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ICLT2023Padang
https://iclt.uitm.edu.my/index.php/about/iclt-2023

e-IPH e-International Publishing House Ltd., United Kingdom

2nd International Conference on Logistics & Transportation 2023
Convention Hall, Universitas Andalas, Padang, Indonesia, 20 - 22 Nov 2023

Organised by: Research Nexus UiTM (ReNeU), Universiti Teknologi MARA

Heavy Goods Vehicle Accident Risk Factors: A systematic literature review

Nor Izzah Zainuddin[1*], Ahmad Kamil Arshad[2], Nurul Elma Kordi[1], Rizati Hamidun[3], Wardati Hashim[1]
**Corresponding Author*

[1] Faculty of Civil Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[2] Institute for Infrastructure Engineering & Sustainable Management, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[3] Malaysian Institute of Road Safety Research, 43000 Kajang, Selangor, Malaysia.

norizzah@uitm.edu.my, drahmadkamil@uitm.edu.my, elma8207@uitm.edu.my, rizati@miros.gov.my, wardati@uitm.edu.my
Tel: +6019-233 4723

Abstract
Heavy goods vehicle (HGV) accidents often result in severe outcomes for both HGV occupants and other road users. This systematic review analysed 36 empirical studies published from 2010 to 2021, selected from 373 peer-reviewed articles. Risk factors were categorised into four main groups: human/behavioural, road infrastructure, environment/weather, and vehicle-related, with 20 sub-factors identified. A Pareto analysis highlighted 10 critical factors, including driver characteristics, road geometry, weather, and vehicle defects. The findings offer a comprehensive overview of key HGV accident risk factors, providing valuable insights.

Keywords: Heavy goods vehicle; Risk factors; Systematic literature review; Thematic analysis; Pareto analysis.

DOI: https://doi.org/10.21834/e-bpj.v10iSI41.7736

1.0 Introduction

Road traffic crashes, also known as road accidents or traffic collisions, are a significant global public health and safety concern. They result in human casualties, property damage and economic losses; impacting individuals, communities, and societies (Kareem, 2003; Masuri et al., 2017).

Road traffic crashes are a global issue affecting countries of all income levels. According to the World Health Organisation (WHO), approximately 1.35 million people die annually in road traffic crashes worldwide, making it one of the leading causes of death globally, particularly among young adults and children. Road traffic injuries are currently estimated to be the eighth leading cause of death across all age groups globally and are predicted to become the seventh leading cause of death by 2030.

A heavy or large goods vehicle is intended to transport heavy loads. This total vehicle weight usually exceeds 3,500 kg (vehicle+load). Unlike vehicles intended for passenger transport, these vehicles are not equipped to transport individuals but are primarily used for the carriage of goods, which can include items like fuel oil, groceries, and machinery. Drivers of such vehicles are responsible for delivering these goods, often without a fixed schedule, as it depends on the day's demand. Specialised training and licensing are mandatory requirements for individuals operating these vehicles.

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DOI: https://doi.org/10.21834/e-bpj.v10iSI41.7736

The growing demand for heavy goods vehicles (HGV) leads to increased safety concerns. The increased number of HGVs each year has resulted in more accidents involving HGVs and other vehicles. While transporting goods, HGV drivers sometimes incur road accidents for several reasons. All those reasons could potentially lead HGV drivers to engage in road accidents. Hence, a clear understanding of the factors contributing to the potential accident should be identified to minimise future accidents.

Furthermore, HGVs impose physical and psychological effects on the surrounding traffic. These effects result from the physical characteristics of heavy vehicles (e.g., length and size) and their operations. Due to the large dimensions, HGVs have operating limitations such as large blind spots, long stopping distances, and limited manoeuvrability, making it essential for other vehicles to focus extra attention on safety. This situation creates a significant need to better understand this vehicle group's accident characteristics towards the safety of other road users.

While accidents involving private vehicles like cars and motorcycles have been extensively researched, only a few literatures focused on HGV accident factors. Thus, this paper aims to identify the HGV accident risk factors using a Systematic Literature Review (SLR).

The research design adopted for this study is the SLR of published literature on the HGV-related crash factor. Kitchenham (2014) explained that an SLR is an important scientific research approach in identifying, evaluating, interpreting, and summarising all available research relevant to a specified research question, topic area, or phenomenon of a particular subject matter. An SLR allows researchers to examine the strength of the published evidence while remaining unbiased where possible.

In conclusion, this systematic literature review (SLR) was conducted to comprehensively address the research question focused on identifying the key risk factors associated with heavy goods vehicle (HGV) accidents. The SLR was executed through a well-structured process encompassing identification, screening, eligibility, data abstraction, and analysis. The ensuing results obtained from this extensive review underwent a rigorous analysis employing both descriptive statistics and thematic analysis. This analytical approach aimed to offer valuable insights into the evolving trends within the main factors and sub-factors of HGV-related accident crash studies, thereby enriching the field of HGV safety research by discerning the most critical factors contributing to HGV accidents.

