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Fatigue Among Heavy Vehicle Drivers on Expressway

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ABSTRACT

Road crashes involving heavy vehicles on expressways accounted for 17% of the overall road crashes on expressways in 2018. Crash investigations conducted by MIROS in 2015 found that fatigue was among the factors of these crash occurrences involving heavy vehicles. People who drive commercial vehicles such as taxis, buses, or trucks normally do shift work which needed them not to follow the regular and normal sleep pattern. Their nature of work and sleeping patterns may lead to fatigue and sleepiness. Thus, this research was proposed with the aim of determining the prevalence factors of fatigue among heavy vehicle drivers on expressways. Data was collected using the face-to-face interview method with heavy vehicle drivers who travelled along the expressway. Around 400 heavy vehicle drivers from the north, south, and central regions of Malaysia participated in this study. This study found that most heavy vehicle drivers report that they usually begin to feel fatigued after 4 hours and 22 minutes of driving and they are more likely to feel tired in the early hours of the morning, specifically around 2:00 am to 6:00 am. This study concluded that the most frequent reported prevalence factors of fatigue among heavy vehicle drivers are insufficient rest breaks, long driving hours, and heavy expressway traffic. The significant factors reported mostly related to resting issues where it may be due to long-distance journeys or they are trying to squeeze in as many trips as possible for extra income.

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1. Introduction

The number of crashes involving heavy vehicles in 2018 accounted for 17% of the overall road crashes on expressways. In terms of vehicle type, this number is higher compared to the number of crashes involving heavy vehicles occurring on non-expressways such as federal, state, and municipal roads, which only accounts for 5% of the road crashes. 60% of the crashes involving heavy vehicles on the expressways are multiple vehicle crashes. The majority of the crashes are also rear-ended collisions (43.6%), followed by out-of-control (28.2%) and sideswipes (10.3%). From the vehicle aspect of crash occurrence factors involving heavy vehicles, brake defects (35.7%) and tyre defects (33.4%) were found to be the highest contributing factors.

Multiple-vehicle crashes involving heavy vehicles usually result in more severe injuries to other vehicle occupants (Jang et al., 2013). MIROS crash investigations was conducted in 2015 on multiple-vehicle crashes involving heavy vehicles, specifically lorries, revealed that the highest factor for crash occurrences is speeding (27.6%) followed by risky driving (16.1%) and fatigue (13.4%). Maclean et al. (2003) found that driver fatigue or falling asleep contributes to 15% of commercial vehicle fatalities. A study in Australia reports that 20% to 30% of heavy vehicle crashes were sleep-related factors (Howard et al., 2004). A study on factors affecting crash risks among truck drivers in Egypt found that fatigue in terms of driving hours and lack of sleep, drug use during driving, and driver obesity are the most influencing factors (Elshamly et al., 2017).

Several issues can be identified for the commercial vehicle drivers, especially on their work nature that constitutes many challenges such as long journey delivery, fixed delivery schedules, uncontrolled fare rates, commission, and other issues. These issues can affect the driving behaviours of the commercial driver including fatigue, stress, and the use of drugs to stay awake (Williamson et al.,

2001). Most of the countries in the world including Malaysia, shift workers such as commercial vehicle drivers tend not to follow the regular and normal sleep patterns. Their nature of work and sleep habits may cause them to get tired and sleepy. Lack of sleep, sleep demands induced by the internal body clock, and poor sleep quality are the most general cause of fatigue. This condition is known as Obstructive Sleep Apnea (OSA).

Many studies have highlighted OSA as one of the major contributing factors in vehicle crashes. Due to poor sleep quality, people with OSA are more likely to fall asleep while driving. OSA is a common disorder in which a person has one or more pauses in breathing or shallow breathing while sleeping, as well as repeated bouts of apnea or hypopnea caused by obstruction of the upper respiratory airway. The breathing process will come to a halt for 10 seconds or more due to obstruction of the upper airway caused by dilating muscles relaxing and failing to maintain the upper airway open. The oxygen level in the blood may drop as a result of the cessation of breathing, and the person may arouse from sleep several times, resulting in poor sleep quality. Excessive daytime sleepiness can occur when nocturnal sleep is disrupted. Furthermore, due to poor sleep quality, people with sleep apnea may feel weary and lose attention during the day. For someone who works as a driver throughout the day, such as a truck driver, this could be dangerous to them.

