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E-Survey of Road users' Attitudes

E-Scooter Riders

ESRA3 Thematic report Nr. 6

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E-Scooter Riders
ESRA3 Thematic report Nr. 6

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List of abbreviations

Country codes (in accordance with ISO 3166-1 alpha-2 (International Organization for Standardization (ISO), 2024))

AM	Armenia
AU	Australia
AT	Austria
BE	Belgium
BA	Bosnia and Herzegovina
BR	Brazil
CA	Canada
CL	Chile
CO	Colombia
CZ	Czech Republic
DK	Denmark
FI	Finland
FR	France
DE	Germany
EL	Greece
IE	Ireland
IL	Israel
IT	Italy
JP	Japan
KZ	Kazakhstan
KG	Kyrgyzstan
LV	Latvia
LU	Luxembourg
MX	Mexico
NL	Netherlands
PA	Panama
PE	Peru
PL	Poland
PT	Portugal
RS	Republic of Serbia
SI	Slovenia
ES	Spain
SE	Sweden
CH	Switzerland
TH	Thailand
TR	Türkiye
UK	United Kingdom
US	United States
UZ	Uzbekistan

Other abbreviations

AICc	Akaike Information Criterion corrected
America8	Eight countries across America
AsiaOceania6	Six countries across Asia and Oceania
ESRA	E-Survey of Road users' Attitudes
EU	European Union
Europe22	22 countries across Europe
GLMM	Generalized Linear Mixed Models
HIC	High income countries based on World Bank classification 2023 (The World Bank Group, 2023)
ICW	Individual country weight used in ESRA3
LMIC	Lower-middle income countries based on World Bank classification 2023 (The World Bank Group, 2023)
OR	Odds Ratio
UMIC	Upper-middle income countries based on World Bank classification 2023 (The World Bank Group, 2023)

Executive summary

Objective and methodology

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

Vias institute in Brussels (Belgium) initiated and coordinates ESRA, in cooperation with ten steering group partners (BASt (Germany), DTU (Denmark), IATSS (Japan), ITS (Poland), KFV (Austria), NTUA (Greece), PRP (Portugal), SWOV (the Netherlands), TIRF (Canada), University Gustave Eiffel (France)). At the heart of ESRA is a jointly developed questionnaire survey, which is translated into national language versions. The themes covered include self-declared behaviour, attitudes and opinions on unsafe traffic behaviour, enforcement experiences and support for policy measures. The survey addresses different road safety topics (e.g., driving under the influence of alcohol, drugs and medicines, speeding, distraction) and targets car occupants, moped riders and motorcyclists, cyclists, pedestrians, and riders of e-scooters. In ESRA3 the questions related to vulnerable road uses (moped riders and motorcyclists, cyclists, pedestrians, and riders of e-scooters) have been expanded and questions on e-scooters and infrastructure have been added.

The present report is based on the third edition of this global survey, which was conducted simultaneously in 39 countries in 2023. In total this survey collected data from more than 37000 road users in 39 countries across five continents. An overview of the ESRA initiative and the project results is available on: www.esranet.eu.

This ESRA thematic report provides an in-depth examination of road safety issues associated with e-scooter (electric-kick style scooter). An electric kick-scooter (e-scooter) features two wheels, a standing platform, handlebars for steering, an electric motor up to 500 watts. It methodically explores the spectrum of safety concerns, including rider impairment due to alcohol consumption, riding on sidewalks, ride without helmet, and non-compliance with traffic signals, notably red lights. The report includes an extensive analysis of self-declared unsafe behaviours in traffic, the utilization frequency of e-scooters, and the incidence of involvement in road crashes among e-scooter riders. It quantifies the percentage of e-scooter riders who were involved in road crashes, segmented by region, sex, and age, providing a detailed demographic breakdown of the incidents. Moreover, the report investigates determinants that may elevate the risk of crash involvement for e-scooter riders, offering a detailed perspective on the complexities of e-scooter road safety.

Key results for e-scooter riders

Mobility & exposure (last 12 months)

Within the last year, 79.1% of Europe22 respondents never used an e-scooters, 69.3% in America8 and 80.5% in AsiaOceania6. In Europe22, Poland reported the highest usage, while the United States leads in America8, and Türkiye tops AsiaOceania6. Gender disparities are evident, with males in Europe22 and AsiaOceania6 using e-scooters more frequently than females. A significant gender difference in usage rates is noted in all regions. Age-wise, there is a marked decline in e-scooter use with increasing age across all regions, particularly significant in America8 and AsiaOceania6 among the 25-34 age group, with a notable drop in the oldest cohort. Overall, e-scooter use is predominantly occasional, with a small minority using them more regularly, showing varied adoption levels by region, gender, and age.

Self-declared unsafe behaviours in traffic (past 30 days)

A majority of e-scooter riders in Europe22 (68.3%) and America8 (69.3%) refrained from riding with more than one person on board, with a lower percentage in Asia-Oceania6 (61.9%). The likelihood of riding post-alcohol consumption showed a consistency in abstinence through all regions. However, the analysis identified a significant age-related reduction in risky behaviors, such as carrying passengers, alcohol-impaired riding, and crossing against red signals, among e-scooter riders in Europe22. This reduction was observed when comparing older age groups to younger ones, indicating that younger riders exhibited these behaviors more frequently than their older counterparts. America8 and Asia-Oceania6 show more varied patterns with no significant age-related trends for alcohol-related riding and red-light infringements. Sidewalk riding was relatively common in Europe22 (44.4%), but less common in America8 (33.2%) and Asia-Oceania6 (38.2%) We found a distinct age correlation where younger riders in Europe22 reported higher incidences. Helmet use varied significantly across regions, with 44.6% in Europe22, 26.0% in America8, and 39.6% in Asia-Oceania6 riding without one at least once. These discrepancies can be partially attributed to varying legislation between countries. For example, in Denmark helmet use is mandatory for all riders which would be expected to influence compliance rates. While in Europe22, the youngest age group had the highest rate of not wearing helmets, in America8 and Asia-Oceania6, it was the oldest age group that most frequently opted to ride without helmets.

Involvement in road crashes

E-scooter riders in Europe22 and America8 reported an identical crash involvement rate of 2.5%, while AsiaOceania6 showed a significantly lower rate at 0.5%. Gender-wise, in Europe22, crash involvement rates are marginally higher for males (2.8%) than females (2.1%), yet without statistical significance. This pattern was repeated with 3.2% of males and 1.8% of females for America8 and 0.2% of males and 0.9% of females for AsiaOceania6, also lacking statistical significance. Age-related data from Europe22 indicates a decline in crash involvement with increasing age, peaking at 3.8% for the 25-34 bracket and bottoming out at 0.5% for those 65-74, albeit with no statistically significant age trends. Conversely, America8 shows a stark peak in crashes among the 45-54 age group at 8.9%, marking a significant deviation from other age groups. AsiaOceania6 reports low crash involvement across all ages, with no significant age-specific trends. Overall, these findings suggest regional variations in e-scooter crash involvement, with no clear gender differences but notable age-related patterns in certain regions.

Factors associated with unsafe self-declared behaviours

To explore factors contributing to unsafe behaviours among e-scooter riders, five mixed-effects binary logistic regression models were constructed. Analysis of these models revealed significant associations between various behaviours and demographic factors, such as gender and age. Women were less likely to engage in risky behaviours like riding under the influence or crossing on red lights, while older individuals showed reduced likelihood of riding with more than one person on board or crossing the road when a traffic light is red compared to younger riders. Moreover, student status consistently predicted higher propensities for risky behaviours. Attitudes towards traffic laws also played a pivotal role, with more permissive attitudes correlating with increased risk-taking. Additionally, personal experiences, particularly involvement in e-scooter crashes, were associated with unsafe behaviours. These findings highlight that demographics and rider attitudes can influence behaviours.

Key recommendations

- Engage with e-scooter riders at the onset of their usage, focusing on safe riding practices. Outreach should include information about the risks of riding with passengers, alcohol-impaired riding, or without helmets. Awareness programs can be crucial in informing riders about the risks of these unsafe behaviours.
- Adapt the e-scooter rental process to assess riders' readiness and ability to operate e-scooters safely. Implement mandatory safety briefings or skill assessments to identify riders who may pose a higher risk due to inexperience or lack of knowledge about local traffic laws.
- Implement uniform traffic regulations globally for e-scooter usage to reduce confusion among riders and streamline enforcement. Clear, standardized rules pertaining to speed limits, e-scooter lane usage, right-of-way, parking, wearing helmets, and standardized and enforced blood alcohol content (BAC) limits for e-scooter riders are essential.

- Continue research into the impact of risk factors on e-scooter crashes, targeting interventions toward age groups at higher risk, particularly younger adults known for more risky behaviours and older adults who may face physical challenges.

Specific recommendations to stakeholders include:

- [To Urban Planners and Local Governments] Enhance infrastructure to accommodate e-scooters safely, such as designated parking areas, and enforce traffic laws to prevent sidewalk riding and red-light violations by e-scooter riders. Establish a well-connected micromobility network and undertake regular maintenance of facilities. Collect data on e-scooter use and safety statistics.
- [To E-scooter Sharing Companies] Invest in technology to limit e-scooter speeds in high-pedestrian areas and to disable e-scooters if erratic or unsafe riding is detected. Encourage helmet use through partnerships with helmet manufacturers and provide incentives for safe riding practices.
- [To Policymakers and NGOs] Run educational campaigns focusing on the risks of riding without a helmet, the dangers of alcohol-impaired riding, and the importance of obeying traffic signals to reduce e-scooter-related injuries and fatalities.

The ESRA initiative has demonstrated the feasibility and the added value of joint data collection on road safety performance by partner organizations all over the world. The intention is to repeat this survey every three to four years, retaining a core set of questions in every edition. In this way, ESRA produces consistent and comparable road safety performance indicators that can serve as an input for national road safety policies and for international monitoring systems on road safety performance. This strategic data collection supports and informs the targeted interventions and recommendations aimed at improving e-scooter safety as outlined above.

1 Introduction

Electric scooters, commonly referred to as e-scooters, have significantly transformed urban mobility by offering an eco-friendly alternative to traditional motor vehicles. Their rapid adoption is evidenced by the expansive growth of the global electric scooter market, which was valued at $33.18 billion in 2022 and is projected to climb to $41.98 billion by 2030, marking a compound annual growth rate of 9.9% (Global Electric Scooter Market Size, 2022). This burgeoning popularity is particularly visible in the United States, where approximately 145 e-scooter sharing systems have been established, underscoring their increasing integration into the urban transport mix (U.S. Scooter Sharing Systems, 2020). E-scooters have also become a transformative element in urban mobility across Europe since the introduction of the first rental schemes in 2018. Their rapid proliferation, characterized by significant sales to private consumers, underscores their growing impact on the micromobility sector. In 2021 alone, France recorded sales of over 900,000 e-scooters, reflecting their widespread acceptance (BFMTV, 2021). Additionally, in the UK, where private e-scooters are not yet legalized for road use, imports had surpassed 1.3 million units by November 2022 (UK Trade Info, 2022).

These developments illustrate the escalating demand for e-scooters which in turn introduces challenges for urban planning, road safety, and public health. As e-scooters become more common in urban areas, the frequency of related collisions has also increased significantly. This trend highlights that most e-scooter crashes occur in these densely populated environments (Kazemzadeh et al., 2023). According to the European Transport Safety Council (2023), serious e-scooter incidents and injuries are primarily single-vehicle incidents (i.e. no motor vehicle involved), often resulting from poor road conditions, lack of proper road maintenance, excessive speed, and not wearing helmets, with head injuries being particularly prevalent (Winchcomb, 2023). Single-vehicle incidents occur more frequently than collisions with other vehicles and account for the prevalence of injuries (Sandt et al., 2023a; Sandt et al., 2023b). The findings suggest that injury patterns primarily involve the upper extremities, head, and lower extremities. The severity of injuries varies, with a considerable number of cases reporting minor injuries, although serious injuries occur as well (Toofany et al., 2021). Toofany et al. (2021) underline that the lack of protective gear, especially helmets, is a significant factor in the severity of injuries sustained in e-scooter crashes. This observation is consistent with findings from Trivedi et al. (2019), who report that only 4% of injured riders were wearing a helmet at the time of their crash, underscoring the need for regulatory measures to enforce helmet use" (p. 494).

E-scooter users involved in incidents predominantly consist of young, urban individuals seeking quick and flexible transportation options, with a substantial number being males who utilize these devices for both short commuting and leisure trips (Badia & Jenelius, 2021; European Commission, 2021; Karpinski et al., 2023; Kazemzadeh et al., 2023; Laura Sandt et al., 2023; Sandt et al., 2023; Toofany et al., 2021; Useche et al., 2022; Winchcomb, 2022, 2023). There is a broader acceptance of e-scooter use among younger urban populations (Badia & Jenelius, 2021; Blanco & Carrone, 2023; European Commission, 2021; Karpinski et al., 2023; Kazemzadeh et al., 2023; Laura Sandt et al., 2023; Pourfalatoun et al., 2023; Sandt et al., 2023; Toofany et al., 2021; Wang et al., 2023; Winchcomb, 2022, 2023). One study shows shared e-scooters are mainly utilized by young individuals, particularly for leisure activities during the weekend, while privately owned e-scooters are more commonly used for commuting purposes (European Commission, 2021). Another study found that users predominantly fall within the age range of 26 to 35 years and choose e-scooters for their efficacy in managing the 'first/last mile' of urban commutes (Šucha et al., 2023). E-scooter trips are often short and involve different behavioural dynamics compared to other micromobility options. Users often display a "hybrid" behaviour, frequently shifting between e-scooters, walking, and other modes of transport within a single trip. (Karpinski et al., 2023). These devices are favored over walking and slightly less so over public transport, appealing due to their low operational costs and quick accessibility. A study found the typical user profile includes individuals who are looking for quick and convenient travel options within urban settings, often as a complement to public transit (Wang et al., 2023).

E-scooter users are generally early adopters of new technologies and are characterized by a higher risk-taking propensity than those who do not use e-scooters (International Transport Forum, 2023; Pourfalatoun et al., 2023). They also tend to have positive perceptions of the safety of e-scooters, often preferring them over bicycles for their ease of use and accessibility (Pourfalatoun et al., 2023). The rapid adoption of e-scooters in urban environments reflects their appeal among technology-savvy users seeking efficient, flexible travel options (Winchcomb, 2023).

The growing integration of e-scooters into the fabric of urban transportation demands a critical examination of their regulatory and safety frameworks. Current regulations, which may include speed limits, wheel sizes, and mandatory equipment like brakes and lights aim to enhance the visibility and control of these vehicles, reflecting a legal landscape that is evolving in response to new challenges posed by e-scooters in urban settings (Winchcomb, 2023). These regulations vary across jurisdictions but typically include measures to enhance visibility and control, reflecting an evolving legal landscape responsive to the challenges posed by e-scooters in urban environments.

