Journal Homepage: www.ijarpr.com ISSN: 3049-0103 (Online)

International Journal of Advance Research Publication and Reviews

Vol 03, Issue 8, pp 473-478, August, 2026

Black Spot Analysis, Weighted Severity Index, Road Safety, Traffic Engineering, Accident Prevention, Transportation Safety

Gourav Kumar[1], Mr. Samik Sharma[2]

Post Graduate Student, SKITM, Bahadurgarh, Jhajjar
Email: gauravkumarribadia@gmail.com
[2] Assistant Professor SKITM, Bahadurgarh, Jhajjar

ABSTRACT :

Road traffic accidents continue to pose a serious challenge to transportation systems due to their adverse impacts on human life, mobility, and economic development. Identifying accident-prone locations is an essential component of road safety management because it enables transportation agencies to prioritize safety interventions and allocate resources effectively. The present study focuses on the identification of accident black spots and the development of safety improvement measures using the Weighted Severity Index (WSI) method in Rohtak, Haryana. Accident data collected for the period from December 2024 to April 2025 were analyzed to determine locations exhibiting high accident severity and frequency.

The Weighted Severity Index method was employed to evaluate accident-prone locations by assigning greater importance to fatal and grievous injury accidents compared with minor injury accidents. The analysis was conducted using accident records obtained from selected road intersections and urban traffic corridors. Based on the calculated WSI values, accident locations were ranked according to their severity levels to identify critical black spots requiring immediate attention. The results revealed that Delhi Road Chowk recorded the highest Weighted Severity Index value and emerged as the most hazardous location within the study area, followed by Hisar Road Junction, Bhiwani Stand, and Medical Mor.

Further assessment of these locations indicated that factors such as traffic conflicts, inadequate traffic control, mixed traffic movement, pedestrian activity, visibility limitations, and speeding contributed significantly to accident occurrence. Based on the findings, a set of engineering, enforcement, educational, and traffic management measures was proposed to improve safety conditions at identified black spots. The study demonstrates that the Weighted Severity Index method provides a practical and effective approach for prioritizing accident-prone locations and supporting evidence-based road safety planning. The findings can assist transportation planners, traffic engineers, and policymakers in developing targeted strategies for reducing accidents and improving roadway safety.

Keywords: Black Spot Analysis, Weighted Severity Index, Road Safety, Traffic Engineering, Accident Prevention, Transportation Safety.

1. INTRODUCTION

Road traffic accidents have become one of the most significant transportation challenges affecting both developed and developing countries[1]. Rapid urban growth, increasing vehicle ownership, expanding road networks, and rising travel demand have contributed to greater traffic congestion and a higher likelihood of road crashes. Apart from causing fatalities and injuries, road accidents impose substantial economic and social burdens on society through medical expenses, productivity losses, infrastructure damage, and emotional distress to affected families. Consequently, improving road safety has become a major priority for transportation planners, policymakers, and traffic management authorities[2].

One of the most effective approaches for reducing road traffic accidents is the identification and treatment of accident black spots. A black spot refers to a specific road location where accidents occur repeatedly or where accident severity is significantly higher than surrounding locations. Such locations generally exhibit roadway, traffic, or environmental characteristics that contribute to increased crash risk[3]. Identifying black spots enables transportation agencies to focus their resources on locations where safety interventions can produce the greatest benefits.

Various techniques have been developed for black spot identification, including accident frequency methods, accident rate approaches, statistical models, and severity-based assessment methods[4]. Among these techniques, the Weighted Severity Index (WSI) method has gained considerable attention because it incorporates both accident frequency and accident severity into the evaluation process. By assigning greater weight to fatal and grievous injury accidents, the WSI method provides a more realistic representation of road safety conditions and assists in prioritizing locations requiring immediate corrective action[5].

The present study aims to identify accident black spots in Rohtak, Haryana, using the Weighted Severity Index method and to develop suitable safety improvement measures for reducing accident occurrence and severity. The study evaluates accident data collected from major intersections and urban road corridors and proposes practical recommendations for enhancing transportation safety. The outcomes of the research are expected to support evidence-based decision-making and contribute to safer road transportation systems[6].

