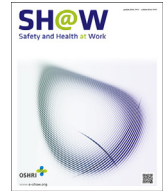




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Original Article

Comparisons of Traffic Collisions between Expressways and Rural Roads in Truck Drivers



Sangbok Lee, Byung Yong Jeong*

Department of Industrial and Management Engineering, Hansung University, Seoul, Republic of Korea

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ABSTRACT

Background: Truck driving is known as one of the occupations with the highest accident rate. This study investigates the characteristics of traffic collisions according to road types (expressway and rural road). **Methods:** Classifying 267 accidents into expressway and rural road, we analyzed them based on driver characteristics (age, working experience, size of employment), time characteristics (day of accident, time, weather), and accident characteristics (accident causes, accident locations, accident types, driving conditions).

Results: When we compared the accidents by road conditions, no differences were found between the driver characteristics. However, from the accident characteristics, the injured person distributions were different by the road conditions. In particular, driving while drowsy is shown to be highly related with the accident characteristics.

Conclusion: This study can be used as a guideline and a base line to develop a plan of action to prevent traffic accidents. It can also help to prepare formal regulations about a truck driver's vehicle maintenance and driving attitude for a precaution on road accidents.

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1. Introduction

Accident prevention plans should be in reasonable agreement with significant variables of occupational accidents, and accident analysis is a typical process in developing preventative policies [1]. Recently, efforts to analyze accidents over diverse industries workers [2–4] have helped to identify similar properties among certain groups of workers [5–7].

Truck or special purpose vehicle (SPV) drivers are classified into truck drivers, dump drivers, trailer truck drivers, and SPV drivers in the Republic of Korea Employment Information Services, and freight vehicle drivers and SPV drivers in the Korean Standard Classification of Occupations [8]. A freight vehicle refers to a truck in which the weight of freight loaded in the load space is larger than the total weight of passengers excluding the driver in it. An SPV is defined as a motor vehicle properly designed to tow, rescue, or execute special tasks. Freight vehicles and SPVs are classified as small, medium, and large sized vehicles. Freight vehicles with a

load capacity > 5 tons or a total weight > 10 tons are referred to as large sized vehicles. An SPV is classified as a large sized when its total weight is > 10 tons [9].

Truck drivers who are self-employed need to drive, take orders, and do their accounts themselves. Thus, they make a contract with a large cargo service to secure their work or to entrust their management activities to the company. Truck drivers who have their own trucks make a contract with a cargo service, and just have to pay for the management activities. However, if they do not own a truck, they purchase it by installments as a form of contract with a cargo service, in which case they have to pay installments on top of the management fees, so that the workload is very heavy in order to pay them back.

Truck drivers' tasks are comprised of checking transportation records that show cargo types, quantity, and destinations, and delivering the freight to the destinations. Most work is done by the driver and includes physical activities such as loading/unloading. In turn, the drivers become so fatigued they are likely to drive while

* Corresponding author. Department of Industrial and Management Engineering, Hansung University, 116 Samseongyoro-16Gil, Seongbuk-Gu, Seoul, 02876, Republic of Korea.

E-mail address: byjeong@hansung.ac.kr (B.Y. Jeong).

drowsy. Because of this, truck driving is known as one of the occupations with the highest accident rate in the US [10]. However, there is a lack of literature on unfolding accident characteristics in Republic of Korea, while there is much research on truck driver's accident prevention plans [11–14].

Truck drivers, in particular those who drive large cargo trucks > 5 tons, are more likely to be involved in traffic accidents because braking takes a longer distance due to the heaviness of their trucks. Moreover, the accidents are usually very severe and thus, the death rate and cost of loss are significantly high [15,16]. It is reported that 80% of accidents are caused by misbehavior of drivers [17,18]. Driving while drowsy, unconsciousness, speeding, passing, non-securing safety distance, driving style, and unlawful acts are the main reasons for accidents [19]. In addition, different accident patterns are recognized according to gender, age, driving experience, and vehicle type [20,21].

Investigating truck-accident characteristics systematically would lead us to establishing an efficient accident prevention plan. This study classifies truck driving-related accidents by road conditions (expressway and rural road). Truck driving-related accidents refer to traffic accidents that occur in the middle of freight delivery by truck drivers.

