Vulnerable road users: Cross-cultural perspectives on performance and attitudes

Abstract

Pedestrians, cyclists and powered two-wheeler riders are considered vulnerable road users, as they are prone to a high risk of injury in the event of vehicular collision. This paper sought to elucidate the road safety performance and attitudes of vulnerable road users in 32 countries. In addition, comparisons between countries and demographic characteristics have been conducted, and recommendations that could enhance vulnerable road users' safety have been provided. For the study, data from the second edition of the ESRA survey (E-Survey on Road Users' Attitudes – ESRA2) conducted in 2018 were utilized. The results indicate that crossing the road at places other than nearby pedestrian crossings, reading a text message or checking social media while walking on the streets, cycling and riding without wearing a helmet, and speeding on powered two-wheelers outside built-up areas but not on motorways/freeways were the most frequently reported self-declared behaviours in the 32 countries. Finally, some solutions on preventing road crashes and increasing vulnerable road users' safety such as infrastructure interventions, use of protective equipment, and training and educational campaigns are discussed.

Keywords: road safety, vulnerable road users, behaviour, survey, ESRA

1. Introduction

The term ‘vulnerable road user’ is applied to those most at risk in traffic, that is, those unprotected by an external shield [1]. Pedestrians, pedal cyclists and motorcyclists are considered vulnerable road users (VRUs), as they are prone to injury in any vehicular collision, primarily because there is little or no external protective device that could absorb the impact of a road crash. The kinetic forces resulting from differences in the mass and speed of various types of vehicles largely determine the severity of a road crash [2]. According to the latest global assessment of road safety, the World Health Organization (WHO) indicates that vulnerable road users account for more than half of all road fatalities [3].

1.1 Pedestrians

Walking as a transport mode is mainly considered for short distance trips to specific destinations such as shops or for leisure [4]. Approximately 15-30% of all person-kilometres walked daily correspond to shopping purposes and 30-55% to home-leisure trips [1]. Pedestrians represent 23% of all road fatalities worldwide. Africa has the highest proportion of pedestrian fatalities, accounting for 40% of overall deaths [3]. In 2017, pedestrians accounted for 21% of all road fatalities in the European Union (EU). Although a 36% reduction has been observed in pedestrian fatalities during the last decade [5], pedestrian falls due to poor quality of pavements or the actions of other road users are mostly not reported. Therefore, pedestrian crashes are heavily under-reported in police crash statistics [1].

Major risk factors for pedestrians’ road traffic injuries are speed, drink driving, unsafe infrastructure, and inadequate visibility of walkers [6]. The probability of a fatal injury for a pedestrian hit by a motor vehicle increases significantly with impact speed [7]. Alcohol consumption increases the likelihood of a crash as it leads to poor judgement, increases reaction time, and decreases visual acuity [8]. Pedestrians’ risk of crash involvement escalates with increasing concentration of alcohol in the blood [9]. Lack of proper infrastructure facilities for pedestrians is another risk factor [10]. Inadequate visibility of pedestrians is also a risk factor, which might be exacerbated by the lack of roadway lighting and the absence of reflective clothing worn by pedestrians [11]. Some other risk factors are inadequate traffic law enforcement, reduced walking speed for the elderly, pedestrians’ distraction [12], etc.

1.2 Cyclists

Cyclists account for 3% of all fatalities among road users worldwide. The respective rates based on WHO figures are 5% in Europe, 3% in North and South America, 4% in Africa, 2% in the Eastern Mediterranean and South East Asia, and 6% in the Western Pacific [3]. Between 2010 and 2018, the number of cyclists killed in the EU has been decreasing at a slower rate than that of motorised vehicle occupants killed in road crashes [13]. Under-reporting of road crashes, including those involving bicycle riders, is a common phenomenon [14-16]. This is more frequent in road crashes not involving motor vehicles (e.g. a cyclist hits a fixed object or falls) [15]. However, under-reporting is less prevalent in the case of fatal road crashes involving cyclists [2].

Many risk factors play a role in the likelihood or the outcome of a road crash involving a bicycle. The most important factors are related to an inherently unsafe traffic system and unsafe infrastructure [2]. Further risk factors are associated with age, gender, knowledge of traffic regulations, hazard awareness, alcohol, speed, distraction, weather, etc. [15, 17]. The risk of a

cyclist being killed is considerably high among people aged 65 and above [18]. Male cyclists are more likely to be involved in a road crash than females. Additionally, cycling at night, cycling under the influence of alcohol, and at a high speed are more prevalent among male cyclists [15]. Cycling under the influence of alcohol increases the risk of a fatal road crash by almost three times [19]. The visibility of cyclists is also a crucial issue. In many road crashes, car drivers cannot detect cyclists early enough, indicating that cyclists' clothing may be more relevant than the bicycle light [20]. Nowadays, an increasing number of people are using electronic devices while cycling. The results of a study in the Netherlands showed that young adult cyclists who use portable electronic devices on each trip are 1.6 to 1.8 times more likely to be involved in a road crash than cyclists in the same age groups who do not use such a device when cycling [21].

1.3 Powered two-wheeler riders

Mopeds and motorcycles, henceforth called powered two-wheelers (PTWs), form an important component of the transport system, as they offer increased mobility at a reduced cost and a special sense of pleasure. However, riding a PTW is much more dangerous than using other motor vehicles [22]. PTWs accounted for 18% of overall road fatalities in EU countries in 2017 [5]. Globally, users of motorised two- and three-wheelers represent 28% of all road fatalities. In South-East Asia and the Western Pacific, motorised two- and three-wheeler riders account for 43% and 36% of all fatalities, respectively [3].

The correlation of injury severity with external variables such as speeding, drink driving, infrastructure, and weather has been examined in many studies. When the interactions between behaviour, crash rates, and severity are co-investigated along with other contributory factors, the crash causes and related solutions can be better identified [23]. Examples include negative influence for crashes while speeding, at junctions, while in darkness, and for specific crash types. Vehicle age and the lack of helmet use have been found to have an impact on increased crash severity. The majority of PTW crashes are recorded in residential and commercial areas, during daylight conditions, in good weather, and dry surface conditions and in local or collector roads [24]. Behavioural issues play a major role in PTW crashes. Risk taking and sensation seeking are typical behaviours of riders that are usually expressed through speeding, disobeying traffic signals and signs, ignoring overtaking restrictions or pedestrian crossings and maintaining short distances with the vehicles ahead of them [25]. PTW users' behaviour is related to age and riding exposure. PTW drivers that speed appear to be more often younger and male [25]. Lastly, a useful handbook on VRU safety-related issues, including PTW riders, cyclists and pedestrians, was developed in the framework of the Horizon2020 InDev project. Its aim was to help road safety professionals diagnose road safety problems by gaining more insights into the mistakes by road users that lead to a collision [26].