2.0 Methodology

According to Kraus et al. (2020), SLR is a transparent and reproducible approach to reviewing the existing literature to produce high-quality outputs. The study method enables scientific literature mapping and assessment, creating future research opportunities. A study by Tranfield et al. (2003) proposed that the SLR involves a three-stage process: planning, conducting the review, and reporting and disseminating.

2.1 Planning the Review

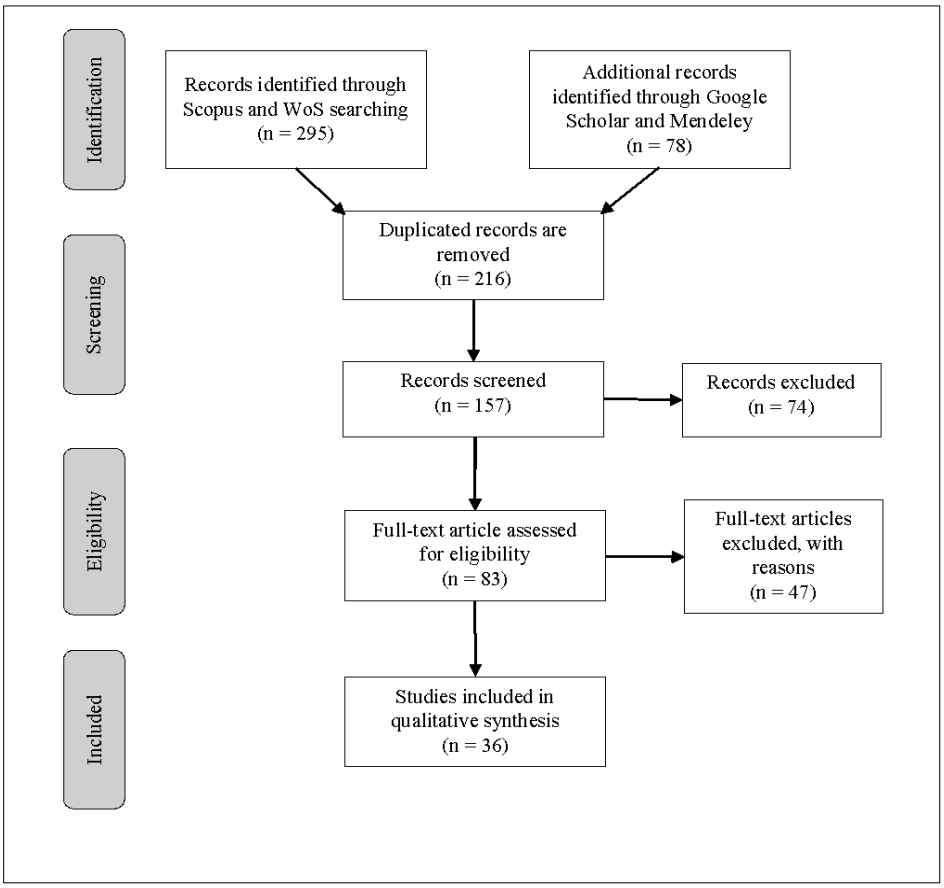

Fig. 1: The PRISMA Diagram

2.2 Conducting the Review

The SLR approach entailed an unbiased and comprehensive search, differentiating between an SLR and a traditional narrative review (Tranfield et al., 2003). The stage was subdivided into five phases: research identification, data extraction, study selection, quality assessment, monitoring and data synthesis (Tranfield et al., 2003). According to past studies, the identification phase comprised keyword spotting followed by similar words. The keyword selection was followed by developing the research string created with the keyword combination and Boolean operators to retrieve the research articles. The 'AND' Boolean operator connects keyword groups, while the 'OR' Boolean operator links each group keyword. All keywords were searched in the database's title, abstract and keywords sections.

The search string was applied to the well-known databases. The study consulted database experts and identified Scopus and Web of Science (WoS) as the primary databases for searching for high-quality and robust research articles. Nonetheless, Shaffril et al. (2019) argued that no database is perfect or comprehensive. Because of that reason, the literature search was also performed on Google Scholar and Mendeley, which were considered credible (Shaffril et al., 2019). Table 1 depicts the keywords and search strings used in the databases.

