Periodica Polytechnica Transportation Engineering, 53(3), pp. 301–307, 2025

Accident Risk Analysis of Road Accidents Involving Personal Injury

Brúnó Péter[1*], Gergő Sütheö[2], István Lakatos[1]

[1] Department of Road and Rail Vehicles, Audi Hungarian Faculty of Vehicle Engineering, Széchenyi István University, Egyetem tér 1., H-9026 Győr, Hungary
[2] Zalaegerszeg Innovation Park, Széchenyi István University, Dr. Michelberger Pál út 3., H-8900 Zalaegerszeg, Hungary
[*] Corresponding author, e-mail: peter.bruno@sze.hu

Received: 31 July 2024, Accepted: 08 May 2025, Published online: 04 June 2025

Abstract

In both the European Union Member States and Hungary, a large number of people are killed in road traffic accidents. Reducing road collisions, personal injuries, and fatalities is a priority. To get an accurate picture of the situation, it is necessary to know the accident statistics of the European Union and the main EU directives that define a Safe Transport System. We then review the road safety situation in Hungary, using data from 2017 to 2020. In preparing the statistical overview, particular attention will be paid to the spatial distribution of severity, over time and by county, the distribution of accident participants by type of transport, the characteristics of the persons involved in the accident, the causes of the accidents and the distribution by type of accident. The analysis includes an explanation of the variables related to the vehicles involved in the accident and the causes of accidents related to human factors.

Keywords

accident injuries, fatal injury, accident analysis, causes of accidents

1 Introduction

In the 21st century, road safety is one of the most important factors in our daily lives (Elvik, 2024). The network policy of the European Union regulates the transportation safety factors in several ways in order to create a more coherent and safer mobility (European Commission, 2024b). In 2022, more than 20,000 people were killed in transport-related accidents in the European Union (EU). The majority of these accidents are still linked to speeding, failure to yield right of way, and failure to maintain a safe following distance (Jagicza et al., 2023). The paper examines road accidents from a statistical point of view based on the standards (The National Statistical Council, 1993).

Road accidents are commonplace, and the outcome of each one depends on a number of factors. The most important of these are:

- People regularly get behind the wheel after drinking alcohol. In some countries, this is not an offence up to a certain blood alcohol level. However, research has shown that alcohol dulls our driving skills, which increases the risk of an accident.
- Another problem is that many people do not respect the speed limits for a particular stretch of road, do not take into account the current weather and traffic conditions, or the limits of their own vehicle (relative speeding), and therefore drive too fast.
- Many accidents are caused by one or more drivers making reckless driving decisions because they have misjudged the situation.
- Safe driving is based on ensuring that vehicles are able to travel on safe roads of the right quality. It is not enough to build the right infrastructure; roads must be maintained (European Parliament, 2019; Lakatos, 2021; Muslim and Antona Makoshi, 2022).

Table 1 from the CARE database shows that in Europe, the number of (known) road accident fatalities decreased for almost all road user types between 2001 and 2015. Road transport is therefore becoming safer in Europe (European Commission, 2024a).

The European Union intends to contribute to the road safety efforts of the Member States by:

- Setting targets up to 2050 and interim targets and objectives up to 2030: "EU Towards Zero" road safety strategy.

Cite this article as: Péter, B., Sütheö, G., Lakatos, I. (2025) "Accident Risk Analysis of Road Accidents Involving Personal Injury", Periodica Polytechnica Transportation Engineering, 53(3), pp. 301–307. https://doi.org/10.3311/PPtr.38004

Table 1 Road accidents by type of road users (European Commission, 2024a)

Types of road users	Ratio of all known types 2015	Deaths rate between 2010–2015	Deaths rate between 2001–2015
Car users	45%	–21%	–58%
Pedestrians	22%	–15%	–45%
Motorcyclists	15%	–14%	–27%
Cyclists	8%	–2%	–36%
Moped users	3%	–36%	–68%
Caravan users	3%	–17%	–35%
Hev* users	2%	–21%	–62%
Agricultural vehicles	1%	–13%	–43%
Bus users	1%	–5%	–59%
Other road users	1%	33%	1%

* Heavy-duty truck

- The coordination of operations at the EU level will be carried out by the Commission's Executive Board.
- Legislation to fulfil road safety tasks.
- Road safety initiatives, EU goals, targets, and programs are supported, such as the Trans-European Transport Network (TEN).
- Road traffic accidents, injury analysis, and risk exposure monitoring and assessment in the transport and health sectors.
- Research and development of road safety interventions and tools to implement the Safe System, like using radar, cameras and lidar sensors.
- The mandatory introduction of advanced driver assistance systems (ADAS) began in 2015 for heavy-duty vehicles and will begin in 2023 for passenger cars, such as automatic braking system, adaptive cruise control, lane departure warning system and more (European Parliament, 2024; Jagicza et al., 2023).

