Received: 12 November 2024 | Revised: 15 January 2025 | Accepted: 8 April 2025 | Published online: 1 May 2025

RESEARCH ARTICLE

Archives of Advanced Engineering Science
2025, Vol. 00(00) 1–15
DOI: 10.47852/bonviewAAES52024784

BON VIEW PUBLISHING

Review of the Road of Safety in the Years 2001–2023

Piotr Gorzelańczyk[1,*]

[1]*Transport Department, Stanislaw Staszic State University of Applied Sciences in Pila, Poland*

Abstract: Polish roadways are seeing an annual increase in the number of automobiles. Even though the frequency of traffic accidents is declining, many individuals lose their lives and suffer serious injuries each year. Driving while intoxicated or under the influence of drugs is the leading cause of traffic accidents and a major problem on Polish roads. Over 80 accidents occur every day on average in recent years, resulting in 7 fatalities and over 1,000 injuries. For this reason, it makes sense to examine Poland's road traffic safety situation from 2001 to 2023 in order to make improvements. On the basis of the research carried out, it was found that the highest number of accidents occurs in the holiday months, on Friday, during the day, in the afternoon, in good weather conditions, and in a built-up area on a straight section of road. On the basis of a review of the state of security in Poland in the years 2001–2023, solutions are proposed to improve the state of road safety in Poland.

Keywords: traffic accidents, road traffic collision, road safety

1. Introduction

Road traffic safety (RTS) depends on many factors. Human behavior is the most significant of these; driving by someone under the influence of drugs or alcohol is a common occurrence on Polish roads. Human behavior is most often influenced by road solutions and vehicle design, which can help drivers to make the right decisions in critical driving situations or limit the consequences of their mistakes. Unfortunately, the life or health of other road users often depends on the decision of one driver. Developments in traffic technology are increasingly aimed not only at mitigating the consequences of accidents but also at avoiding them altogether. Despite all kinds of innovative safety systems in vehicles, common sense must be used when using them. Despite modern equipment in vehicles that makes traveling easier, this does not relieve the driver of the duty to concentrate fully when driving the means of transport. It should be kept in mind that the driver is in charge of the speed at which the car he is operating.

Numerous articles have addressed the issue of RTS. Road traffic risk indicators were found by Pałegą [1]. At the provincial level, Wachnicka [2] examined the variables influencing RTS. Rafalski [3] examined RTS in Poland with a focus on big trucks. Additionally, studies have examined the reasons behind traffic accidents [4, 5]. Professional drivers' risky driving behaviors were examined by Gądek-Hawlena and Los [5], who also evaluated how heavy vehicle solutions affected RTS [6, 7]. Publications [8, 9] and books [10, 11] also include general information on RTS. Road accident data also include this subject [12]. Previous studies [13–35] also addressed issues related to road safety.

With the exception of 2020 and the ongoing pandemic, Poland's automobile market is expanding gradually. There were 26,457,659 passenger automobiles registered in 2022 [12]. Ten years ago, there were 18,744,412 units. Additionally, the number of cars per 1,000 people is rising annually. Poland ranked 15th in Europe in 2011 with 470 cars per 1,000 people, according to the European Automobile Manufacturers Association (ACEA). According to the most recent data, Poland will rank first in Europe in 2024 when this number rises to 703 cars [36].

The average age of automobiles on Polish roads is over 15 years, compared to 12.3 years for the entire EU, according to ACEA data. This was certainly made possible by Poland's admittance into the Schengen region and its membership in the European Union. As a result, mass car imports began, and international trade flourished. The number of cars and tractors registered in Poland is shown in Figure 1 [37].

The article's goal is to analyze Poland's safety situation from 2001 to 2023 and the associated road traffic environment. The events that take place there, as well as the connections between the behaviors of the participants and the results of those behaviors. Road accidents in the context of RTS are the focus of the study. The research's objectives are to learn more about the perception of safety and the conditions and causes of traffic accidents.

2. Materials and Methods

The information above will show the key beneficiaries and the directions of the safety improvement programs that have been put into place. The main goal of the survey is to provide answers to the following question: What measures should be taken to increase

***Corresponding author:** Piotr Gorzelańczyk, Transport Department, Stanislaw Staszic State University of Applied Sciences in Pila, Poland. Email: pgorzelanczyk@ans.pila.pl

Figure 1
Number of registered vehicles in Poland between 1999 and 2023

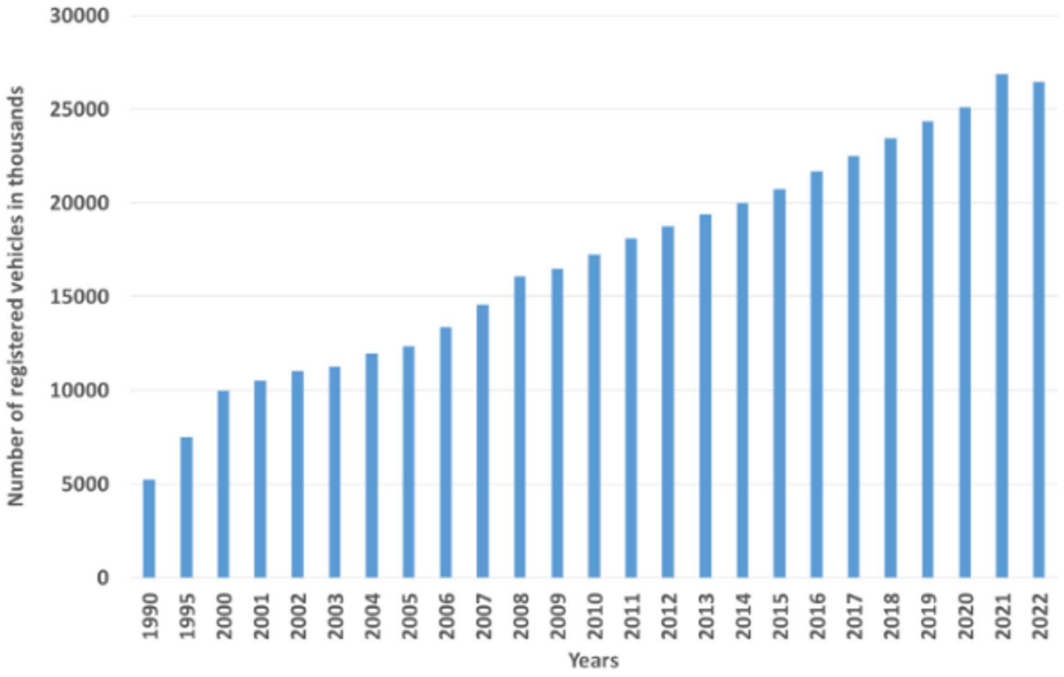


Figure 2
Accident, injury, and death trends from 2001 to 2023

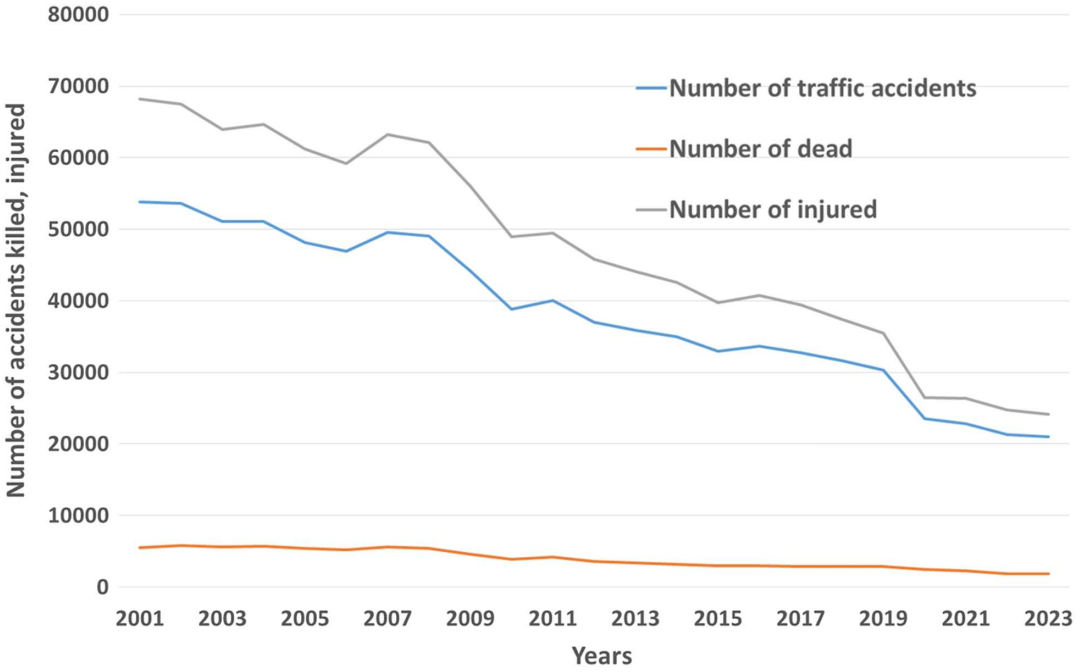


Figure 3
Trend of accidents, injuries, and fatalities between 2001 and 2023 per number of vehicles