Table 1. Keywords Search Strings

Research Databases	Strings Used For Search	The Search Strings Used In Databases
Web of Science (Core collection)	(TS = (heavy vehicle* OR heavy good* vehicle* OR large good* vehicle* OR truck OR lorry)) AND (accident, injury, OR crash) AND Language: (English) AND Document types: (Article)	"TS =" refers to WoS search in titles, abstracts, and keywords. A "*" refers to any suffix/prefix that can be added at the place of *. The search resulted in 138 papers.
Scopus	TITLE-ABS-KEY((heavy vehicle* OR heavy good* vehicle* OR large good* vehicle* OR truck OR lorry)) AND (accident, injury, OR crash)) AND (Limit-to (DOCTYPE "ar")) AND (Limit-to (Language, "English"))	TITLE-ABS-KEY refers to Scopus search in titles, abstracts, and keywords. A "*" refers to any suffix/prefix that can be added at the place of *. The search resulted in 157 papers.
Google Scholar	"Heavy vehicle" OR "Heavy goods vehicle" OR Trucks and accident or crash.	
Mendeley	"Heavy vehicle" OR "Heavy goods vehicle" OR Trucks and accident or crash.	

The current research work successfully retrieved a total of 295 articles from both Scopus and WoS. As previously mentioned, searching based on similar keywords was conducted on Google Scholar and Mendeley, resulting in an additional 78 articles. In total, 373 articles were retrieved in the identification stage of the systematic review process. The primary objective of the initial screening phase was to eliminate duplicate articles. In this instance, 216 articles were eliminated in the first stage, while 157 were screened in the second stage based on the researchers' inclusion and exclusion criteria. The first criterion is the type of literature that the study chose to emphasize empirical data articles. Hence, the study excluded publications in a conceptual, qualitative, systematic review, meta-analysis, book series, books, and chapters in a book. The analysis concentrated solely on English-written papers.

Moreover, a 12-year timeline (2010-2021) was selected. Most significantly, articles published in science and technology, transportation engineering, accident analysis and prevention were chosen to increase the probability of obtaining related articles. Summarily, 74 articles were excluded according to the exclusion criteria described in Table 2.

Table 2. The Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Article type	Empirical articles, conference empirical articles.	Conceptual, Systematic review, review, meta-analysis, book series, books, and chapters in a book
Timeline	Between 2010 and 2021	< 2009
Language	English	Non-English

The stage involved a thorough review of all paper titles, abstracts, and key content to ensure the inclusion requirements were fulfilled and fit for study purposes. A total of 83 research articles were retained for quality assessment. Additionally, 47 articles were excluded, considering that the articles were not based on observational evidence and concentrated more on medical research than engineering on heavy vehicle crash factors. Finally, 36 articles were eligible for further analysis.

3.0 Reporting and Dissemination

Tranfield et al. (2003) suggested following a two-step reported mechanism in research. The descriptive results were disseminated in the first step. The descriptive section comprised publication year, journal type and country of research. The second step involves presenting a thematic analysis highlighting emerging themes and future research.

3.1 SLR Descriptive Results

The analysis results of 36 empirical research articles are presented in a descriptive form, including publication year, journals and countries of study. The following section outlines the descriptive results in more detail.

3.1.1 Publication Years

The review of articles in this study spanned from 2010 to 2021, as demonstrated by Fig. 2, which provides a visual representation of the publication years. Notably, no empirical studies were discovered in 2010, while a total of eight studies were included for analysis in both 2011 and 2013, with four studies from each of these years. Interestingly, there was a lack of significant studies in 2012 and 2015, as only two empirical studies, one for each year, were deemed suitable for inclusion. Conversely, 2016, 2019, and 2020 exhibited higher activity in this field, with a notable nine studies published (three each year). The years 2017 and 2018 stood out with the highest number of publications, featuring six research articles in 2017 and five in 2018.

