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PRELIMINARY REPORT

Development of road traffic safety in the republic of Serbia from 2014 to 2024

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Abstract: The paper analyzes the development of road traffic safety in the Republic of Serbia from 2014 to 2024, aiming to determine the progress achieved in reducing traffic accident consequences and improving institutional management in this field. The research is based on data from the Statistical Office of the Republic of Serbia, the Ministry of Interior, and local road safety strategies, using descriptive–comparative and indicator analyses. The total number of fatalities decreased by 7%, while the number of injured persons increased by 8%, indicating partial effectiveness of implemented measures and the need for further improvement. A population decrease of more than 7% led to a 12% increase in public risk, whereas a 32% rise in the number of registered vehicles resulted in a 22% reduction in traffic risk. The highest increase in mortality was recorded among children, while the most severe consequences occurred on roads outside urban areas. At the same time, the number of local road safety strategies increased from one in 2014 to 96 in 2024, representing significant institutional progress. The results confirm the necessity of an integrated approach combining infrastructural, educational, and technological measures, as well as the application of analytical methods such as benchmarking and Data Envelopment Analysis (DEA) in the planning process. Achieving the "Vision Zero" goal requires consistent monitoring of performance indicators and cooperation across all levels of governance to ensure long-term improvement of road traffic safety in the Republic of Serbia.

Key words: Road traffic safety; risk analysis; safety strategies; benchmarking; Data Envelopment Analysis (DEA).

INTRODUCTION

Road traffic safety represents one of the key challenges of sustainable development and public health in contemporary society. Despite continuous efforts by international organizations and national governments, road traffic crashes remain among the leading causes of death and injury worldwide, with more than 1.35 million fatalities annually, according to the World Health Organization. This situation highlights the need for systematic and scientifically grounded approaches that enable a detailed assessment of road traffic safety performance and the identification of factors that significantly contribute to risk. It is important to emphasize that road traffic crashes do not only result in loss of life and disability, but also lead to unemployment, financial hardship, and psychological trauma that have long-term consequences for the families of victims (Másilková, 2017). Health professionals consistently recognize road traffic injuries as one of the leading public health issues - a "silent epidemic" - yet this problem remains insufficiently acknowledged at the level of national policy (Fanai & Mohammadnezhad, 2023).

Road traffic safety today is no longer viewed solely as an engineering challenge, but as an integral component of social and economic sustainability. In other words, road traffic safety represents one of the key issues of contemporary society, as it lies at the intersection of technological progress, social transformation, and human behaviour within a dynamic environment (Stipdonk et al., 2012). Modern research trends increasingly shift the focus away from traditional approaches that examine road traffic crashes in isolation, toward integrated frameworks that incorporate infrastructure, road user behaviour, institutional capacity, public health, and

economic impacts. This paradigm shift has contributed to the development of interdisciplinary models that connect different levels of the system - from technical and managerial to political and societal.

One of the most influential concepts shaping contemporary road traffic safety research is benchmarking - a systematic process of comparing performance across countries, regions, and local jurisdictions in order to identify best practices in road traffic safety management. Wegman and Oppe (2010), through the SUNflower model, emphasized the importance of linking Safety Performance Indicators (SPIs) with policy frameworks and institutional factors. This model enabled a deeper understanding of the interdependencies between political governance, infrastructural characteristics, and actual road traffic outcomes. Utilizing data from multiple EU Member States, the authors demonstrated a strong correlation between the maturity of institutional systems and road traffic safety performance. Countries with stable institutional structures, long-term strategies, and independent research institutes consistently achieve the best results. Wegman and Oppe highlight that the development of evidence-based policy is essential for the sustainable reduction of road traffic fatalities and injuries.

Shen et al. (2020) prepared a study with the aim of developing an integrated model that links road traffic safety performance, institutional capacity, and the effectiveness of policy implementation. The authors argue that benchmarking should not be limited to a quantitative comparison of indicators (e.g., fatalities per capita), but should instead represent a learning process based on comparing systems, policies, and institutional structures. Shen et al. developed a Multi-Layer Data Envelopment Analysis (DEA) model that enables integrated performance assessment across three levels: the Operational level (measuring the efficiency of specific interventions), the Tactical level (evaluating the effectiveness of implementing national strategies and action plans), and the Strategic level (analyzing institutional maturity and the quality of road traffic safety management). Countries such as Sweden, the United Kingdom, the Netherlands, and Norway achieved the highest efficiency values across all levels, while Bulgaria, Romania, and Latvia ranked among the least efficient. The study particularly emphasizes that middle-income countries, although often making progress in certain areas (e.g., infrastructure), tend to lag behind in institutional coordination and policy implementation.

The study prepared by Pinna et al. (2024) presents an integrated approach to analyzing road traffic safety in urban environments, aligned with the European Union's objectives of halving the number of road traffic fatalities by 2030 and achieving "vision zero" by 2050. The authors developed a method based on Geographic Information Systems (GIS) that enables a multi-layered assessment of road traffic safety, taking into account not only the locations of road traffic crashes but also factors such as traffic flow, pavement condition, and the presence of attraction points such as schools, hospitals, and commercial areas. The methodology is grounded in the superposition of four georeferenced data layers: crash locations, traffic flows, pavement conditions, and attraction points. Each layer contains a distinct set of information, and their integration enables a comprehensive spatial analysis of road traffic safety patterns. All data are collected and integrated within a GIS environment, allowing for the overlay and examination of interrelationships among variables. The results indicate that 71% of saturated road segments experience at least two or more crashes, while 72% of crashes occur on segments with poor or very poor pavement conditions.

