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Driving Conditions and Occupational Accident Management in Large Truck Collisions

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Objective: Objective of this study is to provide characteristics of injury frequency and severity by driving condition in large truck-related traffic collisions.

Background: Traffic accidents involving large trucks draw a lot of attention in accident prevention and management policies since they bring about severe human and financial damages.

Method: In order to identify the major risk factors of accidents by driving condition, 255 recognized traffic accidents by large truck drivers were analyzed in terms of time of the day, road type, and shape of the road.

Results: The driving conditions in the results are represented by the following form of combination, "Road Type (Non-expressway or Express) – Shape of Roads (Straight, Curved, Downhill, or Intersection) – Time of Accidents (Day or Night)". In the analysis of injury frequency, Non-expressway-Straight-Day condition was the most frequent one. Meanwhile, Expressway-Curved-Day, Non-expressway-Curved-Night and Non-expressway-Intersection-Night were evaluated as high level in view of injury severity. Also, Expressway-Straight-Night is the driving condition that is the highest in risk among the conditions that have to be managed as grade "High". Non-expressway-Straight-Night, Non-expressway-Downhill-Day, and Non-expressway-Curved-Day are also categorized as grade "High".

Conclusion and Application: Safety managers in the fields require basic information on accident prevention that can be easily understood. The research findings will serve as a practical guideline for establishing preventive measures for traffic accidents.

Keywords: Large truck driver, Road traffic collision, Driving condition, Occupational injury, Accident analysis

1. Introduction

The trucking industry continues to have some of the highest work-related injury and illness rates, and large truck drivers are exposed to road traffic crashes (BLS, 2015; Chen et al., 2014; Smith, 2015; Smith and Williams, 2014; Starnes, 2006). In this sense, a safety issue for truck driving is one of the studies that need to be done. A first step to establish the preventive control from the traffic accidents is to gather and analyze data. Recently, accident analysis by occupational classification has been performed, which is more detailed one than accident analysis by industrial classification. Some studies have been done for the truck driving job (Friswell and Williamson, 2010; Lin and Cohen, 1997; Smith and Williams, 2014; Spielholz et al.,

2008). However, particularly in Korea, there is a lack in the literature about a systematic analysis for the accidents occurred to truck drivers (Lee and Jeong, 2016). Since work environments are different country by country, an accident analysis of truck drivers in Korea could provide another insight. The major reason why there is few literature in truck drivers' traffic accidents is that contacting truck drivers is not easy because most of them are employed as subcontractors and they keep driving around.

Freight trucks are defined as vehicles that have enough loading capacity and in that total weight of freight, when fully loaded, is heavier than total weight of passengers. They are classified into small, medium, and large sized vehicles by its loading capacity. Large sized truck is a freight vehicle of larger than 5 tons of maximum loading capacity or larger than 10 tons of total weight. This study focuses on the traffic accidents of large-sized trucks.

Traffic accidents involving large trucks draw a lot of attention in accident prevention and management policies since they bring about severe human and financial damages. In particular, the relative likelihood of an accident or its relative degree of damage under diverse conditions serves as important information for accident prevention, and is critical for determining the priorities in preventive measures. Just as researchers and policymakers need an accident model based on statistical approach to be able to accurately describe accidents, safety managers in the fields require basic information on accident prevention that can be easily understood. Causes of truck-related accidents can be categorized into human factors related to the driver, factors related to the truck's failure such as failed brake or flat tire, and environmental factors. Environmental factors known to have impact on accidents include time of the day, road type, shape of the road, type of the truck, and its loading capacity (Lee and Jeong, 2016).

In this study, from many aspects of traffic accidents of truck driving, we focus on different characteristics of the accidents by driving conditions. It is natural to believe that truck drivers' physiological reactions are different according to the time when they drive. And also, the driving conditions on shape and type of the road must be different. This study analyzes large truck crashes using an injury analysis to find out the conditions when there is a greater likelihood of injuries or heavier damage. Based on this information, priorities in accident prevention measures are determined to serve as an efficient guideline to prevent large truck driver-related crashes.