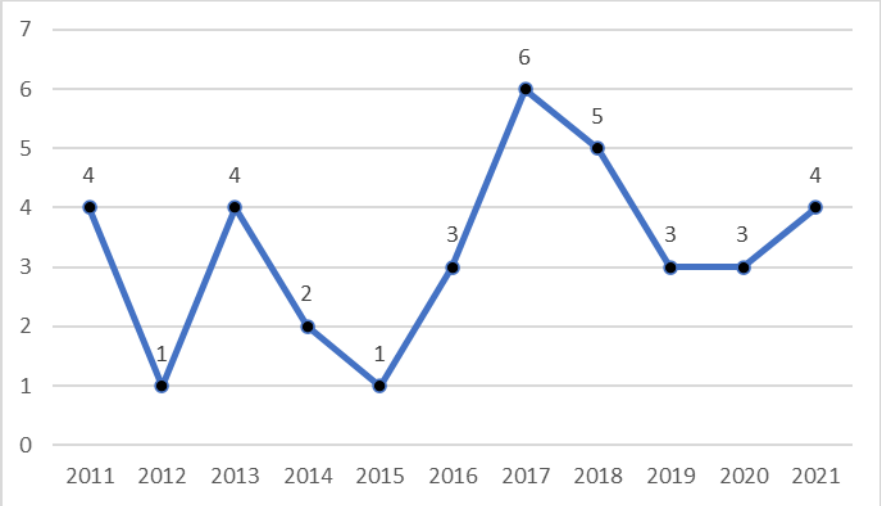

Fig. 2: Publication Years

3.1.2 Journal Publication

The 36 identified empirical articles were published in 15 journals. Table 3 demonstrates the complete journal list with journal impact factor (JIF-2020) and Scopus cite score for 2020. Out of 36 studies, 12 articles were published in "Accident Analysis and Prevention", whereas six were published in "Analytic Methods in Accident Research". Three articles were published in the Journal of Safety Research. In comparison, two journals published four articles (two each) in the Iranian Journal of Science and Technology and the Transportation Research Record: Journal of the Transportation Research Board. Out of 15 journals, 30 articles were published in 10 WOS journals. Only one conference article was added to the study.

Table 3. Distribution of Articles Journal

Journal Name	JIF (2020)	Cite score (2020)	Frequency
Accident Analysis and Prevention	4.993	7.8	12
Analytic Methods in Accident Research	11.806	17.6	6
Journal of Safety Research	3.487	5	3
Iranian Journal of Science and Technology	1.194	1.8	2
Transportation Research Record: Journal of the Transportation Research Board	1.56	2.4	2
European Transport Research Review	2.415	5	1
International Association of Traffic and Safety Sciences (IATSS) Research	0	5.1	1
Int. J of Environmental Research and Public Health	3.39	3.4	1
Int. J. of Transportation Science and Technology	0	6.8	1
Journal of Advanced Transportation	2.419	3.4	1
Journal of Transportation Engineering	0	2.1	1
Safety (MDPI)	0	2.2	1
Transportation Research Procedia	0	2.8	1
Transportation Research Part A	5.594	8.5	1
Transportation Research Part F	3.261	5.4	1
Conference	0	0	1
Total			36

3.1.3 Article Distribution by Country

The selected articles were categorised based on the countries of origin, and Table 4 provides an overview of article distribution by country. Notably, in developed countries, the United States (65.38%), Australia (11.54%), and the United Kingdom (7.69%) emerged as the primary drivers of heavy vehicle research. The remaining developed nations, including Finland, Norway, South Korea, and the European Union (EU), made minor contributions in this context. Shifting focus to developing countries, China (33.33%) took the lead as the major contributor to research on heavy vehicle risk factors. On the contrary, other countries such as Egypt, Ethiopia, Ghana, India, Iran, and Saudi Arabia played minor roles in advancing the study of heavy vehicle accident risk factors.

Table 4. Article Distribution by Developed and Developing Countries

Country (Developed)	Frequency	Contribution (%)	Country (Developing)	Frequency	Contribution (%)
US	17	65.38	China	4	40.00
Australia	3	11.54	Egypt	1	10.00
UK	2	7.69	Ethiopia	1	10.00
EU	1	3.85	Ghana	1	10.00
Finland	1	3.85	India	1	10.00
Norway	1	3.85	Iran	1	10.00
South Korea	1	3.85	Saudi Arabia	1	10.00
Total	26	100.00	Total	10	100.00

3.2 Thematic Analysis

Tranfield et al. (2003) suggested that researchers should present the findings of their 'thematic analysis' by identifying and illustrating the main emerging themes. Accordingly, the HGV risk factor was identified for this study based on its occurrence in past research. Table 5 depicts the risk factors linked to HGV. The risk factors are grouped into Human / Behavioural, Road / Infrastructure, Environment / Weather, and Vehicles. The table highlighted 20 sub-factor HGV risks under all four main factors mentioned above.

