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# IATSS Research

## Age and road safety performance: Focusing on elderly and young drivers

--Manuscript Draft--

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<b>Abstract:</b>	<p>The existing literature on young and elderly drivers indicates that they have the highest crash risks compared to other age groups of drivers. This study improves our understanding of the risk factors contributing to young and elderly drivers' elevated crash risk by examining self-report data from the E-Survey of Road User's Safety Attitudes (ESRA). The primary objective of this study is to compare the attitudes and behaviours of young, elderly, and middle-age drivers in Canada, the United States, and Europe. The main focus is on the practice of driving while distracted by mobile phones and driving while fatigued, as these are two dangerous behaviours that demonstrate the impact age may have. The analyses consistently showed that there are differences in the responses attributable to age. In all regions, drivers aged 18–21 years consistently reported higher rates of distracted and fatigued driving and higher rates of perceived social and personal acceptability of these behaviours than drivers aged 35–54 years. Elderly drivers aged 65+ years reported even lower rates of these behaviours and acceptability. Young drivers were also the least likely to believe that distraction and fatigue are frequent causes of road crashes, while elderly drivers were the most likely to believe this. This pattern with respect to age repeats in the support for policy measures as well; young drivers are least likely to support zero tolerance policies for mobile phone use when driving, while elderly drivers are the most likely to support this measure. Multivariate logistic regression modeling confirmed that elderly drivers were the least likely to engage in the use of mobile phones while driving or driving while fatigued. Statistically significant results showed that the middle-age group was less likely than young drivers to read a text message/email or check social media while driving and driving while fatigued.</p>
<b>Response to Reviewers:</b>	

Highlights:

- Young drivers (18–21 years) reported higher rates of distracted and fatigued driving than middle-age drivers (35–54 years).
- Young drivers also showed higher rates of perceived social and personal acceptability of these behaviors.
- Elderly drivers (65+ years) reported even lower rates of these behaviours and acceptability.
- These trends are consistent across Canada, the United States, and Europe.

## **Age and road safety performance: Focusing on elderly and young drivers**

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## **Age and road safety performance: Focusing on elderly and young drivers**

### **Abstract**

The existing literature on young and elderly drivers indicates that they have the highest crash risks compared to other age groups of drivers. This study improves our understanding of the risk factors contributing to young and elderly drivers' elevated crash risk by examining self-report data from the E-Survey of Road User's Safety Attitudes (ESRA). The primary objective of this study is to compare the attitudes and behaviours of young, elderly, and middle-age drivers in Canada, the United States, and Europe. The main focus is on the practice of driving while distracted by mobile phones and driving while fatigued, as these are two dangerous behaviours that demonstrate the impact age may have. The analyses consistently showed that there are differences in the responses attributable to age. In all regions, drivers aged 18–21 years consistently reported higher rates of distracted and fatigued driving and higher rates of perceived social and personal acceptability of these behaviours than drivers aged 35–54 years. Elderly drivers aged 65+ years reported even lower rates of these behaviours and acceptability. Young drivers were also the least likely to believe that distraction and fatigue are frequent causes of road crashes, while elderly drivers were the most likely to believe this. This pattern with respect to age repeats in the support for policy measures as well; young drivers are least likely to support zero tolerance policies for mobile phone use when driving, while elderly drivers are the most likely to support this measure. Multivariate logistic regression modeling confirmed that elderly drivers were the least likely to engage in the use of mobile phones while driving or driving while fatigued. Statistically significant results showed that the middle-age group was less likely than young drivers to read a text message/email or check social media while driving and driving while fatigued.

**Keywords:** young, elderly, self-report, behaviour, attitudes, beliefs

## **1. Introduction**

Young and elderly drivers have the highest crash risk compared to other age groups of drivers. In literature, this age-based pattern of crash risk is described as a U-shaped curve and has been shown to be most pronounced for young and elderly drivers when crash risk is measured for fatal crashes or motor vehicle fatalities per distance driven [1,2,3,4,5]. In 2017 in the United States, for example, drivers age 16-19 and drivers age 85 and over had per vehicle mile fatal crash rates of 4.7 and 7.6, respectively compared to a rate of only 1.4 fatal crashes per 100 million miles traveled for those age 45-49 [6].

This study improves our understanding of the risk factors contributing to young and elderly drivers' elevated crash risk by examining self-report data from the E-Survey of Road User's Safety Attitudes (ESRA; [www.esranet.eu](http://www.esranet.eu)). The ESRA project is a joint initiative of road safety institutes, research organisations, public services, and private sponsors, aiming at collecting comparable (inter)national questionnaire-based data on road users' opinions, attitudes, and behaviour with respect to road traffic risks. The ESRA database enables a wide range of analyses that are useful for understanding road safety risks of young and elderly drivers and the effectiveness of measures to reduce their risk.

The primary objective of this study is to compare the attitudes and behaviours of young, elderly, and middle-age drivers in Canada, the United States, and Europe. The main focus will be on the influence of driving while distracted by mobile phones and driving while fatigued, as these are two dangerous behaviours that demonstrate the impact age may have.

