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Risk Indicators and Road Accident Analysis for the Period 2012–2016

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Abstract: Road accidents are a major societal issue for every country. The purpose of this paper is to assess the number of traffic and road accidents depending on a series of variables (collision mode, road configuration, conditions of occurrence, road category, type of vehicle involved, personal factors, and length of time of the driving license) in Romania from 2012–2016. The analysis of the road accident trend identifies the causes of accidents, road safety performance indicators, and risk indicators. Having these identified data, a framework is proposed for improving the road safety system and reducing accidents. The Romanian Police, the National Institute of Statistics (NIS) in Romania, and the European Commission provided the data used for this analysis. The data obtained from these databases are analysed and evaluated according to a series of variables. This paper will outline an informative image of road accidents and establish a framework for reducing their effects in road transport. As a result of the analysis, we have seen that the combination of vehicles and personal factors influences the number of traffic and road accidents.

Keywords: road accident; traffic accident; risk indicator; road safety; road safety performance indicators

1. Introduction

Road and traffic accidents involve uncertainty and are unpredictable. These accidents are based on a number of causes that depend on a number of variables, such as: no priority to pedestrians, no priority to vehicles, the unlawful crossing of pedestrians, bicycle rider's deviations, speed not adapted to road conditions, deviations of the drivers of animal traction vehicles, and so on. It can be argued that road and traffic accidents are defined by a set of variables, some known and others unknown, which are more subtle [1–3]. Accident reduction and road safety are major concerns for public health. This statement is supported by statistics: over 3000 people from all over the world decease daily because of road traffic [4]. These road accidents cause a series of global economic losses estimated in road traffic damage costs of $518 billion a year [4]. These huge economic losses contribute to the country's economic imbalance. In developing countries, the cost of road accidents is estimated to be $100 billion [4]. Besides these economic effects, road accidents also influence the demographics of each country. In this context, identifying strategies to counteract these effects is an important direction for each country.

In 49 studies from 13 countries, it was concluded that reporting injuries in official accident statistics is incomplete at all levels of severity of injuries. These reports found that there were differences compared with the real situation. It was found that 95% of the reported cases had lesions as follows: 70% serious injuries, 20% minor injuries, and 5% very slight injuries [4–6].

According to various road accident studies, there are a number of factors that influence these incidents. Environmental conditions, motorway design, type of accident, driver characteristics, and vehicle attributes are factors identified in research [7]. In another study [8], the factors that cause the severity of accidents in Hong Kong were examined. The study [9], Alonso et al., examined the impact of Spanish drivers' health, and the health conditions that could affect their physical ability to drive. It has been found that fatigue, alcohol, emotional state, sleepiness, headaches, respiratory illness, and fever are the most widespread diseases that affect the health of the driver. The intensity of driving and risk exposure is also a major cause of road accidents, and has implications for road safety [10]. Personal factors (age, experience, fatigue, health) influence the number of accidents [11–13]. It could be concluded that personal factors considerably affect the number of road accidents.

These factors are dependent on three types of vehicles: private vehicles, commercial vehicles, and motorcycles. The study highlights that each type of vehicle is associated with its own particular factors of severity. In the case of a personal vehicle, the severity levels of accidents were influenced by the driver's gender, the vehicle age, the driver's age, and street light factors. The factors that influence the accidents involving commercial vehicles are: the use of seat belts, the driver's health, vehicle age, the day of the week, and the time of driving. Road accident factors presented in another study include: time of the accident, location of the accident, road category, the guilty driver's age, vehicle characteristics, nationality, and driver experience [9].

In 2012, there were 5,710,773 registered vehicles, of which: 202,030—age $\leq$ 2 years, 677,031—age between 2–5 years, 1,732,941—age between 5–10 years and 3,098,771 over 10 years old. In 2016, the number of vehicles increased by 19%, reaching 7,010,608 vehicles. Of these there were: 254,042—age $\leq$ 2 years, 335,308—age between 2–5 years, 1,473,870—age between 5–10 years and 4,947,388 over 10 years old. It is noticed that the number of vehicles older than 10 years is increasing.

As a result of the evaluation of the specialised literature [9–19], it can be noticed that the road accident factors are mainly dependent on: the driver's experience, the environment of the accident, the road category, the driver's age, the type of the vehicle and the length of time from acquiring the driving license. Based on these factors, plus others proposed by the authors, the road accidents in Romania will be analysed. Following the research, a framework for improving the road safety system in Romania is proposed based on a bibliographic review and qualitative and semi-quantitative statistical data analysis.

2. Objective

The purpose of this study is to evaluate road and traffic accidents in order to get a picture of performance and safety in Romania. Performance refers to the best results/characteristics obtained on roads in Romania. To accomplish this goal, the presented study evaluates and analyses the trend of road accidents in the period 2012–2016. Road accident assessments identify the causes of accidents, road safety performance indicators, and risk indicators. At the end of the paper, a framework for improving the road safety system is proposed.