Looking at the graph from the CARE database in Fig. 1, half of the EU countries exceeded the EU target in 2023 compared to 2013, which meant a 16% reduction

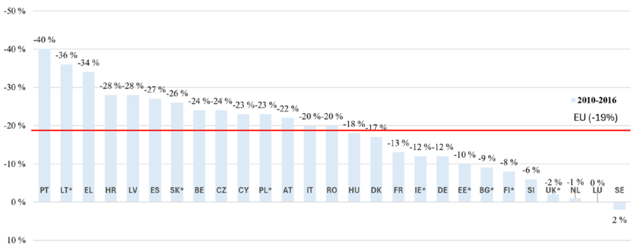

Fig. 1 Relative change in road deaths in the European Union member states between 2013 and 2023 (European Transport Safety Council (ETSC), 2023)

in road deaths. Six countries achieved an outstanding result (above 30%), while data from six countries shows a result below 10%. Hungarian road death statistics show a 19% reduction, which is an average value in the European Union (European Commission, 2023; European Transport Safety Council (ETSC), 2023).

2 Road safety situation in Hungary

The source of the additional information is a review of the accident database for the period 2018-2020, received from the Hungarian National Police Headquarters. This includes the presentation of basic information related to accidents in a systematic form and a descriptive analysis of accident factors and variables (ORFK, 2024).

The analyses presented below are based on the data from the mandatory on-site accident reports pursuant to Article 8(2) of Act XLVI of 1993 (The National Statistical Council, 1993). The aim of the analysis is to systematize the available data and use it to support the planning of practical accident prevention measures (ORFK, 2024).

Within this, the following main themes are examined:

In the first part of the analysis, basic accident data are presented in the next subsections:

- by severity, spatial distribution over time, and by county,
- by basic data on the vehicles involved in the accident, and,
- by the basic accident characteristics of the persons involved in the accident. In the plots, we have presented the database systematics by time series (grouped by month or year) and by county spatial grouping.

In the second part of the analysis, the variables of the main causes of accidents were presented. As in the first part, several subsections are discussed. These are:

- type of accident and distribution of causes,
- environmental variables: distribution by natural environment and road conditions,
- pavement condition,
- road marking, etc.,
- weather and visibility conditions,
- variables related to the vehicles involved in the accident, and,
- human factors.

2.1 Analysis of basic accident data

Due to the design of the database, several records can be linked to a single accident, e.g., separate records for each vehicle and separate records for each casualty. During the data cleaning process, the database is simplified in certain aspects to avoid duplications during visualization.

2.2 The variables of the main causes of accidents

As shown in Fig. 2, the number of accidents has decreased over the years in all severity categories, with an average decrease of 14.7% between categories in 2019 and an average decrease of 28% in 2020. The largest decreases in 2020 were in minor and fatal injuries, with decreases of 30% and 31%, respectively, compared to 2019. Serious accidents accounted for the highest proportion in all three years studied (ORFK, 2024).

Fig. 3 shows the monthly distribution of accidents. The number of incidents increased in the summer months.

The number of accidents and the severity of injuries by area are presented below in Fig. 4. The territorial observation was based on county-level data, with the Budapest territorial area (agglomeration unit) recorded as a separate category, not including the data for Pest County. The first figure below shows the annual cumulative data. It can be observed that the highest number of accidents occurred in the Budapest area in all three years under study, with 638 accidents

