

# Changes in the characteristics of trauma patients after the early COVID-19 outbreak

## A retrospective study of a regional level 1 trauma center in Republic of Korea

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### Abstract

Gyeonggi-do (Gyeonggi province) has the second highest number of coronavirus disease (COVID-19) cases in the Republic of Korea after Seoul, with approximately 25% of the COVID-19 patients as of January 2021. Our center is a level I trauma center located in south Gyeonggi-do, and we aimed to evaluate whether the characteristics of trauma patients changed after the COVID-19 pandemic.

We retrospectively reviewed the trauma patients registered with the Korea Trauma Database of the Center from February 2019 to January 2021. The patients were dichotomized into pre-coronavirus disease (pre-COVID) and coronavirus disease (COVID) groups, and their trauma volumes, injury characteristics, intentionality, and outcomes were compared.

A total of 2628 and 2636 patients were included in the pre-COVID and COVID groups, respectively. During the COVID-19 period, motorcycle accidents, bicycle accidents, and penetrating injury cases increased, and pedestrian traffic accidents, slips, and injury by machines decreased. The average daily number of patients in the COVID group was lower in March ( $5.6 \pm 2.6/\text{day}$  vs  $7.2 \pm 2.4/\text{day}$ ,  $P = .014$ ) and higher in September ( $9.9 \pm 3.2/\text{day}$  vs  $7.7 \pm 2.0/\text{day}$ ,  $P = .003$ ) compared to the pre-COVID group. The COVID group also had a higher ratio of direct admissions (67.5% vs 57.2%,  $P < .001$ ), proportion of suicidal patients (4.1% vs 2.7%,  $P = .005$ ), and injury severity scores (14 [9–22] vs 12 [4–22],  $P < .001$ ) than the pre-COVID group. The overall mortality (4.7% vs 4.9%,  $P = .670$ ) and intensive care unit length of stay (2 [0–3] days vs 2 [0–4] days,  $P = .153$ ) was not different between the 2 groups.

Although the total number of patients did not change, the COVID-19 pandemic affected the number of monthly admissions and the injury mechanisms changed. More severely injured patients were admitted directly to the trauma center.

**Abbreviation:** COVID = coronavirus disease.

**Keywords:** coronavirus disease, epidemiology, pandemic, trauma

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The study protocol was approved by the Ajou Institutional Review Board (AJIRB-MED-MDB-21-041) and followed the latest Declaration of Helsinki (2013).

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The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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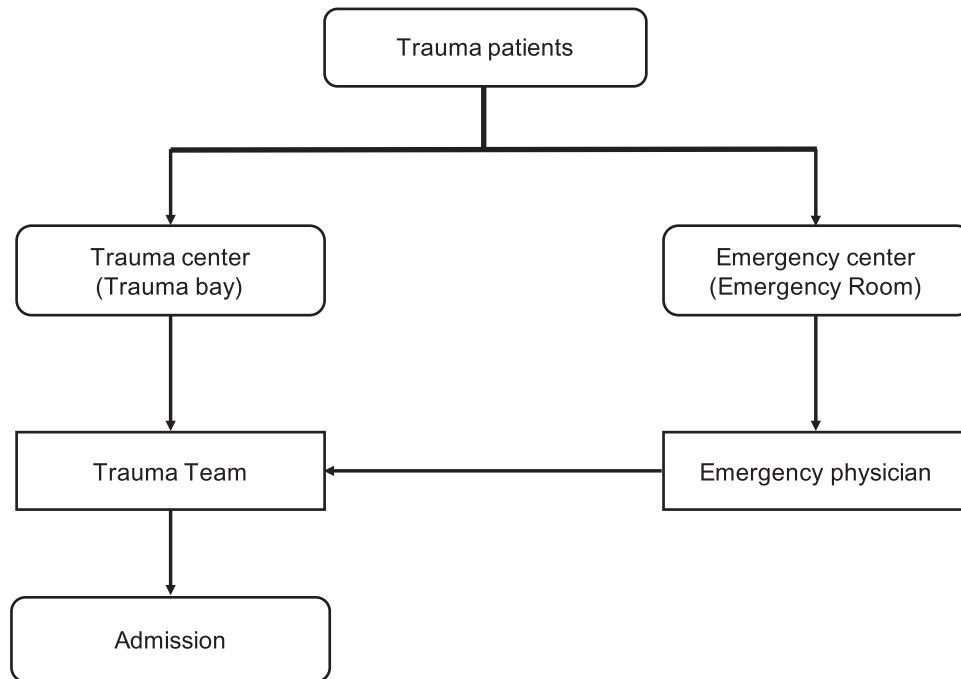
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## 1. Introduction