Christoforou et al. (2012) investigate the potential for integrating real-time road traffic data into road traffic safety analysis. The primary goal of the study is to develop a method that links variations in traffic flow and volume to the occurrence of road traffic crashes, thereby enabling dynamic risk assessment and proactive road traffic management. The authors emphasize that traditional road traffic safety analysis methods predominantly rely on historical crash data, which are static and limited in scope, whereas real-time data allow for a dynamic evaluation of risk. The study highlights that advancements in information and communication technologies - such as sensors, GPS systems, and Intelligent Transportation Systems (ITS) - provide opportunities for continuous collection and analysis of variables such as speed, volume, and travel time. These data can be used to detect "critical situations." By applying a 15-minute time period (loop detector) before and after each crash, the researchers identified changes in key traffic variables - volume, speed, and flow - and thus detected patterns that precede road traffic crashes. The findings show that most crashes are preceded by periods of increased instability in traffic flow. Specifically, a substantial decrease in average speed and an increase in speed variance typically occur within 5 to 10 minutes prior to a crash. These changes are particularly pronounced in high-volume traffic zones, where drivers are required to brake and accelerate frequently.

This study is based on an analysis of data collected from various sources, with the aim of determining the degree of reliability, comparability, and applicability of information in assessing the state and development of road traffic safety in 2024 relative to 2014. The core methodological principle employed is a multi-layered approach, which involves the use of primary, secondary, and tertiary data sources. Primary sources include official statistical databases and reports issued by competent institutions. Secondary sources encompass relevant scientific and professional publications, as well as data obtained from international databases, while tertiary sources consist of local road traffic safety strategies, of-

ficial gazettes, and the official websites of local self-government units.

DEMOGRAPHIC CHARACTERISTICS

In the Republic of Serbia, population censuses are conducted periodically (the two most recent censuses were carried out in 2011 and 2022). In this study, census data are used as a source of information on the total population and projected population figures, which serve as the basis for calculating public exposure to road traffic risk. In addition, the Statistical Office of the Republic of Serbia (RZS) annually publishes the Statistical Yearbook, which is used in this study as a source of information on the number of registered vehicles, enabling the calculation of vehicle-based exposure to road traffic risk.

Population Size

According to the 2011 Population Census in the Republic of Serbia, the country had 7,186,862 inhabitants, while the 2022 Census recorded 6,647,003 inhabitants. Based on annual population estimates (derived from the previously conducted census, natural population change, and internal migration), it is possible to obtain approximate population figures for 2014 and 2024 - the two reference years used to evaluate the development of road traffic safety in the Republic of Serbia. It is estimated that Republic of Serbia had 7,131,787 inhabitants in 2014 and 6,623,183 inhabitants in 2024. When comparing only these two reference years, the population of the Republic of Serbia decreased by 508,604 inhabitants, or −7.13%.

Number of Registered Vehicles

According to the annual reports of the Statistical Office of the Republic of Serbia (SORS), data on the number of registered vehicles are available both at the national level and for each local self-government unit individually. The data show that in 2014 a total of 2,067,547 vehicles were registered (including 1,797,427 passenger cars), while in 2024 the number of registered vehicles increased to 2,792,489 (of which 2,389,105 were passenger cars). It is important to note that the total count includes motorcycles, mopeds, passenger cars, buses, freight vehicles, and work vehicles, whereas trailers were not considered in the analysis. Based on these data, the number of registered vehicles increased by 724,935, representing a growth of +32.16%.

The motorization rate in 2014 was 289.9 vehicles per 1,000 inhabitants, while in 2024 it increased to 421.6 vehicles per 1,000 inhabitants, representing a rise of approximately 45.4%. This increase indicates a significant growth in the level of motorization, meaning that the number of vehicles per inhabitant is considerably higher than a decade earlier. Although the population decreased by 7% between 2014 and 2024, the number of registered vehicles increased by 32%, which demonstrates a substantial rise in the motorization rate. This trend may be attributed to improved economic conditions, greater affordability and availability of vehicles, weakening public transport systems, and changes in lifestyle and demographic patterns. Higher motorization levels can lead to increased pressure on the road network, elevated crash risk, and greater strain on urban infrastructure. In other words, this trend may have negative effects on road traffic safety, the environment, and urban mobility - manifesting through higher congestion levels, increased pollution, and greater parking demand - which in turn influences the broader concept of urban road traffic safety.

ROAD TRAFFIC SAFETY ANALYSIS

Data on the number and consequences of road traffic crashes were collected using the Integrated Road Traffic Safety Database of the Road Traffic Safety Agency of the Republic of Serbia (RTSA). In the period from 2014 to 2024, a total of 376,847 road traffic crashes occurred, resulting in 5,986 fatalities and 215,269 injured persons. When comparing the research period, it is evident that the lowest number of crashes and their consequences occurred in 2020. However, due to the COVID-19 pandemic and the measures implemented to limit the spread of the virus, this year cannot be considered representative. According to the data presented in Table 2, a decrease in the total number of crashes, as well as crashes resulting only in material damage, was recorded in 2024 compared to 2014. This trend may indicate improvements in traffic control and regulation, as well as increased driver caution in lower-risk situations. However, at the same time, an increase in the number of crashes involving injured and fatally injured persons is observed, meaning that the number of crashes with casualties has risen. This phenomenon suggests that although the overall frequency of crashes is declining, the severity of their consequences for road users is increasing.