## **2. Literature Review**

Young and elderly drivers are at elevated crash risk, but for different reasons. The literature clearly establishes that young drivers do not have enough driving experience to fully develop the skills needed to identify and safely respond to hazards on the road [7,8,9,10,11]. Additionally, youthfulness also contributes to elevated crash risk [12,13]. Certain biological, mental, and developmental changes during adolescence contribute to young drivers having a disproportionate crash rate. The key factors include overconfidence, sensation seeking, widespread sleep deprivation and fatigue, peer influences to engage in risky driving behaviours, and intentional risky driving behaviours, such as speeding, tailgating, distracted driving, and fatigued driving [14,6,15,16,17,18].

The literature also clearly establishes that like young drivers, elderly drivers have a high crash risk owing to ageing-related factors—primarily, deteriorating motor, perceptual and cognitive skills critical for driving safely [1,16,19,20]. Additionally, lifestyle factors including chronic health problems and the side effects of medications also contribute to elderly drivers' crashes. Furthermore, the increasing frailty of elderly drivers makes them more likely to be seriously injured or killed in a collision than young drivers. They also restrict their driving and drive fewer miles than young and middle-age drivers, often in urban areas that place them at higher crash risk, especially at intersections [1,19,20,21]. These frailty and low-mileage biases, in part, explain the elevated risk of fatal crashes and serious injuries when rates are calculated per miles driven.

Although young and elderly drivers have an elevated crash risk for different reasons, they also share a few risk factors, such as distracted driving and fatigued driving [22,23,24,25,26]. However, there are also important differences in the distracted and fatigued driving behaviours of young and elderly drivers. Research has shown that both young and elderly drivers are negatively affected by distractions while driving, although elderly drivers engage in distracting tasks less than young and middle-age drivers. Additionally, young drivers are more frequently observed to be manipulating handheld (HH) devices than elderly drivers [27,28,29]. Young and elderly drivers have been found to be more adversely impacted by secondary tasks than middle-age drivers. Visual-manual distractions impact drivers of all ages, but cognitive distraction may have a larger impact on young drivers [30]. Fatigue is a risk factor for all drivers [31,32,33]. Even though young and elderly drivers drive while fatigued, research has shown that young drivers are likely to be fatigued after midnight into the early morning hours, while elderly drivers are more likely to be fatigued in the afternoon [34,35,36].

Understanding such similarities and differences in risk factors of young and elderly drivers is critical to developing effective policies and programs to reduce their elevated crash risk. Previous surveys have attempted to explore age-related factors in distracted and fatigued driving. Survey data from the United States indicated that drivers aged 65+ years have the lowest rates of mobile phone use (call, text, or apps), while drivers aged 20 years or younger do not have the highest rates for these behaviours, and the highest rates are between the ages of 21 to 54, depending on the question asked [37]. An Australian survey [38] found that younger drivers (aged 18–30 or 18–49 years depending on the question posed) were more likely to report distracting activities while driving and rated distracting activities to be significantly less risky than elderly drivers. Drivers aged 18–30 years were also more likely to report a crash due to distraction. A survey on fatigued driving in Europe found that the odds of falling asleep at the wheel were significantly higher in drivers under the age of 70 years compared to those over 70 years [39]. Data from the first ESRA survey conducted in 2015 [40] found that the percentage of mobile phone use while driving was particularly high among drivers up to 34 years old and fatigued driving was also more prevalent in this age group. This study extends on this earlier work by using data from the more extensive ESRA survey conducted in 2019 to examine distracted driving and fatigued driving behaviours of young and elderly drivers. It also contributes to the field by using common measures to allow for direct comparisons between young and elderly driver behaviour in different geographic regions. This better informs our understanding of where similarities and differences exist in distracted and fatigued driving behaviour across age groups and regions as findings from a previous study in only one country may not necessarily apply to another. For example, the finding from one country that young drivers are more likely to report specific distracted driving activities than elderly drivers may not extrapolate to other countries that differ culturally, politically, economically, and in terms of road safety policy and program development. The ESRA survey results in this study pose the same questions to young and elderly drivers from different countries so the knowledge and insights gained from this research are directly applicable to all of the countries in the investigation, which facilitates direct international comparisons.

### 3. Methodology

The ESRA project is a joint initiative of research organizations and road safety institutes all over the world. The aim is to collect comparable national data on road users' opinions, attitudes, and behaviour with respect to traffic and road safety, and to provide policy makers with data to inform policy measures. The themes covered include self-declared behaviour, attitudes and opinions on unsafe traffic behaviour, enforcement experiences, involvement in road crashes, 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 different types of road users. The second ESRA survey (ESRA2) was conducted in 32 countries, including Canada (n = 602 drivers), the United States (n = 595 drivers), and Europe (n = 14,250 drivers), which are the focus of this paper. The focus was laid on these countries because they are similar in terms of being western, developed and industrialized. In general, there are similarities in the driver licensing processes and traffic environments in North America and Europe – e.g., learners have to practice driving under supervision of a parent/guardian and/or driver trainer, and pass knowledge and road tests before they can obtain a driver's licence; there are roundabouts to control traffic, and a mix of road types, including two-lane highways, residential streets, and expressways/freeways. However, there are also important differences across and even within these countries in terms of culture, politics, demographics, economics, and traffic safety laws, programs and policies. For example, Canada and the United States generally have a younger driver licensing age than in Europe (16 years old versus 17 or 18 years old) and all jurisdictions in North America have some form of graduated driver licensing (GDL) system, which is not the case in Europe, although the features of GDL differ across U.S. states and Canadian provinces. Traffic safety laws and penalties regarding, for example, cell phone use when driving and driving fatigued also differ across and within these countries.

