

IDENTIFICATION OF DOMINANT FACTORS CAUSING TRAFFIC ACCIDENTS ON NATIONAL ROADS: A SYSTEMATIC LITERATURE STUDY

¹Lintang Angelina Khristiyan Putri, ²Ashila Putri Nayifa, ³Mutia Ilma Ramandhani,
⁴Ubaidillah

^{1,2,3,4} Universitas Pertahanan, Bogor, Indonesia

*Corresponding author:

lintangangelinakp@gmail.com

ABSTRACT

Traffic accidents in national roads have always been a major issue since national roads accommodate intercity movement with high-speed movements and mixed vehicle types. The purpose of this research is to find out the key factors leading to traffic accidents in the case of national roads by using the literature review method. The data for this research was collected from 24 scientific articles written in the past ten years, and all articles are open-access where one can download them whenever they want. The factors identified were recorded in an Excel table and categorized into six groups, including human/driver factors, vehicle factors, road factors, road furniture/safety factors, environment/weather factors, and traffic factors plus accident-prone locations. The analysis was done based on the frequency of appearance of each factor among all the articles. From the analysis of data obtained from the study, it is evident that the first factor with a frequency of occurrence of 18 or 31.6 percent is that of human and driver behavior, followed by that of road condition and geometry having a frequency of occurrence of 13 or 22.8 percent, traffic characteristics and accident-prone locations occurring 12 times or 21.1 percent and environment and weather occurring 6 times or 10.5 percent. Conditions and features of vehicles occur four times as do those of road furniture which have a frequency of occurrence of 7.0 percent. These results prove that accidents along national highways are created by the interaction of driver mistakes with conditions in the roadsides which cannot tolerate such mistakes, and therefore, the way out lies in combining law enforcement with the improvement of accident-prone sites and construction of safety facilities.

Keywords: Traffic accident, national road, dominant factor, accident prone location, systematic literature review.

I. INTRODUCTION

National roads are strategic because they connect regions and serve as supporting facilities for the movement of goods and services. Their function as arterial and primary collector roads makes these sections of road high-speed traffic corridors, with a high

percentage of heavy trucks and long-distance travel. Therefore, even a small error on a national road can lead to a fatal accident (Susilo, 2023).

Accidents often cause significant losses. This is evidenced by a study conducted on national roads in the northern part of Central Java Province, which found that the cost of accidents at high-risk points reached hundreds of billions of rupiah annually, far exceeding the budget allocated for maintaining the same section of road (Susilo, 2023). Furthermore, there are productivity losses suffered by the victims' families, who are typically in the productive age group (Rizki et al., 2024).

Factors causing accidents can generally be categorized into four: human factors, vehicle factors, road factors, and environmental factors (Mubalus, 2023), (K. Bucsuhaży, E. Matuchová, R. Zuvala, P. Moravcová, M. Kostiková, 2020). Most research findings in Indonesia indicate that the human factor is the most important among these factors, including negligence, drowsiness, high speed, taking risky routes, and violating traffic signs (Afif Mauludi et al., 2021), (Betan et al., 2024). A common characteristic of accident victims is young motorcyclists (Geli et al., 2021), (Hendrati, 2023).

However, placing the entire blame on the driver is not the solution. From a road safety perspective, roads must be constructed to accommodate human error. Research on the influence of geometry indicates that tight curves, irregular road flow, and steep slopes increase the incidence of accidents in some sections (Ellytrina & Zhafirah, 2023), (Miruyama, R. Mudiyo, 2025). Poor road surface conditions and uneven shoulders also contribute to loss of control (Rais, 2023).

Roadside equipment tends to be a vulnerable point on interurban roads. Road markings obscured by trees, faded road lines, lack of curbs on cliffs, and inadequate street lighting at night are frequently cited as safety concerns in accident-prone areas (Rais, 2023), (Bayu, 2023). Weather-related issues, such as rain, fog, and sun glare, add to the difficulties for already fatigued drivers (Rita Kurniati & Wildan, 2021), (Yuni et al., 2025).

