Impact of COVID-19 pandemic on patients with cardio/cerebrovascular disease who visit the emergency department

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ABSTRACT

Introduction: The coronavirus disease 2019 (COVID-19) pandemic situation is a state that has had a great impact on the medical system and society. To respond to the pandemic situation, various methods, such as a pre-triage system, are being implemented in the emergency medical field. However, there are insufficient studies on the effects of this pandemic situation on patients visiting the emergency department (ED), especially those with cardio/cerebrovascular diseases (CVD)[1] classified as time-dependent emergencies.
Methods: We performed a retrospective analysis of a cohort of patients from April 2020 to December 2020 (April 2020 was when the pre-triage system was established) compared to a parallel comparison patient cohort from 2019. The primary outcome was in-hospital mortality. CVD was defined by the patient's final diagnosis.
Results: During the same period, the number of patients who had visited the ED after COVID-19 had decreased to 79.1% of the number of patients who had visited the ED before COVID-19. The overall patient mortality and the mortality in the patients cardiovascular disease had both increased, while the mortality from cerebrovascular disease did not increase. Meanwhile, the ED length of stay had increased in all patients but did not increase in the patients with cardiovascular disease.
Conclusion: As with prior studies conducted in other regions, in our study, the total number of ED visits were decreased compared to before COVID-19. The overall mortality had increased, particularly in the patients with cardiovascular disease.

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1. Introduction

Coronavirus disease 2019 (COVID-19), which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and was first reported in Wuhan, Hubei Province, China, at the end of 2019, was declared a pandemic by the World Health Organization (WHO) in March 2020 [1]. As of July 2021, there were 196,821,191 confirmed cases and 4,205,941 deaths worldwide [2].

Since the first case was diagnosed in Korea on January 20, 2019, the number of cases have been continuously increasing in Korea. As of July

2021, 195,099 people have been confirmed to have SARS-CoV-2, and 2085 cumulative COVID-19-related deaths have occurred [2].

The COVID-19 pandemic situation has had a major impact on the overall health care sector. In the United States and Europe, the number of patients visiting the ED has decreased due to the effect of the shelter-in-place orders and the worries about becoming infected within healthcare settings [3-5]. The COVID-19 pandemic has also strained the healthcare systems through increased care complexity and the need for staff and patient safety [6-8]. In Korea, like in the United States or Europe, ED is used as a primary care safety net, however, unlike in the United States or Europe, total blockade by the government such as shut down or shelter-in-place order was not implemented, and outpatient clinic's primary care was provided without restrictions as before COVID-19. Instead, the Korean government is working to prevent COVID-19 transmission by applying social distancing from March 22, 2020. Social distancing includes following guidelines: meeting restriction that include meals or food sharing; restriction of individuals with fever or respiratory symptoms from visiting work-places; avoiding physical contact with others outside of the family members; social

distancing of over 2 m; frequent handwashing; encouraging individuals to work from home and rely on video conferencing for meetings; and individual monitoring for fever and respiratory symptoms when entering confined spaces [9] [10].

.Nevertheless, the current COVID-19 pandemic has lasted for a long period of more than a year, bringing some changes in the social distancing [10]. For example, Korean government temporarily allowed non-face-to-face treatment in outpatients department, to prevent COVID-19 transmission [11].

In our institution, a pretriage system was installed and implemented in order to screen patients suspected of having COVID-19 according to this situation. This pretriage system was operated based on the other pretriage systems in other institutions [12]. Our institution's pre-triage checklist for COVID-19 screening is based on the following: the patient's symptoms (fever, cough, rhinorrhea, sore throat, and dyspnea), vital signs (oxygen saturation ≤ 90% and body temperature ≥ 37.5 °C), and history of contact or travel (recent travel to any country with a COVID-19 outbreak). If the patient was unconscious or if the checklist could not be completed for any other reason, the patient was first isolated. After the screening via pretriage protocols, the patient's severity classification was made based on the Korean Triage and Acuity Scale (KTAS), and the patients who were nonsevere cases were sent home after a COVID-19 PCR test. In the patients who were severe cases, treatment was carried out after first moving the patient to an isolation room.