According to the data presented in Table 4, opposite trends are observed in the number of fatalities and injured persons in road traffic crashes in 2014 and 2024. The number of fatalities decreased by 7.83%, which represents a positive indicator in terms of reducing the most severe consequences of road traffic crashes. However, the total number of injured persons increased by 8.11%, and the total number of casualties (fatalities and injuries) increased by 7.75% compared to 2014. These data indicate that, although there has been a slight decline in the number of fatal outcomes, overall exposure to risk and the severity of crash consequences remain high, demonstrating the need for more intensive preventive measures and stronger control of road user behaviour.

Table 1. Road Traffic Crashes in the Period 2014–2024

Year	Fatal crashes	Injury crashes	Total casualties	Property-damage-only crashes	Total crashes
2014	476	12568	13044	21969	35013
2015	548	13109	13657	20518	34175
2016	551	13866	14417	21558	35975
2017	525	14226	14751	21715	36466
2018	491	13710	14201	21608	35809
2019	494	13748	14242	21525	35767
2020	459	11850	12309	18401	30710
2021	482	13271	13753	20821	34574
2022	505	12802	13307	19933	33240
2023	470	12993	13463	19385	32848
2024	481	13093	13574	18696	32270

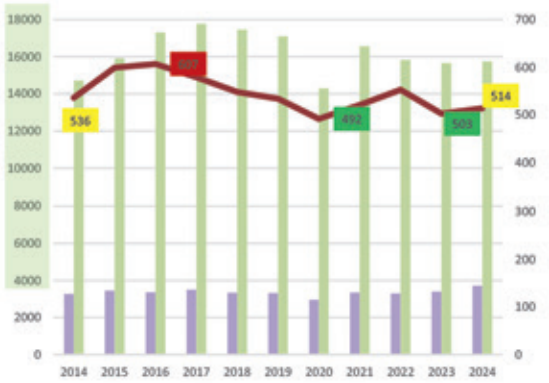

Figure 1. Road Traffic Crashes in the Period 2014–2024.

These results indicate that the road traffic safety management system in the Republic of Serbia, despite notable institutional improvements following the adoption of the Law on Road Traffic Safety and the implementation of national strategies, has not yet reached a sufficient level of effectiveness in reducing the risk of road traffic casualties. The increase in the number of injured persons may be attributed to the growing number of vehicles in traffic, higher exposure levels in urban environments, as well as the limited implementation of local road traffic safety strategies. This is particularly evident in towns and rural areas, where infrastructure development and the enforcement of safety measures lag behind the national average.

Further analysis should examine the influence of factors such as traffic density, vehicle age, the use of seat belts and protective helmets, as well as the implementation of safety measures in school zones and on local roads. Particular attention should be directed toward the so-called weighted risk indicators - public risk and traffic risk - as they provide a more objective representation of the population's actual exposure to road traffic hazards, taking into account demographic changes and shifts in motorization levels throughout the analyzed period.

Table 2. Comparison of the number of road traffic crashes between 2014 and 2024.

Year	Fatal crashes	Injury crashes	Total casualties	Property-damage-only crashes	Total crashes
2014	476	12568	13044	21969	35013
2024	481	13093	13574	18696	32270
Difference	5	525	530	-3273	-2743
Percentage Difference	1.05%	4.18%	4.06%	-14.90%	-7.83%

Table 3. Consequences of Road Traffic Crashes in the Period 2014–2024.

Year	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	536	3275	14720	17995	18531
2015	599	3448	15903	19351	19950
2016	607	3362	17304	20666	21273
2017	579	3503	17765	21268	21847
2018	548	3336	17452	20788	21336
2019	534	3322	17094	20416	20950
2020	492	2954	14297	17251	17743
2021	521	3347	16557	19904	20425
2022	553	3302	15817	19119	19672
2023	503	3397	15660	19057	19560
2024	514	3715	15739	19454	19968

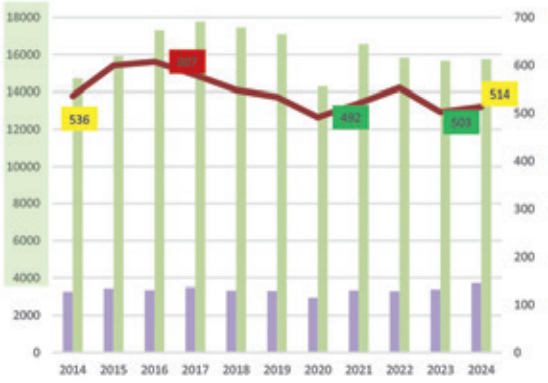

Figure 2. Consequences of Road Traffic Crashes in the Period 2014–2024.

Table 4. Comparison of Road Traffic Crash Consequences Between 2014 and 2024.

Year	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	536	3275	14720	17995	18531
2024	514	3715	15739	19454	19968
Difference	-22	440	1019	1459	1437
Percentage Difference	-7.83%	13.44%	6.92%	8.11%	7.75%

Road Traffic Safety Analysis by Age Groups

The analysis of road traffic safety by age groups for the period 2014-2024 reveals distinct trends in the num-

ber of fatalities, injuries, and overall casualties. In the 0-14 age group, a 60% increase in the number of fatalities was recorded, along with a slight rise in the number of slightly injured and total casualties. This indicates a growing exposure to risk among the youngest road users. Such a trend may be the result of insufficient protection measures in school zones and residential areas, as well as inadequate education of children regarding safe behaviour in road traffic.