1.4 Objective

In this backdrop, this paper seeks to elucidate performance and attitudes of VRUs regarding road safety in 32 countries, based on demographic characteristics. Moreover, the paper aims to provide certain recommendations for road safety stakeholders at different levels which could be implemented in efforts to enhance VRUs' road safety. The analysed data is from the second edition of the ESRA survey (E-Survey on Road Users' Attitudes – ESRA2) conducted in 2018.

2. Methodology

The ESRA project is a joint initiative of road safety institutes, research organisations, public services and private sponsors across 48 countries, aimed at collecting comparable international data on road users' opinions, attitudes and behaviour with respect to road traffic risks. ESRA is an extensive online panel survey, using a representative sample (at least N=1,000) of the national adult population of each participating country. A jointly developed questionnaire was translated into various languages. It addresses different road safety topics such as drink driving, speeding, and distraction. The survey targets car occupants, motorcycle and moped drivers, cyclists, and pedestrians. Data collection was carried out by four market research agencies (INFAS, Ipsos, Punto de Fuga, Dynata). These agencies are members of ESOMAR, an association that has defined the standards for recruiting online panels to minimize selection bias. More details concerning the methodology, the data processing and the questionnaire are available in the ESRA2 methodology report [27]. An overview of the project and its publications are available at www.esranet.eu.

This paper is based on the first wave of ESRA2 spanning 32 countries in 2018. These countries are presented in detail in Figure 1. The VRUs' aspects that were analysed within ESRA2 and which will also be presented in this paper address the following:

a. Safety perception of using each transport mode (pedestrian, bicycle, moped, motorcycle)

Question: 'How safe or unsafe do you feel when using the following transport modes in your country'?

The respondents were asked to rate their answers from 0 to 10, where 0 is 'very unsafe' and 10 is 'very safe'.

b. Self-declared behaviour in the past 30 days

Question: 'Over the last 30 days, how often did you as a pedestrian …'?

- 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
- listen to music through headphones as a pedestrian while walking in the street
- read a text message/email or check social media while walking in the street

Question: 'Over the last 30 days, how often did you as a cyclist …'?

- cycle when you think that you may have had too much to drink
- cycle without a helmet
- cycle on the road next to the cycle lane
- cycle while listening to music through headphones
- read a text message/email or check social media while cycling

Question: 'Over the last 30 days, how often did you as a moped driver or motorcyclist…'?

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

The respondents were asked to respond on a 5-point scale, from 1 'never' to 5 'almost always'.

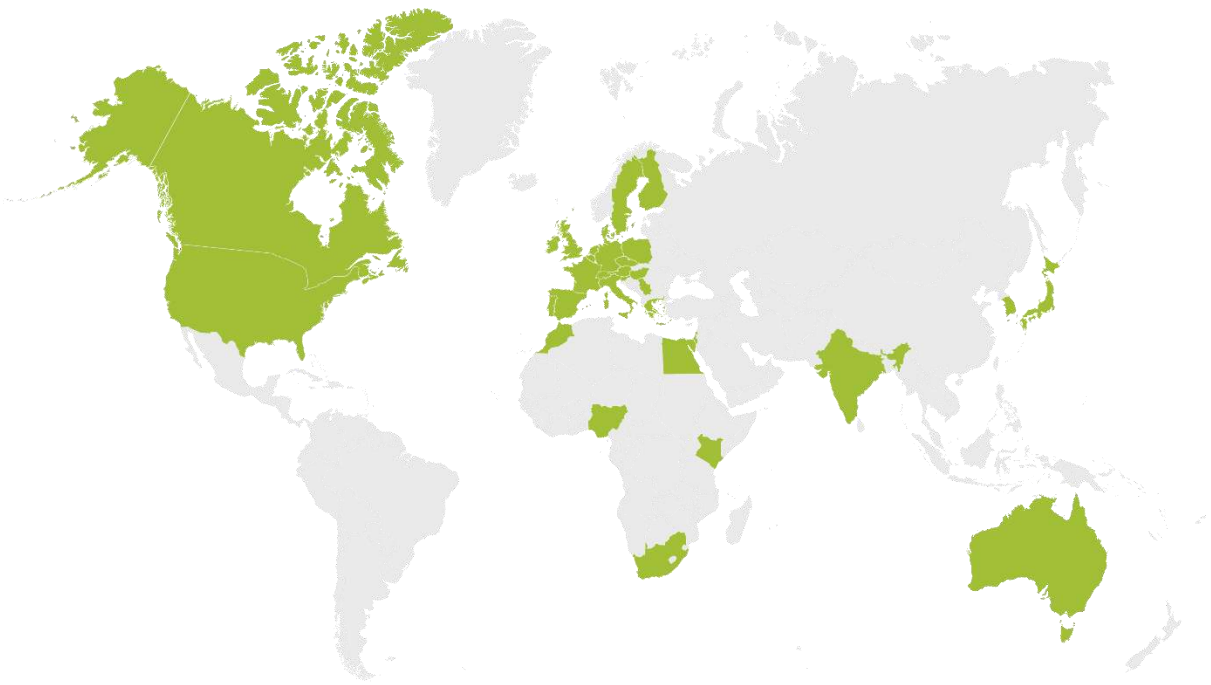

Figure 1. Geographical coverage of the ESRA2 survey in 2018: Europe (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Serbia, Slovenia, Spain, Sweden, Switzerland, United Kingdom), North America (Canada, USA), Asia and Oceania (Australia, India, Israel, Japan, Republic of Korea), Africa (Egypt, Kenya, Morocco, Nigeria, South Africa).

3. Results

3.1. Safety perception of using each transport mode

The respondents who walked, used a bicycle, moped, and motorcycle in the past 12 months were asked how safe they felt using these transport modes. They answered on a scale from 0 to 10, where 0 is 'very unsafe' and 10 is 'very safe'.