After the identification of the first case in Wuhan, China in December 2019, coronavirus disease (COVID-19) affected the whole world, with more than 100 million confirmed cases and 2.5 million deaths. Many governments responded to this catastrophic pandemic with various policies and legal actions, such as quarantines and the lockdown of boundaries. Considering the direct influence of COVID-19 on infected patients and their families, many reports have been published covering the indirect influence of the pandemic in the field of trauma, such as a decrease in motor vehicle crash,<sup>[1]</sup> an increase in alcoholism<sup>[2]</sup> and suicide attempts,<sup>[3]</sup> and changes in trauma volume.<sup>[4,5]</sup>

Since the first domestic confirmation of COVID-19 on January 20, 2020, the Republic of Korea has been one of the countries with an early inflow and spread of COVID-19. The government has developed various policies to prevent the transmission of the virus, including quarantines and social distancing levels. However, despite various efforts, COVID-19 has spread throughout the country. Gyeonggi-do (Gyeonggi province) is the province with the second highest prevalence of COVID-19 after Seoul, and Ajou University Trauma Center is a level 1 trauma center that covers southern Gyeonggi-do. We hypothesized that the COVID-19 outbreak in Gyeonggi-do may have changed the trauma volume and trends experienced by the trauma center. We also investigate whether COVID-19 affected



**Figure 1.** Patients' admission pathways in Ajou trauma center via the trauma bay and the emergency room.

the overall performance and primary outcome of the level 1 trauma center.

## 2. Methods

### 2.1. Patients

Trauma patients registered with the Korea Trauma Data Bank (KTDB) from February 2019 to January 2021 in Ajou Trauma Center were reviewed retrospectively. The center is a level I regional trauma center located in Suwon, South Gyeonggi-do. The KTDB is utilized by all the regional trauma centers to collect data from all trauma admissions, including prehospital data, demographic information, clinical characteristics, and outcomes. Patients admitted to the outpatient clinic were excluded.

In our center, there are 2 entrances for admission: via the trauma bay or the emergency room (ER). Whether a patient should enter via the trauma bay or the ER is decided by an emergency squad following the 4 steps of trauma field triage, which includes physiologic, anatomical, and mechanism criteria and special considerations (Supplemental Digital Content S1, <http://links.lww.com/MD/G584>). In the trauma bay, the patient is examined initially by the trauma surgeon who plays the role of a gatekeeper. In the ER, the emergency physician examines the patient initially and then refers the patient to the trauma team, if needed (Fig. 1).

As a consequence of the COVID-19 outbreak, patient triage protocols changed in the ER, but there were no changes in the trauma bay. In the ER, there was an additional screening process for patients with body temperatures higher than 37.5°C or upper respiratory infection symptoms before they met with the emergency medical doctors. In emergency situations, they were moved to isolated units, but the number of these units was limited.