Table 5. Occurrence of Accident Risk Factors in Heavy Vehicles Studies

Category	Risk factors	Number of time dimensions quoted	Authors/References
Human / Behavioural	Age, gender & experience	28	Vlahogianni et al., 2012; Abrari Vajari et al., 2022; Ghasemi Noughabi et al., 2020; Lee et al., 2020; Meuleners et al., 2017; Yuan et al., 2021; Abegaz et al., 2014; Pahukula et al., 2015; Chen et al., 2020; Islam & Ozkul 2019; Naevestad et al., 2017; Tamakloe et al., 2021; Wang et al., 2019; Zhang et al., 2013; Zhu & Srinivasan, 2011; Chen & Chen, 2011; Hao et al., 2016; Anderson & Hernandez, 2017; Fountas & Anastasopoulos, 2018; Fountas & Anastasopoulos, 2017; Cerwick et al., 2014; Behnood & Mannering, 2019; Uddin & Huynh, 2018; Islam & Hernandez, 2013; Lemp et al., 2011; Islam & Ozkul 2019; Zheng et al., 2018; Assemi & Hickman, 2018;
Road / Infrastructure	Road geometry, alignment & roadside installations	24	Vlahogianni et al., 2012; Abrari Vajari et al., 2022; Evgenikos et al., 2016; Yuan et al., 2021; Abegaz et al., 2014; Pahukula et al., 2015; Chen et al., 2020; Islam & Ozkul 2019; Tamakloe et al., 2021; Wang et al., 2019; Zhang et al., 2013; Hassan & Al-Faleh, 2013; Zhu & Srinivasan, 2011; Chen & Chen, 2011; Zou et al., 2017; Anderson & Hernandez, 2017; Norros et al., 2016; Fountas & Anastasopoulos, 2018; Fountas & Anastasopoulos, 2017; Cerwick et al., 2014; Uddin & Huynh, 2018; Islam & Hernandez, 2013; Lemp et al., 2011; Ahmed et al., 2018;
Environment / Weather	Weather conditions	24	Abrari Vajari et al., 2022; Elshamly et al., 2017; Ghasemi Noughabi et al., 2020; Yuan et al., 2021; Abegaz et al., 2014; Pahukula et al., 2015; Islam & Ozkul 2019; Tamakloe et al., 2021; Wang et al., 2019; Zhang et al., 2013; Chen & Chen, 2011; Zou et al., 2017; Hao et al., 2016; Anderson & Hernandez, 2017; Norros et al., 2016; Fountas & Anastasopoulos, 2018; Cerwick et al., 2014; Behnood & Mannering, 2019; Uddin & Huynh, 2018; Lemp et al., 2011; Islam & Hernandez, 2013; Zheng et al., 2018; Ahmed et al., 2018; Assemi & Hickman, 2018;
Vehicle	Vehicle configuration & defects	21	Abrari Vajari et al., 2022; Evgenikos et al., 2016; Ghasemi Noughabi et al., 2020; Yuan et al., 2021; Abegaz et al., 2014; Pahukula et al., 2015; Chen et al., 2020; Islam & Ozkul 2019; Choudhary et al., 2021; Tamakloe et al., 2021; Wang et al., 2019; Zhang et al., 2013; Zhu & Srinivasan, 2011; Chen & Chen, 2011; Fountas & Anastasopoulos, 2017; Cerwick et al., 2014; Behnood & Mannering, 2019; Uddin & Huynh, 2018; Islam & Hernandez, 2013; Zheng et al., 2018; Assemi & Hickman, 2018;
Human / Behavioural	Fatigue, alcohol & other impairments	15	Vlahogianni et al., 2012; Elshamly et al., 2017; Meuleners et al., 2017; Yuan et al., 2021; Abegaz et al., 2014; Chen et al., 2020; Tamakloe et al., 2021; Chen & Chen, 2011; Fountas & Anastasopoulos, 2018; Fountas & Anastasopoulos, 2017; Behnood & Mannering, 2019; Lemp et al., 2011; Zhu & Srinivasan, 2011; Ahmed et al., 2018; Assemi & Hickman, 2018;
Environment / Weather	Time of the day	13	Abegaz et al., 2014; Chen et al., 2020; Islam & Ozkul 2019; Tamakloe et al., 2021; Zhang et al., 2013; Hassan & Al-Faleh, 2013; Zou et al., 2017; Hao et al., 2016; Anderson & Hernandez, 2017; Norros et al., 2016; Cerwick et al., 2014; Uddin & Huynh, 2018; Islam & Hernandez, 2013;
Environment / Weather	Day of the week	13	Abegaz et al., 2014; Chen et al., 2020; Islam & Ozkul 2019; Tamakloe et al., 2021; Zhang et al., 2013; Hassan & Al-Faleh, 2013; Zou et al., 2017; Hao et al., 2016; Anderson & Hernandez, 2017; Norros et al., 2016; Cerwick et al., 2014; Uddin & Huynh, 2018; Islam & Hernandez, 2013;
Environment / Weather	Light	12	Abrari Vajari et al., 2022; Yuan et al., 2021; Abegaz et al., 2014; Islam & Ozkul 2019; Tamakloe et al., 2021 [18]; Zhang et al., 2013; Zhu & Srinivasan, 2011; Zou et al., 2017; Fountas & Anastasopoulos, 2018; Cerwick et al., 2014; Lemp et al., 2011; Zheng et al., 2018; Assemi & Hickman, 2018;
Human / Behavioural	Attitudes & driving patterns	9	Vlahogianni et al., 2012; Elshamly et al., 2017; Ghasemi Noughabi et al., 2020; Yuan et al., 2021; Abegaz et al., 2014; Hassan & Al-Faleh, 2013; Cerwick et al., 2014; Behnood & Mannering, 2019; Assemi & Hickman, 2018;