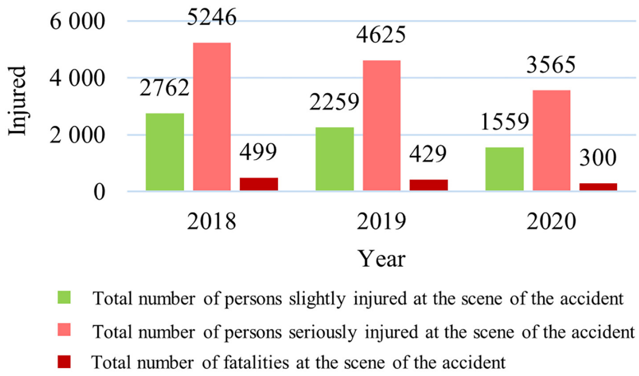

Fig. 2 Distribution of accident severity by year (2018–2020) (ORFK, 2024)

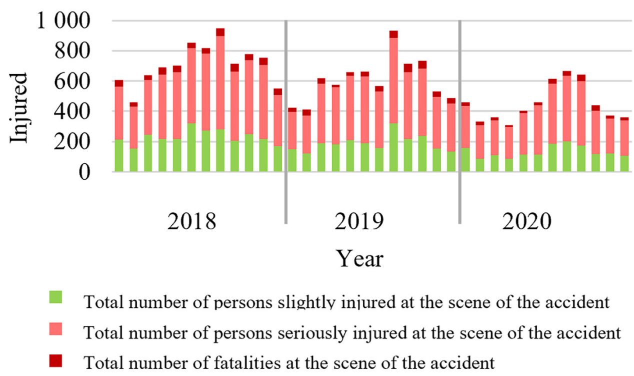

Fig 3 Accidental injury severity per month (people) (ORFK, 2024)

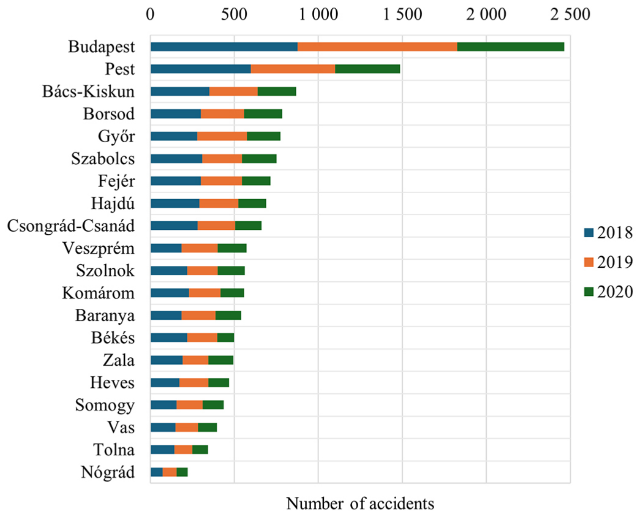

Fig. 4 Breakdown of the number of accidents by county (2018–2020) (ORFK, 2024)

in 2020. This was followed by counties with higher traffic routes, including Pest, Bács-Kiskun, and Borsod counties. Trends between years showed a downward trend, with the exception of a few counties and years, averaging –10.4% in 2019 and –22.2% in 2020. Exceptions include Budapest (+8.5%) and Győr (+5.7%) in 2019. In 2020, without exception, accident rates decreased in all counties (min. –2.6% in Zala, max. –43.8% in Békés) (ORFK, 2024).

Fig. 5 shows a heat map based on the aforementioned high injury severity category, the number of severely injured, with concentrations in the county centres.

Fig. 6 shows that most accidents occurred on roads within built-up areas, followed by other roads, then roads outside built-up areas, and main roads. An analysis of the distribution of casualties by severity shows that there are significant differences between categories. Most fatalities occurred on main roads and roads outside the built-up areas, but roads within the built-up areas ranked first in terms of serious injuries, with a significant difference.

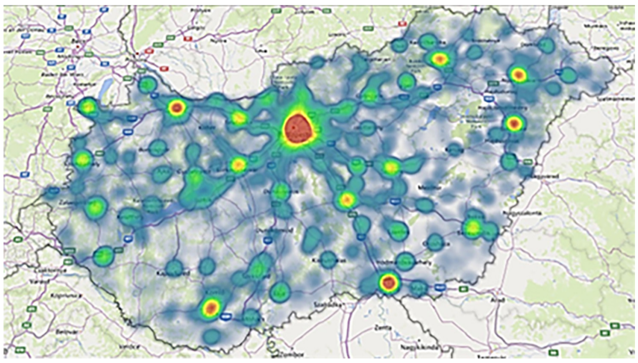

Fig. 5 Heat map by number of severely injured in Hungary (2018–2020) (ORFK, 2024)