In the 15-30 age group, the number of fatalities decreased by 13.53%, yet the number of injured and total casualties increased. This suggests that despite the reduction in fatal outcomes, young people remain one of the most vulnerable categories of road users. Their elevated risk is most commonly associated with limited driving experience, a propensity for speeding, and various forms of risky behaviour. Among the key factors contributing to increased risk in this age group are excessive speed, mobile phone use while driving, and non-compliance with speed limits or right-of-way rules.

In the 31-65 age group, a decrease in the number of fatalities is observed, accompanied by an increase in the number of injured persons and total casualties. Since this group represents the largest share of the active population and participates most frequently in traffic, the rise in the number of injured persons may be attributed to more intensive vehicle use, higher volumes of daily commuting, and increased exposure to urban road traffic congestion. Despite this, the stabilisation of the number of fatalities in this age group may be partially attributed to advancements in passive road safety systems.

In the population aged 65 and above, an increase in the number of fatalities and seriously injured persons is evident, while the total number of casualties shows a slight decrease. These results indicate that older road users are more susceptible to severe outcomes due to physical vulnerability and slower reaction times, which highlights the need for implementing measures aimed at improving infrastructure and ensuring safer mobility for elderly pedestrians and drivers. Furthermore, it is essential to develop systematic programmes for assessing the physical and cognitive abilities of older drivers, as well as improving lighting and traffic signalling in areas they use most frequently.

Overall, the data across age groups confirm that road traffic risk in the Republic of Serbia has not decreased uniformly among all segments of the population. While moderate progress can be observed among the working-age adult population, the youngest and oldest groups have experienced an increase in the severity of crash outcomes. This pattern highlights the need for targeted road traffic safety policies - particularly those focused on protecting children in school zones, educating young drivers, and improving mobility conditions for older adults. Such measures are aligned with the Road Traffic Safety Strategy of the Republic of Serbia, which identifies the reduction of casualties among vulnerable road users and the promotion of equity in access to a safe road traffic environment as key priorities.

Table 5. Comparison of Road Traffic Crash Consequence Indicators by Age Groups for 2014 and 2024.

Analysis of Road Safety for the 0–14 Age Group					
Year	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	10	215	1264	1479	1489
2024	16	196	1328	1524	1540
Difference	6	-19	64	45	51
Percentage Difference	60%	-8.84%	5.06%	3.04%	3.43%
Analysis of Road Safety for the 15–30 Age Group					
Year	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	133	812	4938	5750	5883
2024	115	876	5146	6022	6137
Difference	-18	64	208	272	254
Percentage Difference	-13.53%	7.88%	4.21%	4.73%	4.32%
Analysis of Road Safety for the 31–65 Age Group					
Year	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	270	1711	7342	9053	9323
2024	237	1850	7723	9573	9810
Difference	-33	139	381	520	487
Percentage Difference	-12.22%	8.12%	5.19%	5.74%	5.22%
Analysis of Road Safety for the over 65 Age Group					
Year	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	123	740	1628	2368	2539
2024	146	793	1542	2335	2481
Difference	23	53	-86	-33	-58
Percentage Difference	18.70%	7.16%	-5.28%	-1.39%	-2.28%

Road Traffic Safety Analysis by Road User Category

During 2014 and 2024, different trends were recorded in the consequences of road traffic crashes depending on the category of road users - drivers, pedestrians, and passengers. The analysis of the number of fatalities, seriously and slightly injured persons, as well as the total number of casualties, provides a detailed insight into the dynamics of risk and crash outcomes, and enables the identification of potentially high-risk groups.

Among drivers, a significant increase in all categories of crash consequences has been observed. These data indicate a rise in risk and severity of outcomes for drivers, which may be associated with the growing number of vehicles, higher traffic intensity, and increasingly complex traffic flows. The increase in serious injuries relative to the number of fatalities particularly highlights potential shortcomings in compliance with traffic regulations,

the insufficient use of safety systems, or the effectiveness of preventive measures. Additionally, the increasing use of mobile phones while driving, driver fatigue, and the influence of psychoactive substances should be noted, as these factors substantially elevate the likelihood of crashes with severe consequences. In contrast, pedestrians recorded a decline in almost all indicators. This trend suggests a positive impact of preventive measures and infrastructural solutions, such as pedestrian crossings, improved signalling, traffic-calming devices, and road user education. The slightly smaller reduction in the number of seriously injured pedestrians compared to fatalities may be attributed to improved medical intervention and faster emergency response times. However, continued systematic improvements in pedestrian safety remain necessary, particularly in school zones and densely populated urban areas, where pedestrians continue to represent one of the most vulnerable road user categories.

Among passengers, the number of fatalities decreased, while the number of injured persons increased. These results indicate the effectiveness of in-vehicle safety systems - such as seat belts and airbags - which help reduce mortality but do not fully eliminate injuries in the event of a crash. It is particularly important to highlight the passenger category within the 0-14 age group. Among child passengers, the number of fatalities increased significantly, from 4 to 16 (a 300% increase), accompanied by a rise in the number of injured and total casualties. These data point to a substantial increase in risk for children as passengers, which may be attributed to the higher number of transport modes used, noncompliance with proper child restraint systems, or insufficient enforcement of safety measures within vehicles. This category requires special attention in designing preventive strategies and ensuring strict adherence to child transportation regulations.

