Original Article

Crashes and Traffic Signal Violations Caused by Commercial Motorcycle Couriers

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A B S T R A C T

Background: Motorcycles are one of the important members of commercial transportation because of the convenient use during congested traffic conditions and the ease of parking in narrow streets. This study investigates the characteristics of crashes and traffic signal violations caused by motorcycle couriers.
Methods: From the national compensation data, this study analyzed the traffic crashes caused by 671 motorcycle couriers.
Results: Among 671 injured couriers, 50.6% were aged less than 40 years, 49.2% run in a small business of <5 employees, and 47.2% had work experience of <6 months. Motorcycle crashes occurred mainly due to "rider overturned alone" (67.5%), in the daytime (73.5%), or on cloudy or clear days (77.2%). However, the violation rate caused by motorcycle couriers was high in couriers in a small business of <5 employees (13.9%), with work experience of <6 months (13.9%), on cloudy or clear days (12.4%), on an intersection (29.8%), in the type of "crash with a vehicle" (31.2%), or in a death accident (35.7%)
Conclusion: The findings of this study can be used as a baseline in devising policies for preventing crashes of motorcycle couriers.

1. Introduction

In the Korean Standard Classification of Occupations [1], delivery service workers refer to persons who collect, transport, and deliver documents, parcels, and packages. Delivery workers include a mailer, a carrier, a food delivery worker, or other delivery workers [1]. Because of the convenient use during congested traffic conditions and the ease of parking in narrow streets, the increasing use of motorcycles in commercial transportation has been rising [2,3]. That is, motorcycle couriers are one of the important members of the delivery industry.

However, motorcyclists are vulnerable to injuries [4,5]. Motorcycle crashes account for more than 50% of the total number of traffic deaths in some countries [3]. The risks of injury for motorcyclists are associated with conspicuity of the rider [4,5], road environment factors [6], helmet wearing [7], alcohol and other drug use [8,9], rider's age and gender [10,11], inexperience and driver training [12,14], riding speed [13], and risk-taking behaviors or violations [2,14].

The causes of traffic crashes can be categorized into human factors related to the driver, vehicle factors such as brake malfunction and punctured tire, and environmental factors such as weather and road geometry. The analysis of human factors in traffic crashes usually references the theory by Reason et al [15], who analyzed the human errors of traffic crashes regarding mistakes, slips, lapses, and violations [16]. The environmental factors that affect traffic crashes of motorcycle couriers include traffic status, slippery or bumpy road surface, and driving time of different delivery routes [16—18].

The motorcycle couriers who deliver goods have to drive long hours and work on a tight schedule. Because the amounts of delivery set the earnings of couriers, motorcycle couriers work under time pressure or in unsafe working conditions. Also, the motorcyclists require high speeds on congested or narrow streets. These factors can lead to rider's violations of rules or risk-taking behaviors. Development of preventive measures requires a systematic analysis of occupational accidents [19—21]. However, there were few studies on the aspects of occupational accidents and human factors of the motorcycle couriers in South Korea [19,22].

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Thus, the purpose of this study is to investigate the characteristics of crashes and traffic signal violations caused by commercial motorcycle couriers. In the Republic of Korea, employers are required to have industrial accident compensation insurance under the Industrial Safety and Health Act [19−24]. For compensation purposes, employers are also obliged to report industrial accidents records for injury crashes to the relevant enforcing authority. Workers' compensation records for work-related traffic crashes are based on police reports and drivers' interview [25]. The compensation data do not include the speed at the time of the crash. Thus, in this study, the violation is limited to the signal or lane violation, excluding speed violation.

2. Material and methods

2.1. Research variables and terminologies

This study analyzed the crashes of motorcycle couriers from the national data source for Industrial Accident Compensation. Table 1 shows the classification of variables used in this study, divided into courier-related factors, crash-related factors, and driving conditions. The variables of traffic crashes were categorized into courier-related factors (age, work experience, and company size), crash-related factors (violation, crash type, and injury severity), and environmental factors (road type, weather, and time of crash).

