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Comparison of the characteristics and injury severity of passengers in motor vehicle accidents between urban and rural cities in South Korea

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Objective To analyze motor vehicle accidents in two different traffic environments and compare differences in severity between both regions.

Methods Injury data were collected by the Emergency Medicine and Traffic Accident Research Team as part of the Korean In-Depth Accident Study. Patients admitted to emergency medical centers located in Wonju, Gangwon province (population 345,143, rural, group A) and Bucheon, Gyeonggi province (population 870,735, urban, group B) between January 2011 and December 2017 were included for analysis. Injury severity was classified into four categories based on Injury Severity Score (ISS): minor (1 ≤ < 9), moderate (9 ≤ < 15), major (15 ≤ < 25), and critical (≥ 25).

Results Overall, 1,807 patients were included (group A, 1,484; group B, 323). There was a higher proportion of daytime accidents, accidents involving larger cars, passenger injuries, and accidents involving lack of seat belt use in group A than in group B. The mean ISS value was 8.98 in group A and 4.62 in group B (P < 0.001). Minor (20.4% vs. 10.8%) and major/critical (15.7% vs. 5.0%) injuries were more frequent in group A than group B (P < 0.001). Patient ratios (A/B) for each ISS classification were 0.76 (minor), 1.89 (moderate), 3.43 (major), and 2.77 (critical). The factors showing a significant relationship with severity were driver's seat (P = 0.037) and no seat belt (P < 0.001).

Conclusion Patients in a rural city who visited the emergency room owing to motor vehicle accidents had more severe injuries than those in an urban city.

Keywords Accidents, traffic; Injury Severity Score; Geography, medical; Risk factors

Capsule Summary

What is already known
There are more traffic accidents and more deaths in rural areas than in urban areas. Overall, only statistical data on end-effects, such as mortality, were reported.

What is new in the current study
We analyzed in-depth traffic accident personal injury data from the Korean In-Depth Accident Study, and conducted a clinical analysis of injury severity. Injuries were more severe in the rural city where fewer people wore seat belts.

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INTRODUCTION

Although traffic accidents are declining in South Korea, the death rate caused by traffic accidents is still high. At 8.1 per 100,000, it is higher than the Organization for Economic Cooperation and Development average of 5.3 in 2014.[1] The introduction of legislation that restricts drunk and unauthorized driving has led to a decrease in traffic accidents. In addition, the development of safety devices for vehicles is an important factor in reducing the severity of injuries caused by accidents.[2,3] Internationally, such data on accidents are collected by the National Automotive Sampling System/Crashworthiness Data System and Crash Injury Research and Engineering Network of the National Highway Traffic Safety Administration in the United States, and the German In-Depth Accident Study in Germany. These data enable the in-depth review of more specific injuries.[4] In Korea, the recently introduced Korean In-Depth Accident Study (KIDAS) has facilitated such studies.[5-7] Adequate reviews for understanding the characteristics and merits of safety devices for vehicles were previously impossible due to a lack of cooperation among different companies and a lack of technical knowledge. However, with the introduction of the KIDAS, the accumulation of accident data is improving. It is possible to compare more accident factors than just differences in mortality. A recently conducted yet limited survey of traffic accidents in Korea identified regional differences in mortality, which was twice as high in rural areas than that in the suburbs of Seoul.[8] Because the mortality rate depends on both the frequency of accidents and the treatment after an accident, it is difficult to make inter-regional comparisons of the severity of actual accidents. Many variables reflect regional differences and must also be considered.[9] In order to analyze the severity of human injuries, it is essential to study the specific factors affecting the injuries. Therefore, this study aimed to compare the KIDAS data between two regions with different populations and geographical locations and investigate the general characteristics and severity of specific injuries rather than just mortality. This is the first study of its kind comparing the injury severity of traffic accident victims between rural and urban areas in Korea using in-depth measures of injury severity and accident characteristics.

METHODS

Study setting and population

This study evaluated patients who visited emergency departments (EDs) between January 2011 and December 2017. To compare regional characteristics, the patients who visited an emergency medical center in Wonju, Gangwon province (population 345,143 in 2019, annual ED visit number 50,000), a rural area, were classified as group A, and those who visited an emergency medical center located in Bucheon, Gyeonggi province (population 870,735 in 2019, annual ED visit number 60,000), an urban area, as group B.