Category	Risk factors	Number of time dimensions quoted	Authors/References
Road / Infrastructure	Road type	9	Vlahogianni et al., 2012; Abrari Vajari et al., 2022; Yuan et al., 2021; Abegaz et al., 2014; Islam & Ozkul 2019; Tamakloe et al., 2021; Zhang et al., 2013; Cerwick et al., 2014; Uddin & Huynh, 2018;
Road / Infrastructure	Road or surface conditions	8	Vlahogianni et al., 2012; Abrari Vajari et al., 2022; Ghasemi Noughabi et al., 2020; Hao et al., 2016; Uddin & Huynh, 2018; Zheng et al., 2018; Ahmed et al., 2018; Assemi & Hickman, 2018;
Human / Behavioural	Safety equipment	7	Vlahogianni et al., 2012; Abegaz et al., 2014; Pahukula et al., 2015; Chen et al., 2020; Chen & Chen, 2011; Anderson & Hernandez, 2017; Behnood & Mannering, 2019;
Vehicle	Vehicle speed	7	Elshamly et al., 2017; Wang et al., 2019; Abrari Vajari et al., 2022; Yuan et al., 2021; Chen et al., 2020; Hao et al., 2016; Cerwick et al., 2014;
Human / Behavioural	Errors & violations	6	Vlahogianni et al., 2012; Evgenikos et al., 2016; Lee et al., 2020; Tamakloe et al., 2021; Lemp et al., 2011; Assemi & Hickman, 2018;
Environment / Weather	Season	6	Yuan et al., 2021; Islam & Ozkul, 2019; Naevestad et al., 2017; Wang et al., 2019; Zhang et al., 2013; Cerwick et al., 2014;
Environment / Weather	Lighting & visibility	5	Vlahogianni et al., 2012 ; Ghasemi Noughabi et al., 2020; Norros et al., 2016; Behnood & Mannering, 2019; Islam & Hernandez, 2013;
Human / Behavioural	Education & learning	3	Vlahogianni et al., 2012; Meuleners et al., 2017; Choudhary et al., 2021;
Human / Behavioural	Conspicuity	1	Vlahogianni et al., 2012;
Human / Behavioural	Mobile phone usage	1	Choudhary et al., 2021;
Road / Infrastructure	Junction or intersection type	1	Tamakloe et al., 2021

3.2.1 Vital and Useful Factors of HGV-Related Crash

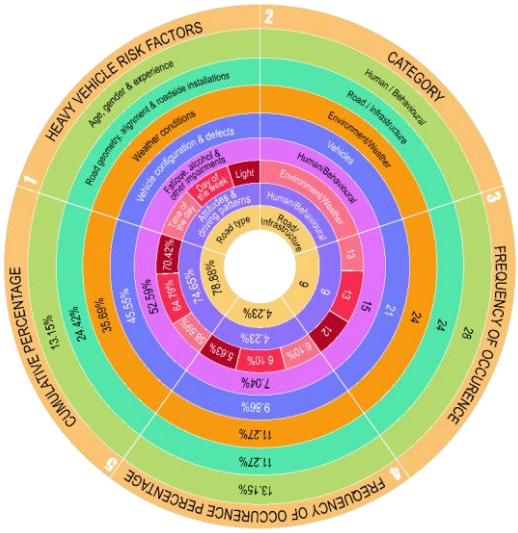

Fig. 3: Vital Few Heavy Vehicle Risk Factors

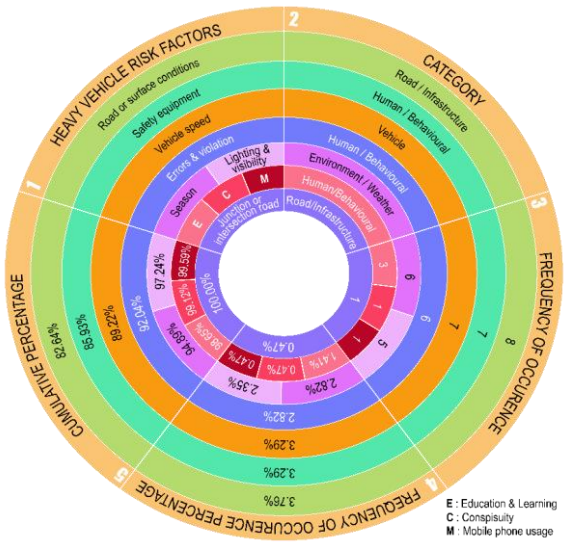

Fig. 4: Useful Many Heavy Vehicles Risk Factors

The Pareto analysis technique was applied to determine the crucial risk factors of heavy vehicles and to separate the vital and useful many factors. An Italian economist, Vilfredo Pareto, developed the approach, which is also known as the 80/20 principle. The nature of the 80/20 principle is analytical instead of absolute, flexible and modifiable into 70/30 or 60/40 (Yuan et al., 2017). Nonetheless, the selection of 80/20, 70/30 or 60/40 is built on the top-heavy distribution of problems (Landay et al., 2020; Tahmidul et al., 2020). For instance, the 80/20 principle identifies project-related issues, but the findings suggest that the rule can be changed to 70/30 or 60/40 if most issues are recorded at 60% (Yuan et al., 2017).