This study analyzed rider's violations based on accident summaries in the Report of Industrial Accidents. The compensation data received from the Korea Occupational Safety and Health Agency do not have the speed information, and any traffic crashes due to drinking alcohol or drug are not included. Thus, in this study, the violation is limited to the signal or lane violation, such as riding a red light/sign, crossing over a center lane, and improper U-turn or turn at an intersection.

The injury severity, approved by Industrial Accident Compensation, is classified as death, disability, and injury. In Table 1, types of crashes or types of roads are not mutually exclusive, such as road type in the road case of not only the curve but also the hill.

2.2. Data collection and analysis

The motorcycle couriers cannot be extracted directly from the national compensation injury database. Hence, the type of industry, occupation, name of the company, and accident details should be identified to classify the motorcycle couriers. This study investigated 671 male motorcycle couriers who have suffered traffic crashes between 2009 and 2012. Among 671 injured couriers, 14 of

the crashes resulted in deaths, 86 suffered disabilities, and 571 suffered injuries.

This study investigated the characteristics of crashes and traffic signal violations caused by commercial motorcycle couriers. The Chi-square test was used to analyze whether there is a significant difference in the distribution of the injured couriers by rider's violations, regarding courier-related factors (age, work experience, and company size), crash-related factors (crash type and injury severity), and environmental factors (road type, weather, and time of crash). The SPSS version 18.0 (SPSS Inc., Chicago, IL, USA) was used, and tests were used with a confidence level of 0.05.

3. Results

3.1. Characteristics of courier-related factors

3.1.1. Distribution of injured couriers by age

Table 2 shows the distribution of injured couriers and traffic signal violations by age. Among 671 injured couriers, 24.1% of injuries occurred in riders aged less than 30 years, 26.5% of injuries occurred in riders in their 30s, 24.3% of injuries occurred in riders in their 40s, and 25.0% of injuries occurred in riders in their 50s or older. Of the injured couriers, 75.0% of injuries occurred in riders aged less than 50 years.

In Table 2, the violation rate is high in riders aged less than 30 years (13.0%). However, there was no significant difference in the distribution of injured couriers between age and violation ($\chi^2 = 2.448$, $p = 0.485$).

3.1.2. Distribution of injured couriers by work experience

Fig. 1 shows the distribution of injured couriers and violation ratios by work experience. Of the injured couriers according to work experience, 47.2% of injured couriers had work experience of <6 months, and 59.3% of injured couriers had <1 year of experience.

Table 2
Distribution of injured couriers by age and violation (persons)

Violation		<30 y	30−39 y	40−49 y	≥50 y	Total
With violation	*n*	21	14	16	17	68
	%	13.0	7.9	9.8	10.1	10.1
Without violation	*n*	141	164	147	151	603
	%	87.0	92.1	90.2	89.9	89.9
Total	*n*	162	178	163	168	671
	%	100.0	100.0	100.0	100.0	100.0
Composition ratio		24.1%	26.5%	24.3%	25.0%	100.0%

y, years.

