ESRA2_2018, considering individual country weight and population size of the country as retrieved from the UN population statistics.
NorthAmerica2 weight	North American weighting factor based on all 2 North American countries participating in ESRA2_2018, considering individual country weight and population size of the country as retrieved from the UN population statistics.
AsiaOceania5 weight	Asian and Oceanian weighting factor based on all 5 Asian and Oceanian countries participating in ESRA2_2018, considering individual country weight and population size of the country as retrieved from the UN population statistics.
Africa5 weight	African weighting factor based on all 5 African countries participating in ESRA2_2018, considering individual country weight and population size of the country as retrieved from the UN population statistics.

Appendix 3: Sample sizes

	car driver (a few days per year)		Total
	no	yes	
AT	847	1152	1999
BE	396	1589	1985
CH	165	855	1020
DE	422	1567	1989
DK	196	788	984
EL	139	876	1015
ES	160	820	980
FI	212	782	994
FR	191	803	994
IE	197	834	1031
IT	93	887	980
NL	243	740	983
PL	201	792	993
PT	97	901	998
SE	245	742	987
SI	133	902	1035
UK	283	680	963
CA	190	790	980
CZ	310	679	989
HU	215	799	1014
IL	124	860	984
KR	236	807	1043
US	178	838	1016
AU	159	809	968
RS	211	830	1041
JP	323	657	980
IN	259	776	1035
EG	301	695	996
KE	300	700	1000
NG	218	782	1000
MA	318	729	1047
ZA	118	895	1013
TOTAL	7680	27356	35036

Appendix 4: Statistical significance results

Chi-Square tests of independence were used to test the statistical association of each binary variable (self-declared behaviour, acceptability, perception accident cause) with region, gender and age group

Further column proportions tests, i.e. pairwise comparisons between pairs of groups (region, gender, age groups), were performed to test for differences between specific regions, or age groups. Significant differences are indicated in the cross-tabulation table with APA-style formatting using subscript letters and are calculated at the 0.01 significance level.

Effect size measure were expressed as Cramer's V. Cramer's V indicates the strength of the association between each binary variable (self-declared behaviour, acceptability, …) and region, gender and age group. The values of Cramer's V can be interpreted as follows (Cohen, 1988)

df=1 (small=.10, medium=.30, large=.50)

df=2 (small=.07, medium=.21, large=.35)

df=3 (small=.06, medium=.17, large=.29)

df=4 (small=.05, medium=.15, large=.25)

df=5 (small=.05, medium=.13, large=.22)

For example, the table A next page indicates the following:

- there is a significant difference in the prevalence of self-declared driving between the four regions (Chi-square= 54,2, p = 0,000);

- Cramer's V (0.048 < 1) indicates the effect or difference is quite small;

- the subscript letters indicate that the difference in rate of self-declared fatigued driving is significant between Europe and Asia-Oceania, but there are no other significant differences between the world regions (Europe and Asia-Oceania sharing similar subscript with North America and Africa).

In subsequent tables A to I statistical tests were performed on region, gender and age group differences:

- Table A Statistical test region differences – self-declared fatigued driving
- Table B Statistical test gender differences – self-declared fatigued driving
- Table C Statistical test age group differences – self-declared fatigued driving
- Table D Statistical test region differences – personal acceptability
- Table E Statistical test gender differences – personal acceptability
- Table F Statistical test age group differences – personal acceptability
- Table G Statistical test region differences – Perception of driving while tired as accident cause
- Table H Statistical test gender differences – Perception of driving while tired as accident cause
- Table I Statistical test age group differences – Perception of driving while tired as accident cause

Table A. Statistical test region differences – self-declared fatigued driving

	Region			
	Europe20	**AsiaOceania5**	**NorthAmerica2**	**Africa5**
never (1)	80.3%a	76.6%b	78.1%a.b	75.4%b
at least once (2-5)	19.7%a	23.4%b	21.9%a.b	24.6%b
	100,0%	100,0%	100,0%	100,0%

Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	54,20	3	0,000
Cramer's V	0,048		

Each subscript letter denotes a region whose column proportions do not differ significantly from each other at the 0.01 level.