As a result, both in the US and Europe, previous studies have reported significant reductions in serious CVD visits, as well as having ED care with a lower acuity [13-15]. In the case of CVD, the decrease in the ED visits may be the result of ED avoidance rather than due to a decrease in the disease incidence. If treatment is not received within an appropriate time because the patient is avoiding the ED, the delay in treatment is highly likely to adversely affect the patient's prognosis [16-18].

However, there are insufficient studies on the effects of COVID-19 on the patient outcomes for patients visiting the ED, especially for patients with CVD, which is a disease that is classified as a time-sensitive condition [17,19] in the field of emergency medicine.

2. Methods

2.1. Study design, setting and measurement

We performed a retrospective observational study of a consecutive cohort admitted to an ED in Seoul, Korea, between April 2019 and December 2020. Our institutional review board approved this study, and a waiver of consent was allowed because of its retrospective nature.

We included patients who were seen in the ED from 2019 to 2020, and the patients seen in the ED before April 2020 were compared to the patients seen after April 2020. April 2020 was used as the cutoff between the two periods because it was when the pre-triage setting was implemented. These comparisons were made except for September, when the patient inflow was limited due to ED remodeling. We included only patients who directly visited the ED in this study, and we excluded patients who were transferred from other institutions.

We collected the following demographics and clinical findings from the medical records of the study populations: age, sex, the acuity of the condition at triage by the KTAS, presence of fever, isolation after the ED visit, and comorbidities, including hypertension, diabetes, dyslipidemia, tuberculosis, hepatitis, chronic kidney disease (CKD), lung disease, previous cerebrovascular disease, known cardiovascular disease and malignancy (Table 1). The KTAS is a scoring system that was created based on the Canadian Triage and Acuity Scale and is measured from 1 to 5; the KTAS has been used for triage in all of the EDs in Korea since 2016 [20]. In our study, KTAS scores of 1 and 2 were classified as high-acuity.

Table 1
Baseline characteristics.

	Before COVID 19 (n = 28,679)	After COVID 19 (n = 22,685)	p-value
Age	50.77 ± 19.44	50.72 ± 19.48	0.770
Sex (male)	13,059 (45.5%)	10,571 (46.6%)	**0.017**
Triage (KTAS)	3.62 ± 0.71	3.57 ± 0.80	**<0.001**
1,2	950 (3.3%)	1446 (6.4%)	**<0.001**
Isolation	–	1086 (4.8%)	
Screening	–	3244 (14.3%)	
Fever	3815 (13.3%)	2714 (12.0%)	**<0.001**
Comorbidities			
Hypertension	4379 (15.4%)	3828 (17.4%)	**<0.001**
Diabetes	2708 (9.5%)	2385 (10.9%)	**<0.001**
Dyslipidemia	1657 (5.8%)	1735 (7.9%)	**<0.001**
Tuberculosis	293 (1.0%)	225 (1.0%)	0.956
Hepatitis	414 (1.5%)	370 (1.7%)	**0.038**
Chronic kidney disease	182 (0.6%)	137 (0.6%)	0.826
Pulmonary disease	116 (0.4%)	62 (0.3%)	**0.019**
Old Cerebrovascular disease	109 (0.4%)	87 (0.4%)	0.814
Known Cardiovascular disase	282 (1.0%)	206 (0.9%)	0.548
Malignancy	617 (2.2%)	369 (1.7%)	**<0.001**

p-value <0.05 are presented in bold.

