

Drowsiness on Industrial Logistics Driver In the Morning and Afternoon Trip

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Abstract

Truck accidents are often as a single accident. Drowsiness is one of the causes of a single accident. Drowsiness usually caused by working in long time, monotonous work, poor health conditions, or lack of sleep. This study aims to assess the drowsiness level of industrial truck driver and analyze drowsiness patterns seen from the relationship between decreasing of driver alertness to road density and time intervals from the start of the trip to the time of measurement. Drowsiness level assessed using Karolinska Sleepness Scale (KSS) questionnaire. The level of driver drowsiness during the trip rises along the travel time. In the morning trip, decreasing of driver alertness have occurred after 120 minutes of travelling and in the afternoon trip the alertness decreasing occurred after 60 minutes travelling. The driver's drowsiness level at two trips shows significant differences using paired sample t-tests. In the morning trip the mean drowsiness level was 2.91 while in the afternoon trip, the mean drowsiness level was 3.56, p value on two tail was 0.0002. There is a low correlation between drowsiness and traffic density that assessed by truck speed, with $R = 0.18$. Traffic density hasn't affected on driver drowsiness for day trip.

Keywords : Drowsiness, alertness, preparedness, trip duration, velocities.

1. Introduction

Freight transportation takes place 24 hours a day. Industrial freight is mostly still using trucks for transportation, but on the other hand traffic accidents involving trucks are quite high. Road truck accidents are often in form of a single accident. A common form of incident is that the truck gets out of its lane and into the green lanes on the side of the road. Drowsiness is often be the caused of a single accident. Logistics trucks usually travel from medium to long distances. But for safety reasons the maximal truck speed is usually limited, so it results on longer truck travel times. If the traffic density is high then the truck travel time will increase more longer. Length of travel time and frequency of task associated with critical incidents in drivers (Di Milia et al., 2011; Hanowski, 2005).

Drowsiness usually is caused by working around the day, monotonous work, poor health conditions, sleep deprivation, and sleep disturbances. In addition, drowsiness is also caused by lack of exercise, symptoms of a disease, and lifestyle. Sleepiness at work can be experienced by drivers. Sleepy and fatigue were significantly associated with fatal accidents on commercial vehicles including truck industry in reseach by Bunn (2005).

Drowsiness is a indication of fatigue. Stressful environments such as traffic jams put the drivers on risk getting fatigue. The National Transport Commission (2007) defines fatigue as a condition in which drivers feel drowsy, physically or mentally exhausted, or underpowered in driving. Fatigue can occur due to the intensity and duration of both physical and mental work. Drivers who experience fatigue while driving increase the risk of traffic

accidents (Williamson et al., 2011). Fatigue can have an impact on decreased alertness which ultimately increases the risk of accidents.

Driving requires the drivers always in alert condition, sometimes the driver must take action to avoid an accident. The duration of driving can have an effect on decline of driver awareness (Yassierli et al., 2015). Based on the measurement of truck driver fatigue during the day trip there wasn't significant increase of fatigue, but there was a significantly higher increase of fatigue at night trip, based on the value of CFF and KSS ($\alpha < 0.05$). Komada et al. (2013) mentions that crowded road conditions have an effect on the high risk of accidents. In addition, Kodaka et al. (2003) states that 90% of incidents and accidents occur on straight roads. Therefore, the factor of location, driving duration, and driving time can affect almost incident and accident.

Some studies are looking for solutions to eliminate drowsiness at work. Some ways can be solution to prevent drowsiness, include changing the position from sitting to standing, drinking water or coffee, listening of loud music, speaking with passengers or opening windows or make sosial interaction. Drowsiness levels can also be reduced by lighting the operator, both characteristic of light include natural or artificial light can effect reducing drowsiness level (Gibbs, 2005). Dunn (2012) observed the machinist's work, by providing a variety of tasks in the form of computative work to the machinist significantly had lower the mental demand.

Evaluation of drowsiness levels is carried out objectively and subjectively. One of the measurements subjectively was using the Karolinska Sleepiness Scale (KSS) questionnaire. This KSS has validated using an electroencephalograph (EEG). The validation showed that the incidence of sleep during driving simulations always began with an increased KSS value (Kaida et al. , 2007). The KSS has scale range from one to nine. Scale 1 showed a very alert and awake condition while scale 9 showed a condition where the subject feel very sleepy and could not be detained anymore.