2. Methods

This study analyzes 255 traffic accidents data of large sized truck drivers that occurred between 2009 and 2011. Traffic accident data included details of the drivers injured and granted four days or more of sick leave, and all of them were found to be male drivers.

In this study, work-related accidents by large truck drivers were analyzed in terms of time of the day, road type, and shape of the road. Time of the day is either daytime or nighttime, with nighttime defined as hours between 20:00 and 5:00. Road type is either an expressway, which is a road for the exclusive use of cars without traffic lights, or a non-expressway which includes all type of roads with intersections and traffic lights for pedestrians. Shape of road is categorized into intersection, straight, downhill or curved.

The level of risk management is determined using accident frequency, which is based on the number of injured persons, and injury severity which is based on the ratio of those who end up with fatalities or disabilities.

We analyze truck drivers' traffic accidents and compare if there is any difference between daytime and nighttime accidents. Also, we identifies the level of risk management for different driving conditions, and finally the overall grade of risk management that takes into account driving conditions.

3. Results

3.1 Characteristics of crashes by accident time

Table 1 classifies 255 traffic accidents of freight trucks according to the accident time and severity of the accident. Overall, the proportion of the accidents that lead to death was 11.0% and there is little difference between day (5.9%) and night (5.1%). However mortality rate of nighttime is much higher than daytime because total daytime accidents are 69.0% while that of nighttime are only 31.0%. That is, there were more accidents in the daytime, but the death rate at nighttime was higher.

Table 1. Distributions of injured persons by accident time (unit: person)

Severity	Daytime		Nighttime		Total	
	N	%	N	%	N	%
Death	15	5.9%	13	5.1%	28	11.0%
Injury	161	63.1%	66	25.9%	227	89.0%
Total	176	69.0%	79	31.0%	255	100%

Table 2 shows the comparison between day and nighttime against injured person's work experience. In the daytime, 44.9% of the injured drivers were novices who have work experience less than six months and 11.4% of the injured were experienced over five years. While at nighttime, novices were 54.4% of them while no record was obtained from the experienced drivers with over five years. That is, the rate of accidents for novices is higher at night and as drivers get experienced, the accident rate at night decreases. This implies that accidents occur frequently to novices who do not get used to this type of life-style, which is driving around and taking care of room and board by themselves without going back home more than six days, and night driving, which makes the driver short-sighted.

Table 2. Distributions of injured persons by work experience (unit: person)

Work experience	Daytime		Nighttime		Total	
	N	%	N	%	N	%
-6 months	79	44.9%	43	54.4%	122	47.8%
6 months-1 yr	31	17.6%	12	15.2%	43	16.9%
1~2 yrs	26	14.8%	14	17.7%	40	15.7%
2~3 yrs	13	7.4%	3	3.8%	16	6.3%
3~5 yrs	7	4.0%	7	8.9%	14	5.5%
Over 5 yrs	20	11.4%			20	7.8%
Total	176	100%	79	100%	255	100%

Table 3 displays distributions of injured persons by location (shape of road) according to the time of accidents. Regardless of the accident time, accidents were occurred on these types of roads in the order; straight road (62.7%), intersection (14.5%), curved

road (9.8%) and downhill (8.6%). While around half of the accidents (54.5%), during daytime, were occurred on a straight road, the ratios of accidents on intersection, curved road, and downhill were 18.2%, 11.9%, and 11.4%, respectively. At night, most accidents (81.0%) were occurred on straight road, which is very different from the daytime-distribution. Two possible reasons can be found. One is inattention. Driving a straight road can be monotonous. Particularly at night, this condition easily makes the driver inattentive and drowsy. The other reason is weakened vision at night. Thus drivers lose the sense of distance and in some situations, this could cause a rear-ending of another vehicle.