For more than a decade, there has been a connection between sleep apnea and motor vehicle crashes (MVC). The connection between MVC and OSA has been proven in numerous research. Seven out of 18 studies indicated a statistically significant positive relationship between the severity of OSA and the probability of a crash, according to a systematic review undertaken by Ellen et al. (2006). Furthermore, studies show a positive relationship and the strength of the association was found to be nearly double (Wahida et al., 2013). Those findings were supported by a similar systematic study conducted by Tregear et al. in 2009. They discovered that those with OSA have a higher crash risk, with the mean crash-rate ratio linked with OSA likely falling between 1.21 and 4.89 (Tregear et al. 2009). In addition, Findley et al. (1988) found that individuals with sleep apnea had a seven-fold higher probability of being involved in road crashes than normal patients. Moreover, approximately 24% of OSA patients reported falling asleep behind the wheel at least once each week (Findley et al., 1988). Recent study shows that individuals with OSA have up to a 15-fold higher crash risk compared to those who do not have the disorder (Garbarino et al., 2016).

Drivers with OSA are more likely to experience fatigue and sleepiness behind the wheel due to their nature of works, such as long-distance driving and driving in the early hours. MIROS research (Norlen et al., 2008) found that fatigue among bus drivers would increase as the duration of driving and working increased. A study done in Finland reported that almost half of the fatigue drivers estimated the reasons for momentarily falling asleep were work-related and the risk of momentarily falling asleep at the wheel was significantly increased with long working shifts and short periods of sleep (Perttula et al., 2011).

On that account, we know that fatigue and sleepiness will increase the risk of heavy vehicle drivers being involved in a multiple-vehicle crash due to deficiency in performance, including slower response times, poor decision making, and failure to focus. Hence, this study aims to determine the prevalence factors of fatigue among heavy vehicle drivers on expressways. This study also investigates the time and duration that the driver is most likely to feel fatigue. The findings from this study are very useful as they provide some insight into fatigue issues concerning heavy vehicles, especially on the expressway.

2. Method

The method used to collect the data is a face-to-face interview with the heavy vehicle drivers at the expressway rest service areas, lay-bys, fleet companies, and vehicle inspection centre. Prior to the interview, respondents were asked to sign a consent form ensuring that their identity will be withheld and treated as confidential data. Tokens were rewarded to the participants at the end of the session.

To achieve the objectives of this study, purposive sampling was applied. The criteria of the respondents were they must be (i) heavy vehicle drivers driving a vehicle with more than 2 axles, and (ii) travelling on a long journey along the north-south expressway. If a heavy vehicle driver does not fit the respondent criteria, the driver will not be included in the study. Around 400 heavy vehicle drivers were required for this study. The sample size is calculated based on the number of registered heavy vehicles, and the minimum number of samples is calculated based on simple random sampling formula.

The questionnaire survey tool used in this research consisted of (i) respondent demographics, (ii) the experience of being summonsed and involvement in a road crash while driving a heavy vehicle, (iii) the time the driver is most likely to feel fatigue, and (iv) factors of fatigue. The survey was adapted from a survey used by Williamson et al. (2001) in their survey on driver fatigue among professional long-distance heavy vehicle drivers in Australia. Besides that, crash data from 2017 until 2019 was also extracted from MHROADS to investigate the time of crash occurrence among heavy vehicle drivers. MHROADS is the Malaysian Highway Road Accident Database and Analysis System that is developed by Malaysian Highway Authorities. The crash data in MHROADS was filled by highway concessionaires. Data from the survey were then analysed using the Statistical Package for Social Sciences (SPSS). Descriptive and inferential analyses were used to interpret the results collectively. Non-parametric analyses like Mann-Whitney and Kruskal-Wallis were used to compare between group categories while Spearman's rank-order correlation was run to determine the relationship. The non-parametric method was chosen because all the tested variables are not normally distributed.