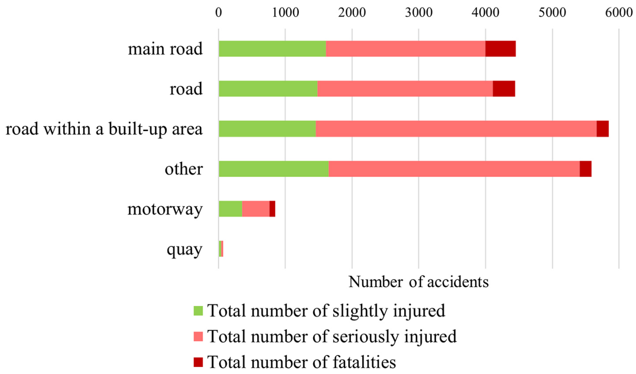

Fig. 6 Distribution by type of public space and severity (by number of fatalities, 2018–2020) (ORFK, 2024)

In this subsection, the number and basic observed characteristics of the vehicles involved in the accident were examined. For the statistics of the vehicles involved, the data used were based on the pedestrian/passenger/animal involved as a unit in Fig. 7. By type of accident causer, vehicles represented the largest proportion of all three years studied (89.9%–91.3%), followed by pedestrians (7.5%–8.9%).

According to another statistical classification in the resulting database (type of accident-causing vehicle), the subtotals of the categories differ slightly, but as shown in Fig. 8, it is possible to distinguish between passenger cars and other types of vehicles. It is worth noting that, in addition to passenger cars (14,100, 53.8%), bicycles

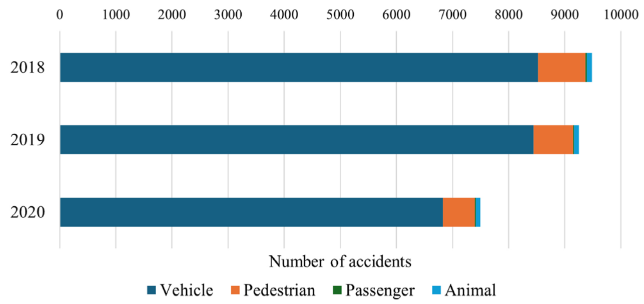

Fig. 7 Breakdown by type of accident by year (2018–2020) (ORFK, 2024)

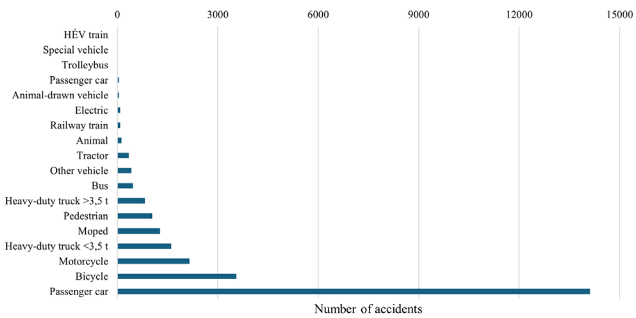

Fig. 8 Breakdown by type of accident (2018–2020) (ORFK, 2024)

(3,600, 13.6%), and motorcycles (2,200, 8.2%), account for a very significant proportion of the accident causes. When designing prevention measures and actions, it is also worthwhile for the enforcement body to take into account the orientation towards these types of vehicles.

Based on the available database, the total number of persons injured in road accidents in the three-year period under review was 30,611, which decreased by 6.8% (10,600) in 2019 compared to 2018 (11,300) and by a further 17.5% (8,700) in 2020.

Fig. 9 shows the role of persons in traffic, which shows that the majority of injured persons, 68% in 2020, were drivers. While the first graph shows the absolute number of injured, the second shows the relative distribution of all injured in a given year. This shows that while the absolute value of all roles except pedestrian casualties in 2019 has decreased over the years, the percentage distribution of drivers has increased slightly compared to the other roles.

