SINERGI Vol. 28, No. 2, June 2024: 347-354
http://publikasi.mercubuana.ac.id/index.php/sinergi
http://doi.org/10.22441/sinergi.2024.2.014

Identification of hazardous road sites: a comparison of blackspot methodology of Narogong Road Bekasi and Johor Federal Roads

Muhammad Isradi[1*], Hermanto Dwiatmoko[1], Joewono Prasetijo[2], Andri Irfan Rifai[3], Zaffan Farhana Zainal[2], Guohui Zhang[4], Hendy Yusman Firdaus[1]
[1]Department of Civil Engineering, Faculty of Engineering, Universitas Mercu Buana, Indonesia
[2]Department of Transportation Engineering, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Malaysia
[3]Faculty of Civil Engineering and Planning, Universitas Internasional Batam, Indonesia
[4]Departemen of Civil and Environmental Engineering, University of Hawai'i at Manoa, United States

Abstract
A traffic accident is an unexpected and inadvertent road event involving a vehicle with or without other road users that results in human injuries and possibly property damage. This study identifies and analyses the characteristics of Indonesian and Malaysian road traffic incidents. The method used was the identification of crash data coordinates and the Equivalent Accident Number (EAN) score per road segment. Accident characteristics are based on the type of road traffic accident, and collision is the most common type of accident. Speed data of two vehicles, cars and motorcycles, was collected through the test driver method by using the same vehicles for cars and motorcycles and following their normal driving habits. From the analysis results, some factors causing accidents on the Bekasi Narogong Road Section are the lack of traffic signs, road surface conditions, and lack of clear road markings. While on the FT050 Johor federal road, every kilometre per segment and along the segment, motorcycles are faster than cars in terms of speed.

Keywords:
Blackspot;
Crash analysis;
Hazardous road location;
Road safety;
Road traffic accident;

Article History:
Received: September 15, 2023
Revised: December 19, 2023
Accepted: December 26, 2023
Published: June 2, 2024

Corresponding Author:
Muhammad Isradi
Civil Engineering Department, Universitas Mercu Buana, Indonesia
Email: isradi@mercubuana.ac.id

INTRODUCTION

A traffic accident is an incident on a public or private road caused by carelessness or negligence by road users, vehicle maintenance, road conditions, or environmental factors, and a collision between a vehicle and an object or a vehicle and another vehicle resulting in death, injury, and/or serious injury recorded by the police [1]. The December 2018 publication of the 2018 Global Status Report on Road Safety by the World Health Organization focused on the 1.35 million annual road traffic deaths. Road traffic accidents are the leading cause of mortality among those aged 5 to 29. Pedestrians, cyclists, and motorcyclists endure a disproportionate amount of the burden, especially in developing countries. [2].

Accidents involving land transportation modes have reached an alarming level in recent years. An accident is an incident that causes injury to individuals and can result in material losses or the death of a person [3]. One type of collision that occurs frequently is on highways and toll roads. According to the most recent data from Indonesia, 116,411 accidents occurred in 2019, with 25,671 fatalities, 12,475 serious injuries, and 137,342 minor injuries. In addition, IDR 254,779,000 in material losses [4]

According to the annual road safety report, every year between 2004 and 2013, road accidents or fatalities increased by 15% in line with rapid motorization as the number of registered vehicles doubled during the same period in Malaysia [5][6]. In addition, the road fatality rate is also high; for example, there were 23 deaths per 100,000 people in 2013. However, since 2000, the risk in terms of deaths per mile or per registered vehicle has decreased significantly due to the large increase in motorization in Malaysia [7].

Hazardous road locations vary; however, road safety administration must identify hazardous road places methodically and scientifically. [8]. Identifying hazardous road locations typically entails key aspects such as defining the location of routes and areas, establishing "hazardous" criteria, such as using frequency, speed, speed quality control, or crash potential reduction methods, and considering into account relevant factors such as exposure, such as traffic volume and traffic mix [9]. It is also necessary to determine the severity of crashes by giving greater weight to fatal crashes than injury crashes and the time period of the crash [10]. While all of these factors are essential for scientific crash analysis, this study, which presents preliminary findings from a larger-scale experiment, concentrates just on the first, namely location definition. The selection of the geographic unit of analysis has ramifications for all other components. Therefore, site definition is fundamental [11], such as determining crash frequency values and locating hazardous roads [12].