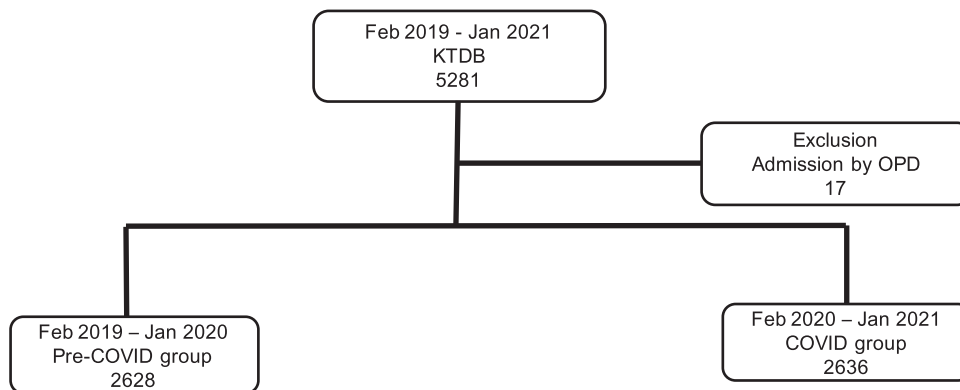
### 2.2. Methods

The first case of COVID-19 in Republic of Korea was confirmed on January 20, 2020. The daily number of cases was less than a dozen and the influence was not evident in January 2020. However, the first breakout of more than a thousand of confirmed cases occurred in Daegu, a city with a population of more than a million, located 240 km from Seoul in February 2020. Though the number of confirmed cases of COVID-19 was not high, the effect of COVID-19 on the emergency medical system in Republic of Korea was significant from the early stages. Hence, patients were included from February and dichotomized to the pre-COVID group (February 2019–January 2020) and the COVID group (February 2020–January 2021) (Fig. 2).

The study was done conducted in a single level 1 trauma center in Ajou medical center, which is located in southern Gyeonggi-do, where more than 2500 trauma patients admitted annually. Demographics, initial vital signs, routes of admission, injury intentionality, injury characteristics and patterns, prehospital times, and hospital times to admission were compared between the pre-COVID and COVID groups. The monthly number of patients was compared between the 2 groups and with the national status.

### 2.3. Statistical analysis

Continuous variables are presented as means  $\pm$  standard deviations or medians [interquartile ranges] and were compared using the Student *t* test or the Mann–Whitney *U* test after testing for normality. The categorical variables are presented as numbers (percentiles) and were compared using the Chi-Squared test. All the statistical analyses were performed using SPSS version 25.0 (IBM Corp, Armonk NY, USA).



**Figure 2.** The number of patients in the pre-COVID and COVID-groups after the application of the exclusion and inclusion criteria. COVID = coronavirus disease.

### 3. Results

#### 3.1. Patient characteristics and demographics

After excluding 17 patients who were admitted to the outpatient clinic, 2628 and 2636 patients were included in the pre-COVID and COVID groups, respectively, indicating that there were 8 more patients than the previous year. The COVID group had a higher proportion of direct admissions, admissions via the trauma bay, and suicidal attempt patients. Among the injury mechanisms, motorcycle accidents, bicycle accidents, penetrating injury cases increased, while pedestrian traffic accidents, slips, and injury by machines statistically decreased. Fall was the most common mechanism of injury in both groups (Table 1).

Compared with the pre-COVID group, the COVID group had a lower daily average number of patients in March 2020 ( $7.2 \pm 2.4$  persons/day vs  $5.6 \pm 2.6$  persons/day,  $P = .014$ ) and a higher number in September 2020 ( $7.7 \pm 2.0$  persons/day vs  $9.9 \pm 3.2$  persons/day,  $P = .003$ ) (Fig. 3). The first wave of the COVID-19 pandemic occurred in Gyeongsangbuk-do in March, which was far from our trauma center, and the second wave occurred in late August in Seoul and Gyeonggi-do (Fig. 4). The third wave of the COVID-19 pandemic started in November around Seoul and Gyeonggi-do and is ongoing.

#### 3.2. Clinical primary outcome

The COVID group had higher injury severity scores but the number of patients with an Abbreviated Injury Scale score of 3 (serious) and higher showed were not different between the pre-COVID and COVID groups except for the thorax. Mortality and intensive care unit (ICU) length of stay (LOS) were not significantly different between the 2 groups (Table 2).

#### 3.3. Stay time before admission

Among patients who were directly admitted to the trauma bay, prehospital time (from injury to admission) increased in the COVID group compared to the pre-COVID group (44 [32–61] minutes vs 51 [37–67] minutes,  $P < .001$ ). The median hospital stay duration was not significantly different between the 2 periods; however, the subgroup comparisons showed different results. The stay times in both the trauma bay and ERs increased. Especially in the ER, which increased by approximately 40 minutes during the COVID-19 period (Table 3). Admissions to