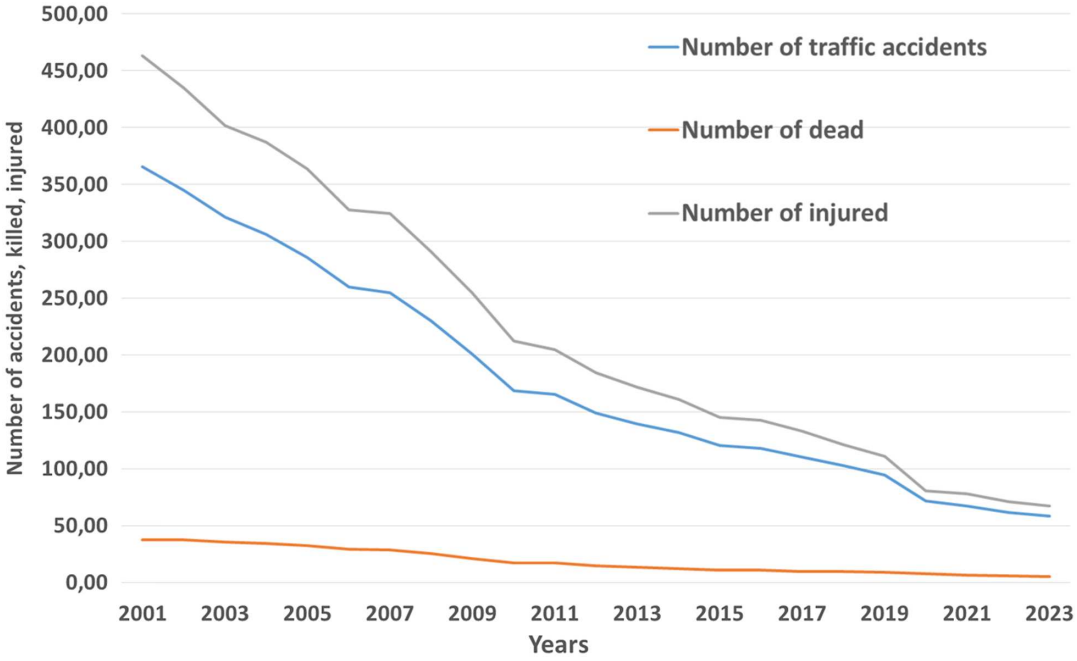
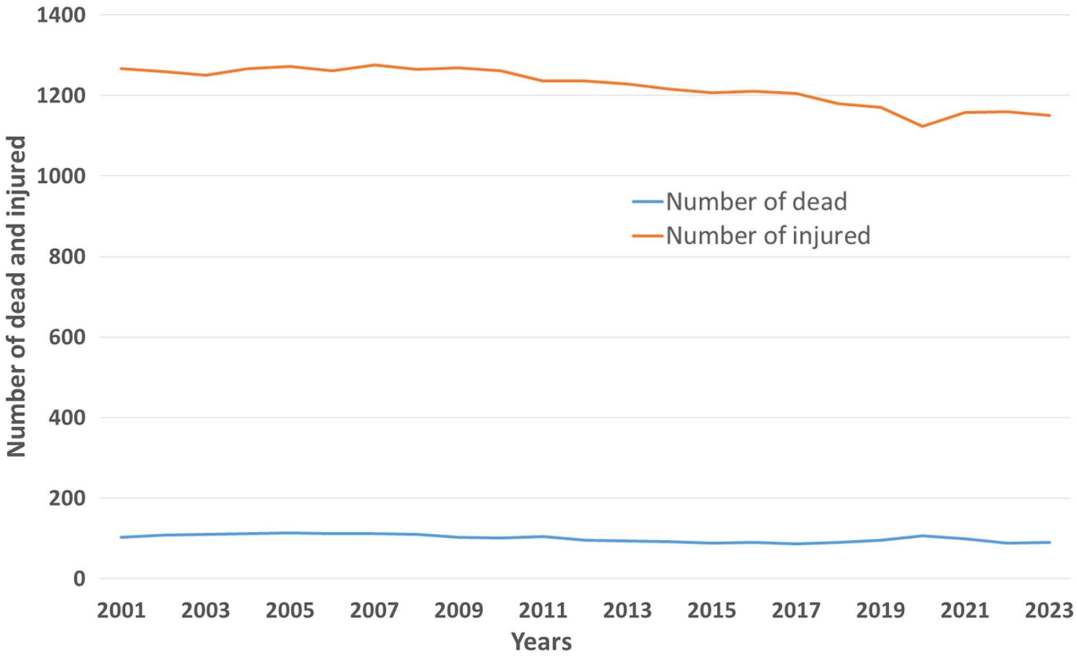


Figure 4
Dynamics of changes in the rate of fatalities and injuries per 1,000 accidents [1]



road safety and reduce the frequency of accidents? This subject was addressed by analyzing statistical data on traffic accidents in Poland from 2001 to 2023 that were provided by the National Police Headquarters. Although statistics on the number of accidents in Poland may be available from 1975, this time frame was selected since there was a dearth of comprehensive statistical data from previous years. But all that was available was data on the quantity of accidents, injuries, and fatalities. To complete the analysis, information from the Polish Motor Association (PZMOT) and the Central Statistical Office was used.

3. Results

Based on statistics from the Polish Police, there were 884,021 accidents on Polish roads between 2001 and 2023, resulting

Figure 5
Average number of accidents, killed, and injured by month

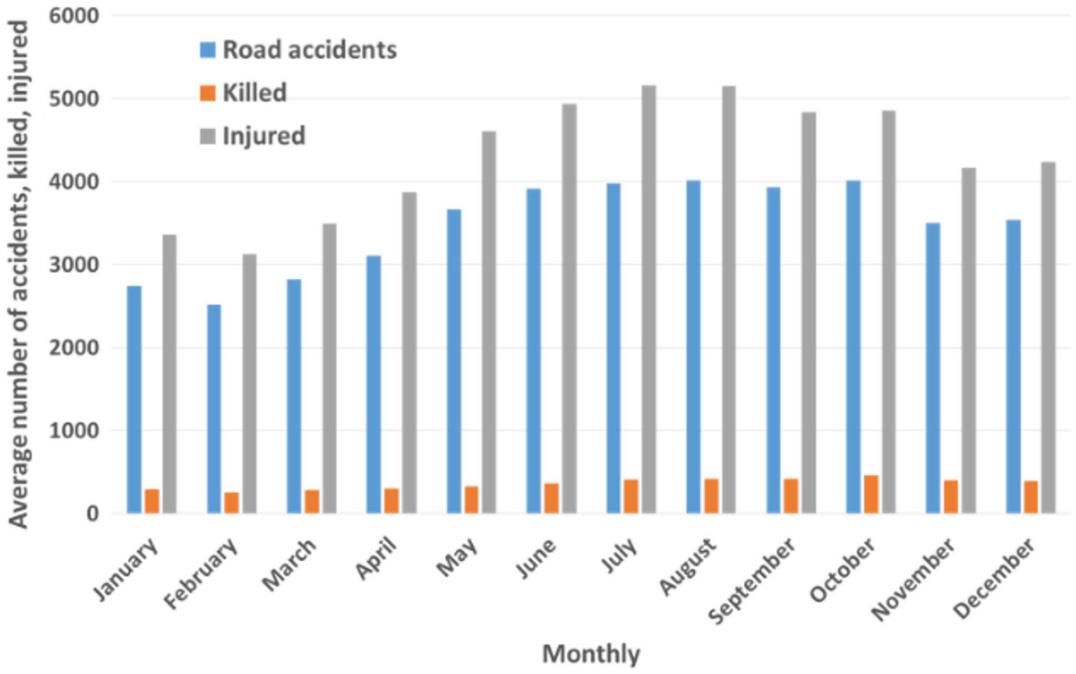
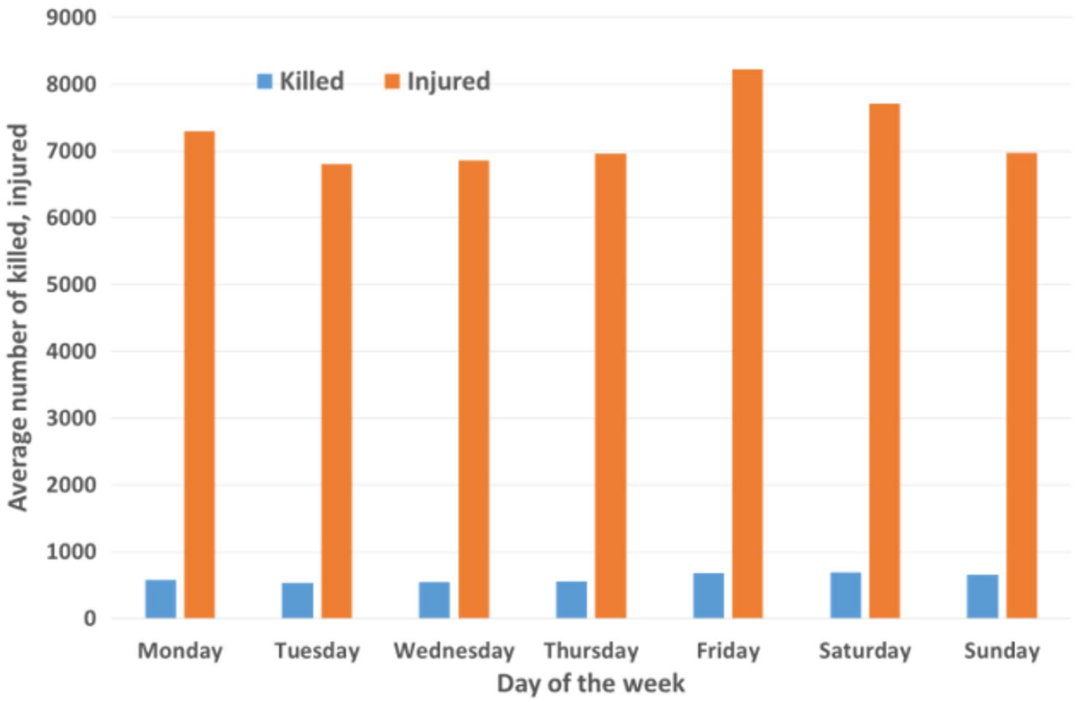