According to much research, the primary causes of road traffic accidents are human error, such as speeding, decreased concentration, errors caused by alcohol, infractions of traffic restrictions, exhaustion, and sleepiness [13]. Human mistakes can cause traffic accidents among drivers, passengers, and vulnerable road users such as pedestrians, cyclists, and motorcyclists [14]. Driver errors are common, the main ones being excessive speeding [15][16], long-distance driving tiredness, emotional driving [17], Inexperienced driving and consuming alcohol [18][19].

Passengers can potentially enhance the likelihood of a traffic accident by distracting drivers [20]. Pedestrian mistakes, such as crossing in front of automobiles, walking on the road, and crossing the road away from crosswalks and streets near the facility, causes traffic accidents [21]. When analyzing environmental risk for road conditions, the physical environment (road design, weather conditions, fixed objects in the safety zone) and the socioeconomic environment (community norms, laws, and regulations) should be taken into consideration [22][23]. The impact of environmental hazards on road collisions is often represented in the literature by items in the safety zone (trees, power poles) [1][24]. Environmental risk factors frequently exacerbate the severity of accidents and serious injuries [25][26]. Vehicles colliding with trees is a typical roadside hazard [8][12]. The most prevalent things that cause vehicle accidents are roadside buildings (signs, fences, barriers, trees, and electrical) [22][25]. Weather has a detrimental impact on road traffic, increasing the severity of accidents and injuries [21]. The amount of rainfall influences the number of traffic accidents [27][28]. In addition, community zones with facilities (street food sellers, supermarkets) influence road traffic crashes and injuries [29].

Vehicle safety standards are necessary in all vehicles to protect the driver and passengers' safety [30]. Several studies have revealed vehicle characteristics that impact collision risk include poor maintenance and worn tyres [31][32]. Common factors contributing to accidents involving public or school transport vehicles include distracted braking, insufficient illumination, excessive loading, and improper usage or alteration of vehicles [33]. Lack of safety equipment in vehicles increases the risk of severe injuries, severe disabilities, and fatalities [34][35]. Transporting passengers in containers and pickup trucks is very dangerous, as passengers are not safe and can be thrown from the pickup or trapped inside the container [36][37]. If the engine burns out or people are stuck in the car, the accident's severity might worsen [38].

The accident rate approach and the equivalent accident frequency method are two of the most extensively utilized accident black spot detection methods. Non-experimental studies were done, for example, before and after the influence of a counting measure on the number of traffic accidents at a crossroads [39]. These approaches are also utilized as fundamental methods in accident black spot detection research, and they are enhanced or combined with other methods to improve identification efficiency and accuracy. Although the abovementioned procedures are basic, clear, and easy to calculate, they have limits. For example, two places with the same number of crashes may or may not have the same hazard level, but the crash frequency technique regards them as the same location. When applied to low-traffic routes, the accident rate approach becomes unclear, and it assumes a linear relationship between collision frequency and traffic volume, which may or may not be accurate [9][40].

This study aims to determine which segments are accident-prone areas, what factors cause accidents, and determine the speed characteristics of motorcycles and cars based on road geometry design. This research focuses on urban road segments in Bekasi, Indonesia and Johor, Malaysia.

Due to the increase in road accidents today, an unresolved issue is accidents at hazardous locations that cause inconvenience to road users. Accident statistics and an increase in the number of cars are frequently used to identify dangerous road spots. Furthermore, accident statistics cannot explain the reasons that lead to accidents at that place. As a result, the real road environment issues of the road site are regarded as vital as road safety indicators in order to address road accidents. Road hazards include physical road defects such as potholes, intersections, including driveways, bends or curves in the road, the position or movement of other road users, a lack of appropriate road markings, poorly graded curves and uneven shoulders, and changes in weather and road conditions.

METHOD

Despite the fact that hotspot zones are hazardous to road users, there is no systematic mechanism for identifying them on road networks. Most previous studies have focused on hypothetical or selected routes rather than the complete road network [41].

The research site on the Bekasi Narogong Road section in Figure 1 is carried out in each segment by identifying blackspot accident-prone locations, which are grouped based on the coordinate points in the accident data.

Tabulating accident data coordinates Accident data is grouped based on the coordinates in the accident data, and the equivalent accident number (EAN) score per road segment is tabulated. The EAN scoring tabulation is obtained by giving points based on (1) [29]:

$$EAN = 12\ FAT + 3\ SVI + 3\ MNI + 1PDO \qquad (1)$$

Where:
FAT = Fatality
SVI = a Severe injury
MNI = a Minor Injury
PDO = Property Damaged Only

Developing an EAN weighting diagram per road segment. The EAN weighting diagram per road segment combines the number of EAN points and road segments divided by km.