Table 1
Definition of research variables and description

| Factors	Variable		Level
Courier	Age (years)		1, <30; 2, 30−39; 3, 40−49; 4, ≥50
	Work experience		1, <6 mo; 2, 6 mo−1 y; 3, 1−5 y; 4, >5 y
	Company size (persons)		1, <5; 2, 5−14; 3, ≥15
Crash	Violation		1, traffic signal or lane violation; 0, otherwise
	Crash type	Rider alone	1, if rider overturned alone; 0, otherwise
		Vehicle	1, if crash with vehicle; 0, otherwise
		Pedestrian	1, if crash with pedestrian; 0, otherwise
		Motorcycle	1, if crash with motorcycle; 0, otherwise
	Injury severity		1, injury; 2, disability; 3, death
Environment	Road type	Intersection	1, if intersection area; 0, otherwise
		Uneven surface	1, if uneven road surface; 0, otherwise
		Curve	1, if curve area; 0, otherwise
		Hill	1, if hill area; 0, otherwise
	Weather	Rain or snow	1, if raining or snowing; 0, otherwise
	Time	Night	1, if night (p.m. 6:00−a.m. 6:00); 0, otherwise
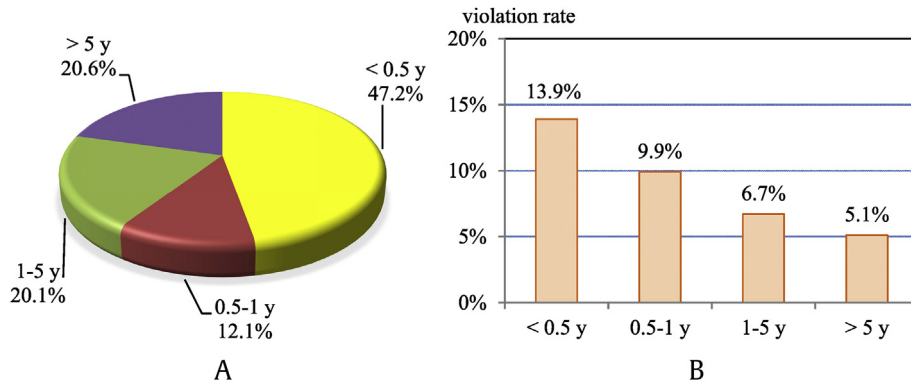
Fig. 1. Distributions of injured couriers and violation rates by work experience (years).

There was a significant difference in the work experience distribution of injured couriers according to work experience and violation (χ^2 =8.758, p = 0.014). The violation rate caused by motorcycle couriers was high in couriers with work experience of <6 months (13.9%). Also, the violation rate was decreased with work experience.

3.1.3. Distribution of injured couriers by company size

Fig. 2 shows the distribution of injured couriers and violation ratios by company size. As shown in the table, 49.2% of injured couriers worked in small companies of less than 5 employees, followed by companies with 5−14 employees (31.6%), and companies with 15 or more employees (17.8%).

The Chi-square test found a difference in the distribution of injured couriers according to company size and violation (χ^2 = 10.555, p = 0.013). The violation rate was higher in couriers in small-sized firms of less than 5 employees (13.9%).

3.2. Characteristics of crash-related factors

3.2.1. Distribution of injured couriers by crash type

Table 3 shows the distribution of injured couriers and violation ratios by crash type. In the distribution of injured couriers according to the type of crash, a "rider overturned alone" accounted for 67.5% of injured couriers, a "crash with a vehicle" accounted for 27.7%, and a "crash with a motorcycle" accounted for 2.8%. In Table 3, types of crashes are not mutually exclusive, such as the crash type in the crash case of not only a vehicle but also a motorcycle.

The distribution of injured riders was statistically different between violation and "rider overturned alone" (χ^2 = 137.358, p < 0.001), "crash with a vehicle" (χ^2 = 125.188, p < 0.001), or "crash with a motorcycle" (χ^2 = 5.622, p = 0.018). The violation rate was highest in the type of "crash with a vehicle" (31.2%), followed by "crash with a motorcycle" (26.3%). Meanwhile, the distribution of injured riders was not statistically different between violation and "crash with pedestrian" (χ^2 = 1.085, p = 0.298).

3.2.2. Distribution of injured couriers by injury severity

Fig. 3 shows the distribution of injured couriers and violation ratios by injury severity. In Fig. 3, a total of 671 injured couriers consisted of 14 deaths (2.1%), 86 disabilities (12.8%), and 571 injuries (85.1%).

There was a significant difference in the distribution of injured couriers between injury severity and violation (χ^2 = 21.530, p < 0.001). The violation rate was highest in death (35.7%), followed by disability (19.8%) and injury (8.1%).

3.3. Characteristics of environment-related factors

3.3.1. Distribution of injured couriers by road type

Table 4 shows the distribution of injured couriers and violation ratios by road type. Most crashes occurred on "intersections" (30.6%) or on "uneven road surfaces" (30.0%). In Table 4, types of road are not mutually exclusive, such as the road type in the crash case of not only the hill but also the curve.