Inconsistencies in local jurisdictions, regions and national laws can lead to confusion and affect the safety and usage of e-scooters (Sandt et al., 2023; Šucha et al., 2023). This highlights the need for standardized and adaptive regulatory practices to inform effective policy and intervention development that can mitigate the risks associated with e-scooter use (Blanco & Carrone, 2023; Kazemzadeh et al., 2023; Laura Sandt et al., 2023; Toofany et al., 2021). The absence of stringent regulations for private e-scooters compared to their rental counterparts creates inconsistencies in safety standards (Winchcomb, 2022). Furthermore, the lack of specialized training for riders and consistent legal frameworks is noted as exacerbating risk-taking behaviours on the road among e-scooter riders (Useche et al., 2022).

Some regions treat e-scooters like bicycles, requiring helmets and specific road use adherence, while others don’t address the integration of e-scooters into urban landscapes. Examples would be the lack of clear traffic regulations, e.g., speed regulation, and helmet mandates, addressing parking, traffic flow, the interaction of e-scooters with other road users to mitigate potential conflicts and the allocation of dedicated lanes and how they can impact on the safety of riders (Badeau et al., 2019; European Commission, 2021; Karpinski et al., 2023; Sandt et al., 2023; Toofany et al., 2021; Trivedi et al., 2019; Wang et al., 2023). Moreover, the variability in e-scooter regulations and the enforcement level can impact safety outcomes. As an example, in the UK, ongoing trials in 24 areas require e-scooter riders to have a license with category Q entitlement, adhere to a maximum speed of 15.5 mph, and avoid driving on pavements (Department of Transport, 2024; Department of Transport, 2023). Similarly, in Denmark, e-scooter riders must follow rules applicable to bicycles, such as using bike lanes only and prohibiting sidewalk usage. Additional requirements include mandatory helmet use, lights at all times, a minimum age of 15, and strict alcohol and drug use prohibitions, with a blood alcohol limit of 0.5 grams/L (Electrotraveller 2024). In Austria, e-scooters are exclusively permitted on bike lanes and are prohibited on other roads. They must adhere to a maximum speed limit of 25 kilometers per hour and are required to be equipped with braking reflectors, retroreflectors, red rear lights, and white front lights. Furthermore, e-scooter riders are subject to the same regulations and guidelines that apply to cyclists (Electrotraveller 2024).

Ensuring the safety and efficiency of e-scooter use not only supports urban sustainability efforts but also enhances the overall functionality of public transport systems, aligning with broader demographic trends towards more sustainable urban transit solutions (BFMTV, 2021; UK Trade Info, 2022). As e-scooters increasingly influence the dynamics of urban mobility, significant research questions have emerged to explore both the benefits and challenges they introduce to city environments. This Thematic ESRA report aims to explore the differences in self-declared unsafe behaviours among e-scooter riders by comparing age groups and gender, across 36 countries spanning Europe22, America8, AsiaOceania6. This study specifically examines e-scooter usage and investigates several key aspects: How frequently have e-scooters been used in the last 12 months? What are the prevalent self-declared behaviours among e-scooter riders over the past 30 days, including riding with others, riding after consuming alcohol, crossing against red lights, riding on sidewalks, and riding without a helmet, and what percentage of e-scooter riders have been involved in road crashes where someone was injured? These questions aim to assess the extent to which these behaviours and attitudes act either as mitigating factors or as contributions to their impact as road safety hazards. Finally, we seek to understand whatl factors significantly influence these self-declared behaviours within/between regions including Europe22, America8, AsiaOceania6 and how these factors integrate into the broader road safety landscape for these demographic groups.

2 Methodology

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

ESRA data are collected through online panel surveys (see Appendix 1), using a representative sample of the national adult populations in each participating country (aiming at n=1000 per country). A few exceptions exist. In four countries (Armenia, Kyrgyzstan, Luxembourg, and Uzbekistan) the targeted sample size was reduced to 500 respondents, as sample sizes of 1000 respondents were not feasible due to limitations of the national panel or too high costs.

At the heart of this survey is a jointly developed questionnaire, which was translated into 49 national language versions in ESRA3. The themes covered include self-declared behaviour, attitudes and opinions on unsafe traffic behaviour, enforcement experiences and support for policy measures. The survey addresses different road safety topics (e.g., driving under the influence of alcohol, drugs and medicines, speeding, distraction) and targets car occupants, moped riders and motorcyclists, cyclists, pedestrians, and riders of e-scooters. In ESRA3 the questions related to vulnerable road users (moped riders and motorcyclists, cyclists, pedestrians, and riders of e-scooters) have been expanded and questions on e-scooters and infrastructure have been added. The present report is based on the third edition of this global survey, which was conducted simultaneously in 39 countries in 2023. In total this survey collected data from more than 37000 road users in 39 countries, across five continents.

The participating countries in ESRA3 were:

- Europe: Austria, Belgium, Bosnia and Herzegovina, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Luxembourg, Netherlands, Poland, Portugal, Republic of Serbia, Slovenia, Spain, Sweden, Switzerland, United Kingdom;
- America: Brazil, Canada, Chile, Colombia, Mexico, Panama, Peru, USA;
- Asia and Oceania: Armenia, Australia, Israel, Japan, Kazakhstan, Kyrgyzstan, Thailand, Türkiye, Uzbekistan.

Vias institute in Brussels (Belgium) initiated and coordinates ESRA, in cooperation with ten steering group partners (BASt (Germany), DTU (Denmark), IATSS (Japan), ITS (Poland), KFV (Austria), NTUA (Greece), PRP (Portugal), SWOV (the Netherlands), TIRF (Canada), and University Gustave Eiffel (France)). The common results of the ESRA3 survey are published in a Main Report, a Methodology Report and 13 Thematic Reports (Table 1). Furthermore, 39 country fact sheets, including different language versions, have been produced in which national key results are compared to a regional mean (benchmark). Scientific articles, national reports and many conference presentations are currently in progress. All common ESRA3 reports have been peer-reviewed within the consortium, following a pre-defined quality control procedure. An overview of the results and news on the ESRA initiative is available on: www.esranet.eu. On this website one can also subscribe to the ESRA newsletter.

Table 1: ESRA3 Thematic Reports

Driving under influence of alcohol, drugs and medication	Support for policy measures and enforcement	Pedestrians	Young and aging road users
Speeding	Subjective safety and risk perception	Cyclists	Male and female road users
Distraction (mobile phone use) and fatigue	Infrastructure	Riders of e-scooters	
Seat belt & child restraint systems		Moped riders and motorcyclists	

The present report summarizes the ESRA3 results with respect to issues related to detailing the prevalent issues among e-scooter riders, including impairment while riding, unlawful sidewalk usage, and traffic infractions ranging from the non-use of helmets to disregarding vital traffic signals, particularly red lights. A more detailed overview of the data collection method and the sample per country can be found in the ESRA3 methodology report (Meesmann & Wardenier, 2024).

The report includes the analysis of several aspects of self-declared unsafe behaviours such as driving while impaired, as well as the utilization frequency of e-scooters, and the incidence of involvement in road crashes among e-scooter riders.

Most of the questions of the survey were presented on Likert scales, which were dichotomized for the analysis. A description of the scales and the correspondent dichotomization are presented in the beginning of each section.

For the descriptive analysis, all the results are presented by region (Europe22, America8, AsiaOceania6) and gender and age group. Note that a weighting of the data was applied in the analyses. This weighting took into account small corrections with respect to national representativeness of the sample based on gender and six age groups: 18-24y, 25-34y, 35-44y, 45-54y, 55-64y, 65-74y (United Nations Statistics Division, 2023). For the regional means, the weighting also took into account the relative size of the population of each country within the total set of countries from this region. SPSS 26.0, R 4.3.1 and Stata 17.0 were used for all analyses.

Due to the nominal nature of the data, the Chi-square Test for Independence was used to assess if the observed differences are statistically significant. using a p-value of 0.01 or less as an indicator of significance. The strength of the association between variables was assessed through the Cramer's V coefficient.

Binary logistic regression models were also estimated to explore what factors increase or decrease the likelihood of involved in a crash while riding an e-scooter.

3 Results

3.1 Descriptive results

This section includes the descriptive statistics of questions related to e-scooter use, risky behaviours including riding with others, riding after consuming alcohol, crossing against red lights, riding on sidewalks, and riding without a helmet. Additionally, this section includes an analysis of reported crash involvement, aiming to quantify the consequences associated with these behaviors (refer to the "Further Analysis" section). By examining both the behaviors and their potential outcomes across different regions, age groups, and genders, the study aims to identify specific risk factors and inform targeted safety interventions. A p-value of 0.05 or less was used as an indicator of statistical significance.

3.1.1 Mobility, exposure and perceived safety (last 12 months)

To assess the frequency of e-scooter use, respondents were queried about their usage over the past 12 months, with response options ranging from 'at least 4 days a week' to 'never.' For a detailed breakdown of the question and response options, see the questionnaire in Appendix 1. In Europe22, a majority of respondents, 79.1%, reported never using e-scooters, while 20.9% did use them at least once. America8 shows a lower percentage of non-users at 69.3%, and AsiaOceania6 has the highest percentage of respondents who have never used an e-scooter at 80.5% (see Table 2). These are statistically significant differences across these regions (p-value < 0.001, Cramer's V = 0.100).

Table 3 shows similar data for using e-scooters at least a few days per month versus never or a few days a year. A similar regional pattern is seen with roughly the same percentage reporting infrequent or no use of e-scooters in Europe22 (86.7%) and AsiaOceania6 (86.7%) which 79% in America8 reporting so (p-value < 0.001, Cramer's V = 0.091). Figure 1 shows that in Europe22, France and Switzerland are at the top with 17.5% and 17.2% of road users respectively using e-scooters at least a few days a month. The regional mean for Europe22 is at 13.3%. On the lower end, Serbia has the least e-scooter usage frequency, with only 4.3% of road users engaging with them a few days a month. For America8, the United States stands out with a significant 35.8% of road users using e-scooters at this frequency, more than double the next country, Peru, with 12.9%. The regional mean is lower, at 21.0%, indicating that the U.S. has an exceptionally high e-scooter usage rate compared to its regional counterparts. In the AsiaOceania6 region, the usage of e-scooters varies significantly: Australia leads with 24.7% of road users utilizing e-scooters at least a few days a month, closely followed by Türkiye and Thailand with 23.1% and 21.8%, respectively. In contrast, the regional mean is substantially lower at 13.3%, with Japan reporting the lowest frequency of e-scooter usage at just 1.9%.

In Europe22, Poland leads with the highest percentage of e-scooter use of at least a few days per year, at 28.2% of road users (see Figure 1). Close behind are Switzerland and Latvia, with 27.4% and 26.4%, respectively. The rest of the European countries follow, with use rates tapering down to Serbia, where e-scooter use of at least a few days per year is at 10.3%. The United States dominates in the America8 region, with 45.3% of road users reporting e-scooter use. The other countries in the region show more moderate usage, with the percentages ranging from 23% in Peru to 13.8% in Chile. For the AsiaOceania6 region, Türkiye shows the highest e-scooter usage at 38.0%, followed by Australia at 33.7% and Thailand at 27.5%. The lowest usage rate is seen in Japan, at just 2.5%.

Table 2: The percentage of e-scooter use (never vs at least once)

	Europe22 (%)	America8 (%)	AsiaOceania6 (%)
never	79.1_a	69.3_b	80.5_a
at least once	20.9_a	30.7_b	19.5_a
	100.0	100.0	100.0
Tests	Value	df	p-value
Chi-Square	153.30	2	<0.001
Cramer's V	0.100		

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

Table 3 The percentage of e-scooter use (never/a few days per year vs at least a few days per month)

	Europe22 (%)	America8 (%)	AsiaOceania6 (%)
never/a few days per year	86.7_a	79.0_b	86.7_a
at least a few days per month	13.3_a	21.0_b	13.3_a
	100.0	100.0	100.0
Tests	Value	df	p-value
Chi-Square	124.51	2	<0.001
Cramer’s V	0.091		

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

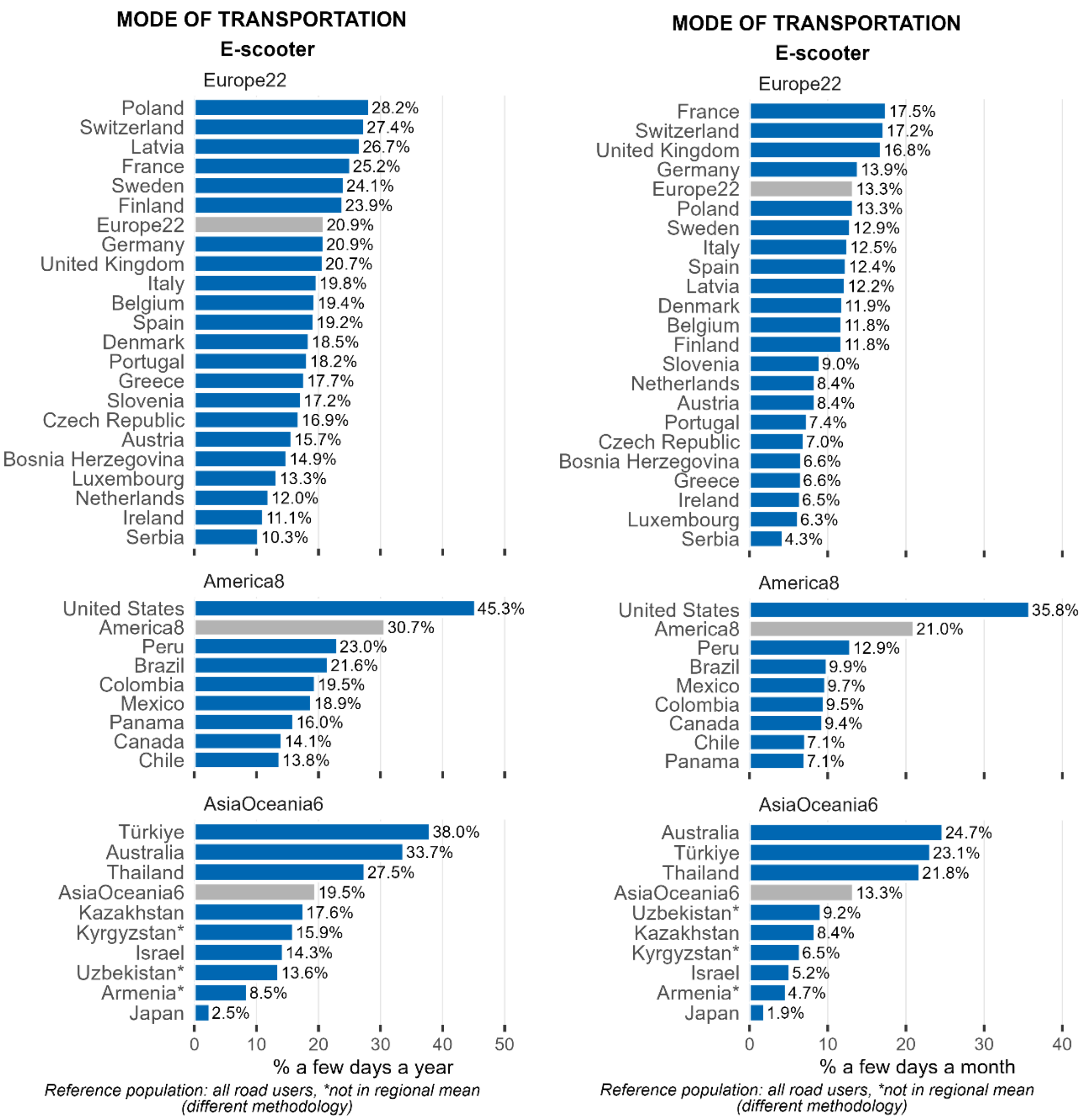

Figure 1: Percentage of using e-scooters at least a few days per year (left) and per month (right), in the different countries included over the past 12 months

The data shown in Figure 2 reveal that males used an e-scooter at least a few days per year at a higher rate than females. In Europe22 24.3% of males used an e-scooter at least a few days per year, compared to 17.6% of females (p-value < 0.001, Cramer's V = 0.081). In America8 32.8% of males did so compared to 28.8% of females (p-value = 0.010, Cramer's V = 0.044). In AsiaOceania6 21.4% of males did so and 17.7% of females (p-value = 0.007, Cramer's V = 0.047).