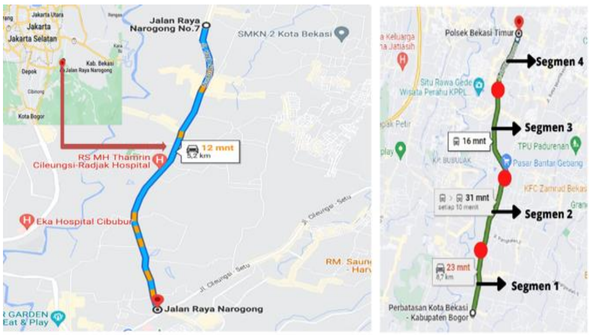

Figure 1. Narogong Road and Segment Observations

The average value plus the standard deviation value obtained from the calculation will be the limit in determining black spots, and then black spots will be determined. A black spot is a value greater than the feasibility interval line (average plus standard deviation) or that intersects with the line.

Determination of accident-prone locations using the statistical Upper Control Limit (UCL) quality control chart [42], which is shown in (2):

$$UCL = \lambda + \Psi\ x \sqrt{\left(\frac{\lambda}{m}\right) + \left(\frac{0{,}892}{m}\right) + \left(\frac{1}{2m}\right)} \qquad (2)$$

Where:
λ = score of average accident
ψ = probability factor = 2.576
m = score accidents in each segment

In the urban road section of Johor Malaysia, Federal Road 50 (FT050) was determined as the research site, as shown in Figure 2. The data collection was divided into multiple sections dependent on the location chosen. Included in the primary data were the speeds of two vehicles, cars and motorcycles. The information was collected using the test driver method, with vehicles and motorcycles using the same moving vehicle and exhibiting conventional driving behaviors. Data speed from signalized intersections was removed around 300 m to prevent the influence of traffic control devices on vehicle speeds and free flow speed [43].

Following data collection and road segmentation to identify the consistency model, the 85th percentile speed profile was created [32]. The segments are divided into analyses that include individual geometry and traffic circumstances before simulating the collisions of motorcycles and cars to facilitate comprehension. Speed data are analyzed to determine the impact of motorcycles and cars on road geometrics such as lane width, shoulder width, access point, length of tangent or curve, and medians, which may vary across the section.

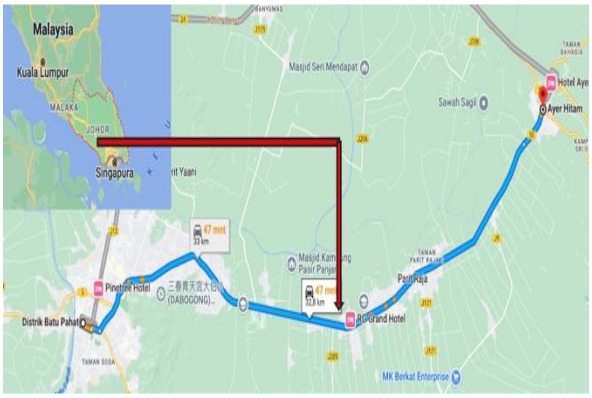

Figure 2. Jalan Kluang - Ayer Itam - Batu Pahat, Federal Route 50 (FT 050)

Multiple linear regression analysis based on 5 km per segment is utilized in (2) model to forecast the 85th percentile speed of cars and motorcyclists based on speed, length of tangent/curve, shoulder width, median, and access point:

$$V_{85} = A_1 + A_2\,(L) + A_3(AP) + A_4\,(SW) - A_5\,(Q) \quad (2)$$

Where:

A_1 = Speed of vehicle (km/h)
L = Length tangent/curve (m)
SW = Shoulder Width (m)
AP = Access Point
Q = Median

As a result, each independent variable's regression coefficients should be considerably different from zero, and each independent variable's symbol should adequately depict its influence on operating speed [44][45].

RESULTS AND DISCUSSION

Previous methodologies were utilized to identify and rank potential locations for safety enhancements. These approaches have eased the construction of roadways with heterogeneous traffic with varying speeds and behaviors; yet there may be mistakes because of selection issues and poor site selection.

Data on accidents on the Narogong Road between 2018 and 2020 are sorted. In addition, the statistics on the number of casualties and material losses in accidents are listed in Table 1.

Furthermore, the Upper Control Limit (UCL) value is determined, and accident-prone points are identified using the quality control statistics method as an Upper Control Limit (UCL) dick chart, which is based on the equivalent number of each kilometre or road segment with an EAN weight value greater than the UCL limit value. Calculations may be done utilizing the quality control statistics approach on each segment of the Narogong Road section based on the accident rate, as indicated in Table 2.