The violation rate was highest on "intersections" (29.8%). The distribution of injured riders was statistically different between
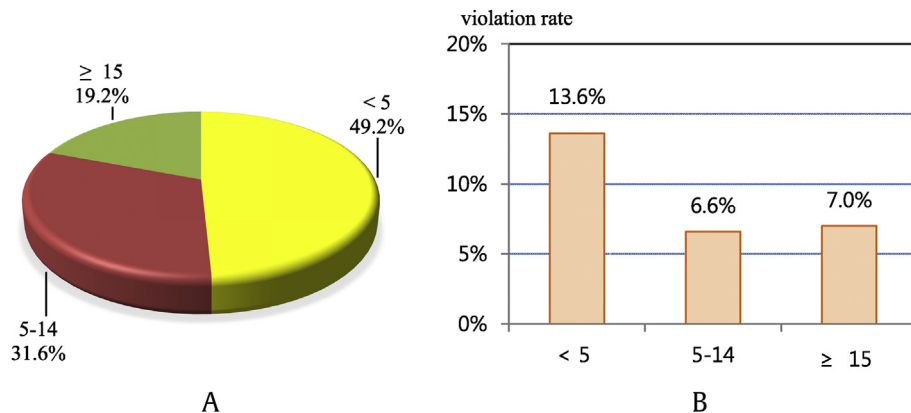

Fig. 2. Distributions of injured couriers and violation rates by company size (persons).

Table 3
Distribution of injured couriers by crash type and violation

Crash type			Violation			Chi-square test
			Without	With	Total	
Rider alone	1*	n	450	3	453	$\chi^2 = 137.358$
		%	99.3	0.7	100.0	$p < 0.001^\dagger$
	0	n	153	65	218	
		%	70.2	29.8	100.0	
Vehicle	1	n	128	58	186	$\chi^2 = 125.188$
		%	68.8	31.2	100.0	$p < 0.001^\dagger$
	0	n	475	10	485	
		%	97.9	2.1	100.0	
Motorcycle	1	n	14	5	19	$\chi^2 = 5.622$
		%	73.7	26.3	100.0	$p = 0.018^\dagger$
	0	n	589	63	652	
		%	90.3	9.7	100.0	
Pedestrian	1	n	8	2	10	$\chi^2 = 1.085$
		%	80.0	20.0	100.0	$p = 0.298$
	0	n	595	66	661	
		%	90.0	10.0	100.0	
Total		n	1147	170	1,317	
		%	87.1	12.9	100.0	

* 1 = if rider overturned alone, 0 = otherwise.
† significant difference at 0.05.

Table 4
Distribution of injured couriers by road type and violation

Road type			Violation			Chi-square test
			Without	With	Total	
Intersection	1*	n	144	61	205	$\chi^2 = 124.794$
		%	70.2	29.8	100.0	$p < 0.001^\dagger$
	0	n	459	7	466	
		%	98.5	1.5	100.0	
Uneven surface	1	n	200	1	201	$\chi^2 = 29.261$
		%	99.5	0.5	100.0	$p < 0.001^\dagger$
	0	n	403	67	470	
		%	85.7	14.3	100.0	
Curve	1	n	42	1	43	$\chi^2 = 3.076$
		%	97.7	2.3	100.0	$p = 0.079$
	0	n	561	67	628	
		%	89.3	10.7	100.0	
Hill	1	n	69	0	69	$\chi^2 = 8.673$
		%	100.0	0.0	100.0	$p = 0.003^\dagger$
	0	n	534	68	602	
		%	88.7	11.3	100.0	
Total		n	1147	170	1,317	
		%	87.1	12.9	100.0	

* 1 = if intersection area, 0 = otherwise.
† significant difference at 0.05.

violation and "intersection" ($\chi^2 = 124.794$, $p < 0.001$), "uneven road surface" ($\chi^2 = 29.261$, $p < 0.001$), or "hill" ($\chi^2 = 8.673$, $p = 0.003$), whereas the distribution of injured riders was not statistically different between violation and "curve" ($\chi^2 = 3.076$, $p = 0.079$).

3.3.2. Distribution of injured couriers by weather

Fig. 4 shows the distribution of injured couriers and violation ratios by weather. Overall, 77.2% of courier crashes occurred on a cloudy or clean day, and 22.8% occurred on a rainy or snowy day.

