Original Article

J Trauma Inj 2023;36(2):121-127
https://doi.org/10.20408/jti.2022.0031

Journal of Trauma and Injury JTI

pISSN 2799-4317 • eISSN 2287-1683

Changes in incidence and severity of commercial motorcycle accidents due to the use of delivery service platforms in Korea: a retrospective cohort study

Dam Moon, MD[1], Jae Ho Jang, MD[1], Jin Seong Cho, MD[1], Jae Yeon Choi, MD[1], Jae-hyug Woo, MD[1], Woo Sung Choi, MD[1], Sung Yeol Hyun, MD[2], Seung Hwan Lee, MD[3]

[1]Department of Emergency Medicine, Gachon University Gil Medical Center, Gachon University College of Medicine, Incheon, Korea
[2]Department of Traumatology, Gachon University Gil Medical Center, Gachon University College of Medicine, Incheon, Korea
[3]Department of Trauma Surgery, Gachon University Gil Medical Center, Incheon, Korea

Received: June 14, 2022
Revised: August 5, 2022
Accepted: August 16, 2022

Correspondence to
Jae Ho Jang, MD
Department of Emergency Medicine,
Gachon University Gil Medical Center,
Gachon University College of Medicine,
21 Namdong-daero 774beon-gil,
Namdong-gu, Incheon 21565, Korea
Tel: +82-32-460-3901
Email: jhjang@gilhospital.com

Seung Hwan Lee, MD
Department of Trauma Surgery,
Gachon University Gil Medical Center,
21 Namdong-daero 774beon-gil,
Namdong-gu, Incheon 21565, Korea
Tel: +82-32-460-3010
Email: surgeonrumi@gmail.com

Purpose: Recently, a sharp increase in the use of delivery services has led to an increase in motorcycle accidents. This study aimed to identify the characteristics of the commercial motorcycle injured patients and factors related to the severity during the past 10 years.

Methods: Patients (15–64 years old) who visited the emergency department with commercial motorcycle accidents injury registered in the Korean Emergency Department-based Injury In-depth Surveillance (2011–2020) database, were included. All included cases were categorized into two groups according to the period: group 1 (2011–2015) and group 2 (2016–2020). General characteristics and the factors associated with severity were investigated.

Results: Among 8,123 emergency department visits, patients in group 1 were 3,071, and patients in group 2 were 5,052. The odds for severity were affected by patients age (odds ratio [OR], 1.008; 95% confidence interval [CI], 1.004–1.013), and overnight/morning (00:00–12:00; OR, 1.243; 95% CI, 1.091–1.415). The odds for severity were higher in head and neck injury (OR, 8.357; 95% CI, 7.410–9.424) and torso injury (OR, 4.122; 95% CI, 3.610–4.708). The odds for the severity of accidents based on excess mortality ratio-adjusted Injury Severity Score (EMR-ISS) after 2015 were significant (OR, 1.491; 95% CI, 1.318–1.687). Hospitalization in the intensive care unit and death were associated with accidents after 2015 (OR, 2.593; 95% CI, 2.120–3.170).

Conclusions: Commercial motorcycle accidents have increased significantly over the past decade. There were statistical differences in severity based on EMR-ISS and the hospitalization in intensive care unit and death.

Keywords: Motorcycles; Wounds and injuries; Injury Severity Score; Traffic accidents

INTRODUCTION

Korea is a country with one of the most advanced food delivery cultures in the world, which has been growing the development of a delivery service market in recent years [1]. These delivery services generally use motorcycles for deliveries [2].

Motorcycles move on two wheels, and as a result, they tend have higher accident rates and severities due to difficulty in maintaining balance, as compared to four-wheeled vehicles. Moreover, the structure of a motorcycle does not protect the driver upon impact, and thus, wearing equipment may affect severity. Because of such characteristics of motorcycles, motorcycle accidents have 34 times higher mortality rate and more than eight times higher incidence than regular automobile accidents [3,4].