Data

Human injury data were collected by the Emergency Medicine and Traffic Accident Research Team as part of the KIDAS. The data collected included demographic characteristics such as age, sex, height, and weight, and passenger characteristics such as accident time, vehicle type, seating position, use of seat belts, and cases of drunk driving. The original KIDAS database was constructed following approval from the research ethics committee of Yonsei University (YWMR-14-5-074).

The accident time was divided into day (7:00 to 19:00) and night (19:00 to 7:00), when the traffic volume is generally lighter. The vehicles were classified into groups 1 (passenger cars and Sports Utility Vehicles [SUVs]), 2 (vans and light trucks), and 3 (buses and heavy trucks).

Abbreviated Injury Score and Injury Severity Score

Abbreviated Injury Score (AIS) is a simple impairment scale established by the American Association for the Advancement of Medicine. It is a useful measure for the injury severity of traffic accident victims. AIS divides the body into 9 areas and scales the severity of injury in each area from 1 to 6 points. The Injury Severity Score (ISS) was developed in 1974 as an improvement over AIS, and is most commonly used for classification of the severity of anatomical indices. After the classification of injuries using AIS, Only the highest AIS score in each body region is used. The 3 most severely injured body regions have their score squared and added together to produce the ISS score.

$$\mathrm{ISS} = AIS(1)^2 + AIS(2)^2 + AIS(3)^2$$

Each ISS value is calculated from a minimum of 1 point to a maximum of 75 points.[10]

ISS scores were then classified into four categories: minor, moderate, major, and critical (Table 1).[11,12] This study is based on AIS 2005: update 2008.

Analysis

Statistical analysis was performed using IBM SPSS Statistics ver. 20.0 (IBM Corp., Armonk, NY, USA). A P-value <0.05 was considered statistically significant in all statistical tests. In the case of numerical variables, the mean $\pm$ standard deviation was used, while in the case of categorical data, the frequency was expressed as a percentage. P-values were derived by Student's t-test or Mann-

Table 1. Classifications of severity based on ISS

ISS	Classification
1 ≤ ISS < 9	Minor injury
9 ≤ ISS < 15	Moderate injury
15 ≤ ISS < 25	Major injury
25 ≤ ISS	Critical injury

ISS, Injury Severity Score.

Table 2. Comparison of the general characteristics of traffic accident patients by region

Variable	Group A (rural) (n = 1,484)	Group B (urban) (n = 323)	P-value
Sex			0.661
Male	904 (60.9)	201 (62.2)	
Female	580 (39.1)	122 (37.8)	
Age[a)]	43.3 ± 18.51	41.3 ± 15.72	0.081
Height[a)]	165.5 ± 13.05	165.1 ± 15.20	0.706
Weight[a)]	64.3 ± 16.92	64.4 ± 15.98	0.910

Values are presented as number (%) or mean ± standard deviation.
[a)]Unknown: age (B, n = 87), height (A, n = 627; B, n = 3), weight (A, n = 591; B, n = 2).

Whitney U-test for numerical data, and by chi-squared test or Fisher exact test for categorical data. Linear multiple regression analysis was used to analyze the variables affecting ISS.

RESULTS

Demographic and passenger characteristics

The study enrolled 1,807 subjects: 1,484 in group A and 323 in group B. In both groups/regions, there were more males than females, but there was no significant gender difference between the two groups (P = 0.661). The average age in group A was 2 years older than in group B, but this difference was not significant (P = 0.081). There were no significant differences in height or weight between the two groups (Table 2).

More patients presented during the day in group A (59.5%) than in group B (51.8%) (P = 0.013). In both regions, the majority of patients were in smaller vehicles. In group B, 80.7% of the patients were in group 1 vehicles versus 72.6% in group A. The rate of larger vehicle accidents (involving group 2 and group 3 vehicles) was significantly higher in group A (P = 0.010). In both regions, patients who presented were most likely to have been in the driver's seats, and less likely to have been in the passenger seats or other seats. There were more passenger-seat and other-seat patients in group A than in group B (P = 0.013). In both regions, more patients were wearing seat belts than not, although the proportion of patients wearing seat belts was significantly higher in group B (83.1%) than in group A (56.4%) (P < 0.001)