2. STUDY AREA AND DATA COLLECTION

2.1 Description of Rohtak, Haryana

Rohtak is an important urban center located in the state of Haryana, India. The city serves as a major educational, commercial, administrative, and transportation hub within the region. Due to its strategic location and connectivity with nearby cities such as Delhi, Hisar, Jind, and Bhiwani, Rohtak experiences substantial traffic movement throughout the day. The city accommodates a diverse mix of road users, including private vehicles, public transport, freight vehicles, motorcycles, cyclists, and pedestrians[7].

In recent years, rapid urban expansion and increasing motorization have resulted in higher traffic volumes and more complex traffic interactions. The growth of commercial activities, educational institutions, healthcare facilities, and residential developments has further intensified travel demand within the city. Consequently, several intersections and roadway sections have experienced increasing accident occurrence, making Rohtak an appropriate case study for black spot identification and road safety assessment[8].

2.2 Road Network Characteristics

The road network of Rohtak consists of national highways, state highways, major urban roads, collector roads, and local streets that facilitate regional and intra-city transportation. Important transportation corridors include Delhi Road, Hisar Road, Jind Road, and Bhiwani Road, which carry significant volumes of passenger and commercial traffic. These corridors connect major residential, commercial, industrial, and institutional areas and therefore experience substantial daily traffic movement[9].

The traffic composition within Rohtak is highly heterogeneous, consisting of motorcycles, cars, buses, trucks, auto-rickshaws, bicycles, and pedestrians operating simultaneously. Such mixed traffic conditions often create conflicts between road users with varying speeds and maneuvering characteristics. Several intersections within the city also experience congestion, frequent turning movements, roadside parking activities, and pedestrian crossings, which may contribute to accident occurrence. Understanding these road network characteristics is essential for evaluating accident patterns and identifying hazardous locations[10].

2.3 Accident Data Sources

The accident data utilized in the present study were obtained from officially maintained road accident records covering the period from December 2024 to April 2025. The collected information included details related to accident location, accident severity, vehicle involvement, road-user category, date of occurrence, and other relevant accident characteristics. The accident records provided the necessary information required for calculating the Weighted Severity Index and identifying accident-prone locations.

The study primarily focused on major intersections and roadway sections where accident occurrence was relatively higher. Four locations, namely Delhi Road Chowk, Hisar Road Junction, Bhiwani Stand, and Medical Mor, were selected for detailed analysis because of their notable accident frequency and severity characteristics. These locations were subsequently evaluated using the Weighted Severity Index method to determine their relative safety performance and ranking[11].

2.4 Data Collection and Validation

The collected accident records were subjected to a systematic validation process before being used for analysis. Initially, all accident entries were reviewed to identify duplicate records, missing information, and inconsistencies that could affect analytical accuracy. Records containing incomplete or contradictory information were carefully examined and corrected wherever possible.

Following verification, the accident data were classified according to severity level, including fatal accidents, grievous injury accidents, and minor injury accidents. The validated dataset was then organized into a structured database suitable for Weighted Severity Index calculations and statistical assessment. Data validation ensured consistency and reliability throughout the analysis process and improved the credibility of the research findings[12].

The final dataset provided a dependable basis for black spot identification and safety evaluation. The systematic data collection and validation procedures adopted in this study ensured that the resulting analysis accurately reflected accident conditions within the selected study area and supported the development of meaningful road safety recommendations[13].

3. RESEARCH METHODOLOGY

3.1 Concept of Accident Black Spots

Accident black spots are specific roadway locations where road traffic accidents occur repeatedly or where accident severity is considerably higher than that observed at nearby locations. These locations are generally characterized by recurring traffic conflicts resulting from deficiencies in roadway design, traffic operations, visibility conditions, driver behavior, pedestrian activity, or environmental factors. The identification of accident black spots is an essential component of road safety management because it enables transportation authorities to concentrate safety improvement efforts on locations that contribute disproportionately to overall accident occurrence and severity[15].

Black spot analysis provides a scientific basis for prioritizing road safety investments and developing targeted corrective measures. Instead of implementing generalized safety interventions across an entire road network, transportation planners can focus on locations where the potential benefits of safety improvements are greatest[16]. The identification of accident-prone locations also assists in understanding the underlying causes of accidents and

supports the development of evidence-based traffic safety strategies.

In the present study, black spots were identified through the evaluation of accident severity characteristics rather than relying solely on accident frequency. This approach recognizes that locations with fewer accidents may still represent serious safety concerns if those accidents result in severe injuries or fatalities. Consequently, a severity-based evaluation method was adopted to ensure a comprehensive assessment of road safety conditions within the study area[14].