2. Materials and methods

2.1. Data collection

This study analyzes the characteristics of truck accidents based on truck drivers' accident data, officially recognized as industrial accidents because they happened in the course of truck driving. We used a dataset that includes 267 traffic accidents caused by trucks in expressways and rural roads in the country.

Table 1 shows 267 traffic accidents caused by trucks, which are classified by accident severity and road conditions. Some 38.6% of the accidents occurred in expressways and 61.4% occurred in rural roads; 10.9% of the accidents resulted in deaths and 89.1% of the accidents resulted in either severe or minor injuries. It is also shown that the death rate was greater in expressways. In this paper, expressways refers to roads only for the use of motor vehicles and rural roads refers to local roads that have traffic signals and intersections.

2.2. Data analysis

We conducted Chi-square tests to understand truck-related traffic accidents and to compare distributions of injured persons from the accidents which occurred on expressways and rural roads, based on the accident characteristics. That is, this study compares expressway accidents and rural road accidents with respect to driver characteristics (age, working experience, size of employment), time characteristics (day of accidents, time, weather), and accident characteristics (accident causes, accident locations, accident types, driving conditions). Chi-square tests were employed with a confidence level of 0.05 and SPSS statistical package version 18 (SPSS Inc., Chicago, IL, USA) was used.

Table 1
Distributions of injured persons by accident severity and road conditions (unit: person)

Severity	Expressway		Rural road		Total	
	Count	%	Count	%	Count	%
Death	14	5.2	15	5.6	29	10.9
Injury	89	33.3	149	55.8	238	89.1
Total	103	38.6	164	61.4	267	100.0

Table 2
Distributions of injured persons by age (unit: person)

Age (y)	Expressway		Rural road		Total	
	Count	%	Count	%	Count	%
< 30	8	7.8	15	9.1	23	8.6
30–39	30	29.1	44	26.8	74	27.7
40–49	38	36.9	59	36.0	97	36.3
50–59	22	21.4	35	21.3	57	21.3
≥ 60	5	4.9	11	6.7	16	6.0
Total	103	100.0	164	100.0	267	100.0

3. Results

3.1. Characteristics of injured truck drivers

3.1.1. Analysis by age of injured persons

Table 2 shows characteristics of injured truck drivers regarding age and road conditions. Some 36.3% of injuries occurred in drivers in their forties, 27.7% of injuries occurred in drivers in their thirties, and 21.3% of injuries occurred in drivers in their fifties. From these statistics, we find that truck driving is a tough task for elderly people (those in their late fifties or older). From a Chi-square test, there were no differences in the accident rates through all age groups between expressways and rural way ($\chi^2 = 0.637, p = 0.959$).

3.1.2. Analysis by work experience of injured persons

Table 3 shows characteristics of injured persons with respect to work experiences. Some 47.9% of injured persons had work experience of < 6 months and 64.4% of injured persons had < 1 year of experience. That is, novices are more likely to have accidents. In terms of the road conditions, it is shown that, between expressways and rural roads, there was no difference in the distribution of the injured persons classified by work experiences ($\chi^2 = 5.927, p = 0.313$).

3.1.3. Analysis by size of employment

Table 4 indicates distributions of injured persons by size of employment. As shown in the table, 56.6% of injured persons worked in a small business of less than five employees. Moreover, 84.7% of them work in a business which has less than 30 employees. Thus, we can say that the accident rate is higher in employees of small-sized firms. From a Chi-square test, it is shown that the distributions of injured persons by size of employment between expressways and rural roads were not significantly different ($\chi^2 = 4.080, p = 0.253$).

3.2. Characteristics of day of accidents

3.2.1. Analysis by accident day of week

From Table 5, we can see the characteristics of injured persons with respect to the day of week. The accidents rates were higher on

Table 3
Distributions of injured persons by work experience (unit: person)

Work experience	Expressway		Rural road		Total	
	Count	%	Count	%	Count	%
< 6 mo	50	48.5	78	47.6	128	47.9
6 mo–1 y	19	18.4	25	15.2	44	16.5
1–2 y	19	18.4	22	13.4	41	15.4
2–3 y	5	4.9	12	7.3	17	6.4
3–5 y	6	5.8	9	5.5	15	5.6
≥ 5 y	4	3.9	18	11.0	22	8.2

