Jurnal Kejuruteraan 35(1) 2023: 3-12
https://doi.org/10.17576/jkukm-2023-35(1)-01

Heavy Goods Vehicle: Review of Studies Involving Accident Factors

Nor Izzah Zainuddin[a*], Ahmad Kamil Arshad[b], Wardati Hashim[a] & Rizati Hamidun[c]

[a]*School of Civil Engineering, College of Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*
[b]*Institute for Infrastructure Engineering and Sustainable Management, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*
[c]*Malaysian Institute of Road Safety Research, 43000 Kajang, Selangor, Malaysia*

**Corresponding author: drahmadkamil@uitm.edu.my*

Received 9 March 2022, Received in revised form 22 June 2022
Accepted 27 July 2022, Available online 30 January 2023

ABSTRACT

The use of heavy goods vehicles (HGV) has grown locally and globally. In this regard, every road user faces a high accident risk and is susceptible to traffic-related injuries and deaths. There is a substantial focus on law enforcement to prevent overloading, speeding, and illegal substance use among drivers. Nonetheless, evidence about the complex causes of HGV accidents is still scarce. Thus, this paper aims to outline the literature related to HGV study and examine factors of HGV accidents. Several factors that significantly contribute to accidents have been identified in the literature review. The study has established three main HGV accident factors with 15 sub-HGV accident factors. The Human Factor was the most dominant, while the Vehicle Factor was the least acclaimed HGV accident factor. The review also found several areas for further empirical improvements by including diverse data sources, a more extensive database, and more advanced data analysis. Moreover, technology advancements are required to capture more detailed and richer data for future studies on HGV. Future studies related to HGV accidents are essential in reducing the fatality rate in line with the Sustainable Development Goals (SDG) Goal 3 target 6, which reduces the number of individuals killed or wounded in vehicle accidents worldwide.

Keywords: Heavy goods vehicle; accident factors; road safety; road transport; commercial vehicles

INTRODUCTION

A nation's economy relies on the supply of products and services to consumers. In most countries, land-based transport, specifically heavy goods or commercial vehicles, has become the backbone of the goods supply chain.

The term "heavy goods vehicle" (HGV) is defined differently in different countries. It may vary depending on the country's regulation, the license required to operate the vehicle, the vehicle's weight, and the Department of Transportation's (DOT) registration. Large load-carrying vehicles are commonly known as lorries in the United Kingdom and most British Commonwealth countries or trucks in the United States and Australia (Cairney et al., 2011). The National Transport Commission of Australia (NTCA) defines heavy vehicles as those with a gross vehicle mass (GVM) of more than 4.5 tons. These vehicles include articulated trucks, rigid trucks, and trucks pulling hefty trailers (Cairney et al. 2011; Guest et al. 2014). Meanwhile, the European Road Safety Observatory (ERSO) defined HGV as goods trucks weighing more than 3.5 tons and exceeding the maximum allowed gross weight. These vehicles must not exceed the maximum permissible length of 16.50 m for semitrailers and 18.75 m for road trains, with a total weight of 40 tons (Castillo-Manzano et al. 2016).

While vehicle classes are clearly stated in several acts in Malaysia, there is yet a simplified or graphic guideline that can help understand vehicle classifications. According to the (Road Transport Act 2013), a "goods vehicle" is any motor vehicle that is specifically manufactured or modified for the purpose of transporting and carrying goods, as well as any motor vehicle that is not specifically manufactured or adapted for the purpose of transporting and carrying goods in addition to passengers. Meanwhile, "vehicle" is a structure capable of transporting, transporting or moving to carry persons or objects. When in motion, these vehicles should maintain contact with the ground.

In addition, the (Land Public Transport Act, 2010) defines "goods" as any objects or loads, excluding luggage. Hence, "goods vehicle" comprises any motor vehicles or trailers manufactured or adapted to carry goods. This classification also includes motor vehicles or trailers not specifically constructed or adapted for carrying loads but are used for transporting goods only or in addition to passengers. The operator's license to operate or supply goods vehicle service specifies the classification for goods vehicles.

PLUS Malaysia Berhad has provided a simplified graphical guideline on vehicle classification on its website, which serves as a guideline for toll rates. The Malaysian Road Transport Department Malaysia (JPJ) has presented lists I and II of the permitted vehicle in the "second schedule" in accordance with the weight restriction for Federal Road (Amendment) order 2003. Goods vehicles are categorized into Rigid, Articulated, and Abnormal Vehicles based on their weight and maximum permissible Gross Vehicle Weight (GVW). This classification depends on the number of axles, configuration, spacing, and vehicle dimensions.

The Royal Malaysia Police (RMP) and the Malaysian Institute of Road Safety Research (MIROS) classified HGV into three main classes, lorry trailer/ articulated lorries, rigid lorries with 2 or more axles and the permissible gross weight exceeding 2.5 tons and small lorries which comprise 2-axle small lorries or pick-up with the permissible gross weight of less than 2.5 tons. Example of a vehicle that can be considered an HGV can be seen in Figure 1.

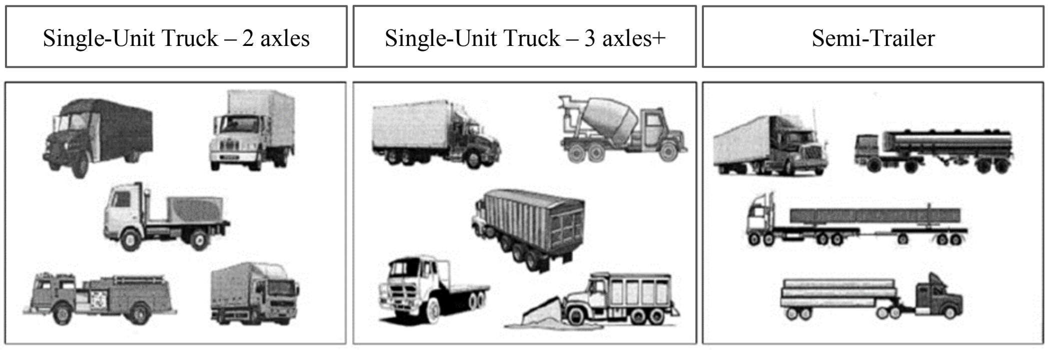

FIGURE 1. Vehicles Considered to be Heavy Goods Vehicle (HGV) (Cerwick, 2013)

ACCIDENTS INVOLVING HGV

Road traffic fatalities are a real concern worldwide. According to World Health Organization (WHO 2018), around 1.35 million people are killed in automobile accidents. This amounts to 3,700 accident-related deaths daily, between 20 and 50 million individuals, with many life-altering injuries with long-term consequences, including disabilities. Road traffic accidents are the eighth leading cause of mortality among adolescents. The figure is projected to rise to fifth place by 2030 (WHO 2018). Road traffic injuries also cause enormous financial damages to individuals and their families. Family members of individuals killed or incapacitated by road traffic injuries must bear the cost of treatment, loss of productivity, and some need to take time off work or study to care for the injured victims.