3.2 Weighted Severity Index Method

The Weighted Severity Index (WSI) method was employed to identify and rank accident-prone locations in Rohtak. The WSI approach is widely used in transportation safety studies because it incorporates both accident frequency and accident severity into a single evaluation framework. Unlike simple accident-count methods, the WSI technique assigns different weights to accidents according to their severity levels, thereby providing greater importance to accidents involving fatalities and serious injuries[17].

The underlying principle of the Weighted Severity Index method is that severe accidents impose greater social, economic, and human costs than minor accidents. Therefore, locations associated with fatal and grievous injury accidents should receive higher priority for safety interventions than locations experiencing only minor accidents. By assigning appropriate weights to different accident categories, the WSI method generates a severity score that reflects the overall safety condition of a location.

The method provides a practical and systematic approach for identifying hazardous locations and establishing priorities for road safety improvement. Due to its simplicity, reliability, and effectiveness, the Weighted Severity Index method has been widely adopted by transportation agencies and researchers for black spot identification and safety assessment studies.

3.3 WSI Formula

The Weighted Severity Index was calculated using accident records classified into fatal accidents, grievous injury accidents, and minor injury accidents. Each accident category was assigned a specific weight reflecting its severity level. Fatal accidents were assigned the highest weight because they involve the loss of human life, while grievous injury accidents received a moderate weight and minor injury accidents received the lowest weight.

The formula used in the present study is given below:

WSI = (41 × Fatal Accidents) + (4 × Grievous Injury Accidents) + (1 × Minor Injury Accidents)

Where:

- Fatal Accidents = Number of accidents resulting in death.
- Grievous Injury Accidents = Number of accidents involving serious injuries.
- Minor Injury Accidents = Number of accidents involving minor injuries.
- WSI = Weighted Severity Index Score.

The calculated WSI score represents the overall severity level of a location. Higher WSI values indicate more hazardous conditions and a greater need for immediate safety intervention. Locations with the highest WSI scores were identified as critical black spots within the study area.

3.4 Black Spot Ranking Procedure

After calculating the Weighted Severity Index values for all selected locations, a ranking procedure was carried out to identify accident-prone sites requiring priority attention. The ranking process involved comparing WSI scores obtained for each location and arranging them in descending order according to severity.

The location with the highest WSI value was assigned the highest priority because it represented the greatest road safety concern. Similarly, locations with lower WSI values received lower rankings. The ranking procedure enabled clear identification of critical black spots and facilitated the prioritization of safety improvement measures.

For the present study, four major locations were evaluated: Delhi Road Chowk, Hisar Road Junction, Bhiwani Stand, and Medical Mor. The WSI calculations revealed that Delhi Road Chowk recorded the highest severity score and was therefore identified as the most hazardous location. Hisar Road Junction ranked second, followed by Bhiwani Stand and Medical Mor. The ranking results formed the basis for subsequent safety evaluation and recommendation development.

The black spot ranking process ensured that safety interventions could be directed toward locations with the highest accident severity levels, thereby maximizing the effectiveness of available resources and improving overall transportation safety performance[18].

3.5 Safety Measure Development Process

Following the identification of black spots, a systematic process was adopted for developing safety improvement measures. The objective of this stage was to formulate practical recommendations capable of reducing accident frequency and severity at identified hazardous locations.

Initially, the accident characteristics associated with each black spot were examined to understand the factors contributing to accident occurrence. Particular attention was given to traffic conflicts, roadway geometry, visibility conditions, traffic control devices, pedestrian movement, roadside activities, and vehicle operating characteristics. The findings from accident analysis and location assessment were then used to identify potential safety deficiencies.

Based on the identified deficiencies, suitable engineering, enforcement, educational, and traffic management measures were proposed. Engineering measures included improvements such as upgraded road markings, enhanced signage, intersection channelization, pedestrian facilities, speed calming

devices, and improved street lighting. Enforcement measures focused on speed regulation, helmet compliance, traffic monitoring, and violation control. Educational initiatives emphasized public awareness and road-user training programs, while traffic management measures aimed to improve traffic flow and reduce conflict points.

The proposed safety measures were developed with the intention of addressing the specific conditions observed at each black spot. This location-specific approach increases the likelihood of achieving meaningful reductions in accident occurrence and contributes to long-term improvements in transportation safety within the study area.