The process of identifying accident-prone areas has been carried out in numerous studies using various techniques such as Equivalent Accident Rates, Upper Control Limits, and even clustering with geographic information systems (Ma'shum & Moetriono, 2022), (Wijaya, 2020), (Latifah et al., 2022). This information can help determine treatment priorities but must always be used in conjunction with causal

information to select the appropriate treatment for the actual problem on the ground (I Made Agus Ariawan et al., 2025).

However, the challenge is that the findings from these studies are scattered across different locations and also use varying terminology for similar factors. Very few studies have generalized the findings and systematically ranked them based on their relevance to national roads. Therefore, the following study attempts to bridge this gap by ranking the most important factors behind traffic accidents on national roads based on the frequency of citations in the literature. All sources used in the following study have been obtained from journals that are freely accessible to anyone at any time.

II. RESEARCH METHODOLOGY

The following study used the Systematic Literature Review (SLR) method. The SLR method was chosen because it allows for the systematic collection, evaluation, and analysis of previous research results, allowing for collaborative analysis of findings across multiple articles. Reporting steps adhere to the general criteria used in conducting systematic reviews (Page et al., 2021).

Data sources included scientific articles from national journals indexed in Sinta and Garuda, national seminar proceedings, open-access international journals, and university repositories. Data collection was conducted in Google Scholar, Garuda, and the Open Journal System from individual publishers using the following keywords: traffic accidents, accident reasons, accident-prone locations, black spots, national roads, Accident Equivalent Rate, and road traffic accident factors. All articles used are available with open access and contain full download links to ensure the replication of the following study's results.

The inclusion criteria included four main aspects. First, the articles must discuss the causes of traffic accidents or identify accident-prone areas on intercity and national roads. Second, the articles must have been written within the last ten years. Third, all articles are free and available for download. Fourth, the articles contained sufficient data or discussion to be extracted as factors. Paid articles, those that were repetitive, and those whose discussion was completely unrelated to roads were excluded from the following study. This screening process resulted in 24 articles for further research.

Each article was thoroughly read, and factors contributing to or related to accidents were extracted and recorded in an Excel file for ease of calculation. The extracted factors were grouped into six groups based on their similarity. These groups include human and driver behavior factors, vehicle factors, road condition and geometry

factors, road infrastructure and safety facilities factors, environmental and weather factors, and traffic characteristics and accident-prone areas. The research phase is briefly presented in Figure 1 below.