3. Results

3.1. Demographic

Table 1 shows the demographic distribution of the respondents. 400 heavy vehicle drivers participated in this study, 99.5% of the respondents were male drivers. As we know, most heavy vehicle drivers in Malaysia are male thus most of the respondents are male. 36.2% of the drivers were aged between 36 to 45 years old, while 30.7% were aged between 26 to 35 years old. A large majority of the respondents (81.0%) were made up of Malay ethnicity. Most of the respondents (87.8%) were married at the time of the data collection. 40.4% of the drivers reported that their monthly income falls between the range of RM2,001 to RM3,000. 31.9% of the drivers have a driving experience of five to ten years. 19.7% have driven for less than five years, while 19.4% have driven for more than 20 years.

Table 1: Demographic distribution of the respondents

		%
Gender	Male	99.5
	Female	0.5
Age	< 18 years	0.3
	18 - 25 years	4.7
	26 - 35 years	30.7
	36 - 45 years	36.2
	46 - 55 years	22.4
	> 56 years	5.7
Race	Malay	81.0
	Chinese	2.5
	Indian	16.0
	Other	0.5
Marital status	Single	10.2
	Married	87.8
	Widower/Widow	2.0
Income	< RM1,000	1.7

	RM1,001 - RM2,000	13.2
	RM2,001 - RM3,000	40.4
	RM3,001 - RM4,000	28.7
	RM4,001 - RM5,000	12.0
	> RM5,001	4.0
Driving experience	< 5 years	19.7
	5 - 10 years	31.9
	11 - 15 years	18.0
	16 - 20 years	11.0
	> 20 years	19.4

3.2. Time the driver feels fatigued

Respondents were also asked about the time and duration they start to feel fatigued during their work trip. The time which drivers are most likely to feel fatigued while working as reported by the respondents themselves are shown in Table 2. Generally, most heavy vehicle drivers reported that they are more likely to feel tired during midday and in the early hours of the morning. Specifically, 29.2% and 27.9% of the respondents reported that they feel tired when driving during midday around 12:00 pm until 1:00 pm and 1:00 pm until 2.00 pm, respectively. This may be due to the hot weather during the afternoon and maybe because the drivers just having their lunch which can lead to sleepiness.

Meanwhile, around 29% and 28% of the drivers informed that they start to feel fatigued in the early morning around 2:00 am to 3:00 am and 3:00 am to 4.00 am, respectively. This may be due to the human norm that usually during these times we are having a rest and sleep. This finding is similar to the Horne and Reyner (1995) study results where they calculated that drivers are 50 times more likely to fall asleep at the wheel at 2:00 am than at 10:00 am. A study done in Australia on their long-distance heavy vehicle drivers found that drivers experienced fatigue most in the early hours of the morning (Williamson et al., 2001). This study also indicates that night work between 12:00 am to 6:00 am was related to increased fatigue. A study conducted by Zhang et al. (2014) concluded that drivers were most likely to feel tired between 2:00 am and 4:00 am and between 2:00 pm and 4:00 pm. Based on a study conducted in Washington, drivers were affected by fatigue and drowsiness in the early morning and near the end of their shift (Barr et al., 2011). However, findings from this study also indicated that sleepiness was twice as likely to occur between 6:00 am and 9:00 am.

Table 2: The time which drivers are most likely to feel fatigued while working

Time	AM	PM
12:00 – 1:00	18.7%	29.2%
1:00 – 2:00	19.7%	27.9%
2:00 – 3:00	28.7%	12.2%
3:00 – 4:00	28.4%	12.5%
4:00 – 5:00	25.9%	6.0%
5:00 – 6:00	22.2%	6.0%
6:00 – 7:00	9.7%	2.2%
7:00 – 8:00	9.2%	2.5%
8:00 – 9:00	3.0%	1.7%
9:00 – 10:00	3.5%	2.7%
10:00 – 11:00	4.5%	8.5%
11:00 – 12:00	6.2%	8.7%