4. RESULTS AND DISCUSSION

4.1 Identification of Accident Black Spots

The identification of accident black spots was carried out using accident records collected from major intersections and roadway sections within Rohtak. Black spots are locations where accident frequency and severity are significantly higher than those observed at other locations within the road network. Identifying such locations is important because it allows transportation authorities to prioritize safety interventions and allocate resources efficiently. In the present study, four major locations were selected for detailed analysis based on their accident occurrence characteristics, namely Delhi Road Chowk, Hisar Road Junction, Bhiwani Stand, and Medical Mor.

The selected locations were evaluated using the Weighted Severity Index (WSI) method, which considers not only the number of accidents but also the seriousness of accident outcomes. This approach provides a more realistic representation of road safety conditions because locations associated with fatal and grievous injury accidents receive higher priority than those experiencing only minor injury accidents. The calculated WSI values were subsequently used to rank the selected locations and identify the most critical accident-prone areas within the study area.

4.2 Weighted Severity Index Assessment

Table 1. Weighted Severity Index Ranking of Accident Black Spots in Rohtak

Location	Fatal	Grievous Injury	Minor Injury	WSI Score	Rank
Delhi Road Chowk	4	8	12	208	1
Hisar Road Junction	3	7	11	162	2
Bhiwani Stand	2	6	10	116	3
Medical Mor	2	5	8	110	4

The results presented in Table 1 indicate substantial variation in accident severity among the selected locations. Delhi Road Chowk recorded the highest Weighted Severity Index value of 208 and was therefore identified as the most hazardous black spot within the study area. The location experienced four fatal accidents, eight grievous injury accidents, and twelve minor injury accidents during the study period. The high WSI score suggests that this location is characterized by significant safety deficiencies and requires immediate intervention. The presence of multiple fatal and serious injury accidents indicates that accident consequences at this location are particularly severe.

Hisar Road Junction obtained the second-highest WSI value of 162 and was ranked as the second most critical black spot. Although the number of fatal accidents was slightly lower than that recorded at Delhi Road Chowk, the location still exhibited a considerable number of grievous injury and minor injury accidents. The high severity score indicates the existence of substantial traffic conflicts and operational deficiencies that contribute to accident occurrence.

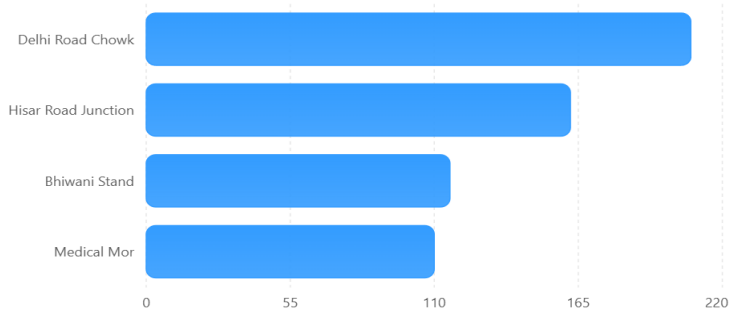
Bhiwani Stand recorded a WSI value of 116 and was ranked third among the evaluated locations. The location experienced two fatal accidents, six grievous injury accidents, and ten minor injury accidents. While the severity level was lower than that observed at the top two locations, the recorded WSI value still indicates significant safety concerns requiring corrective measures. The accident pattern suggests that pedestrian activity, roadside parking, and mixed traffic movement may contribute to accident occurrence at this location[19].

Medical Mor obtained the lowest WSI value among the analyzed locations, with a score of 110. Nevertheless, the location still recorded multiple fatal, grievous injury, and minor injury accidents, indicating the presence of road safety issues. Although Medical Mor was ranked fourth, the difference between its WSI value and that of Bhiwani Stand was relatively small, suggesting that both locations require attention from transportation authorities.

The ranking obtained through the Weighted Severity Index method clearly demonstrates the usefulness of severity-based analysis in identifying hazardous locations. Unlike accident-frequency approaches, the WSI method places greater emphasis on fatal and grievous injury accidents, thereby ensuring that locations associated with severe crash outcomes receive higher priority. The results indicate that Delhi Road Chowk and Hisar Road Junction should receive immediate consideration for safety improvements, while Bhiwani Stand and Medical Mor should be included in medium-term safety planning initiatives.