Figure 2 also shows a larger percentage of males than females use an e-scooter at least a few days a month, although the differences are not always significant. In Europe 22 15.8% of males and 10.8% of females did so (p-value < 0.001, Cramer's V = 0.074). In America8, 21.9% of males and 20.3% of females did so (p-value = 0.239, Cramer's V = 0.020). In AsiaOceania6 14.9% of males and 11.6% of females did so (p-value = 0.005, Cramer's V = 0.049).

Age is a significant predictor of e-scooter use although the patterns show some differences between regions as shown in Figure 3. In Europe22, e-scooter ridership at least a few days a year is 40.2% for the 18-24 age group and 43.9% for the 25-34 age group, falling consistently thereafter to only 3.8% for 65-74 (p-value < 0.001, Cramer's V = 0.384). In America8, the percentage of using e-scooters differs among age groups, with the highest reported rates in the 25-34 and 35-44 age groups at 52.4% and 50.8%, respectively. A decrease in usage is observed in older age groups, where only 1.4% of those aged 65-74 use the transport modes a few days per year (p-value < 0.001, Cramer's V = 0.415). AsiaOceania6 demonstrates a similar trend to America8, with the highest usage rate at 36.2% for 25-34) and usage dropping to 4.7% for the 65-74 age group (p-value < 0.001, Cramer's V = 0.293). The same age-related patterns exist for the percentages who reported riding an e-scooter at least a few days a month. In Europe22, the youngest group (18-24) reports 22.5% usage at least a few days per month, which significantly drops to 1.8% in the oldest age group (65-74). America8 and AsiaOceania6 shows the highest monthly usage frequency in the 25-34 age group (37.4%, and 24.8%, respectively) decreasing progressively to just 0.9% and 4.1, respectively, in the 65-74 age group.

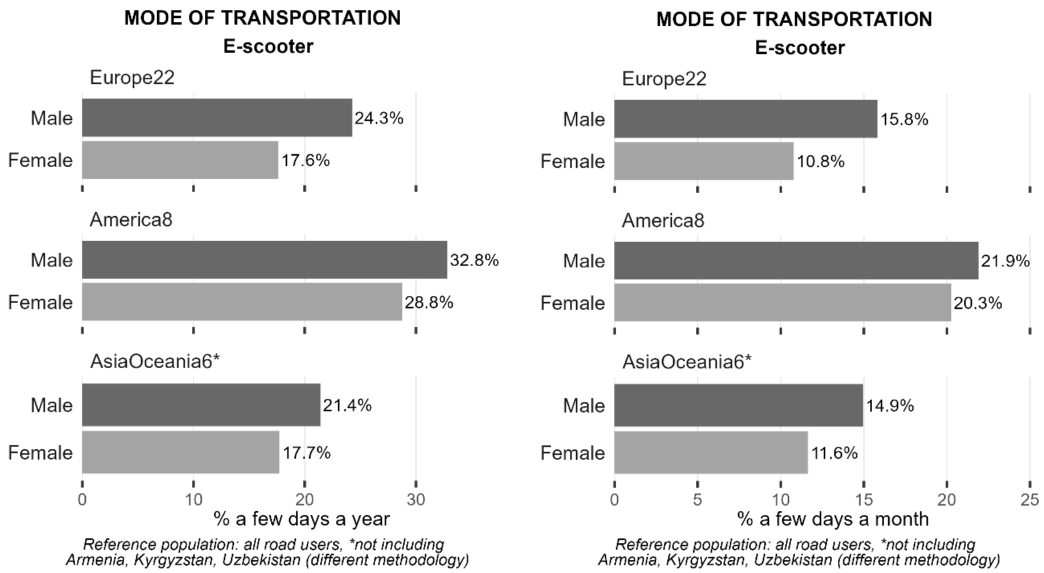

Figure 2: Percentage of using e-scooter at least a few days per year (left) and per month (right) by gender over the past 12 months

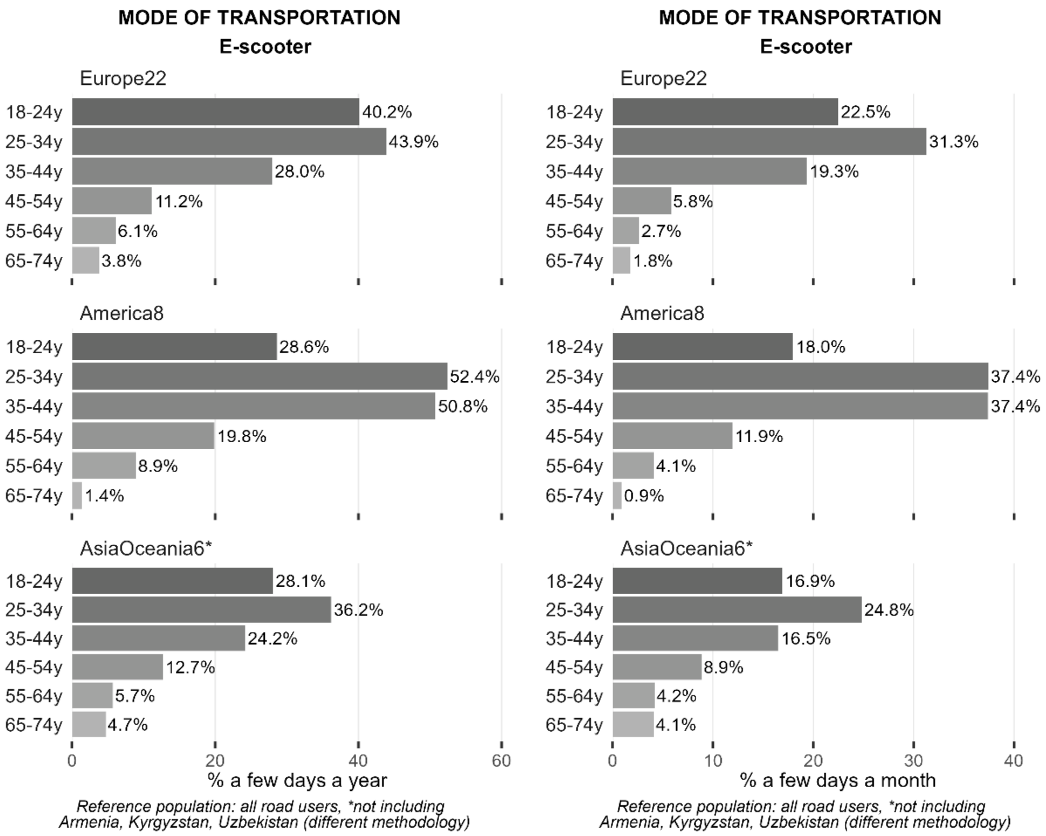

Figure 3: Percentage of using e-scooter at least a few days per year (left) and per month (right) by age group over the past 12 months

Figure 4 shows the ratings of perceived safety of e-scooter use by country amongst those who ride at least a few days a year. The ratings are on an 11-point scale with 0 representing very unsafe and 10 representing very safe. The mean ratings by region are 5.8 in Europe22, 6.7 in America8, and 5.7 in AsiaOceania6 (p-value <0.001, Cramer’s V = 0.028).

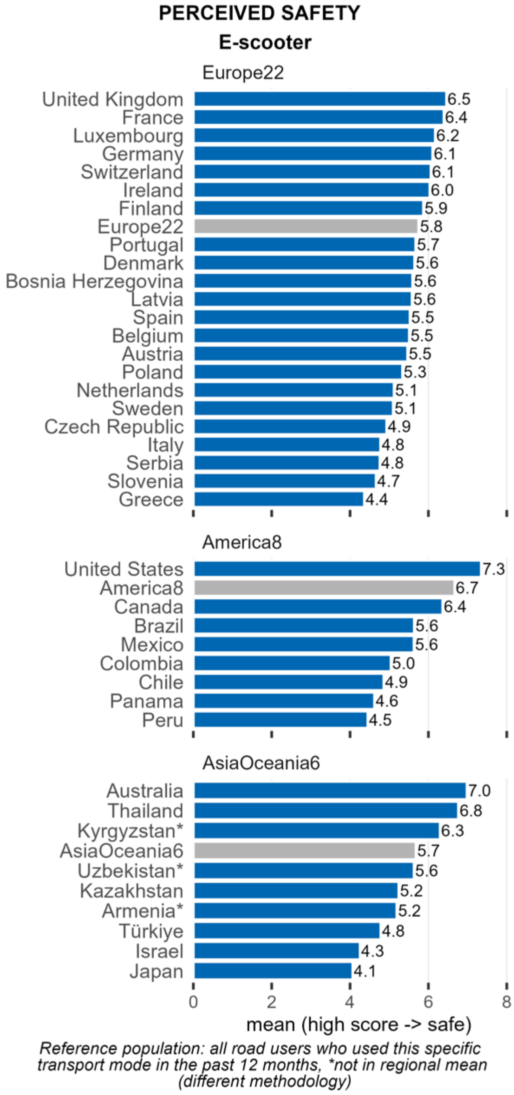

Figure 4: Perceived safety rate among e-scooter users who ride at least a few days per year by country

3.1.2 Involvement in road crashes

Tables 4 to 6 present data on e-scooter usage and crash involvement over the past 12 months. Overall, 2.5% of e-scooter users in both Europe22 and America8 reported being involved in a crash resulting in injury, while only 0.5% in AsiaOceania6 reported the same. Statistical tests reveal that there is a significant difference between the regions in the proportion of respondents involved in injury-related crashes (p-value = 0.029, Cramer's V = 0.047).

In Europe22 and America8 the percentage is higher for male than female respondents but the differences are not statistically different. In Europe the percentages are 2.8% for males and 2.1% for females (p-value = 0.388, Cramer's V = 0.021). In America8 3.2% of males have been involved in a crash and 1.8% of females (p-value = 0.183, Cramer's V = 0.045). In the AsiaOceania6 region, the percentage for males involved in crashes is 0.2%, while for females it is slightly higher at 0.9% (p-value = 0.184, Cramer's V = 0.046).

Regarding age groups, in Europe22, crash involvement peaks at 3.8% for the 25-34 age group, with a decrease observed in older age groups, down to 0.5% for those aged 65-74 (p-value = 0.109, Cramer's V = 0.073). America8 displays a notable peak in the 45-54 age group, where 8.9% reported being involved in a crash, which is a significant departure from the other age groups and overall differences by age are statistically significant (p-value = 0.002, Cramer's V= 0.150). In AsiaOceania6, crash involvement remains low across all age groups, with a slight peak at 1.1% for the 25-34 age group (p-value = 0.665, Cramer's V = 0.062).

Table 4: Percentage of riders who use an e-scooter at least a few days a year and were involved in road crashes over the past 12 months by region

(a)	Europe22 (%)	America8 (%)	AsiaOceania6 (%)
no	97.5_a	97.5_a	99.5_b
yes	2.5_a	2.5_a	0.5_b
	100.0	100.0	100.0
Tests	Value	df	p-value
Chi-Square	7.11	2	0.029
Cramer's V	0.047		

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

Table 5: Percentage of riders who use an e-scooter at least a few days a year and were involved in road crashes over the past 12 months by region and sex

(b)			
Europe22	Male (%)	Female (%)	
no	97.2_a	97.9_a	
yes	2.8_a	2.1_a	
	100.0	100.0	
Tests	Value	df	p-value
Chi-Square	0.74	1	0.388
Cramer's V	0.021		
America8	male	female	
no	96.8_a	98.2_a	
yes	3.2_a	1.8_a	
	100.0	100.0	
Tests	Value	df	p-value
Chi-Square	1.77	1	0.183
Cramer's V	0.045		
AsiaOceania6	male	female	
no	99.8_a	99.1_a	
yes	0.2_a	0.9_a	
	100.0	100.0	
Tests	Value	df	p-value
Chi-Square	1.76	1	0.184
Cramer's V	0.046		

Each subscript letter denotes that gender column proportions do not differ significantly from each other at the 0.01 level.

Table 6: Percentage of riders who use an e-scooter at least a few days a year and were involved in road crashes over the past 12 months by region and age

(c)						
Europe22	18-24 (%)	25-34 (%)	35-44 (%)	45-54 (%)	55-64 (%)	65-74 (%)
no	97.8_{a}	96.2_{a}	97.7_{a}	99.8_{a}	98.5_{a}	99.5_{a}
yes	2.2_{a}	3.8_{a}	2.3_{a}	0.2_{a}	1.5_{a}	0.5_{a}
	100.0	100.0	100.0	100.0	100.0	100.0
Tests	Value	df	p-value			
Chi-Square	8.99	5	0.109			
Cramer's V	0.073					
America8	18-24	25-34	35-44	45-54	55-64	65-74
no	$98.5_{a,b}$	98.8_{a}	$97.4_{a,b}$	91.1_{b}	$99.6_{a,b}$	$100.0_{a,b}$
yes	$1.5_{a,b}$	1.2_{a}	$2.6_{a,b}$	8.9_{b}	$0.4_{a,b}$	$0.0_{a,b}$
	100.0	100.0	100.0	100.0	100.0	100.0
Tests	Value	df	p-value			
Chi-Square	19.51	5	0.002			
Cramer's V	0.150					
AsiaOceania6	18-24	25-34	35-44	45-54	55-64	65-74
no	99.9_{a}	98.9_{a}	99.8_{a}	99.7_{a}	100.0_{a}	100.0_{a}
yes	0.1_{a}	1.1_{a}	0.2_{a}	0.3_{a}	0.0_{a}	0.0_{a}
	100.0	100.0	100.0	100.0	100.0	100.0
Tests	Value	df	p-value			
Chi-Square	3.22	5	0.665			
Cramer's V	0.062					

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

3.1.3 Self-declared behaviour (last 30 days)

To evaluate self-declared behaviors, the frequency of the following safety-critical behaviors that e-scooter riders engaged in over the last 30 days was surveyed.