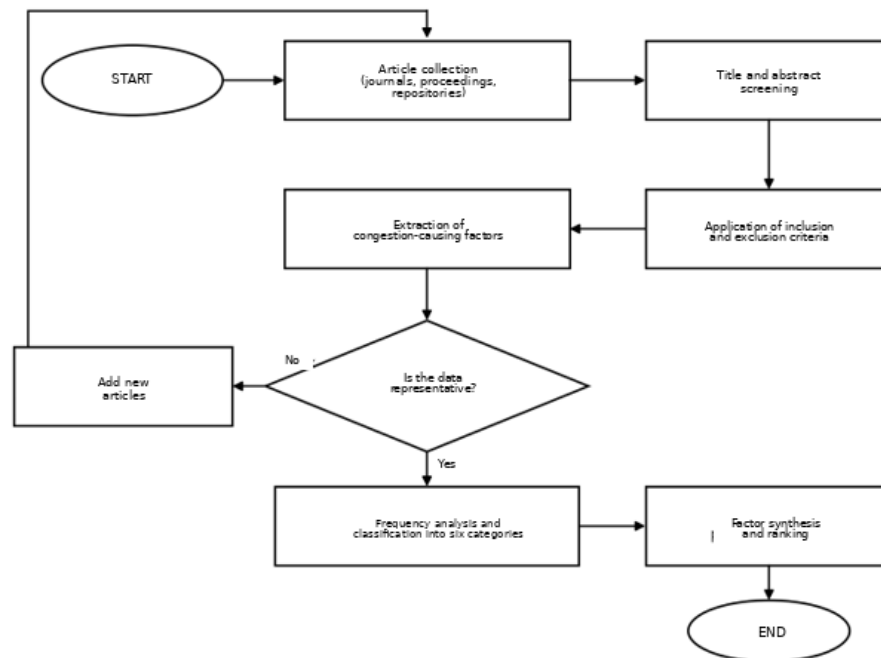


Figure 1. Flowchart of research stages

The frequency method was applied in data analysis. The total number of articles in each category was determined, and then the total number of occurrences across all categories was compared to obtain a percentage. The same article could fall into different categories because a single study may mention more than one causal factor for an accident. Therefore, the total number of occurrences may exceed the number of articles explored. The more frequently a particular category appears, the more attention it has received in the literature.

In addition to frequency, the factors mentioned also take into account accident characteristics described in the articles, such as vehicle type, accident time, collision type, and methods for detecting accident-prone locations. These characteristics were used to provide a general pattern of accidents on intercity roads. If the number of articles was insufficient, the article collection and selection procedure was repeated until the collected articles met the criteria.

III. RESULT AND DISCUSSION

After extracting 24 articles that met the criteria, the identified causes were grouped into six groups. This grouping facilitated the discussion because causes with different

editorials but similar meanings could be combined into one group. The grouping of causes in each article is presented in Table 1.

Table 1. Distribution of categories of factors causing accidents in the 24 articles reviewed

No	Ref	Researcher Name	Humans and Behavior	Vehicle	Road Conditions and Geometries	Safety Facilities	Environment and Weather	Traffic and Hazardous Locations
1	[1]	F. Triawan, B. H. Susilo			x	x		x
2	[2]	B. H. Susilo, L. W. Cahyadi			x			x
3	[3]	F. Rais			x	x	x	
4	[4]	R. Suletae, I. Elvina	x		x			x
5	[5]	Y. Simanullang, M. M. HR, A. Pramono Hadi	x					x
6	[6]	S. F. E. Mubalus	x	x	x		x	
7	[7]	E. E. S. Putra, S. Y. Ratih, L. Primantari	x		x			x
8	[8]	K. Selen, G. D. Pandulu, P. D. Rahma			x			x
9	[9]	I. J. Effendi, A. N. N. Rizki, D. O. R. Rahman, B. Fadel	x	x				x
10	[10]	M. A. Ma'shum, H. Moetriono	x		x			x
11	[11]	A. Maudyna, R. H. Bayu	x		x	x		
12	[12]	A. A. Mauludi, Z. Djunaedi, L. S. Arif	x					
13	[13]	Miruyama, R. Mudiyo, J. A. Sulisty			x			x
14	[14]	A. S. Wijaya			x			x
15	[15]	N. L. W. R. Kurniati, A. Wildan	x		x		x	
16	[16]	L. L. Latifah, S. A. Hudjimartsu, I. Yanuarsyah	x					x
17	[17]	D. T. Permadi, R. D. Rachmayanti	x					
18	[18]	W. S. Yuni, A. D. Pratiwi, R. E. S. O. Kohali	x	x			x	
19	[19]	H. Geli, M. Sahdan, D. O. Dodo	x				x	
20	[20]	D. Handayani, R. O. Ophelia, W. Hartono	x					
21	[21]	Ariawan, et al.	x		x	x		x
22	[22]	D. Ratnasari, L. Y. Hendrati	x					
23	[23]	K. Bucsuahazy, et al.	x	x			x	
24	[24]	H. C. Haryanto	x					
Jumlah			18	4	13	4	6	12

Note: a cross (x) indicates that the article discusses the listed category.