According to a survey conducted by the Market Research Bureau of Korea Consumer Agency, the number of users since the introduction of delivery app platforms in 2010 has increased sharply from 870,000 in 2013 to 10.46 million in 2015 and 25 million in 2018 [5]. In the past, individual stores had their own delivery service; however, in recent years, there has been an increase in the number of delivery workers called "riders" who are managed by delivery platforms [6]. With such increasing trends in delivery services, motorcycle traffic accidents are also increasing. According to the Korea Road Traffic Authority, the number of motorcycle traffic accidents has increased recently, from 16,357 cases in 2012 to 20,898 cases in 2019 [7]. The severity of motorcycle accidents may vary depending on the speed, time of accident, and violation of traffic laws [8,9]. Meanwhile, active use of delivery services has created competition among the riders, and as a result, speeding and reckless driving in violation of laws are believed to affect the severity of accidents, which would also bring changes to the sites of injury. Moreover, such exponential growth in large platforms has also led to systematic management of individually operated motorcycle delivery businesses and gradual improvement in safety systems. In particular, regular safety education and recommendation for wearing proper equipment are being implemented through industrial safety and health guidelines [10].

Although there is an increasing trend in commercial motorcycle accidents due to the growth of delivery services, studies on this topic are still lacking. There are concerns that this increase in accidents is not just a temporary phenomenon and could become a serious problem with the accelerating expansion of a platform-based economy. This study investigated if the severity of accidents can be lowered by changes in driver awareness and rider management and safety education provided by platforms. Accordingly, the study aimed to identify whether there are changes in the incidence of commercial motorcycle accidents, severity of accidents, and sites of injury. For this objective, the authors investigated the 10-year trend in the incidence of commercial motorcycle accidents, changes in severity, and related factors.

METHODS

Ethics statements

The study was approved by the Institutional Review Board of Gachon University Gil Medical Center and received a waiver for participant consent form (No. GBIRB2022-102).

Study design

This study is a retrospective cohort study based on a chart review. This study used data from the Emergency Department-based Injury In-depth Surveillance (EDIIS), a part of the hospital-based injury surveillance system of Korea Disease Control and Prevention Agency (KDCA).

The study data was collected from the EDIIS registry and patients' medical records. The EDIIS was established by the KDCA in 2006. The number of participating hospitals in this surveillance has increased from five to 23 hospitals nationwide. A trained coordinator at each hospital registers the data for 246 variables in the KDCA online system, including patient demographics, injury-related profiles, prehospital records, diagnosis, disposition, and outcomes. The KDCA manages the quality of the input data through periodic error analyses.

The study retrospectively investigated patients who were admitted to an emergency department (ED) for a commercial motorcycle accident between January 2011 and December 2020. Upon confirmation of a sharp increase in the number of delivery app users since 2015, 10-year data were analyzed after dividing the period as before (group 1, 2011–2015) and after (group 2, 2016–2020) 2015. Data from a total 8,857 patients were collected for the study period, and of these, data from those aged ≥16 years, who can legally obtain a driving license for motorized bicycle, were used in the study. After excluding 12 patients with re-

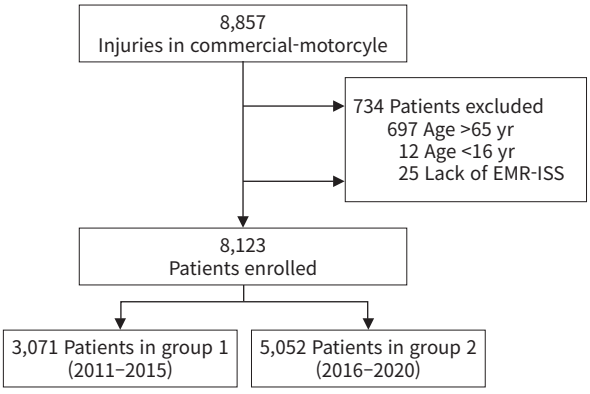

Fig. 1. Flow diagram of the patient selection and exclusion process. EMR-ISS, excess mortality ratio-adjusted Injury Severity Score.

https://doi.org/10.20408/jti.2022.0031

cording error and aged < 16 years, 25 patients with missing raw data, and 697 patients aged ≥ 65 years since economically active population is up to age of 64 years, data of 8,123 patients were used in the study (Fig. 1).