Table 3. Comparison of traffic accident passenger characteristics by region

Variable	Group A (rural) (n = 1,484)	Group B (urban) (n = 323)	P-value
Time[a)]			0.013
Day	889 (59.9)	142 (51.8)	
Night	595 (40.1)	132 (48.2)	
Car type[a)]			0.010
Group 1[b)]	1,078 (72.6)	260 (80.7)	
Group 2[b)]	353 (23.8)	55 (17.1)	
Group 3[b)]	53 (3.6)	7 (2.2)	
Seat location			0.013
Driver	870 (59.9)	222 (68.7)	
Assistant	320 (22.0)	56 (17.3)	
Others	263 (18.1)	45 (13.9)	
Seat belt[a)]			< 0.001
Restrained	755 (56.4)	246 (83.1)	
Not restrained	548 (43.6)	50 (16.9)	
Drink driving[a)]			0.171
Drunk	123 (10.2)	6 (5.8)	
Not drunk	1,087 (89.8)	98 (94.2)	

Values are presented as number (%).
[a)]Unknown: time (B, n = 49), car type (A, n = 1), seat belt (A, n = 145; B, n = 27), drink driving (A, n = 274; B, n = 219). [b)]Group 1, sedan and sport utility vehicle; group 2, light truck and van; group 3, bus, middle truck, and heavy truck.

Table 4. Comparison of seat belt restraint rate by seat location in two regions

Seat location	Seat belt	Group A (rural) (n = 1,321)	Group B (urban) (n = 296)	P-value
Driver	Restrained	532 (65.4)	184 (90.6)	< 0.001
	Not restrained	281 (34.6)	19 (9.4)	
Assistant	Restrained	151 (53.2)	41 (82.0)	< 0.001
	Not restrained	133 (46.8)	9 (18.0)	
Others	Restrained	69 (30.8)	31 (48.8)	0.024
	Not restrained	155 (69.2)	22 (51.2)	

Values are presented as number (%).

(Table 3). The rate of seat belt use was higher in group B than group A for those in the driver's seat, the passenger's seat and other seats at the time of the initial accident (Table 4). There was no significant difference (P = 0.171) in the percentage of drunk drivers between the two regions.

Comparison of injury severity between the two regions

The mean ISS of the patients was twice as high in group A (8.98 ± 12.19) as it was in group B (4.62 ± 8.30) (P < 0.001), with a greater proportion of minor injury patients in group B (84.2%) than in group A (63.9%). Moderate injuries were twice as common in group A (20.4% vs. 10.8%), whereas major and severe injuries were three times more common in group A (15.7% vs. 5.0%) (P < 0.001). The

Table 5. Comparison of Injury Severity Score and severity classification between the two regions

	Group A (rural) (n = 1,484)	Group B (urban) (n = 323)	P-value
Injury Severity Score	8.98 ± 12.19	4.62 ± 8.30	< 0.001
Minor injury	948 (63.9)	272 (84.2)	< 0.001
Moderate injury	303 (20.4)	35 (10.8)	
Major injury	142 (9.6)	9 (2.8)	
Critical injury	91 (6.1)	7 (2.2)	

Values are presented as mean ± standard deviation or number (%).

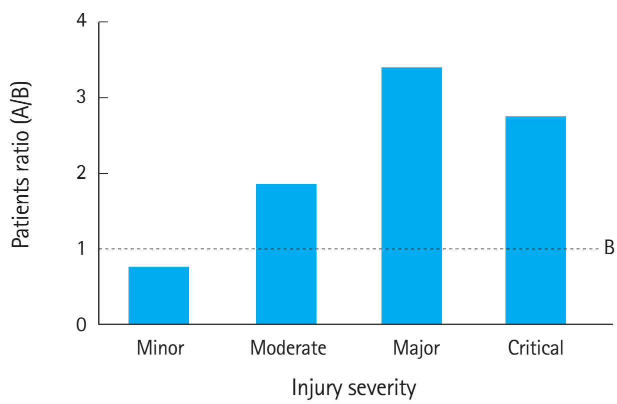

Fig. 1. Patient ratios in group A compared to group B are shown as A/B by Injury Severity Score category. Minor severity was 0.76, moderate severity was 1.89, major severity was 3.43, and critical severity was 2.77. In the rural area, the proportion of minor severity patients is lower than that of the urban area, but the proportion of patients classified as moderate, major or critical severity is higher.

greater the injury severity, the greater the difference between groups was (Table 5 and Fig. 1).