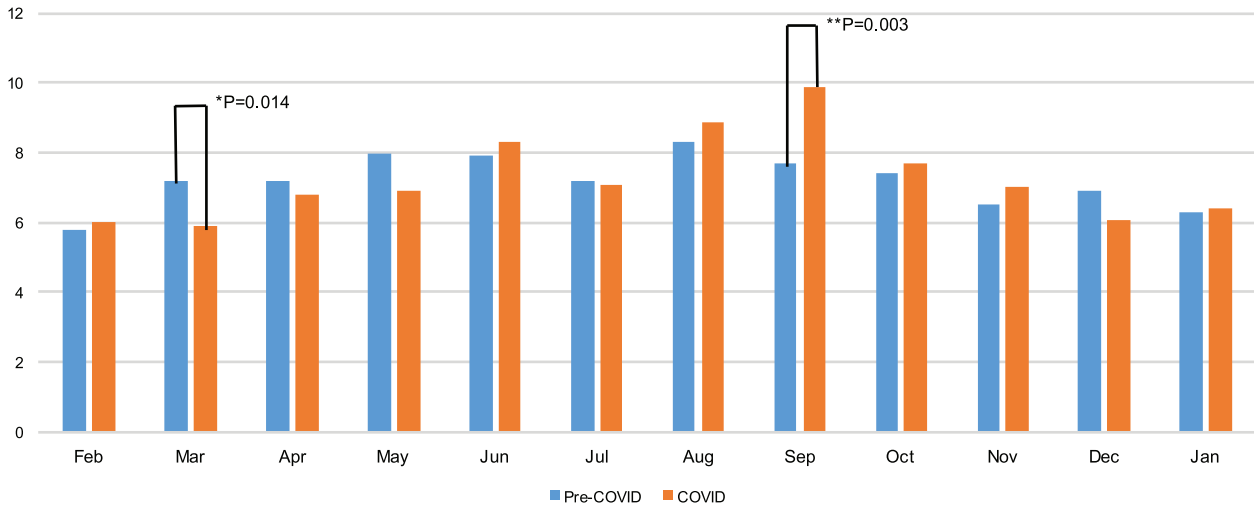
the general ward were excluded because those admissions were confirmed after the COVID-19 test results were obtained.

### 4. Discussion

The global COVID-19 pandemic has changed every aspect of our society from daily life to the clinical field. Currently, the burden of COVID-19 is growing rapidly; however, a decrease in trauma volume and trauma team activation has been reported in many

**Table 1**  
Patients' characteristics.

	Pre-COVID (n = 2628)	COVID (n = 2636)	P
Age (y)	51 [32–64]	52 [35–65]	.053
Sex, Male (%)	1876 (71.4%)	1901 (72.1%)	.555
Initial vital sign			
Systolic blood Pressure (mm Hg)	137 [120–154]	138 [122–154]	.352
Heart rate (/min)	86 [76–100]	86 [75–101]	.652
Body temperature (°C)	36.5 [36.2–36.8]	36.7 [36.2–37.1]	<.001
Glasgow coma scale	15 [14–15]	15 [14–15]	.537
Route of admission			
Direct	1503 (57.2%)	1778 (67.5%)	<.001
Transfer	1125 (42.8%)	858 (32.5%)	
Entrance			
Trauma bay	1739 (66.2%)	1998 (75.8%)	<.001
Emergency room	889 (33.8%)	638 (24.2%)	
Intend of injury			
Accident	2350 (89.4%)	2270 (86.1%)	.952
Suicide	71 (2.7%)	109 (4.1%)	.005
Homicide	56 (2.1%)	73 (2.8%)	.159
Unspecified	151 (5.7%)	184 (7.0%)	.075
Mechanism of injury			
Fall	617 (23.5%)	647 (24.5%)	.382
Slip down	439 (16.7%)	315 (13.1%)	<.001
Motor vehicle crash	246 (9.4%)	330 (12.5%)	<.001
Pedestrian accident	372 (14.2%)	299 (11.3%)	.003
Motorcycle crash	246 (9.4%)	330 (12.5%)	<.001
Bicycle crash	84 (3.2%)	116 (4.4%)	.027
Struck	169 (6.4%)	195 (7.4%)	.184
Penetrating	139 (5.3%)	175 (6.6%)	.045
Machine	71 (2.7%)	38 (1.4%)	.002
Other	44 (1.7%)	39 (1.5%)	.648
Unspecified	64 (2.4%)	75 (2.8%)	.400