The causes of the accidents were divided into seven categories for the analysis, as shown in Fig. 10. Based on the distribution of the individual values, the most common individual cause of accidents was related to road conditions (road alignment, pavement quality), which was the primary cause of 3,497 (2018: 1,355, and 2019: 1,163, and 2020: 979) accidents based on the field data. At the same

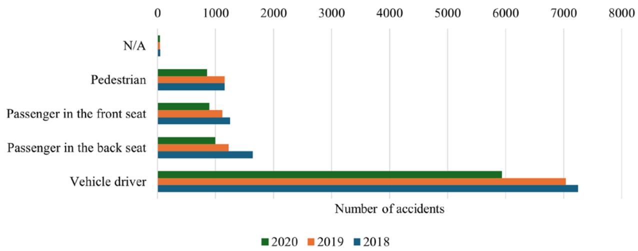

Fig. 9 Percentage distribution by role in traffic by year (2018–2020) (ORFK, 2024)

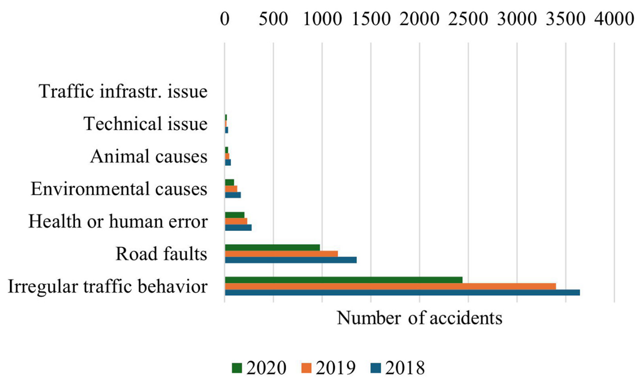

Fig. 10 Breakdown of the number of accidents by contributing cause (2018–2020) (ORFK, 2024)

time, when looking at the cause categories, the category causing the most accidents was irregular traffic behaviour. Examples of specific causes in this category include failing to yield the right of way, obstructing traffic, overtaking, and disregarding road signs.

In addition to these two critical categories, the most common cause categories were health or human error causes, environmental causes, and technical failure causes, as shown in Fig. 11 below. When grouped by the severity of injuries from the different causes, as shown in the next graph, the order of criticality changes slightly.

Weather conditions and visibility are assumed to be related, also taking into account the influence of the time of day. Consequently, the distribution of these two variables, along with their absolute values, is plotted in Fig. 12 according to their relative (100%) distribution across the months. In the latter case, in order to contribute to the development of month-by-month procedural strategies, average distributions for the same months were calculated based on the three years of data examined. Filtered by month, the weather conditions show that mainly cloudless (68.9% of accidents) and overcast (21.7%) conditions predominated. Additionally, foggy weather was a significant factor, particularly from September to March (on average, 9% of accidents occurred in these months).

The distribution of accident visibility is similar to weather conditions, but the influence of the time of day is more noticeable in this study. The categories, day, natural light' and ‚night, street lighting in operation' differ the most between the months of the year. The next chart, Fig. 13 shows that the number of accidents at night typically increased significantly between September and March, months in which measures could be more focused on night-time prevention.

Among the accident factors related to roads, besides the condition of the road surface, features such as traffic direction, road layout, traffic control methods, and other traffic characteristics are also included. We analysed these characteristics descriptively in the distribution of all examined accidents, which is presented in Fig. 14. According to road conditions, 56% of accidents occurred on straight road sections, followed by crossroads with a share of 27%.

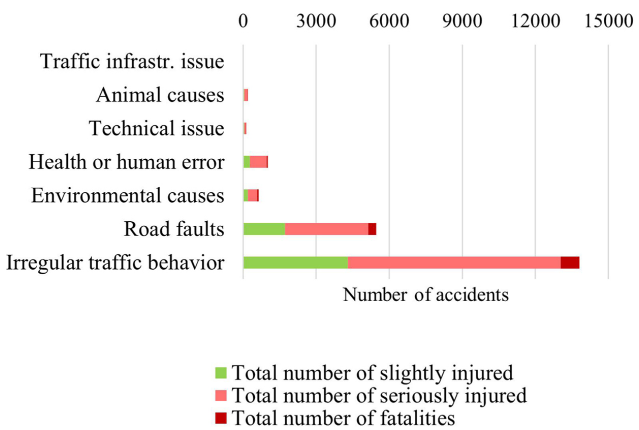

Fig. 11 Distribution of injuries by severity and cause (2018–2020) (ORFK, 2024)