Variables associated with injury severity in both regions

Four variables (time, vehicle, seat location, and seat belts) that differed significantly between the two regions were subjected to regression analysis in order to determine the variables that most affected injury severity. R^2 was 0.016, and the explanatory power was low. Sitting on the driver's seat (P = 0.037) and wearing a seat belt (P < 0.001) were significantly associated with injury severity in both regions. Time and vehicle type did not show any significant correlations with injury severity (Table 6).

Table 6. Multiple regression analysis between the variables that differ between the two regions and the Injury Severity Score classification

Variable	Unstandardized coefficients		Standardized coefficients	t	P-value
	B	SE	β		
Time	0.021	0.045	0.012	0.468	0.640
Car type					
Group 1	-0.112	0.150	-0.056	-0.750	0.453
Group 2	-0.018	0.154	-0.009	-0.117	0.907
Group 3	Reference				
Seat location					
Driver	0.132	0.063	0.073	2.093	0.037
Assistant	0.052	0.073	0.024	0.716	0.474
Others	Reference				
Seat belt use	0.214	0.047	0.120	4.555	< 0.001

B, unstandardized coefficients; SE, standard error.

DISCUSSION

In South Korea, metropolitan areas account for 11.8% of the total land area and contain 50% of the population. Central management functions, industries, and universities are concentrated in metropolitan areas.[13] The city that group B was drawn from has the highest population density per unit area in Korea. Both regions were located on the East-West Expressway.

The rural city has a lower population and fewer annual ED visits than the urban city, but more patients were enrolled in the study. This could be explained by the fact that the number of hospitals in the urban city is larger than in the rural city, so there is likely to be a decentralized influence on the visiting patients. This is supported by the fact that the ratio of annual ED visits as a proportion of the city's overall population is lower in Bucheon compared to Wonju.

The two groups differed in the severity of injuries (Table 5). The risk of a mild injury was lower in the rural area, about 0.76 times that in the urban area; however, the risk of a severe injury was higher in the rural area by about 1.9 times for ISS ≥ 9, 3.4 times for ISS ≥ 15, and 2.8 times for ISS ≥ 25. These results suggest that injuries from traffic accidents are more serious in rural cities.

The degree of injury to a passenger in a traffic accident is affected by the characteristics of the vehicles, passengers, details of the accident, and the use of safety equipment.[14,15] In this study, accident time, vehicle type, seat location, and seat belt use differed significantly between accidents in the rural and urban areas. The accidents in rural areas tended to occur more often in the daytime and involve large vehicles, passengers in a seat other than the driver's seat, and no seatbelt use. It is possible that even though the traffic burden in the urban area is greater regardless of the time of day as more drivers commute by car, seatbelts are worn more often due to police crackdowns and greater safety awareness.

Death, disability due to physical injury, and financial loss from traffic accidents are serious social burdens. Seatbelts are the only safeguards that prevent serious injury in passenger traffic accidents.[16,17] In this study, not wearing a seat belt correlated significantly with a higher ISS (Table 3). In both regions, the rate of seatbelt use tended to be higher for patients in the driver's seat, and lower for those in the passenger seat or other seats (Table 4). In September 2018, it became mandatory for all passengers in South Korea to wear seatbelts, which will likely reduce overall traffic accident injury severity. However, it may be necessary to take additional measures to solve the traffic accident injury severity difference between regions because of the difference in the rate of seatbelt use between regions, regardless of which seat the passengers are in. Considering the lower rate of seatbelt use in the rural area, strengthening education and regulations related to safety devices such as seat belts may be very important.

This study had several limitations. First, it enrolled patients who visited an emergency medical center in one of two regions. Because patients who visited other medical institutions in the areas were not included, it is impossible to expand the results to all regional accidents. However, considering the roles of regional tertiary hospitals and medical emergency centers, our results are likely valid. Second, it is possible that patients with mild injuries did not visit a hospital. Because the regional center was selected as the target hospital, the selection error was believed to be small. Third, the study did not consider specific mechanical variables, such as collision speed. In human injury studies, variables such as speed cannot be measured easily because this requires cooperation between private sources of information and public institutions for specific vehicles.

In conclusion, our study found that the mean ISS was higher for accidents in a rural region than in an urban region, and these differences between the two regions increased with the ISS. Wearing seat belts was a major factor contributing to the difference in severity between the two regions studied. Further studies are needed to improve the regional difference in the severity of traffic accidents, and it is necessary to collect and analyze human injury data in more regions.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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