Journal of Engineering and Technology

ISSN 2180-3811 eISSN 2289-814X https://jet.utem.edu.my/jet/index

DOI: https://doi.org/10.54554/jet.2025.16.2.008

EXPLORING HEAVY GOODS VEHICLE (HGV) CRASHES: A STUDY ON CRASH SEVERITY CHARACTERISTICS OF RIGID LORRIES

N. A. Ali*[1], R. Rusli[2] and S. A. S. M. Rahim[3]

[1] Road Transport Department of Malaysia.

[2] School of Civil Engineering, College of Engineering, University Teknologi MARA, Shah Alam, Selangor, Malaysia.

[3] Malaysian Institute of Road Safety Research (MIROS).

*corresponding: atiqah.ali@jpj.gov.my

Article history:
Received Date: 24 December 2024
Revised Date: 1 May 2025
Accepted Date: 1 June 2025

Keywords: Crash Report, Crash Severity, Heavy Goods Vehicle, Lorries, Malaysia, Rigid

Abstract— Rigid lorries is the most common HGV in Malaysia due to practicality and efficiency. However, they are overrepresented in fatal road crashes, which raises concerns about their safety. This study aims to identify and analyse the crash severity characteristics of rigid lorries using three years (2018-2020) of crash data. Utilizing data from the Malaysia Highway Road Accident Analysis & Database System (MHROADS), 306 crashes involving rigid lorries were analysed. A 2x2 contingency table analysis was applied by calculating the odds ratios to quantify the associations between 22 crash characteristics and

Lorry

severity. Findings revealed that rear-end collisions are the most frequent type of crash, while single-vehicle crashes significantly increased the likelihood of fatality despite their lower occurrence. Additionally, drivers with more than five years of experience were found to be involved in most fatal crashes. Road characteristics, such as road conditions and surface quality, were also significant factors influencing crash outcomes. Crashes on slope roads and poor surface conditions were found increasing the odds of fatalities compared to flat and smooth surface conditions. These results emphasize the need for targeted interventions, including improving road infrastructure, stricter enforcement and enhancing driver training, to reduce the severity and frequency of rigid lorry crashes in Malaysia.

I. Introduction

Heavy goods vehicles (HGV) are motor vehicles built for transporting goods with a gross vehicle weight (GVW) exceeding 3,500kg [1]. In Malaysia, 1,390,676 HGVs were registered as of 2022, representing 4% of all vehicle registrations [2].

Despite their significant role in the economy, the presence of HGVs on the road raises global concerns, particularly regarding road traffic crashes. Between 2017 and 2019, there were a total of 109,556 crashes involving HGVs in Malaysia, representing a 6.2% rise from 2017 to 2018 and a further 2.65% rise from 2018 to 2019 [3]. Despite minor increments, HGVs are responsible for over 1,000 fatalities each year [4].

There are two types of HGVs: rigid and articulated lorries. These vehicles are constructed with different configurations. As of 2022, rigid lorries account for 81.7% of total HGV registration in Malaysia, reflecting their practicality and efficiency [5].

Truck configuration significantly influences crash outcome [6]. Rigid lorries are designed with shorter wheelbase and lower load capacity for easier manoeuvrability. In Malaysia, the maximum length for a rigid lorry is 13 meters and the maximum permissible GVW limited to 33 tonnes [7, 8].

Previous studies [4, 9, 10] show that rigid lorries are the most prevalent type of HGV to collide with other vehicles, often resulting in fatality. According to NTSB [11], rigid lorries, commonly used for short-haul operations in urban areas, are more frequently involved in crashes at intersections and on urban roads, increasing the hazard to passenger vehicles, pedestrians, and cyclists.

The vehicle's design and operation can affect the type of crash and severity. For example, Chen [12] found that rigid lorries were 37.9% more likely to result in serious injury or death in multi-vehicle crashes on rural highways. In addition, [6] found that rigid lorries were more prone to rollover or loss of control in rural areas, increasing injury severity in rural single-vehicle crashes.

Other factors influencing crash severity among HGV including driver characteristics and road conditions. Experienced lorry drivers may reduce crash severity as driving a lorry requires skills distinct from regular driving [13]. Familiarity with the vehicle operation improves driver's ability to handle the vehicle better during collision. Road conditions also affect lorry performance in terms of manoeuvrability, stability, acceleration, and deceleration [14]. For example, flat and straight roads provide a comfortable ride, causing drivers to be less cautious leading to speeding [15]. Sharp curves can cause the load to shift and changing the centre of gravity (CG) of the vehicle, contributing to rollover [14].