Of the 24 studies analyzed, 57 factors were identified. This number is higher than the total number of articles because most of the studies highlighted multiple causes within their respective research locations. A summary table of frequencies, percentages, and rankings for all categories is presented in Table 2 below.

Table 2. Ranking of categories of factors causing accidents on national roads

No	Factor Categories	Frequency	Percentage	Rating
1	Human Factors and Driver Behavior	18	31,6 %	Rank 1
2	Road Conditions and Geometries	13	22,8 %	Rank 2
3	Traffic Characteristics and Hazard Locations	12	21,1 %	Rank 3
4	Environmental and Weather Factors	6	10,5 %	Rank 4
5	Vehicle Factors	4	7,0 %	Rank 5
6	Road Equipment and Safety Facilities	4	7,0 %	Rank 6
	Total Factor Occurrences	57	100 %	Rating

Human Factors and Driver Behavior were mentioned 18 times, or 31.6 percent, and ranked first. These behaviors included negligence, excessive speeding, overtaking other vehicles in inappropriate lanes, drowsiness due to long journeys, and violating traffic signs and signals (Afif Mauludi et al., 2021). Several sources link these behaviors to age and driving experience, with the largest number of accident victims being among the productive age group who ride motorcycles (Geli et al., 2021), (Haryanto, 2016). The dominance of these categories aligns with information provided by the police, who have for years cited driver error as the primary cause of accidents in Indonesia (Rizki et al., 2024).

Road Conditions and Geometry ranked second, mentioned 13 times, or 22.8 percent. These conditions include sharp turns, vertical adjustments to steep slopes, sudden changes in lane width, and recurring potholes (Ellytrina & Zhafirah, 2023), (Miruyama, R. Mudiyo, 2025). Uneven shoulder surfaces and shoulder surfaces that differ from the road surface can be problematic on intercity routes, as vehicles stopped at the side of the road can have difficulty getting back on the road (Rais, 2023), (Rita Kurniati & Wildan, 2021).

Traffic characteristics and accident-prone locations ranked third, with 12 mentions, or 21.1%. These characteristics include daily traffic flow, a high proportion of heavy vehicles and motorcycles, high operating speeds, and accident locations in multiple sections. Most researchers use the Equivalent Accident Rate in conjunction with the Upper Control Limit (UCL) to classify these sections as accident-prone (Susilo, 2023), (Ma'shum & Moetriono, 2022), (Wijaya, 2020). Other methods for identifying accident-prone sections include cluster analysis and the Geographic Information System approach (Latifah et al., 2022).

Environmental and weather conditions were mentioned six times, or 10.5%. It is

believed that rain makes roads slippery, fog on mountain roads, reflection of sunlight in the morning and afternoon, and lack of lighting at night increase the likelihood of accidents (Rita Kurniati & Wildan, 2021), (Yuni et al., 2025), (Geli et al., 2021). These factors rarely stand alone and mostly act as amplifications of driver error and roadway weaknesses.

Causes related to vehicles and road equipment both appeared at 4 or 7.0 percent. Regarding vehicle-related causes, problems identified included faulty brakes, worn tires, overloading, and substandard lighting (Mubalus, 2023), (Yuni et al., 2025), (K. Bucsuhaży, E. Matuchova, R. Zuvala, P. Moravcova, M. Kostikova, 2020). Regarding road equipment, frequently encountered problems were signs obscured by trees or in the wrong position, faded signs, missing safety barriers, and missing speed limit signs where they should be present (Rais, 2023), (Bayu, 2023), (I Made Agus Ariawan et al., 2025). The low percentages in both categories are an indicator of the limited data available to the researchers, not conclusive evidence of their influence. A comparison of the percentages for the six categories is shown in Figure 2.