In most countries, road traffic accidents are attributed to 1-3% of their gross domestic product (WHO 2017). More than 90% of road traffic deaths occur in low- and middle-income nations. Even in high-income countries, people with a lower socioeconomic background are more likely to involve in traffic accidents. Malaysia is not excluded from the increasing rate of accidents yearly, as evidenced by an indicator provided by the Malaysian government (MOT 2020). Because traffic accidents and fatalities significantly affect Malaysian socioeconomics and lives, prompt action on this issue is vital. While it is good that the number of road fatalities has decreased from 6,284 in 2018 to 6,167 in 2019, the number of deaths remains high (MOT 2020).

In recent years, the demand for goods and loads to be delivered and transported has increased, and freight lorry drivers must work long hours to complete multiple trips, contributing to a higher risk of an accident involving HGV. Traffic engineers question how safe and roadworthy these giants are roaming around us because of the severity of crashes and the increased risk of secondary impacts. HGV made up 4.15% of all vehicles on Malaysian highways in 2019 and was involved in 4.55% of all accidents (MOT 2019) 3% of accidents resulted in the deaths of Malaysian HGV drivers and uncountable secondary crash deaths involving HGV accidents. HGV accidents result in a significant impact on logistic costs and the death of other road users.

Thus, it is imperative to understand this group of vehicles better, as they are unique road users with distinct safety needs and characteristics due to their unique characteristics and their different mobility behaviour (Evgenikos et al. 2016).

AIM AND RESEARCH QUESTION

Building on the shortcomings identified from previous studies, this study aims to provide a more definable understanding of HGV accidents and examine factors contributing to HGV accidents. Therefore, this study is determined to answer the following research question: (i) What factors contribute to HGV accidents?

HGV ACCIDENT STUDIES

In HGV accidents, the severity of the injuries tends to be higher than in other accidents due to the vehicles' high mass (ERSO 2016). Consequently, HGV accidents could bring severe injuries or fatalities among drivers or passengers of lighter vehicles such as cars and motorcycles (Gothié 2006). More than 80 per-cent of the second vehicle fatalities are caused by an HGV accident (Hamidun et al. 2019), which shows that fatalities are more likely to occur in HGV accidents when involved in an accident with a smaller vehicle.

HGV affects the surrounding traffic both physically and psychologically. These effects are caused by the physical characteristic of HGV (such as length and size) and their operation. HGV has operating constraints due to the large dimension, which causes long stopping distances, large blind spots, and limited maneuverability. In this situation, drivers of other vehicles must be more cautious about their safety. Based on these issues, there is a need for a greater understanding of the accident characteristics of HGV, which could impact the safety of other road users.

Vehicle crashes are complicated events frequently influenced by driving behaviors, road geometry, and driving environments. This study categorizes the Main HGV accident factors into the human, vehicle, road, and environmental factors and further categorizes them into sub-HGV accident factors. The finding of the study will be discussed in the following sections, based on the established research questions.

HUMAN FACTORS

The human factor has been identified as a leading cause of traffic accidents (Ahmed & Ghasemzadeh 2018; Al-Bulushi et al. 2015; Azahari et al. 2019; Bener 2012; Borhan et al. 2018; Chang et al. 2019; Hatami et al. 2019; Hilton et al. 2009). The literature review found that studies have examined the impacts of the human factors, including driver's background, fatigue and sleep deprivation, driver's behavior, driver mental health, driver distraction, and information failure.

DRIVER'S BACKGROUND

Among sociodemographic factors, gender was a significant predictor of road traffic accidents. According to Bener (2012) and Eboli et al. (2020), men experienced significantly higher road traffic injuries than women. This data is corroborated by Moomen et al. (2019), who found that male drivers relate to an increased risk of truck crashes than female drivers due to a positive coefficient for gender. Male drivers are about five times more likely than female drivers to be involved in HGV crashes, according to the chance ratio of 5.49. Males contribute more than three-quarters of fatalities in events involving HGVs (76%), according to Evgenikos et al. (2016). However, great variation exists between countries (i.e., 50% in Denmark and over 90% in Cyprus and Croatia). This finding is consistent with the fact that gender concentrations in transportation-related activities such as truck driving vary globally. Additionally, countries with a disproportionate male population are likely more vulnerable to road traffic because of their enhanced economic prospects and risk-taking behavior.

Numerous published studies indicate that road traffic injuries adversely affect the productive age range. Research by Moomen et al. (2019) discovered that younger drivers (those under the age of 25) contribute to reducing HGV accidents. In contrast, Yuan et al. (2017) found that young drivers incur more serious injuries in HGV collisions. A study by Evgenikos et al. (2016) reported that over 40% of those who died in traffic incidents involving heavy goods vehicles in the EU were aged 25–49. Guest et al. (2014) found that drivers beyond the age of 64 were no more likely to cause a crash than drivers between the ages of 45 and 54. The same was true for drivers between the ages of 55 and 64. This is because the older generation is more conservative towards taking risks and acts more cautiously when driving (Landay et al. 2020). On the other hand, younger drivers are more prone to engage in risky and aggressive behavior and are less worried about road safety (Shams et al. 2020) insomnia, and working conditions of drivers individually on inattention-related error as well as expression of anger in driving. Nevertheless, so far no study has tested the concurrent effect of these factors on crashes. This study has dealt with indirect investigation of the effect of variables including demographic characteristics, insomnia, and working conditions of drivers on inattention-related error and expression of anger in driving (as mediation model. As a result, they are more likely to be engaged in accidents.