Data collection is done in real time in the activities of logistics truck drivers. The research focus on logistic trip which need 3 to 5 hours on a trip or 6 to 10 hours on the round trip. The trip was experience of drivers along the journey of industrial trucks in natural condition. All natural independent variables along truck travel affect the driver, and cannot be issued. It was an actual condition that driver facing along the trip so the driver's subjective answer has a high level of external validity. Several other studies have also been conducted in the real world.

1.1 Objectives

This study observed medium-distance logistics truck travel with travel distances about 100-150 km, this distance have taken about 2,5 until 5 hours per-trip. The study aims to assess the level of drowsiness of logistics drivers during travel and analyze drowsiness patterns by looking at the relationship between decreased of driver preparedness and time intervals from the start of the journey to the time of measurement and road density.

2. Literature Review

The National Transport Commission (2007) defines fatigue as a condition when the driver feels sleepy, physically or mentally tired, or lacks of energy in driving. Fatigue can occur due to the intensity and duration of physical as well as mental work. Drivers who experience fatigue while driving increase the risk of involving in traffic accidents, because fatigue can have an impact on reducing alertness (Yassierli et al., 2015). Drivers who are drowsy can be identified by a decrease in interesting on the environment. Objectively drowsiness can also be identified from the increased duration of blinking or the duration of the eyes closing. Under normal conditions (not drowsy) the position of the eyelids opens wide before closing. And when closing has a fast time interval (less than a second). According to studies conducted by Caffier, PP et al (2005) generally the average blink duration is less than 400 MS, in sleepy people the duration of blinking is more than 400 Ms.

Sleep deprivation is associated with impaired alertness and psychomotor performance. Sleep deprivation is recognised to significantly increase the risk of road traffic accidents. Sleep deprivation identified have impact on lateral vehicle control, braking reaction time and lane change reaction time (Lowrie, 2020). Strong correlation was observed between driving impairment and sleepy. The research by Lowrie (2020) indicates that sleepiness degrades driving performance, reaction times and the ability to maintain and manoeuvre the vehicle.

A simple way to know someone have sleep deprivation is by asking them whether they are sleepy, or alert and we also know the sleep deprivation condition by identify some specific symptoms of sleepiness that they experience. Some specific symptoms related to sleepiness and driving performance such sleepier, such as "wandering thoughts", difficulties keeping eyes open and difficulty concentrating (Howard et al, 2014). Next are some methods to identify sleep deprivation.

1. Psychomotor Vigilance Task (PVT)

The PVT is a 10 min simple reaction time task which is sensitive to circadian rhythm changes and sleep deprivation (Howard et al., 2007). The primary outcome variable investigated was the number of lapses (reaction times > 500 ms).

2. Driving simulation

The Driving simulation is a computer based simulate which simulate driving task and give some stimulus to divide attention along driving activity. In this task a full screen image of the participants' view of a dual lane highway is projected on a screen, with the speedometer in the top left corner of the screen. The simulation is controlled using a steering wheel, brake, and accelerator. A 30-min monotonous night drive was performed on curved and straight road. Participants were asked to maintain their position in one lane on the road and to keep their speed within specific velocity. The primary performance measure was variation in lateral lane position (lateral deviation from the participants' median lane position in centimetres averaged every 40 Ms) and variation in speed (deviation outside the prescribed speed zone) was also measured. The mean variation of each measure was calculated for each subject in Research. These measures are sensitive to sleep deprivation.

3. Electroencephalography (EEG)

Alpha and theta brain activity was evaluated on the wake EEG during the driving task, as an indicator of driver preparedness.

4. Slow eyelid closure

Using analysis of time locked digital video of the face, the proportion of time that the eyelids were more than 80% closed (slow eyelid closure) was measured during the driving task.

5. Sleepiness questionnaires

Some questionnaires can be used to assessed subject sleepiness. the Karolinska sleepiness scale (KSS) was used to measure sleepiness. Participants completed questionnaires to assess subjective sleepiness.