Table 1. Average safety perception of using each transport mode by country (11-point scale from 0 = very unsafe to 10 = very safe).

Country	Pedestrian	Bicycle (non-electric)	Bicycle (electric)	Moped (≤50cc or ≤4kW; non-electric)	Moped (electric ≤4kW)	Motorcycle (>50cc or >4kW; non-electric)	Motorcycle (electric >4kW)
Australia	8.2	6.3	6.0	5.7	5.8	5.8	5.8
Austria	8.4	7.2	6.6	6.0	4.9	6.1	5.2
Belgium	6.7	5.6	6.0	5.6	5.3	5.7	5.6
Canada	8.1	6.7	6.0	5.8	5.9	6.1	6.7
Czech Rep.	7.3	6.1	6.0	5.6	5.3	5.6	5.6
Denmark	8.4	7.4	7.0	6.6	6.2	5.8	5.6
Egypt	6.6	6.0	5.5	5.6	5.3	5.4	5.4
Finland	8.2	7.3	6.8	6.5	6.2	6.4	6.7
France	7.6	5.9	6.0	5.5	5.1	5.3	5.6
Germany	8.3	7.2	7.0	6.5	5.3	6.5	5.8
Greece	7.1	4.6	5.0	4.8	4.8	4.7	4.8
Hungary	7.4	6.2	5.5	5.5	5.1	5.1	4.9

India	7.3	7.1	6.8	6.7	6.6	6.6	6.7
Ireland	7.3	5.4	5.5	5.3	5.8	5.6	5.6
Israel	8.0	5.1	4.1	4.0	3.9	4.0	3.9
Italy	7.5	6.2	5.6	5.5	5.1	5.8	5.2
Japan	7.1	6.1	6.2	5.5	5.1	5.4	5.4
Kenya	7.0	6.3	5.1	5.2	5.2	5.4	5.6
Morocco	6.7	6.1	5.5	5.6	5.5	5.2	5.1
Netherlands	7.3	6.9	6.9	6.5	6.4	6.4	5.9
Nigeria	6.4	5.5	4.7	5.0	4.6	5.1	4.7
Poland	7.0	6.4	6.5	6.1	6.0	6.2	6.0
Portugal	7.5	6.3	6.2	5.7	5.8	5.9	6.2
Rep. of Korea	6.8	4.8	4.6	4.0	4.1	4.2	4.0
Serbia	6.8	5.8	4.8	5.4	5.0	5.2	4.7
Slovenia	7.5	6.1	6.4	6.0	5.9	5.7	5.8
South Africa	5.7	4.9	4.4	4.7	4.8	4.6	5.0
Spain	7.8	6.1	5.5	5.3	5.3	5.6	5.6
Sweden	8.3	7.2	6.3	5.7	5.7	5.8	5.0
Switzerland	8.9	7.3	6.9	6.4	5.6	6.8	6.2
United Kingdom	7.8	6.1	6.0	5.5	5.6	5.7	5.3
United States	7.1	6.3	5.5	5.2	5.4	5.6	5.4

Note: The highest safety perception scores are highlighted in green while the lowest in orange.

Regarding walking, African respondents felt the most unsafe when compared with respondents from other countries. The lowest safety perception scores for walking are found in South Africa (5.7) and Nigeria (6.4). On the contrary, countries with the highest safety perception scores on walking are in Europe, with Switzerland at the top (8.9), followed by Denmark and Austria (8.4).

The highest safety perception scores among people using conventional bicycles are all European, with Denmark at the top (7.4). India with 7.1 points is the country with the highest score among non-European countries. Greece (4.6) has the lowest safety perception score among the 32 examined countries. The safety perception scores for electric bicycles are quite similar, with Denmark at the top (7.0) and Israel placed last (4.1).

Regarding PTWs, road users perceive them as less safe compared to bicycles and walking. Among all the examined countries, the safety perception scores for PTWs do not exceed 7 points. The country with the lowest scores for both moped and motorcycles is Israel. Among European countries, the lowest safety perception scores for PTWs correspond to Greece. With regard to non-electric motorcycles, Switzerland is at the top of the safety perception ranking (6.8) followed by India (6.6). India is also the country with the highest safety perception scores for mopeds and electric motorcycles (6.6 and 6.7 respectively).

3.2 Pedestrians' self-declared behaviour

This sub-section presents pedestrians' responses to the questions about their self-declared behaviour, described in the Methodology section. The responses will be presented by country and world region, by age group per region and by gender per region.

Table 2. Pedestrians' self-declared behaviour in the past 30 days by country and region (% of pedestrians that did it at least once). Reference population: pedestrians, at least a few days a month

Country	Cross road when pedestrian light is red	Cross road at places other than at nearby pedestrian crossing	Walk while wearing headphones	Read a text message/email or check social media while walking
Australia	41.6%	65.3%	33.8%	52.3%
Austria	43.0%	71.7%	27.4%	60.7%
Belgium	42.9%	71.5%	27.4%	55.5%
Canada	45.6%	69.3%	37.7%	47.7%
Czech Rep.	37.7%	77.7%	28.8%	62.0%
Denmark	45.8%	69.8%	35.4%	58.4%
Egypt	45.5%	70.4%	62.2%	70.2%
Finland	56.3%	80.2%	39.0%	65.2%
France	65.7%	72.8%	31.0%	61.1%
Germany	41.8%	67.2%	25.6%	49.8%
Greece	62.8%	80.6%	35.8%	62.9%
Hungary	36.0%	69.0%	31.8%	52.2%
India	40.0%	70.3%	43.9%	53.6%
Ireland	67.2%	80.3%	44.5%	66.1%
Israel	48.2%	73.4%	46.7%	77.1%
Italy	37.7%	74.6%	32.2%	56.0%
Japan	46.5%	73.3%	27.3%	47.9%
Kenya	51.6%	80.5%	55.4%	72.3%
Morocco	52.7%	73.6%	55.1%	70.6%
Netherlands	44.7%	66.8%	32.5%	52.4%
Nigeria	37.5%	72.4%	56.3%	67.0%
Poland	35.5%	69.0%	36.7%	51.9%
Portugal	67.3%	79.8%	34.0%	69.0%
Rep. of Korea	42.4%	58.4%	56.1%	71.8%
Serbia	52.1%	81.9%	28.6%	70.6%
Slovenia	30.1%	74.2%	20.9%	57.3%
South Africa	53.8%	76.2%	40.6%	62.8%
Spain	75.5%	84.5%	46.6%	73.7%
Sweden	64.1%	79.9%	47.6%	61.4%
Switzerland	47.2%	73.8%	35.5%	60.4%
United Kingdom	62.0%	77.9%	35.5%	60.6%
United States	42.5%	62.4%	38.2%	52.4%
Europe20	51.8%	74.1%	33.4%	58.7%
Asia-Oceania5	40.8%	70.0%	42.6%	53.9%
North America2	42.8%	63.1%	38.2%	51.9%
Africa5	49.1%	73.3%	55.0%	68.8%

Note: The highest percentages are highlighted in orange while the lowest in green.