Table B. Statistical test Gender differences - self-declared fatigued driving

Region	**Gender**		
Europe20	**male**	**female**	
never (1)	76.3%a	84.6%b	
at least once (2-5)	23.7%a	15.4%b	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	164,57	1	0,000
Cramer's V	0,104		
AsiaOceania5	**male**	**female**	
never (1)	77.3%a	75.5%a	
at least once (2-5)	22.7%a	24.5%a	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	1,55	1	0,213
Cramer's V	0,021		
NorthAmerica2	**male**	**female**	
never (1)	71.9%a	83.8%b	
at least once (2-5)	28.1%a	16.2%b	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	32,60	1	0,000
Cramer's V	0,144		
Africa5	**male**	**female**	
never (1)	72.1%a	79.2%b	
at least once (2-5)	27.9%a	20.8%b	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	21,76	1	0,000
Cramer's V	0,082		

Each subscript letter denotes a subset of gender / age categories whose column proportions do not differ significantly from each other at the 0.01 level.

Table C. Statistical test age group differences - self-declared fatigued driving

Region	Age group					
Europe20	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
never (1)	70.6%a	72.7%a	76.4%b	79.6%c	86.1%d	89.3%e
at least once (2-5)	29.4%a	27.3%a	23.6%b	20.4%c	13.9%d	10.7%e
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	427,89	5	0,000			
Cramer's V	0,168					
AsiaOceania5	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
never (1)	75.2%a	72.5%a	75.8%a	84.9%b	78.4%a.b	76.4%a
at least once (2-5)	24.8%a	27.5%a	24.2%a	15.1%b	21.6%a.b	23.6%a
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	28,54	5	0,000			
Cramer's V	0,091					
NorthAmerica2	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
never (1)	64.9%a	69.0%a	72.8%a	85.4%b	82.8%b	89.1%b
at least once (2-5)	35.1%a	31.0%a	27.2%a	14.6%b	17.2%b	10.9%b
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	71,99	5	0,000			
Cramer's V	0,213					
Africa5	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
never (1)	73.7%a	76.9%a	77.5%a	77.8%a	87.7%b	54.0%c
at least once (2-5)	26.3%a	23.1%a	22.5%a	22.2%a	12.3%b	46.0%c
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	85,50	5	0,000			
Cramer's V	0,162					

Each subscript letter denotes a subset of gender / age categories whose column proportions do not differ significantly from each other at the 0.01 level.

Table D. Statistical test regional differences - Personal acceptability of fatigued driving

	Region			
	Europe20	**AsiaOceania5**	**NorthAmerica2**	**Africa5**
unacceptable/neutral (1-3)	98.4%a	94.6%b	98.8%a	95.7%b
acceptable (4-5)	1.6%a	5.4%b	1.2%a	4.3%b
	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*	
Pearson Chi-Square	294.807a	3	0,000	
Cramer's V	0,096			

Each subscript letter denotes a region whose column proportions do not differ significantly from each other at the 0.01 level.

Table E. Statistical test gender differences - Personal acceptability of fatigued driving

Region	**Gender**		
Europe20	**male**	**female**	
unacceptable/neutral (1-3)	97.9%a	98.8%b	
acceptable (4-5)	2.1%a	1.2%b	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	24.134a	1	0,000
Cramer's V	0,035		
AsiaOceania5	**male**	**female**	
unacceptable/neutral (1-3)	95.7%a	93.4%b	
acceptable (4-5)	4.3%a	6.6%b	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	13.623a	1	0,000
Cramer's V	0,052		
NorthAmerica2	**male**	**female**	
unacceptable/neutral (1-3)	98.1%a	99.4%a	
acceptable (4-5)	1.9%a	0.6%a	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	6.717a	1	0,010
Cramer's V	0,058		
Africa5	**male**	**female**	
unacceptable/neutral (1-3)	94.9%a	96.5%b	
acceptable (4-5)	5.1%a	3.5%b	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	6.776a	1	0,009
Cramer's V	0,037		

Each subscript letter denotes a subset of gender categories whose column proportions do not differ significantly from each other at the 0.01 level.