Prior studies have found that the driver's experience significantly affects injury severity (Chang & Chien 2013; Hatami et al. 2019; Peng et al. 2018). A study by Al-Bulushi et al. (2015) discovered that drivers with more than five years of driving experience had a higher prevalence of road traffic injuries (41.1%) than those with less driving experience. In contrast, a study by Bener (2012) reported that accidents are more prevalent in the first 3 years of driving, irrespective of age. Similarly, Guest et al. (2014), Mehdizadeh et al. (2019) and Shams et al. (2020) discovered that more experienced HGV drivers have a lower risk of being involved in an accident. In this aspect, experienced drivers adapt more quickly to changed conditions, exhibited less vocal and physical reactions, and involved in fewer accidents. Experienced drivers are calmer when driving in stressful situations. They can handle these situations more effectively due to prior experience.

FATIGUE AND SLEEP DEPRIVATION

Fatigue and sleep deprivation are also important variables in HGV collisions (Crizzle et al. 2017; Howard et al. 2004; Meuleners et al. 2017; Stevenson et al. 2010). "Fatigue" is a word coined by Stutts et al. (2003) to characterize drowsy drivers who did not fall asleep and were physically weary but not sleepy. While "drunk" refers to drivers who fell asleep at the wheel before crashing, "asleep" refers to drivers who fell asleep at the wheel before crashing.

Driving while fatigued during peak hours, chasing trip-based pay at the expense of safety, uncounted non-driving scheduling tasks, and loading and unloading delays have been proven to be statistically significant predictors of high-level injury severity (Alaiakbari & Moridpour 2017; Hao et al. 2016).

Long-distance driving has been linked to falling asleep at the wheel and increased injury severity in the case of a collision (Cairney et al. 2011). While sleep deprivation and fatigue are highly dangerous for all road users, the impact is severe for heavier and high-risk vehicles such as the HGV.

DRIVER'S BEHAVIOR

Ninety per-cent (90%) of road crashes are linked to a driver's behavior (Ellison et al. 2015). Some driver behaviours are likely to have been unsuitable for the circumstances at the time of the accident. When confronted with varying road conditions, each driver will exhibit varied behavioral responses (Islam & Hernandez 2013).

Furthermore, most crashes were caused by risky driving behaviors such as speeding, inappropriate vehicle maneuvers, inattention, and failing to maintain a safe distance from the preceding vehicle (Al-Bulushi et al. 2015; Pokorny et al. 2017).

The maximum speed limit for HGV on a highway is 90 km/h, and 60 km/h to 80 km/h on the federal and state roads (Sim et al. 2017)commercial or heavy vehicle-related accident is drawing serious attention. In 2014 alone, a total of 57,430 road accidents involving lorry, bus, and taxi was recorded (MOT 2014). The study by Hashim et al. (2016) reported that, on average, heavy vehicles exceed the permitted speed limit for the designated expressway section. Speeding right before a crash has been shown to cause more severe impacts (Islam & Hernandez 2013; Lemp et al. 2011). Safe speed is an essential factor when driving on the expressway.

In other circumstances, due to HGV having slower speed, heavy mass, and high volume, other vehicles tend to slow down or change lanes when driving behind an HGV. Changing from one lane to another will be more difficult, and the risk of collision drastically increases.

DRIVERS' MENTAL HEALTH

Even though both HGV and other road users are operating machinery on the roads, the impact of mental health on HGV and other road users differs (Hilton et al. 2009). First, HGV drivers, for example, spend significantly more time on the road than other road users, increasing their chances of being involved in an accident. Operating an HGV requires skills distinct from those required for regular driving. Furthermore, HGV drivers have a different lifestyle from other drivers.

Numerous things can contribute to depression biologically, but the primary reason is an imbalance in the brain's stress adaption mechanism. In rare instances, occupational stress can be detrimental to brain systems, resulting in depression (Kunz-Ebrecht et al. 2004). Job insecurity, lengthy and hard journey excursions, weariness, unpredictable rest and sleep cycles, long work hours, and traffic congestion are all common sources of stress for HGV drivers (Hatami et al. 2019). Because stress can result in depression, improving mental health in the workplace requires identifying pressures and the occurrence of mental illnesses. Low education levels, stimulant usage, and wage-earning contributed to an elevated risk of depression.

Inadequate employment support contributes to anger and sadness, decreases job satisfaction, and increases absenteeism. These findings are consistent with Crizzle et al. (2017) and Stevenson et al. (2010), which showed that depression increases significantly as job stress increases.

Depressed drivers are just as deadly as drunk drivers. Long-term stress is a leading risk factor for depression, and serious exhaustion can lead to sadness. Drivers without co-drivers are more prone to experience stress, burnout, and depression, according to Hatami et al. (2019), because there is no shared responsibility between drivers and co-drivers. The drivers on their own must complete all the difficult duties. On top of that, most truck drivers travel alone and without coworkers. Furthermore, they are frequently away from home due to the distances involved.

According to Hilton et al. (2009), mental health impairment includes difficulties with attention, concentration, motivation, decision-making, and visuomotor controls. Thus, HGV driving should be considered one of the community's vulnerable occupations. Due to the nature of the profession, long-distance HGV drivers have been highlighted as having greater exposure to health risks and medical indigence. As a result, HGV drivers must maintain good mental health to protect their safety, health, and capability from working.

DISTRACTION OF DRIVERS

Driver distraction is regarded as any inattention by the driver (Romo et al. 2014). Driving distractions, including mobile phones use, drinking alcohol, drug consumption, eating, and traffic violations, are the leading causes of HGV-related traffic accidents (Chang & Chien 2013). A study by (Cairney et al. 2011) discovered that alcohol was involved in about half of all crashes (not only HGV crashes). Drinking and driving are likely to contribute to road fatalities and accidents significantly.

Bener (2012) driving history, type of vehicle driven, driver behavior, severity of motor vehicle injuries, and the cause of the RTC was used to collect data. Results young drivers in the age group (25-34 found that the majority of injured drivers (27.9%) were distracted when driving by eating or drinking; this was followed by a substantial proportion of drivers (25.4%) who were using mobile phones or typing SMS/text messages (22.7%).

INFORMATION FAILURE

An improper or inadequate evaluation of another road user's road conditions or conduct is called a "faulty diagnosis." This situation is usually linked to information failures like assuming another car has not completely stopped and collided with it and interaction failures like moving out of the ongoing route of a motorist who signaled a turn too soon (Berrington et al. 2003; Evgenikos et al. 2016). Such information failure highly contributes to accidents caused by human factors.