3. Materials and Methods

3.1. Methods

In this study, the qualitative and semi-quantitative method was used to interpret the statistical data on the number of traffic and road accidents in Romania. From the statistical data, the selected variables for analysis included collision mode, road configuration, conditions of occurrence, road category, type of vehicle involved, personal factors, and length of time of the driving license. For statistical analysis, the period 2012 to 2016 was chosen. The analysis of the road accident trend identifies the causes of accidents, road safety performance indicators and risk indicators. Analysing and evaluating the data lead to obtaining a framework for the improvement of the road safety system and reducing accidents, which is included in this research.

3.2. Data Sources

The purpose of this paper is to evaluate the accidents that occurred in Romania. To clarify the position of Romania regarding the subject of road accidents, a series of data about other European Union (EU) Member States will be presented. The data used in this research was selected and collected from the databases related to the following entities: data from the European Commission [18,19], the National Institute of Statistics (NIS) in Romania [20], and the Romanian Police [21]. These collected data are evaluated and analysed to identify the causes of accidents, road safety performance indicators, and risk indicators. For the clarity and accuracy of the identification process, a number of variables were used to analyse and evaluate the collected data. The variables were established according to the priorities of the European strategy [18] and the literature [1–9].

3.3. Study Variables

For this study, seven variables were selected to assess and analyse road traffic accidents in Romania. Table 1 presents the variables used for the study, the types of each variable, and the implications of each variable. Having established these details, the results of the analysis are presented in Section 3.

Table 1. The variables used in the present study.

Variable	Variable Type	Variable Implication
Collision mode	Between vehicles Vehicle and pedestrian One vehicle	This variable highlights the severity of accidents according to the number of factors involved in the accident.
Road configuration	Curves Tunnel Intersections Bridges Crossing the railway Alignment	The most important road configurations that are involved in road accidents are these types. These are found on all road categories.
Condition of occurrence	Daylight Low brightness Darkness	The intensity of light within a day was considered to form the three categories of values for the condition of an accident occurrence.
Road category	Occurred on motorways Occurred in localities Occurred outside of localities	For this variable, the main values were considered depending on the intensification of the use of each type of road
Type of involved vehicle	car, van, bike, moped & motorcycle, animal traction, auto-trailer, intervention vehicle, and lorry/truck	All vehicle categories were considered as values for this variable. The type of vehicle involved in an accident is important for improving the road system on the direction of action
Personal factors	Age of the driver Gender of the driver	The two values for the variable were considered relevant for the improvement of the national road system.
Length of time of the driving license	Period of years	The length of time measured in years was considered for the evaluation of this variable.

3.4. Road Safety System Approach

Road safety is very important in every country because it affects the economic and social dimension of sustainable development [22,23]. Road traffic affects the environmental dimension of sustainability. Thus, it can be said that transport contributes directly to the sustainable development of a country [16].

The accelerated development of road traffic, along with the increase in its complexity and the intensification of drivers, draw/impose/suggest to automotive companies the approach of innovation in the production process and the increase of the quality of products and services. The action to prevent the severity of road accidents can be addressed from the perspective of actions that can be developed within the automotive industry [17].

In this research, the safety of the road system is assessed and improved in three directions: accident causes, road safety performance indicators, and risk indicators.

3.5. European Road Safety Strategy

The overall objective of the European Union is to reduce the number of road accidents by 50% by 2020. In 2010–2015, the EU recorded a reduction in deaths of only 17%, whereas a 29% decrease was needed to reach the 2020 target [18]. Efforts in the field of traffic safety need to be intensified globally, as over 1.2 million people die annually from road accidents. Death from road accidents is the main cause of mortality among young people aged 15–29, which is why this cause became a priority in the European strategy for 2030 [18,19].

Globally, depending on the type of road variable, it can be seen from statistics that European roads remain the safest in the world. At the EU level, in 2016 there were 50 road deaths per million inhabitants, compared with 174 deaths per million globally [17–19].

In the year 2016, the ascending [19] ranking per country according to the mortality rate for one million inhabitants highlights: Sweden (27), the United Kingdom (28), the Netherlands (33), Spain (37), Denmark, Germany (39), Ireland (40), Poland (79), Latvia (80), Romania (97), and Bulgaria (99). As the European strategy refers to the decrease in the number of accidents, an assessment of the situation in the different countries shows that some countries have seen a significant decrease in the number of road deaths, such as: Lithuania (22%), Latvia (16%), and the Czech Republic (16%) [18].

Four EU member states have achieved a decrease in the number of accidents in line with the general objective: Denmark, Greece, Portugal and Spain. In relation to this objective, Romania recorded a 19% decrease in deaths by 2016 compared to 2010. Actions and approaches to this end are sustained at the national level, with real chances for achieving the EU's overall objective.