Figure 6
Average number of killed and injured depending on the day of the week



in 90,309 fatalities, 1,091,375 injuries, and 8,913,544 collisions (Figure 2 [12]). According to statistical analysis, the year 2001 had the most accidents, while 2023 had the fewest. With the exception of 2020, when fewer cars were on the road because of the ongoing pandemic, the frequency of crashes rose with time. In 2001, there were 342,408, and in 2023, there were 365,991. In 2012, there were 339,581 collisions, the fewest ever reported. The largest number of injuries occurred in 2001 (68,194), while the lowest

Figure 7
Average number of accidents, killed, and injured by hour

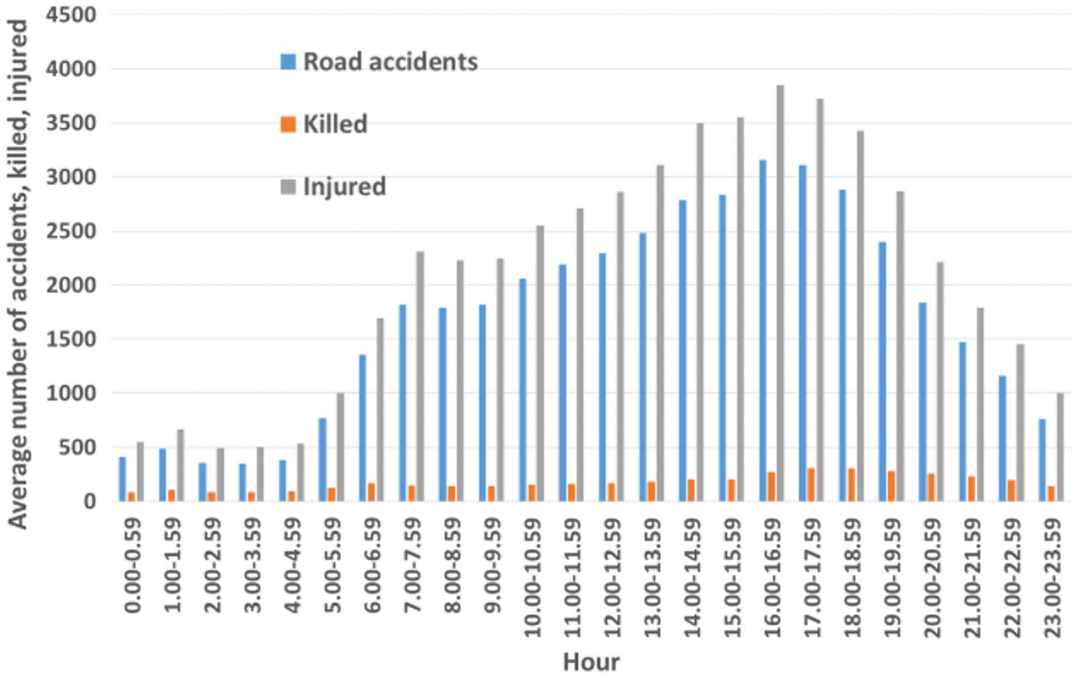
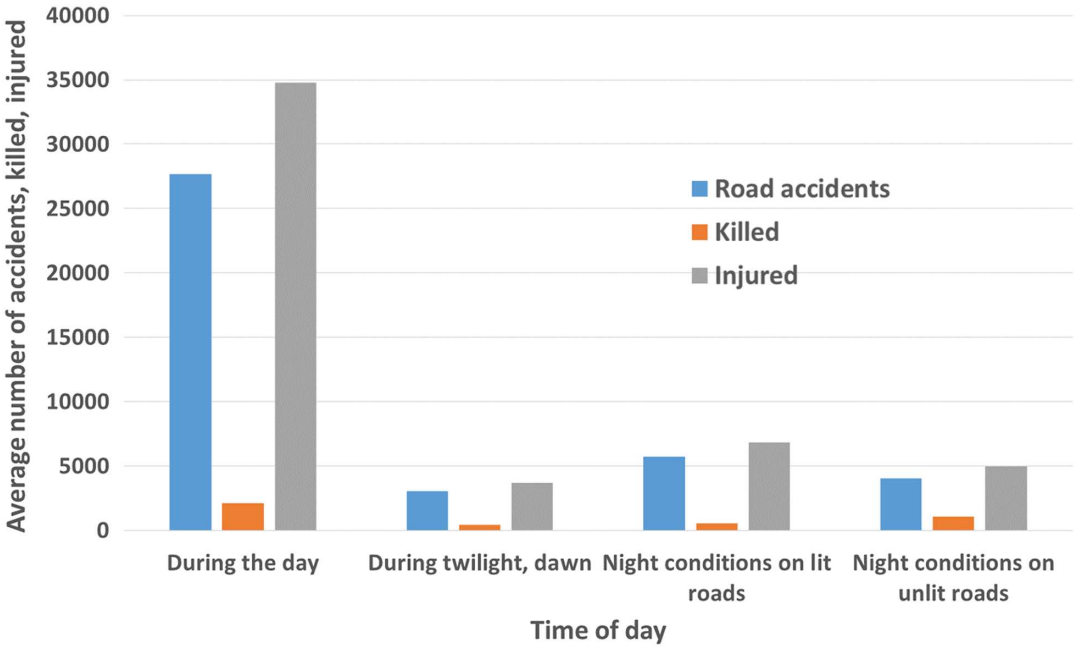


Figure 8
Average number of accidents, fatalities, and injuries by time of day



number occurred in 2023 (24,125). The greatest number of fatalities occurred in 2002 (5,827), while the lowest number occurred in 2023 (1,893). Additionally, it should be mentioned that throughout the time under analysis, there were more injuries than accidents [12]. Compared to 1975, when accident statistics were maintained, 2023 had the fewest traffic accidents. This is because traffic restrictions were implemented as a precautionary measure during the SARS-CoV-2 outbreak (Figure 2 [12]).

Road accidents have been declining annually in Poland, even though the number of cars on the road has been rising (Figure 1 [37]). For this purpose, the density of vehicles and its influence on the number of accidents (W_i), fatalities (O_i), and injuries (R_i) in

Table 1
Rate of accidents, fatalities, and injuries per 100,000 inhabitants

Voivodeship/rate per 100,000 inhabitants	Accidents	Killed	Injured
Dolnośląskie	88,43	9,13	112,74
Kujawsko-pomorskie	72,13	10,83	85,89
Lubelskie	80,73	11,50	98,34
Lubuskie	73,41	11,56	95,55
Łódzkie	156,01	12,51	190,81
Małopolskie	117,85	10,00	146,68
Mazowieckie	115,16	17,36	141,33
Opolskie	84,13	10,40	102,90
Podkarpackie	87,63	8,78	108,52
Podlaskie	72,14	12,13	88,81
Pomorskie	119,33	9,10	152,22
Śląskie	99,12	9,26	121,12
Świętokrzyskie	117,75	13,34	146,99
Warmińsko-mazurskie	109,41	12,54	138,10
Wielkopolskie	103,45	10,62	128,30
Zachodniopomorskie	89,08	9,95	108,47