Furthermore, this study also asks the respondents to report the average time duration in which drivers are most likely to start feeling fatigued when driving. Table 3 shows the average time duration in which drivers are most likely to start feeling fatigued demographic group. Overall, most heavy vehicle drivers reported that they usually begin to feel fatigued after 4 hours and 22 minutes of driving. This result is in line with the Safety, Health and Environment Code of Practice (2007) that the maximum continuous driving hours is four hours and the drivers must rest at least 30 minutes after four hours of driving or else the driver is at risk to feel fatigued and could be dangerous to them. A study done by Jovanis et al. (2012) also found that drivers will experience fatigue and the crash risk will increase after driving for four hours without rest or break. Another study found that crash risk in the first four hours of driving is low but the risk would rise more than 50% in the following three hours, and increased up to 80% to 130% during the final hour of driving (Lin et al., 1994).

Meanwhile, the comparison between demographic groups exhibits that there is no statistically significant difference among the group categories (p-value > 0.05) except for the race group. A Spearman's rank-order correlation was run to determine the relationship between age, income, and driving experience and the time duration in which drivers are most likely to start feeling fatigued. Only age shows a significant negative relationship ($\rho = -0.103$, $p = 0.039$) with the time duration in which drivers are most likely to start feeling fatigued. We can say that as age increases, the time duration will decrease and it can be explained simply that older drivers more quickly start feeling fatigued compared to the younger drivers. Fatigue may increase even more because aging is always associated with physiological impairment and functional declines at the cognitive skills level (Eby & Molnar, 2012). Older people (> 70 years) and persons with poor physical condition are more prone to feel fatigued (European Road Safety Observatory, 2015).

Contrastingly, a survey done on fatigued driving by Goncalves et al. (2015) found that the probabilities of falling asleep at the wheel were significantly lower in drivers over the age of 70 years compared to those under 70 years. A study done by Barr et al. (2011) also concluded that higher levels of fatigue were associated with the younger drivers. These findings may relate to the young people's behaviour where they tend to have less sleep and irregular sleep pattern.

Table 3: Average time duration which drivers are most likely to start feeling fatigued by demographic group

		Average time	Correlation
Total		4 hours 22 mins	-
Gender	Male	4 hours 21 mins	-
	Female	6 hours	
Age	< 18 years	4 hours	-0.103 (0.039)*
	18 - 25 years	5 hours 7 mins	
	26 - 35 years	4 hours 46 mins	
	36 - 45 years	4 hours 13 mins	
	46 - 55 years	3 hours 59 mins	
	> 56 years	3 hours 59 mins	
Race*	Malay	4 hours 15 mins	-
	Chinese	3 hours 48 mins	
	Indian	5 hours 3 mins	
	Other	3 hours 30 mins	
Marital status	Single	4 hours 41 mins	-
	Married	4 hours 20 mins	
	Widower/Widow	4 hours 23 mins	

Income	< RM1,000	5 hours 34 mins	0.041 (0.408)
	RM1,001 - RM2,000	3 hours 41 mins	
	RM2,001 - RM3,000	4 hours 20 mins	
	RM3,001 - RM4,000	4 hours 34 mins	
	RM4,001 - RM5000	4 hours 44 mins	
	> RM5,001	3 hours 42 mins	
Driving experience	< 5 years	4 hours 8 mins	-0.039 (0.436)
	5 - 10 years	4 hours 40 mins	
	11 - 15 years	4 hours 21 mins	
	16 - 20 years	4 hours 33 mins	
	> 20 years	4 hours 6 mins	

To understand further the time-related variables, this study has analysed the time of crash occurrence for heavy vehicles from the crash data. Table 4 shows that in general there is not much difference between the percentages except for three hours that have a percentage of more than 5.0%. The crash data showed that 6.0% of the crashes occurred between 6:00 am to 7:00 am, followed by 5.5% of crash occurrences between 3:00 pm to 4:00 pm and between 5:00 am to 6:00 am (5.0%). This happens probably because after the onset of fatigue a few hours before, the drivers do not get their rest and their driving performance gets poor which leads to crashes.