The ESRA2 survey is a web survey using access panels coordinated by the Vias Institute in Belgium ([www.vias.be](http://www.vias.be)) with a core group of partner organisations from 11 countries. The target population was the adult population ( $\geq 18$  years) of each country. The targeted number of respondents was 1,000 in each country, with at least 600 respondents being regular car drivers. If needed, the sample of 1,000 respondents could be extended in order to fulfill both the aforementioned requirements. Twenty individual countries were included in the European region (list of countries available on [www.esranet.eu](http://www.esranet.eu)). The total sample size consisted of more than 35,000 road users from 32 countries with just over 30,000 of those holding a driving license or learner's permit. Hence, the ESRA2 database is a comprehensive dataset, which enables a wide range of analyses useful for understanding road safety risks and the effectiveness of measures. Further details on the design and administration of the survey are available in a separate article in this special issue.

In view of comparability, not just between the countries but also with past surveys, almost all questions of the ESRA2 survey were based on, and often identical to, questions previously used and validated in Belgian (41,42), European [43], and American [44] surveys. The survey covered diverse themes in varying detail due to survey duration constraints (all information on the questionnaire is available on [www.esranet.eu](http://www.esranet.eu)). The questionnaire was produced in 30 different country-language versions. The translated versions were reviewed by the ESRA team to ensure

consistency and concept validity within each language. Data collection took place in two waves in 2018 and 2019.

Table 1 shows the distribution of the full sample used per region. The questions related to driver behaviour in the last 30 days were only posed to respondents who reported driving a car at least a few times a month, while all other questions were posed to all respondents.

**Table 1 Sample Distribution per Region [frequency, percentage by region]**

Sex	Age	Region					
		Europe		Canada		United States	
Male	18–21	641	4.5%	34	5.6%	26	4.3%
	35–54	4,231	29.7%	164	27.2%	166	27.6%
	65+	2,151	15.1%	95	15.8%	90	15.0%
Female	18–21	562	3.9%	29	4.8%	30	5.0%
	35–54	4,108	28.8%	171	28.4%	173	28.7%
	65+	2,557	17.9%	109	18.1%	110	18.3%
Total		14,250		602		595	

Note: Sample distribution is unweighted.

In the first part of our analysis, we reported descriptive results of the three regions for several aspects: self-declared behaviours, acceptability (personal and social), risk perception, and support for policy measures. Most of the questions of the survey were presented on Likert scales, which were dichotomized for the analysis. Description of the scales and correspondent dichotomization is discussed in the results. For this first set of analyses, responses are tested for statistically significant differences with respect to the age categories. Three age categories were considered. The participants between the ages of 18 and 21 were considered young drivers and above 65, elderly drivers. For comparison, participants between the ages of 35 and 54 were considered middle-age drivers. Weighting of the data was done taking into account small corrections with respect to representativeness of the sample based on gender and the three age groups (18–21, 35–54, 65+) using population statistics from the United Nations data [45]. The weights were determined separately for each region and determined by dividing the proportion of each age/gender category in the population by the proportion in the survey sample. Due to the ordinal nature of the data, the chi-square test for independence was used to assess if the observed differences were statistically significant. The strength of the association between variables was assessed using Cramer's V coefficient. These tests indicate if age is a significant factor overall and do not compare each age group to all others.

In the second part, we carried out multivariate analyses, investigating factors predicting self-declared behaviours. The predictive factors included in this analysis were relevant because previous research had shown that one or more of these factors (e.g., age, gender, amount of driving) contributed to explaining distracted driving and fatigued driving behaviours. Binary logistic regression models were used to investigate the association between several explanatory variables, including age and self-declared behaviours. Note that the data were also weighted in the same manner as the descriptive analyses.

## 4. Results

### 4.1. Descriptive analysis

The respondents surveyed in each region were asked questions about distraction from mobile phone use and driving while fatigued. The results are grouped into several sections: self-declared behaviours in traffic, acceptability of unsafe traffic behaviours, attitudes toward safe and unsafe traffic behaviours, risk perception, and support for policy measures.

#### 4.1.1 Self-declared behaviours in traffic

Rates of self-declared handheld mobile use, hands-free mobile use, sending or reading a text message or checking social media, and driving while fatigued at least once within the last 30 days are reported by region in Table 2. All questions were answered on a Likert scale from 1 (never) to 5 (almost always). The percentages of ‘at least once’ (answers 2 to 5) and the 95<sup>th</sup> percentile confidence intervals (CIs) are presented in the results along with the p-value for the chi-squared statistical test of differences between age groups and with the corresponding value of Cramer’s V.

In all regions, the young age category of 18–21 years reported the highest proportion of respondents engaging in behaviours related to distraction and fatigue, and the elderly age category of 65+ years reported the lowest proportion. These differences by age group of the reported proportions are all statistically significant at the 95<sup>th</sup> percentile level or better.

In all three regions, the largest differences by age category, as measured by Cramer’s V, were in reading a text/email or consulting social media while driving. The proportions of young and elderly drivers reporting this behaviour were 63.6% and 28.1% in Canada, 62.8% and 30.4% in the United States, and 62.9% and 35.4% in Europe, respectively. In the United States and Europe, the smallest differences by age category as measured by Cramer’s V, were found for driving when one is so sleepy that it is difficult to keep one’s eyes open. In the United States, the proportions were 54.4% and 28.4% for young and elderly drivers, respectively, and 54.1% and 38.3% in Europe. In Canada, the smallest difference by age category was found for hands-free cell phone conversations while driving, where the proportions for young and elderly drivers were 63.6% and 48.1%, respectively.