Despite numerous studies on HGV, there is a lack of focused research on rigid lorries. Their high percentage on the road and significant involvement in fatal crashes, underscores the need to understand contributing factors. This study aims to identify and analyse the crash severity characteristics of rigid lorries in Malaysia. Findings of this study are expected to inform targeted safety interventions to reduce fatalities and improve road safety for heavy goods transportation.

II. Methodology

A. Data Collection

The study used secondary crash data sourced from the Malaysia Highway Road Accident Analysis & Database System (MHROADS), primarily collected by the Royal Malaysian Police (RMP). The dataset contains detailed information of the crash. Despite the variety of information, only 22 variables will be analysed.

This study included HGV crashes from 2018-2020 with a representative sample of 306 rigid lorries crashes. The period also aligns with a time when HGV related crashes in Malaysia were rising, providing relevant context for analysing crash severity patterns.

B. Data Analysis

To analyse crash severity of rigid lorries, a 2x2 contingency table analysis was conducted. This method quantified the association between 22 crash characteristics and crash severity (fatal or non-fatal) using odds ratios (OR). The Pearson chi-square test was used to check for statistical significance at a 0.05 level.

This approach is commonly applied in road safety studies, as it allows for robust exploration of the relationships between categorical variables.

III. Results

A. Crash Occurrence and Severity

The data shown in Table 1 revealed that rigid lorries accounting for the majority with 306 (56.8%) crashes, compared to 233 (43.2%) for articulated lorries. However, crashes involving rigid lorries declined from 113 (62.8%) in 2018 to 94 (48.7%) in 2020.

Table 1: Distribution of Crash Occurrence and Severity

Type of lorry	Year			Crash severity		Total
	2018	2019	2020	Fatal	Non-fatal	
Rigid, N (%)	113 (62.8%)	99 (59.6%)	94 (48.7%)	188 (57.3%)	118 (55.9%)	306 (56.8%)
Articulated, N (%)	67 (37.2%)	67 (40.4%)	99 (51.3%)	140 (42.7%)	93 (44.1%)	233 (43.2%)

Regarding crash severity, the proportion of fatal crashes involving rigid lorries is slightly higher (57.3%) than their non-fatal crashes (42.7%). Despite the overall decline in 2020, the fatality rate remains a concern, as rigid lorries still account for a significant number of fatal crashes.

B. Crash Severity Characteristics

Six variables showed significant associations with crash severity ($p<0.05$). Table 2 provides detailed results revealing primary factors that may influence fatal crashes related to rigid lorries.

Table 2: Crash Severity Characteristics of Rigid Lorry

Variables	Fatal, N (%)	Non-fatal, N (%)	OR (95% CI)	χ^2, *p*-value
Collision type				
Rear end*	58 (30.9%)	40 (33.9%)	1	
Angular	7 (3.7%)	18 (15.3%)	0.27 (0.1 – 0.7)	7.77, p = 0.01
Head on	32 (17.0%)	16 (13.6%)	1.38 (0.67 – 2.84)	0.76, p = 0.38
Out of control	52 (27.7%)	28 (23.7%)	1.28 (0.7 – 2.36)	0.63, p = 0.43
Others	39 (20.7%)	16 (13.6%)	1.68 (0.83 – 3.41)	2.09, p = 0.15
Crash type				
Multi-vehicle*	125 (66.5%)	95 (80.5%)	1	
Single-vehicle	63 (33.5%)	23 (19.5%)	2.08 (1.21 – 3.6)	7.05, p = 0.01
Driving experience				
< 5 years*	32 (17.0%)	32 (27.1%)	1	
> 5 years	139 (73.9%)	76 (64.4%)	1.83 (1.04 – 3.21)	4.46, p = 0.03
No License / Police/ Army	17 (9.0%)	10 (8.5%)	1.7 (0.68 – 4.27)	1.28, p = 0.26
Road condition				
Flat*	154 (81.9%)	107 (90.7%)	1	
Slope	34 (18.1%)	11 (9.3%)	2.15 (0.98 – 2.86)	4.44, p = 0.03
Road surface				
Bitumen*	163 (86.7%)	111 (94.1%)	1	

Others	25 (13.3%)	7 (5.9%)	2.43 (1.02 – 5.82)	4.2, p = 0.04
Surface quality				
Smooth*	163 (86.7%)	112 (94.9%)	1	
Corrugation/ Rutted/ Pothole	25 (13.3%)	6 (5.1%)	2.86 (1.14 – 7.21)	5.37, p = 0.02

IV. Discussion

A. Collision type

Rear-end collisions were the most frequent type of crash (30.9%). These collisions often associated with speeding and poor vision at night [16]. Most rear-end collisions involving HGV occurred in traffic jams [14]. This is probably due to their large size and weight which affects their braking capabilities and visibility of surrounding vehicles. This is likely exacerbated in Malaysia due to mixed traffic conditions with smaller vehicles and motorcycles. Implementation of automatic emergency braking (AEB) and collision warning system in rigid lorries could mitigate the risks particularly in situations requiring quick reactions.