Table F. Statistical test age group differences - Personal acceptability of fatigued driving

Region			**Age group**			
Europe20	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
unacceptable/neutral (1-3)	96.3%a	97.3%a.b	97.8%b.c	98.5%c	99.3%d	99.5%d
acceptable (4-5)	3.7%a	2.7%a.b	2.2%b.c	1.5%c	0.7%d	0.5%d
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	137.271a	5	0,000			
Cramer's V	0,083					
AsiaOceania5	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
unacceptable/neutral (1-3)	94.4%a	90.9%b	94.3%a	97.9%c	97.7%c	95.9%a.c
acceptable (4-5)	5.6%a	9.1%b	5.7%a	2.1%c	2.3%c	4.1%a.c
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	60.748a	5	0,000			
Cramer's V	0,110					
NorthAmerica2	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
unacceptable/neutral (1-3)	97.3%a.b	96.7%a	99.4%a.b	99.3%a.b	100.0%1	99.6%b
acceptable (4-5)	2.7%a.b	3.3%a	0.6%a.b	0.7%a.b	0.0%1	0.4%b
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	26.078a	5	0,000			
Cramer's V	0,114					
Africa5	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
unacceptable/neutral (1-3)	95.6%a	96.0%a	96.9%a	96.3%a	99.9%b	85.4%c
acceptable (4-5)	4.4%a	4.0%a	3.1%a	3.7%a	0.1%b	14.6%c
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	109.477a	5	0,000			
Cramer's V	0,148					

Each subscript letter denotes a subset of age categories whose column proportions do not differ significantly from each other at the 0.01 level.

Table G. Statistical test regional differences - Perception of driving while tired as accident cause

	Region			
	Europe20	**AsiaOceania5**	**NorthAmerica2**	**Africa5**
not that often/not frequently (1-3)	25.6%a	47.2%b	31.1%c	35.7%d
often/frequently (4-6)	74.4%a	52.8%b	68.9%c	64.3%d
	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*	
Pearson Chi-Square	936,95	3	0,000	
Cramer's V	0,171			

Each subscript letter denotes a region whose column proportions do not differ significantly from each other at the 0.01 level.

Table H. Statistical test gender differences - Perception of driving while tired as accident cause

Region	**Gender**		
Europe20	**male**	**female**	
not that often/not frequently (1-3)	28.0%a	23.4%b	
often/frequently (4-6)	72.0%a	76.6%b	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	56,88	1	0,000
Cramer's V	0,053		
AsiaOceania5	**male**	**female**	
not that often/not frequently (1-3)	49.8%a	44.8%b	
often/frequently (4-6)	50.2%a	55.2%b	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	12,34	1	0,000
Cramer's V	0,050		
NorthAmerica2	**male**	**female**	
not that often/not frequently (1-3)	35.6%a	26.7%b	
often/frequently (4-6)	64.4%a	73.3%b	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	17,99	1	0,000
Cramer's V	0,095		
Africa5	**male**	**female**	
not that often/not frequently (1-3)	35.8%a	35.6%a	
often/frequently (4-6)	64.2%a	64.4%a	
	100,0%	100,0%	
Tests	*Value*	*df*	*p-value*
Pearson Chi-Square	0,01	1	0,926
Cramer's V	0,001		

Each subscript letter denotes a subset of gender categories whose column proportions do not differ significantly from each other at the 0.01 level.

Table I. Statistical test age group differences - Perception of driving while tired as accident cause

Region	**Age group**					
Europe20	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
not that often/not frequently (1-3)	34.6%a	29.4%b	28.7%b	24.2%c	21.6%c.d	20.9%d
often/frequently (4-6)	65.4%a	70.6%b	71.3%b	75.8%c	78.4%c.d	79.1%d
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	208,62	5	0,000			
Cramer's V	0,102					
AsiaOceania5	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
not that often/not frequently (1-3)	48.5%a.b	51.7%a	46.1%b	44.2%b.c	42.8%b.d	46.0%a.b
often/frequently (4-6)	51.5%a.b	48.3%a	53.9%b	55.8%b.c	57.2%b.d	54.0%a.b
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	17,46	5	0,004			
Cramer's V	0,059					
NorthAmerica2	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
not that often/not frequently (1-3)	39.8%a	33.0%a.b	38.4%a	30.6%a.b.c	24.6%b.c	23.9%c
often/frequently (4-6)	60.2%a	67.0%a.b	61.6%a	69.4%a.b.c	75.4%b.c	76.1%c
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	33,50	5	0,000			
Cramer's V	0,129					
Africa5	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
not that often/not frequently (1-3)	39.2%a.d	35.1%a.b	32.6%b	30.0%b.c	35.5%a.b	45.6%d
often/frequently (4-6)	60.8%a.d	64.9%a.b	67.4%b	70.0%b.c	64.5%a.b	54.4%d
	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Tests	*Value*	*df*	*p-value*			
Pearson Chi-Square	35,03	5	0,000			
Cramer's V	0,084					

Each subscript letter denotes a subset of age categories whose column proportions do not differ significantly from each other at the 0.01 level.



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