VEHICLE FACTORS

The size and weight of HGV have a significant role in the severity of its impact on other vehicles engaged in traffic accidents (Cairney et al. 2011; Evgenikos et al. 2016; Hamidun et al. 2019; Pokorny et al. 2017). Due to its mass and engine performance, HGV drive at a lower speed than other vehicles, which might result in collisions (Dimitriou et al. 2018). The previous study covered vehicle variables contributing to HGV accidents, including overloading, braking faults, blind spots, HGV design, and tire issues.

OVERLOADING

HGV is prone to overloading because it is in the supply chain, construction, and primary produce industries, and many operators tend to overload their containers (Cairney et al. 2011). The study by Ismail et al. (2020), Lemp et al. (2011) and Zamzamzadeh et al. (2016) found that overloading increases the weight of vehicles and leads to higher kinetic energy. A previous study has observed that 6.36% of HGV are overloaded (Faruk et al. 2016). These vehicles would have larger collision forces and damage other vehicles more seriously. While a higher vehicle's mass could protect its passengers during a collision, it inflicts a massive impact on other road users. They are causing a higher likelihood of fatalities (Cairney et al. 2011). This is because HGV has a high moment of inertia due to their weight and hence does more damage to other vehicles in the event of a collision (Arshad et al. 2020).

BREAK DEFECTS

A defective brake system is a major factor in HGV accidents, especially when the vehicles are poorly maintained and experience faulty braking systems (Cairney et al. 2011). Some mechanical flaws cause the failure of the entire vehicle components, while others could reduce vehicle performance and their ability to avoid accidents (Mahdzir 2013; Sarabi & Moosavi 2010). In this regard, poor maintenance directly contributes to road accidents, creating an unsafe driving situation (Newnam & Goode 2015).

BLIND SPOTS

A blind spot is a space or zone surrounding a vehicle that is invisible to the driver and not visible through the side or rearview mirrors (Daud et al. 2019). While all vehicles have blind spots, they create more serious issues in larger vehicles (Musa 2017). A blind spot is a common cause of accidents involving HGV. A study on the risk of a motorbike colliding with a turning lorry found that lorry drivers drive more cautiously when they are aware that a motorcycle is riding close to them. Meanwhile, most road users believe that lorry drivers are unaware of the presence of a motorbike (Daud et al. 2019; Musa 2017). Sight deficiencies can also occur in addition to lorry blind spots (Richter & Sachs 2017).

There are blind spots in a vehicle's front, rear, and side views (Daud et al. 2019). For HGV, many lorry drivers assume its blind spot zone is the lorry's rear. Some are unaware of blind spots on the lorry's front and sides (Hamidun et al. 2019; Musa, 2017).

HGV DESIGN

Different types of vehicles are designed to address different risks. For instance, the structural design and size difference between large trucks and passenger cars would cause the larger trucks to suffer minor damages when hit by the smaller vehicles (Islam & Hernandez 2013). In such collisions, the risk of fatal injuries among drivers and passengers of smaller cars is greater as their energy absorbers might not correspond during a collision with larger trucks (Chen et al. 2020). As highlighted by Hamidun et al. (2019), improving some of the safety features on the HGV, such as the rear view mirror, could reduce blind spots. Resultantly, the possibility of road accidents is diminished.

TIRE DEFECTS

Vehicle defects elevate the likelihood of accidents. Tire problems have been linked to greater accident severity (Haq et al. 2020). The study identified one element related to the vehicle defect based on previous research. The driver lost control of the vehicle after the tire blew out and entered the opposing lane (Larsen 2004). Tire explosions are commonly attributed to faulty design flaws, poor tire condition, inflation, loss of control, overheating, hazards on the road, flying parts, unsecured cargo, and road debris.

ROAD AND ENVIRONMENTAL FACTORS

Road and environmental conditions are factors that highly contribute to HGV accidents. In this regard, studies have considered factors, including geometric road design, location and road type, weather effects, and timing of HGV operation.

ROAD GEOMETRY

Researchers have highlighted the dangers of road geometry along curves or straight roads. An accident involving HGV has a higher risk of fatality on a straight road than on other road geometry such as T/Y junction, interchange or roundabout (Hamidun et al. 2019). This is probably due to the higher travelling speed at non-junction sites than on straight roads. In addition, violations of commercial vehicles' speed limits are very high. They could also mean that the speed limit is inappropriate for the road portion because of poor design Sim et al. (2017) or less traffic regulation for that road type.

Even though signalized intersection has separate movements in time and space, accidents are likely to occur at signalized junctions (Ahmed et al. 2018). Because of too many conflicting activities in mixed traffic of HGV with other vehicles, signalized intersections have become one of the most complex traffic events (Azahari et al. 2019). As a result, relations amongst other road users become more complicated, challenging, and diverse. It was found that complex road geometry often contributes to challenging driving environments (Rusli et al. 2018).

Road geometry such as curves, exit slipways, roundabouts and slopes are all structures that can cause accidents. According to Bener (2012), most crashes happened at roundabouts. Sanchez Rodrigues et al. (2015) revealed variations in the kind and position of roundabouts that may increase the likelihood of crashes. According to the research, certain roundabouts, particularly those with double and triple lanes, are more prone to crashes.

Due to the size of the vehicle, HGV has difficulty with low radius curves (Cerezo & Conche 2016; Islam & Hernandez 2013). Previous studies found that most HGV accidents were caused by superelevation and skid resistance (Cerezo & Gothie, 2006a; Gothié, 2006; Hao et al. 2016). Berrington et al. (2003) argued that vehicles travelling on roads with high superelevation and low skid resistance face a higher risk of rolling over. In this case, these vehicles have exceeded the vehicle dynamic's parameters. Furthermore, vehicles travelling on roads with slopes gradient of 5 per-cent or more over long distances generate speed differentials with other road users exceeding 30 km/h. This situation undoubtedly increases the risk of collision (Cerezo & Conche 2016).