Figure 9
Accident rate per 100,000 inhabitants by voivodeship

Figure 10
Rate of deaths per 100,000 inhabitants by voivodeship

Figure 11
Injury rate per 100,000 inhabitants according to voivodeship

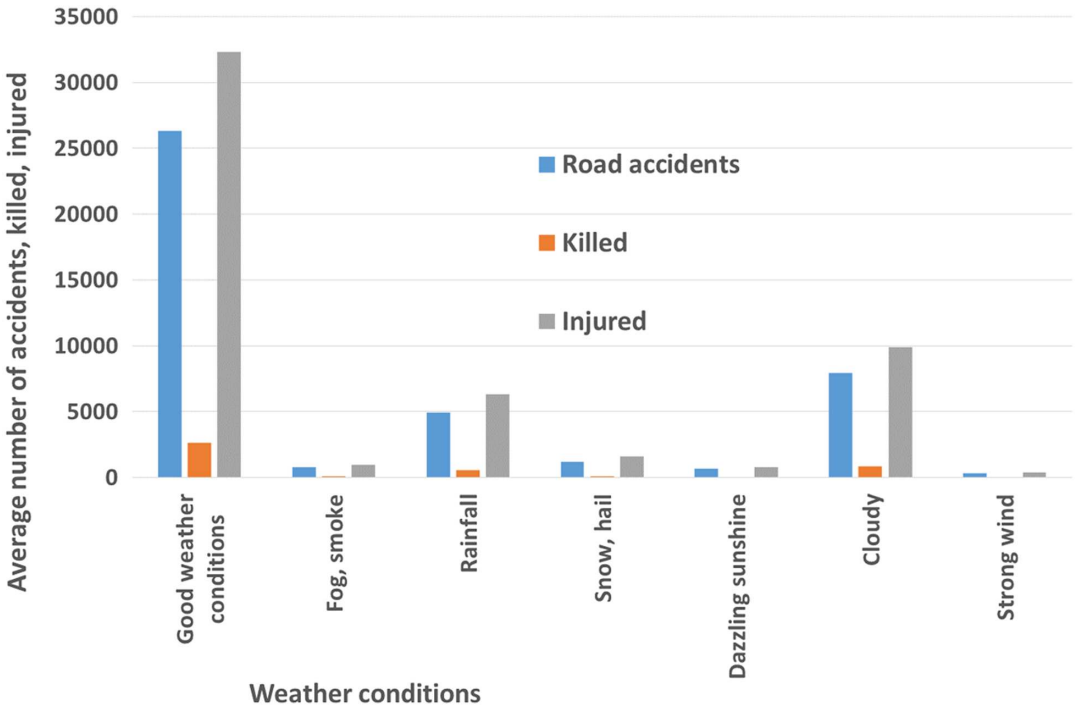
relation to the number of registered vehicles in a given year (L_{poj}) was analyzed in Equation (1). This is mainly due to road safety campaigns and the equipping of cars with ever newer safety systems. In the period under discussion, there was a downward trend in the analyzed indices. When it comes to traffic accidents and injuries, this is most evident. Despite the pandemic, the death rate is essentially unchanged in 2023. It should be mentioned that during the past 23 years, there has been a threefold decrease in the frequency of accidents and fatalities per registered car (Figure 3 [12, 37]).

$$W_i = W_l * \frac{100000}{L_{poj}};\ O_i = O_l * \frac{100000}{L_{poj}};\ R_i = R_l * \frac{100000}{L_{poj}} \quad (1)$$

Where:
W_l – number of accidents
O_l – number of fatalities
R_l – number of injured

Another indicator analyzed is the number of fatalities O_{i1} and injured R_{i1} in relation to 1,000 accidents (Equation (2)). During the

Figure 12
Average number of accidents, killed, and injured by weather conditions



period in question, there was a downward trend in the number of injuries. In contrast, the rate of fatalities is practically stable. It is worrying that this rate increased in 2023, when there was a pandemic and fewer vehicles on the roads (Figure 4).

$$O_{i1} = O_l * \frac{1000}{W_l};\ R_{i1} = R_l * \frac{1000}{W_l} \tag{2}$$

The following section analyzes the average time spent producing accidents between 2001 and 2023. For this purpose, the total number of accidents was divided into the number of years analyzed. According to the study given, most accidents happen in the afternoons of the day (16:00–18:00) during the holiday months of July and August, and the fewest happen at night and in the winter, when there is less traffic and people drive more defensively. A similar relationship can be observed for the number of people injured, which is highest during the summer period, on Friday, in the afternoon (14:00–18:00), and during the day. In contrast, the number of people killed is more even regardless of the month, time of day, day of the week, and hour (Figures 5–8 [12]).

The areas with the greatest number of traffic accidents, fatalities, and injuries were then analyzed. The indicator of incidents per 100,000 residents was added to the data to help with data unification (Table 1 [12]). The Mazowieckie Voivodeship, which includes Warsaw, the Polish capital, has, without a doubt, the largest number of accidents, fatalities, and injuries. Figures 9–11 [12] show that Lubuskie Province had the fewest accidents, Dolnośląskie Province had the fewest fatalities, and Kujawsko-Pomorskie Voivodeship had the fewest injuries.

The average number of accidents, fatalities, and injuries, depending on weather conditions, road geometry, area, and type of road, was also analyzed for the period under study. On the basis of the presented graphs (Figures 12–15 [12]), it may be concluded that most accidents occur in good weather conditions on a straight section of road or crossroads, in built-up areas, and on two-way, single-carriageway roads, which are the most numerous in Poland. As a result, a rapid road segment has a high incidence of fatalities and injuries during favorable weather circumstances. While the number of fatalities is similar across all locations, the number of injuries is significantly higher in urban areas than in rural ones. Bravado on the road is mostly to blame for this.

Inappropriate human behavior is the leading cause of traffic accidents. The most important element is the man and his actions. According to RTS, drivers were responsible for 727,528 incidents between 2001 and 2023, or 82% of all accidents (Figure 16 [12]). Accidents were mainly caused by people aged 25–39 years (34%) and 40–59 years (26%). However, when counting the number of accidents per population, most accidents were caused by people aged 40–59 (27%) and people over 60 (25%) (Figures 17 [12] and 18 [12, 37]).

Driver-caused accidents occurred during the time under discussion (Figure 19 [12]), with the most common ones being:

1) failure to adjust speed to traffic circumstances (23%),
2) failure to cede the right of way (21%),
3) inappropriate overtaking (5%),
4) inappropriate pedestrian behavior (11%),
5) incorrectly crossing a zebra crossing (7%)
6) not giving priority to a pedestrian on a crosswalk (7%).

In the analyzed period, the most frequent causes of road accidents were pedestrians (29%), side collisions of moving vehicles (26%), and frontal and rear-end collisions of moving vehicles (11%) (Figure 20 [12]). Accidents mainly occurred on the carriageway (74%) and at pedestrian crossings (11%), involving a passenger car (75%) or a bicycle (7%) (Figures 21 and 22 [12]).

The number of road accidents caused by technical failures per 100,000 registered vehicles in the years 2001–2023 is shown in

Figure 13
Average number of accidents, killed, and injured by area

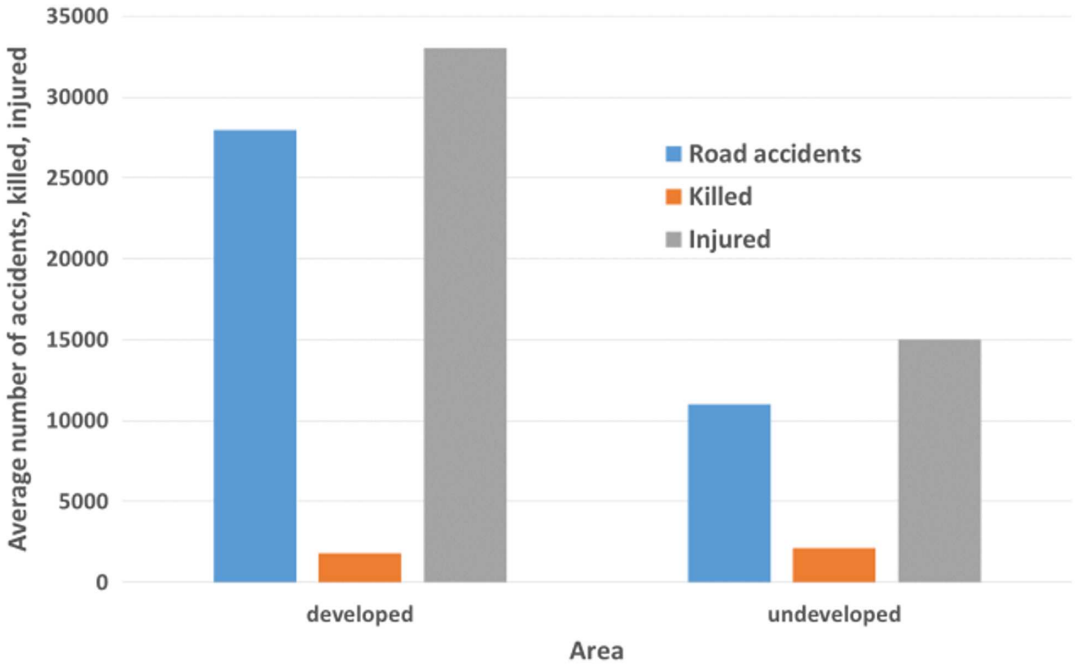


Figure 14
Average number of accidents, killed, and injured depending on road geometry