Table 4
Distributions of injured persons by size of employment

Size (persons)	Expressway		Rural road		Total	
	Count	%	Count	%	Count	%
< 5	63	61.2	88	53.7	151	56.6
5–15	27	26.2	48	29.3	46	17.2
16–29	10	9.7	14	8.5	29	10.9
≥ 30	3	2.9	14	8.5	24	9.0
Total	103	100.0	164	100.0	267	100.0

Table 5
Distributions of injured persons by accident day of week (unit: person)

Day of wk	Expressway		Rural road		Total	
	Count	%	Count	%	Count	%
Mon	14	13.6	31	18.9	45	16.9
Tue	23	22.3	29	17.7	52	19.5
Wed	20	19.4	27	16.5	47	17.6
Thu	17	16.5	22	13.4	39	14.6
Fri	16	15.5	31	18.9	47	17.6
Sat	10	9.7	18	11.0	28	10.5
Sun	3	2.9	6	3.7	9	3.4
Total	103	100.0	164	100.0	267	100.0

wk, week.

Tuesday, Wednesday, and Friday and relatively low on Sunday and Saturday. Again, no differences in the distribution of accidents by day of the week were found between the road conditions ($\chi^2 = 3.096$, $p = 0.797$).

3.2.2. Analysis by time of accident

Table 6 shows the distributions of injured persons by time of accidents. There are less accidents (31.1%) in the nighttime (from 20:00 to 05:00).

From a Chi-square test, two distributions of injured persons between expressways and rural roads were significantly different ($\chi^2 = 32.480$, $p < 0.001$). On rural roads, the accident rate in the daytime was much higher (81.7%) than the nighttime, while on expressways, we cannot see any significant differences.

3.2.3. Analysis by weather

The distributions of injured persons by weather are displayed in Table 7. The accident-injury rate was 77.1% on cloudy or clear days, 14.2% on rainy days, and 6.4% on snowy days, and 2.3% on foggy days. The road conditions had no impact on the distributions of injured persons ($\chi^2 = 1.212$, $p = 0.750$).

3.3. Characteristics of traffic collisions

3.3.1. Analysis by cause of collision

Table 8 shows that 73.0% of accidents were caused by driving problems, 14.6% by drowsiness, 9.4% by truck breakdown (brake or tire failure), and 3.0% by being hit by another car. Here, driving

Table 6
Distributions of injured persons by time of accident (unit: person)

Time of accident	Expressway		Rural road		Total	
	Count	%	Count	%	Count	%
Daylight	50	48.5	134	81.7	184	68.9
Night	53	51.5	30	18.3	83	31.1
Total	103	100.0	164	100.0	267	100.0

Table 7
Distributions of injured persons by weather (unit: person)

Weather	Expressway		Rural road		Total	
	Count	%	Count	%	Count	%
Cloudy, clear	81	78.6	125	76.2	206	77.1
Rain	12	11.7	26	15.9	38	14.2
Snow	7	6.8	10	6.1	17	6.4
Fog	3	2.9	3	1.8	6	2.3
Total	103	100.0	164	100.0	267	100.0

problems refer to traffic collisions which were the driver's fault or were due to unconsciousness, such as speeding, passing, non-securing safety distance, and traffic violations.

A Chi-square test showed that distributions of injured persons were different with respect to road conditions ($\chi^2 = 16.631$, $p = 0.002$). The major cause of accidents is driving problems followed by drowsiness and truck breakdown on both road conditions. However, detailed distributions are different. On expressways, 66.0%, 20.4%, and 9.7% of accidents are caused by driving problems, drowsiness, and truck malfunction, respectively. On rural roads, 77.4%, 11.4%, and 9.1% of accidents are caused by driving problems, drowsiness, and truck malfunction, respectively.

3.3.2. Analysis by road characteristics

Table 9 shows the distributions of injured persons by road characteristics. Most accidents occurred on a straight road (62.2%), followed by an intersection (15.4%), a curved road (9.4%), downhill (9.0%), and a tunnel (2.6%).

A Chi-square test was conducted and it showed that road characteristics had an impact on the distribution of injured persons ($\chi^2 = 48.690$, $p < 0.001$). On expressways, 85.4% of accidents occurred on a straight road compared with 47.6% on rural roads.