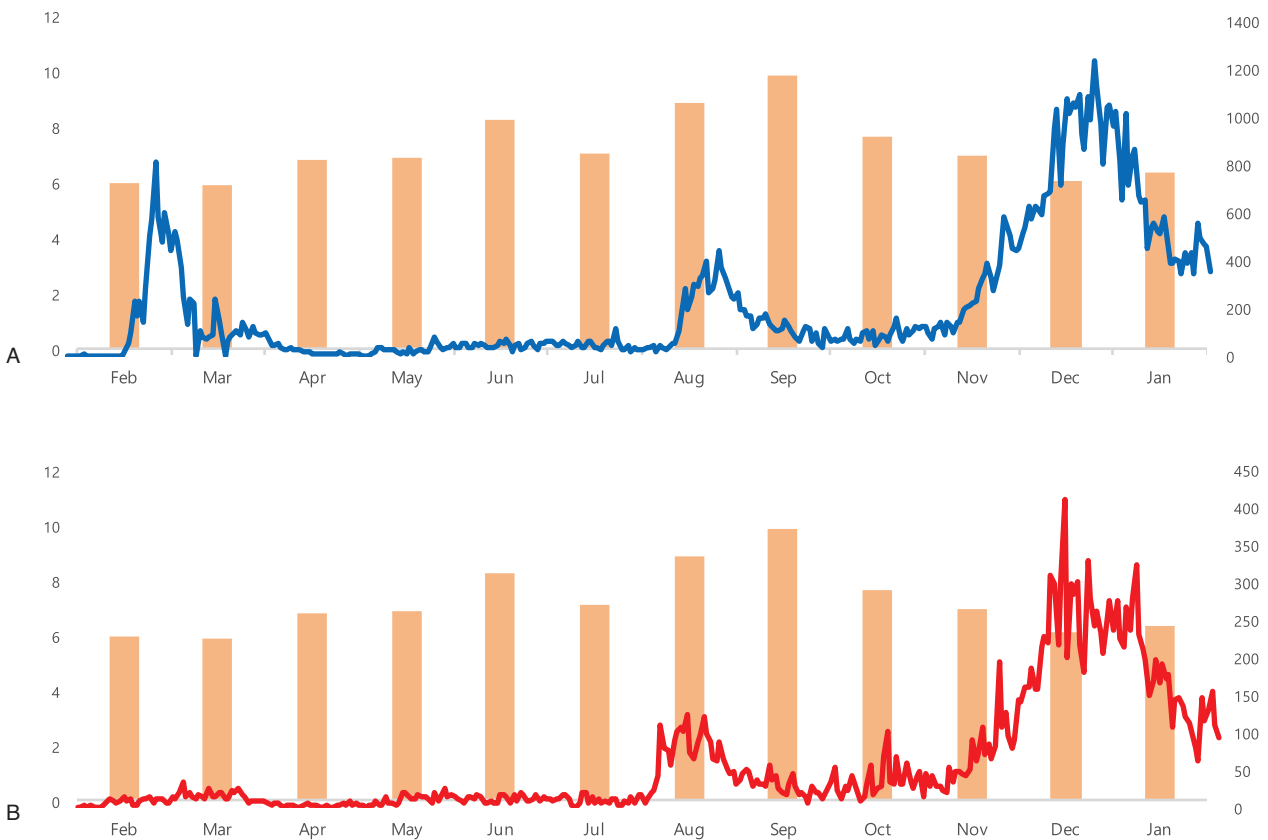


**Figure 3.** Comparison of the daily average number of patients (n, y axis) on monthly basis (month, x axis) between the pre-COVID and COVID groups. COVID = coronavirus disease.

countries.<sup>[4,5]</sup> While the major reasons may be the voluntary decrease in traffic and the preventive measure policies adopted by governments,<sup>[5]</sup> this could also be caused by the reluctance of patients without COVID-19 to visit hospitals and emergency

departments, although this may be less likely to apply to major trauma patients.<sup>[6]</sup>

Unlike most previous reports, our study revealed that the total number of trauma patients admitted to our center was similar



**Figure 4.** (A) Blue line: Diachronic change of the number of daily confirmed COVID-19 cases in Republic of Korea, Orange bar: Overlapping the daily average number of patients admitted to Ajou trauma center. (B) Red line: Diachronic change of the number of daily confirmed COVID-19 confirmation cases in Gyeonggi-do. Orange bar: Same as (A). COVID = coronavirus disease.