Table 1. Number of Victims and Losses of Accidents on Narogong Road

Segment	EAN	UCL	Description	Property loss (IDR)
1	75	187,025	No Prone	49800000
2	240	185,255	No Prone	20250000
3	**261**	**185,157**	**Prone**	**18250000**
4	156	185,798	No Prone	15300000
Total	**732**			

Table 2. Number of Victims and Losses of Accidents on Narogong Road

Years	Crash Victims			Number of Crash	Material Loss (IDR)
	Fatal	Serious injury	Minor injury		
2018	4	5	55	64	22000000
2019	12	19	41	72	23500000
2020	6	11	39	56	58600000
Total	22	35	135	192	104100000

Based on Table 2, accident victims and material losses are Rp. 104,100,000, with a total of 192 victims. Minor injuries alone ranked the highest at 135 people, followed by serious injuries of 35 people, and 22 people died. 2019 was the year with the highest number of victims, with 72 and 64 victims in 2018.

Analysis of Accident-Prone Areas

Analysis of hazardous areas The Equivalent Accident Number (EAN) approach was used in this study to define accident-prone locations by sorting based on the mortality rate of accident victims that happened on the Narogong Roads Section. EAN is determined by adding each victim's mortality rate multiplied by the severity weight, as shown in (1) shown in Table 3.

According to Figure 3, segment 3 is an accident-prone location on the Narogong Highway Road, with the most vulnerable EAN and UCL values among other segments, approximately IDR. 18,250,000 in material damages. As a result, careful management is required to limit accidents at that place.

Table 3. EAN Calculation Results for Research Location

Segment	FAT	SVI	MNI	EAN Value
1	1	2	19	75
2	9	8	36	240
3	6	19	44	261
4	5	6	26	156
	Total			**732**

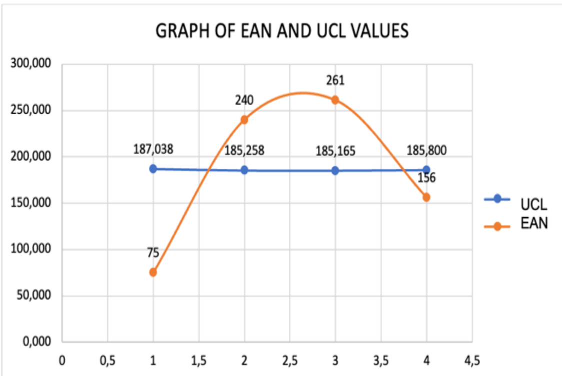

Figure 3. Accident Rate Ranking Graph with EAN and UCL Methods

Operating Speed Model

The operating speed data was collected by 100 test drivers and motorcyclists using GPS devices, and they were directed to execute the test during the day and in unrestricted movement along the specified sectors. The site of FT 050 is divided into three portions. To build an operating speed model in chosen segments, tangent length, curve length, shoulder width, median, and access point were used as independent variables.

Table 4 illustrates the analysis of variance outputs for motorcycles, while Table 5 provides the analysis of car variance outputs. The degrees of freedom for each source of variation indicate the number of effects at that level minus the number of restrictions.

The regression coefficient outputs are shown in Table 6, which shows the regression coefficients of motorcycles, and Table 7, which shows the regression coefficients of cars.

A statistical relationship between a dependent variable and an independent variable; consequently, the equations for motorcycle operating speed:

V_{85M} = 94.1–13.2 L+0.564 AP–8.27 SW–3.43 Q
R^2 = 0.61

V_{85C} = 95.7–6.30 L–0.535 AP–5.59 SW–1.89 Q
R^2 = 0.61

Figure 4 represents the best fit linear relationship between observed and predicted speed for motorcycles. Figure 5 shows the relationship between observed and projected speeds for cars.

Table 4. Analysis of variance of motorcycles

Source	DF	SS	MS	F	P
Regression	4	1766.13	441.53	15.91	0.000
Residual Error	43	1193.57	27.76		
Total	47	2959.69			

Table 5. Analysis of variance of cars

Source	DF	SS	MS	F	P
Regression	4	1981.94	495.49	16.62	0.000
Residual Error	43	1282.29	29.82		
Total	47	3264.23			

Table 6. The regression coefficient of motorcycles

Predictor	Coefficient	SE Coefficient	T	P
Constant	95.665	3.575	26.76	0.000
Length (m)	-6.297	3.093	-2.04	0.047
AP	-0.5350	0.2611	-2.05	0.046
SW	-5.592	2.619	-2.14	0.038
Median	-1.8909	0.5903	-3.20	0.003