The general characteristics of the patients were identified through their age, sex, site of injury, time of injury, and with or without surgery. The time of injury was divided into two time periods considering the delivery service time: afternoon/ evening (working hours, 12:00–23:59) and overnight/morning (non-working hours, 00:00–11:59). The severity of injury was assessed using the excess mortality ratio-adjusted Injury Severity Score (EMR-ISS). EMR-ISS is derived using the S or T code in the International Classification of Diseases (ICD). Each diagnosis is graded on a scale of 1 to 5 points and the three codes with the highest scores, regardless of the body part, are scored and added: EMR-ISS = (first highest EMR grade)^2 + (second highest EMR grade)^2 + (third highest EMR grade)^2. The EMR-ISS was classified into four categories: mild (1 ≤ EMR-ISS ≤ 8), moderate (9 ≤ EMR-ISS ≤ 24), severe (25 ≤ EMR-ISS ≤ 74), and critical (EMR-ISS ≥ 75 or death). In this study, the scores were divided into two groups with 15 points as the cutoff. Whether the patients were wearing a helmet was determined and the treatment outcomes were classified as discharged to home, transferred to another hospital, admitted to general ward, admitted to intensive care unit (ICU), and death. Among the classified patients, those admitted to ICU and patients who died were classified as severe patients for reassessment of severity that was not assessed by EMR-ISS.

The site of injury was classified using ICD-10 code S according to the diagnosis based on the injury data investigated from patients who visited an ED. Codes consisted of S01–S19 for head and neck injury, S20–S39 for torso injury, S40–S69 for upper limb injury, and S70–S99 for lower limb injury.

For the statistical analyses, each variable was expressed as frequency and percentage. Continuous variables were expressed as mean and standard deviation or median and quartile, as needed. Categorical data were analyzed using chi-square test and continuous variables were analyzed using t-test. In addition, multivariate logistic regression analysis was performed to determine factors related to severe injury. Statistical significance was set to $P < 0.05$. Data were collected using a Microsoft Excel database (Microsoft Corp) and statistical analyses were performed using IBM SPSS ver. 23.0 (IBM Corp).

RESULTS

After classifying into group 1 and group 2, the demographic characteristics of patients who were admitted to our ED for commercial motorcycle accidents during the 10-year period were identified (Table 1). With respect to sex, the percentage of male patients was significantly higher with 95.1% (n = 2,921) and 97.0% (n = 4,901) in groups 1 and 2, respectively.

The mean age was similar with 36.01 ± 14.33 and 36.10 ± 13.27 years in groups 1 and 2, respectively. Meanwhile, the number of patients who were wearing a helmet at the time of accident increased from 1,682 in group 1 (54.7%) to 4,108 in group 2 (81.3%).

The time of accident was investigated by dividing the time into two groups in consideration of when delivery services are mostly used. Time was divided in peak hours and other hours. The number of accidents that occurred during 12:00 to 23:59 and 00:00 to 11:59 were 2,287 (74.5%) and 784 cases (25.5%), respectively, in group 1, and 3,876 (76.7%) and 1,176 cases (23.3%), respectively, in group 2.

Based on EMR-ISS, which was used as a scale for assessing the severity of injury, group 1 had 2,079 mild cases (67.7%) and 992 severe cases (32.3%), while group 2 had 3,073 mild cases (60.8%) and 1,979 severe cases (39.2%). Of these, the number of patients requiring surgery increased from 236 in group 1 (7.7%) to 721 in group 2 (14.3%).