Further analysis on collision type shows that angular collisions significantly lower crash severity about 75% *(95% CI: 0.1-0.7)* compared to rear-end collisions. Angular collisions in Malaysia typically occur at unsignalized intersections during right-turning manoeuvres [17]. This condition may result in less severe outcomes for rigid lorries, as their typical operation in urban areas involves lower speeds. Additionally, angular collisions often impact the sides of the vehicles, which may provide better energy absorption compared to the direct impact in rear-end collisions.

B. Crash Type

Multi-vehicle crashes contribute 66.5% of fatalities. However, the odds of single-vehicle crashes being fatal was 2.08 times *(95% CI: 1.21-3.6)* higher than multi-vehicle crashes. This finding aligns with a study in [6]. They found that rigid lorries were more prone to rollover or loss control in rural areas, increasing injury severity levels for the vehicle occupants.

Rollovers or loss control in heavy lorries often result from speeding when cornering and centre of gravity (CG) issues [18]. Higher speeds reduce cornering ability, increase braking distances and impact forces [19]. While rigid lorries may have a lower CG, improper load placement can affect handling during sharp turns at high speeds. Urban environments and high traffic density require evasive manoeuvres, which can further compromise their stability.

C. Driving Experience

Drivers with more than five years of experience were involved in 73.9% of fatal crashes. Compared to drivers with less experience, these drivers had higher likelihood with an odds ratio of 1.83 *(95% CI: 1.04-3.21)*. A study by [20] found that more experienced drivers have lower likelihood to be involved in a crash by 52%. They have adequate skill and experience to adapt more quickly to changing conditions, especially in stressful situations. The counterintuitive findings may be due to the operational differences. Less experienced drivers often involve in short-distance trips and tend to be more cautious due to unfamiliarity with lorry or routes. In contrast, more experienced drivers typically engage in longer-haul trips, intense workload, and tight deadlines. This can lead to fatigue, stress, and risky driving behaviour.

D. Road Condition and Surface

Three variables related to road significantly affect crash severity: road condition, road surface, and surface quality. Most fatal crashes occurred on flat road (81.9%), bitumen road surface type (86.7%), and smooth road surface (86.7%). However, crashes on slope roads had 2.15 times higher odds *(95% CI: 0.98-2.86)* in fatalities compared to flat roads. Slope can affect cargo movement, altering the vehicle's CG and braking performance [14, 21]. Uphill slopes may cause unsecured load to shift backwards, raising the CG and increasing rollover risks.

Downhill slopes push load forward, posing challenges in maintaining control and stability of the vehicle. Driving on slopes presents additional challenges including braking and the potential of out of control that contribute to more severe crash outcomes [6]. Enforcing stricter load-securing would mitigate these risks.

The odds of fatalities on poor road surfaces such as concrete, crusher run, and earth were 2.43 times *(95% CI: 1.02-5.82)* higher than bitumen surfaces. Similarly, the odds of fatal crashes on poor road surface quality, such as corrugation, potholes, and rutted were 2.86 times *(95% CI: 1.14-7.21)* higher than on smooth road. Road infrastructure significantly influences crash outcomes. Poor road surface may cause uneven movement leading to instability, especially at higher speed or when heavily loaded [14]. During braking, the weight of the load shifts forward, increasing front load axle and reducing traction on the rear axle load, increasing likelihood of skidding and loss of control, particularly during braking or evasive manoeuvres [19].

V. Conclusion

This study reveals that driver behaviour, road and environmental factors are critical in determining the severity of crashes involving rigid lorries. Rear-end collisions are the most frequent type of fatal crash, while angular collisions result in lower severity. Although multi-vehicle crashes are commonly associated with fatalities, single-vehicle crashes are more likely to be fatal, due to rollovers or loss of control. Interestingly, experienced drivers are involved in more fatal crashes, likely due to fatigue and stress. Furthermore, challenging road conditions, such as slope roads and poor surface quality, pose additional difficulties in vehicle control and braking, increasing likelihood of fatal outcomes.

In conclusion, this study highlights significant risks associated with rigid lorries. However, it is important to acknowledge data limitations in this study. Relevant details including specific driver behaviour, vehicle details (e.g. GVW, type of load, mechanical issues) are needed to identify other factors like overloading or brake failure, which often been linked to HGV crashes in Malaysia. Incorporating this information in future studies will help to identify risk factors, improve safety technologies, strengthen regulation, enhance enforcement, and management practices. Despite some limitations, the findings underline the need for targeted interventions to improve road safety for rigid lorries in Malaysia. Enhancing driver training programs, stricter enforcement, and improvement in road conditions are key steps to reduce crash severity and create safer road environments for heavy goods transportation.