Table 7. The regression coefficient of cars

Predictor	Coefficient	SE Coefficient	T	P
Constant	94.120	3.706	25.40	0.000
Length (m)	-13.184	3.221	-4.09	0.000
AP	0.5643	0.2714	2.08	0.044
SW	-8.266	2.714	-3.05	0.004
Median	-3.4276	0.616	-5.60	0.000

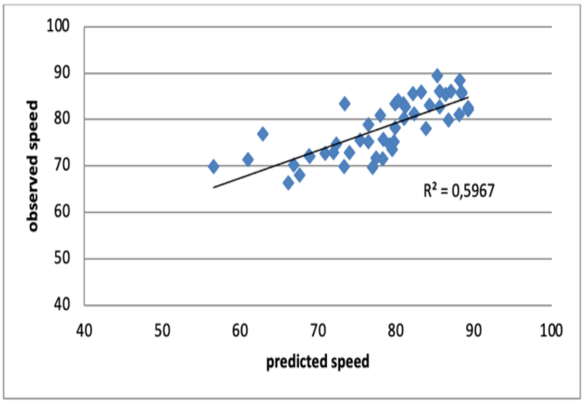

Figure 4. Observed Speed vs. Predicted Speed of Motorcycles

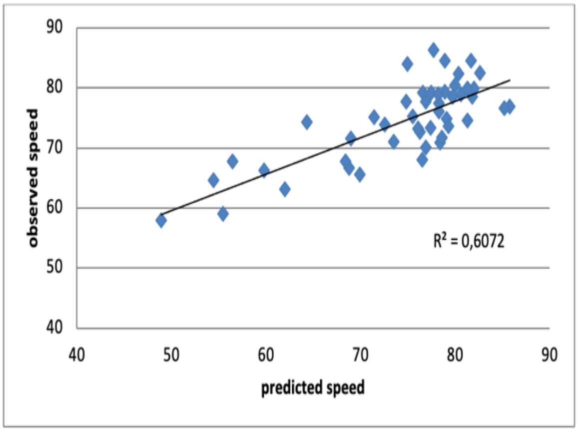

Figure 5. Observed Speed vs. Predicted Speed of Cars

The vehicle speed for both motorcycles and autos rejects the null hypothesis since $F_{0.05}$ > $F_{critical}$, and the difference is substantial. Furthermore, the observed speed is greater than the expected speed.

Based on the analysis of Narogong Bekasi Road, several factors trigger accidents, such as the lack of traffic signs, some faded road markings, sidewalk fence safety, and uneven road conditions that increase the number of accidents. On the FT050 Johor federal road, the triggering factors for accidents are geometric elements related to motorcycle speed and car speed, illegal parking, and uneven road markings of the lane width and shoulder width.

Both roads are accident-prone areas, so it is necessary to conduct a comparative study of the causes of accidents on these roads. In particular, the authorities need to improve geometric elements, road conditions, and speed restrictions, especially in hazardous road locations.

CONCLUSION

Based on the results of the segment analysis, segment 3 was identified as an accident-prone area with an EAN value of 216 69 accidents and a total material loss of IDR 18,250,000. Accident-causing factors include a lack of traffic signs, road markings that are incomplete or faded, the absence of safety fences and sidewalks, road damage, and uneven road conditions.

According to the results, motorcycles are faster than cars for every km per segment and along segments, and the speed thresholds for motorcycles and cars are the same. Speed characteristics are determined by geometric components such as shoulder width, lane width, median, and access points, which impact road safety or a road accident for motorcyclists and cars. Road geometry and driver attitude impact the link between geometric elements and vehicle speed.

ACKNOWLEDGMENT

This research is an international collaboration research program (KLN) supported by Mercu Buana University and Universiti Tun Hussein Onn Malaysia. In addition, we are grateful to our colleagues from the Research and Community Service Center of Universitas Mercu Buana and all the reviewers who have provided insights and expertise that immensely helped this research.

REFERENCES

[1] Y. Wan, W. He, and J. Zhou, “Urban Road Accident Black Spot Identification and Classification Approach: A Novel Grey Verhuls–Empirical Bayesian Combination Method,” *Sustainability (Switzerland)*, vol. 13, no. 20, 2021, doi: 10.3390/su132011198.

[2] J. Sawin, E. Martinot, and D. Appleyard, “Global Status Report on Road Safety,” *World Health Organization*, pp. 81, 2018. [Online]. Available: https://www.who.int/publications/i/item/9789240086517

[3] M. Isradi, Z. Arifin, M. I. Setiawan, R. D. Nasihien, and J. Prasetijo, “Traffic Performance Analysis of Unsignalized Intersection Using the Traffic Conflict Parameter Technique,” *SINERGI*, vol. 26, no. 3, pp. 397-402, 2022, doi: 10.22441/sinergi.2022.3.015.