The situation of the member states in terms of achieving the overall objective is presented in Figure 1 according to the data provided by the European Commission [19]. In this situation, two periods are evaluated: 2015–2016, and 2010–2016. Differences in the number of accidents per million inhabitants for the two periods are analysed. The result is expressed in percentage terms by 2015 for the period 2015–2016, and by 2010 for 2010–2016. For the period 2015–2016, it is noticed that Lithuania recorded the largest drop in road deaths per million inhabitants (22%), followed by Latvia (16%). In the antithesis, the largest increase in road deaths is registered in Malta. In 2016, there were 51 deaths per million inhabitants, up 20% compared to 2015, when 42 deaths per million inhabitants were recorded. For this period, 13 member states recorded an increase in the number of deaths per million inhabitants. This increase is in the range of 1–10%. In this situation, the EU's general objective can be achieved only with major investments in the infrastructure and actions of the countries [18,19].

If the 2010–2016 period is analysed, the data provided [19] in Figure 1 show that Portugal has the largest decrease in deaths per million inhabitants (40%), followed by Lithuania (37%) and Greece (35%). The largest increase in deaths per million inhabitants is recorded in Malta. This increase is 69% in 2016 compared with 2010.

At the EU level [18,19,23,24], there are a number of actions and strategies proposed to achieve the overall objective. European road safety actions are structured in four major directions:

- A well-functioning internal market—harmonisation of transport requirements with infrastructure and industry capacity.
- Fair competition and workers' rights—developing a competitive business environment based on collaboration.
- Reducing greenhouse gas emissions—a 30% reduction in CO_2 emissions, as stipulated in the Paris COP21 agreement.
- Digital technologies—using innovations in the automotive field to increase road safety.

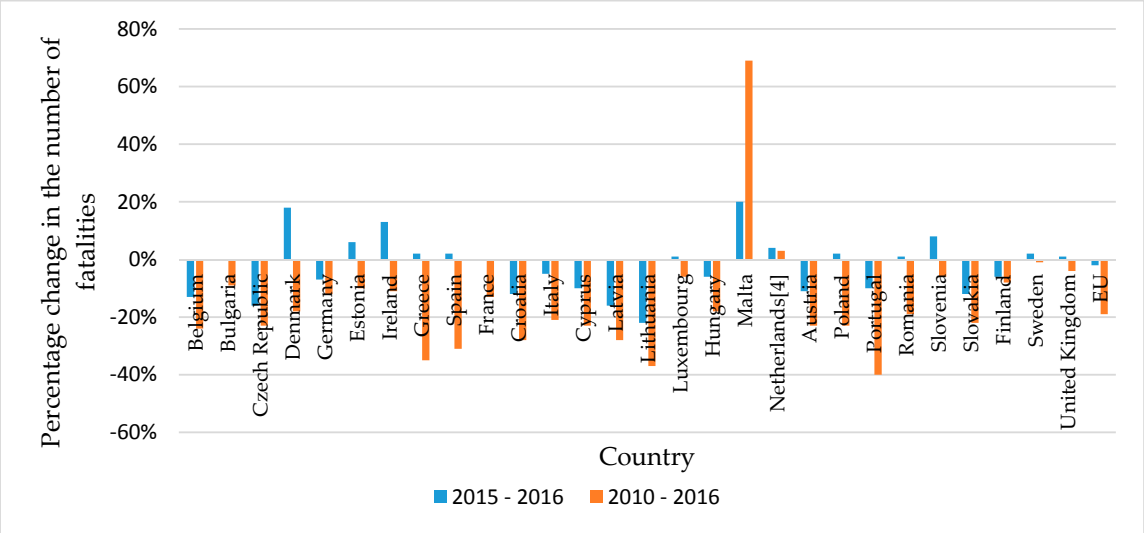

Figure 1. Number of road deaths per million inhabitants in the period 2015–2016 and 2010–2016 expressed as a percentage [19,20].

3.6. National Road Safety Strategy

The overall objective of Romania's national strategy [16,21], which is aligned with the European strategy, is to reduce the number of deaths from road accidents by 50% by 2020, compared with 2010. In this respect, it is expected that in 2020 there will be no more than 1188 deaths, compared with the 2377 deaths registered in 2010. Among the specific objectives formulated in this direction are:

- Developing a road-safe country for its inhabitants, tourists, and investors by progressively reducing the number of road accidents in the period 2016–2020;
- Improving road infrastructure on all road types to reduce the number of road accidents;
- Building additional motorway kilometres and express roads to reduce the number of accidents;
- Operational coordination of integrated interventions through interoperability and cooperation between intervention services;
- Improving the emergency service by renewing the telecommunications infrastructure;
- Implementation of an integrated system of information and statistical data for the continuous monitoring of road accidents and related actions;
- Continuous improvement of the quality of the emergency medical act and of the intervention system;
- Carrying out actions to raise road safety awareness among children, adolescents, and students.