LOCATION AND ROAD TYPE

Most traffic accidents occur on highways and main roads (Kamarudin et al. 2018; Sarabi & Moosavi 2010). Road expansion, traffic, less road width, and non-compliance with regulations are the top causes of accidents on main roads (Sarabi & Moosavi 2010). The poor quality of service on these routes and their high capacity is critical (Choudhary et al. 2018; Ramírez et al. 2009). According to (Evgenikos et al. 2016), in the EU, 58 per cent of HGV accidents in 2013 occurred in rural areas. Seventy per-cent of fatalities in HGV accidents in Latvia, Finland, and Sweden and forty per-cent of fatal HGV accidents in the Netherlands were reported in non-urban areas.

EFFECTS OF WEATHER

Considering HGVs are often huge and heavy, stopping them in adverse weather is more difficult than halting other trucks due to lower friction forces. Weather conditions influence the skid resistance of highways, lowering braking and steering capabilities and ultimately leading to narrower impact angles and more severe injuries in accidents. For truck drivers, sleet is the most dangerous weather condition, followed by snow, fog, rain, and cloudiness (Hao et al. 2016). A study by (Ahmed & Ghasemzadeh 2018) discovered that rainy weather crashes might be 2–3 times more than those from clear weather crashes. It is crucial to keep in mind that road traffic accidents increase significantly when it rains.

In contrast, (Mase et al. 2020) found that most road traffic injuries happened more during dry and sunny days than on shady days. When the temperature is high, this effect is due to increased stress and diminished motor abilities (Shao et al. 2020).

TIMING OF HGV OPERATION

Previous studies had also considered days when the accidents occurred, specifically weekdays or weekends. One may note that the fatality rate in HGV accidents is about the same throughout all weekdays, with fewer fatalities on weekends, Monday and Tuesday being the most dangerous days of the week (Evgenikos et al. 2016). As HGV operations are scheduled under commercial activity, their use is banned during specified times in some countries, especially during the weekends (Evgenikos et al. 2016). In the meantime, in Slovenia. 43 per-cent of HGV-related fatalities were reported on Saturdays. This situation is probably because no driving ban is enforced during the weekend. Another study by (Hao et al. 2016) reported that HGV drivers are more severely injured during peak hours than during off-peak hours in accidents.

DISCUSSION AND CONCLUSION

The rising number of HGV accidents and the profound implications of such collisions have sparked research and the implementation of knowledge-based safety measures. Although, understanding the factors associated with HGV accidents is complicated. Previous studies have examined past events to determine the factors contributing to the risky encounters between HGV to other road users. Numerous factors were identified through the literature review, categorized into main HGV accident factors: human, vehicle, and road and environment.

In reference to Table 1, the percentages correspond to the sub-HGV accident factors highlight the importance of the main-HGV accident factors found in the reviewed literature. The percentages for each main-HGV accident factor were calculated based on the number of reviewed articles containing the relevant factors. From the findings, most attention was given to human factors (50%), followed by road and environment factors (26.5%) and vehicle factors (23.5%).

The research trend for human factors indicates that distraction of drivers and information failure have received the least attention. Drug and alcohol use, mobile phone use, the presence of peers in the vehicle, and unfamiliarity with the roadway can all lead to driver distraction. More research needs to be carried out in this area, particularly to describe new methodologies that can be developed to determine when factors such as distraction and inattention may have contributed to an accident.

TABLE 1. The summary of main and sub-HGV accident factors

No	Sub-HGV accident factors	Number of articles	Main HGV accident factors	Example of references
1	Driver's Background	12	Human Factors (50%)	(Al-Bulushi et al., 2015; Bener, 2012; Chang & Chien, 2013; Evgenikos et al., 2016; Guest et al., 2014; Hatami et al., 2019; Landay et al., 2020; Mehdizadeh et al., 2019; Moomen et al., 2019; Peng et al., 2018; Shams et al., 2020; Yuan et al., 2017)
2	Fatigue and Sleep Deprivation	7		(Alaiakbari & Moridpour, 2017; Cairney et al., 2011; Crizzle et al., 2017; Hao et al., 2016; Howard et al., 2004; Meuleners et al., 2017; Stevenson et al., 2010)
3	Driver's Behavior	6		(Al-Bulushi et al., 2015; Hashim et al., 2016; Islam & Hernandez, 2013; Lemp et al., 2011; Pokorny et al., 2017)
4	Drivers' Mental Health	4		(Crizzle et al., 2017; Hatami et al., 2019; Hilton et al., 2009; Stevenson et al., 2010)
5	Distraction of Drivers	3		(Cairney et al., 2011; Chang & Chien, 2013; Romo et al., 2014)
6	Information Failure	2		(Berrington et al., 2003; Evgenikos et al., 2016)
7	Overloading	5	Vehicle Factors (23.5%)	(Arshad et al., 2020; Cairney et al., 2011; Ismail et al., 2020; Lemp et al., 2011; Zamzamzadeh et al., 2016)
8	Break Defects	3		(Cairney et al., 2011; Mahdzir, 2013; Newnam & Goode, 2015)
9	Blind spots	3		(Daud et al., 2019; Hamidun et al., 2019; Musa, 2017; Richter & Sachs, 2017)
10	HGV Design	3		(Chen et al., 2020; Hamidun et al., 2019; Islam & Hernandez, 2013)
11	Tire Defects	2		(Haq et al., 2020; Larsen, 2004)
12	Road Geometry	8	Road and Environment Factors (26.5%)	(Ahmed et al., 2018; Azahari et al., 2019; Berrington et al., 2003; Véronique Cerezo & Gothie, 2006; Hamidun et al., 2019; Hao et al., 2016; Sanchez Rodrigues et al., 2015; Sim et al., 2017)
13	Location and Road Type	4		(Choudhary et al., 2018; Evgenikos et al., 2016; Ramírez et al., 2009; Sarabi & Moosavi, 2010)
14	Effects of Weather	4		(Ahmed & Ghasemzadeh, 2018; Hao et al., 2016; Mase et al., 2020; Shao et al., 2020)
15	Timing of HGV Operation	2		(Evgenikos et al., 2016; Hao et al., 2016)
	Total	68		

This is a particularly important area of research that needs to be done to describe some consequences of distraction and inattention in driver behavior.

For better prevention and management of HGV accidents, interventions addressing driver behavior adjustment regarding adherence to traffic rules and regulations with strict implementation are required. Road users will benefit from the improvements in future research in either one or all those mentioned areas.