- ride with more than 1 person on board.
- ride when you think you may have had too much to drink.
- cross the road when a traffic light is red.
- ride on pedestrian pavement/sidewalk.
- ride without a helmet.

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) are presented in the results. Figure 5 shows the self-declared behaviours of an e-scooter riders by region.

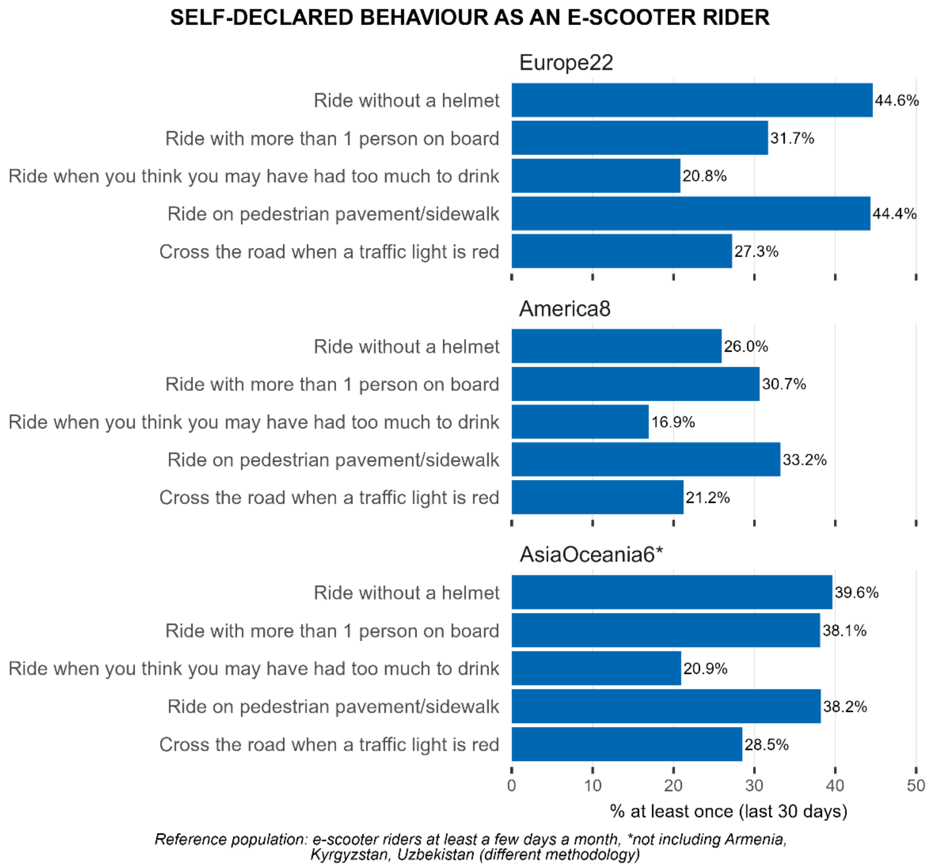

Figure 5 Percentage of self-declared risky behaviours as an e-scooter rider

Regarding the use of helmets while riding e-scooters, in Europe22, a significant proportion of respondents (44.6%) declared riding without a helmet at least once, in contrast to 26.0 % in America8 and 39.6% in AsiaOceania6. Such variation in safety-critical behaviors may reflect differing national regulations regarding helmet use, which can influence rider behavior. These regional differences are statistically different (p-value <0.001, Cramer's V = 0.172). Looking at age, in Europe22, the youngest age group (18-24) reported the highest non-use of helmets at 64.4%, with generally significant decreasing non-use with age, but still, a notable percentage of 56.1% among those aged 65-74 did not wear helmets (p-value <0.001, Cramer's V = 0.208). In America8, the trend inversely correlates with age, starting at 34.9% for 18-24 year-olds and escalating to 72.1% for the 65-74 age group not wearing helmets, indicating a significant difference across age groups (p-value = 0.002, Cramer's V = 0.186). AsiaOceania6 presents an even starker contrast, with the 65-74 age group reporting the highest non-use at an alarming rate of 81.3%, and significant age-specific differences as well (p-value < 0.001, Cramer's V = 0.207).

Considering e-scooter ridership involving multiple passengers, a notable number engage in this behaviour, with 31.7% in Europe, 30.7% in America, and 38.1% in AsiaOceania6 doing so (p-value = 0.066, Cramer’s V = 0.053). Notably, in Europe22, a decline was observed in the tendency to carry passengers as age increases, starting with 52.7% of riders aged 18-24 engaging in the act, dwindling to just 11.9% for those aged 65-74 (p-value < 0.001, Cramer’s V = 0.231). Conversely, America8 and AsiaOceania6 show a varied pattern with no significant age-related trends, as indicated by p-values exceeding the 0.05 threshold for significance.

For riders of e-scooters doing so under the influence of alcohol, a significant number of riders do so with 20.8% in Europe22, 16.9% in America8, and 20.9% in AsiaOceania6 (p-value = 0.124, Cramer’s V = 0.046). In Europe22, a downward but non-statistically significant trend with age is apparent, where 26.7% of the youngest group (18-24) admitted to riding e-scooters after potentially consuming too much alcohol, decreasing to 11.9% in the 65-74 age bracket (p-value = 0.100, Cramer's V = 0.096). In contrast, America8 shows an irregular pattern, with the oldest group (65-74) reporting the highest prevalence of riding after drinking at 41.2%, yet these variations do not amount to statistical significance (p-value = 0.135, Cramer's V = 0.123,). The same trend observed for AsiaOceania6 but with a significant difference among age brackets (p-value = 0.002, Cramer's V = 0.183).

For riding e-scooters on pedestrian pavements or sidewalks, nearly half of the respondents in Europe22 (44.4%) have ridden on the pedestrian pavements or sidewalk at least once, compared to a lower 33.2% in America8 and 38.2% in AsiaOceania6 (p-value < 0.001, Cramer's V = 0.102). The age breakdown within regions paints a more varied picture. In Europe22, the youngest adults (18-24) report the highest incidence of sidewalk riding (61.7%), with a generally declining trend as age increases, although this trend sees a reversal in the 55-64 age group before decreasing again for those aged 65-74 (p-value < 0.001, Cramer's V = 0.188). America8 shows a different pattern; sidewalk riding is least reported by the 25-34 age group (24.0%), but there's a notable increase in the older age groups, peaking at 67.7% for those aged 65-74, with significant age-related variation (p-value < 0.001, Cramer's V = 0.232). In AsiaOceania6, those in the 65-74 age bracket reported the highest rate of riding on the sidewalk (64.1%), with the test results indicating significant differences across age groups (p-value = 0.014, Cramer's V = 0.161).

Considering crossing the road against a red traffic light amongst e-scooter riders, this behaviour is reported by 27.3% in Europe22, 21.2% in America8, and 28.5% in AsiaOceania6 (p-value = 0.011, Cramer's V = 0.067). Within Europe22, a distinct trend across age groups is observed: the youngest adults (18-24) have the highest percentage of crossing against a red light at 38.5%, with a steady decline observed as age increases, dropping to 10.8% among those aged 65-74 (p-value = 0.005, Cramer's V = 0.130). In America8, the pattern is less consistent; the 55-64 age group has a notably higher percentage (37.7%) of crossing against red lights compared to younger age groups, with statistical significance detected across ages (p-value = 0.027, Cramer's V = 0.151). AsiaOceania6 displays the same trend, with the 65-74 age group reporting the highest incidence at 50.4% of crossing against red lights, although these differences are not statistically significant across age groups (p-value = 0.185, Cramer's V = 0.117).

3.2 Further analyses

3.2.1 Statistical Methodology

In this section, mixed effects logistic regression model approach under the generalized linear mixed models (GLMMs) framework was employed. GLMMs extend the capabilities of linear mixed models to accommodate dependent variables from various distributions, including binary responses. These responses are similar to the dichotomized variables concerning e-scooter riders' self-declared behaviours. Originally characterized by values ranging from 1 to 5, these variables denote binary occurrences from 'never' (1) to 'at least once' (2-5) in the past 30 days.

Mixed effects logistic regression is used to model binary outcome variables, in which the log odds of the outcomes are modeled as a linear combination of the independent variables when there are both fixed and random effects. The adjusted odds ratio (OR) serves as a valuable metric for evaluating the association between the independent variable and the outcome, often aiding interpretation.

The corrected Akaike Information Criterion (AICc), which accounts and corrects for the number of included independent variables, is used for the process of model selection between models with different combination of explanatory variables. It is important to mention that the extra value of any random effects is assessed either through a custom ANOVA (log-likelihood test) comparing the fixed-effects binary Generalized Linear Model with any formulated GLMMs or by calculating the Bayes Factor (BF), a measure of the relative strength of evidence for one model over another. For further in-depth explanations of the underlying statistical background, the reader can refer to Washington et al. (2020).

It is also noted that the analyses of this section were conducted in R-studio with the "lme4" package following Bates et al. (2008).

3.2.2 Factors associated with self-declared drink and riding

Table 7 presents the fixed-effect results of the binary GLMM for riding an e-scooter under the influence of alcohol. The e-scooter riders sample sizes per country are presented in Appendix 3. Specifically, the dependent variable is the item from the ESRA3 questionnaire "Over the last 30 days, how often did you as rider of an e-scooter (electric-kick style scooter) ride when you think you may have had too much to drink?". The variable was coded as 0=never and 1=at least once.

Table 7: Binary GLMM for e-scooter riding under the influence of alcohol

Independent Variables	Beta Estimate	S.E.	z-value	P(>|z|)	Adj. Odds Ratio
(Intercept)	-1.343	0.117	-11.458	<0.001	-
Gender (ref. male)					
Female	-0.296	0.100	-2.955	0.003	0.74
Age group (ref. 18-34)					
35-54	-0.074	0.103	-0.715	0.475	0.93
55-74	-0.723	0.226	-3.204	0.001	0.49
Are you currently a student? (ref. no)					
Yes	0.242	0.112	2.160	0.031	1.27
In the past 12 months, have you personally been involved as an e-scooter rider in a road crash where at least one person was injured (light, severe or fatal crashes)? (ref. no)					
Yes	0.977	0.283	3.453	<0.001	2.66
How acceptable do you, personally, feel it is for a car driver to drive when he/she may be over the legal limit for drinking and driving? (ref. unacceptable/neutral)					
Acceptable	1.409	0.162	8.726	<0.001	4.09
How acceptable do you, personally, feel it is for a cyclist to cycle when he/she may have had too much to drink? (ref. unacceptable/neutral)					
Acceptable	1.246	0.156	7.986	<0.001	3.48
How acceptable do you, personally, feel it is for a pedestrian to walk down the street when he/she may have had too much to drink? (ref. unacceptable/neutral)					
Acceptable	0.400	0.118	3.379	<0.001	1.49
For short trips, one can risk driving under the influence of alcohol. (ref. disagree/neutral)					
Agree	1.463	0.150	9.727	<0.001	4.32

Independent Variables	Beta Estimate	S.E.	z-value	P(>|z|)	Adj. Odds Ratio
Do you oppose or support a legal obligation forbidding all drivers of motorized vehicles to drive with a blood alcohol concentration above 0.0 ‰ (zero tolerance)? (ref. oppose/neutral)					
Support	-0.557	0.118	-4.722	<0.001	0.57
Do you oppose or support a legal obligation forbidding all cyclists to ride with a blood alcohol concentration above 0.0 ‰ (zero tolerance)? (ref. oppose/neutral)					
Support	-0.404	0.119	-3.388	<0.001	0.67
AICc	2979.5				

The fixed-effect results reveal significant insights. Firstly, women exhibit a 26% lower likelihood than men of reporting e-scooter riding under the influence of alcohol (OR=0.74). Secondly, individuals aged 55-74 years old demonstrate a 51% reduced probability compared to young riders aged 18-34 years old (OR=0.49). Additionally, students are 27% more inclined to admit riding under the influence than non-students (OR=1.27). Furthermore, those involved in e-scooter crashes where at least one person was injured show a higher propensity for riding after alcohol consumption, with odds approximately 2.66 times greater than those uninvolved in such incidents.

Moreover, e-scooter riders who perceive it as acceptable for car drivers, cyclists, and pedestrians to travel under the influence of alcohol are more prone to riding under the influence of alcohol (OR=4.09, 3.48, 1.49 respectively). Respondents who agree that for short trips, one can risk driving under the influence of alcohol are four times more likely to ride an e-scooter when they may have had too much to drink. Lastly, e-scooter riders supporting legal mandates prohibiting drivers and cyclists from riding with a blood alcohol concentration above 0.0‰ are 43% and 33% less likely, respectively, to ride an e-scooter under such conditions.

The visual representation in Figure 6 illustrates the values of random intercepts for the countries participating in the ESRA3 survey. Random intercepts are additional terms in the equation that account for variability between groups or clusters in the data (in this case ESRA participating countries). The random intercepts assigned to each country account for discrepancies in the baseline level of the dependent variable when compared to the fixed effect intercept. A positive random intercept for a specific country indicates that the baseline log odds of the outcome variable for that country exceed the overall average as estimated by the fixed effect intercept. Conversely, a negative random intercept signifies that the baseline log odds of the outcome variable for that country fall below the overall average. Incorporating random intercepts for each country into the model allows for the accommodation of between-country variations in the baseline level of the outcome variable, thereby facilitating more precise and robust estimates of the effects of other predictors in the model. It is noted that the added value occurring from the inclusion of random intercepts improves the quality of the model by a statistically significantly amount (BF=7.13).