4. Results

This chapter presents the results obtained from the evaluation of the databases considered. The data are evaluated in the set of variables established and presented in Table 1. These data refer to road and traffic accidents registered in Romania. To support the presentation of road accident data, it is necessary to present the situation of existing road categories at the national level. Romania owns 86,080 km of public roads, of which 747 km were motorway in 2016 (see Table 2). About 90% of the national road network is at the single carriageway road standard, which significantly influences traffic safety. Table 2 presents the road categories in Romania for the period 2012–2016 [20,21].

It is noticed that the national roads are upgraded in proportion of 35% of the total public roads. The county and communal roads require improvements. This presentation of the road situation in Romania is closely related to the recorded accidents. The registered accidents are also dependent on the road category, and the road performance is directly proportional to the quality of the public roads.

Table 2. Road categories in Romania [20].

Category of Public Roads	Improvement Status	UM	2012	2013	2014	2015	2016
Total	Total	km	84,185	84,709	85,184	85,920	86,080
	Upgraded	km	27,665	29,166	30,247	32,648	33,928
	Motorways	km	550	644	683	747	747
National	Total	km	16,887	17,110	17,272	17,606	17,612
	Upgraded	km	15,645	15,956	16,172	16,557	16,600
County and communal	Total	km	67,298	67,599	67,912	68,314	68,468
	Upgraded	km	12,020	13,210	14,075	16,091	17,328

4.1. Road Traffic Accidents Analysis According to the Established Variables

In this section, the data obtained from the database collections used for research are presented [16–21]. Road and traffic accidents are assessed based on the established variables. These data are analysed and evaluated in the discussion section.

4.1.1. Collision Mode

This section presents the data on the three types of collisions that may occur in road accidents: collisions between vehicles, collisions between a vehicle and a pedestrian, and collisions involving only one vehicle. Table 3 presents road traffic accidents causing bodily injury by their nature and how they occurred [18–21]. It can be seen that collisions between vehicles account for over 40% of the total number of accidents recorded. Total accidents registered a decrease in the period 2013–2014, after which the number of accidents increased. Taking 2010 as the reference year, which is also a reference year for the European reports (regarding the achievement of the general objective), it is noticed that in 2013 there is a 4.5% decrease in the number of accidents. The largest increase is recorded in 2016, an increase of 12%. The variance between accidents in 2016 is +8.1% compared with 2012.

Table 3. Situation of road accidents depending on how they occurred [20].

Collision Mode	2012	2013	2014	2015	2016	Variation (%) 2012–2016
Collisions between vehicles	11,932	11,128	11,432	13,540	13,690	+14.7%
Collisions between a vehicle and a pedestrian	8791	8301	8576	8995	9010	+2.4%
Collisions involving only one vehicle	6205	5398	5347	6409	6423	+3.5%
Total	26,928	24,827	25,355	28,944	29,123	+8.1%
Dynamics compared to 2010, year 2010 = 100%	+3.5%	−4.5%	−2.5%	+11.3%	+12%	-

4.1.2. Road Configuration

From the road configuration perspective, the main types of road accidents are road alignment (71%), curves (18%), and intersections (9%). Table 4 presents the situation of deaths and injuries according to the characteristics of the road for 2016 [20,21]. The 2012–2016 period is taken into account. In 2012, there were 36,251 accidents, which included 2042 deaths and 34,209 injuries. For 2016, there is a 6.7% increase in incidents.

Table 4. Situation of deaths and the number of injuries depending on road configuration [20].

Characteristic	No. of Deaths	No. of Injured
Curves	2353	8917
Tunnel	16	82
Intersections	1135	8405
Bridges	117	330
Crossing the railway	147	135
Alignments	9144	33,653
Total	12,912	51,522

4.1.3. Conditions of Occurrence

The situation of accidents according to the occurrence conditions is presented in Table 5 [18–21]. The process conditions of the accidents considered for the assessment are: daylight, low light, and darkness. The highest number of road accidents is recorded during the day (that is daylight). Darkness brings the least road accidents for the entire analysed period 2012–2016. The total accident rate variation in 2016 compared to 2012 is +8.1%.

Table 5. Situation of road accidents depending on occurrence conditions [20].

Conditions of Accident Occurrence	2012	2013	2014	2015	2016	Variation (%) 2012–2016
Daylight	18,866	17,494	18,012	20,768	21,121	+11.9%
Low brightness	5677	5167	5152	5770	5801	+2.1%
Darkness	2385	2166	2191	2406	2201	+7.8%
Total	26,928	24,827	25,355	28,944	29,123	+8.1%

4.1.4. Road Category

Depending on the road category, the registered accidents are evaluated within the three categories of accidents produced on motorways, in the locality and outside the locality [20,21]. These accidents are presented in Table 6. It is noticed that most accidents are produced in the locality, followed by those outside the locality. The density of road accidents in relation to km of motorway shows a value between 3.71–4.73. Accidents in localities show an increase of 11% compared with 2012. The period 2013–2014 is one that has a decrease in the number of accidents. Starting with 2015, the number of accidents increases considerably. This is due to the increase in the number of vehicles by 12% in 2015 compared with 2012. In 2015, there were 6,600,325 registered vehicles, and in 2012 there were 5,710,773 registered vehicles.