[4] BPS-West Java, *Transportation Statistics of West Java Province 2020*. Bandung: Central Bureau of Statistics of West Java Province, 2020.

[5] J. Prasetijo, Z. F. Zainal, S. W. Mudjanarko, M. F. Ramli, and D. Supriyatno, “Accident prediction model by relating integrated design consistency model,” *International Journal of Integrated Engineering*, vol. 12, no. 1, pp. 260-269, 2020, doi: 10.30880/ijie.2020.12.01.026.

[6] J. Prasetijo, G. Zhang, Z. F. Zainal, W. Z. Musa, and N. A. A. Guntor, “Performance Level of Road Geometric Design Based on Motorcycle–Cars Linear Speed Profile,” in *International Congress and Exhibition" Sustainable Civil Infrastructures: Innovative Infrastructure Geotechnology"*, Springer, 2017, pp. 40–50, doi: 10.1007/978-3-319-61627-8_3

[7] OECD, *Road Safety Annual Report 2015*. OECD Publishing, 2015.

[8] M. S. Alam and N. J. Tabassum, “Spatial Pattern Identification and Crash Severity Analysis of Road Traffic Crash Hot Spots in Ohio,” *Heliyon*, vol. 9, no. 5, 2023, doi: 10.1016/j.heliyon.2023.e16303.

[9] Z. Babaei and M. M. Kunt, “Tempo-Categorization of Road Accident Hotspots to Enhance the Problem Diagnosis Process and Detect Hidden Hazardous Locations,” *Journal of Transportation Safety and Security*, vol. 15, no. 12, pp. 1271-1298, 2023, doi: 10.1080/19439962.2023.2169800.

[10] A. A. Mekonnen, T. Sipos, and N. Krizsik, “Identifying Hazardous Crash Locations Using Empirical Bayes and Spatial Autocorrelation,” *ISPRS International Journal of Geo-Information*, vol. 12, no. 3, pp. 85, Mar. 2023, doi: 10.3390/ijgi12030085.

[11] Y. Yosritzal, R. Aziz, M. Noer, D. O. Putri, and A. Sani, “Determinant Factors in Increasing the Livability of the City of Padang from the Perspective of Transportation,” *SINERGI*, vol. 27, no. 1, pp. 73–80, 2023, doi: 10.22441/sinergi.2023.1.009

[12] M. T. Obaidat and T. M. Ramadan, “Traffic Accidents at Hazardous Locations of Urban Roads,” *Jordan Journal of Civil Engineering*, vol. 6, no. 4, pp. 436–447, 2012.

[13] A. H. Albayati and I. M. Lateef, “Characteristics of Traffic Accidents in Baghdad,” *Civil engineering journal*, vol. 5, no. 4, pp. 940–949, 2019, doi: 10.28991/cej-2019-03091301