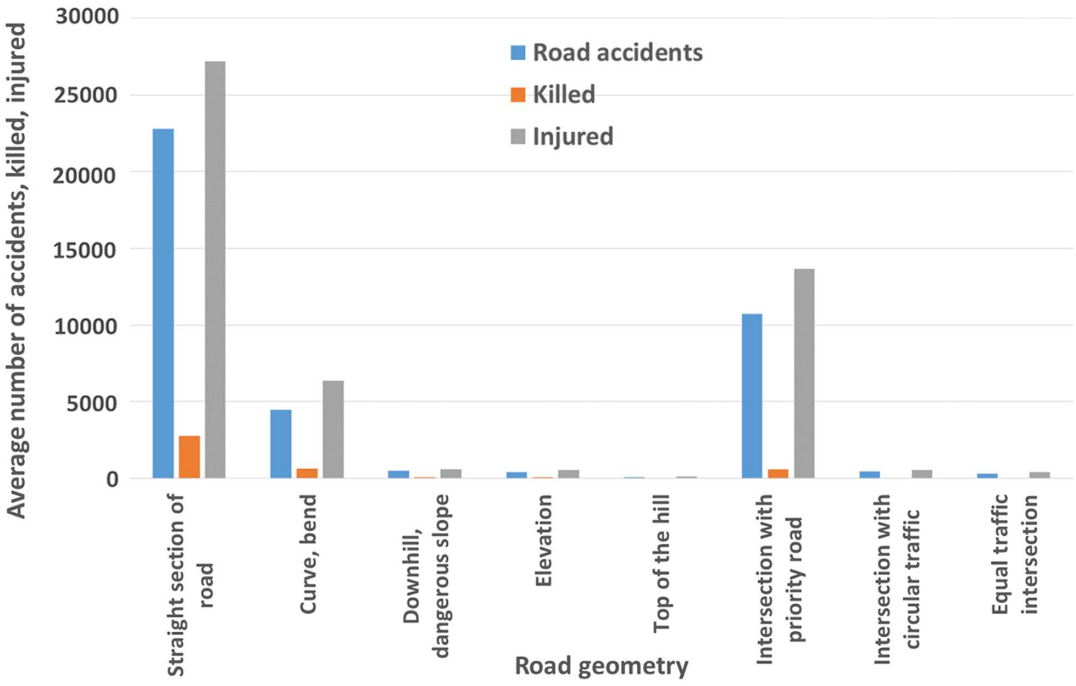


Figure 15
Percentage of accidents by road type

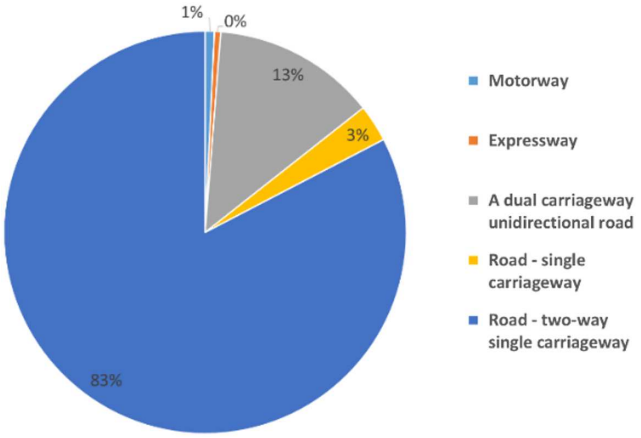


Figure 16
Percentage of the number of accidents according to the perpetrator of the accident

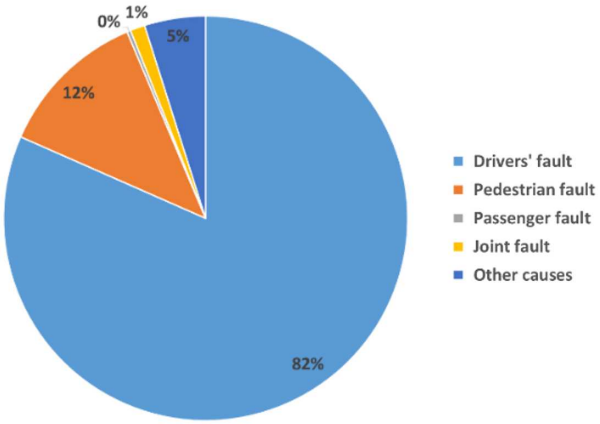


Figure 23 [12]. The value of this indicator in relation to 100,000 registered vehicles shows a sharp increase in 2006. This was caused by a large number of cars imported from abroad, whose technical condition was not verified. According to ACEA data on Poland's rapidly growing automobile population, the number of accidents caused has significantly increased in recent years. Defects in the braking system, illumination, and tires were the primary technical causes of traffic accidents throughout the time under analysis (Figure 24 [12]). In this case, there is no data on a number of vehicles that were involved in accidents and are still in use, but not always reliably repaired.

4. Conclusions

Analyzing the above data, one may come to a conclusion that it is mostly man and his behavior that contributes to the highest number of road accidents. Accidents caused by drivers, pedestrians, and passengers account for 94% of all accidents in the analyzed period from 2001 to 2023. This shows that the human factor is the most dangerous factor influencing RTS. Mistakes made by drivers and other

Figure 17
Percentage of the number of accidents according to the age of the perpetrator

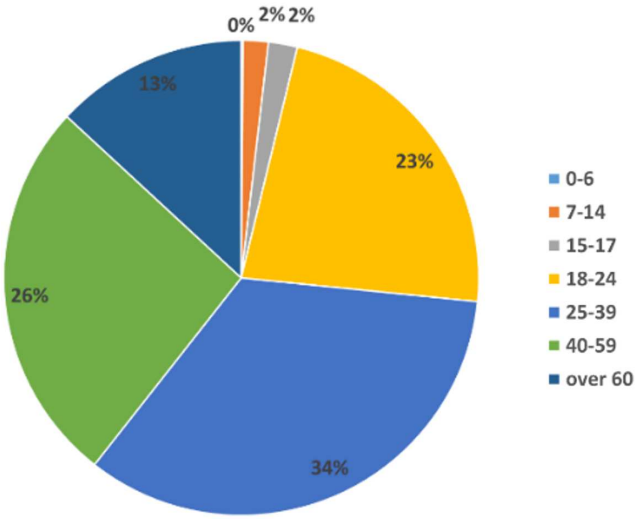
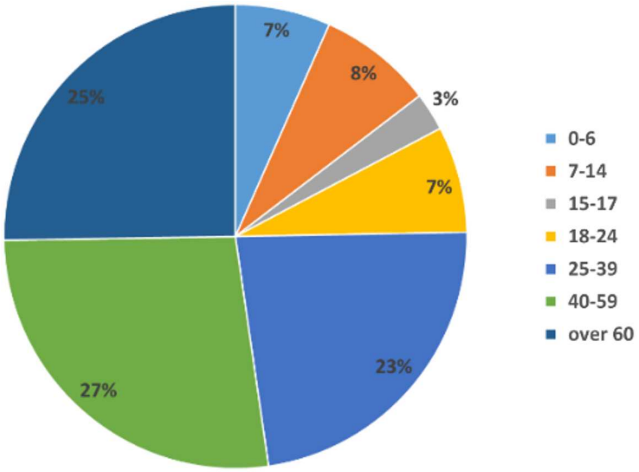


Figure 18
Percentage of accidents per 100,000 population according to the age of the perpetrator



road users can be divided into inattention, carelessness (e.g., not keeping a safe distance between vehicles [5.17% of accidents]), and intentional mistakes (e.g., not adapting speed to road conditions [22.7% of accidents]). This last factor is the most dangerous and, at the same time, the most frequent cause of driver accidents. Excessive speed is not only the cause of more accidents, but also of more injuries and fatalities in accidents outside built-up areas. As a result, there has been a significant decrease in RTS, and Poland is in the lead among the countries with the highest number of road accident fatalities and the highest road danger measured by the number of fatalities.

An equally dangerous situation on the road is not giving priority, which is the second most frequent cause of accidents. It can result from impaired psychomotor skills of drivers, from

Figure 19
Percentage share of the number of accidents depending on the cause

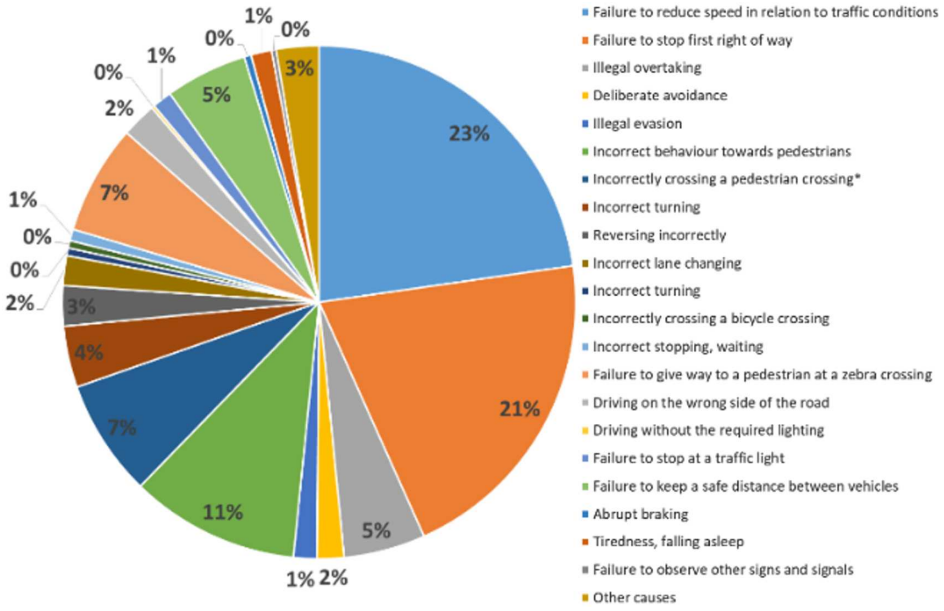
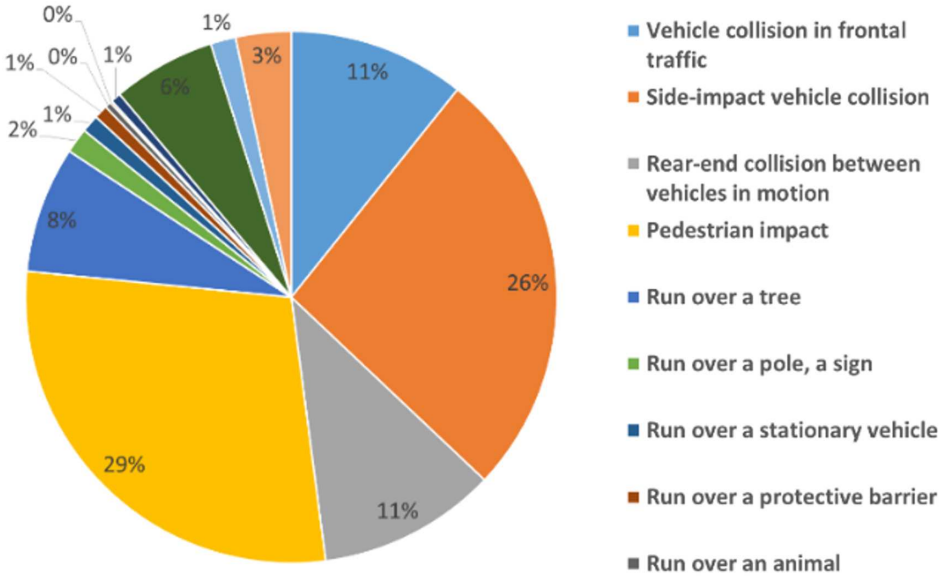


Figure 20
Percentage of accidents by type



overconfidence and aggression on the road, lack of concentration or haste, or lack of divided attention.