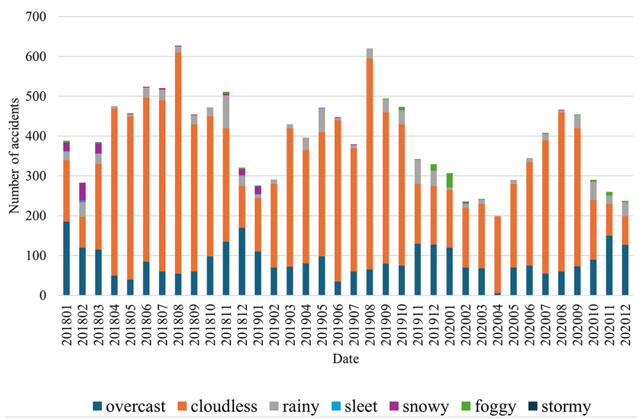

Fig. 12 Absolute distribution of the number of accidents by weather conditions and months (2018–2020) (ORFK, 2024)

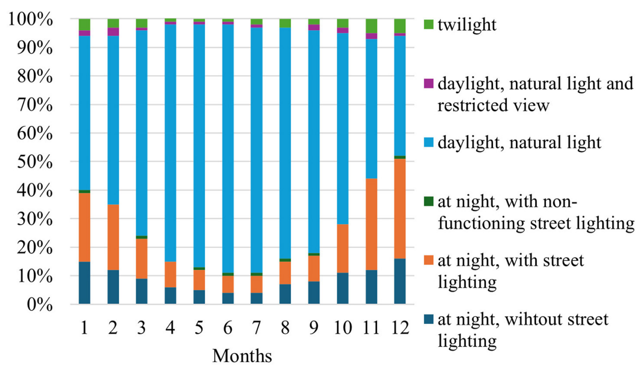

Fig 13 Relative distribution of the number of accidents by visibility conditions generalized for the month of occurrence (2018–2020) (ORFK, 2024)

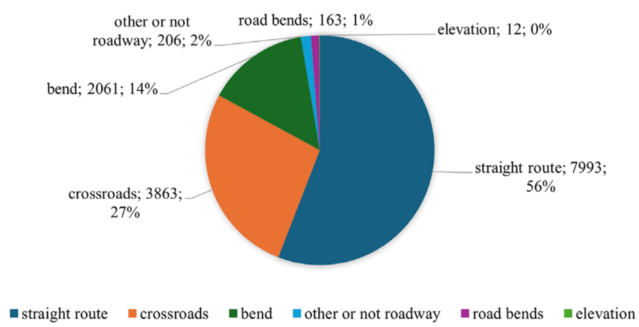

Fig. 14 Distribution of accidents by road conditions (2018–2020 aggregated) (ORFK, 2024)

The category of road bends (one or more) was characteristic of the accident scene in more than 2,200 cases.

The condition of the road surface appeared as a factor influencing accidents in two variables. Although poor condition is not primarily a characteristic cause of accidents, its role combined with other influencing factors can increase the likelihood of accidents occurring. Fig. 15 shows that in most cases, however, the road surface was flawless (70.3%), with the second most common category showing minor deterioration (cracking, unevenness, waviness). This latter category was characteristic of 3,700 accidents, and when combined with more serious road surface issues (ruts, holes, potholes), it was present in 28.4% of all accidents, totaling more than 4,000 cases. However, these are not necessarily the direct causes of the accidents. Referring back to the analysis of previous causes of accidents, reasons arising from road characteristics (which include traffic conditions such as crossroads and road bends, besides the condition of the road surface) were linked to a total of 3,500 accidents.

Alcohol and drugs, as mind-altering substances, are also human factors that significantly influence the outcome of accidents. We examined these factors based on post-accident checks. Out of 30,600 injured individuals, 19,500 were tested for alcohol, with 92% yielding negative results. Among those under the influence of alcohol, the majority had higher blood alcohol levels, with 591 out of the 1,600 individuals tested over the three years having blood alcohol levels above 1.51‰ / 0.76 mg/L. In cases where blood alcohol levels were tested, the results were distributed as shown in Fig. 16.