In group 1, 2,007 patients (65.3%) were discharged to home from ED, 182 patients (5.9%) were transferred to another hospital, 669 patients (21.8%) were admitted to the general ward, 190 patients (6.2%) were admitted to ICU, and 23 patients (0.7%) died in the ED. In group 2, 3,294 patients (65.2%) were discharged to home from ED, 252 patients (5.0%) were transferred to another hospital, 868 patients (17.2%) were admitted to the general ward, 602 patients (11.9%) were admitted to ICU, and 36 patients (0.7%) died.

Multivariate logistic regression analysis was performed to identify the factors that increase the severity of commercial motorcycle accidents (Table 2). Statistical analysis was performed using variables that showed statistical significance in univariate logistic regression analysis and other variables that the researchers believed must be included. Of these, sex did not show a statistically significant difference. The severity tended to increase by 1.008 times as age increased by one year (95% confidence interval [CI], 1.004–1.013). The severity of injury was 1.243 times higher during overnight/morning, as compared to afternoon/evening (95% CI, 1.091–1.415).

Severity increased by 1.491 times in group 2, as compared to group 1 (95% CI, 1.318–1.687). With respect to the site of injury, severity was 8.357 times higher for head and neck injury (95%

Table 1. Characteristics of commercial motorcycle accidents that visited ED in 10 years

Characteristic	Group 1[a] (n=3,071)	Group 2[b] (n=5,052)	P-value
Sex			<0.001
Male	2,921 (95.1)	4,901 (97.0)	
Female	150 (4.9)	151 (3.0)	
Age (yr)	36.01±14.33	36.10±13.27	<0.001
Helmet use	1,682 (54.8)	4,108 (81.3)	<0.001
Time of the accident			0.064
12:00–23:59	2,287 (74.5)	3,876 (76.7)	
00:00–11:59	784 (25.5)	1,176 (23.3)	
EMR-ISS			<0.001
Mild (<15)	2,079 (67.7)	3,073 (60.8)	
Severe (≥15)	992 (32.3)	1,979 (39.2)	
Operation case	236 (7.7)	721 (14.3)	<0.001
ED result			<0.001
Discharge	2,007 (65.4)	3,294 (65.2)	
To ward	669 (21.8)	868 (17.2)	
To intensive care unit	190 (6.2)	602 (11.9)	
Transfer	182 (5.9)	252 (5.0)	
Death	23 (0.7)	36 (0.7)	
Injury			
Head and neck	1,150 (37.4)	1,764 (34.9)	0.021
Torso	607 (19.8)	1,278 (25.3)	<0.001
Upper limb	848 (27.6)	1,800 (35.6)	<0.001
Lower limb	1,209 (39.4)	2,451 (48.5)	<0.001

Values are presented as number (%) or mean ± standard deviation.
ED, emergency department; EMR-ISS, excess mortality ratio-adjusted Injury Severity Score.
[a]Accidents from 2011 to 2015; [b]Accidents from 2016 to 2020.

Table 2. Multivariate logistic regression analysis of factors contributing to the severity of injury associated with commercial motorcycle accidents

Variable	Odds ratio	95% Confidence interval	P-value
Sex	1.013	0.751–1.365	0.933
Age	1.008	1.004–1.013	<0.001
Time			
00:00–11:59	1.243	1.091–1.415	0.001
12:00–23:59	Reference		
No helmet use	1.476	1.284–1.696	<0.001
Injury			
Head and neck	8.357	7.410–9.424	<0.001
Torso	4.122	3.610–4.708	<0.001
Upper limb	1.657	1.470–1.867	<0.001
Lower limb	1.466	1.303–1.648	<0.001
Group 2[a]	1.491	1.318–1.687	<0.001

[a]Accidents from 2016 to 2020.

CI, 7.410–9.424) and 4.122 times higher for torso injury (95% CI, 3.610–4.708).