Table 3. Pedestrians' self-declared behaviour in the past 30 days by age group and region (% of pedestrians that did it at least once). Reference population: pedestrians, at least a few days a month

Region	Age group	Cross road when pedestrian light is red	Cross road at places other than at nearby pedestrian crossing	Walk while wearing headphones	Read a text message/email or check social media while walking
Europe20	18-24	67.6%	83.0%	75.5%	85.1%
	25-34	60.1%	77.3%	54.4%	77.6%
	35-44	52.2%	73.6%	41.3%	71.3%
	45-54	50.5%	71.9%	28.6%	59.3%
	55-64	48.0%	71.1%	17.5%	45.0%
	65+	42.6%	72.2%	10.0%	33.9%
Asia-Oceania5	18-24	44.4%	73.2%	52.9%	61.2%
	25-34	40.2%	64.8%	47.8%	57.3%

	35-44	41.8%	71.5%	43.5%	56.3%
	45-54	42.2%	71.7%	37.0%	50.6%
	55-64	38.9%	67.8%	36.0%	50.3%
	65+	33.8%	72.7%	24.8%	36.7%
North America2	18-24	51.2%	74.1%	61.3%	71.0%
	25-34	49.9%	70.0%	50.4%	70.0%
	35-44	50.3%	67.0%	54.3%	69.0%
	45-54	42.6%	59.9%	40.3%	48.4%
	55-64	32.0%	55.4%	21.8%	35.5%
	65+	32.7%	54.8%	6.8%	21.5%
Africa5	18-24	55.3%	75.7%	73.2%	76.9%
	25-34	51.3%	73.7%	59.8%	75.7%
	35-44	43.5%	70.7%	44.1%	64.4%
	45-54	44.9%	75.9%	40.7%	59.7%
	55-64	37.0%	68.7%	28.3%	48.6%
	65+	53.9%	69.8%	52.8%	61.9%

Table 4. Pedestrians' self-declared behaviour in the past 30 days by gender and region (% of pedestrians that did it at least once). Reference population: pedestrians, at least a few days a month

Region	Gender	Cross road when pedestrian light is red	Cross road at places other than at nearby pedestrian crossing	Walk while wearing headphones	Read a text message/email or check social media while walking
Europe20	Male	56.8%	76.2%	36.5%	60.2%
	Female	47.0%	72.0%	30.5%	57.2%
Asia-Oceania5	Male	41.8%	70.6%	42.9%	54.8%
	Female	39.9%	69.1%	42.1%	52.8%
North America2	Male	48.8%	64.7%	41.4%	51.1%
	Female	36.8%	61.5%	35.2%	53.3%
Africa5	Male	51.0%	73.6%	58.3%	71.8%
	Female	47.2%	73.0%	51.6%	65.8%

The results indicate that the most common pedestrian risky behaviour is crossing the road outside the pedestrian crossing, followed by reading a text message on the phone or checking social media while walking on the street. Respondents listening to music through headphones was the least frequent reported behaviour. An interesting finding is that a respondent's region of residence had very little influence on the prevalence of risky behaviours.

Crossing the road during a red light at the pedestrian crossing is one of the most risky pedestrian behaviours, as the risk of being hit by a motor vehicle is high, and other road users do not anticipate such behaviour [28]. Respondents were asked how often they had crossed the road in the last month during a red pedestrian light. The differences between the regions are not significant. The country with the highest rate is Spain (76%), while this behaviour was reported the least frequently by Slovenian respondents (30%). The ESRA2 study examined the impact of gender and age on the frequency of risky behaviours when crossing the road. Research on self-reported or observed crossing behaviours has shown that red light violation is more frequent among young people and among males [28-30]. The ESRA2 survey results record a similar trend, although gender differences are not major.

Over 50% of respondents declared that in the past 30 days they had crossed the road at places other than a pedestrian crossing at least once. The differences between the regions are not significant. Crossing the road in a prohibited area is proclaimed by 75% of respondents in

Africa, 74% in Europe, 68% in Asia-Oceania and 66% in North America. Pedestrians in Spain (85%) mostly affirmed this behaviour. The fewest attempts to cross the road outside the pedestrian crossing were recorded in the Republic of Korea (58%). As expected, men and young pedestrians more often admitted to crossing the road outside the designated crossing. The frequency of crossing the road at places other than designated crossings decreases with age. However, even in the group of respondents aged 65 and above, the percentage of people indulging in such behaviour is quite high.

Calling and texting on the phone led to more unsafe behaviour, compared to listening to music [31]. The ESRA2 study examined how widespread is listening to music among pedestrians. The respondents were asked how often in the last month had they listened to music on headphones while walking. The differences between regions ranged from 33% in Europe to 54% in Africa. The countries with the highest proportion include Egypt (62%), Nigeria (56%) and the Republic of Korea (56%), while the lowest shares were recorded in Slovenia (21%). Regarding gender and age, the results indicate a clear impact of age on the frequency of using mobile devices. In the 18-24 age group, over 70% of respondents stated that they had been listening to music using headphones while walking during the past month. No major gender differences were found in terms of listening to music amid traffic.