**Table 2**  
**Clinical outcome.**

	Pre-COVID (n = 2628)	COVID (n = 2636)	P
Abbreviated injury scale (n[%])			
Head $\geq 3$	692 (26.3%)	743 (28.2%)	.131
Face $\geq 3$	9 (0.3%)	6 (0.2%)	.434
Thorax $\geq 3$	1070 (40.7%)	1381 (52.4%)	<.001
Abdomen $\geq 3$	301 (11.5%)	311 (11.8%)	.697
Extremity $\geq 3$	537 (20.4%)	596 (22.6%)	.055
Injury severity score (ISS)	12 [4–22]	14 [9–22]	<.001
ISS > 15 (n[%])	1094 (41.6%)	1251 (47.5%)	<.001
Mortality	4.9%	4.7%*	.670
ICU LOS (d)	2 [0–4]	2 [0–3]*	.153

ICU LOS = Intensive Care Unit Length of Stay.

\* 80 patients in COVID group were excluded because of incomplete data.

before and during the COVID-19 period. Although the number of trauma patients decreased during the first outbreak in March, as expected, the number of patients increased during the second outbreak. The number of patients seemed to decrease during the third outbreak, but there was no significant difference compared to pre-COVID-19 period. Although the number of direct visits to trauma centers increased significantly, the proportion of transferred patients decreased during the COVID-19 period. The government of Republic of Korea announced the new policies for quarantine and public guidelines in 2019; however, there were no specific instructions issued for clinicians and medical centers. Therefore, ER of local hospitals, without isolation rooms, were instructed to refuse patients who had a fever or any other symptoms that mimicked COVID-19. We could not find any actual evidence of refusals for this study and were only able to conclude this based on the paramedic's statements during the outbreak. In addition, the prehospital time increased for patients who visited the trauma bay directly. This may be interpreted as more trauma patients being centralized to the trauma center bypassing the other hospitals. It was not known whether other hospitals refused to admit patients of unknown COVID-19 status; however, it may have been a burden to examine obtunded or febrile patients in hospitals other than at our center. Since the Injury Severity Score was higher in the COVID group, this phenomenon might have been an unexpected positive effect of COVID-19. Similarly, triage and management did not change at the trauma bay because personal protective equipment was required even before the COVID-19 pandemic, unlike in the ER, where an additional screening process was implemented, resulting in an increase in the number of patients admitted via the trauma bay rather than via the ER. Sometimes, patients who

**Table 3**  
**Stay time of trauma bay or emergency room. Admission to general ward were excluded, because another process for COVID status was made after epidemic.**

	Pre-COVID (n = 1741)	COVID (n = 1855)	P
Stay time (min)			
Total	35 [26–50]	36 [27–50]	.174
Trauma bay	33 [25–43] (n = 1517)	35 [26–45] n = (1689)	<.001
Emergency room	234 [170–327] (n = 224)	276 [197–434] n = (166)	.001

did not satisfy the field triage were admitted via the trauma bay when the isolation unit in the ER was not available.

There are 2 separate sections in the trauma bay of our center, which enables us to accommodate 2 new patients simultaneously. Each trauma bay bed has a hepa-filter and a 35 minute disinfection process was performed after any case of unknown contact history or suspicious radiologic findings. If three or more patients came in simultaneously, stable patients were allocated to the observation bay with 4 beds. After the initial resuscitation, the patients were moved to an operating room or ICU. There were 10 isolated beds among 40 trauma ICU beds, and three of the 10 beds had negative pressure ventilation systems. We allocated the patients with no information of contact history, unclear chest x-ray or computed tomography (CT) scans, or body temperatures higher than 37.5°C to the isolated beds. We allocated patients who had contact history with confirmed cases or showed more suspicious radiologic findings, such as ground glass opacities or pneumonia consolidation, to the negative pressure ventilation system. Our center's internal policy for the confirmed cases was to process emergency operations in an operating room with a separate air conditioning system and transfer patients to the designated public hospital for COVID-19 after stabilizing them; however no confirmed COVID-19 case was found during the study period. Every staff member in our trauma center was obligated to wear 5 kinds of personal protective equipment (gown, glove, hair cap, goggle, mask) until the patients were confirmed negative with a polymerase chain reaction examination (gene TM test, SG medical, Seoul).