Table 3. Distributions of injured persons by location of traffic collision (unit: person)

Accident location (Shape of Road)	Daytime		Nighttime		Total	
	N	%	N	%	N	%
Straight	96	54.5%	64	81.0%	160	62.7%
Intersection	32	18.2%	5	6.3%	37	14.5%
Curved	21	11.9%	4	5.1%	25	9.8%
Downhill	20	11.4%	2	2.5%	22	8.6%
Others	7	3.9%	4	5.0%	11	4.3%
Total	176	100%	79	100%	255	100%

3.2 Injury occurrence and severity by driving condition

This study explores the risk factors of large truck accidents in terms of the risk according to different driving conditions. Risks related to the driving condition is assessed according to road type, shape of the road, and time of the day.

Table 4 presents findings of an injury assessment on different driving conditions based on the data of 255 accidents. In "Frequency" row of Table 4, "Injury %" indicates the composition of accidents among the 255 accidents that occurred under different driving condition respectively. "Death %" in "Severity" row show the proportion of accidents that led to deaths under that particular driving condition. Non-expressway-Straight-Day condition was the most frequent one, which is 21.0%. After that, the frequency was following as the order; Expressway-Straight-Night 17.3%, Expressway-Straight-Day 16.0%, and Non-expressway-Intersection-Day 13.2%. Meanwhile, in the "Death %", Expressway-Curved-Day was 50.0%, Non-expressway-Curved-Night was 50.0%, and Non-expressway-Intersection-Night was 20.0%.

Table 5 shows the criteria for calculating the accident frequency grade, accident severity grade, and management level grade. These criteria were determined through consultation with managers and experts involved in the prevention of accidents by large freight truck drivers. Accident frequency is classified into three grades: Grade 3 (High) for 10% or more of the composition ratio of injury, Grade 2 (Medium) for 5~10%, and Grade 1 (Low) for less than 5%. For accident severity, it is Grade 3 (High) if the proportion ratio of deaths is higher than 20%; Grade 2 (Medium) if the proportion ratio of deaths is higher than 10%; and Grade 1 (Low) for the other cases.

The risk management level of accident (R) is calculated by multiplying the frequency level (F) and severity level (S) ($R = F \times S$), and this is used to determine the management grade that shows how much of the risk should be accepted. Management grade is also classified into three grades: Grade "H: Red" implies a high level of risk that requires actions to reduce the risk and other

Table 4. Injury assessment by driving condition factors

Driving condition			Frequency		Severity		Risk level	
Road type	Road shape	Time	Injury %	F	Death %	S	R	Grade
Expressway	Straight	Day	16.0%	H	7.7%	L	3	M
		Night	17.3%	H	16.7%	M	6	H
	Downhill	Night	0.8%	L		L	1	L
	Curved	Day	1.6%	L	50.0%	H	3	M
		Night	1.2%	L		L	1	L
Non-expressway	Straight	Day	21.0%	H	5.9%	L	3	M
		Night	8.2%	M	15.0%	M	4	H
	Intersection	Day	13.2%	H	6.3%	L	3	M
		Night	2.1%	L	20.0%	H	3	M
	Curved	Day	7.4%	M	16.7%	M	4	H
		Night	0.8%	L	50.0%	H	3	M
	Downhill	Day	7.0%	M	11.8%	M	4	H
		Night	0.4%	L		L	1	L

Table 5. Injury level criteria for driving condition

Level	Frequency level		Severity level		Management level	
	F	Ratio (%)	*S*	Ratio (%)	$R = F \times S$	Grade
High	3	Over 10%	3	Death≥20%	6 or more	H: Red
Medium	2	5~10%	2	Death≥10%	3~5	M: Yellow
Low	1	Under 5%*	1	Death<10%	Under 3	L: Green

aggressive risk management measures, and it is a grade where work should be allowed only if special protection measures and conditions are fulfilled for accident prevention. Grade "M: Yellow" is a grade where the risk can accepted only under certain conditions, which means that work can be allowed only after providing necessary training to workers and checking that they are wearing protective gear. Grade "L: Green" is a grade where work is allowed without any pre-training or measures.