Increased driving time is known to be a factor in the degradation of a driver's alertness level. [Van der Hulst et al \(2001\)](#) in [Howard et al \(2014\)](#) showed that the length of the simulated driving task had a significant effect on sleepiness ratings (Stanford sleepiness scale). An increase in accident rate in line with increased driving time on real roads. Occurrence of sleepiness is also promoted by nocturnal driving. In fact, physiological decline in alertness occurs at two times of the day: in the afternoon post-lunch dip (between 1 and 4 p.m.) and during the night (between 4 and 6 a.m.), driving in this time coinciding with the occurrence of numerous sleep-related accidents. Professional drivers were less alert and sleepier in the evening session as shown by the alertness and sleepiness Visual Analog Scales scores, the Karolinska sleepiness scale (KSS) and EEG data. Mental load score was higher in the evening condition. Time of day interacted with time on task to affect the driver's alertness. KSS score and spectral power in α band from EEG strongly increased during the driving task when it took place in the evening. [Otmani S, \(2005\)](#) found it more difficult to drive in a low traffic condition than in a heavy traffic condition, because subjects were more likely to feel sleepy. In this research the low traffic condition took place in the late evening.

3. Methods

The study was conducted by collecting data of driver drowsiness based on driver statements and assessing the influence of two variables, they were traffic density and time intervals from the start of the trip to the time of measurement to the driver alertness.

3.1 Respondent

Respondents in this study were industrial truck drivers. All respondents have more than five years of experience as truck drivers. Respondent is in good health and gets enough night's sleep with duration more than six hours. Data of 10 truck trips was collected for several destinations around the business city of Jakarta and its buffer zone. A truck trip is a medium-distance journey between 100 and 150 km. However, due to the company's restrictions on truck speed for traffic safety and traffic density along the way, the length of one trip varies from 3 to 5 hours.

3.2 Variables

The level of alertness of the driver during the trip is a dependent variable that is analyzed in along the travel time. Some of the independent variables that are seen to affect the level of driver alertness are the time, traffic density, and travel interval from the departure time to measuring from. The Karolinska Sleepiness Scale (KSS)

Questionnaire is used to measure drivers' sleepiness levels during travel. Drivers were asked to rate the level of sleepiness that they felt every hour during the journey. There is a nine point scale level of drowsiness starting from 1 = extremely alert, 2= very alert, 3 = alert, 4 = fairly alert, 5 = neither alert nor sleepy, 6 = some sign of sleepiness, 7 = sleepy – but no difficulty remaining awake, 8 = sleepy, some effort to keep alert, and 9 = extremely sleepy – fighting sleep. The questionnaire is given to the driver at the beginning of departure from PT X and they filled it in during the travel.

The *Global Positioning System (GPS)* that mounted on the truck is used to measure truck speed during the travel. The speed of the truck is averaged per-thirty minutes of travel, the speed of the vehicle describes the density of traffic on the path of the travel. The observed trucking was predominantly over the toll road. The toll road has characteristics of straight and monotonous travel, so it has a huge effect on the increase in driver sleepiness. Average speed of truck is recorded using *the Global Positioning System (GPS)* that mounted on the truck.

3.3 Research Time

Respondents' alertness level were reported every 30 minutes along the travel time until the truck reaches its destination and respondent have reported again along the travel time on the return trip. The research focused on medium-distance truck trip. The truck depart in the morning and the return trip in the afternoon. One trip takes between 3 and 5 hours, and vice versa for the return trip. The trip that began before 12:00 a.m. is referred as morning trip and the trip that began after 14:00 a.m. is referred to as afternoon trip.

4. Data Collection

Respondents were 30 to 45 years old, with more than five years of experience as a truck driver. All respondents got enough night's sleep, with times varying between 7 and 8 hours. There are two areas of the truck destination that meets the specified distance criteria. The travel destinations are in the industrial areas of Cilegon and the industrial areas of Cikarang, where the origin of the trip from PT X which is in Kabupaten Bogor. There is uniformity of traffic conditions passed by trucks because they pass through the Jakarta area and its buffer zone. The travel time of each truck can be different because it depends on the location of the destination and traffic conditions.

4.1 Driver Drowsiness

Drowsiness level assessed using KSS questionnaire, the questionnaire using a 9 point scale. The driver drowsiness that has been collected along the trips of logistic truck is presented in next Table 1 and Table 2.