Fig. 17 shows the influence of drugs as a human factor showed a lower rate of positive results in tests examining this (3% of tests). Among injury cases, those involving drivers testing positive for drugs showed the highest

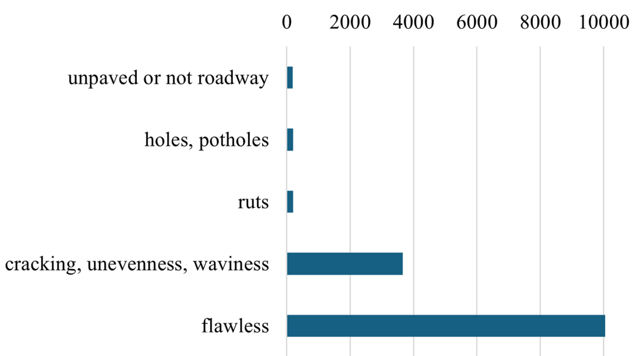

Fig. 15 Distribution of accidents by road pavement condition (2018–2020 aggregated) (ORFK, 2024)

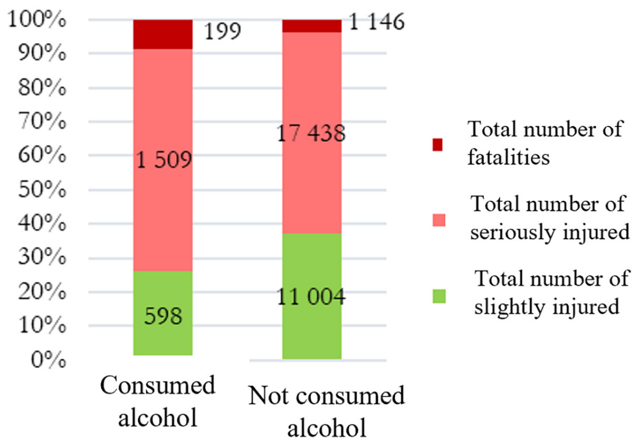

Fig. 16 Distribution by severity of alcohol-related injuries (2018–2020) (ORFK, 2024)

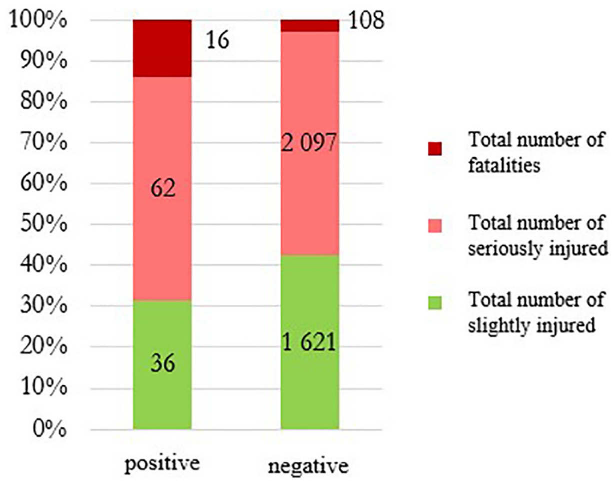

Fig. 17 Distribution of drug test results and injury severity rates (2018–2020) (ORFK, 2024)

increase in fatalities. Similarly to other human factors mentioned earlier, the number of positive drug tests also increased from 22 to 26 annually between 2018 and 2020.

3 Reducing traffic risks for vulnerable road users

In the EU, approximately 95% of all road traffic accidents are caused by human error, and in 2017 alone, 25,300 people died on the European Union's roads. Driverless cars and trucks can drastically reduce these numbers and improve road safety, while new digital technologies can reduce traffic congestion and decrease greenhouse gas and air pollution emissions. Mobility can also be improved, for example, by opening road transport to the elderly and people with reduced mobility or disabilities (Lakatos, 2021; Muslim and Antona-Makoshi, 2022).

Automated cars are equipped with sensors, built-in cameras, on-board computers, high-precision GPS, satellite receivers, lidars, and short-range radars, and they perform some or all driving tasks. Vehicle assistance systems (levels 1 and 2 of automation) are already present in the European market, such as pre-collision safety systems, which are effective in avoiding collisions with pedestrians and bicycles. Fully automated vehicles (level 5) will arrive starting in 2030 (Sütheö, 2021).