**Table 2 Self-declared Behaviour [percentage, (95% CI)]**

Question	Age	Canada	United States	Europe
Talk on handheld mobile phone while driving	18–21	54.0 (41.7–65.9)	70.0 (56.8–80.6)	59.2 (56.3–61.9)
	35–54	36.6 (31.6–41.9)	54.6 (49.2–59.8)	51.4 (50.3–52.5)
	65+	28.6 (22.8–35.2)	37.5 (31.1–44.5)	40.7 (38.9–42.5)
	p-value	0.001	<0.001	<0.001
	Cramer’s V	0.15	0.20	0.12

Talk on hands-free mobile phone while driving	18–21	63.6 (51.0–74.5)	70.8 (57.7–81.1)	69.8 (67.2–72.4)
	35–54	57.9 (52.5–63.1)	64.9 (59.7–69.8)	65.4 (64.4–66.5)
	65+	48.1 (41.3–55.0)	46.0 (39.2–53.0)	56.0 (54.2–57.9)
	p-value	0.035	<0.001	<0.001
	Cramer's V	0.11	0.19	0.10
Read a text message/email or check social media while driving	18–21	63.6 (51.1–74.5)	62.8 (49.4–74.4)	62.9 (60.1–65.6)
	35–54	43.2 (38.0–48.6)	53.1 (47.8–58.4)	48.0 (46.9–49.1)
	65+	28.1 (22.3–34.7)	30.4 (24.5–37.2)	35.4 (33.6–37.3)
	p-value	<0.001	<0.001	<0.001
	Cramer's V	0.22	0.23	0.16
Drive when so sleepy that they had trouble keeping their eyes open	18–21	60.4 (47.9–71.7)	54.4 (41.2–66.9)	54.1 (51.3–56.9)
	35–54	35.5 (30.5–40.8)	37.8 (32.8–43.1)	42.1 (41.0–43.2)
	65+	31.9 (25.8–38.6)	28.4 (22.5–35.0)	38.3 (36.5–40.1)
	p-value	<0.001	0.001	<0.001
	Cramer's V	0.17	0.15	0.08

#### 4.1.2. Acceptability of safe and unsafe traffic behaviours

Rates of the perceived social acceptability of handheld mobile use and sending or reading a text message/checking social media; personal acceptability of handheld mobile use, hands-free mobile use, sending or reading a text message/checking social media, and fatigued driving are reported by region in Table 3. All questions were answered on a Likert scale from 1 (unacceptable) to 5 (acceptable). The percentages of acceptability (answers 4 or 5) are shown in the results with 95<sup>th</sup> percentile confidence intervals (CIs), the p-value for the chi-squared statistical test of differences between age groups, and the corresponding value of Cramer's V.

When asked how acceptable most other people would say it is to talk on a handheld mobile phone while driving, or to read a text message/email or check social media while driving, the young drivers reported the highest rates of perceived social acceptability and elderly drivers, the lowest in all regions. These differences by age group of the reported proportions are all statistically significant at the 95<sup>th</sup> percentile level or better. The magnitude of the impact of age on responses as measured by Cramer's V is similar for the two behaviours. The largest difference between the two behaviours was in the United States, where 38.0% of the younger drivers reported social

acceptability for talking on a handheld mobile phone while driving, and 16.4% reported so for the reading of a text message/email or checking social media while driving.

When asked if they felt it was personally acceptable to talk on a handheld phone, talk on a hands-free phone, read a text message/email, or check social media while driving or to drive when so sleepy that they have trouble keeping their eyes open, the young drivers reported the highest rates and elderly drivers, the lowest in all regions. The differences by age category in Canada and the United States as measured by Cramer's V are notable, ranging from 0.11 to 0.31. In contrast, in Europe, the differences are smaller, ranging from 0.07 to 0.13.

**Table 3 Acceptability of Safe and Unsafe Traffic Behaviour [percentage, (95% CI)]**

Question	Age	Canada	United States	Europe
Social Acceptability - Talk on handheld mobile phone while driving	18–21	25.5 (16.2–37.7)	38.0 (26.2–51.4)	13.2 (11.4–15.3)
	35–54	2.7 (1.4–5.2)	13.9 (10.6–18.0)	9.2 (8.6–10.0)
	65+	1.0 (0.3–3.9)	5.5 (3.0–9.6)	5.2 (4.1–6.5)
	p-value	<0.001	<0.001	<0.001
	Cramer's V	0.35	0.26	0.09
Social Acceptability - Read a text message/email or check social media while driving	18–21	23.9 (15.0–36.0)	16.4 (8.7–28.7)	8.6 (7.2–10.4)
	35–54	3.0 (1.6–5.5)	5.6 (3.6–8.7)	5.9 (5.4–6.5)
	65+	1.0 (0.3–3.9)	2.0 (0.7–5.1)	3.3 (2.4–4.5)
	p-value	<0.001	<0.001	<0.001
	Cramer's V	0.33	0.18	0.07
Personal Acceptability - Talk on handheld phone while driving	18–21	19.2 (11.2–30.8)	20.0 (11.4–32.7)	6.5 (5.2–8.0)
	35–54	2.1 (1.0–4.4)	8.6 (6.0–12.1)	3.8 (3.4–4.3)
	65+	0.5 (0.1–3.3)	0.5 (0.1–3.4)	1.0 (0.7–1.3)
	p-value	<0.001	<0.001	<0.001
	Cramer's V	0.31	0.22	0.10
	18–21	38.2 (27.1–50.7)	48.0 (35.2–61.0)	45.9 (43.1–48.8)