Table 1 Level of driver drowsiness along the trip in the morning trip

Respondent	Age (years)	Destination	Night slept (hours)	Drowsiness level after travel duration							
				30'	60'	90'	120'	150'	180'	210'	240'
R1	42	Clg	8	1	1	1	1	2	2	3	3
R2	42	Ckr	8	1	2	2	2	3	3		
R3	42	Bks	7	1	2	2	3	4			
R4	42	Clg	7	3	4	4	4	4	4	4	4
R5	36	Clg	8	1	1	1	1	3	3	4	4
R6	36	Ckr	8	3	3	3	3	3	3		
R7	36	Bks	7	1	3	3	4	4			
R8	36	Clg	7	4	4	4	4	4	4	4	4
R9	36	Tjp	7	1	1	1	1	2			
R10	42	Tjp	7	1	1	1	1	3			
Average of Drowsiness				1,70	2,20	2,20	2,40	3,20	3,17	3,75	3,75

Table 2 Level of driver drowsiness along the trip in the afternoon trip

Duration	Age (years)	Origin	Night sleep (hours)	Drowsiness level after travel duration								
				30'	60'	90'	120'	150'	180'	210'	240'	300'
R1	42	Clg	8	2	4	4	4	4	4	4	4	4
R2	42	Ckr	8	2	2	2	3	3				
R3	42	Bks	7	3	3	4	4	4				
R4	42	Clg	7	4	4	4	4	4	4	4	4	
R5	36	Clg	8	4	4	4	3	3	3	3	4	
R6	36	Ckr	8	3	3	3	3	3				
R7	36	Bks	7	3	3	4	4	4				
R8	36	Clg	7	3	3	3	3	4	4	4	4	
Average of Drowsiness				3	3,25	3,50	3,50	3,63	3,75	3,75	3,75	4

Data processing on the departing and returning trips is separated because there is a long interval of break time to loading logistics and industrial goods into the truck at the destination. This activity takes two until four hours. This interval time is also be used by drivers for rest and have lunch. The trip from origin at PT X to destination and got the break time is then referred as the morning trip, meanwhile the trip back to PT X after the break time is then referred as the afternoon trip. Driver preparedness during travel time is influenced by several factors. Two independent variables will be analyzed their effect on driver preparedness, namely the duration of departure to observation time and traffic density.

4.2 Truck speed

Truck speed is obtained from Geographic Positioning System (GPS), the data that have reported by GPS is the speed of the truck per minute. Every 30 minutes the data is averaged to represent the speed of the truck per-half hour and is used to represent traffic density. According to the company law the trucks have ran at a maximum speed of 60 km/hour, in the research the truck speed that have reported by GPS was between 0 to 56 km/hour. Next Table 3 describe velocity and level of driver drowsiness in the research. (Table 3)

Table 3 Velocity and driver drowsiness

Respondent	Velocity (km/hr)	Drowsy	Respondent	velocity (km/hr)	Drowsy	Respondent	velocity (km/hr)	Drowsy
R1	21	1	R4	20	3	R7	21	1
	4	1		49	4		17	3
	41	1		52	4		17	3
	50	1		39	4		24	4
	52	2		57	4		17	4
	55	2	59	4	R8	20	4	
	55	3	36	4		49	4	
	55	3	20	4		52	4	
	15	4	R5	21	1		39	4
	10	4		4	1		57	4
R2	21	1		41	1		59	4
	32	2	50	1		36	4	
	31	2	52	3	R9	20	4	
	42	2	55	3		13		
	33	3	55	4		21		
18	3	55	4		48			
R3	21	1		15	4		37	
	17	2		10	4		5	
	17	2	R6	21	3	R10	13	
	24	3		32	3		21	
17	4	31		3	48			
		42		3	37			
			33	3		5		
			18	3				

5. Results and Discussion

5.1 The effect of travel time on driver drowsiness level

Drowsiness and travel time were in line, drowsiness will increase as the travel time increases. In this study, drivers only experienced an increase in sleepiness from level 1 or extremely alert to level 4 or fairly alert in the morning trips, while in the afternoon trips there was the same increasing in drowsiness levels up to level 4 (fairly alert), but in the afternoon trips the drowsiness level was dominated by level 4. The company's policy on safety makes drivers work in good readiness or drive in alert levels. In each trip there are always two drivers in the truck who work alternately, this policy applies to every destination of the truck trip. Drivers also get enough night's sleep that makes them have good preparedness when working in the morning. Figure 1 illustrates the increased drowsiness in the morning and the evening trips.