Another common cause of traffic accidents is inappropriate behavior toward pedestrians. These behaviors include improperly reversing, failing to maintain speed, failing to avoid or overtake, and failing to cede the right of way at pedestrian crossings and in other situations. Accidents involving pedestrians have a high fatality rate (around 20%). Pedestrian accidents occur when drivers fail to exercise due care on the road and do not adjust their speed when approaching pedestrian crossings. When approaching a pedestrian crossing, one should be extra vigilant and reduce the speed of the vehicle in order to be able to brake properly. Very often, such accidents happen in built-up areas, in the autumn and winter months, when darkness falls quite quickly and pedestrians are hardly visible. Poorly developed road infrastructure, inadequate lighting of pedestrian crossings and pavements, or their complete lack can also contribute to an increase in the number of accidents involving pedestrians. In addition, a pedestrian wearing dark clothing and standing at an insufficiently lit pedestrian crossing may not be visible, making it impossible for a vehicle driver to react quickly enough.

Driving on the wrong side of the road, passing, and failing to keep a safe space between cars are other frequent causes of traffic accidents. Known as ”tailgating” or bumper-to-bumper driving, this practice of failing to keep a reasonable distance is especially risky while traveling at high speeds. This happens most frequently on expressways and motorways and in built-up areas. This creates a high risk of RTS, as one vehicle may collide with another when driving fast and having to brake suddenly. Situations occurring on

Figure 21
Percentage of accidents by location

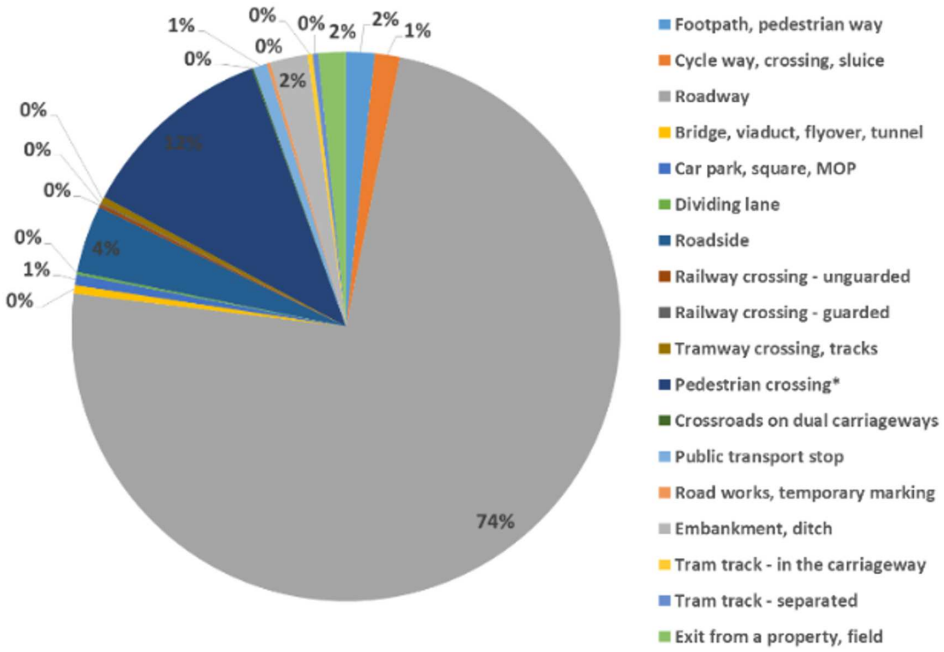
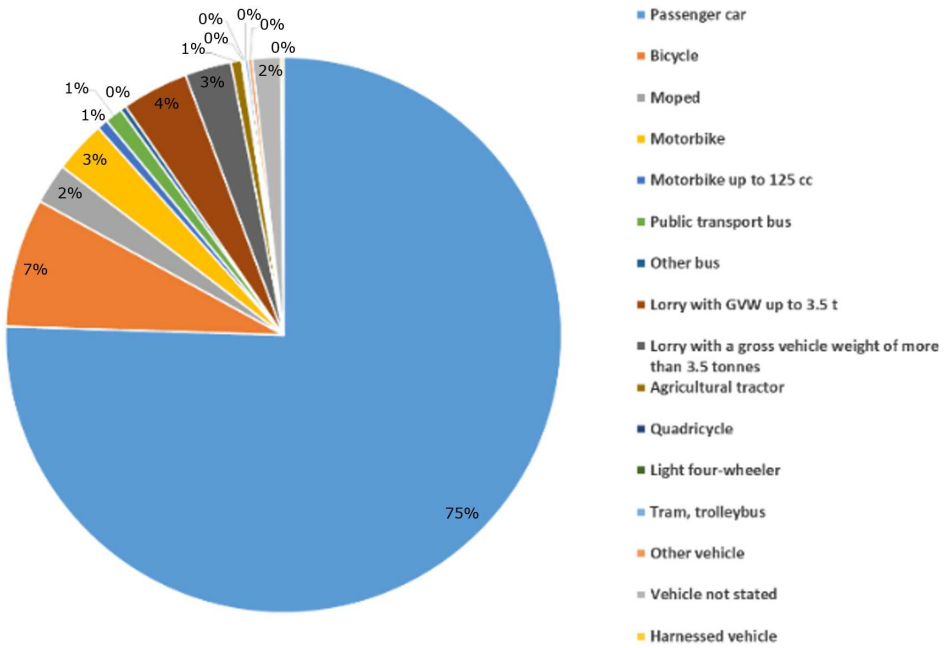


Figure 22
Percentage of accidents by mode of transport



motorways, where several vehicles collide with each other or trucks collide with passenger cars, are particularly dangerous. In urban, built-up areas, such accidents are characterized by much smaller consequences – fewer victims and injuries. They can be caused by inattentive drivers or distracted drivers, for example, using a phone while driving.

Incorrect overtaking and driving on the wrong side of the road create a significant safety hazard that affects not only the health and life of the driver but also his passengers and other road users. Overtaking on hills, bends, and junctions, that is, in places where it is forbidden, causes accidents. Such places are marked with appropriate horizontal markings, that is, a double continuous line. Another cause of such accidents is the driver's failure to ensure that he can safely perform an overtaking maneuver, that is, that the vehicle being overtaken is not going to turn or that the vehicle behind has not signaled beforehand that it wants to start the same maneuver.

Careless crossing of the street or running into an obstruction are the most frequent causes of pedestrian-related accidents. Such incidents often force drivers to brake suddenly, and the number of road accidents shows that it is often impossible to stop a vehicle suddenly. Pedestrians forget that if they step in front of a moving car, the driver is not able to react quickly enough to immediately