Multivariate logistic regression analysis was performed to identify the factors leading to ICU admission and death in commercial motorcycle accident cases (Table 3). With respect to age, based on the age of 16 years, increase in age by 1 year caused ICU

https://doi.org/10.20408/jti.2022.0031

Table 3. Multivariate logistic regression analysis of factors contributing to the intensive care unit and death associated with commercial motorcycle accidents

Variable	Odds ratio	95% Confidence interval	P-value
Sex	1.190	0.771–1.838	0.432
Age	1.012	1.006–1.018	<0.001
Time			
00:00–11:59	1.102	0.913–1.329	0.311
12:00–23:59	Reference		
No helmet use	2.100	1.739–2.535	<0.001
Injury			
Head and neck injury	1.428	1.206–1.690	<0.001
Torso injury	1.818	1.537–2.165	<0.001
Upper limb injury	0.302	0.243–0.376	<0.001
Lower limb injury	0.291	0.239–0.354	<0.001
Group 2[a)]	2.593	2.120–3.170	<0.001

[a)]Accidents from 2016 to 2020.

admission or death to increase by 1.012 times (95% CI, 1.006–1.018). ICU admission or death increased by 2.593 times in group 2, as compared to group 1 (95% CI, 2.120–3.170).

DISCUSSION

Since 2000, single-person households have become a common household type, increasing sharply from 15.5% in 2000 to 23.9% in 2010; this proportion is expected to increase to 31.3% in 2025 [11]. With the increase in single-person households, the frequency of delivery service use has also increased, while food delivery culture has increased over twofold due to coronavirus disease 2019, thus becoming a global service industry [12]. Since the introduction of delivery platforms, the number of its users has increased sharply, and consequently, the commercial use of motorcycles has also increased. This study, which used injury data of ED patients, also confirmed such increase in the past 10 years (Fig. 2). There have not been many studies investigating the increase in delivery service use and changes in motorcycle accidents in the past 10 years. Byun et al. [13] reported on the general characteristics of commercial motorcycle accident victims, including their sex, age, time of accident, work background, and site of injury, for the period till 2015; however, they did not identify the changing trends in motorcycle accidents.

The comparison of the severity of accidents before and after 2015 using EMR-ISS revealed significant results. It is possible that result of increased speeding and traffic law violations due to intensifying competition in commercial motorcycles. Despite the efforts of delivery platforms to prevent accidents, results contrary to our initial expectations were derived. Accordingly, we determined that the policies implemented by delivery service platforms have not been successful.

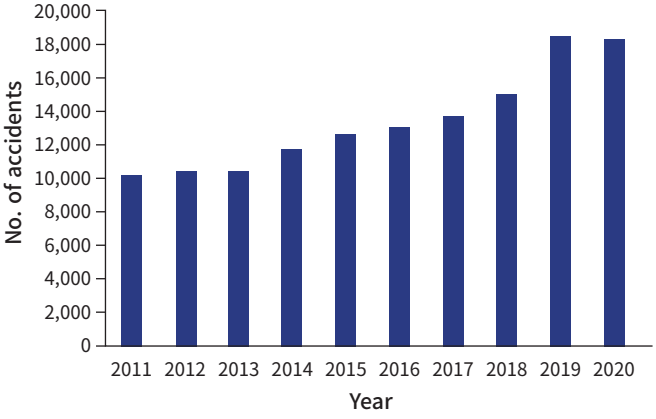

Fig. 2. Number of commercial motorcycle accidents in 10 years.

EMR-ISS can be a suitable tool for identifying severity from large-scale data [14]. However, although ISS may indicate the severity of anatomical injury, it has the limitations of not reflecting physiological indicators and not representing severity in anatomical sites in cases involving multiple injuries [15]. Accordingly, the authors of this study recognized the limitations of using EMR-ISS. When a motorcycle accident patient admitted to ED must immediately undergo surgery to treat the most urgent injuries, problems in other areas could be diagnosed or detected later on, and problems not diagnosed in ED are not reflected in the score. The data used in this study identified EMR-ISS of patients admitted to ED, and this score system, which uses three different scores, has limitations in reflecting the severity of patients' inju-

ries. Accordingly, ICU admission and death were investigated as another scale for assessment of severity (Table 3). Such standard was applied because there may be sites of injury not detected during the process of identifying severity based on diagnosis and the physiological condition of the patient may not be fully accounted for. Statistical data that can differentiate patients admitted to ICU as an indicator of the anatomical and physiological conditions of the patient can be meaningful. In this study, both the EMR-ISS and ICU admissions showed significant increases, but the ICU hospitalization results showed a high odds ratio. The authors considered these results that hospitalization decisions for trauma patients are not objective because they depend on the physician's opinion.