The analysis by road user category shows that progress in road traffic safety in the Republic of Serbia is not occurring uniformly. While pedestrians and passengers are, to some extent, better protected, the risk for drivers and child passengers is increasing significantly. These results highlight the need for targeted measures within the Road Traffic Safety Strategy of the Republic of Serbia, particularly in the areas of driver behaviour control, the use of safety systems, and the protection of children as passengers. At the same time, the findings suggest that the existing monitoring and evaluation system requires further improvement through better integration of data related to crash causes, demographic characteristics, and the spatial distribution of crashes. Such an approach would enable more precise, data-driven decision-making aimed at reducing casualties among the most vulnerable categories of road users.

Table 6. Comparison of Road Traffic Crash Consequence Indicators by Participant Type for 2014 and 2024.

Year	Participant Type	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	DRIVER	281	1663	7459	9122	9403
2024	DRIVER	308	2031	8457	10488	10796
Difference		27	368	998	1366	1393
Percentage Difference		9.61%	22.13%	13.38%	14.97%	14.81%
Year	Participant Type	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	PEDESTRIAN	128	825	2002	2827	2955
2024	PEDESTRIAN	111	803	1794	2597	2708
Difference		-17	-22	-208	-230	-247
Percentage Difference		-13.28%	-2.67%	-10.39%	-8.14%	-8.36%
Year	Participant Type	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	PASSENGER	127	785	5247	6032	6159
2024	PASSENGER	95	872	5465	6337	6432
Difference		-32	87	218	305	273
Percentage Difference		-25.20%	11.08%	4.15%	5.06%	4.43%

Table 7. Comparison of Road Traffic Crash Indicators by Participant Type for the 0–14 Age Group in 2014 and 2024.

Year	Participant Type	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	DRIVER	1	56	133	189	190
2024	DRIVER	0	44	155	199	199
Difference		-1	-12	22	10	9
Percentage Difference		-100%	-21.43%	16.54%	5.29%	4.74%
Year	Participant Type	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	PEDESTRIAN	5	101	456	557	562
2024	PEDESTRIAN	0	75	311	386	386
Difference		-5	-26	-145	-171	-176
Percentage Difference		-100%	-25.74%	-31.80%	-30.70%	-31.32%
Year	Participant Type	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	PASSENGER	4	58	675	733	737
2024	PASSENGER	16	77	856	933	949
Difference		12	19	181	200	212
Percentage Difference		300%	30.76%	26.81%	27.29%	28.77%

Spatial Analysis of Road Traffic Safety

Data for 2014 and 2024 show a substantial increase in road traffic crashes and their consequences, with trends varying considerably depending on the location of occurrence - within settlements and outside settlements. In urban areas, an increase in all categories of crash outcomes has been recorded. These results indicate significant growth in the number of injury-related crashes in urban environments, which may be attributed

to higher traffic density, more intensive movement of vehicles and pedestrians, and increasingly complex traffic flows in cities. Urban areas also face challenges such as limited parking capacity, insufficiently safe pedestrian and cycling infrastructure, and a growing number of vehicles on short-distance trips, all of which further increase the risk of interaction between different categories of road users.

In contrast, areas outside settlements recorded a far more dramatic increase across all indicators. These data point to substantially higher risk levels on rural and interurban roads, which may be associated with higher driving speeds, unfavourable road conditions, limited traffic control, and reduced accessibility of emergency medical services. Crashes outside settlements more frequently result in severe outcomes, making these areas critical points for infrastructure improvements and increased safety interventions. Insufficient protection along hazardous segments, lack of roadside barriers, poor night-time visibility, and inadequate pavement maintenance further intensify the severity of crash consequences on these roads.

The observed differences between crashes within and outside settlements highlight the need for a spatially differentiated approach to road traffic safety management. While urban areas require measures aimed at reducing interactions between motorized and non-motorized traffic (e.g., traffic-calming devices, 30 km/h zones, safe pedestrian crossings, cycling lanes), roads outside settlements require systemic interventions in infrastructure and speed management. In this context, recommendations from the European Safe System approach, as well as the Road Traffic Safety Strategy of the Republic of Serbia, emphasize the necessity of adapting safety management practices to the typology of space - urban, rural, and interurban.

Furthermore, it is essential to develop spatial risk indicators that combine crash frequency with demographic and traffic data (such as population density, number of vehicles, and road network length) to identify priority areas for intervention. This would enable the allocation of resources and measures to the highest-risk areas, in accordance with the principles of efficient and equitable road traffic safety management.

Table 8. Comparison of Road Traffic Crash Consequence Indicators Based on Spatial Analysis for 2014 and 2024.

Year	Urban Area	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	Urban Area	225	1569	7227	8796	9021
2024	Urban Area	237	2470	11407	13877	14114
Difference		12	901	4180	5081	5093
Percentage Difference		5.33%	57.43%	57.84%	57.76%	56.46%
Year	Urban Area	Fatalities	Severe Injuries	Slight Injuries	Injured Persons	Total Injured
2014	Non-Urban Area	95	377	1205	1582	1677
2024	Non-Urban Area	277	1245	4332	5577	5854
Difference		182	868	3127	3995	4177
Percentage Difference		191.58%	230.24%	259.50%	252.53%	249.08%

Table 9. Comparison of Road Traffic Crash Consequence Indicators According to Spatial Analysis for 2014 and 2024.