Information failure is another topic that has not been adequately investigated. Information or communication failure usually happens when the driver mistakenly acts following what he believes to be the correct course of action when driving on the roadway. Thus, more research needs to be conducted to explore and understand the circumstances under which a driver has information or communication failure and how it can be prevented.

Based on the review, road geometry is the most common sub-HGV accident factor studied under the road and environment factors, followed by locations and road type, weather effects, and HGV operation timing. Even though road geometry is the most studied, the insufficiency of previous HGV studies focusing on road defects in existing roadways and the absence of remedial action at black spot HGV crash sites are still limited.

Pavement degeneration is heavily linked to its optimum operation and may contribute to HGV fatal crashes with other road users. An investigation into the road environment elements that substantially impact fatal HGV accidents should be conducted in the future.

The timing of HGV operation has received the least attention in previous research. It is imperative to investigate areas where optimal planning of HGV operations reduces the average cost of travel during free flow and congestion and reduces the number of fatalities during peak and off-peak hours. There should be a study on the effects of prohibiting these massive giants from roaming at specific times. The significance of having strict entry restrictions should also be investigated.

Vehicle factors have received the least amount of research compared to other main HGV accident factors. Future research on HGV should concentrate on the impact of overloading, brake, and tire defects and their safety implications. Thus, to evaluate the vehicle's impact on crash severity, it is necessary to research the correlation between the age of HGV and the severity of crashes.

Understanding and awareness of HGV blind spot zones are still lacking, necessitating a study that will aid in the future prevention of fatal accidents. Overall, with onboard warning systems and crash prevention technologies, the stability and control of vehicles could be enhanced. The use of crash prevention technologies and onboard tracking devices should be expanded to detect the blind spot, vehicle defects, location, movement, and speeds of a vehicle. At the same time, logistic companies should be trained to use their information systems to improve safety protocols.

These studies are beneficial for assessing the effects of initiatives to mitigate hazards and enhance HGV safety to avoid collisions with other road users. While previous research has concentrated on direct and indirect visibility, system-level indicators linked to policy, planning, design, and operations should also be considered. Further empirical enhancements that incorporate more diverse data sources, a more extensive database, and more advanced data analysis are surely needed. Moreover, technology advancements are required to capture more detailed and richer data for future studies on HGV.

Future review studies can be enhanced by adopting more comprehensive approach such as systematic literature review. Systematic literature review enables researchers to evaluate the quality of published evidence while maintaining unbiased as possible. The identification of keywords should be performed with rigor to identify related and similar terms. Additionally, search strings should be included in a well establish database not just in science direct and Scopus but extended to Web of Science, dimension.ai and transport research international documentation (TRID).

The good service performance of road transportation benefits individuals, communities, and our nation. On an individual level, it reduces such deaths, serious injuries, hospitalizations, and disabilities affected by families and provides an individual better quality of life. Good road transport supports the Sustainable Development Goals (SDG) Goal 3 target 6, reducing the number of people killed or injured in road traffic accidents worldwide.

ACKNOWLEDGEMENTS

The authors are grateful 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 College of Engineering for their constant support. Gratitude is also extended to the reviewers who have contributed valuable ideas, input, energy, and time to this paper.

DECLARATION OF COMPETING INTEREST

None

REFERENCES

Ahmed, M. M., Franke, R., Ksaibati, K. & Shinstine, D. S. 2018. Effects of truck traffic on crash injury severity on rural highways in Wyoming using Bayesian binary logit models. *Accident Analysis and Prevention* 117:(March): 106–113.

Ahmed, M. M. & Ghasemzadeh, A. 2018. The impacts of heavy rain on speed and headway Behaviors: An investigation using the SHRP2 naturalistic driving study data. *Transportation Research Part C: Emerging Technologies 91:*371–384.

Al-Bulushi, I., Edwards, J., Davey, J., Armstrong, K., Al-Reesi, H. & Al-Shamsi, K. 2015. Heavy vehicle crash characteristics in Oman 2009–2011. *Sultan Qaboos University Medical Journal* 15(2):e191–e201.

Alaiakbari, M. & Moridpour, S. 2017. Managing heavy vehicle drivers ' Fatigue : A critical review of the Literature and safe system interventions 3(1): 20–24.

Arshad, A. K., Mohd Tukiran, M. F., Zainuddin, N. I., Hashim, W. & Kamaluddin, N. A. 2020. Heavy goods vehicle accidents: Drivers' perspective. *International Journal of Advanced Research in Engineering and Technology (IJARET)*, 11(6):1006–1011.

Azahari, M. A. A., Kordi, E. & Hamidun, R. 2019. Assessing heavy goods vehicle driver ' s behavior at signalized intersection via assessing heavy goods vehicle driver ' s behavior at signalized intersection via risk assessment model. May.

Bener, A. 2012. A study on road traffic crashes and injuries in Qatar as reported by drivers. *Journal of the Egyptian Public Health Association* 87(5–6): 85–89.

Berrington, K., Pitt, R. & Porteous, H. 2003. Transport At Work: Rollover of Lorries. *Transporting Paper Reels*.

Borhan, M. N., Ibrahim, A. N. H., Aziz, A. & Yazid, M. R. M. 2018. The relationship between the demographic, personal, and social factors of Malaysian motorcyclists and risk taking behavior at signalized intersections. *Accident Analysis and Prevention*, *121:* 94–100.

Cairney, P., Tariro, M. & Adam, R. 2011. Road safety measures for heavy vehicles in APEC. *Transport Supply Chains Final Report*.

Castillo-Manzano, J. I., Castro-Nuño, M. & Fageda, X. 2016. Exploring the relationship between truck load capacity and traffic accidents in the European Union. *Transportation Research Part E: Logistics and Transportation Review*, *88:* 94–109.

Cerezo, V., & Conche, F. 2016. Risk assessment in ramps for heavy vehicles - A French study. *Accident Analysis and Prevention*, *91:* 183–189.

Cerezo, V., & Gothie, M. 2006. *Heavy goods vehicles accidents on roundabouts: parameters of influence*.

Cerwick, D. M. 2013. A study of single and multiple vehicle crashes involving heavy trucks in Iowa. In *Iowa State University*. Iowa State University.