It has been accepted that with the increase in the prevalence of portable electronic devices, there has been a corresponding increase in the number of people who use these devices, also while driving and walking. In the ESRA2 survey, respondents were asked how often during the last month they had read a text message/email or checked social media while walking on the street. The differences between regions are distinct. These activities were mostly proclaimed by respondents from Africa (69%), followed by Asia-Oceania (61%), Europe (60%) and North America (50%). Countries with the highest rates of pedestrians reading text messages, emails, or checking social media include Israel (77%), Spain (74%) and Kenya (72%). Meanwhile, pedestrians who were least likely to admit to this type of behaviour were from Canada (48%), Japan (48%) and Germany (50%). With regard to the impact of gender and age on the frequency of reading text messages, emails, or checking social media, 79% of young men and 82% of young women (18-24 years old) admitted to these behaviours in the past 30 days. There are only marginal differences among the first three age groups. The decrease in the frequency of using these phone functionalities in traffic was observed among respondents aged over 45. Among all age groups except 18-24 and 25-34, men were more likely to read texts and check social media while walking, but the gender differences were subtle.

3.3 Cyclists' self-declared behaviour

The respondents were asked about five unsafe behaviours they might have adopted as cyclists, which have already been mentioned in the Methodology section. These results are presented by country and world region, by age and by gender per region.

Table 5. Cyclists' self-declared behaviour in the past 30 days by country and region (% of cyclists that did it at least once). Reference population: cyclists, at least a few days a month

Country	Drink and cycle	Cycle without a helmet	Cycle on the road next to the bicycle lane	Cycle while listening to music through headphones	Read a text message/email or check social media while cycling

Australia	15.1%	29.7%	34.8%	37.0%	17.6%
Austria	17.8%	69.1%	35.9%	21.4%	14.4%
Belgium	28.2%	82.8%	37.2%	28.3%	22.5%
Canada	22.0%	51.6%	43.6%	38.9%	23.9%
Czech Rep.	26.4%	70.1%	29.4%	23.5%	12.7%
Denmark	27.8%	71.9%	30.6%	33.9%	22.6%
Egypt	21.6%	62.3%	54.4%	61.9%	39.2%
Finland	21.2%	72.0%	31.9%	35.0%	26.5%
France	17.5%	74.3%	44.8%	32.8%	20.5%
Germany	17.3%	72.9%	41.3%	23.0%	15.3%
Greece	7.9%	53.1%	66.2%	38.7%	23.0%
Hungary	15.7%	83.5%	33.4%	21.7%	10.8%
India	19.5%	72.1%	57.5%	44.6%	31.9%
Ireland	16.1%	50.9%	43.0%	39.6%	18.0%
Israel	8.6%	47.8%	27.9%	39.4%	21.5%
Italy	12.7%	63.9%	32.2%	30.5%	17.3%
Japan	9.0%	68.1%	52.7%	13.7%	16.1%
Kenya	9.5%	68.0%	57.6%	52.9%	28.4%
Morocco	17.5%	58.0%	56.3%	50.3%	40.5%
Netherlands	26.2%	87.0%	26.3%	30.0%	24.7%
Nigeria	10.1%	48.7%	42.3%	43.8%	15.1%
Poland	15.8%	79.6%	41.0%	33.0%	19.3%
Portugal	9.1%	45.8%	28.0%	26.7%	19.3%
Rep. of Korea	15.7%	67.0%	46.0%	46.2%	20.1%
Serbia	11.7%	81.8%	37.9%	24.0%	26.2%
Slovenia	14.4%	72.2%	26.6%	14.9%	10.5%
South Africa	14.9%	45.1%	43.7%	39.7%	17.7%
Spain	11.5%	53.6%	38.7%	32.3%	21.1%
Sweden	28.9%	70.7%	54.0%	37.8%	23.3%
Switzerland	20.1%	55.1%	39.2%	23.0%	14.4%
United Kingdom	22.3%	49.4%	43.5%	35.5%	22.6%
United States	15.7%	50.9%	35.1%	34.9%	22.2%
Europe20	17.4%	69.2%	38.7%	29.4%	18.9%
Asia-Oceania5	18.4%	71.2%	56.5%	41.8%	30.0%
North America2	16.5%	51.0%	36.2%	35.4%	22.4%
Africa5	17.4%	57.7%	52.7%	52.8%	33.9%

Note: The highest percentages are highlighted in orange while the lowest in green.

Table 6. Cyclists' self-declared behaviour in the past 30 days by age group and region (% of cyclists that did it at least once). Reference population: cyclists, at least a few days a month

Region	Age group	Drink and cycle	Cycle without a helmet	Cycle on the road next to the bicycle lane	Cycle while listening to music through headphones	Read a text message/email or check social media while cycling
Europe20	18-24	29.9%	75.7%	50.1%	56.1%	42.7%
	25-34	21.9%	66.7%	43.6%	42.6%	29.1%
	35-44	18.9%	70.7%	42.6%	33.1%	20.4%
	45-54	12.0%	65.7%	34.1%	22.5%	12.4%
	55-64	12.4%	70.7%	33.5%	14.5%	7.3%
	65+	11.6%	67.8%	29.9%	11.5%	5.5%
Asia-Oceania5	18-24	16.8%	76.3%	60.0%	45.2%	34.9%
	25-34	19.8%	60.0%	52.9%	42.9%	31.3%
	35-44	22.3%	71.9%	54.1%	42.6%	33.5%
	45-54	18.6%	82.2%	55.2%	39.2%	24.0%
	55-64	15.8%	76.1%	58.9%	35.3%	15.7%
	65+	10.2%	65.2%	63.1%	36.8%	26.3%
North America2	18-24	20.4%	46.2%	37.2%	36.9%	26.6%

	25-34	25.5%	54.3%	45.5%	47.5%	34.7%
	35-44	17.9%	58.4%	41.3%	51.6%	30.1%
	45-54	7.4%	52.2%	33.3%	23.5%	18.0%
	55-64	10.7%	45.3%	29.0%	21.4%	6.0%
	65+	10.0%	42.8%	19.6%	12.5%	4.5%
Africa5	18-24	15.9%	62.0%	51.7%	58.3%	36.2%
	25-34	12.7%	58.2%	53.9%	52.1%	35.6%
	35-44	15.5%	47.4%	46.6%	46.6%	29.8%
	45-54	19.1%	59.0%	52.9%	49.5%	24.8%
	55-64	9.8%	45.8%	56.8%	32.4%	15.5%
	65+	46.1%	68.0%	61.9%	66.5%	53.0%