3.3.3. Analysis by collision type

Table 10 displays the distributions of injured persons by type of collisions. Overall, collisions at the rear end of vehicles accounted

Table 8
Distributions of injured persons by cause of collision (unit: person)

Cause of collision	Expressway		Rural road		Total	
	Count	%	Count	%	Count	%
Drowsiness	21	20.4	18	11.0	39	14.6
Driving style	68	66.0	127	77.4	195	73.0
Brake failure	3	2.9	14	8.5	17	6.4
Tire failure	7	6.8	1	0.6	8	3.0
Hit by car	4	3.9	4	2.4	8	3.0
Total	103	100.0	164	100.0	267	100.0

Table 9
Distributions of injured persons by location of traffic collision (unit: person)

Location	Expressway		Rural road		Total	
	Count	%	Count	%	Count	%
Straight	88	85.4	78	47.6	166	62.2
Intersection			41	25.0	41	15.4
Downhill	3	2.9	21	12.8	24	9.0
Curve	7	6.8	18	11.0	25	9.4
Tunnel	3	2.9	4	2.4	7	2.6
Others	2	1.9	2	1.2	4	1.5
Total	103	100.0	164	100.0	267	100.0

Table 10
Distributions of injured persons by type of collision (unit: person)

Collision type	Expressway		Rural road		Total	
	Count	%	Count	%	Count	%
Head on	1	1.0	17	10.4	18	6.7
Sideswipe			19	11.6	19	7.1
Rear end	55	53.4	45	27.4	100	37.5
With parked car	2	1.9	5	3.0	7	2.6
Hit by car	4	3.9	4	2.4	8	3.0
With utility wall	34	33.0	55	33.5	89	33.3
Rollover/fall down	7	6.8	19	11.6	26	9.7
Total	103	100.0	164	100.0	267	100.0

for 37.5% of injured persons, a “crash with utility wall” accounted for 33.3%, a rollover/fall down accounted for 9.7%, sideswipes accounted for 7.1%, and head-on crashes accounted for 6.7% of injured persons.

From a Chi-square test, the distributions for expressways and rural roads were significantly different ($\chi^2 = 33.831, p < 0.001$). On expressways, a rear end hit was the largest accident cause, while median crossover crash was the largest one on rural roads.

3.3.4. Analysis by driving situation

The distributions of injured persons by driving situation are displayed in Table 11. Some 48.7% of accidents occurred when the cargo vehicle was moving straight and 20% when the truck made a sudden stop. When it moved on a curve, made a turn, passed, and engaged in a chain accident, 10.9%, 9.0%, 6.7%, and 4.5% of accidents occurred, respectively.

A Chi-square test showed statistical difference between the distributions with respect to the road conditions ($\chi^2 = 39.918, p < 0.001$). On expressways, the accident rates were 61.2%, 14.6%, 10.7%, 6.8%, and 6.8%, for driving straight, sudden stop, chain accidents, passing, and driving on a curve, respectively. On rural roads, 40.9%, 23.8%, 14.6%, 13.4%, and 6.7% of accidents occurred when the vehicle moved straight, stopped suddenly, made a turn, moved on a curve, and passed, respectively.

4. Discussion

Freight vehicles, which are the bases for a logistic of a country, are one of the important driving forces for the country's economy. The accidents of these vehicles on the road result in loss of lives and huge property damages. Most freight vehicle drivers (truck drivers in this work) are treated as self-employed, however, there is no formal classification for their job in Republic of Korea. Most companies outsource their freight deliveries, and logistic companies who take their jobs compete for prices to survive in the market. In turn, the working conditions of the employees in the logistic firms become worse and worse.