Personal Acceptability - Talk on hands-free phone while driving	35–54	22.4 (18.3–27.2)	37.2 (32.2–42.5)	36.1 (35.1–37.2)
	65+	14.6 (10.4–20.2)	16.9 (12.3–22.8)	26.3 (24.6–28.0)
	p-value	<0.001	<0.001	<0.001
	Cramer’s V	0.17	0.23	0.13
Personal Acceptability - Read a text message/email or check social media while driving	18–21	16.0 (8.8–27.2)	7.6 (2.9–18.6)	4.8 (3.8–6.2)
	35–54	1.2 (0.5–3.2)	1.5 (0.6–3.5)	1.9 (1.5–2.3)
	65+	0.0 (n/a)	0.5 (0.1–3.4)	1.0 (0.4–0.5)
	p-value	<0.001	<0.001	<0.001
	Cramer’s V	0.31	0.15	0.08
Personal Acceptability - Drive when so sleepy they have trouble keeping their eyes open	18–21	14.4 (7.6–25.4)	4.0 (1.0–14.6)	3.4 (2.5–4.7)
	35–54	1.2 (0.5–3.2)	0.6 (0.1–2.4)	1.5 (1.2–1.8)
	65+	0.0 (n/a)	0.5 (0.1–3.4)	0.6 (0.3–1.0)
	p-value	<0.001	0.034	<0.001
	Cramer’s V	0.29	0.11	0.07

#### 4.1.3. Beliefs concerning risk perception

The respondents were asked how often they thought risky behaviours caused a road crash involving a car. Several items were asked including using a handheld phone while driving, using a hands-free phone while driving and driving while fatigued. The scale of answers ranged from 1 (never) to 6 (almost always). The percentages of often/frequently (answers 4 to 6) are shown in the results by region in Table 4.

For using a handheld phone while driving, in the United States and Europe, young drivers reported the lowest rates of agreement and elderly drivers, the highest. In Canada, the middle-age group reported the lowest rate of agreement (69.7%), while the young age group and elderly age group reported 77.8% and 87.4%, respectively. For using a hands-free phone while driving, in the United States and Europe, young drivers again reported the lowest rates of agreement and elderly drivers, the highest. In Canada, the percentages of the young and middle-aged groups were roughly equal at 50.9% and 49.7%, respectively. The elderly age group reported the highest rate of agreement (65.8%). For fatigued driving, young drivers reported the lowest rates of agreement and elderly drivers, the highest in all regions.

**Table 4 Risk Perception [percentage, (95% CI)]**

Question	Age	Canada	United States	Europe
Using a handheld phone while driving	18–21	77.8 (65.9–86.4)	56.4 (43.2–68.8)	63.8 (61.0–66.4)
	35–54	69.7 (64.6–74.4)	66.0 (60.8–70.9)	73.4 (72.4–74.4)
	65+	87.4 (82.1–91.3)	79.0 (72.8–84.1)	81.4 (80.0–82.8)
	p-value	<0.001	0.001	<0.001
	Cramer's V	0.19	0.16	0.12
Using a hands-free phone while driving	18–21	50.9 (38.7–63.0)	28.4 (18.1–41.6)	36.1 (33.4–38.9)
	35–54	49.7 (44.4–55.1)	40.4 (35.3–45.7)	46.2 (45.1–47.3)
	65+	65.8 (59.0–72.0)	60.6 (53.6–67.1)	58.5 (56.7–60.3)
	p-value	0.001	<0.001	<0.001
	Cramer's V	0.15	0.22	0.14
Driving while fatigued	18–21	63.5 (50.9–74.4)	56.8 (43.5–69.2)	62.9 (60.1–65.6)
	35–54	70.0 (64.9–74.7)	64.9 (59.6–69.8)	73.7 (72.7–74.7)
	65+	79.5 (73.4–84.5)	76.1 (69.7–81.5)	80.0 (78.5–81.4)
	p-value	0.015	0.005	<0.001
	Cramer's V	0.12	0.13	0.11

#### 4.1.4. Support for policy measures

By asking the participants to answer “Do you support or oppose a legal obligation to have zero tolerance for using any type of mobile phone while driving for all drivers?,” the support for policy measures was assessed. The question was answered on a Likert scale from 1 (oppose) to 5 (support). The percentages of ‘support’ (answers 4 to 5) are presented in Table 5.

In the United States and Europe, young drivers reported the lowest rates of support and elderly drivers, the highest. In Canada, the percentages of the young and middle-age groups were roughly equal at 58.8% and 56.9%, respectively. The elderly age group reported the highest rate of support (78%).