Table 7. Cyclists' self-declared behaviour in the past 30 days by gender and region (% of cyclists that did it at least once). Reference population: cyclists, at least a few days a month

Region	Gender	Drink and cycling	Cycle without a helmet	Cycle on the road next to the bicycle lane	Cycle while listening to music through headphones	Read a text message/email or check social media while cycling
Europe20	Male	22.5%	69.3%	43.9%	32.0%	21.2%
	Female	11.0%	69.0%	32.2%	26.2%	16.0%
Asia-Oceania5	Male	16.2%	73.6%	56.9%	41.5%	30.9%
	Female	21.3%	68.1%	55.8%	42.0%	28.9%
North America2	Male	21.0%	52.8%	39.5%	35.2%	24.0%
	Female	9.1%	48.5%	31.1%	36.0%	19.9%
Africa5	Male	15.9%	62.0%	54.7%	54.8%	35.3%
	Female	19.9%	51.0%	49.6%	49.7%	31.8%

Cycling without using a helmet was the most frequently mentioned unsafe behaviour. The percentage of cyclists stating that they had not used a helmet at least once in the past 30 days ranged from 51% in North America to 71% in Asia-Oceania. The least frequently mentioned unsafe behaviour was cycling under the influence of alcohol (17-18%). The proportion of cyclists who reported that they had listened to music through headphones at least once in the past 30 days ranged from 29% in Europe to 53% in Africa. The corresponding lowest and largest percentages for the behaviour 'read a text message/email or checked social media' were again recorded in Europe (19%) and in Africa (34%), respectively. Finally, cycling adjacent to the cycling lane was reported the least frequently by respondents in North America (36%) and most frequently by cyclists in Asia-Oceania (56%).

The percentage of cyclists indicating that they cycled when they might have had consumed too much alcohol at least once in the past 30 days varied considerably between the countries within the world regions. In Europe, for example, the country with the highest proportion is Sweden (29%) and at the other end of the scale, Greece (8%). In Asia-Oceania, Indian respondents reported this behaviour more than twice as often (20%) as Israelis (9%). In Europe and North America significantly more male than female respondents reported this behaviour; in Asia-Oceania and Africa, the opposite is the case. In Europe, North America, and Asia-Oceania, the rates of self-declared drink and cycling tend to decrease with age. In Africa, there is no clear pattern.

The proportion of cyclists without a helmet differed considerably from one country to another within the world regions. In Europe, the country with the highest rate is the Netherlands (87%), and the country with the lowest rate is Portugal (46%). In Asia-Oceania, the countries at the two extremities are India (72%) and Australia (30%), while in Africa, the corresponding

countries are Kenya (68%) and South Africa (45%). The percentage of individuals reporting cycling without a helmet are markedly lower (between 30% and 54%) in jurisdictions where helmet use is mandatory for all cyclists (Australia, Nigeria, South Africa, some states of Canada and the United States, as well as Spain and Israel when riding outside built-up areas) than in most other countries. In Asia-Oceania and in Africa, significantly more men than women reported cycling without a helmet at least once in the past 30 days. In Europe and North America, there are no significant gender differences. No clear age trends were observed in the different world regions.

The largest national differences in the percentage of respondents reporting that they have ridden next to the cycling lane at least once in the past 30 days are found in Europe and Asia-Oceania. In Europe, the country with the highest share is Greece (66%), and the country with the lowest share is the Netherlands (26%). The corresponding countries in Asia-Oceania are India (58%) and Israel (28%). More men than women acknowledged that they had cycled next to the cycling lane. In Europe and North America, this behaviour is more prevalent among younger age groups and tends to decrease with age. In Africa and Asia-Oceania, there is no clear age trend.

The three countries with the highest proportion of persons reporting that they cycled while listening to music through headphones at least once in the past 30 days are all African (Egypt, 62%, Kenya, 53% and Morocco, 50%) while the corresponding lowest proportion is found in Asia-Oceania and Europe (Japan, 14% and Slovenia, 15%). In Asia-Oceania, the countries with the largest share of cyclists exhibiting this behaviour are in the Republic of Korea (46%) and India (44%). In Europe, the respective countries are Ireland (40%) and Greece (39%). While in Europe and Africa, significantly more male than female respondents reported this behaviour, in North America and Asia-Oceania, there appear no gender differences. In Europe and North America, this behaviour is more prevalent in the youngest age groups and tends to decrease with age. In Europe, the age group with the highest percentage comprised the 18-24-year-olds (56%), and in North America, the 35-44-year-olds (52%). In Africa and Asia-Oceania, there is no clear age trend.

Reading a text message/email or checking social media while cycling is also particularly widespread in the African region. Two of the three countries with the highest proportions are African: Morocco and Egypt (41% and 39%, respectively), and one is Asia: India (32%). The countries with the lowest percentage of cyclists reporting this behaviour at least once in the past 30 days are found in Europe, that is, in Slovenia and Hungary (both 11%). More men than women reported this behaviour, and it is more prevalent among younger age groups and tends to decrease with age.

3.4 PTW riders' self-declared behaviour

The results of four questions based on PTW riders' self-declared behaviour, which have been stated in the Methodology section, will be shown by country and world region, by age per region and by gender per region.

Table 8. PTW riders' self-declared behaviour in the past 30 days by country and region (% of PTW riders that did it at least once). Reference population: PTW riders, at least a few days a month