4.3 Analysis of Accident-Prone Locations

Figure 1. Weighted Severity Index Ranking of Black Spots



The graphical representation of Weighted Severity Index values highlights the severity differences among the identified black spots. Delhi Road Chowk exhibits a substantially higher severity score than the remaining locations, confirming its status as the most hazardous site within the study area. The graph also illustrates a gradual decline in severity scores from Delhi Road Chowk to Medical Mor. The visual representation supports the ranking obtained through the WSI analysis and provides a clear understanding of the relative safety performance of the selected locations.

4.4 Assessment of Contributing Factors

A detailed assessment of accident-prone locations revealed several factors contributing to accident occurrence and severity. Traffic congestion was identified as a major issue at Delhi Road Chowk and Hisar Road Junction due to high traffic volumes and frequent turning movements. Inadequate traffic control, lane discipline violations, and speed variations further increased the likelihood of traffic conflicts at these locations[20].

Pedestrian activity emerged as a significant contributing factor at Bhiwani Stand, where commercial activities and public transport operations attract large numbers of pedestrians. Limited pedestrian facilities and uncontrolled crossing movements increase accident risk. Similarly, roadside parking and encroachment reduce effective roadway width and create additional traffic conflicts.

At Medical Mor, visibility limitations, mixed traffic conditions, and inadequate traffic guidance were identified as major concerns. The interaction of different vehicle categories operating at varying speeds contributes to accident occurrence. These findings indicate that accident causation is influenced by a combination of roadway, traffic, operational, and behavioral factors.

4.5 Development of Safety Improvement Measures

Based on the identified deficiencies, several safety improvement measures were developed for the accident-prone locations. Engineering interventions include improved road markings, upgraded traffic signage, enhanced street lighting, pedestrian crossings, and intersection channelization. These measures are intended to improve traffic guidance, visibility, and operational efficiency.

Traffic calming measures such as speed breakers, rumble strips, and speed display devices are recommended for locations experiencing excessive vehicle speeds. Dedicated turning lanes and improved signal timing may further reduce traffic conflicts at major intersections.

Enforcement-based measures include stricter monitoring of speed violations, helmet usage, seat belt compliance, and traffic signal adherence. Educational initiatives involving road safety awareness campaigns, driver training programs, and pedestrian safety education are also recommended. The integration of these measures is expected to reduce accident frequency and improve overall transportation safety[21].

4.6 Discussion of Major Findings

The results of the study demonstrate that accident severity is concentrated at a limited number of locations within the study area. The application of the Weighted Severity Index method successfully identified Delhi Road Chowk, Hisar Road Junction, Bhiwani Stand, and Medical Mor as critical accident-prone locations. The findings indicate that accident occurrence is influenced by traffic congestion, mixed traffic conditions, pedestrian activity, visibility limitations, and operational deficiencies.

The severity-based ranking approach proved effective because it incorporated both accident frequency and accident consequences into the evaluation process. The analysis revealed that locations associated with fatal and grievous injury accidents require immediate priority in road safety planning. The proposed engineering, enforcement, and educational measures provide a practical framework for improving safety conditions at identified black spots. Overall, the findings highlight the importance of data-driven road safety management and demonstrate the effectiveness of the Weighted Severity Index method as a tool for accident black spot identification and prioritization.

5. CONCLUSIONS

5.1 Major Findings

The present study employed the Weighted Severity Index (WSI) method to identify accident black spots and develop safety improvement measures for Rohtak, Haryana. The analysis demonstrated that accident severity is concentrated at a limited number of locations within the study area. Among the evaluated locations, Delhi Road Chowk emerged as the most hazardous black spot with a WSI score of 208, followed by Hisar Road Junction, Bhiwani Stand, and Medical Mor. The results indicate that locations experiencing fatal and grievous injury accidents require greater attention than locations characterized solely by accident frequency.

The study further revealed that traffic congestion, inadequate traffic control, mixed traffic movement, pedestrian activities, visibility limitations, and speed-related issues were major contributors to accident occurrence. The application of the Weighted Severity Index method successfully integrated accident frequency and severity into a single assessment framework, enabling a more realistic evaluation of road safety conditions. The findings confirmed that severity-based approaches provide a more effective basis for prioritizing road safety interventions than simple accident-count methods.

5.2 Practical Implications

The findings of the study provide valuable insights for transportation planners, highway engineers, traffic police authorities, and road safety policymakers. The identified black spots can be prioritized for immediate safety improvements, thereby maximizing the effectiveness of available financial and technical resources. The use of the Weighted Severity Index method allows decision-makers to focus on locations associated with severe accident outcomes and

greater social costs.