VI. Acknowledgement

The authors gratefully acknowledge the support of the College of Engineering, Universiti Teknologi MARA, Shah Alam, Selangor to carry out this research. We also extend our heartfelt appreciation to our colleagues and friends from the same college for their valuable assistance throughout the project.

VII. References

[1] P. Evgenikos, G. Yannis, K. Folla, R. Bauer, K. MacHata, and C. Brandstaetter, "Characteristics and causes of heavy goods vehicles and buses accidents in Europe," *Transportation Research Procedia*, vol. 14, pp. 2158-2167, 2016.

[2] MOT, *Buku Statistik Keselamatan Jalan Raya 2023*.

[3] MOT, "Transport Statistics Malaysia 2019."

[4] R. Hamidun, A. P. Wah Hoong, A. Roslan, A. Shabadin, and H. Jamil, "Characteristics of heavy goods vehicles (HGV) accidents in Malaysia," *IOP Conf. Ser. Mater. Sci. Eng.*, Apr. 2019.

[5] RTD, "Road Transport Department of Malaysia," 2023.

[6] M. T. Haq, M. Zlatkovic, and K. Ksaibati, "Assessment of commercial truck driver injury severity based on truck configuration along a mountainous roadway using hierarchical Bayesian random intercept approach," *Accident Analysis & Prevention*, vol. 162, 2021.

[7] RTD, "Motor Vehicle (Construction and Use Rules) (Amendment) 2024."

[8] JKR, *Statistik Jalan Malaysia Edisi 2022*, Cawangan Senggara

Fasiliti Jalan, 2022.

[9] BITRE, "Heavy truck safety: crash analysis and trends—At a glance," 2016. [Online]. Available: https://infrastructure.gov.au/transport/australia/dangerous/str_compauth.aspx

[10] A. K. Celik and E. Oktay, "A comparison of ordered and unordered response models for analyzing road traffic injury severities in the North-Eastern Turkey," *Periodica Polytechnica Transportation Engineering*, vol. 45, no. 3, pp. 119-132, 2017.

[11] NTSB, "Crashes involving single-unit trucks that resulted in injuries and deaths," 2013. [Online]. Available: http://www.ntsb.gov

[12] F. Chen and S. Chen, "Injury severities of truck drivers in single- and multi-vehicle accidents on rural highways," *Accident Analysis & Prevention*, vol. 43, no. 5, pp. 1677-1688, 2011.

[13] N. I. Zainuddin, A. K. Arshad, W. Hashim, and R. Hamidun, "Heavy goods vehicle: Review of studies involving accident factors," *Jurnal Kejuruteraan*, vol. 35, no. 1, pp. 3-12, 2023.

[14] F. Slootmans, "European Road Safety Observatory: Road Safety Thematic Report—Professional drivers of trucks and buses," 2023.

[15] J. Hong, R. Tamakloe, and D. Park, "Discovering insightful rules among truck crash characteristics using Apriori algorithm," *Journal of Advanced Transportation*, vol. 2020, 2020.

[16] J. Xi, H. Guo, J. Tian, L. Liu, and W. Sun, "Analysis of influencing factors for rear-end collision on the freeway," *Advances in Mechanical Engineering*, vol. 11, no. 7, 2019.

[17] A. Ahmed, A. F. M. Sadullah, and A. S. Yahya, "Field study on the behavior of right-turning vehicles in Malaysia and their contribution on the safety of unsignalized intersections," *Transportation Research Part F*, vol. 42, pp. 433-446, 2016.

[18] A. S. Trigell, M. Rothhämel, J. Pauwelussen, and K. Kural, "Advanced vehicle dynamics of heavy trucks with the perspective of road safety," *Vehicle System Dynamics*, vol. 55, no. 10, pp. 1572-1617, 2017.

[19] LTNZ, "Land Transport NZ: An introduction to heavy rigid vehicle stability and dynamics."

[20] L. Meuleners, M. L. Fraser, M. H. Govorko, and M. R. Stevenson, "Determinants of the occupational environment and heavy vehicle crashes in Western Australia: A case–control study," *Accident Analysis & Prevention*, vol. 99, pp. 452-458, 2017.

[21] D. M. Cerwick, K. Gkritza, M. S. Shaheed, and Z. Hans, "A comparison of the mixed logit and latent class methods for crash severity analysis," *Analytical Methods in Accident Research*, vol. 3-4, pp. 11-27, 2014.