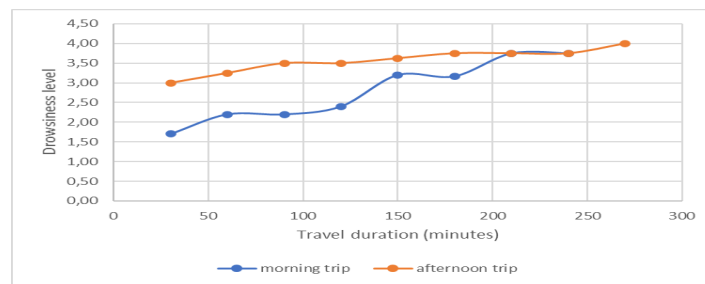


Figure 1. Trend of drowsiness level in the morning and afternoon trip

Based on the average drowsiness value in the morning trip, the decreasing of driver preparedness or steep increase of drowsiness have occurred after 120 minutes of travelling. And in the afternoon trip the alertness decreasing or increase of drowsiness occurred after 60 minutes travelling. This condition occurs because in the afternoon trip the operator has experienced by fatigue before back trip because he has been doing driving activities from origin to destination. Fatigue condition makes drivers experience a decrease in alertness faster and continue linearly along with travel duration.

Based on the pattern of increasing the level of drowsiness that obtained from this research, that truck trip need rest after two hours of driving to restore work readiness and reduce fatigue after driving. Activities that can eliminate drowsiness are changing driver positions from sitting to standing or walking, get eating or drinking, stretching, or doing light physical movements (Dunn (2005)).

5.2 The effect of traffic density on driver drowsiness level

Traffic density is inversely proportional to vehicle speed, the lower the speed of the truck means the more traffic disruption and vice versa the higher the speed of the truck the smoother the traffic conditions. The hypothesis of this study is there is a correlation between vehicle speed and the level of drowsiness. The high speed describes the smooth traffic conditions on the toll road with very few disturbances along the way. This condition creates monotonous drive conditions for drivers so that it can increase the level of driver drowsiness. To test the hypothesis data processing is carried out only for morning trips to reduce the influence of fatigue factors on drowsiness levels. However, correlation test between drowsiness and truck speed indicates low correlation with $R = 0.18$. Traffic density wasn't effect on driver drowsiness. This output is not in line with the research of Otmani S, et al. (2005) that it is more difficult to drive in a low traffic condition than in a heavy traffic condition. This difference is caused difference of travel time, this study was carried out for day trips while the Otmani S, et al. (2005) study was carried out on night trips

5.3 Difference in drowsiness rates of morning trip and afternoon trip

Environmental conditions during the morning trip and afternoon trip are different, the environmental temperature in the afternoon is generally hotter than that it in the morning. In the morning the drivers just starts his job while in the afternoon they have worked five hours before start the trip, so it can increase drivers fatigue.

The driver's preparedness during the trip was tested between the morning trip and the afternoon trip. Paired sample t-tests were performed to see the difference in operator readiness in the two trips. Next is the t-test of between the two trips. The driver's drowsiness level at two trips shows significant differences using paired sample t-tests. In the morning trip have got the mean drowsiness level at 2.91 while in the afternoon trip, the mean drowsiness level was 3.56. P value on two tail is 0.0002. (Table 4)

Table 4. Difference of driver drowsiness between morning trip and afternoon trip

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Drowsiness1</i>	<i>Drowsiness2</i>
Mean	2,913793103	3,559322
Variance	1,308227465	0,354179
Observations	58	59
Hypothesized Mean Difference	0	
Df	85	
t Stat	-3,81985315	
P(T<=t) one-tail	0,000126616	
t Critical one-tail	1,6629785	
P(T<=t) two-tail	0,000253232	
t Critical two-tail	1,988267907	

6. Conclusion

The medium-range industrial truck trip (100 –150 km) is taken in around 2.5 until 5 hours. The level of driver drowsiness during driving rises along the travel time. In the morning trip, decreasing of driver alertness have occurred after 120 minutes of travelling and in the afternoon trip the alertness decreasing occurred after 60 minutes travelling. The traffic density assessed by the speed of the truck, has no effect on the level of driver drowsiness. Drivers who travel in the morning have difference in drowsiness level significantly than drivers who travel in the afternoon, t test got $p=0,0002$.

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Biography

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