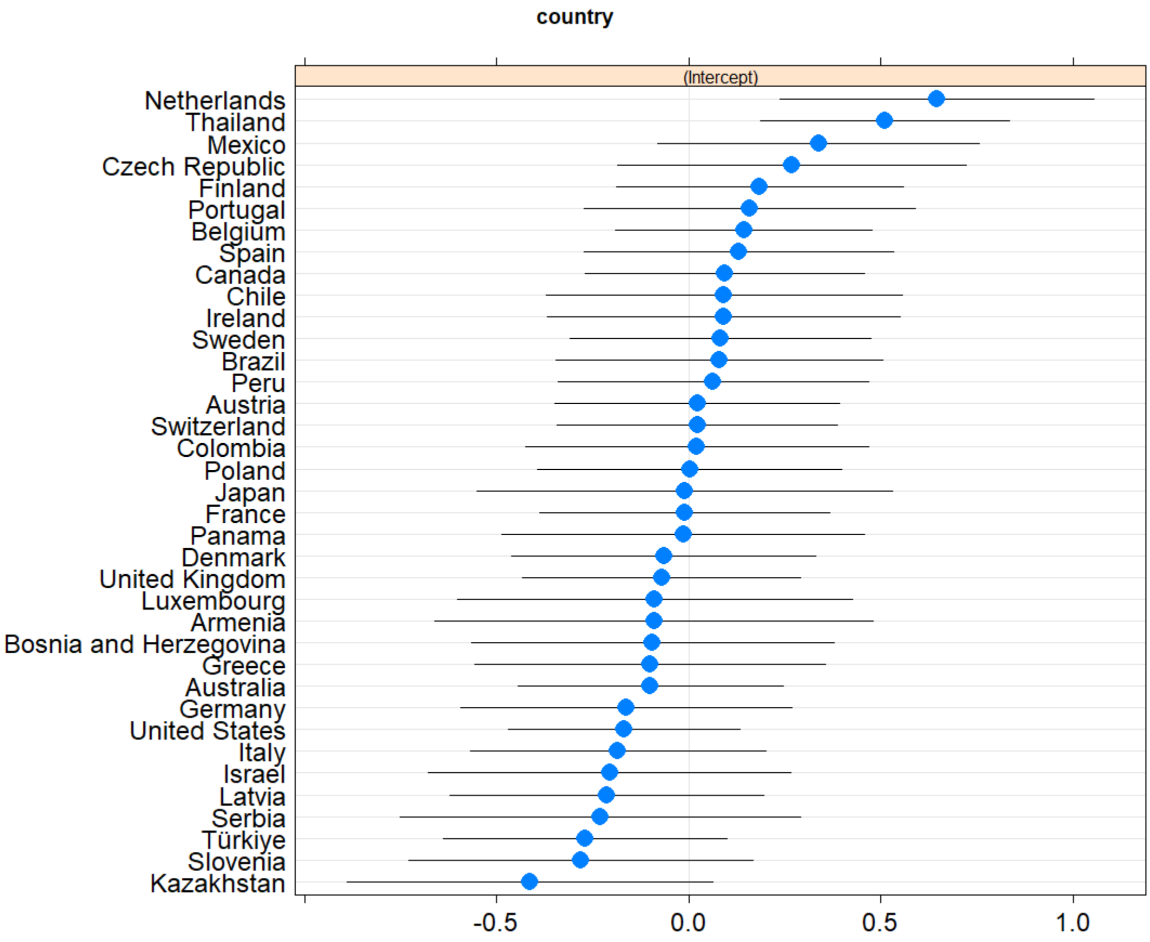

Figure 6: Random intercepts for "country" in the Binary GLMM for self-declared drink and riding.

3.2.3 Factors associated with self-declared riding with more than one person on board

Table 8 presents the fixed-effect results of the binary GLMM, which includes as dependent variable the questionnaire item "Over the last 30 days, how often did you as rider of an e-scooter (electric-kick style scooter) ride with more than 1 person on board?". The variable was coded as 0=never and 1=at least once.

Table 8: Binary GLMM for e-scooter riding with more than one person on board

Independent Variables	Beta Estimate	S.E.	z-value	P(>|z|)	Adj. Odds Ratio
(Intercept)	-0.594	0.144	-4.122	<0.001	-
Age group (ref. 18-34)					
35-54	-0.336	0.079	-4.224	<0.001	0.71
55-74	-0.805	0.164	-4.887	<0.001	0.45
Are you currently a student? (ref. no)					
Yes	0.489	0.087	5.600	<0.001	1.63
In the past 12 months, have you personally been involved as an e-scooter rider in a road crash where at least one person was injured (light, severe or fatal crashes)? (ref. no)					
Yes	0.665	0.235	2.826	0.005	1.94
Level of urbanization (ref. rural)					
Urban/semi-urban	-0.265	0.119	-2.232	0.026	0.77
How acceptable do you, personally, feel it is for a car driver to drive too fast for the road/traffic conditions at the time (e.g., poor visibility, dense traffic, presence of vulnerable road users)? (ref. unacceptable/neutral)					
Acceptable	1.837	0.127	14.456	<0.001	6.28
Do you oppose or support a legal obligation limiting the speed limit to 30 km/h in all built-up areas (except on main thoroughfares)? (ref. oppose/neutral)					
Support	-0.284	0.076	-3.733	<0.001	0.75
AICc	4624.9				

Based on the fixed-effect results, it was observed that both the 35-54 age group and the 55-74 age group exhibit a decreased likelihood of riding with more than one person on board compared to the reference group (18-34 age group). The odds of e-scooters in the 35-54 age group riding with more than one person are approximately 0.71 times the odds for individuals in the reference group, while the odds for individuals in the 55-74 age group are approximately 0.45 times the odds for individuals in the reference group. Moreover, students are 63% more likely to ride with more than one person on board compared to non-students. E-scooter riders who have been personally involved in road crashes where at least one person was injured are almost 2 times more likely to ride with more than one person on board (OR=1.94).

Furthermore, respondents living in urban/semi-urban areas are 23% less likely to ride with more than one person on board compared to those living in rural areas. It was also found that respondents who perceive it as acceptable for car drivers to drive too fast for the road/traffic conditions at the time are 6 times more likely to ride with more than one person on board (OR=6.28). Lastly, e-scooter riders who support a legal obligation limiting the speed limit to 30 km/h in all built-up areas (except on main thoroughfares) are 25% less likely to ride with more than one person on board (OR=0.75).

Figure 7 illustrates the random intercepts for the participating countries. It is noted that the inclusion of random intercepts significantly enhances the model's quality by a statistically significant margin (BF>1000, χ^2=90.86, P (>χ^2) <0.001).

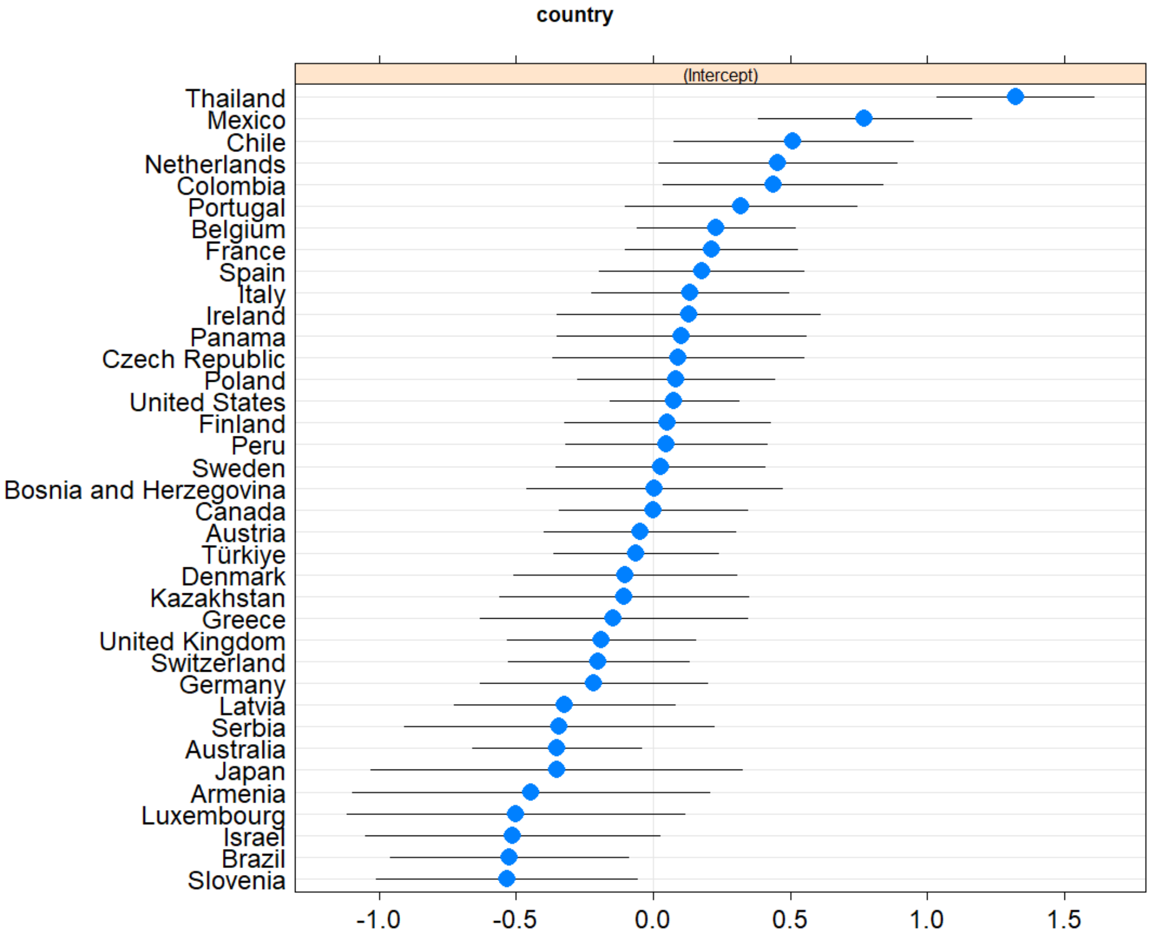

Figure 7: Random intercepts for "country" in the Binary GLMM for self-declared riding with more than one person on board.

3.2.4 Factors associated with self-declared riding without a helmet

The questionnaire item "Over the last 30 days, how often did you as rider of an e-scooter (electric-kick style scooter) ride without a helmet?" formed the dependent variable of another Binary GLMM. This variable was coded as 0=0=never and 1=at least once. The fixed-effect results of the developed model are presented in Table 9.

Table 9: Binary GLMM for e-scooter riding without a helmet

Independent Variables	Beta Estimate	S.E.	z-value	P(>|z|)	Adj. Odds Ratio
(Intercept)	0.332	0.159	2.074	0.038	-
Are you currently a student? (ref. no)					
Yes	0.198	0.088	2.255	0.024	1.22
Level of urbanization (ref. rural)					
Urban/semi-urban	-0.259	0.121	-2.141	0.032	0.77
How acceptable do you, personally, feel it is for a cyclist to cycle without a helmet (ref. unacceptable/neutral)					
Acceptable	1.809	0.102	17.772	<0.001	6.10
Do you oppose or support a legal obligation requiring all cyclists to wear a helmet? (ref. oppose/neutral)					
Support	-0.751	0.079	-9.401	<0.001	0.47
AICc	4596.9				

Based on the fixed-effects output of the model, it is evident that students are 22% more likely to report riding without a helmet compared to respondents who are not students (OR=1.22). Furthermore, e-scooter riders residing in urban/semi-urban areas are 23% less likely to ride without a helmet compared to those in rural areas (OR=0.77). Additionally, individuals who perceive it as acceptable for cyclists to cycle without a helmet are 6 times more likely to ride without a helmet themselves (OR=6.10). Lastly, e-scooter riders who support a legal obligation requiring all cyclists to wear a helmet are 53% less likely to ride without a helmet themselves (OR=0.47).

The random intercepts of the GLMM for the participating countries are presented in Figure 8. It is highlighted that the inclusion of random intercepts significantly improves the model's quality by a statistically significant margin (BF>1000, χ^2=208.19, P (>χ^2) <0.001).

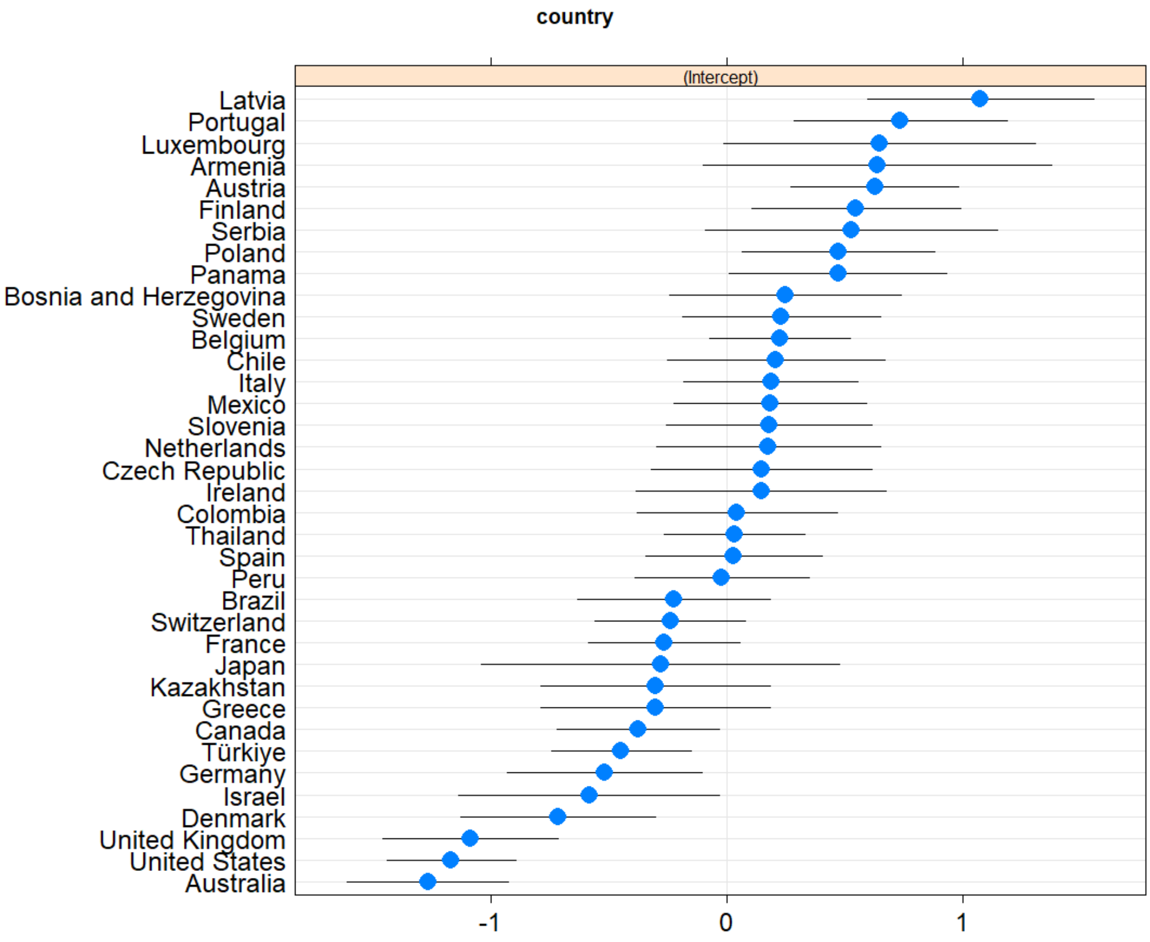

Figure 8: Random intercepts for "country" in the Binary GLMM for self-declared riding without a helmet.