Year	Urban Area	Fatal crashes	Injury crashes	Total casualties	Property-damage-only crashes	Total crashes
2014	Urban Area	199	6343	6542	10581	17123
2024	Urban Area	231	10069	10300	15383	25683
Difference		32	3726	3758	4802	8560
Percentage Difference		16.08%	59.74%	57.44%	45.38%	49.99%
Year	Urban Area	Fatal crashes	Injury crashes	Total casualties	Property-damage-only crashes	Total crashes
2014	Non-Urban Area	90	901	991	1123	2114
2024	Non-Urban Area	250	3024	3274	3313	6587
Difference		160	2123	2283	2190	4473
Percentage Difference		177.78%	235.63%	230.37%	195.01%	211.59%

Risk Indicator Analysis

When comparing 2014 and 2024, significant changes can be observed in the structure and magnitude of road traffic crash consequences. The total number of fatalities decreased by 7.83%, which represents a positive trend in absolute terms, while the number of injured persons increased by 8.11%. These data indicate that although the number of fatal outcomes has slightly declined, the overall severity of road traffic casualties remains high, with a pronounced increase in the number of individuals sustaining serious bodily injuries.

When these changes are examined in relation to demographic indicators, a clearer picture emerges regarding the factors that influence overall risk levels. The decrease in the total population of the Republic of Serbia has resulted in an increase in the weighted public risk by +12.15% (the Public Risk Indicator – PRI was 154.7 casualties per 10,000 inhabitants in 2014, compared to 173.5 in 2024), since a smaller population is being compared with a similar or only slightly reduced number of casualties. This means that the individual risk per inhabitant has increased, indicating the need to evaluate road traffic safety not only through absolute numbers but also through relative indicators that more accurately reflect the population's true exposure to road traffic hazards.

On the other hand, the increase in the number of registered vehicles during the same period led to a reduction in the weighted traffic risk by −22.91% (the Traffic Risk Indicator – TRI was 533.8 casualties per 10,000

registered vehicles in 2014, compared to 411.5 in 2024). This reduction indicates that the rise in motorization has not been accompanied by a proportional increase in the number of crashes. Such a trend may be interpreted as a result of technological advancements in vehicles, stricter regulations, improved road maintenance, and more effective traffic enforcement. Moreover, the increasing adoption of active and passive vehicle safety systems contributes to mitigating the consequences of crashes.

It can be concluded that the weighted public and traffic risk indicators move in opposite directions, confirming the complexity of road traffic safety analysis. A decreasing population increases individual (public) risk, whereas a growing number of vehicles reduces the systemic (traffic) risk. These findings underscore the importance of a multidimensional approach to assessing and planning road traffic safety measures, particularly within the context of strategic management and the development of local and national programmes that must incorporate demographic, technological, and infrastructural factors.

These results confirm the need for road traffic safety evaluations to rely not only on absolute indicators of the number of casualties, but also on composite indicators that account for demographic changes, motorization levels, and economic activity. For this reason, the road traffic safety monitoring system should be oriented toward the introduction of performance indicators in line with European practices (EU Road Safety Performance Framework), in order to obtain a more realistic assessment of risk trends and to define intervention priorities more accurately in the forthcoming strategic period.

ROAD TRAFFIC SAFETY PERFORMANCE INDICATORS

Road Safety Performance Indicators (RSPI) represent measurable indicators that monitor key risk factors and the effects of road safety measures, such as the use of seat belts and helmets, speed, alcohol impairment, vehicle technical condition, and infrastructure quality. Their purpose is to enable the assessment, comparison, and improvement of road safety systems at both national and local levels by measuring the actual conditions that influence the occurrence of road traffic crashes.

In the Republic of Serbia, systematic measurement of these indicators began in 2013, in accordance with the guidelines of the European Commission and the ETSC, and is carried out by the Road Traffic Safety Agency of the Republic of Serbia in cooperation with the Ministry of Interior, the Statistical Office of the Republic of Serbia, and local road safety councils. This process forms the foundation for the development of analytically driven road safety management and for monitoring progress toward national strategic objectives.

Data on the average vehicle speed indicator for 2014 and 2024 show different trends depending on road type and vehicle category. Within settlements, a decrease in speed was recorded across all vehicle categories, most notably among passenger cars (−6.03%). This trend indicates a positive effect of speed-control measures, the installation of traffic-calming devices, enforcement cameras, and increased police supervision, as well as the gradual development of a safer driving culture in urban environments. On roads outside settlements, a slight reduction in speed was observed for most vehicle categories, with the exception of heavy goods vehicles, which recorded a moderate increase (+2.23%). This result may be attributed to improved road conditions, modernization of the vehicle fleet, and increased commercial activity, while simultaneously signalling the need for more intensive monitoring and control of freight traffic. On motorways, an increase in average speeds was recorded across all vehicle categories, particularly among heavy goods vehicles (+6.21%) and passenger cars (+1.85%). This increase may be associated with improved vehicle performance, more stable driving conditions, and an expanded motorway network; however, it also carries the potential risk of more severe crash outcomes. In summary, the results show that Serbia has recorded a reduction in speeds within settlements over the past decade, which is a positive indicator of the effectiveness of local measures; however, the gradual increase in speeds on motorways highlights the need for continued investment in enforcement measures and safety technologies to maintain stable levels of road traffic safety.