Chang, F., Xu, P., Zhou, H., Lee, J. & Huang, H. 2019. Identifying motorcycle high-risk traffic scenarios through interactive analysis of driver behavior and traffic characteristics. *Transportation Research Part F: Traffic Psychology and Behaviour*, *62:* 844–854.

Chang, L. Y. & Chien, J. T. 2013. Analysis of driver injury severity in truck-involved accidents using a non-parametric classification tree model. *Safety Science*, *51*(1): 17–22.

Chen, M., Chen, P., Gao, X. & Yang, C. 2020. Examining injury severity in truck-involved collisions using a cumulative link mixed model. *Journal of Transport and Health*, 19*:* 100942.

Choudhary, P., Imprialou, M., Velaga, N. R. & Choudhary, A. 2018. Impacts of speed variations on freeway crashes by severity and vehicle type. *Accident Analysis and Prevention*, *121:* 213–222.

Crizzle, A. M., Bigelow, P., Adams, D., Gooderham, S., Myers, A. M. & Thiffault, P. 2017. Health and wellness of long-haul truck and bus drivers: A systematic literature review and directions for future research. *Journal of Transport and Health*, *7:* 90–109.

Daud, M. S. M., Hamid, Z. J. M. H., Suliman, M. S., Abdullah, R. & Zulkarnain, I. I. 2019. The awareness of blind spot area in heavy goods vehicle (HGV). *International Journal of Innovative Technology and Exploring Engineering*, *8*(12):5619–5623.

Dimitriou, L., Stylianou, K. & Abdel-Aty, M. A. 2018. Assessing rear-end crash potential in urban locations based on vehicle-by-vehicle interactions, geometric characteristics and operational conditions. *Accident Analysis and Prevention*, *118*(December 2017): 221–235.

Eboli, L., Forciniti, C. & Mazzulla, G. 2020. Factors influencing accident severity: An analysis by road accident type. *Transportation Research Procedia*, *47:* 449–456.

Ellison, A. B., Greaves, S. P. & Bliemer, M. C. J. 2015. Driver behaviour profiles for road safety analysis. *Accident Analysis and Prevention*, *76:* 118–132.

European Road Safety Observatory. 2016. *Basic Facts 2016 Heavy Goods Vehicles and Buses*. 22.

Evgenikos, P., Yannis, G., Folla, K., Bauer, R., MacHata, K. & Brandstaetter, C. 2016. Characteristics and Causes of Heavy Goods Vehicles and Buses Accidents in Europe. *Transportation Research Procedia*, *14:* 2158–2167.

Faruk, A. N. M., Liu, W., Lee, S. I., Naik, B., Chen, D. H. & Walubita, L. F. 2016. Traffic volume and load data measurement using a portable weigh in motion system: A case study. *International Journal of Pavement Research and Technology 9*(3):202–213.

Gothié, M. 2006. Heavy vehicle accident factors. 9th International Symposium on Heavy Vehicle Weights and Dimensions, 1–10.

Guest, M., Boggess, M. M. & Duke, J. M. 2014. Age related annual crash incidence rate ratios in professional drivers of heavy goods vehicles. *Transportation Research Part A: Policy and Practice 65:* 1–8.

Hamidun, R., Wah Hoong, A. P., Roslan, A., Shabadin, A. & Jamil, H. 2019. Characteristics of heavy goods vehicles (HGV) accidents in Malaysia. *IOP Conference Series: Materials Science and Engineering* 512(1).

Hao, W., Kamga, C., Yang, X., Ma, J. Q., Thorson, E., Zhong, M. & Wu, C. 2016. Driver injury severity study for truck involved accidents at highway-rail grade crossings in the United States. *Transportation Research Part F: Traffic Psychology and Behaviour* 43*:* 379–386.

Haq, M. T., Zlatkovic, M. & Ksaibati, K. 2020. Assessment of tire failure related crashes and injury severity on a mountainous freeway: Bayesian binary logit approach. *Accident Analysis and Prevention* 145(June): 105693.

Hashim, W., Arshad, A. K., Mustaffa, M. & Kamaluddin, N. A. 2016. Heavy vehicles speed profiling on urban expressway: The case of federal highway. *Jurnal Teknologi* 78(7–2):19–23.

Hatami, A., Vosoughi, S., Hosseini, A. F. & Ebrahimi, H. 2019. Effect of Co-Driver on Job Content and Depression of Truck Drivers. *Safety and Health at Work* 10(1): 75–79.

Hilton, M. F., Staddon, Z., Sheridan, J. & Whiteford, H. A. 2009. The impact of mental health symptoms on heavy goods vehicle drivers' performance. *Accident Analysis and Prevention*, *41*(3): 453–461.

Howard, M. E., Desai, A. V., Grunstein, R. R., Hukins, C., Armstrong, J. G., Joffe, D., Swann, P., Campbell, D. A. & Pierce, R. J. 2004. Sleepiness, sleep-disordered breathing, and accident risk factors in commercial vehicle drivers. *American Journal of Respiratory and Critical Care Medicine*, *170*(9): 1014–1021.

Islam, M. & Hernandez, S. 2013. Large truck-involved crashes: Exploratory injury severity analysis. *Journal of Transportation Engineering*, *139*(6):596–604.

Ismail, A., Intan Suhana, M. R., Masri, K. A. & Rapar, N. H. 2020. Exploration on Pavement Surface Conditions Attributed to Mineral Freight and Logistics Operations on Kuantan Road Network. *IOP* Conference Series: Materials Science and Engineering, 712(1).

Kamarudin, M. K. A., Abd Wahab, N., Umar, R., Mohd Saudi, A. S., Md Saad, M. H., Nik Rosdi, N. R., Abdul Razak, S. A., Merzuki, M. M., Abdullah, S. A., Amirah, S. & Mohd Ridzuan, A. 2018. Road Traffic Accident in Malaysia: Trends, Selected Underlying, Determinants and Status Intervention. *International Journal of Engineering & Technology. 7*(4.34): 112.

Kunz-Ebrecht, S. R., Kirschbaum, C. & Steptoe, A. 2004. Work stress, socioeconomic status and neuroendocrine activation over the working day. *Social Science & Medicine (1982)*. *58*(8): 1523–1530.

Land Public Transport Act. 2010. Land Public Transport Act 2010 (Act 715). In *Report* (Issue January).