According to previous studies, the injury mechanisms have changed after COVID-19. Chodos et al reported that penetrating trauma increased significantly during COVID-19, and other mechanisms, including falls and motor vehicle accidents, showed no change during COVID-19 in Washington DC.<sup>[7]</sup> Sephton et al reported that all the injury patterns were reduced, except for pushbike-related accidents.<sup>[8]</sup> Maletzke et al also reported that the proportion of household injuries, bicycle accidents, and domestic violence increased during the COVID-19 pandemic.<sup>[9]</sup> Worldwide systemic reviews covering Asia, the UK, the United States, Europe, Australia, and New Zealand reported that all types of traffic accidents decreased, while interpersonal violence, self-harm, and falls increased.<sup>[10]</sup> They commonly reported increased penetrating injuries, and our study showed similar results. Motorcycle and bicycle collisions also increased. The Republic of Korea developed delivery services by motorcycles or bicycles, which were fast-growing due to the quarantine and social distancing policies. These changes may have been reflected by the increased motorcycle and bike-related accidents. Pedestrian traffic accidents and slips decreased, which may have been due to the lockdown policy that was introduced on May 6, 2020 and was strengthened or slackened throughout the study period depending on the number of daily confirmed COVID-19 cases, epidemiological links, and community transmission. The government recommended that people refrain from going out and closed some facilities to allow for social distancing.

Previous studies demonstrated that there was no significant difference in outcomes after the COVID-19 pandemic.<sup>[10,11]</sup> Our study also presented consistent results with mortality and ICU LOS. However, the stay time in the trauma bay and ER increased. The stay time in the ER was increased because of the additional screening process (epidemiological history, chest x-ray and CT scan, body temperature, and COVID test) which lasted for approximately 42 minutes. Ben-Heim et al also reported an

increase in the time taken from the door to the intervention for patients with myocardial infarctions, while the total hospital LOS and mortality did not change during the COVID-19 period.<sup>[12]</sup> Less severe trauma patients who did not satisfy field triage went to the ER to ensure that the delay did not lead to worse primary outcomes in terms of the statistics; however, this does not mean that no harm occurred. Our center consistently requested the emergency department members of our hospital to directly refer the patients who seemed to have been under-triaged before arriving at the selection area. The center director and the trauma coordinator also regularly gave feedback to the Gyeonggi-do fire department after gathering examples of under-triaged cases. However, a more effective method needs to be developed. The evacuation time to the operating room was slightly delayed, which may have been due to the isolation preparations in the operating room.

The psychological negative effects of social isolation included increased alcoholic consumption,<sup>[13]</sup> depression, and anxiety.<sup>[14]</sup> Many studies and the press have reported a spread of depression and anxiety named “corona blue” or “corona fear” which may have led to an increase in suicidal patients.<sup>[15,16]</sup> Our study revealed that the number of suicidal patients significantly increased from 2.7% to 4.1% ( $P=.005$ ) during the COVID-19 period.

This study had some limitations. First, this study was based on data from a single level 1 trauma center; therefore, it cannot represent the change or progress for the total trauma patterns of the Republic of Korea during the COVID-19 pandemic. Second, because the data were based only on KTDB, detailed reviews such as those on prehospital data were not possible. Third, there were no COVID-19 confirmed trauma patients.

In conclusion, the trauma center volume did not change because the patients were centralized to the trauma center during the COVID-19 pandemic. Regarding the injury mechanisms, penetrating injuries, motorcycle and bicycle collisions, and suicidal patients increased, while pedestrian traffic accidents, slips, and injuries by machines decreased. It can be considered that the changes in habits and lifestyle, following the COVID-19 pandemic, have modified the injury mechanisms. The mortality and ICU LOS did not change, although stay time before admission slightly increased. Thus, further study on the profound effects of COVID-19 on the quality of treatment for trauma patients is required.

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**Writing – review & editing:** Jiye Park, Junsik Kwon, Jonghwan Moon, Yo Huh, Yun Jung Heo, Byung Hee Kang.

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