Wearing a helmet in a motorcycle accident affects ICU admission, consciousness at admission, and mortality rate, while its importance continues to be emphasized [16]. Logistic regression analyses in this study showed that the percentage of severe patients did not change significantly in groups 1 and 2, but wearing a helmet reduced the severity. With the development of the delivery service industry, the need to manage motorcycle riders has emerged and the rate of wearing a helmet is increasing due to active management (Fig. 3). However, the fact that the percentage of severe patients has not changed requires further examination. Such results demonstrate the importance of having full-body protective equipment, as well as wearing a helmet, in a motorcycle accident. While the need for full-body protective equipment and clothing in motorcycle accidents is being emphasized, there are advances in protective equipment for different parts of the body. de Rome et al. [17] conducted a study in 2011 on hospitalization rate and sites of injury according to wearing equipment other than helmet. Injury risk was compared by jackets, gloves, pants, and boots for different parts of the body and the results showed decrease of 0.77, 0.55, 0.61, and 0.55 times, respectively [17]. Therefore, studies on protective equipment other than helmet should continue in the future.

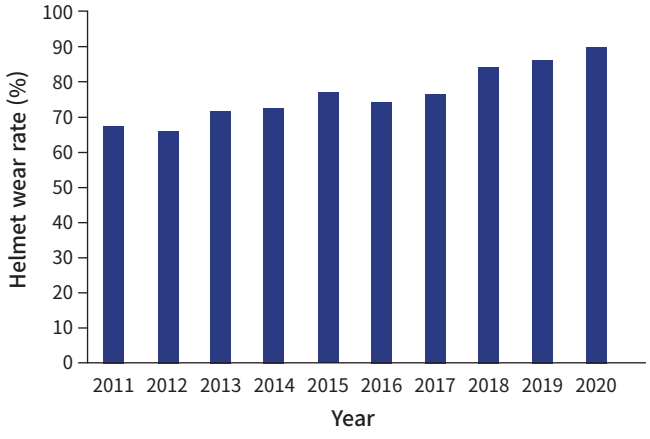

Fig. 3. Helmet wear rates in 10 years.

A 2016 study by Xiong et al. [18] reported that accidents occurring during 00:00 to 06:00 increased in severity by 2.45 times. As shown in Table 1, the findings in this study showed that the number of accidents during the afternoon was higher by approximately three times or more than at other times. However, the results in Tables 2 and 3 show that severity was higher in accidents that occurred during overnight hours, rather than in the afternoon, with higher number of cases. During overnight hours, competition among riders may be more severe due to fewer delivery cases, and accidents with more severe injuries occur as riders travel at higher speeds on empty roads. During overnight hours, driving through dark areas with poor lighting and frequent traffic violations, such as speeding, signal violations, and lane violations, may have affected the severity of accidents. Although the number of accident cases may be low, medical and policy plans must be established in consideration of physical and economic damages caused by an accident and its severity.

This study had some limitations. First, while advancement of delivery platforms may have influenced motorcycle accidents, the time point of such advancement is unclear. Second, this study investigated only patients who were admitted to ED, and not all admitted patients. Therefore, there is a lack of statistics on patients who died at the scene of the accident or were transferred from another hospital. Lastly, underlying diseases may have affected the prognosis and treatment outcomes of accident victims. However, despite such limitations, the significance of this study was that it used a considerable amount of data accumulated over 10 years to examine the trends. Additionally, the findings of the study can be helpful for future studies on commercial motorcycle accidents.