[14] M. Kalantari, S. Z. Shahraki, B. Yaghmaei, S. Ghezelbash, G. Ladaga, and L. Salvati, “Unraveling Urban form and Collision Risk: The Spatial Distribution of Traffic Accidents in Zanjan, Iran,” *International Journal of Environmental Research and Public Health*, vol. 18, no. 9, May 2021, doi: 10.3390/ijerph18094498.
[15] G. Cheng, R. Cheng, Y. Pei, and J. Han, “Research on Highway Roadside Safety,” *Journal of Advanced Transportation,* vol. 2021, pp. 1–19, 2021, doi: 10.1155/2021/ 6622360
[16] S. Gaweesh, M. N. Khan, and M. M. Ahmed, “Development of a Novel Framework for Hazardous Materials Placard Recognition System to Conduct Commodity Flow Studies using Artificial Intelligence AlexNet Convolutional Neural Network,” in *Transportation Research Record*, vol. 2675, no. 11, 2021. doi: 10.1177/ 03611981211026653.
[17] M. B. Ulak, E. E. Ozguven, O. A. Vanli, M. A. Dulebenets, and L. Spainhour, “Multivariate Random Parameter Tobit Modeling of Crashes Involving Aging Drivers, Passengers, Bicyclists, and Pedestrians: Spatiotemporal Variations,” *Accident Analysis & Prevention*, vol. 121, pp. 1–13, 2018, doi: 10.1016/j.aap.2018.08.031
[18] T. Chen, N. N. Sze, S. Chen, S. Labi, and Q. Zeng, “Analyzing the Main and Interaction Effects of Commercial Vehicle Mix and Roadway Attributes on Crash Rates Using a Bayesian Random-Parameter Tobit Model,” *Accident Analysis & Prevention*, vol. 154, p. 106089, 2021, doi: 10.1016/j.aap.2021. 106089
[19] G. Fancello, M. Carta, and P. Serra, “Data Envelopment Analysis for the Assessment of Road Safety in Urban Road Networks: A Comparative Study using CCR and BCC Models,” *Case Studies on Transport Policy*, vol. 8, no. 3, pp. 736–744, Sep. 2020, doi: 10.1016/j.cstp.2020.07.007.
[20] K. Athiappan *et al.*, “Identifying Influencing Factors of Road Accidents in Emerging Road Accident Blackspots,” *Advances in Civil Engineering*, vol. 2022, 2022, doi: 10.1155/2022/9474323.
[21] K. G. Le, P. Liu, and L. T. Lin, “Traffic Accident Hotspot Identification by Integrating Kernel Density Estimation and Spatial Autocorrelation Analysis: A Case Study,” *International Journal of Crashworthiness*, vol. 27, no. 2, pp. 543–553, 2022, doi: 10.1080/13588265.2020.1826800.
[22] P. Tiberi, A. Tripodi, A. Dragomanovits, A. Deliali, and G. Yannis, “A State-of-Practice Review on Crash Occurrence Analysis and Hazardous Location Identification,” *Advances in Transportation Studies*, vol. 3, pp. 33–44, 2022, doi: 10.53136/ 97912218030374.
[23] R. Żochowska, M. J. Kłos, and P. Soczówka, “Analysis of Traffic Safety at Intersections of Roadways and Tram Tracks,” *Roads and Bridges - Drogi i Mosty*, vol. 20, no. 1, pp. 41–56, 2021, doi: 10.7409/rabdim.021.003.
[24] N. Klinjun, M. Kelly, C. Praditsathaporn, and R. Petsirasan, “Identification of Factors Affecting Road Traffic Injuries Incidence and Severity in Southern Thailand Based on Accident Investigation Reports,” *Sustainability (Switzerland)*, vol. 13, no. 22, 2021, doi: 10.3390/su132212467.
[25] E. Sam, S. Shaheem, A. Chandran, and D. Radhakrishnan, “Identification and Prioritization of Crash-Prone Locations for Selected Road Corridor in Kerala,” in *Lecture Notes in Civil Engineering*, Springer Science and Business Media Deutschland GmbH, 2022, pp. 47–60. doi: 10.1007/978-981-16-9925-2_3.
[26] O. Erieba, G. Pappalardo, A. Hassan, D. Said, and S. Cafiso, “Assessment of the Transferability of European Road Safety Inspection Procedures and Risk Index Model to Egypt,” *Ain Shams Engineering Journal*, Mar. 2023, doi: 10.1016/j.asej.2023.102502.
[27] S. Mathew and S. S. Pulugurtha, “Effect of Weather Events on Travel Time Reliability and Crash Occurrence,” *Technical Report*, Mineta Transportation Institute, College of Business, San Jose State University, 2022.
[28] J. Schaefer, VR; Wang, K; Suleiman, MT; Kavern, “Mix design development for pervious concrete in cold weather climates, Final Report,” *National Concrete Pavement Technology Center*, Iowa State University, Ames, IA, USA, pp. 83, 2006.
[29] W. B. Dermawan, M. Isradi, and P. Pawaztris, “Analysis of Accident-Prone Areas Along Jenderal Ahmad Yani Road in Bekasi,” *Journal of Applied Science, Engineering, Technology, and Education*, vol. 1, no. 2, pp. 124–130, 2020, doi: 10.35877/454ri. asci1239.
[30] N. Widyaningsih and O. Daniel, “Analisis Karakteristik Dan Perilaku Penyeberangan Orang Pada Fasilitas Penyeberangan Zebra Cross Dan Pelican Cross (Studi Kasus Ruas Jalan M. H. Thamrin),” *Jurnal Pengembangan Rekayasa dan Teknologi*,