The data show that between 2014 and 2024 there was a substantial increase in the percentage of speed-limit violations across most vehicle categories, indicating a heightened tendency toward risky behaviour in traffic despite existing enforcement measures. Within settlements, the largest increases were recorded among heavy goods vehicles (+89.36%) and mopeds (+346.45%), which may be attributed to intensified commercial activity and weaker implementation of local enforcement measures. In contrast, a decrease was observed among motorcycles (−51.36%), which may be associated with stricter enforcement and increased awareness of risk among riders. On roads outside settlements, speed-limit violations increased dramatically among buses (+178.11%), mopeds (+265.08%), and passenger vehicles (+68.10%), indicating insufficient enforcement and the need for additional speed-control measures, such as automated systems or physical infrastructure. On motorways, the trend is likewise upward - particularly among heavy goods vehicles (+474.77%) and motorcycles (+108.29%). This suggests insufficient compliance with speed limits and a potentially higher level of road traffic risk. Overall, the data indicate that despite a slight reduction in average speeds in some zones, the frequency of speed-limit violations has increased, suggesting the need to strengthen preventive measures, enhance driver education, and expand the use of automated speed enforcement systems.

The use of mobile phones while driving has remained very high, with no meaningful improvement. Among passenger car drivers, only a minimal decrease was recorded (−0.10%), while slightly larger reductions were observed among heavy goods vehicle drivers (−3.76%) and bus drivers (−3.53%). However, these decreases are still insufficient to indicate a genuine change in driver behaviour. This highlights the need for strengthened enforcement and targeted awareness campaigns addressing the risks associated with mobile phone use while driving. In contrast, the use of seat belts shows a significant increase. On front seats, seat belt use among passenger car occupants rose from 70.3% to 85.8% (+22.05%), while heavy goods vehicles recorded an even higher increase (+76.85%). The most substantial improvement was observed among bus drivers, where seat belt use increased by more than +480%, representing a major institutional success in the implementation of safety regulations. Particularly noteworthy is the growth in rear-seat seat belt use among passenger car occupants - from only 4.0% in 2014 to 21.3% in 2024 (+432.5%), indicating a shift in passenger attitudes and the broader adoption of safe travel practices. Overall, the data show that seat belt use has become more widespread and socially accepted, whereas mobile phone use remains a persistent risk factor in road traffic. These findings confirm that educational campaigns and legal measures have had a positive impact on passenger protection, but also emphasize the need to direct greater attention toward digital risks while driving.

The indicators show remarkable progress in the use of child restraint systems. The overall usage rate increased from 18.4% to 60%, representing an improvement of more than 225%. The largest increase was recorded outside settlements (+278.88%), indicating heightened parental awareness of risks during longer trips and improved compliance with child safety regulations. Within settlements, usage increased from 17.2% to 56.1%, which is a positive signal in the context of urban safety and the effectiveness of educational campaigns. Although the results on motorways show a somewhat more moderate increase (+152.48%), they still demonstrate a stable upward trend and broader adoption of safety standards. These findings confirm that institutional measures, media campaigns, and traffic police enforcement have contributed significantly to the increased use of child restraint systems. However, continuous parental education and strict enforcement of regulations remain essential in order to reach European standards, where child safety system usage exceeds 90%.

STRATEGIC DOCUMENTS

According to the Law on Road Traffic Safety of the Republic of Serbia ("Official Gazette of the RS", Nos. 41/2009, 53/2010, 101/2011, 32/2013 – CC, 55/2014, 96/2015 – other law, 9/2016 – CC, 24/2018, 41/2018, 87/2018, 23/2019, 128/2020 – other law, 76/2023 and 19/2025), Article 11 introduced for the first time the obligation for the Government of the Republic of Serbia to adopt a Road Traffic Safety Strategy as the principal strategic document in this field. This article specifies that the Strategy must include a comprehensive assessment of the existing road safety situation, a clearly defined vision, long-term and short-term objectives, as well as key areas of action accompanied by deadlines for adopting the corresponding action plan.

Furthermore, Article 12 of the same law establishes the obligation to prepare an Action Plan, which defines in detail the measures and activities within key areas of work, the competent and responsible entities, implementation deadlines, and the required financial resources. In accordance with this legal provision, the Road Traffic Safety Strategy of the Republic of Serbia, together with its accompanying Action Plan, was adopted for the first time in 2015 for the period 2015–2020. After the expiration of this period, a new strategic document was adopted in 2023 for the period 2023–2030, accompanied by an Action Plan covering the period 2023–2025. It is important to note that a three-year gap occurred between the expiration of the first strategy and the adoption of the new one, during which no valid national strategic document existed. This interruption disrupted the continuity of systematic planning and road traffic safety management in the Republic of Serbia.

From the perspective of local self-government units, Article 13 of the Law on Road Traffic Safety prescribes the obligation of each local government to develop and adopt a local road traffic safety strategy and an annual road safety plan, in accordance with the national strategy and action plan. However, in 2014 only one local self-government unit had prepared and adopted a strategic document in this field. Ten years later, in 2024, a total of 96 local self-government units had developed their own strategic documents, of which a substantial number (77) had officially adopted them. This represents a significant advancement in the institutional approach to road traffic safety management at the local level.