Since a sharp increase in the use of delivery services, motorcycle accidents have increased. There was increased severity based on EMR-ISS and severity based on ICU admission and death. Safety management and education by large platforms and implementation of systematic upgrades by the government can gradually improve the results with respect to commercial motorcycle accidents in the future. With the increasing development of the platform-based delivery industry, further investigation and studies are needed on factors that affect severity of accidents.

https://doi.org/10.20408/jti.2022.0031

NOTES

Conflicts of interest
The authors have no conflicts of interest to declare.

Funding
None.

Data sharing statement
The data of this article are available from the corresponding author upon reasonable request.

Acknowledgments
This research was supported by the research of Korea Disease Control and Prevention Agency (KDCA).

Author contributions
Conceptualization: SHL, JHJ, SYH; Methodology: DM, SHL, JHJ, JSC; Data curation: DM, JYC; Formal analysis: JSC, JW, JHJ; Writing–original draft: DM, JHJ; Writing–review & editing: all authors. All authors read and approved the final manuscript.

REFERENCES

1. Kwon J, Kim S, Park E, Song J. A study on the number of domestic food delivery services. Korean J Appl Stat 2015;28:977–90.
2. Choi EJ. Current situation of food delivery O2O platform industry and policy suggestions. J Channel Retail 2021;26:171–97.
3. Lin MR, Kraus JF. A review of risk factors and patterns of motorcycle injuries. Accid Anal Prev 2009;41:710–22.
4. Talving P, Teixeira PG, Barmparas G, et al. Motorcycle-related injuries: effect of age on type and severity of injuries and mortality. J Trauma 2010;68:441–6.
5. Kim MJ. Delivery service platform (app) consumer problem survey. Korea Consumer Agency; 2019.
6. Song JW. An effect of food delivery App service convenience of rising-generation single households on the continuous use intention: focusing on moderating effect of willingness to pay delivery App service charge. Foodserv Ind J 2019;15:161–76.
7. Lee JS. Improvement of delivery motorcycle traffic safety. Mon KOTI Mag Transp 2020;269:24–9.
8. Chung Y, Song TJ, Yoon BJ. Injury severity in delivery-motorcycle to vehicle crashes in the Seoul metropolitan area. Accid Anal Prev 2014;62:79–86.
9. Oh P, Cho JS, Jang JH, Choi JY, Choi WS, Yu B. Impact of obesity on the severity of trauma in patients injured in pedestrian traffic accidents. J Trauma Inj 2022;35:240–1.
10. Kim SG. Safety and health system for the protection of workers in special employment types: platform labor and occupational health. Ind Health 2019;373:13–26.
11. Kang EN, Lee MH. Single-person households in South Korea and their policy implications. Health Welf Policy Forum 2016;234:47–56.
12. Kim J, Lim S. An analysis of delivery and take-out food consumption according to household type. J Converg Inf Technol 2021;11:327–34.
13. Byun JH, Jeong BY, Park MH. Characteristics of motorcycle crashes of food delivery workers. J Ergon Soc Korea 2017;36:157–68.
14. Kim J, Shin SD, Im TH, et al. Development and validation of the excess mortality ratio-adjusted Injury Severity Score using the International Classification of Diseases 10th Edition. Acad Emerg Med 2009;16:454–64.
15. Hwang JY, Lee KH, Shin HJ, Cha KC, Kim H, Hwang SO. Correlation analysis of trauma scoring system in predictive validity in motor vehicle accident. J Korean Soc Emerg Med 2011;22:329–34.
16. Patel PB, Staley CA, Runner R, Mehta S, Schenker ML. Unhelmeted Motorcycle riders have increased injury burden: a need to revisit universal helmet laws. J Surg Res 2019;242:177–182.
17. de Rome L, Ivers R, Fitzharris M, et al. Motorcycle protective clothing: protection from injury or just the weather? Accid Anal Prev 2011;43:1893–900.
18. Xiong L, Zhu Y, Li L. Risk factors for motorcycle-related severe injuries in a medium-sized city in China. AIMS Public Health 2016;3:907–22.