Table 11
Distributions of injured persons by driving situation (unit: person)

Driving situation	Expressway		Rural road		Total	
	Count	%	Count	%	Count	%
Go straight	63	61.2	67	40.9	130	48.7
Overtaking	7	6.8	11	6.7	18	6.7
Curve driving	7	6.8	22	13.4	29	10.9
Sudden stop	15	14.6	39	23.8	54	20.2
Chain accident	11	10.7	1	0.6	12	4.5
Making turn			24	14.6	24	9.0
Total	103	100.0	164	100.0	267	100.0

Truck drivers are likely to overwork because of different and inconsistent loading/unloading times and driving hours. Particularly, for them, it is normal to be away from home for 6 days or 7 days because they have to drive to various destinations following the work orders to prevent from dropping earnings by stopping their vehicles. Moreover, truck drivers have to focus on driving for a long time on top of the delivery work including freight loading/unloading and frequently have to drive at night. In turn, they are likely to have irregular meal timing, lack of sleep, and stress.

This study compared characteristics of accidents with respect to two different road conditions, expressways and rural roads. We classify the accidents in terms of driver-specific conditions and accident-specific conditions. The driver-specific conditions refer to age, working experience, and size of employment and the accident-specific conditions refer to cause and location of accidents, collision type, and driving conditions. From the driver-specific conditions, it is shown that there was no difference between the distributions of injured persons on expressways and rural roads. By contrast, from the accident-specific conditions we found differences in the distributions.

On expressways, 66.0% of accidents occurred due to the negligence of the driver, 20.4% due to driving while drowsy, and 9.7% because of truck breakdown such as tire/brake problems. The distributions of injured persons classified by daytime and nighttime were statistically similar. Based on driving situations, most accidents (85.4%) occurred when a truck driver was driving on a straight road while only 6.8% occurred when driving on a curve. In the case of types of collision, a collision at the rear end accounted for > 50%, median-crossover-crash for 33.3%, and rollover or falling down for 6.8%. When we classified the accidents by driving situations, straight driving was 61.2%, sudden stop 14.6%, chain collision 10.7%, passing 6.8%, and driving on a curve 6.8%.

On rural roads, when compared expressways, driving while drowsy (11.1%) and truck breakdown (9.1%), as a cause of the accidents decreased, while the negligence of the driver increased, and most accidents (81.7%) occurred at daytime. Classifying the accidents by locations, we found that the rate of accidents on straight roads decreased to 47.6%. Based on the collision types, median-crossover-crash and hit at the rear end decreased, while the other collision types increased. With respect to driving situations, the accident rate of straight driving decreased, while sudden stops, making a turn, and driving on a curve increased the accident rate.

It is necessary to come up with measures in order to relieve truck drivers' chronic fatigue, based on the finding that the accident rate caused by drowsiness is 20.4% on expressways and 11.1% on rural roads. The Federal Motor Carrier Safety Administration in the US states that truck drivers must not work 14 hours continuously and the driving part from the work must be < 11 hours with a 10 hour break time between two consecutive drives. It is also stated that truck drivers must drive < 70 hours in 7 days or 80 hours in 8 days, and they have to rest for at least 34 hours after 7 days or 8 days of work. All of these activities must be noted on driving record files [9,10,21]. In Republic of Korea, reregulating the rule of driving hours should be considered to secure the safety of truck drivers. In addition, it is necessary to have more rest areas and convenience facilities on expressways.

In our dataset, 47.9% of injured truck drivers are novices whose experience is < 6 months, and moreover, 64.4% of them have work experiences of < 1 year. This result is the same as that of a study in Washington State [14], and it implies a realistic and systematic training for truck drivers, which helps them to get used to this job-related life pattern.

Cargo truck maintenance is one of the problems. Some 9.7% and 9.1% of accidents on expressways and rural roads, respectively, occur because of problems with the vehicle. In particular, brake

failure accounts for up to 6.4% and tire failure 3.0% of accidents. This is natural because cargo truck drivers keep driving for a long time with a lot of freight. Thus, the cargo truck maintenance issue must be modified and restated in regulations.

Overall, the characteristic of truck drivers who are involved in traffic accidents is as follows. Some 72.6% of injured persons are < 50 years old. It is known that elderly drivers are less likely to commit violations; however, they are more likely to make personal errors [20]. In this study, we did not investigate personal errors, and thus it seems that the analysis on the accident characteristic according to personal errors needs additional attention. In this paper, we studied and analyzed traffic accidents by cargo trucks on both expressways and rural roads. As a further study, an integrated accident analysis including personal effects is required. Based on that, a systematic prevention policy for the accidents must be developed.

Conflicts of interest

All authors declare that there are no conflicts of interest.

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