Figure 23
Technical failure per 100,000 vehicles, 2001–2023

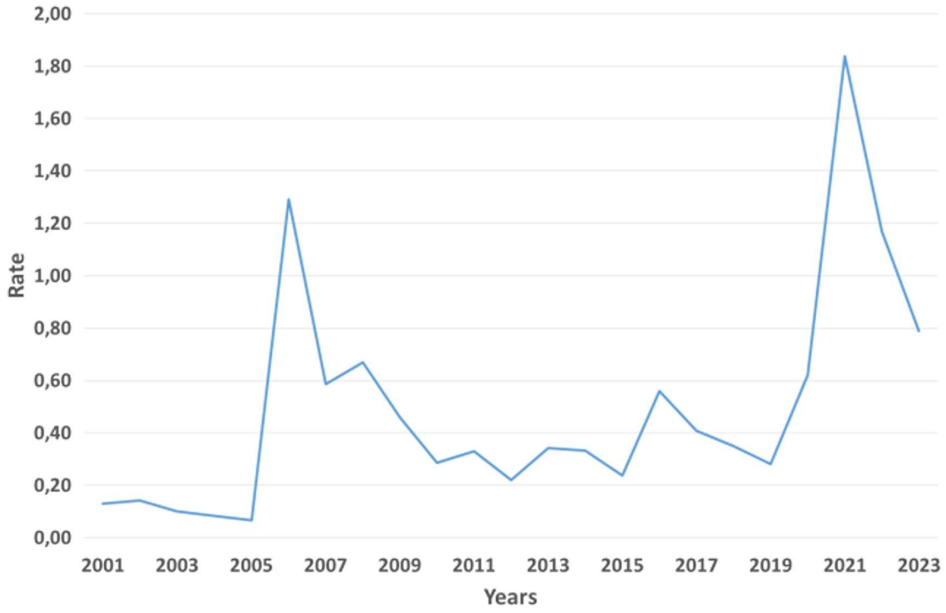
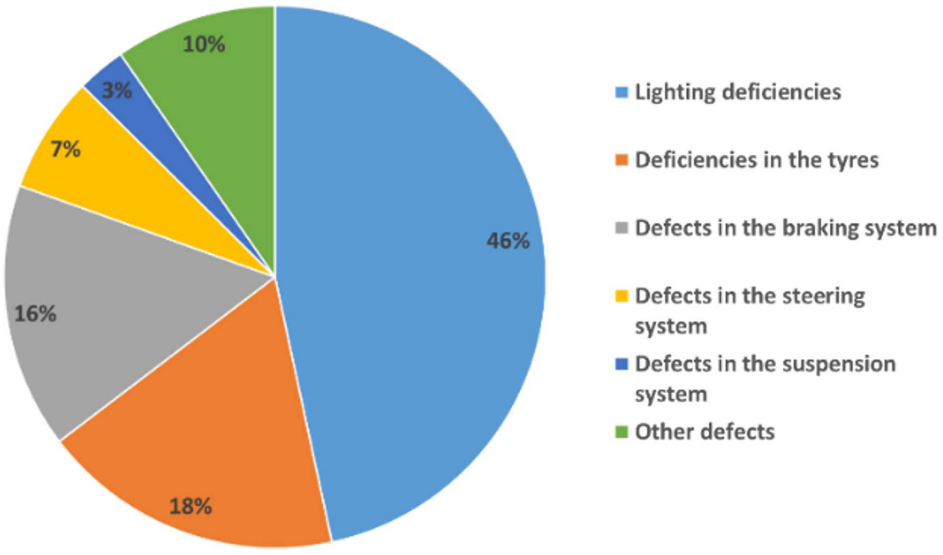


Figure 24
Percentage of the number of accidents depending on the technical condition of the means of transport



immobilize the machine, which weighs several tons. Most accidents of this kind take place in the months when darkness falls very quickly, making pedestrians less visible.

In the vehicle system, accidents that result from a vehicle's mechanical malfunction are considered RTS factors. They are easily avoidable and make up fewer than 0.5% of all accidents. The most frequent reasons for these mishaps are poor illumination and tires. Daily or seasonal maintenance can readily eliminate such issues. An organoleptic examination of the whole condition, including the illumination, operating fluids, tires, wipers, and brake system, is made possible by daily maintenance done before every journey. Along with inadequate illumination, the car may be dangerous on the road due to improperly set lights and the use of inappropriate bulbs. In order to prepare the vehicle for future usage, the condition of the tires should also be examined during each seasonal service. Depending on the season, the tires should be changed to either summer or winter tires. In RTS, it is dangerous to drive a car with evident flaws (tire hardening and evaporation) and worn tread.

Failures of the steering or braking systems accounted for a lower proportion of incidents. Leaky brake calipers or cylinders, worn braking drums and disks, worn friction linings, and leaky lines can all lead to brake system failures. The most common occurrences in the steering system are the following: excessive clearance of steering rods or ends of steering rods, spherical connecting components (ball stud of control arm), rubber-metal bushings of control arms, and steering gear leakage with power steering (oil leaks). Steering gear end position sensors malfunction in power steering transmissions (electric motors). Road traffic is greatly endangered by vehicles in poor technical condition; thus, routine checkups are crucial. You should see a car technician right away if you see any

unsettling signs that point to a decline in the vehicle's technical state. Serious traffic accidents can result from even apparently small flaws paired with unfavorable weather.

The police headquarters also distinguishes the category of "other causes of accidents," which includes causes that do not qualify for the previously mentioned options. Between 2001 and 2023, the most frequent accidents were caused by undetermined and other causes. Such events include, for example, accidents in which the vehicle, for unknown reasons, drifted into the opposite lane, into a ditch, or hit a roadside tree. It is possible that such accidents may be suicide attempts.

Other causes of accidents include objects and animals on the road, driver collapse, non-fault technical failure of the vehicle, driver blindness, and poor road conditions. Objects and animals on the road pose a significant risk to traffic as they usually appear suddenly and their presence and behavior are difficult to predict. Particular vigilance should be exercised if a wildlife sign appears on the road, as there is likely to be a large number of wild animals on that stretch of road. Other objects that can appear on the road and lead to an accident include pieces of ice sheets falling from trucks in winter or branches and trees overturning during gusty winds.

A non-fault technical failure of a vehicle can be said to occur when there is a sudden, unpredictable malfunction, such as a burst tire or a sudden fire while driving. These types of events are usually beyond human control and difficult to guard against. Referring to the poor condition of the road surface as a cause of accidents, it can cause damage to chassis, suspension, or driveline components. The most common factors causing driver glare while driving are sunlight and the headlights of other vehicles.

5. Summary

An examination of Poland's traffic accident causes showed that the human factor has the greatest influence on RTS, that is, improper behavior of vehicle drivers, as well as pedestrians and other road users. The most frequent causes of accidents include underestimation of speed, failure to yield the right of way, improper overtaking, and improper behavior toward pedestrians. The most important contributing factor to RTS, not just in Poland but globally as well, is improper human behavior on the road, according to an analysis of accident causes in other nations. There was also a significant correlation between the number of accidents caused by speeding, failure to yield the right of way, and improper behavior toward pedestrians and the number of fatalities.

It is important to note that the author has only considered information on the overall number of road accidents and not the factors influencing the number of accidents, which will be the stage for the author's subsequent research.

On the basis of its research, it proposes the following solutions to improve road safety:

1) Introduce more frequent roadside checks to check blood alcohol levels;
2) Equip vehicles with breathalyzers that require the driver to use one before starting the vehicle;
3) Equip vehicles with safety systems to prevent road accidents, for example, the introduction of emergency braking systems that automatically apply the brakes in the event of a collision risk, which can minimize the consequences of accidents;
4) Introduce sectional speed measurements;
5) Install speed bumps, especially around schools;
6) Introduce legislation that criminalizes organizing and participating in illegal street racing and driving in a way that endangers other road users;
7) Introduce intelligent speed assistants that help drivers maintain a safe speed;
8) Conduct regular road safety education campaigns to raise awareness among drivers and pedestrians;
9) Organize driver training and workshops, especially for young drivers and senior citizens, to improve driving skills;
10) Introduce advanced traffic monitoring systems that analyze accident data and help identify dangerous areas;
11) Publish regular reports on road accidents to understand their causes and prevent them in the future;
12) Introduce road checks, especially in areas with a high risk of accidents, to enforce traffic regulations;
13) Introduce tougher penalties for serious offenses such as drunk driving and speeding, especially for repeat offenders;
14) Improve road infrastructure by creating new cycle lanes and pedestrian zones to increase the safety of these road users;
15) Improve lighting in pedestrian crossing areas and on roads with heavy traffic;
16) Introduce mobile apps that inform drivers about road conditions and accidents and remind them to drive safely;
17) Develop autonomous vehicle technologies, which have the potential to significantly reduce accidents caused by human error;
18) Introduce mandatory wearing of reflectors by pedestrians and cyclists at night or in severe weather conditions;
19) Improve road markings, including better horizontal markings (e.g., pedestrian lanes) and vertical markings (e.g., traffic signs);
20) Implement intelligent traffic light systems that adjust the timing of light changes according to traffic volumes;
21) Develop public transport to reduce the number of cars on the road, which contributes to reducing traffic jams and accidents;
22) Modernize public transport stops to make them more passenger-friendly and safe;
23) Enable people with disabilities to travel safely on the roads by building special crossings and facilities.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by the author.

Conflicts of Interest

The author declares that he has no conflicts of interest to this work.

Data Availability Statement

Data available on request from the corresponding author upon reasonable request.

Author Contribution Statement

Piotr Gorzelańczyk: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration.

References

[1] Pałegą, M. (2017). Bezpieczeństwo ruchu drogowego w polsce w świetle wypadków drogowych i ich skutków [Road safety in the aspect of road accidents and their effects]. *Buses–Technology, Operation, Transport Systems*, *18*(12), 332–337.

[2] Wachnicka, J. (2012). Badania czynników wpływających na bezpieczeństwo ruchu drogowego w województwach [Surveys of factors affecting road safety in voivodeships]. *Urban and Regional Transport*, *4*, 20–22.

[3] Rafalski, L. (2012). Bezpieczeństwo ruchu drogowego w Polsce ze szczególnym uwzględnieniem pojazdów ciężkich [Safety of road traffic in Poland with special reference to heavy vehicles]. In *Conference: Safety in Road and Rail Transport*, *1*, 1–11. https://doi.org/10.13140/2.1.1013.5683

[4] Klepacki, B., & Koper, M. (2018). Bezpieczeństwo w ruchu drogowym w opiniach jego uczestników [Road safety in the opinion of its participants]. *Scientific Journal of Warsaw University of Life Sciences: Economics and Organization of Logistics*, *3*(3), 51–59. https://doi.org/10.22630/EIOL.2018.3.3.21

[5] Gądek-Hawlena, T., & Los, M. (2018). Nowoczesne rozwiązania w pojazdach ciężarowych i ich wpływ na bezpieczeństwo ruchu drogowego [Modern solutions in heavy goods vehicles and their influence on road safety]. *Scientific Journal of Warsaw University of Life Sciences: Economics and Organization of Logistics*, *3*(3), 25–35. https://doi.org/10.22630/EIOL.2018.3.3.19

[6] Orłowski, Ł., & Wszeborowski, R. (2020). Bezpieczeństwo w ruchu drogowym [Road safety]. *Journal of Military Logistics Systems*, *53*(2), 87–102. https://doi.org/10.37055/slw/133858

[7] Yannis, G., & Papadimitriou, E. (2021). Road safety. *International Encyclopedia of Transport*, 51–58. https://doi.org/10.1016/B978-0-08-102671-7.10613-X

[8] Wojtas, A., & Szkoda, M. (2018). Analiza wybranych czynników wpływających na bezpieczeństwo w ruchu drogowym [Analysis of selected factors influencing safety in road transport]. *Buses–Technology, Operation, Transport Systems*, *220*(6), 1149–1154.