Landay, K., Wood, D., Harms, P. D., Ferrell, B. & Nambisan, S. 2020. Relationships between personality facets and accident involvement among truck drivers. *Journal of Research in Personality*, *84*, 103889.

Larsen, L. 2004. Methods of multidisciplinary in-depth analyses of road traffic accidents. *Journal of Hazardous Materials* 111(1–3): 115–122.

Lemp, J. D., Kockelman, K. M. & Unnikrishnan, A. 2011. Analysis of large truck crash severity using heteroskedastic ordered probit models. *Accident Analysis and Prevention* 43(1): 370–380.

Mahdzir, A. H. B. M. 2013. *Effectiveness of Defensive Driving Among Commercial Truck Drivers: a Case Study At Misc Integrated Logistics Sdn* (Issue June). Universiti Teknologi Malaysia.

Mase, J. M., Majid, S., Mesgarpour, M., Torres, M. T., Figueredo, G. P. & Chapman, P. 2020. Evaluating the impact of Heavy Goods Vehicle driver monitoring and coaching to reduce risky behaviour. *Accident Analysis and Prevention* 146(September), 105754.

Mehdizadeh, M., Shariat-Mohaymany, A. & Nordfjaern, T. 2019. Driver behaviour and crash involvement among professional taxi and truck drivers: Light passenger cars versus heavy goods vehicles. *Transportation Research Part F: Traffic Psychology and Behaviour* 62*:* 86–98.

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

Ministry of Transport, M. (2014). Pelan Keselamatan Jalan Raya Malaysia 2014 - 2020. In *Malaysia Institute of Road Safety Research*.

Ministry of Transport, M. 2020. Statistical Report of Road Accident Malaysia. In *Road Safety Department of Malaysia* (Issue april).

Moomen, M., Rezapour, M. & Ksaibati, K. 2019. An investigation of influential factors of downgrade truck crashes: A logistic regression approach. *Journal of Traffic and Transportation Engineering (English Edition)* 6(2): 185–195.

Musa, M. 2017. *Awareness and prevalence of vehicle blind spot issues among lorry drivers* (Issue MRR No. 220).

Newnam, S. & Goode, N. 2015. Do not blame the driver: A systems analysis of the causes of road freight crashes. *Accident Analysis and Prevention.* 76*:*141–151.

Peng, Y., Wang, X., Peng, S., Huang, H., Tian, G. & Jia, H. 2018. Investigation on the injuries of drivers and copilots in rear-end crashes between trucks based on real world accident data in China. *Future Generation Computer Systems* 86*:* 1251–1258.

Pokorny, P., Drescher, J., Pitera, K. & Jonsson, T. 2017. Accidents between freight vehicles and bicycles, with a focus on urban areas. *Transportation Research Procedia. 25:* 999–1007.

Ramírez, B. A., Izquierdo, F. A., Fernández, C. G. & Méndez, A. G. 2009. The influence of heavy goods vehicle traffic on accidents on different types of Spanish interurban roads. *Accident Analysis and Prevention. 41*(1): 15–24.

Richter, T. & Sachs, J. 2017. Turning accidents between cars and trucks and cyclists driving straight ahead. *Transportation Research Procedia. 25:* 1946–1954.

Road Transport Act. 2013. *Road Transport Act (Act333)* (Issue February). http://www.agc.gov.my/agcportal/uploads/files/Publications/LOM/EN/Act 333 - Road Transport Act 1987.pdf

Romo, A., Hernandez, S. & Cheu, R. L. 2014. Identifying precrash factors for cars and trucks on interstate highways: Mixed logit model approach. *Journal of Transportation Engineering 140*(3): 04013016.

Rusli, R., Haque, M. M., Saifuzzaman, M. & King, M. 2018. Crash severity along rural mountainous highways in Malaysia: An application of a combined decision tree and logistic regression model. *Traffic Injury Prevention* 19(7):741–748.

Sanchez Rodrigues, V., Piecyk, M., Mason, R. & Boenders, T. 2015. The longer and heavier vehicle debate: A review of empirical evidence from Germany. *Transportation Research Part D: Transport and Environment* 40*:*114–131.

Sarabi, E. R. & Moosavi, M. S. 2010. Introducing the main factors of accidents on the roads of Iran and studying its causes and strategies applied to decrease it. *World Academy of Science, Engineering and Technology* 66(6): 466–470.

Shams, Z., Naderi, H. & Nassiri, H. 2020. Assessing the effect of inattention-related error and anger in driving on road accidents among Iranian heavy vehicle drivers. *IATSS Research*,.

Shao, X., Ma, X., Chen, F., Song, M., Pan, X. & You, K. 2020. A random parameters ordered probit analysis of injury severity in truck involved rear-end collisions. *International Journal of Environmental Research and Public Health* 17(2).

Sim, H. J., Manan, M. M. H. A., Ismail, M. F., Ghani, M. R. A., Ishak, S. Z. & Hoong, A. P. W. 2017. A study on commercial vehicle speeds and its operational characteristics. In *Malaysian Institute of Road Safety Research (MIROS)*.

Stevenson, M., Sharwood, L. N., Wong, K., Elkington, J., Meuleners, L., Ivers, R. Q., Grunstein, R. R., Williamson, A., Haworth, N. & Norton, R. 2010. The heavy vehicle study: A case-control study investigating risk factors for crash in long distance heavy vehicle drivers in Australia. *BMC Public Health*, *10*.

Stutts, J. C., Wilkins, J. W., Osberg, J. S., & Vaughn, B. V. 2003. Driver risk factors for sleep-related crashes. *Accident Analysis and Prevention*, 35(3), 321–331.

World Health Organization. 2017. A Road Safety Technical Package. In *Save LIVES*.

World Health Organization. 2018. Global Status Report on Road Safety 2018. In *International Reviews of Immunology* 66 (1).

Yuan, Q., Lu, M., Theofilatos, A. & Li, Y. B. 2017. Investigation on occupant injury severity in rear-end crashes involving trucks as the front vehicle in Beijing area, China. *Chinese Journal of Traumatology - English Edition*, 20(1): 20–26.

Zamzamzadeh, M., Saifizul, A. ., Ramli, R. & Soong, M. 2016. Dynamic simulation of brake pedal force effect on heavy vehicle braking distance under wet road conditions. *International Journal of Automotive and Mechanical Engineering (IJAME)* 13(3): 1–6.