**Table 5 Support for Policy Measures [percentage, (95% CI)]**

Question	Age	Canada	United States	Europe
Have zero tolerance for using any type of mobile phone while driving for all drivers	18–21	58.8 (46.3–70.2)	36.4 (24.9–49.7)	34.5 (31.9–37.3)
	35–54	56.9 (51.5–62.2)	48.6 (43.3–53.9)	49.3 (48.2–50.4)
	65+	78.0 (71.8–83.2)	59.5 (52.6–66.1)	62.4 (60.7–64.1)
	p-value	<0.001	0.004	<0.001
	Cramer’s V	0.20	0.14	0.16

#### 4.2. Multivariate analysis

Four dependent variables were selected for further analysis: self-declared behaviour in the last 30 days for talking on a handheld mobile phone, talking on hands-free mobile phone, reading a text message/email or checking social media, and driving when so sleepy that they had trouble keeping their eyes open.

For each behaviour, logistic regression models were estimated to study the association between a set of explanatory variables and the reported behaviour. For each model, the dependent variable is binary, and indicates the absence (0 = never) or presence (1 = at least once) of the self-declared behaviour within the past 30 days. Demographics (region, gender, age, and education level), frequency of driving, and the perceived social and personal acceptability of unsafe traffic behaviour, risk perception, and support for road safety measure were treated as the explanatory variables where available. Odds ratios (ORs) and 95% confidence intervals (CIs) were used to estimate the strength of the relationship between these explanatory variables and the reported behaviours. All results are presented in Table 6. The reference categories are listed in brackets following each independent variable in the model.

**Table 6 Logistic Regression Models of Self-declared Driver Behaviours**

Independent variables (reference categories)	Dependent variable: reported behaviour (last 30 days) (0 = never; 1 = at least once)			
	Handheld mobile phone use	Hands-free mobile phone use	Text message/email /social media	Fatigued driving
	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)
<b>Sociodemographic</b>				
<b>Gender</b> (Ref. category male)				
female	0.76 (0.69–0.83)**	0.77 (0.71–0.84)**	0.84 (0.76–0.93)**	0.58 (0.53–0.64)**
<b>Age group</b> (Ref. category 35–54)				
18–21	1.07 (0.91–1.25)	0.93 (0.80–1.09)	1.59 (1.35–1.86)**	1.46 (1.24–1.73)**
65+	0.44 (0.39–0.49)**	0.65 (0.58–0.72)**	0.25 (0.22–0.30)**	0.53 (0.47–0.60)**
<b>Region</b> (Ref. category Canada)				
Europe	1.96 (1.53–2.51)**	1.08 (0.89–1.32)	1.07 (0.85–1.35)	1.17 (0.92–1.48)
United States	2.49 (1.80–3.43)**	1.02 (0.77–1.35)	1.52 (1.11–2.07)**	1.02 (0.73–1.43)
<b>Driving Exposure</b> (Ref. category a few days a month)				
1 to 3 days a week	1.08 (0.89–1.33)	1.08 (0.86–1.36)	0.91 (0.71–1.16)	1.18 (0.95–1.46)
at least 4 days a week	1.77 (1.48–2.12)**	1.78 (1.44–2.21)**	1.51 (1.21–1.89)**	1.57 (1.29–1.90)**
<b>Acceptability of Safe and Unsafe Behaviour</b> (variable equal to 1 if respondent rated acceptability as 4 or 5 on 5-point scale; Ref. category 0 otherwise)				
Social acceptability to talk on a handheld phone while driving	1.79 (1.48–2.16)**			
Social acceptability to read a text message/email or check social media while driving			1.92 (1.47–2.50)**	
Personal acceptability to talk on a handheld phone while driving	3.62 (2.70–4.86)**			
Personal acceptability to talk on a hands-free phone while driving		2.49 (2.24–2.77)**		
Personal acceptability to read a text message/email or check social media while driving			7.01 (3.11–15.83)**	

Personal acceptability to drive when so sleepy that they have trouble keeping their eyes open				5.45 (3.46–8.58)**
<b>Risk Perception</b> (variable equal to 1 if respondent rated risk as 4 to 6 on 6-point scale; Ref. category 0 otherwise)				
Using a handheld mobile phone while driving is often a factor in road crashes	0.75 (0.67–0.83)**			0.76 (0.68–0.85)**
Using a hands-free mobile phone while driving is often a factor in road crashes		0.78 (0.71–0.85)**		
Driving while fatigued is often a factor in road crashes				0.79 (0.71–0.89)**
<b>Support for policy measures</b> (variable equal to 1 if respondent rated support as 4 or 5 on 5-point scale; Ref. category 0 otherwise)				
Have zero tolerance for using any type of mobile phone while driving for all drivers	0.51 (0.47–0.56)**	0.50 (0.45–0.55)**		0.52 (0.47–0.57)**

Notes: (1)\*  $p$ -value < 0.05, \*\* $p$ -value < 0.01.