Table 6. Situation of road accidents according to the place of occurrence [20].

The Place Where Accidents Occur	2012	2013	2014	2015	2016	Variation (%) 2012–2016
Occurred on motorways	131	136	129	175	201	+53%
Occurred in localities (excluding motorways)	22,108	20,541	21,080	23,921	24,568	+11.12%
Occurred outside of localities (excluding motorways)	4689	4150	4146	4848	4354	−7.2%
Total	26,928	24,827	25,355	28,944	29,123	+8.2%
Km of motorway	550	644	683	747	747	+35.8%
Density of road accidents reported per km of motorway	4.19	4.73	5.29	4.26	3.71	+14.5%

During the analysed period, there were decreases in accidents on the streets and county roads, and increases in the accidents on the communal roads and other categories of roads [20]. The death rate on national roads is higher than the average for all other categories. At the national level in 2016, the death rate for national roads was 0.09 per km compared with the average of 0.04 per km for all roads. The variation of the road accidents according to the place of production is +8.2% taking into account the years 2012 and 2016.

4.1.5. Type of Vehicle Involved

The Romanian motor vehicle fleet increased by 21.8% in 2015 compared with 2010. One third of the cars registered in Romania are over 15 years old. In the year 2016, the trend of cars is an upward one, with the fleet registering more vehicles older than 10 years [20,21].

An important part of this variable is bicyclists and small vehicles (moped, motorcycle). The types of variables considered in this analysis are: car, van, bicycle, moped and motorcycle, animal traction, auto-trailer, intervention vehicle, and lorry/truck. Vehicle typology is presented in Table 7 [20,21]. Since the number of bicycles is increasing [20] as a result of various actions related to sustainable development, the number of accidents involving bicycles is considerable, and 19–27% of the bicycle

accidents involve cars. The fewest accidents are registered for auto-trailers, intervention vehicles, and lorries/trucks.

Table 7. Typology of vehicles involved in road accidents in 2012–2016 [20].

Variable Type	2012	2013	2014	2015	2016	Variation (%) 2012–2016
Car	4427	3590	3470	4511	4670	+5.4%
Van	570	636	726	732	756	+32%
Bicycle	634	858	944	912	898	+41%
Moped & Motorcycle	860	598	559	560	589	−32%
Animal traction	258	245	212	260	273	+5.8%
Auto-trailer	82	151	139	142	147	+79%
Intervention vehicle	38	34	48	52	54	+42%
Lorry/truck	23	47	40	43	47	+104%

4.1.6. Personal Factors

Personal factors considered for assessing the trend of road accidents and for identifying risk factors are the driver's age and sex.

These types were chosen for the "*personal factors*" variable because it was found [20–25] to be the most important data for road accident analysis.

A. Driver's age

From the perspective of personal factors, the distribution by age groups of drivers is presented in Table 8 [20,21]. According to data provided by the Romanian Police, people over 65 have the highest risk of death. This share in total road deaths is higher than the share of total population (21.4% vs. 15.4% of the population). This distribution refers to serious traffic accidents for which the offense has been established by the competent authorities. Most accidents occur in the 26–35 years and 36–45 years categories. According to the data provided by NIS, these age classes drive most vehicles. We chose to analyse the years 2012 and 2016 because there are no relevant data for the years 2013, 2014, and 2015.

Table 8. Situation of accidents by age category [20].

Age Category	2012		2016	
	Involved	Involved with Guilt	Involved	Involved with Guilt
<18	26	21	32	26
18–25	1811	1142	1922	1252
26–35	2705	1467	2804	1535
36–45	2211	1088	2397	1191
46–55	1497	899	1637	907
56–65	1042	611	1048	625
66–75	312	208	328	226
>75	71	56	82	58

B. Gender of the driver

Depending on the gender of the vehicle driver, Table 9 lists fatalities and serious injuries [20]. From the data, men are involved in 75% of deaths and 65% of serious injuries. For 2016, data on deaths and injuries are not public. There were about 7.14 million people holding a valid driving license and registered in Romania on 31 December 2016, of whom 4.84 million were men.

Table 9. Deaths and serious injuries by sex [20].

Year	Deaths		Serious Injuries	
	Masculine	Feminine	Masculine	Feminine
2012	1542	500	5783	3077
2013	1374	487	5164	2994
2014	1361	457	5204	2918
2015	1356	455	5197	2903
2016	-	-	-	-

4.1.7. Length of Time of the Driving License

Regarding the length of time since obtaining the driving license [20], most accidents are produced by drivers with one-year-old driving licenses. They are followed by those who have six-year-old driving licenses. One-year-old drivers are involved in road accidents on all road categories. The frequency of involvement in road accidents is higher with less experienced drivers [20,21].