Important traffic safety checks for:

- Truck and bus: The aim of the inspection is to check compliance with the rules on driving and rest periods, the rules on the transport of dangerous goods by road, and the legality of entry and staying in the country.
- Seat belt: Checking seat belt use,
- Speed: Speed control (overspeed),
- Drugs and alcohol: Testing,
- Focus on the road: The inspection covers the use of handheld mobile phones while driving, the use of navigation devices, the use of communication devices (tablet, laptop), other distracting activities (watching TV/DVD, reading newspapers), eating/drinking, and the use of headphones/earbuds in both ears.

4 Conclusion

Improving road safety, especially for vulnerable road users, can fundamentally be achieved by enhancing human and technical conditions. In both aspects, the widespread adoption and use of artificial intelligence and highly autonomous vehicles are promising. Naturally, during the transitional period, it is important to implement road safety actions and campaigns (by the police) and utilize technical equipment built into cars, like advanced driving assistant systems (for example, emergency braking systems).

Acknowledgement

The article was supported by the Széchenyi István University – Zalaegerszeg Innovation Park.

References

Elvik, R. (2024) "The development of a road safety policy index and its application in evaluating the effects of road safety policy", Accident Analysis and Prevention, 202, 107612. https://doi.org/10.1016/j.aap.2024.107612

European Commission (2023) "Road safety statistics 2023 in more detail", [online] Available at: https://transport.ec.europa.eu/background/road-safety-statistics-2023_en [Accessed: 07 May 2025]

European Commission, (2024a) "Serious injuries", [online] Available at: https://road-safety.transport.ec.europa.eu/european-road-safety-observatory/data-and-analysis/serious-injuries_en [Accessed: 07 May 2025]

European Commission, (2024b) "2024/1679 Trans-European transport network (TEN-T)", [online] Available at: https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t_en [Accessed: 07 May 2025]

European Parliament (2019) "Self-driving cars in the EU: from science fiction to reality", [online] Available at: https://www.europarl.europa.eu/topics/en/article/20190110STO23102/self-driving-cars-in-the-eu-from-science-fiction-to-reality [Accessed: 07 May 2025]

European Parliament (2024) "Road traffic and safety provisions", [online] Available at: https://www.europarl.europa.eu/factsheets/en/sheet/129/road-traffic-and-safety-provisions [Accessed: 07 May 2025]

European Transport Safety Council (ETSC) (2023) "Road deaths in the European Union – latest data", [online] Available at: https://etsc.eu/euroadsafetydata/ [Accessed: 07 May 2025]

Jagicza, M., Sütheö, G., Kocsis-Szürke, S., Őri, P., Lakatos, I. (2023) "Kalibráció hatása személyautó Front Assist rendszerének működésére", (Effect of calibration on the operation of a car's Front Assist system), XVII. IFFK Conference, Budapest, Hungary, pp. 1–7. ISBN 978-963-88875-3-5 (in Hungarian) [online] Available at: https://mmaws.bme.hu/2023/pages/program/papers/IFFK_2023_Paper_17_Jagicza-Sutheo-Kocsis-Szurke-Ori-Lakatos.pdf [Accessed: 07 May 2025]

Lakatos, I. (2021) "Traffic accidents involving personal injury, accident risk analysis, formulation of proposals for action", Universitas, Győr, Hungary.

Muslim, H., Antona-Makoshi, J. (2022) "A review of vehicle-to-vulnerable road user collisions on limited-access highways to support the development of automated vehicle safety assessments", Safety, 8(2), 26. https://doi.org/10.3390/safety8020026

Országos Rendőr-főkapitányság Rendészeti Főigazgatóság (ORFK) (2024) "2010–2020. évek közötti időszak statisztikai kimutatása", (Statistical statement for the period of 2010–2020), (in Hungarian) [online] Available at: https://www.police.hu/sites/default/files/Kozlekedesrendeszet%20SK%202020_12.pdf [Accessed: 12 June 2024]

Sütheö, G. (2021) "Univerzális tartószerkezet radar-szenzor járműszintű teszteléséhez", (Universal support structure for vehicle-level testing of radar sensors), Level (MSc), Széchenyi István University. (in Hungarian) [online] Available at: https://szerep.sze.hu/hu/record/-/record/123456789-5329 [Accessed: 07 May 2025]

The National Statistical Council (1993) "Act XLVI of 1993 on statistics".