#### 4.2.1. Factors predicting self-declared talking on a handheld mobile device while driving

Compared to drivers in the age group 18–21 years elderly drivers were 56% less likely to report this behaviour (OR = 0.44; 95% CI: 0.39–0.49;  $p < 0.01$ ). Handheld mobile use was also associated with respondents' gender, as female drivers were 24% less likely to report talking on a handheld mobile while driving, in comparison with male drivers (OR = 0.76; 95% CI: 0.69–0.83;  $p < 0.01$ ). In comparison with those who drove only a few days a month, individuals who reported a driving frequency of at least a few days a week were 77% more likely to talk on a handheld device while driving (OR = 1.77; 95% CI: 1.48–2.12;  $p < 0.01$ ). Those who felt that it was socially acceptable to talk on a handheld device while driving were 79% more likely to report having performed this behaviour (OR = 1.79; 95% CI: 1.48–2.16;  $p < 0.01$ ). Those who personally felt that it was acceptable to talk on a handheld device while driving were 262% more likely to report having performed this behaviour (OR = 3.62; 95% CI: 2.70–4.86;  $p < 0.01$ ). How drivers perceive the risk of handheld mobile use also impacts the reported behaviour. Those who reported that handheld mobile use is often a factor in road crashes were 25% less likely to report having performed this behaviour (OR = 0.75; 95% CI: 0.67–0.83;  $p < 0.01$ ). Drivers with zero tolerance to using any type of mobile phone while driving were 49% less likely to have reported talking on a handheld mobile phone while driving (OR = 0.51; 95% CI: 0.47–0.56;  $p < 0.01$ ).

#### 4.2.2 Factors predicting self-declared talking on a hands-free mobile device while driving

Compared to drivers in the age group 18–21 years elderly drivers were 35% less likely to report this behaviour (OR = 0.65; 95% CI: 0.58–0.72;  $p < 0.01$ ). Hands-free mobile use was also associated with respondents' gender, as female drivers were 23% less likely to report talking on a hands-free mobile while driving, in comparison with male drivers (OR = 0.77; 95% CI: 0.71–0.84;

$p < 0.01$ ), a result similar to that for handheld use. In comparison with those who only drove a few days a month, individuals who reported a driving frequency of at least a few days a week were 78% more likely to talk on a hands-free device while driving (OR = 1.78; 95% CI: 1.44–2.21;  $p < 0.01$ ). Those who personally felt that it was acceptable to talk on a hands-free device while driving were 149% more likely to report having performed this behaviour (OR = 2.49; 95% CI: 2.24–2.77;  $p < 0.01$ ). How drivers perceive the risk of hands-free mobile use also impacts the reported behaviour. Those who reported that hands-free mobile use is often a factor in road crashes were 22% less likely to report having performed this behaviour (OR = 0.78; 95% CI: 0.71–0.85;  $p < 0.01$ ). Drivers with zero tolerance to using any type of mobile phone while driving were 50% less likely to have reported talking on a hands-free mobile phone while driving (OR = 0.50; 95% CI: 0.45–0.55;  $p < 0.01$ ).

#### *4.2.3. Factors predicting self-declared use of text message/email/social media while driving*

When comparing drivers in the age group 18–21 years with those aged 35–54 years, the likelihood of drivers reporting the use of text message/email/social media while driving increased by 59% when controlling for all other factors (OR = 1.59; 95% CI: 1.35–1.86;  $p < 0.01$ ). For drivers aged 65+, these odds decreased by 75% (OR = 0.25; 95% CI: 0.22–0.30;  $p < 0.01$ ). Use of text message/email/social media was associated with respondents' gender, as female drivers were 16% less likely to report this behaviour (OR = 0.84; 95% CI: 0.76–0.93;  $p < 0.01$ ). In comparison with those who only drive a few days a month, individuals who reported a driving frequency of at least a few days a week were 51% more likely to report doing so (OR = 1.51; 95% CI: 1.21–1.89;  $p < 0.01$ ). Those who felt that it was socially acceptable to use text message/email/social media while driving were 92% more likely to report having performed this behaviour (OR = 1.92; 95% CI: 1.47–2.50;  $p < 0.01$ ). Those who personally felt that it was acceptable to do so were 601% more likely to report having performed this behaviour (OR = 7.01; 95% CI: 3.11–15.83;  $p < 0.01$ ). How drivers perceive the risk of text message/email/social media use also impacts the reported behaviour. Those who reported that this behaviour is often a factor in road crashes were 24% less likely to report having performed this behaviour (OR = 0.76; 95% CI: 0.68–0.85;  $p < 0.01$ ). Drivers supportive of zero tolerance of using any type of mobile phone while driving were 48% less likely to have reported this behaviour while driving (OR = 0.52; 95% CI: 0.47–0.57;  $p < 0.01$ ).

#### *4.2.4. Factors predicting self-declared driving while sleepy*

When comparing drivers in the age group 18–21 years to those aged 35–54 years, the likelihood of drivers reporting driving while sleepy increased by 46% when controlling for all other factors (OR = 1.46; 95% CI: 1.24–1.73;  $p < 0.01$ ). For drivers aged 65+, these odds decreased by 47% (OR = 0.53; 95% CI: 0.47–0.60;  $p < 0.01$ ). Driving while sleepy was associated with respondents' gender, as female drivers were 42% less likely to report this behaviour (OR = 0.58; 95% CI: 0.53–0.64;  $p < 0.01$ ). In comparison with those who only drive a few days a month, individuals who reported a driving frequency of at least a few days a week were 57% more likely to report doing so (OR = 1.57; 95% CI: 1.29–1.90;  $p < 0.01$ ). Those who personally felt that it is acceptable to drive while sleepy were 445% more likely to report having performed this behaviour (OR = 5.45; 95% CI: 3.46–8.58;  $p < 0.01$ ). How drivers perceive the risk of driving while sleepy also impacts the reported behaviour. Those who reported that this behaviour is often a factor in road crashes

were 21% less likely to report having performed this behaviour (OR = 0.79; 95% CI: 0.71–0.89;  $p < 0.01$ ).