Country	Drink driving	Ride without a helmet	Ride faster than the speed limit outside	Read a text message/email or

			built-up areas (not on motorways/freeways)	check social media while riding
Australia	30.5%	29.0%	45.7%	29.3%
Austria	21.9%	19.7%	52.3%	18.6%
Belgium	21.2%	23.5%	42.2%	21.7%
Canada	52.8%	49.3%	63.5%	50.6%
Czech Rep.	9.7%	21.9%	42.0%	7.9%
Denmark	28.1%	37.8%	54.8%	25.7%
Egypt	22.3%	58.0%	54.5%	46.5%
Finland	5.4%	22.0%	56.4%	11.0%
France	33.6%	31.4%	59.5%	41.5%
Germany	18.0%	22.8%	48.8%	17.5%
Greece	16.3%	42.6%	46.5%	16.1%
Hungary	8.6%	30.5%	46.5%	10.5%
India	18.0%	47.0%	41.5%	29.5%
Ireland	22.2%	32.7%	40.9%	27.7%
Israel	4.2%	8.3%	41.7%	12.4%
Italy	16.1%	17.0%	42.4%	17.5%
Japan	10.2%	15.7%	53.7%	14.8%
Kenya	12.2%	52.6%	39.0%	29.8%
Morocco	23.2%	44.2%	48.8%	36.5%
Netherlands	18.5%	36.2%	37.6%	20.8%
Nigeria	13.5%	45.7%	33.8%	23.7%
Poland	13.9%	33.7%	46.6%	20.8%
Portugal	10.1%	13.6%	39.2%	16.4%
Rep. of Korea	16.2%	30.6%	46.0%	26.3%
Serbia	10.2%	37.6%	27.8%	11.8%
Slovenia	19.8%	26.0%	47.5%	12.6%
South Africa	21.2%	25.9%	41.2%	26.1%
Spain	20.1%	21.1%	38.6%	20.3%
Sweden	18.1%	27.2%	50.6%	22.4%
Switzerland	15.1%	17.2%	51.7%	14.4%
United Kingdom	39.2%	40.6%	46.2%	42.1%
United States	21.1%	37.9%	47.0%	30.7%
Europe20	19.9%	25.7%	45.3%	21.9%
Asia-Oceania5	17.8%	46.2%	41.8%	29.1%
North America2	24.4%	39.1%	48.7%	32.7%
Africa5	20.7%	48.5%	47.7%	37.2%

Note: The highest percentages are highlighted in orange while the lowest in green.

Table 9. PTW riders' self-declared behaviour in the past 30 days by age group and region (% of PTW riders that did it at least once). Reference population: PTW riders, at least a few days a month

Region	Age group	Drink driving	Ride without a helmet	Ride faster than the speed limit outside built-up areas (not on motorways/free ways)	Read a text message/email or check social media while riding
Europe20	18-24	31.6%	37.6%	56.4%	36.6%
	25-34	26.8%	30.8%	49.2%	31.9%
	35-44	21.6%	27.3%	46.6%	22.7%
	45-54	9.6%	14.9%	37.5%	12.0%
	55-64	10.1%	19.9%	42.7%	7.4%
	65+	11.5%	17.7%	32.4%	8.0%
Asia-Oceania5	18-24	18.3%	55.8%	48.2%	33.9%

	25-34	18.4%	41.8%	38.7%	29.4%
	35-44	21.9%	47.8%	45.8%	31.2%
	45-54	12.1%	41.7%	35.4%	22.0%
	55-64	14.2%	36.1%	34.0%	15.7%
	65+	16.1%	44.2%	40.3%	35.4%
North America2	18-24	26.1%	53.5%	48.4%	31.1%
	25-34	37.1%	45.4%	59.6%	49.6%
	35-44	26.0%	29.9%	52.2%	40.1%
	45-54	0.7%	19.1%	36.7%	11.9%
	55-64	27.7%	46.7%	41.5%	18.8%
	65+	0.0%	18.9%	21.2%	0.0%
Africa5	18-24	15.5%	50.6%	46.4%	41.3%
	25-34	18.9%	53.8%	46.2%	40.8%
	35-44	16.6%	47.4%	43.8%	30.9%
	45-54	15.6%	42.2%	48.3%	32.3%
	55-64	3.2%	26.1%	29.7%	13.4%
	65+	61.2%	46.1%	70.3%	41.8%

Table 10. PTW riders' self-declared behaviour in the past 30 days by gender and region (% of PTW riders that did it at least once). Reference population: PTW riders, at least a few days a month

Region	Gender	Drink driving	Ride without a helmet	Ride faster than the speed limit outside built-up areas (not on motorways/freeways)	Read a text message/email or check social media while riding
Europe20	Male	22.8%	28.7%	51.8%	22.7%
	Female	14.2%	19.6%	32.3%	20.3%
Asia-Oceania5	Male	15.4%	48.1%	44.2%	26.7%
	Female	21.2%	43.6%	38.9%	32.2%
North America2	Male	25.7%	41.6%	47.4%	35.8%
	Female	22.6%	35.5%	52.5%	28.0%
Africa5	Male	19.4%	51.2%	49.8%	40.3%
	Female	22.9%	43.9%	44.2%	32.0%

The most frequent unsafe behaviour reported by PTW riders is riding faster than the speed limits outside built-up areas (but not on motorways/freeways) followed by riding without a helmet. In a majority of countries, the proportion of PTW riders who admitted to speeding in the past 30 days is between 40% and 50%. Regarding riding without a helmet, in most countries, the percentage of PTW riders who confessed to riding without a helmet in the past 30 days varies between 20% to 40%.

Self-declared drink driving varies from 18% in Asia-Oceania to 25% in North America. With regard to the two North American countries, a significant difference can be observed between Canada (53%) and the United States (21%). In Europe, PTW riders from the United Kingdom (39%) reported the highest rates of drink driving, whereas PTW riders in Finland (5%) reported the lowest rates. In Asia-Oceania, Australian PTW riders most frequently reported drink driving (31%) and Israeli PTW riders the least frequently (4%). In Africa, Moroccan PTW riders reported drink driving (23%) more frequently than riders in Nigeria (14%) and Kenya (12%). A similar pattern cannot be observed for drink driving among the different age groups in the four world regions. Regarding gender, in Europe and North America, drink driving rates are higher for males than for females. On the contrary, in Asia-Oceania and Africa, the self-declared drink driving rates are higher for females than for males.

The results for riding without a helmet vary from 26% in Europe to 49% in Africa. Among European countries, the highest rates of the self-declared behaviour of riding without a helmet are found in Greece (43%). In North America, nearly half of Canadian PTW riders (49%) admitted to riding without a helmet. In Asia-Oceania, significant differences are observed between the countries. The highest rates are found in India (47%), while the lowest rates are in Israel (8%). The rates of African PTW riders who acknowledged riding without a helmet are quite high compared to the respective rates in the other regions. The self-declared behaviour of riding without a helmet by PTW riders is higher among younger PTW riders than among older age groups. With respect to gender, in all world regions, the rates of male PTW riders are higher than the respective rates of female PTW riders.