The results can assist transportation agencies in developing location-specific safety programs rather than implementing generalized safety measures across an entire road network. Furthermore, the methodology adopted in this research can be replicated in other cities and urban road networks for identifying hazardous locations and improving transportation safety performance. The study also highlights the importance of maintaining reliable accident databases to support evidence-based road safety planning and monitoring.

5.3 Recommendations

Based on the findings of the study, several recommendations are proposed to improve road safety conditions at the identified black spots. Engineering measures such as improved road markings, enhanced traffic signage, upgraded street lighting, intersection channelization, and pedestrian crossing facilities should be implemented at critical locations. Traffic calming measures including speed breakers, rumble strips, and speed monitoring systems should be introduced where excessive vehicle speeds contribute to accident occurrence.

Strict enforcement of traffic regulations, including helmet usage, seat belt compliance, speed limits, and traffic signal adherence, should be strengthened. Public awareness campaigns and driver education programs should be conducted regularly to promote safe driving practices and improve road-user behavior. In addition, periodic road safety audits and continuous accident monitoring should be undertaken to evaluate the effectiveness of implemented measures and identify emerging safety concerns. The adoption of these recommendations is expected to reduce accident frequency, minimize accident severity, and contribute to a safer transportation environment in Rohtak.

REFERENCES

1. Abdel-Aty, M., & Keller, J. (2005). Exploring the overall and specific crash severity levels at signalized intersections. *Accident Analysis & Prevention, 37*(3), 417–425.
2. Aarts, L., & Van Schagen, I. (2006). Driving speed and the risk of road crashes: A review. *Accident Analysis & Prevention, 38*(2), 215–224.
3. Ahmed, M., Abdel-Aty, M., & Lee, J. (2015). A study of crash severity using roadway and traffic characteristics. *Journal of Safety Research, 54*, 109–117.
4. Elvik, R. (2014). Road safety management by objectives. *Safety Science, 65*, 89–95.
5. Elvik, R., Høye, A., Vaa, T., & Sørensen, M. (2009). *The handbook of road safety measures* (2nd ed.). Emerald Group Publishing.
6. Evans, L. (2004). *Traffic safety*. Science Serving Society.
7. Geurts, K., Wets, G., Brijs, T., & Vanhoof, K. (2005). Identification and ranking of black spots. *Transportation Research Record, 1908*(1), 20–27.
8. Ghadi, M., Török, Á., & Tánczos, K. (2018). Review of black spot identification methods. *Periodica Polytechnica Transportation Engineering, 46*(2), 111–117.
9. Gururaj, G. (2008). Road traffic injury prevention in India. *National Medical Journal of India, 21*(1), 14–20.
10. Hauer, E. (1997). *Observational before–after studies in road safety*. Pergamon.
11. Hauer, E. (2015). The art of identifying hazardous road locations. *Accident Analysis & Prevention, 78*, 110–118.
12. Kumar, P., Singh, S., & Verma, A. (2017). Black spot analysis on national highways. *Journal of Transportation Engineering, 143*(5), 04017015.
13. Lord, D., & Mannering, F. (2010). The statistical analysis of crash-frequency data. *Transportation Research Part A, 44*(5), 291–305.
14. Mohan, D. (2017). Traffic safety in India: Challenges and opportunities. *Indian Journal of Transport Management, 41*(3), 215–228.
15. Persaud, B., & Lyon, C. (2007). Empirical Bayes approach for black spot identification. *Transportation Research Record, 2019*(1), 17–24.
16. Prato, C. G. (2013). Injury severity analysis in traffic accidents. *Accident Analysis & Prevention, 50*, 109–117.
17. Singh, S. K. (2017). Road traffic accidents in India: Issues and challenges. *Transportation in Developing Economies, 3*(1), 1–12.
18. Sørensen, M. (2007). Black spot management and safety improvements. *Transport Reviews, 27*(4), 447–463.
19. Tiwari, G. (2016). Pedestrian and cyclist safety in Indian cities. *Transportation Research Procedia, 17*, 402–411.
20. Washington, S. P., Karlaftis, M. G., Mannering, F., & Anastasopoulos, P. (2020). *Statistical and econometric methods for transportation data analysis* (3rd ed.). CRC Press.
21. World Health Organization. (2023). *Global status report on road safety 2023*. World Health Organization.