4.2. Case Study: Assessing Accidents on a Road Section

For this case study, we have selected two roadways located in the Western Region of Romania. These road sections link the two cities of Timisoara and Arad. One of these sections is composed of national and European roads, and the second is the A1 motorway. These road sections are identified with the most severe accidents, and the causes of accidents and risk indicators are assessed. These road sections connect two major cities in the West of Romania.

The connection between the two cities, Timisoara and Arad, can be covered via DN69/E671 (58.80 km) or Via A1 (58.60 km). The Timisoara–Arad motorway section was put into operation in December 2011 and has a length of 38.9 km. The difference is that this section is covered by the European national road DN69/E671. According to the data provided by Google Maps, the time duration is close for the two routes. This is because the European national road to the highway entrance is very crowded. It takes about 20 km to enter the highway. It is appreciated that on this 20-km portion, the running speed is below 40–50 km/h. In order to investigate whether there are different risk factors for injury, two types of roads were considered (national/European and motorway). These road sections are shown in Figure 2.

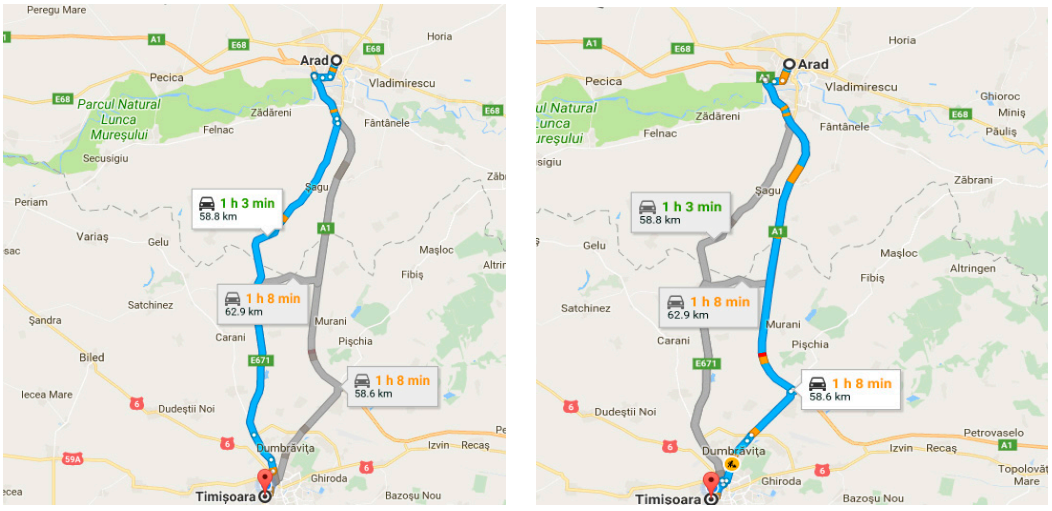

Figure 2. Roadway chosen for studying Timisoara—Arad: (**a**) the European national road (via DN69/E671); (**b**) the A1 motorway (Google Maps capture).

The accidents that occurred on these road sections were analysed from the perspective of the variables used and data analysis for 2012–2016. In addition to these variables, the severity of the impact was used to identify whether the accident resulted in deaths or injuries only. The data provided by the Romanian Police were used to assess accidents. The analysis period is 2016 on accidents declared publicly [20,21]. For the two variants of the section, 50 accidents were randomly considered that took place at different times of the year. The following are the results obtained [20,21] according to the evaluation:

A. European national road via DN69/E671

- Type of collision: 70% of the accidents occurred as a result of collision between two cars, and 20% as a result of collision with road furniture.
- Road configuration: 90% of road accidents were caused by road alignment.
- Conditions of occurrence: 45% of accidents occurred in daylight, and 35% in low light.
- Road category: 30% in localities and 70% outside localities.
- Vehicle type involved: 65% cars, 45% animal traction, 55% bicycles. In this variable, it was considered that in an accident where there may be a collision between a car and a vehicle with animal traction, taking into account both variants is considered in the expressed percentage.
- Personal factors: most accidents have been committed by drivers in the following age categories: 26–35, 36–45, and over 56 years. In the situation of collisions with animal traction vehicles, the driver's age is over 56 years.
- Driving license length of time: one year and over six years. In vehicles with animal traction, the experience cannot be accurately determined (the duration of use is over 15 years of use of the vehicle).

B. A1 motorway

- Type of collision: 95% of accidents occurred as a result of collision between two cars and 5% as a result of collision with road furniture.
- Road configuration: 60% of road accidents were caused by road alignment, 40% due to non-compliance with the role of the emergency lane.
- Conditions of occurrence: 85% of accidents occurred in the daylight.
- Road category: 100% outside localities.
- The type of vehicle involved: 65% cars, 55% intervention vehicles, 50% auto-trailers and 35% lorries/trucks. In this variable, it was considered that in an accident there may be a collision between a car and a truck, taking into account both variants in the expressed percentage.
- Personal factors: most accidents were committed by drivers in the following age categories: 26–35, 46–55, and 56–65 years. The age of drivers of trucks, auto-trailers and intervention vehicles is in the 56–65 years category.
- Driving license length of time: over six years. The driver's duration of use for trucks, auto-trailers, and intervention vehicles is over 10 years.