The rates of PTW riders who admitted to speeding vary from 42% in Asia-Oceania to 49% in North America. Among European countries, the highest rates are found in France (60%), whereas PTW riders in Serbia (28%) reported the lowest rates. In North America, the self-declared speeding rate in Canada (64%) is significantly higher than the respective rate in the United States (47%). In Asia-Oceania, Japanese PTW riders most frequently reported speeding (54%) and Indian PTW riders the least frequently (42%). In Africa, the highest rate is observed in Egypt (55%) and the lowest in Nigeria (34%). In Europe, Asia-Oceania, and North America, the self-declared speeding by PTW riders is higher among younger PTW riders than among older age groups. However, in Asia-Oceania and Africa, the self-declared rate of PTW riders aged 65 and above is also relatively high. In Europe, Asia-Oceania and Africa, self-declared speeding rates are higher for male PTW riders, compared to female riders. In North America, slightly higher rates correspond to female PTW riders (53%) in comparison with the respective rates for male PTW riders (47%).

The results of PTW riders for the self-declared behaviour of reading a text message/email or checking social media while riding vary from 22% in Europe to 37% in Africa. In Europe, the highest rates are found in the United Kingdom and France (42%). Conversely, PTW riders in the Czech Republic reported the lowest rates (8%). Among the two North American countries, half of Canadian PTW riders (51%) confessed to reading a text message/email or checking social media while riding, whereas the rate of PTW riders indulging in this behaviour in the United States is lower (31%). In Asia-Oceania, there are no particular differences between the countries. In Africa, the highest rates are found in Egypt (47%), whereas Nigerian PTW riders reported the lowest rates (24%). The respective rates by European PTW riders are higher among younger PTW riders than among older age groups. With respect to gender differences, in all the examined regions with the exception of Asia-Oceania, the rates of male PTW riders are higher than the respective rates of female PTW riders.

4. Discussion

The relatively high percentages correspond to specific unsafe behaviours reported by VRUs. Approximately 70% of pedestrians reported that they had crossed the road at places other than at nearby pedestrian crossings at least once in the past 30 days. The percentage of pedestrians who reported that they had read a text message/email or had checked their social media account at least once in the past 30 days while walking was also particularly high (52-69%). This behaviour was even more pronounced among younger pedestrians. Regarding cyclists, the self-declared behaviour with the highest rates was cycling without a helmet (51-71%). For PTW riders, speeding outside built-up areas but not on motorways/freeways (40-50%) and riding without a helmet (20-40%) were the most frequently reported behaviours. These two behaviours were most prevalent among younger PTW riders.

In addition, based on the safety perception results of walking as a transport mode, it is revealed that the lowest safety perception scores correspond to African countries, which may also be associated with the high share (40%) of pedestrian fatalities in Africa region [3]. Regarding PTWs, road users perceive them as less safe compared to walking and cycling, which means that the road users feel more unprotected when they are riding a moped or a motorcycle.

The results of the present study can be a valuable source of information to understand the causes underlying road crashes among VRUs. This survey offers a unique database and provides policy makers and researchers with valuable insights into the public perception of road safety. The standardized methodology and sampling procedure in all participating countries can be used as a benchmark of road safety performance indicators and assist in identifying appropriate road safety measures in each country. The high proportion of unsafe behaviours reported by VRUs in combination with their high risk of injury in any collision against a vehicle underscore the need for targeted road safety measures.

Long-term planning is needed to create fundamental changes that will improve the safety of pedestrians and cyclists [32]. Safe road design plays a key role in making walking and cycling safe and attractive. The implementation of safe road crossings, safe walking routes, separated cycle paths and other traffic calming schemes could be some promising infrastructure measures. A safe infrastructure may also be important in eliminating undesirable behaviours. There are several other measures that can contribute to pedestrian and cyclist safety, such as the use of light-coloured and retro-reflective clothing. Moreover, bicycles should be equipped with reflective devices. These measures could increase pedestrians and cyclists' visibility in the dark. Especially for cyclists, the mandatory use of helmet by cyclists of all ages could improve their safety. Injuries to pedestrians and cyclists can be reduced by better design of cars and heavy vehicles [33]. Infrastructure interventions provide safety benefits for pedestrians and cyclists. Training and awareness campaigns could be another way to improve pedestrians' and cyclists' safety.

Measures for PTWs' safety focus on either crash prevention or increased protection from injuries [34]. Literature suggests that some interventions might be recommended, especially in terms of reducing speed as a key factor in PTW crashes. However, from a technology perspective, it is difficult to imagine what might work effectively [35]. Active safety systems (e.g. antilock braking) are likely to play a significant role in PTW safety. More tangible benefits might be derived through rider education, campaigns, and more aggressive enforcement of speed limits and helmet use. Wearing protective clothing would prevent many minor injuries. For PTW crashes that are not related to speed, particularly junction crashes, Intelligent Transport System functions which can inform vehicle drivers of the presence of the PTW might prove to be beneficial [35].

This study has certain limitations. It is based on self-reported behaviours on road safety issues, which have known deficiencies regarding their accuracy and lack of direct observation capabilities [36]. Self-reported data are vulnerable to a number of biases such as desirability bias, misunderstanding of the questions, and recall error [37]. In the present study, the main questions about VRUs' self-declared behaviour provide a clear behavioural criterion and refer to a recent time period. Therefore, it is expected that problems with misunderstanding and recall errors may be very modest. Despite the advantages of online surveys, the representativeness of the populations may be a problem especially for countries with low rates of Internet use. In African nations, a lower percentage of people has access to and uses the

Internet. Within the African countries, the numbers of respondents aged 65 and above who answered the ESRA2 survey were quite low, and the answers of this particular age group in African countries cannot be considered representative.

Finally, it can be concluded that the ESRA survey is a valuable source of information and provides unique data on VRUs' performance. These data could offer valuable insights to decision makers and researchers into road users' perception of road safety. The intention is to repeat the ESRA initiative on a triennial basis that will allow the development of time series of road safety performance indicators to monitor the progress of road safety in countries worldwide. Regarding further research, it would be interesting to use the ESRA survey data for longitudinal comparisons between countries. Moreover, investigations on the development of attitudes over time, given a variety of educational campaigns and other human factor-related countermeasures could be conducted.

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