## 5. Discussion

The objective of this study was to examine and compare the rates of self-reported behaviours, beliefs, and attitudes related to distracted driving due to mobile phone use and driving while fatigued among young, elderly, and middle-age drivers. Analyses were conducted using self-report data from Canada ( $n = 602$ ), the United States ( $n = 595$ ), and Europe ( $n = 14,250$ ).

The analyses consistently showed that there are differences in the responses attributable to age. The magnitude of the effects as measured by Cramer's  $V$  tended to be the smallest in Europe, while the largest effects were found in Canada or the United States depending on the question asked. In all regions, young drivers aged 18–21 years consistently reported higher rates of distracted and fatigued driving and higher rates of perceived social and personal acceptability of these behaviours than drivers aged 35–54 years. Elderly drivers aged 65+ reported even lower rates of these behaviours and acceptability. Young drivers were also the least likely to believe distraction and fatigue to be frequent causes of road crashes, while elderly drivers were the most likely to believe this. This pattern with respect to age repeats in the support for policy measures as well; young drivers are least likely to support zero tolerance policies for mobile phone use while driving, while elderly drivers are the most likely to support this measure.

An analysis was also done to examine the factors impacting four types of self-declared behaviour: talking on a handheld mobile phone, talking on hands-free mobile phone, reading a text message/email or checking social media, and driving when so sleepy that they had trouble keeping their eyes open.

Statistically significant results showed that elderly drivers were the least likely to engage in all four behaviours and the young drivers were more likely than the middle-age drivers to read a text message/email or check social media while driving and driving while fatigued. However, the difference was not significant for handheld and hands-free phone use, once the other variables were controlled. In other words, age has an effect on the reported behaviours of the elderly drivers for the four behaviours studied and for young drivers' use of phone for text messaging or social media and driving while fatigued. For young drivers, it appears that their increased likelihood over middle-age drivers is fully accounted for through attitudes and perceptions of risky behaviour with respect to phone use for conversing while driving. Thus, the effect of age on distraction and fatigue is not fully captured through the attitudes and perceptions measured here for elderly drivers. This is also true for young drivers with respect to texting/social media and fatigue and this needs further investigation.

Female drivers were found to be less likely to engage in all four behaviours. Those who reported perceived social acceptability or personal acceptability for these behaviours were more likely to report having engaged in them. Respondents who reported a belief that these behaviours contribute to crash risk and respondents who support zero tolerance for mobile phone use while driving were less likely to engage in the related behaviour. More frequent driving exposure (at least 4 days a week) increases the likelihood of all four behaviours. It should be noted, however, that because of

the larger sample size, the European results are more precise and have more influence on the estimated logistic regression models.

Finally, some statistically significant differences were seen between regions when controlling for all other variables. For handheld mobile use, respondents in Canada were least likely to report this behaviour, followed by Europe and the United States. This means that Canadians are the least likely to report talking on a handheld mobile device while driving. These results are in line with the descriptive analysis in this study and a previous ESRA study [27] showing that Canadian drivers report the lowest proportions of talking on a handheld mobile device, whereas Europeans and Americans report higher proportions of this behaviour. Compared to Canada, respondents from the United States were more likely to report the use of text message/email or social media while driving.

## **6. Conclusions**

The results of this study improve upon our understanding of age-related factors in Europe and North America with respect to driving while distracted by mobile phones and driving while fatigued. Understanding the similarities and differences by age group can inform policies and programs to reduce crash risk. For example, the findings that young drivers aged 18–21 years, especially males, consistently reported higher rates of distracted and fatigued driving and higher rates of perceived social and personal acceptability of these behaviours than older age groups suggest that young male drivers should be the primary target for policies and programs on distracted and fatigued driving. This is the case in Canada, the United States and Europe, the three regions included in this study. Moreover, road safety education efforts on distracted and fatigued driving should focus on reducing the acceptability of these behaviours and better informing young drivers about the associated crash risks as those who believed that these behaviours contributed to crash risk were less likely to engage in them. Research shows that interventions based on road user behaviours in road safety education may improve behavioural outcomes. Positive associations between knowledge of traffic rules, positive attitudes towards road safety and risk perception suggest the need to strengthen these elements in road safety education interventions [46]. The design of interventions should consider that drivers with high rates of reported stress or physiological stress have been found to have higher rates of both unintentional errors and deliberate transgressions when driving [47].

In the United States more so than in Canada and Europe, safety efforts should focus on encouraging drivers to refrain from using handheld mobile phones because respondents in the United States were most likely to report this behaviour. Although regional differences were apparent in distracted and fatigued driving, there were also similarities in behaviours and associated predictive factors across regions suggesting that in general, new and proven safety measures implemented to better address distracted and fatigued driving in one region may also work in another region despite the fact that these regions differ in many ways, including in traffic safety laws, programs and policies. Additionally, this work demonstrates the use of large-scale survey data to inform the development of road safety policies and programs.

## Limitations of the Data

While self-reported survey data are informative, there are some limitations. In general, self-reported survey data are vulnerable to a number of biases, such as [48,49] desirability bias – the tendency of respondents to provide answers that 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 or long questions); and recall error – unintentional faulty answers due to memory errors. Despite the advantages of online surveys, the representativeness of the surveyed populations may be a problem, mainly for countries with low rates of internet use. That is, however, unlikely for the countries used in the analyses discussed in this paper.

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