There was a significant difference in the distribution of injured couriers according to weather and violation ($\chi^2 = 12.306$, $p < 0.001$). The violation rate was higher on a cloudy or clean day (12.4%) than on a rainy or snowy day (2.6%).

3.3.3. Distribution of injured couriers by time of crash

Fig. 5 shows the distribution of injured couriers and violation ratios by time of crash. Of the injured couriers, 73.5% of courier crashes occurred in daytime (from 6:00 to 18:00), and 26.5% occurred in nighttime (from 18:00 to 6:00).

The violation rate was high in nighttime (12.4%). However, there was no significant difference in distribution according to the time of crash and violation of driver ($\chi^2 = 1.317$, $p = 0.241$).

4. Discussion and conclusion

Motorcycle couriers are one of the important members of the delivery industry, and the increasing use of motorcycles in commercial transportation has been rising. This study investigates the characteristics of traffic crashes and traffic signal violations caused by motorcycle couriers.

This study showed that 47.2% of injured couriers had work experience of <6 months and that the violation rate was also high in couriers with work experience of <6 months (13.9%). The problems of labor turnover and unsafe working conditions are common in motorcycle couriers [2,19,22]. Also, the motorcycle couriers are recognized as a poorly paid job. Because of low barriers to entry, some novice couriers may start the delivery work without proper education or training [22]. In this study, motorcycle crashes occurred mainly due to "rider overturned alone" (67.5%). Furthermore, the violation rate decreased with work experience. These findings suggest that it is necessary to provide for systematic safety education for the novice motorcycle couriers.

The delivery riders, working in the small business, may be more likely to ride a motorcycle that is old, poorly maintained, and lacking a protective structure [22]. Also, employer's consciousness for the safety and health in the small-sized firms may be lower than in large-sized firms. Furthermore, there is no established legal
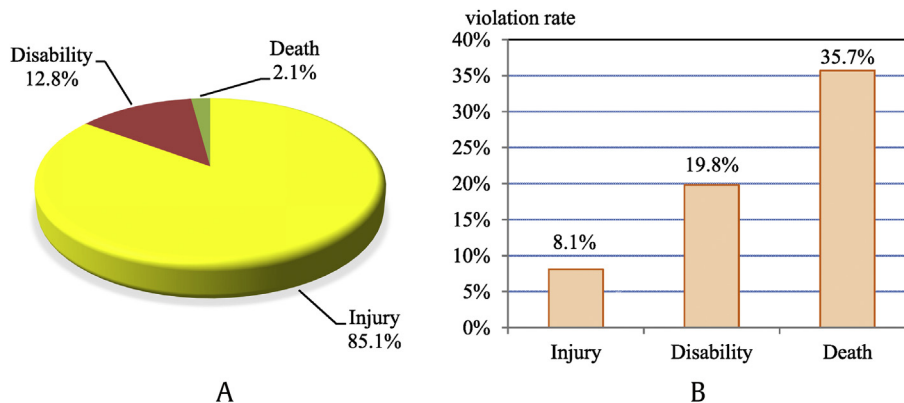
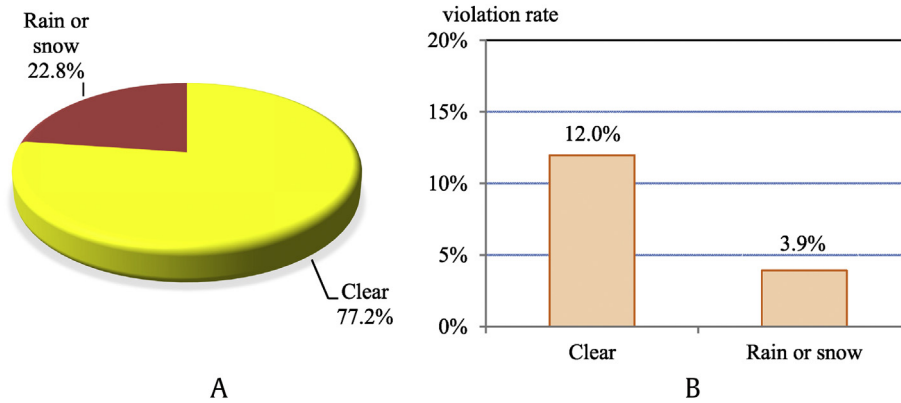**Fig. 3.** Distributions of injured couriers and violation ratio by injury severity.