3.2.5 Factors associated with self-declared crossing the road when a traffic light is red

Table 10 demonstrates the fixed-effect results of the binary GLMM for crossing the road when a traffic light is red. Specifically, the dependent variable is the item of the ESRA3 questionnaire "Over the last 30 days, how often did you as rider of an e-scooter (electric-kick style scooter) cross the road when a traffic light is red?". The variable was coded as 0=never and 1=at least once.

Table 10 Binary GLMM for crossing the road when a traffic light is red

Independent Variables	Beta Estimate	S.E.	z-value	P(>|z|)	Adj. Odds Ratio
(Intercept)	-1.315	0.098	-13.362	<0.001	-
Gender (ref. male)					
Female	-0.244	0.088	-2.743	0.006	0.78
Age group (ref. 18-34)					
35-54	-0.361	0.094	-3.864	<0.001	0.70
55-74	-0.740	0.194	-3.819	<0.001	0.48
Are you currently a student? (ref. no)					
Yes	0.287	0.102	2.810	0.005	1.33
In the past 12 months, have you personally been involved as an e-scooter rider in a road crash where at least one person was injured (light, severe or fatal crashes)? (ref. no)					
Yes	0.659	0.282	2.336	0.019	1.93
How acceptable do you, personally, feel it is for a car driver to drive too fast for the road/traffic conditions at the time (e.g., poor visibility, dense traffic, presence of vulnerable road users)? (ref. unacceptable/neutral)					
Acceptable	0.623	0.160	3.895	<0.001	1.86
How acceptable do you, personally, feel it is for a cyclist cross the road when a traffic light is red? (ref. unacceptable/neutral)					
Acceptable	1.220	0.157	7.747	<0.001	3.39
How acceptable do you, personally, feel it is for a pedestrian cross the road when a pedestrian light is red? (ref. unacceptable/neutral)					
Acceptable	1.240	0.134	9.227	<0.001	3.46
I have to drive fast; otherwise, I have the impression of losing time. (ref. disagree/neutral)					
Agree	1.478	0.152	9.712	<0.001	4.38
AICc	3542.5				

The fixed-effect results of the binary GLMM for crossing the road when a traffic light is red reveal several interesting insights. Firstly, gender appears to have a significant influence, with female riders being 22% less likely to cross the road when the traffic light is red compared to male riders (OR=0.78). Age also plays a role, as individuals in the 35-54 and 55-74 age groups are less likely to engage in this behavior compared to younger riders aged 18-34 (OR=0.70 and 0.48 respectively). Interestingly, being a student increases the likelihood of crossing the road when the traffic light is red by 33% (OR=1.33), suggesting that student status may influence risk-taking behaviour. Moreover, individuals who have been involved in e-scooter crashes where at least one person was injured are almost 2 times more likely to cross the road when the traffic light is red, indicating a potential disregard for traffic laws or safety precautions (OR=1.93).

Attitudes towards driving behaviour also affect the dependent variable, with individuals who find it acceptable for car drivers to drive too fast for the road/traffic conditions at the time being 86% more likely to cross the road when the traffic light is red (OR=1.86). Furthermore, e-scooter riders who find it acceptable for cyclists and pedestrians to cross the road when the traffic light is red are almost 3.5 times more likely to cross the road themselves in similar circumstances (OR= 3.39 and 3.46). Lastly, e-scooter riders who agree that they have to drive fast to avoid feeling like they are losing time are 4 times more likely to cross the road when the traffic light is red (OR=4.38).

The random intercepts of the GLMM on crossing the road when a traffic light is red for the participating countries are presented in Figure 9. The addition of the country related random intercepts led to statistically significant improvement of the model when compared to the respective model that includes only the fixed effects (BF>1000).

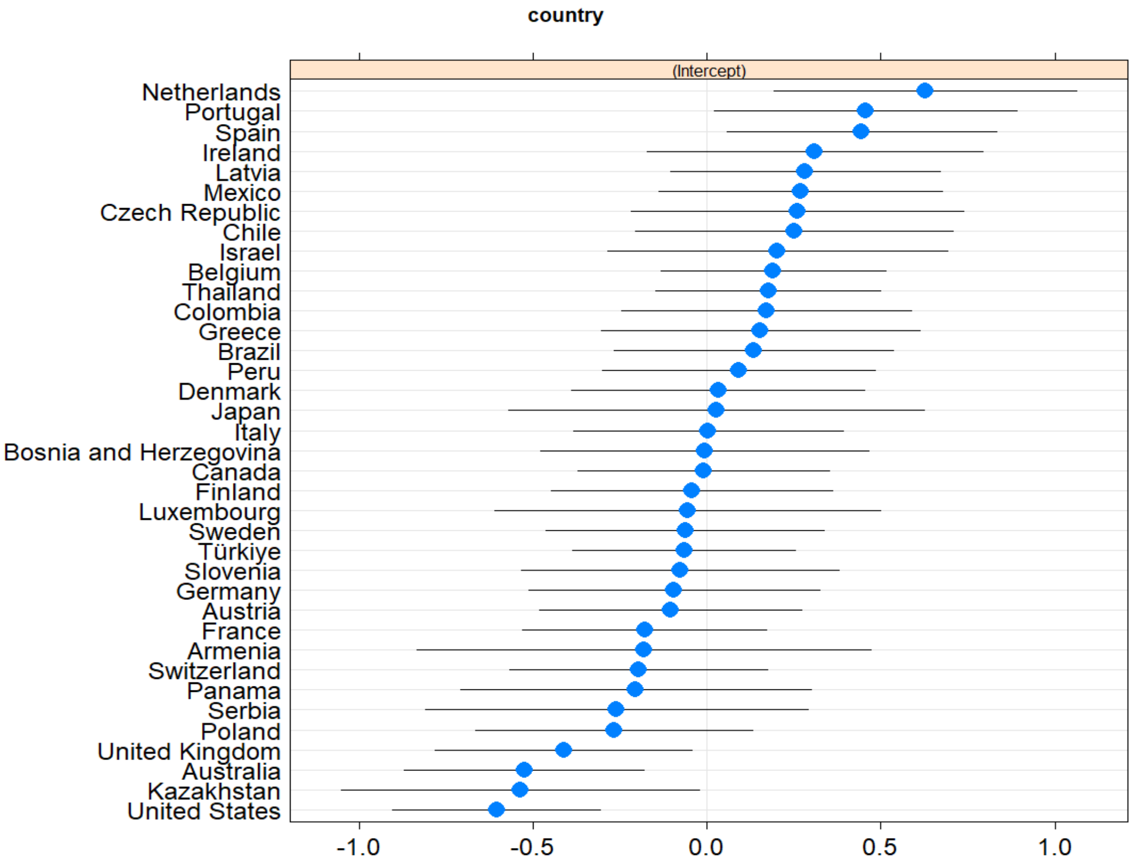

Figure 9: Random intercepts for "country" in the Binary GLMM for self-declared crossing the road when a traffic light is red

3.2.6 Factors associated with self-declared riding on the sidewalk

The last developed GLMM model concerns self-declared riding on the sidewalk. Specifically, the dependent variable is the item of the ESRA3 questionnaire "Over the last 30 days, how often did you as rider of an e-scooter (electric-kick style scooter) ride on pedestrian pavement/sidewalk?". The variable was coded as 0=never and 1=at least once. The fixed-effect results of the developed model are shown in Table 11.

Table 11: Binary GLMM for riding on the sidewalk

Independent Variables	Beta Estimate	S.E.	z-value	P(>|z|)	Adj. Odds Ratio
(Intercept)	-0.302	0.134	-2.250	0.024	-
Gender (ref. male) Female	-0.091	0.075	-1.203	0.229	0.91
Are you currently a student? (ref. no) Yes	0.332	0.088	3.738	<0.001	1.39
In the past 12 months, have you personally been involved as an e-scooter rider in a road crash where at least one person was injured (light, severe or fatal crashes)? (ref. no) Yes	0.751	0.259	2.895	0.004	2.12
How acceptable do you, personally, feel it is for a car driver to drive faster than the speed limit inside built-up areas? (ref. unacceptable/neutral) Acceptable	1.673	0.137	12.203	<0.001	5.33
Motorized vehicles should always give way to pedestrians or cyclists. (ref. disagree/neutral) Agree	0.425	0.074	5.740	<0.001	1.53
AICc	4524.2				

Based on the fixed-effect results, gender does not seem to have a significant influence on riding on the sidewalk, as there is no significant difference between female and male riders in this regard. Being a student increases the likelihood of riding on the sidewalk by 39%, suggesting that students may be more inclined to choose this option (OR=1.39). Individuals who have been involved in road crashes as e-scooter riders where at least one person was injured are 2 times more likely to ride on the sidewalk (OR=2.12). Attitudes towards driving behavior also play a significant role, as individuals who find it acceptable for car drivers to drive faster than the speed limit inside built-up areas are more likely to ride on the sidewalk (OR=5.33). Lastly, e-scooter riders who agree that motorized vehicles should always give way to pedestrians or cyclists are 53% more likely to ride on the sidewalk, potentially reflecting a belief that it is safer to avoid sharing the road with vehicles (OR=1.53).

The random intercepts of the GLMM on self-declared riding on the sidewalk for the participating countries are presented in Figure 10. Once again, it was found that the inclusion of random intercepts significantly enhances the model's quality by a statistically significant margin (BF>1000, χ^2=349.29, P ($>\chi^2$) <0.001).

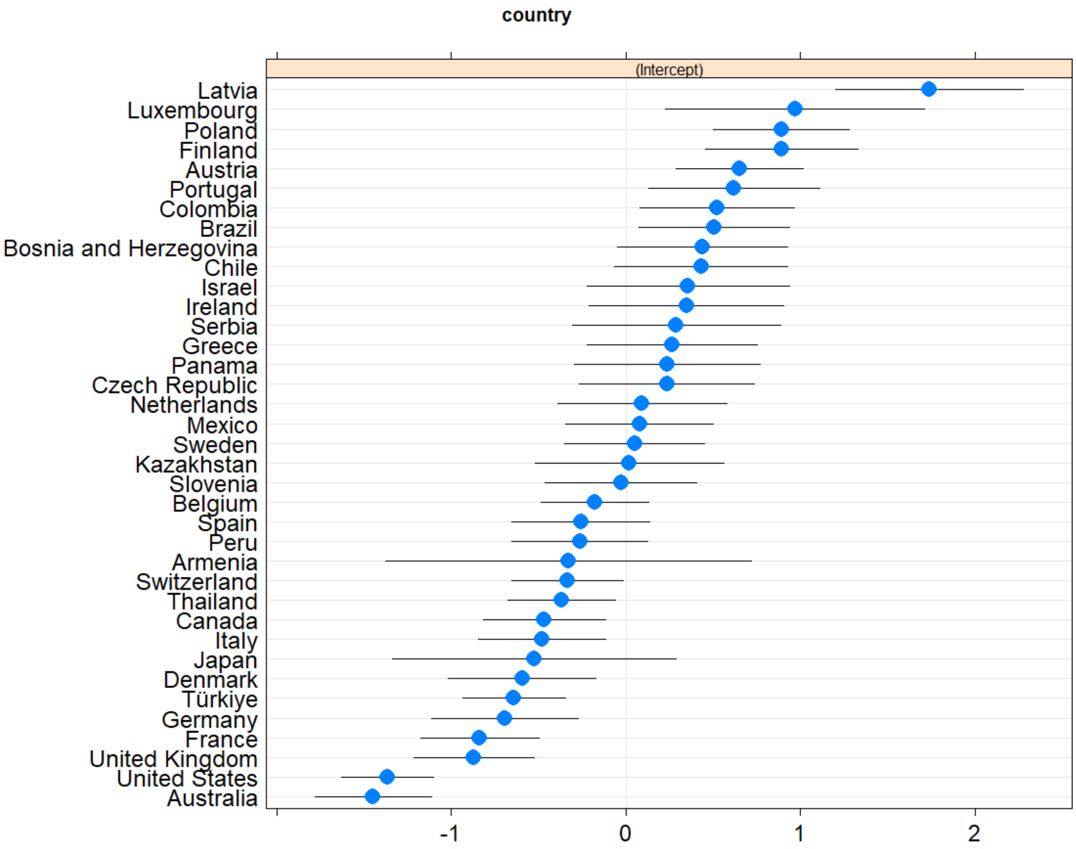

Figure 10: Random intercepts for "country" in the Binary GLMM for self-declared riding on the sidewalk

3.2.7 Limitations of the data

Self-reported data are often susceptible to various biases, as highlighted by research (Choi & Pak, 2005; Krosnick and Presser, 2010). These include desirability bias, where respondents tend to provide answers that paint a favourable image of themselves, potentially exaggerating positive behaviours and downplaying negative ones. Another concern is bias resulting from misunderstanding questions, particularly those with complex language or lengthy formulations, which can lead to misinterpretation of the intended query. Also, recall errors may occur, leading to unintentional inaccuracies in responses due to memory lapses or mistakes. However, self-reported data through questionnaires are generally reliable indicators of actual behavior and the sample size (N=1000) is large enough in our study to reduce the impact of individual biases and attempted to be representative in terms of credibility of the data.

4 Summary and discussion

This ESRA thematic report explores road safety concerns related to e-scooter riders, addressing issues including rider impairment from alcohol, riding on sidewalks, and traffic violations including the failure to wear helmets and non-compliance with traffic signals like red lights, as well as the frequency of using e-scooters and the percentage of riders involved in collisions among different demographics. The analysis also addresses the differences among age and gender groups and investigates factors that increase the likelihood of crash involvement for these demographics.

The assessment of e-scooter exposure shows significant variations in usage frequency across different regions and demographics. In Europe22, a majority of 79.1% reported not using e-scooters at all, with 69.3% in America8 and 80.5% in AsiaOceania6 indicating never using e-scooters. These statistics not only illustrate regional differences in e-scooter adoption but also highlight the varying cultural and infrastructural influences on micro-mobility. The higher rate of usage in America8, particularly in the United States, where 45.3% of road users reported using e-scooters a few days a year, may point to a more accepting attitude towards e-scooters as a viable transport option.

There is a slight gender disparity in e-scooter usage across all regions, with a consistently higher percentage of males engaging in e-scooter use compared to females in Europe22 and America8. Lower rates of usage amongst females may reflect a higher tendency for risk taking among males resulting in more incidents compared to females (Karpinski et al., 2023; Kazemzadeh et al., 2023; Laura Sandt et al., 2023; Sandt et al., 2023; Toofany et al., 2021; Useche et al., 2022; Winchcomb, 2022, 2023). In Europe22, for instance, 24.3% of males used an e-scooter at least a few days per year, compared to only 17.6% of females. Such insights necessitate a gender-focused approach in policy-making and service provision to ensure equitable access to, and benefits from, e-scooter services. Also, further research is required to explore the reasons behind these slight differences and to assist policymakers in making more informed decisions.