4.3. The Performance of the Romanian Road System and the Risk Factors

This subchapter identifies road safety performance indicators, risk indicators, and causes of accidents. The causes and indicators are identified based on road accidents assessment (see Section 3.1) and the case study from the Western Region of Romania (see Section 3.2). In order to create a complete picture of road transport in Romania, it is necessary to analyse the most important performance indicators that contribute to the competitiveness of the road system.

Road safety performance indicators highlight those optimal operating conditions of the road traffic system that influence system security performance and serve as evaluation tools [20,21]. It is noted [23–31] that the following are among the most important performance indicators:

- Daytime usage of low beam light on all road categories—using daytime low beam lights helps reduce the number of accidents.
- The degree of use of seatbelts on all road categories—the percentage of use of seatbelts on motorway roads is more than one third higher than the one on national/European roads.
- Average running speeds—average running speed for vehicles is 33 km/h in localities, 66 km/h on national/European roads, and 124 km/h on motorways.
- The number of kilometres covered annually—cars register up to 15,000 km a year, heavy vehicles about 35,000 km, buses 50,000 km.
- The current state of the auto fleet in Romania has seen a considerable increase in vehicles over 10 years old over the last 10 years.
- Vehicle equipment contributes to driving performance on all road categories due to the comfort and special features offered to the driver (lane keep assist, rain sensors, driver fatigue warning, etc.).

All exposures related to road accidents that contribute to the emergence of risks to human health should be considered risk factors. The risk factors [26–31] that are required to be monitored in a safe road system are:

- The driver's behaviour, including: individual risk factors, administered drugs, tiredness, lack of experience, drink, hearing and visual impairment, the use of mobile phones, distributional attention, health status, and more.
- Vulnerable road traffic subjects include: pedestrian behaviour, unattended children, and older road users.
- Protective behaviours, including all tools that help reduce the likelihood of a road accident.
- Environment, including all attributes related to the environment, road condition, and other adjacent elements.

The causes of accidents [18–21,31,32] are directly proportional to the variables analysed in this paper. The most important causes of accidents include: infrastructure (the reduced number of km of motorway), vehicle state (Romania fleet has grown in recent years, and vehicle age is over 10 years), and personal experience (which is different from one driver to another). A description of these causes by category of road is presented in Table 10. These data refer to the year 2016.

Table 10. The main causes of road accidents by category of road [20].

Road Category	The Main Cause	Percentage Cause/Road Type
Street	No priority to pedestrians	21%
	No priority to vehicles	15%
	Unlawful crossing of pedestrians	23%
	Bicycle rider's deviations	12%
National road	Speed not adapted to road conditions	25%
	The irregular crossing of pedestrians	13%
	Non-regulatory overtaking	10%
County Road	Speed not adapted to road conditions	30%
	The irregular crossing of pedestrians	15%
	Bicycle rider's deviations	10%
Communal road	Bicycle rider's deviations	25%
	Speed not adapted to road conditions	18%
	Deviations of the drivers of animal traction vehicles	13%
Motorway	Failure to observe the distance between vehicles	25%
	Speed not adapted to road conditions	20%
	Attention distraction with other activities	15%

It is important to monitor and improve the road performance indicators in order to reduce risk factors, address the causes of risk, contribute to increasing road safety, and achieve the EU's objective of reducing road traffic accidents by 50% by 2020 compared with 2010 [31,32].

4.4. Improvement of Road Safety System

Following the analysis (see Sections 3.1–3.3), the road safety system can be improved. These improvements are related to the driver, vehicle, and road safety specialist. This proposal is presented in Figure 3.