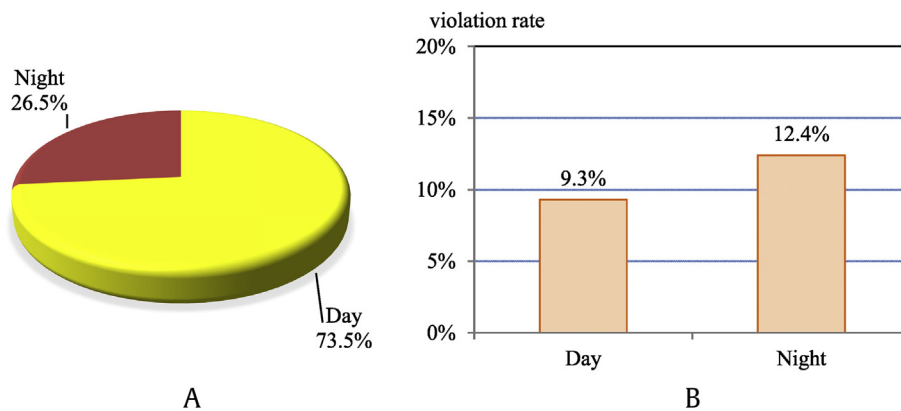**Fig. 4.** Distributions of injured couriers and violation ratio by weather.

Fig. 5. Distributions of injured couriers and violation ratio by time of crash.

framework for couriers who deliver by motorcycles even while they continue to increase in number in response to the growing demand for motorcycle couriers. The results of this study showed that 49.2% of injured couriers worked in a small business of <5 employees and that the violation rate was also high in small-sized firms of less than 5 employees.

The incomes of motorcycle couriers are set by riding hours and the amounts of delivery goods [2,22]. Owing to intensified competition among couriers and excessive price competition, the couriers can maintain their income by delivering more volume. These lead to prolonged working hours and cause the working environment to become even worse. Thus, they are more likely to take risks and tend to run a red light. However, the violation rate was highest in death (35.7%), followed by disability (19.8%) and injury (8.1%). Motorcycle riding is a physically demanding profession. There is no limit rule for driving hours continuously per day and break time in the motorcycle couriers [23–25]. Legislative frameworks will likely need to address issues going beyond protective gear use [22], driving hour limits [23–25], and motorcycle driver's licensing procedures [22] to include motorcycle industry responsibilities and occupational safety provisions for workers.

The motorcycle couriers have a low barrier to entry and a broad range of age distribution [19,22]. In this study, injured couriers were distributed widely between the teens and the 60s. It is necessary to introduce appropriate support policies tailored to different age groups to ensure that the elderly couriers with less stamina and teen couriers with less experience can deliver safely. The study calls for the establishment of "universal safety" [26] as a

philosophy for designing working environments and riding equipment that are convenient and easy for all couriers [27]. Especially, it is important to consider the delivery method, volume, and schedule not only just based on the delivery area and road condition but also based on the couriers' physical ability.

This study has some limitations. First, because the accidents reported in this study resulted in more than four days of absence from work, minor accidents are not included in the analysis. Hence, the accident rates reported in this study show a lower frequency rate than those reported in traffic accident analysis. Second, violation rates may be underestimated due to data analysis problems such as unknown intention. Finally, this study is a descriptive study of compensation injury data. Thus, further research needs to be required to investigate the qualitative relationships. In spite of those limitations, the findings of this study show the characteristics of injured couriers and the traffic violations caused by motorcycle couriers. The results can be used to provide useful insight for designing crash prevention policies and guidelines for motorcycle couriers.

Conflicts of interest

All authors declare that there are no conflicts of interest.

Acknowledgments

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.shaw.2018.10.002.

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