**RANKING OF FACTORS CAUSING TRAFFIC ACCIDENTS
BASED ON ANALYSIS OF 24 ARTICLES**

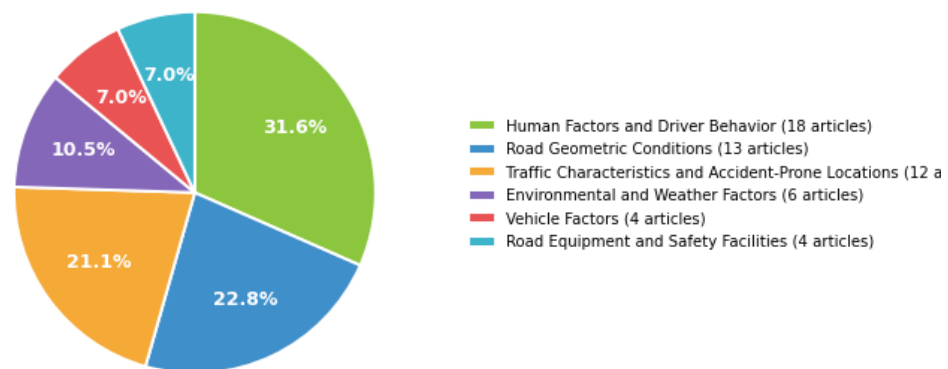


Figure 2. Percentage of occurrence of accident-causing factor categories

The pattern emerging from these findings is quite clear. The top three factors—human error, road conditions, and traffic characteristics—account for 75.5 percent of all factors. Each of these factors operates at a different level. Driver error is the direct catalyst for accidents, while road conditions determine whether driver error can be mitigated, and traffic characteristics determine how likely it is that driver error will result in contact with another vehicle. Analyzing these factors separately would yield conflicting recommendations.

It should be noted that the dominance of human factors is partly due to the method of collecting traffic accident statistics. In police reports, errors are blamed on the at-fault party, and road network deficiencies are rarely listed as the primary cause of accidents. Several studies using a field survey approach have identified several real problems at accident-prone locations, ranging from illegible signs to a lack of dangerous roadside safety barriers (Rais, 2023), (Bayu, 2023). These findings suggest that traffic accident statistics should be complemented by road safety audits.

Another significant issue is the discrepancy between the identification of high-accident areas and their management. A study of the Northern Cross-Country National Highway showed that road preservation programs focused solely on improving the road surface and excluded budget planning for addressing high-accident areas (Susilo, 2023) (Cahyadi, 2019). Consequently, the annual cost of accidents often exceeds the cost of repairing these high-accident areas. The proposed solution is multi-level. The first level is behavioral, encompassing speed limit enforcement, driver work hour controls, and motorcyclist education. The second level is geometric, encompassing modification of dangerous curves, construction of safety barriers, repainting road signs and markings, and installing lighting in vulnerable segments. The third level is managerial, encompassing the inclusion of road safety programs in the national road preservation project budget.

IV. CONCLUSION

An analysis of 24 open-access articles yielded six categories of causes of accidents on national roads, with human factors and driver behavior accounting for 18 incidents (31.6%), road conditions and geometry accounting for 13 incidents (22.8%), traffic characteristics and accident-prone locations accounting for 12 incidents (21.1%), and environmental and weather factors accounting for 6 incidents (10.5%). Vehicle and road equipment factors each accounted for four incidents, or 7.0% each.

The dominance of human factors does not automatically mean that responses should focus solely on drivers. Driver errors lead to accidents when they encounter sharp turns, uneven shoulders, unclear signs, or poor lighting. This means that responses must be multi-layered, including driver education and law enforcement, geometric improvements, safety facility improvements in accident-prone locations, and ultimately, road safety programs incorporated into the national road maintenance budget.

The following study has its own limitations in the number of articles reviewed and the method used, namely frequency. Frequency only indicates the number of times a factor appears in an article without considering its contribution to the number and severity

of traffic accidents. Future research should include expanding the number of articles reviewed, dividing the results by road type and classification, and adding weighting through the Analytical Hierarchy Process or statistical models based on causal factors and victim severity.

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