Age also plays a critical role in determining e-scooter usage, with younger individuals more likely to engage with e-scooters across all regions. In Europe22, it was observed that e-scooter usage varies by age group, with 40.2% of users aged 18-24 engaging in usage, compared to only 3.8% among those aged 65-74.

This pattern suggests that while younger populations are adopting e-scooter services enthusiastically, there is a significant drop in interest or perceived utility among older adults. Given the high adoption rates among the youth, e-scooter usage can become an increasingly important safety topic as these younger users continue using the service into the future, potentially expanding its prevalence across older age groups as well. Addressing these demographic differences requires tailored approaches that cater not only to the preferred modes of transport but also to the specific needs and safety concerns of different age groups, enhancing the overall integration of e-scooters into the urban transport ecosystem.

While Europe22 and America8 show an identical involvement rate of 2.5% in injury-related crashes amongst e-scooter riders, AsiaOceania6 reports a significantly lower rate of only 0.5%, suggesting the traffic environment, such as road and infrastructure design, as well as traffic culture and regulations, play an important role in influencing these regional differences in risk.

Interestingly, age-related data suggests different trends across regions; for example, a notable peak in crash involvement among the 45-54 age group in America8 indicates that age may increase the risk of collisions. This could be due to riding skills as decrease by increasing age. For instance, cognitive skills and mental workload may also diminish with age, affecting attention, memory, and spatial cognition, which can impact driving behaviors like double-checking merge spaces or noticing other road users (Abd Rahman et al., 2020; Gökçe et al., 2022; Romoser and Fisher 2009).

For risky riding behaviours, a minority but notable and concerning percentage of riders reported riding without using a helmet, riding with multiple passengers, riding under the influence of alcohol, riding on pedestrian pavements or sidewalks, and crossing the road against a red traffic light. The findings call for continued efforts in enforcement and education. Interestingly, clear age-related declines in risky behaviours like carrying extra passengers or riding after alcohol consumption indicates older riders in Europe tend to be more cautious. However, this trend does not hold in America or Asia-Oceania, pointing to the potential influence of differing societal norms which may affect the behaviours of older adults.

In order to investigate factors associated with self-declared unsafe behaviours of e-scooter riders, five mixed effects binary logistic regression models were developed. The analyses examining various behaviours related to e-scooter riding revealed several noteworthy patterns. Firstly, demographic factors such as gender and age significantly influence behaviours like riding under the influence of alcohol, riding with more than one person on board, and crossing the road when traffic light is red. Women are less likely to engage in risky behaviours such as riding under the influence or crossing the road on red lights, while older individuals show a decreased likelihood of riding with more than one person on board or crossing on red lights compared to younger riders. Additionally, student status emerges as a consistent predictor of risk-taking behaviour across multiple scenarios, with students generally exhibiting higher propensities for such unsafe behaviours. Attitudes towards traffic laws and safety regulations also play a crucial role, with individuals who endorse lenient attitudes towards speeding and disregard for traffic signals being more likely to engage in risky e-scooter behaviours. Moreover, our findings indicate that self-declared engagement in unsafe riding behaviors is associated with higher rates of crash involvement among e-scooter riders, although this association does not imply causation.. These findings collectively underscore the multifaceted influences on e-scooter riding behaviours, encompassing demographic, attitudinal, and experiential factors.

Recommendations

Key recommendations

- Engage with e-scooter riders at the onset of their usage, focusing on safe riding practices. Outreach should include information about the risks of riding with passengers, alcohol-impaired riding, or without helmets. Awareness programs can be crucial in informing riders about the risks of these unsafe behaviours.
- Adapt the e-scooter rental process to assess riders' readiness and ability to operate e-scooters safely. Implement mandatory safety briefings or skill assessments to identify riders who may pose a higher risk due to inexperience or lack of knowledge about local traffic laws.
- Implement uniform traffic regulations globally for e-scooter usage to reduce confusion among riders and streamline enforcement. Clear, standardized rules pertaining to speed limits, e-scooter lane usage, right-of-way, parking, wearing helmets, and standardized and enforced blood alcohol content (BAC) limits for e-scooter riders are essential.
- Continue research into the impact of risk factors on e-scooter crashes, targeting interventions toward age groups at higher risk, particularly younger adults known for more risky behaviours and older adults who may face physical challenges.

Specific recommendations to stakeholders include:

- [To Urban Planners and Local Governments] Enhance infrastructure to accommodate e-scooters safely, such as designated parking areas, and enforce traffic laws to prevent sidewalk riding and red-light violations by e-scooter riders. Establish a well-connected micromobility network and undertake regular maintenance of facilities. Collect data on e-scooter use and safety statistics.
- [To E-scooter Sharing Companies] Invest in technology to limit e-scooter speeds in high-pedestrian areas and to disable e-scooters if erratic or unsafe riding is detected. Encourage helmet use through partnerships with helmet manufacturers and provide incentives for safe riding practices.
- [To Policymakers and NGOs] Run educational campaigns focusing on the risks of riding without a helmet, the dangers of alcohol-impaired riding, and the importance of obeying traffic signals to reduce e-scooter-related injuries and fatalities.

The initial aim of ESRA was to develop a system for gathering reliable and comparable information about people’s attitudes towards road safety in several European countries. This objective has been achieved and the initial expectations have even been exceeded. ESRA has become a global initiative which already conducted surveys in more than 60 countries across six continents. The outputs of the ESRA project have become building blocks of national and international road safety monitoring systems.

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

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Appendix 1: ESRA3 Questionnaire

Introduction

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

Socio-demographic information

Q1) **In which country do you live? ______**

Q2) **Are you …** male – female - other

Q3) **How old are you (in years)?** [Drop down menu]

Q4_1) **Are you currently a student?** yes - no

Q4_2) **What is the highest qualification or educational certificate which you want to achieve?** primary education - secondary education - bachelor's degree or similar - master's degree or higher

Q4_3) **What is the highest qualification or educational certificate that you have obtained?** none - primary education - secondary education - bachelor's degree or similar - master's degree or higher

Q5) **Which of the descriptions comes closest to how you feel about your household's income nowadays?** living comfortably on present income - coping on present income - finding it difficult on present income - finding it very difficult on present income

Q6a) **Is the car you regularly drive equipped with seatbelts in the front seat?** yes – no
Only asked to LMIC countries.

Q6b) **Is the car you regularly drive equipped with seatbelts in the back seat?** yes - no
Only asked to LMIC countries.

Q7) **Are you using a carsharing organization (e.g., poppy or cambio[1])?** yes – no
Only asked to HIC/UMIC countries.

Q8) **Do you have to drive or ride a vehicle during your main professional activity?** yes, I transport mainly other person(s) (e.g., taxi, bus, rickshaw, …) - yes, I transport mainly goods (e.g., truck, courier, food delivery,…) - yes, I transport mainly myself (e.g., visiting patients, salesperson,…) - no, I drive or ride a vehicle only for commuting or private reasons

Q9) **Which phrase best describes the area where you live?** a farm or home in the countryside - a country village - a town or a small city - the suburbs or outskirts of a big city - a big city

Q10) **In which region do you live?** [List of regions per country]

Q11a) **How far do you live from the nearest stop of public transport?** less than 500 metres - between 500 metres and 1 kilometre - more than 1 kilometre

Q11b) **What is the frequency of your nearest public transport?** at least 3 times per hour - 1 or 2 times per hour - less than 1 time per hour

Mobility & exposure

[1] *The examples in brackets were adapted to national context.*

Q12) **During the past 12 months, how often did you use each of the following transport modes in [country]? How often did you …?** at least 4 days a week - 1 to 3 days a week - a few days a month - a few days a year - never

Items (random order): take the train - take the bus or minibus - take the tram/streetcar - take the subway, underground, metro - take a plane - take a ship/boat or ferry - be a passenger on non-motorized individual public transport mode (e.g., bike taxi, animal carriages,…) - be a passenger on motorized individual public transport mode (e.g., car-taxi, moto-taxi, tuk-tuk, auto rickshaw, songthaew,…) - walk or run minimum 200m down the street - cycle (non-electric) - cycle on an electric bicycle / e-bike / pedelec - drive a moped (≤ 50 cc or ≤ 4 kW) - drive a motorcycle (> 50 cc or > 4kW) - ride an e-scooter (electric-kick style scooter) - drive a car (non-electric or non-hybrid) - drive a hybrid or electric car - be a passenger in a car - be a passenger on a moped or motorcycle - use another transport mode

Q13) **Over the last 30 days, have you transported a child (<18 years of age) in a car?** yes - no

Items (random order): under 150cm - above 150cm[2]

Self-declared safe and unsafe behaviour in traffic

Q14_1a) **Over the last 30 days, how often did you as a CAR DRIVER …?** You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.
Binary variable for most items: at least once (2-5) - never (1); only exception: items on protective systems: always wear/transport (1) – not always wear/transport (2-5)
Items (random order):

- drive when you may have been over the legal limit for drinking and driving
- drive after drinking alcohol
- drive within 1 hour after taking drugs (other than prescribed or over the counter medication)
- drive within 2 hours after taking medication that may affect your driving ability
- drive faster than the speed limit inside built-up areas
- drive faster than the speed limit outside built-up areas (except motorways/freeways)
- drive too fast for the road/traffic conditions at the time (e.g., poor visibility, dense traffic, presence of vulnerable road users)
- drive faster than the speed limit on motorways/freeways
- drive without wearing your seatbelt
- transport children under 150cm[3] without using child restraint systems (e.g., child safety seat, cushion)
- transport children above 150cm[4] without wearing their seat belt
- talk on a hand-held mobile phone while driving
- talk on a hands-free mobile phone while driving
- read a message or check social media/news while driving
- drive when you were so sleepy that you had trouble keeping your eyes open

Q14_1b_1) You said that you have driven a car when you may have been over the legal limit for drinking and driving. Was this …? You can indicate multiple answers: in the week during daytime - in the week during night-time - in the weekend during daytime - in the weekend during night-time - on motorways - on urban roads - on rural roads
Only asked to HIC/UMIC countries.

Q14_1b_2) You said that you have driven a car within 1 hour after taking drugs (other than prescribed or over the counter medication). Was this …? You can indicate multiple answers: cannabis - cocaine - amphetamines (e.g., speed, extasy) - illicit opiates (e.g., morphine, codeine; not prescribed as medication) - other

Q14_1b_3) You said that you have driven a car within 2 hours after taking medication that may affect your driving ability. Was this …? You can indicate multiple answers[5]: antihistamines and/or cough medicines (such as Claritin, Allegra, Benadryl) - antidepressants (such as Prozac, Zoloft, Wellbutrin) - prescription pain medicines (such as Tylenol with codeine, OxyContin, Percocet, Vicodin/ hydrocodone) - muscle relaxants (such as Soma, Flexeril) - sleep aids, Barbiturates, or

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2 *This question was adapted to national legal regulation.*
3 *This question was adapted to national legal regulation.*
4 *This question was adapted to national legal regulation.*
5 *The examples in brackets were adapted to national context.*

Benzodiazapines (such as Ambien, Lunesta, phenobarbital, Xanax, Valium, Ativan) - amphetamines (such as Adderall, Dexedrine, phentermine) - other

Q14_2) **Over the last 30 days, how often did you as a CAR PASSENGER ...? You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.**

Binary variable for most items: always wear/transport (1) – not always wear/transport (2-5)
Items (random order):

- travel without wearing your seatbelt in the back seat
- travel without wearing your seatbelt in the front seat

Q14_3) **Over the last 30 days, how often did you as a MOPED RIDER or MOTORCYCLIST ...?** You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.

Binary variable for most items: at least once (2-5) - never (1); only exception: items on protective systems: always wear/transport (1) – not always wear/transport (2-5)
Items (random order):

- ride when you may have been over the legal limit for drinking and driving
- ride faster than the speed limit outside built-up areas (except motorways/freeways)
- not wear a helmet on a moped or motorcycle
- read a message or check social media/news while riding
- ride within 1 hour after taking drugs (other than prescribed or over the counter medication)
- ride too fast for the road/traffic conditions at the time (e.g., poor visibility, dense traffic, presence of vulnerable road users) - Only asked to LMIC countries.
- ride a motorcycle with more than 1 passenger

Q14_4) **Over the last 30 days, how often did you as a CYCLIST ...?** You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.

Binary variable for most items: at least once (2-5) - never (1); only exception: items on protective systems: always wear/transport (1) – not always wear/transport (2-5)
Items (random order):

- cycle when you think you may have had too much to drink
- cycle without a helmet
- cycle while listening to music through headphones
- read a message or check social media/news while cycling
- cycle within 1 hour after taking drugs (other than prescribed or over the counter medication)
- cross the road when a traffic light is red

Q14_5) **Over the last 30 days, how often did you as a PEDESTRIAN ...?** You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.

Binary variable for most items: at least once (2-5) - never (1); only exception: items on protective systems: always wear/transport (1) – not always wear/transport (2-5)
Items (random order):

- listen to music through headphones while walking down the street
- walk down the street when you think you may have had too much to drink
- read a message or check social media/news while walking down the street
- text a message while walking down the street
- cross the road when a pedestrian light is red
- cross the road at places other than at a nearby (distance less than 30m[6]) pedestrian crossing

Q14_6) **Over the last 30 days, how often did you as RIDER OF AN E-SCOOTER (electric-kick style scooter) ...?** You can indicate your answer on a scale from 1 to 5, where 1 is "never" and 5 is "(almost) always". The numbers in between can be used to refine your response.

Binary variable for most items: at least once (2-5) - never (1); only exception: items on protective systems: always wear/transport (1) – not always wear/transport (2-5)
Only asked to HIC/UMIC countries.

[6] *This question was adapted to national legal regulation.*

Items (random order):

- ride with more than 1 person on board
- ride when you think you may have had too much to drink
- cross the road when a traffic light is red
- ride on pedestrian pavement/sidewalk
- ride without a helmet

Acceptability of safe and unsafe traffic behaviour

Q15) Where you live, how acceptable would most other people say it is for a CAR DRIVER to ....? You can indicate your answer on a scale from 1 to 5, where 1 is "unacceptable" and 5 is "acceptable". The numbers in between can be used to refine your response.

Binary variable: acceptable (4-5) – unacceptable/neutral (1-3)
Items (random order):

- drive when he/she may be over the legal limit for drinking and driving
- drive faster than the speed limit outside built-up areas (except motorways/freeways)
- drive without wearing the seatbelt
- talk on a hand-held mobile phone while driving
- read a message or check social media/news while driving

Q16_1) How acceptable do you, personally, feel it is for a CAR DRIVER to ...? You can indicate your answer on a scale from 1 to 5, where 1 is "unacceptable" and 5 is "acceptable". The numbers in between can be used to refine your response.