The current study applied the 80/20 principle of these HGV crashes to identify heavy vehicle risk factors. Although the Pareto technique gained considerable attention in past studies, the approach was adopted to determine the crucial factors in quality management, occupational health and safety (Soro et al., 2020) and Agile manufacturing (Kulanthayan et al., 2001). Nevertheless, limited studies in road safety examined heavy vehicle crash risk factors. Hence, the current study fills the methodological gap by applying the Pareto technique to identify the risk factors of HGV.

The Pareto technique involves three steps: first, the possible factors were listed based on their occurrence in the literature. Table 5 highlights all HGV risk factors found in the SLR. The second step, the 80/20 principle, was applied to the cumulative percentage of occurrences. The risk factors with an 80% cumulative percentage of events are deemed “vital few”, while the remaining 20% cumulative percentage of occurrence is “useful many”. Fig. 3 illustrates the vital few HGV risk factors accounting for 10 sub-factors. The remaining 10 sub-factors fall under the many HGV risk factors shown in Fig. 4.

The findings demonstrate that age, gender, and experience under human/behavioural are the most occurring heavy vehicle risk factors. The second most occurring is road geometry, alignment & roadside installations under road/infrastructure. The third most occurring is weather conditions under environment/weather, followed by vehicle configuration and defects under vehicle factor. Fatigue, alcohol and other impairments ranked fifth place among the most common HGV risk factor study. Time of the day and day of the week accounted for 13 counts that made it into sixth place. The frequency of occurrence for lighting accounted for 12 cases, followed by driver attitude and driving patterns, as well as road type, with 9 cases.

In the third step, the vital few and useful factors are presented in a graphical form. Fig. 5 demonstrates the graphical results of heavy vehicle risk factors.

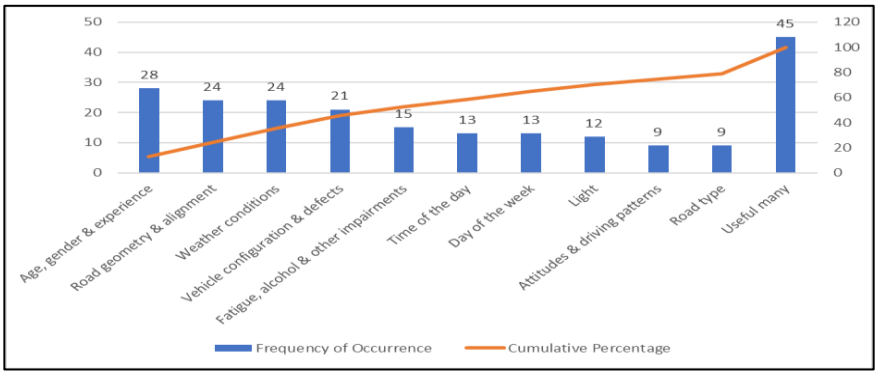

Fig. 5: Pareto Analysis of Heavy Vehicle Risk Factors

4.0 Discussion

Although other countries have been implementing road safety measures for several years, there is always a potential for improvement and innovation in terms of technical and institutional aspects of HGV road safety. Consequently, the number of HGVs increases yearly, resulting in increased heavy vehicle accidents. Road accidents involving large vehicles are more severe and have a higher fatality rate for the HGV occupants and other road users. From the literature review study conducted, it was found that the HGV accident study has not been studied extensively, especially for developing countries compared to developed countries. A total of 26 studies were conducted in developed countries where the road and traffic characteristics differ markedly from those of developing countries. In developing countries, deaths and severe injuries from heavy vehicles constitute many road casualties, especially in Asian countries. In general, this study addresses critical research needs in the context of developing countries.

Many factors cause HGV accidents, and understanding the factors associated with heavy vehicle accidents is complex. The literature review combines previous research to present numerous accident factors, which can be grouped into human/behavioural, road/infrastructure, environment/weather, and vehicle factors. Subsequently, this has resulted in 20 sub-factors of HGV accident risk identified from the 36 articles through the SLR approach. The Pareto analysis technique was used to determine the most significant risk for heavy vehicle accidents and to separate the vital few and useful many. All the sub-factors have been considered key factors, and it is important to consider them independently because each sub-factor represents the key element of HGV accidents as well as the severity of the accident. The 10 vital few HGV accident risk factors include age, gender & experience, road geometry, alignment & roadside installations, weather conditions, vehicle configuration & defects, fatigue, alcohol & other impairments, time of the day, day of the week, light, attitudes & driving patterns, and road type.