Gothié (2006) concluded that crashes involving heavy good vehicles are more evenly distributed between 6:00 am and 6:00 pm and 65% of fatalities occur in the daytime and 35% at night. In 2001, a study on driver fatigue and road crashes suggested that sleep-related crashes were highest in the early hours of the morning between 2:00 am and 6:00 am, and in the middle of the afternoon, between 3:00 pm to 4:00 pm (ROSPA, 2001).

Table 4: Time of crash occurrence among heavy vehicle drivers

Time	AM	PM
12:00 - 1:00	4.5%	4.4%
1:00 - 2:00	3.9%	4.1%
2:00 - 3:00	4.2%	4.3%
3:00 - 4:00	3.9%	5.5%
4:00 - 5:00	4.8%	4.8%
5:00 - 6:00	5.0%	4.3%
6:00 - 7:00	6.0%	3.6%
7:00 - 8:00	4.8%	3.0%
8:00 - 9:00	3.9%	3.2%
9:00 - 10:00	3.9%	3.3%
10:00 - 11:00	4.0%	2.8%
11:00 - 12:00	4.4%	3.5%

3.3. Prevalence Factors of Fatigue

The prevalence factors of fatigue are shown in Table 5. The most self-reported factors of fatigue among heavy vehicle drivers along the expressway are insufficient rest breaks (73.1%), long driving hours (71.6%), heavy expressway traffic (70.1%), inadequate amount of sleep before trips (67.6%), and irregular or inadequate sleep during trips (55.6%). A report about fatigue by European Road Safety Observatory (2015) concludes that apart from the lack of sleep, poor sleep quality, sleep demands induced by the internal body clock and long-distance driving can increase driver fatigue especially when drivers have insufficient rest breaks. A study done by Perttula et al. (2011) found that the factors that significantly increased the risk of momentarily falling asleep at the wheel are long working shifts and short periods of sleep. The study also found that if the drivers were unable to choose the time of their breaks, the risk of fatigue was the highest. A survey of long-distance heavy vehicle drivers in Australia revealed that the most commonly reported contributors to fatigue were dawn driving, waiting to load and unload, long driving hours and poor road conditions (Williamson et al., 2001).

A study conducted by Wylie et al. (1996) in Washington suggested that the significant factor influencing driver fatigue is the time of driving where sleepiness was greatest during night driving. According to Zhang et al. (2014), fatigue levels had significantly affected by both circadian rhythms and long driving hours. Brown (1994) has identified five general causes of fatigue in general and driver fatigue. In particular, are lack of sleep, internal biological clock, the time spent driving, driving on a monotonous road and individual characteristics such as age, physical condition and use of alcohol including medical conditions. On the other hand, an assessment of driver drowsiness, distraction, and performance in a naturalistic setting in 2011 concluded that the relationship was fairly weak between fatigue and sleep quality or quantity (Barr et al., 2011). Besides the three most reported factors mentioned earlier, there are many other factors that can affect fatigue and these factors may also be interrelated.

Table 5: Factors of fatigue among heavy vehicle drivers along expressway

Rank	Factors of fatigue	Percentage
1	Insufficient rest break	73%
2	Long driving hours	72%
3	Heavy expressway traffic	70%
4	Inadequate amount of sleep before trips	68%
5	Irregular or inadequate sleep during trips	56%
6	Heavy city traffic	49%
7	Not enough night time sleep	45%
8	Uninteresting/monotonous driving route	40%
9	Having to rest away from home	39%
10	Poor road conditions	37%
11	Poor weather conditions (e.g., fog, rain)	35%
12	Driving at dawn	33%
13	Driving during early afternoon	32%
14	Poor truck ventilation	25%
15	Poor diet/irregular eating	24%
16	Too much non-driving work	16%
17	Driving at night	15%
18	Family problems	13%
19	Driving at dusk	8%
20	After-effects of using stay-awake drugs	8%