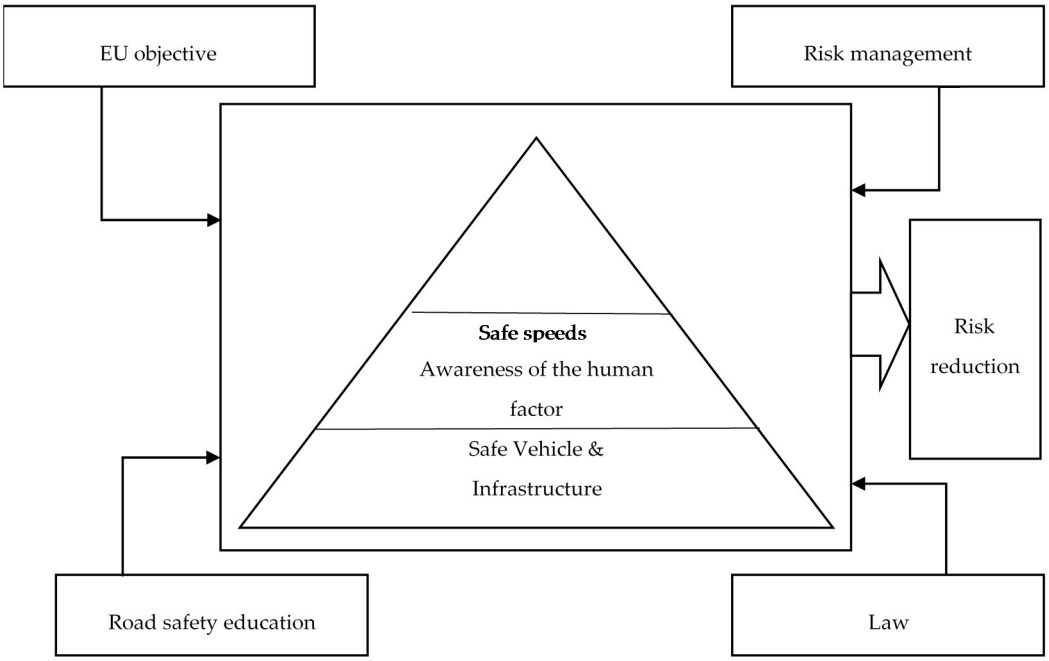

Figure 3. The proposed framework for improving the road safety system.

This proposal focuses on a series of elements of compulsory systematisation in the form of a pyramid on which four areas are concerned: EU objective, Risk management, Road safety education, and Law.

For the pyramid, there is an analogy with Maslow's Pyramid [33], which requires a series of fundamental needs. In the case of this proposal, there are vehicle and infrastructure needs. If these needs are met, the security level is passed to the next level by awareness of the human factor. The last level that needs to be met is that of safe speeds adapted to previous needs. This pyramidal system acts on the four areas that contribute to the competitiveness of the road system, and to the reduction of road and traffic risks.

5. Discussion

Within this chapter, the results obtained in the previous section are discussed (see Section 3). Discussions are structured on the addressed topics and supported by arguments:

- In terms of collision type, 47% of road accidents occur as a result of collision between vehicles. This is also supported by studies conducted in this respect [27–33].
- Curves are the cause of the most accidents when considering the road configuration. Thus, 2353 deaths and 8917 injuries were recorded in the year 2016.
- During the entire analysed period, accidents occurring in the daylight are those that occur most frequently. The number of road accidents according to the configuration in 2012 is 26,928, and in

2013 and 2014 there was a decrease in the number of accidents. However, in 2015, these kinds of accidents become more frequent again. In studies [28–30], Wells, Mikulik, Zhao, daylight is an important factor in monitoring road safety.

- The number of accidents caused by motor vehicles is in the range of +5.4% in 2016 compared with 2012. The number of accidents is increasing over the last two years as a result of overcoming the impact of the economic crisis and the increase in the number of vehicles in the Romanian fleet [20,31].
- More than 60% of serious accidents took place on national roads and streets, resulting in three quarters of the number of serious injuries and deaths.
- Drivers aged between 26 and 45 are involved in most road accidents. From the perspective of gender, men are involved in 75% of road accidents. Studies show that women exhibit balanced behaviour leading to a decrease in the number of their implication [30–35].
- Most accidents are caused by low-skilled drivers, with less than six years of driving experience. The length time of the driving license highlights that human experience contributes to increasing positive results [34–36].
- 55% of the injuries produced on DN69/E671 resulted in the death of at least one person.
- 85% of the accidents produced on the A1 motorway resulted in the death of at least one person.
- It is seen from the literature that physical and mental health influence the number of accidents.
- By properly monitoring the health status of drivers, the number of accidents could be lower.
- Road quality and country strategy contribute to improving road performance and safety.

Road safety performance indicators provide the best conditions for safe traffic. The assessment of these factors contributes to increasing safety and reducing the impact of risk indicators [37,38].

Risk indicators are presented to highlight the importance of risk management in the field of road safety [39–41]. It can be concluded that through improved risk management, the road safety system in Romania can be greatly improved. Under these circumstances, the EU target of 50% reduction in road accidents by 2020 compared to 2010 can be achieved.

Achieving the EU objective contributes to the alignment of the country with European standards and requirements, and to the sustainable development of the country [18,19].

6. Conclusions

The progressive reduction in the number of road accidents in the period 2016–2020, the central objective of the strategy, is at the same time the main result that can be expected from the sustainable development of a country. Sustainable development of an entity should consider the assessment of all risks and activities related to the human factors.

Most road accidents are caused by human behaviour with certain deficiencies. That's why its correction is of great importance. In Romania, a considerable number of road accidents are due to personal factors. To improve the current situation, the national road safety and security strategy must include infrastructure investments and raise awareness for the drivers of the importance of physical and mental health monitoring.

The limitations of this study refer to the fact that the data used was taken from the European Commission [18,19], the National Institute of Statistics (NIS) in Romania [20], and the Romanian Police [21], and these represent the data declared by authorised institutions.

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