[9] Zbyszyński, M. (2017). Bezpieczeństwo niechronionych uczestników ruchu drogowego: Stan obecny i przyszły [Safety of vulnerable road users: Present and future situation]. *Motor Transport*, *1*, 49–64.

[10] Bąk-Gajda, D., & Bąk, J. (2010). *Psychologia transportu i bezpieczeństwa ruchu drogowego [Psychology of transport and road traffic safety]*. India: Difin.

[11] Wicher, J. (2012). *Bezpieczeństwo samochodów i ruchu drogowego [Car and road safety]*. Poland: Publishing House of Communication and Communications.

[12] KOMENDA GŁÓWNA POLICJI BIURO RUCHU DROGOWEGO. (2023). Road accidents: Annual reports. Retrieved from: file:///C:/Users/Administrator/Downloads/Wypadki_drogowe_2023.pdf

[13] Golakiya, H. D., Chauhan, R., & Dhamaniya, A. (2020). Evaluating safe distance for pedestrians on urban midblock sections using trajectory plots. *European Transport*, *75*(2), 1–17.

[14] Wachowiak, P., Gorzelańczyk, P., & Kalina, T. (2018). Badanie skuteczności działania amortyzatorów w świetle obowiązujących przepisów prawnych w Polsce i na Słowacji [Analysis if shock absorbers efficiency in the eyes of Polish and Slovakian legislation]. *Buses–Technology, Operation, Transport Systems*, *19*(6), 764–770. http://dx.doi.org/10.24136/atest.2018.172

[15] Gorzelańczyk, P., & Górniak, W. (2019). Assessment of technical condition of forklift tyres used in internal transport by studying damages and operating conditions. *Engineering Sciences and Technologies*, *2*(33), 44–59. https://doi.org/10.15611/nit.2019.2.03

[16] Ashish, & Mhaske, S. Y. (2023). Road safety audit (RSA) guidelines of selected nations: A comparative review. *Journal of Road Safety*, *34*(4), 42–50. https://doi.org/10.33492/JRS-D-23-209291

[17] Torbaghan, M. E., Sasidharan, M., Reardon, L., & Muchanga-Hvelplund, L. C. W. (2022). Understanding the potential of emerging digital technologies for improving road safety. *Accident Analysis & Prevention*, *166*, 106543. https://doi.org/10.1016/j.aap.2021.106543

[18] Giribabu, D., Ghosh, K., Hari, R., Chadha, I., Rathore, S., Kumar, G., ..., & Srivastav, S. K. (2024). Road accidents on Indian national highways, ambulance reachability and transportation of injured to trauma facility: Survey-based introspection of golden hour. *Journal of Family Medicine and Primary Care*, *13*(2), 704–712. https://doi.org/10.4103/jfmpc.jfmpc_1832_23

[19] Joshi, E., Gautam, P., Khadka, A., Pilkington, P., Parkin, J., Joshi, S. K., & Mytton, J. (2022). Experience of living near a highway in Nepal: Community perceptions of road dangers in Makwanpur district. *Journal of Transport & Health*, *24*, 101337. https://doi.org/10.1016/j. jth.2022.101337

[20] Katsarov, I., & Penkov, S. (2023). Application of artificial intelligence in road network inventory and network-wide road safety assessment. *IOP Conference Series: Materials Science and Engineering*, *1297*(1), 012020. https://doi.org/10.1088/1757-899x/1297/1/012020

[21] Kaul, A., & Altaf, I. (2022). Vanet-TSMA: A traffic safety management approach for smart road transportation in vehicular ad hoc networks. *International Journal of Communication Systems*, *35*(9), e5132. https://doi.org/10.1002/dac.5132

[22] Regmi, M. B. (2021). What does it take to improve road safety in Asia? *Journal of Road Safety*, *32*(4), 29–39. https://doi.org/10.33492/JRS-D-21-00040

[23] Shafiq, S., Dahal, S., Siddiquee, N. K. A., Dhimal, M., & Jha, A. K. (2020). Existing laws to combat road traffic injury in Nepal and Bangladesh: A review on cross country perspective. *Journal of Nepal Health Research Council*, *17*(4), 416–423. https://doi.org/10.33314/jnhrc.v17i4.2363

[24] Tiwari, H., & Luitel, S. (2023). Re-orienting towards safer roads infrastructure in Nepal. *Journal of Recent Activities in Infrastructure Science*, *8*(3), 14–27. https://doi.org/10.46610/JoRAIS.2023.v08i03.003

[25] Toriumi, A., Abu-Lebdeh, G., Alhajyasee, N. W., Christie, N., Gehlert, T., Mehran, B., ..., & Nakamura, H. (2022). A multi-country survey for collecting and analyzing facts related to road traffic safety: Legislation, enforcement, and education for safer drivers. *IATSS Research*, *46*(1), 14–25. https://doi.org/10.1016/j.iatssr.2022.01.004

[26] Wei, L., Li, Z., Gong, J., Gong, C., & Li, J. (2021). Autonomous driving strategies at intersections: Scenarios, state-of-the-art, and future outlooks. In *2021 IEEE International Intelligent Transportation Systems Conference*, 44–51. https://doi.org/10.1109/ITSC48978.2021.9564518

[27] Tomasch, E., & Gstrein, G. (2024). Correlation of road safety criteria with occupant safety criteria in impacts on crash

cushions. *Infrastructures*, *9*(8), 136. https://doi.org/10.3390/infrastructures9080136

[28] Ziegler, J., Unger, T., Spitzhüttl, F., & Malcyk, A. (2022). *Anforderungen an Schutzeinrichtungen neben der Fahrbahn [Requirements for protective devices next to the roadway]*. Germany: Accident Research of the Insurers.

[29] Meng, Y., & Untaroiu, C. (2020). Numerical investigation of occupant injury risks in car-to-end terminal crashes using dummy-based injury criteria and vehicle-based crash severity metrics. *Accident Analysis & Prevention*, *145*, 105700. https://doi.org/10.1016/j.aap.2020.105700

[30] Tomasch, E., & Gstrein, G. (2024). Impacts on crash cushions—Analysis of the safety performance of passenger cars with improved safety equipment compared with test vehicles based on assessment criteria as defined in EN 1317. *Infrastructures*, *9*(3), 59. https://doi.org/10.3390/infrastructures9030059

[31] Tomasch, E., Heindl, S. F., Gstrein, G., Sinz, W., & Steffan, H. (2021). Assessment of the effectiveness of different safety measures at tunnel lay-bys and portals to protect occupants in passenger cars. *Infrastructures*, *6*(6), 81. https://doi.org/10.3390/infrastructures6060081

[32] Davidović, J., Antić, B., & Pešić, D. (2024). The importance of road safety inspection for the improvement of pedestrian safety in traffic. *Journal of Road and Traffic Engineering*, *70*(2), 45–51. https://doi.org/10.31075/PIS.70.02.06

[33] Семченко, Н. О., Ніколаєнко, І., В, Маслак, Г. В., & Хара, М. В. (2024). Оцінювання динаміки зміни показників безпеки руху вукраїні [Assessment of the dynamics of changes in traffic safety indicators in Ukraine]. *Transport Systems and Traffic Technologies*, *28*, 52–59. https://doi.org/10.15802/tstt2024/312024

[34] Alokwu Stella, O., Ewuim Ngozi, C., Obi Emeka, F., & Asoya Nkem, P. (2021). Human approach to road safety administration in Nigeria's federal road safety commission. *International Journal of Academic Multidisciplinary Research*, *5*(8), 92–97.

[35] Gustavo, V., & Chaves, D. (2024). Governmental expenditures and the challenges to improve road safety in Brazil. *Journal of Public Administration and Governance*, *14*(2), 125–141. http://dx.doi.org/10.5296/jpag.v14i2.22370

[36] ACEA. (2023). *Motorisation rates in the EU, by country and vehicle type*. Retrieved from: https://www.acea.be/statistics/tag/category/vehicles-per-capita-by-country/

[37] PZPM. (2022). *Pojazdy samochodowe i motorowery zarejestrowane w Polsce, stan na 31 grudnia [Motor vehicles and mopeds registered in Poland, as of December 31]*. Retrieved from: https://www.pzpm.org.pl/content/download/2591/10569/file/park%20pojazdow%20PL%201990_2018.pdf

How to Cite: Gorzelańczyk, P. (2025). Review of the Road of Safety in the Years 2001–2023. *Archives of Advanced Engineering Science*. https://doi.org/10.47852/bonviewAAES52024784