4. Discussion

The study aims to determine the prevalence factors of fatigue among heavy vehicle drivers on expressways. Fatigue is a gradual decline of mental and physical awareness that can lead to drowsiness or sleepiness. Fatigue reduces the driver's ability to concentrate, affects judgement and reflexes therefore consequently decreases the ability to drive. Based on the results discussed earlier, insufficient rest breaks, long driving hours, heavy expressway traffic, inadequate amount of sleep before trips, and irregular or inadequate sleep during trips are the most self-reported factors of fatigue among heavy vehicle drivers along the expressway. This result is similar to other studies such as insufficient rest breaks (European Road Safety Observatory, 2015) and long driving hours (European Road Safety Observatory, 2015; Perttula et al., 2011; Williamson et al., 2001; Zhang et al., 2014) can increase driver fatigue. As suggested in the code of practice of Safety, Health and Environment (2007), the driver should have at least 30 minutes of rest break after four hours

of continuous driving to reduce the risk to feel fatigued while driving.

Besides that, fatigue has always been related to lack of sleep and time of sleep. Respondents of this study also reported that inadequate amount of sleep before trips, and irregular or inadequate sleep during trips are among the factor of fatigue for heavy vehicle drivers along the expressway. Pertulla et al. (2011) and Brown (1994) also found that lack of sleep significantly increased the risk of feeling fatigue while driving. A comprehensive review of fatigue-related impairment and the capacity to drive safely suggests that if the amount of sleep is less than five hours, the driver might reasonably be deemed impaired to drive (Dawson et al., 2021).

In addition, this study also investigates the time and duration that driver is most likely to feel fatigued. Driving time is being highlighted in this study because driving time affects the focus of the driver thus this variable is important to be investigated and can be used to recommend to the stakeholders. In general, most heavy vehicle drivers stated that they are more likely to feel tired during midday around 12:00 pm to 2:00 pm, and in the early hours of the morning specifically around 2:00 am to 4:00 am. Similar findings were found by Horne and Reyner (1995), Williamson et al. (2001) and Zhang et al. (2014) that they start to feel fatigued in the early morning due to biologically the body is trained to sleep during that time. Thus, if the driver has to stay awake to focus on driving, he would have to fight his body's desire to sleep and put in extra effort to stay awake. Furthermore, respondents also reported that they always feel fatigued during midday. Zhang et al. (2014) figured out that drivers were most likely to feel tired during noon. However, some of the findings from other studies that are not similar to this study like the study by Barr et al., (2011) indicated that sleepiness was twice as likely to occur between 6:00 am and 9:00 am. This difference may be due to climate conditions or the environment the study was conducted.

On the other hand, this study also investigates the average time duration in which drivers are most likely to start feeling fatigued when driving. Generally, most respondents stated that they start to feel fatigued after 4 hours and 22 minutes of driving. Few studies have obtained similar findings such as Jovanis et al. (2012) and Lin et al. (1994). One of the prevalence factors of fatigued is long driving hours hence these findings are in line with what has been reported previously and also it is similar to what is stated in the Safety, Health and Environment Code of Practice (2007).

5. Conclusion and Recommendations

Fatigue and sleepiness are dangerous for drivers because it is always associated with driving performance. Poor driving performance may lead to risky driving that can lead to crashes, hence research needs to be done to understand the issues. This study is aimed to determine the prevalence factors of fatigue among heavy vehicle drivers on expressways. Based on the results of this study, it can be concluded that the most frequently reported prevalence factors of fatigue among heavy vehicle drivers are insufficient rest breaks, long driving hours, and heavy expressway traffic. Besides that, this study also investigates the time and duration that the driver is most likely to feel fatigued. This study concludes that most heavy vehicle drivers are more likely to feel tired during midday and in the early hours of the morning. In addition, most heavy vehicle drivers stated that they usually begin to feel fatigued after 4 hours and 22 minutes of driving.

It is recommended that all these findings are considered in planning any intervention on heavy vehicle issues especially when it is related to fatigue and sleepiness. It is proven that rest is important for heavy vehicle drivers, particularly for long-distance drivers. Hence, to ensure they can get to rest on time, we must make sure that the rest area is available and enough for them to rest. In addition, logistic companies also should plan their schedule properly to keep their drivers from getting tired where they should follow a maximum of 4 hours of driving with at least 30 minutes breaks. On top of that, heavy vehicle drivers should avoid driving during midday and the early hours of the morning.

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