For instance, Table 4 shows that 16.0% of the 255 accidents took place in Expressway-Straight-Day condition (driving straight in daytime on an expressway), making its frequency level H. Among the accidents that occurred in this Expressway-Straight-Day condition, 7.7% led to deaths, which means its severity level is L. And thus, its risk management grade $R\ (= 3 \times 1 = 3)$ is "M: Yellow". Table 6 reveals that Expressway- Straight-Night is the driving condition that is the highest in risk among the conditions that have to be managed as Grade "H: Red". Non-expressway-Straight-Night, Non-expressway-Downhill-Day, and Non-expressway-Curved-Day are also categorized as Grade "H: Red".

Table 6. Injury management matrix for driving condition

Severity (S) Frequency (F)	3: High Death ≥ 20**	2: Medium Death ≥ 10%	1: Low Death < 10%
3: High Over 10%*		Expressway-Straight-Night	Expressway-Straight-Day Non-expressway-Straight-Day Non-expressway-Intersection-Day
2: Medium 5~10%		Non-expressway-Straight-Night Non-expressway-Curved-Day Non-expressway-Downhill-Day	
1: Low Under 5%	Expressway-Curved-Day Non-expressway-Intersection-Night Non-expressway-Curved-Night		Expressway-Downhill-Night Expressway-Curved-Night Non-expressway-Downhill-Night

*Percentage of 255 injured persons, **Percentage of death among injured persons in that condition

4. Discussion and Conclusion

This study analyzes truck drivers' traffic accidents according to accident-times. From 255 records, 69.0% of the accidents were occurred during daytime and the remaining 31.0% were occurred at nighttime. Although there were more accidents in the daytime, the death rate at nighttime was higher. In terms of the locations (shape of road), at daytime, straight road marks the highest composition ratio 54.5%, intersection 18.2%, curved road 11.9%, and downhill 11.4%. At nighttime, most accidents (81.0%) were occurred on straight roads.

This study also identified the major factors that impact large truck accidents and based on these, carried out an accident analysis to determine the level of risk management. In the analysis of injury occurrence, Non-expressway-Straight-Day condition was the most frequent one, and the frequency was following as in the order; Expressway-Straight-Night, Expressway-Straight-Day, and Non-expressway-Intersection-Day. Meanwhile, in the proportion ratio of deaths among injured persons, Expressway-Curved-Day, Non-expressway-Curved-Night, and Non-expressway-Intersection-Night were evaluated as high level of proportion ratio. Also, Expressway-Straight-Night is the driving condition that is the highest in risk among the conditions that have to be managed as Grade "H: Red". Non-expressway-Straight-Night, Non-expressway-Downhill-Day, and Non-expressway-Curved-Day are also categorized as Grade "H: Red".

Based on the analysis results, we can see that truck driver's tight and tough schedule is one of the main reasons of the accidents. Thus, a preventive action from truck driver's chronic fatigue is necessary. Since truck driver's income is directly related to the amount of their deliveries, they drive their vehicle with a lot of freights and they are likely to do speeding. Additionally, it is necessary to prepare training about driving habits reflecting truck driver's physiological characteristics. The reasons why there were many accidents on straight road at night are as follows; 1) It is more likely to do drowsy driving because the road and weather is so monotonous that drivers are likely to be loosened. 2) Since one's distance perception becomes worse at night, if a driver tailgates, it is more likely to hit rear-end of another vehicle. Particularly drivers more than 40 years old would experience poor visibility issues under low light condition. Thus a driver who has symptoms presbyopia must have a driving habit to keep distance and speed limits. Also, lighting, particularly for the roads where many trucks use, must be maintained in an appropriate level.

This study does not provide accurate descriptions of accidents through statistical approach using a mathematical model on large truck accidents. However, those on the field who are developing accident prevention measures or training programs have a great

demand for practical information related to accident prevention that can be easily understood by drivers. Therefore, the results of the study can serve as an efficient guideline for preventing accidents involving freight trucks.

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