vol. 15, no. 1, p. 27, 2019, doi: 10.26623/jprt.v15i1.1486.
[31] J. Prasetijo *et al.*, “Crash Model Based on Integrated Design Consistency with Low Traffic Volumes (due to Health Disaster (COVID-19)/Movement Control Order),” *Innovative Infrastructure Solutions*, vol. 6, no. 1, p. 22, 2021, doi: 10.1007/s41062-020-00388-7.
[32] J. Prasetijo *et al.*, “Investigation of Road Crash Rate at FT050, Jalan Batu Pahat – Kluang: Pre and Post Road Median Divider,” *International Journal of Road Safety*, vol. 1, no. 1, pp. 16–19, 2020.
[33] K. Athiappan *et al.*, “Identifying Influencing Factors of Road Accidents in Emerging Road Accident Blackspots,” *Advances in Civil Engineering*, vol. 2022. 2022. doi: 10.1155/2022/9474323.
[34] W. B. Dermawan, M. Y. K. Fuadi, M. Isradi, and A. Mufhidin, “Analysis of Accident-Prone Areas in North Jakarta,” *Neutron*, vol. 21, no. 1, pp. 1–9, 2021, doi: 10.29138/neutron.v21i1.119.
[35] M. Isradi, N. Aulia Tarastanty, W. Budi Dermawan, A. Mufhidin, and J. Prasetijo, “Performance Analysis of Road Section and Unsignalized Intersections on Jalan Cileungsi Setu and Jalan Raya Narogong,” *International Journal of Engineering, Science and Information Technology*, vol. 1, no. 2, pp. 72–80, 2021, doi: 10.52088/ijesty.v1i2.108.
[36] C. Se, T. Champahom, S. Jomnonkwao, and V. Ratanavaraha, “Driver Injury Severity in Single-Vehicle Run off Road Crash on 2-Lanes and 4-Lanes Highway in Thailand,” *Engineering and Applied Science Research*, vol. 47, no. 4, pp. 393–400, 2020.
[37] Z. Z. Wang, Y. N. Lu, Z. H. Zou, Y. H. Ma, and T. Wang, “Applying OHSA to Detect Road Accident Blackspots,” *Int J Environ Res Public Health*, vol. 19, no. 24, Dec. 2022, doi: 10.3390/ijerph192416970.
[38] T. Chen, N. N. Sze, S. Chen, S. Labi, and Q. Zeng, “Analyzing the Main and Interaction Effects of Commercial Vehicle Mix and Roadway Attributes on Crash Rates Using a Bayesian Random-Parameter Tobit Model,” *Accident Analysis & Prevention*, vol. 154, p. 106089, 2021, doi: 10.1016/j.aap.2021.106089
[39] G. Cheng, R. Cheng, Y. Pei, and J. Han, “Research on Highway Roadside Safety,” *Journal of Advanced Transportation*, vol. 2021, pp. 1–19, 2021, doi: 10.1155/2021/6622360
[40] S. Pandey and G. S. Bura, “Identification of Risk Factors Associated with Road Traffic Accident in Hilly Road Segment Using Accident Severity Model,” *International Journal of Health Sciences (Qassim)*, vol. 6, no. S3, pp. 5864-5873, 2022, doi: 10.53730/ijhs.v6ns3.7285.
[41] A. I. Rifai, Y. A. Surgiarti, M. Isradi, A. Mufhidin, U. Mercu, and B. Jakarta, “Analysis of Road Performance and the impact of Development in Pasar Minggu, Jakarta (Case Study of Jalan Lenteng Agung - Tanjung Barat),” *ADRI International Journal of Civil Engineering*, vol. 6, no. 1, pp. 68–74, 2021, doi: 10.29138/aijce.v6i1.22
[42] J. Prasetijo, G. Zhang, M. Isradi, Z. F. Zainal, W. Z. Musa, and M. I. Setiawan, “Accident Prediction based on Integrated Design Consistency with the Lower Number of Vehicles/Traffic Volumes (due to Health Disaster/COVID-19),” *IJEBD (International Journal of Entrepreneurship and Business Development)*, vol. 3, no. 3, pp. 287–295, 2020, doi: 10.29138/ijebd.v3i3.1112.
[43] K. Schurr, P. T. McCoy, G. Pesti, D. Jessen, and R. Huff, “Relationship between Design, Operating and Posted Speeds under High-Posted Speed Conditions,” 2000.
[44] S. Ahmed, M. A. Hossain, S. K. Ray, M. M. I. Bhuiyan, and S. R. Sabuj, “A study on road accident prediction and contributing factors using explainable machine learning models: analysis and performance,” *Transportation Research Interdisciplinary Perspectives*, vol. 19, 2023, doi: 10.1016/j.trip.2023.100814.
[45] B. M. Adji et al., “A study on the operational performance of the Trans Padang bus Corridor VI (City center - Andalas University),” *Journal of Integrated and Advanced Engineering (JIAE)*, vol. 4, no. 1, pp. 65-86, 2024, doi: 10.51662/jiae.v4i1.131