Based on previous research, it was seen that the critical factor and the most studied would be the human/behavioural factor since it was found that the human/behavioural is a leading cause of HGV accidents. Under the human behaviour factor, most of the previous researchers obtained the raw data through onsite interviews, observations, surveys, or questionnaires (Hatami et al., 2019; Mase et al., 2020; Mehdizadeh et al., 2019; Pokorny et al., 2018; Shams et al., 2020).

The road/infrastructure is the second crucial aspect. Existing road/infrastructure should be improved by setting appropriate safety standards for all road users, particularly HGV, that would improve road safety and positively alter driver behaviour. Environment/weather also gained attention in HGV research. Specifically, it should be noted that weather conditions were significant factors that may have harmed driver attentiveness and control behaviour. The literature reviews found that most of the researchers studied factors on the road and environment using the police traffic crash data (Behnood & Al-Bdairi, 2020; Evgenikos et al., 2016; Haq et al., 2020; Pokorny et al., 2017).

The current literature on vehicle-related factors is limited, and the minimal study was found to extensively investigate the factors associated with vehicle failures and their implication for road safety. Data collection methods include interviews, online questionnaires, camera monitoring, and on-site simulator observations.

The comprehensive analysis of these factors contributes to the ongoing efforts to improve road safety and reduce the severity of accidents involving Heavy Goods Vehicles. By understanding the role of each variable, road safety initiatives can be more precisely targeted, ultimately leading to safer road networks and fewer severe HGV crashes.

Taking into account the study's findings and associated limitations, a set of key recommendations is presented here. While the research objectives were satisfactorily achieved, there remains room for several recommendations for future research. Firstly, based on the findings of this study, it can be stated that there is still a huge gap in research into the HGV study, particularly in developing countries, and that this is an issue that requires attention in future studies. This is because it takes a consistent effort over time to improve the road safety situation in different countries and to make better decisions for safety improvement. Secondly, future review studies can enhance the results by adopting more comprehensive article selection criteria, including impact factors, publication years and citations. The identification of keywords should be performed rigorously to identify related and similar terms according to the thesaurus, dictionaries, encyclopedia and past research. Additionally, search strings should be included not just in Web of Science and Scopus databases but extended to other databases, such as Science Direct, dimension.ai and transport research international documentation (TRID). Thirdly, the outcomes of Pareto techniques suggested ten crucial heavy vehicle risk factors, which are complex to rank. Ultimately, future research should emphasise determining the relationship between critical factors involved in heavy vehicle accidents to test for the most critical to the lowest level of heavy vehicle accidents that would result in severity of injuries and fatal accidents. The assessment could provide a possible essential selection of risk factors and identify low-cost and economically viable road safety countermeasures for further consideration in making decisions to improve road safety in the future. As a result, it is prudent to note the following: further research is required to extend the scope of this work and verifying the generalizability of the findings is needed to meet the Sustainable Development Goals 2030 agenda. Additionally, research in HGV safety is recommended to assess the future impact of developing countries on reducing fatalities in road accidents.

5.0 Conclusion

The increasing number of heavy vehicle-related accidents and their severe consequences raised research interest and promoted knowledge-based safety measures. The review compiled the existing research on the topic and considered the heavy vehicles related accidents. Several accident factors were identified from the studies to address the research question. The present study examined the risks related to human/behavioural, road/infrastructure, environment/weather, and vehicle factors. Having found the 10 vital few HGV accident risk factors, which are age, gender & experience, road geometry, alignment & roadside installations, weather conditions, vehicle configuration & defects, fatigue, alcohol & other impairments, time of the day, day of the week, light, attitudes & driving patterns, and road type.

These results offer a foundation for future research and the development of data-driven safety measures in the field of road transportation. They underscore the importance of considering a wide array of variables when addressing HGV crash severity right from the planning of infrastructure, instead of treating them as an afterthought. As a conclusion, decision-makers should prioritise and select critical factors to achieve long-term progress in reducing road traffic fatalities and injuries caused by heavy vehicle accidents. By selecting and implementing appropriate, cost-effective countermeasures, the findings of this study can provide engineers and policymakers with more reliable and informative knowledge of the contributing factors to HGV accidents.

Acknowledgements

The authors would like to express their appreciation to the Ministry of Higher Education (MOHE) for the financial support of the Fundamental Research Grant Scheme (FRGS) (Ref: FRGS/1/2021/TK02/UITM/02/5). Thanks to Universiti Teknologi MARA (UiTM) and the Faculty of Civil Engineering for their constant support. Gratitude is also extended to the reviewers who have contributed valuable ideas, input, energy, and time to this paper.

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