The particular importance of this finding lies in the fact that, in the forthcoming period, all existing local strategies will be subject to individual and critical evaluation. The purpose of this analysis is to examine the extent to which local documents are aligned with national strategic objectives, whether they contain measurable performance indicators, and whether they reflect the specific safety challenges present in different contexts (urban, rural, and peri-urban). In this way, the study will provide a foundation for a critical assessment of the institutional maturity of the road traffic safety management system in the Republic of Serbia, with special emphasis on the local level as the key link in implementing

a "bottom-up" approach[1].

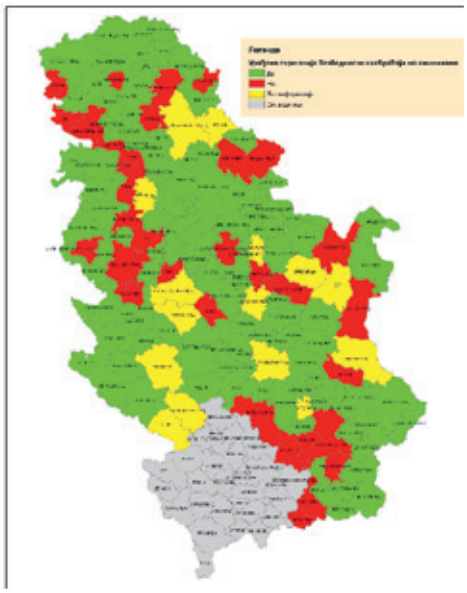

Figure 3. Map of Local Self-Governments in the Republic of Serbia That Have Developed a Strategic Document.

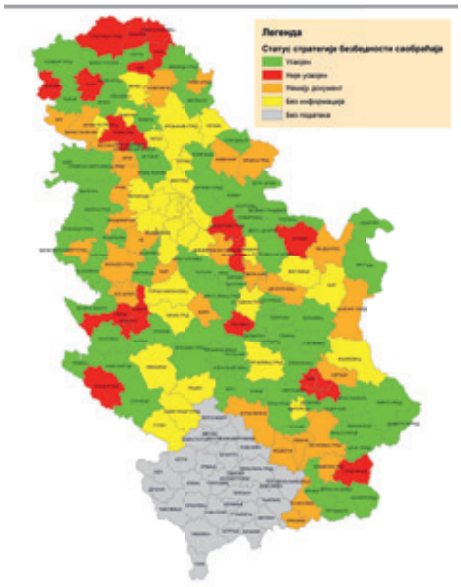

Figure 4. Map of Local Self-Governments in the Republic of Serbia That Have Adopted a Strategic Document.

DISCUSSION OF RESULTS AND CONCLUDING CONSIDERATIONS

The results of the study indicate that road traffic safety in the Republic of Serbia achieved certain institutional and analytical improvements between 2014 and 2024; however, these advancements have had only a limited effect on reducing the consequences of road traffic crashes. Although the total number of fatalities decreased by 7.83%, the number of injured persons increased by more than 8%, suggesting that preventive measures have not sufficiently reduced the overall severity of crash outcomes. These findings highlight the need to strengthen a comprehensive systemic approach that includes improved driver behaviour control, education, infrastructural interventions, and consistent monitoring of road safety performance indicators.

A particularly important observation is the increase in the weighted public risk (+12.15%) due to demographic decline, while the weighted traffic risk decreased by 22.91%. This contrast confirms the complex relationship between motorization, demography, and road traffic safety. The reduction in average speeds within settlements, combined with a simultaneous rise in the percentage of speed-limit violations outside settlements and on motorways, demonstrates that the problem lies not in the average value but in the distribution of risky behaviour. This indicates the presence of a significant group of drivers who systematically exceed speed limits, requiring more precisely targeted enforcement measures and sanctions.

A positive development is seen in the increased use of seat belts and child restraint systems—particularly on front seats and on roads outside settlements—where usage rose by more than 200%. This suggests the effectiveness of educational campaigns and institutional enforcement mechanisms implemented by the Road Traffic Safety Agency. At the same time, mobile phone use while driving remains high, indicating the need for a new approach to behavioural regulation and digital discipline in traffic.

A key institutional improvement is the growth in the number of local road safety strategies—from one in 2014 to 96 in 2024. This reflects the gradual development of a "bottom-up" management system that integrates local communities into the national road safety framework. In the coming period, all local strategies will undergo individual and critical evaluation to assess their quality, alignment with national objectives, and actual effects on road user safety.

In conclusion, although the results show a moderate reduction in fatal outcomes and substantial institutional progress, the Republic of Serbia continues to face challenges related to driver behaviour, infrastructural conditions, and enforcement of legislation. Achieving the vision of "zero fatalities" requires continued development of performance indicator monitoring, the introduction of measure effectiveness analysis through benchmarking and DEA models, and ensuring strategic continuity without institutional gaps. This study provides a foundation for further critical evaluation of local strategies

1 The "bottom-up approach" represents a road traffic safety management model in which initiatives, measures, and data originate from local self-government units and communities and are subsequently coordinated at the national level. This approach is based on decentralizing responsibilities and tailoring measures to local conditions, thereby ensuring greater effectiveness and sustainability of the system. Under this model, the state establishes the general framework and standards, while local actors ensure the concrete implementation of measures and monitoring of results on the ground.

and for the development of an integrated road safety management model in the Republic of Serbia.

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