Binary variable: acceptable (4-5) – unacceptable/neutral (1-3)
Items (random order; instructed response item (trick item) as last item):

- drive when he/she may be over the legal limit for drinking and driving
- drive within 1 hour after taking drugs (other than prescribed or over the counter medication)
- drive within 2 hours after taking a medication that may affect the driving ability
- drive faster than the speed limit inside built-up areas
- drive faster than the speed limit outside built-up areas (except motorways/freeways)
- drive too fast for the road/traffic conditions at the time (e.g., poor visibility, dense traffic, presence of vulnerable road users)
- drive faster than the speed limit on motorways/freeways
- drive without wearing the seatbelt
- transport children in the car without securing them (child's car seat, seatbelt, etc.)
- talk on a hand-held mobile phone while driving
- talk on a hands-free mobile phone while driving
- read a message or check social media/news while driving
- drive when he/she is so sleepy that he/she has trouble keeping their eyes open
- Please, select the answer option number 5 "acceptable". (Instructed response item (trick item))

Q16_2) How acceptable do you, personally, feel it is for a MOPED RIDER or MOTORCYCLIST to ...? You can indicate your answer on a scale from 1 to 5, where 1 is "unacceptable" and 5 is "acceptable". The numbers in between can be used to refine your response.

Binary variable: acceptable (4-5) – unacceptable/neutral (1-3)
Items (random order):

- ride when he/she may have been over the legal limit for drinking and driving
- ride faster than the speed limit outside built-up areas (except motorways/freeways)
- not wear a helmet on a moped or motorcycle
- read a message or check social media/news while riding
- ride a motorcycle with more than 1 passenger – Only asked to LMIC countries.

Q16_3) How acceptable do you, personally, feel it is for a CYCLIST to ...? You can indicate your answer on a scale from 1 to 5, where 1 is "unacceptable" and 5 is "acceptable". The numbers in between can be used to refine your response.

Binary variable: acceptable (4-5) – unacceptable/neutral (1-3)
Items (random order):

- cycle when he/she may have had too much to drink
- cycle without a helmet
- read a message or check social media/news while cycling
- cross the road when a traffic light is red

Q16_4) **How acceptable do you, personally, feel it is for a PEDESTRIAN to …?** You can indicate your answer on a scale from 1 to 5, where 1 is "unacceptable" and 5 is "acceptable". The numbers in between can be used to refine your response.

Binary variable: acceptable (4-5) – unacceptable/neutral (1-3)
Items (random order):

- walk down the street when he/she may have had too much to drink
- read a message or check social media/news while walking down the street
- cross the road when a pedestrian light is red

Attitudes towards safe and unsafe behaviour in traffic

Q17) **To what extent do you agree with each of the following statements?** You can indicate your answer on a scale from 1 to 5, where 1 is "disagree" and 5 is "agree". The numbers in between can be used to refine your response.

Binary variable: agree (4-5) – disagree/neutral (1-3)
Items (random order):
Behaviour believes & attitudes

- For short trips, one can risk driving under the influence of alcohol.
- I have to drive fast; otherwise, I have the impression of losing time.
- Respecting speed limits is boring or dull.
- Motorized vehicles should always give way to pedestrians or cyclists.
- I use a mobile phone while driving, because I always want to be available.
- To save time, I often use a mobile phone while driving.

Perceived behaviour control = self-efficacy

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

Habits

- I often drive after drinking alcohol.
- I often drive faster than the speed limit.
- I often use my mobile phone while driving.

Intention

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

Subjective safety & risk perception

Q18) **How safe or unsafe do you feel when using the following transport modes in [country]?** You can indicate your answer on a scale from 0 to 10, where 0 is "very unsafe" and 10 is "very safe". The numbers in between can be used to refine your response.

Items (random) = Items indicated by the respondent in Q12 are displayed.

Q19) **How often do you think each of the following factors is the cause of a road crash involving a car?** You can indicate your answer on a scale from 1 to 6, where 1 is "never" and 6 is "(almost) always". The numbers in between can be used to refine your response.

Binary variable: often/frequently (4-6) – not that often/not frequently (1-3)
Items (random order):

- driving after drinking alcohol
- driving within 1 hour after taking drugs (other than prescribed or over the counter medication)
- driving faster than the speed limit
- using a hand-held mobile phone while driving
- using a hands-free mobile phone while driving
- inattentiveness or daydreaming while driving
- driving while tired

Support for policy measures

Q20) **Do you oppose or support a legal obligation …?** You can indicate your answer on a scale from 1 to 5, where 1 is "oppose" and 5 is "support". The numbers in between can be used to refine your response.

Binary variable: support (4-5) – oppose/neutral (1-3)
Items for all countries (random order):

- forbidding all drivers of motorized vehicles to drive with a blood alcohol concentration above 0.0 ‰ (zero tolerance)
- forbidding all drivers of motorized vehicles to use a hand-held mobile phone while driving
- limiting the speed limit to 30 km/h in all built-up areas (except on main thoroughfares)
- requiring all cyclists to wear a helmet
- limiting the speed limit to a maximum of 80 km/h on all rural roads without a median strip
- forbidding all novice drivers of motorized vehicles (license obtained less than 2 years ago) to drive with a blood alcohol concentration above 0.0 ‰ (zero tolerance)

Items only for HIC/UMIC countries (random order):

- installing an alcohol 'interlock' for drivers who have been caught drunk driving on more than one occasion (technology that won't let the car start if the driver's alcohol level is over a certain limit)
- requiring cyclists under the age of 12 to wear a helmet
- forbidding all cyclists to ride with a blood alcohol concentration above 0,0‰ (zero tolerance)

Items only for LMIC countries (random order):

- forbidding all professional drivers of motorized vehicles (e.g., taxis, vans, trucks, buses, …) to drive with a blood alcohol concentration above 0.0 ‰ (zero tolerance)
- requiring all moped and motorcycle riders and passengers to wear a helmet
- requiring all car drivers and passengers (front- and back seat) to wear a seatbelt
- making liability insurance mandatory for owners of cars

Q21) **Please think of the policy measure: "…" and indicate if you agree or disagree with the following statements about it. This policy measure would …?** Disagree – agree

Random selection of one of the first 4 items in Q20 per respondent. All first 4 items in Q20 are be asked equally often in each country.
Items (random order):

- reduce the number of road crashes and injuries
- increase the safety feeling on the streets
- have negative side effects
- restrict people's individual freedom
- reduce the privacy of people
- limit people's mobility
- lead to discrimination
- be fair
- be expensive for people
- be easy to implement
- be difficult to enforce by the police
- be a burden for people
- be an unjustifiable intervention by the state
- be supported by many of my friends

Enforcement

Q22) **On a typical journey, how likely is it that you (as a car driver) will be checked by the police (including camera's or radars) for …?** You can indicate your answer on a scale from 1 to 7, where 1 is "very unlikely" and 7 is "very likely". The numbers in between can be used to refine your response.

Binary variable: likely (5-7) – unlikely/neutral (1-4)
Items (random order):

- alcohol, in other words, being subjected to a Breathalyser test
- the use of illegal drugs
- respecting the speed limits
- wearing your seatbelt
- the use of hand-held mobile phone to talk or text while driving

Q23_1) **In the past 12 months, how many times have you been checked by the police for using alcohol while driving a car (i.e., being subjected to a Breathalyser test)?** Never – 1 time – at least 2 times – Binary variable: at least once – never

Q23_2) **In the past 12 months, how many times have you been checked by the police for using drugs (other than prescribed or over the counter medication) while driving a car?** Never – 1 time – at least 2 times – Binary variable: at least once – never

Involvement in road crashes

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

Q24a) **In the past 12 months, have you personally been involved in a road crash where at least one person was injured (light, severe or fatal crashes)?** Yes – no

Q24b) **Please indicate the transport mode(s) YOU were using at the time of these crashes.** **You can indicate multiple answers:** as a car driver – as a car passenger – as a moped or motorcycle rider – as a moped or motorcycle passenger – as a cyclist – as a pedestrian – as a rider of an e-scooter (electric-kick style scooter) – other

Infrastructure

Q25_1_a) **As a CAR DRIVER, what type of roads do you regularly use in [country]?** You can indicate multiple answers: inter-city motorways – thoroughfares and high-speed roads within cities – rural roads and roads connecting towns and villages – other streets and roads in urban areas

Q25_1_b) **As a CAR DRIVER, how would you rate the roads that you regularly use in terms of safety?** You can indicate your answer on a scale from 1 to 7, where 1 is "very unsafe" and 7 is "very safe". The numbers in between can be used to refine your response.

Binary variable: safe (5-7) – unsafe/neutral (1-4)
Items (random order):

- inter-city motorways
- thoroughfares and high-speed roads within cities
- rural roads and roads connecting towns and villages
- other streets and roads in urban areas

Q25_2_a) **As a MOPED RIDER or MOTORCYCLIST, what type of roads do you regularly use in [country]?** You can indicate multiple answers: thoroughfares and high-speed roads within cities – rural roads and roads connecting towns and villages – other streets and roads in urban areas

Q25_2_b) **As a MOPED RIDER or MOTORCYCLIST, how would you rate the roads that you regularly use in terms of safety?** You can indicate your answer on a scale from 1 to 7, where 1 is "very unsafe" and 7 is "very safe". The numbers in between can be used to refine your response.

Binary variable: safe (5-7) – unsafe/neutral (1-4)
Items (random order):

- thoroughfares and high-speed roads within cities
- rural roads and roads connecting towns and villages
- other streets and roads in urban areas

Q25_3_a) **As a CYCLIST, what type of roads/cycle lanes do you regularly use in [country]?** You can indicate multiple answers: rural roads and roads connecting towns and villages with cycle lanes – rural roads and roads connecting towns and villages without cycle lanes – streets and roads in urban areas with cycle lanes – streets and roads in urban areas without cycle lanes

Q25_3_b) **As a CYCLIST, how would you rate the roads/cycle lanes that you regularly use in terms of safety?** You can indicate your answer on a scale from 1 to 7, where 1 is "very unsafe" and 7 is "very safe". The numbers in between can be used to refine your response.

Binary variable: safe (5-7) – unsafe/neutral (1-4)
Items (random order):

- rural roads and roads connecting towns and villages with cycle lanes
- rural roads and roads connecting towns and villages without cycle lanes
- streets and roads in urban areas with cycle lanes
- streets and roads in urban areas without cycle lanes

Q25_4_a) As a PEDESTRIAN, what type of roads/sidewalks do you regularly use in [country]? You can indicate multiple answers: rural roads and roads connecting towns and villages with sidewalks – rural roads and roads connecting towns and villages without sidewalks – streets and roads in urban areas with sidewalks – streets and roads in urban areas without sidewalks

Q25_4_b) As a PEDESTRIAN, how would you rate the roads/sidewalks that you regularly use in terms of safety? You can indicate your answer on a scale from 1 to 7, where 1 is "very unsafe" and 7 is "very safe". The numbers in between can be used to refine your response.

Binary variable: safe (5-7) – unsafe/neutral (1-4)
Items (random order):

- rural roads and roads connecting towns and villages with sidewalks
- rural roads and roads connecting towns and villages without sidewalks
- streets and roads in urban areas with sidewalks
- streets and roads in urban areas without sidewalks

Social desirability scale

Introduction: The survey is almost finished. Some of the following questions[7] have nothing to do with road safety, but they are important background information. There are no good or bad answers.

Q26) To what extent do you agree with each of the following statements? You can indicate your answer on a scale from 1 to 5, where 1 is "disagree" and 5 is "agree". The numbers in between can be used to refine your response.

Items (random order; instructed response item (trick item) as last item):

- In an argument, I always remain objective and stick to the facts.
- Even if I am feeling stressed, I am always friendly and polite to others.
- When talking to someone, I always listen carefully to what the other person says.
- It has happened that I have taken advantage of someone in the past.
- I have occasionally thrown litter away in the countryside or on to the road.
- Sometimes I only help people if I expect to get something in return.
- Please, select the answer option number 5 "agree". (Instructed response item (trick item))

Closing comment: Thank you for your contribution!

[7] *Q26 is asked together with some last questions on sociodemographic information, which have already been listed in the beginning of the questionnaire.*

Appendix 2: ESRA3 weights

The following weights were used to calculate representative means on national and regional level. They are based on UN population statistics (United Nations Statistics Division, 2023). The weighting took into account small corrections with respect to national representativeness of the sample based on gender and six age groups (18-24y, 25-34y, 35-44y, 45-54y, 55-64y, 65-74y). For the regions, the weighting also took into account the population size of each country in the total set of countries from this region.

Individual country weight	Individual country weight is a weighting factor based on the gender*6 age groups (18-24y, 25-34y, 35-44y, 45-54y, 55-64y, 65-74y) distribution in a country as retrieved from the UN population statistics.
Europe22 weight	European weighting factor based on all 22 European countries participating in ESRA3, considering individual country weight and population size of the country as retrieved from the UN population statistics.
America8 weight	American weighting factor based on all 8 North and Latin American countries participating in ESRA3, considering individual country weight and population size of the country as retrieved from the UN population statistics.
AsiaOceania6 weight	Asian and Oceanian weighting factor based on the 6 Asian and Oceanian countries participating in ESRA3 with data collected through online panel (Australia, Israel, Japan, Kazakhstan, Thailand, Türkiye - Armenia, Kyrgyzstan, and Uzbekistan were not included due to different methodology in data collection – face-to-face CAPI), considering individual country weight and population size of the country as retrieved from the UN population statistics.

Appendix 3: ESRA3 weighted samples

Country	All road users	e-scooter riders, at least a few days a month
Armenia	467	22
Australia	953	236
Austria	1804	151
Belgium	1795	212
Bosnia and Herzegovina	914	61
Brazil	947	94
Canada	1904	178
Chile	923	66
Colombia	909	87
Czech Republic	965	67
Denmark	874	104
Finland	993	117
France	965	169
Germany	832	116
Greece	978	65
Ireland	901	59
Israel	965	50
Italy	1007	126
Japan	986	19
Kazakhstan	845	71
Kyrgyzstan	468	30
Latvia	911	111
Luxembourg	471	29
Mexico	932	91
Netherlands	905	76
Panama	855	60
Peru	843	109
Poland	927	123
Portugal	1032	76
Serbia	982	42
Slovenia	945	85
Spain	935	116
Sweden	922	119
Switzerland	979	168
Thailand	870	190
Türkiye	897	208
United Kingdom	921	155
United States	938	336
Uzbekistan	433	40
Region	**All road users**	**e-scooter riders, at least a few days a month**
Europe22	22000	2918
America8	8000	1683
AsiaOceania6*	6000	796

* Not including Armenia, Kyrgyzstan, Uzbekistan (different methodology)

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