2.2. Definition of cardio/cerebrovascular disease

We included the following final diagnoses according to the primary International Classification of Diseases, Tenth Revision (ICD-10) classification criteria for cardiovascular disease: myocardial infarction (MI), coronary artery stenosis/spasm, angina, heart failure (HF), and cardiomyopathy. The cerebrovascular diseases included the following final diagnoses: cerebrovascular accident (CVA), cerebral/cerebellar infarction, intracranial hemorrhage (ICH), intraventricular hemorrhage (IVH), subarachnoid hemorrhage (SAH), subdural hemorrhage (SDH), epidural hemorrhage (EDH), and middle cerebral artery (MCA)/anterior cerebral artery (ACA)/posterior cerebral artery (PCA)/pontine infarction or stenosis. The patients with cardiac arrest were also included in this analysis. Additionally, the patients with sudden cardiac arrest were included.

2.3. Outcomes

The primary outcome of this study was mortality in the ED. The secondary outcomes included ICU admission, admission, ED length of stay, and time to ED. Time to ED means the time from the onset or worsening of symptoms to the ED visit. The mortality in the ED did not include the deaths after hospitalization.

2.4. Analysis

Normality tests were performed for continuous variables, and continuous variables are presented as the means with the standard deviation or as median values with interquartile ranges, as appropriate. Categorical variables are presented as frequencies and percentages. For the patient characteristics and comparisons between the groups, we used Student's *t*-test or the Mann–Whitney *U* test for continuous variables and Fisher's exact test and the chi-square test for categorical variables.

Statistical analysis was performed using SPSS version 24.0 (SPSS, Chicago, IL, USA), and *p* values ≤0.05 were considered statistically significant.

3. Results

3.1. Characteristics of the study subjects

The total number of ED visits before COVID-19 was 28,679, which was 26.42% more than the 22,685 visits after COVID-19. The mean age

was not significantly different before (50.77 ± 19.44) and after COVID-19 (50.72 ± 19.48, $P = 0.770$). The triage score was lower in the ED visits after COVID-19, indicating that the proportion of high-acuity patients among the ED visitors after COVID was higher than that before COVID-19. The ED visits for patients with fever decreased from 13.3% before COVID-19 to 12.0% after COVID-19, and 14.3% of the patients who visited after COVID-19 were selected as potential COVID-19 patients through the pretriage system and were then tested for COVID-19. Regarding comorbidities, the number of ED visits after COVID-19 involving patients with hypertension, diabetes, and dyslipidemia had increased, but the number of ED visits involving patients with pulmonary disease and malignancy after COVID-19 had decreased (Table 1).

3.2. Comparison of the ED variables

After COVID-19, the number of ED visits had decreased by 20.9% to 22,685 compared to before COVID-19. The mortality, ICU admission rate, admission rate, and ED length of stay all had increased after COVID-19, but the time from the start of symptoms to the ED visit had decreased after COVID-19. The mortality in the patients with cardiovascular disease had increased after COVID-19 compared to before COVID-19, but there was no significant difference in the other ED variables, while in the patients with cerebrovascular disease, there was a significant increase in their ED visits and ED length of stay. For patients with a triage score of 2 or less, which represents high-acuity patients, the ED visit ratio, admission rate, and ED length of stay were increased, but there was no significant difference in the mortality and ICU admission rate. The number of ED visits for cardiac arrest had increased, but the admission rate was lower (Table 2). The number of patients who were screened as suspected COVID-19 patients in the pretriage setting was 14.3%, and there was no significant difference in the mortality or ICU admission rate between the group who underwent screening tests and the group who did not (Table 3A). Meanwhile, the isolated patients

Table 3A
Comparison according to screening status.

	Screening	Non-screening	p-value
ED visits	3244 (14.3%)	19,441 (85.7%)	
Mortality	58 (1.8%)	415 (2.1%)	0.201
ICU admission	88 (2.7%)	521 (2.7%)	0.915
Admission	361 (11.1%)	3514 (18.1%)	**<0.001**
Length of stay (hour)	2.61 ± 6.69	4.98 ± 8.47	**<0.001**
Time to ED (hour)	27.85 ± 96.06	29.65 ± 114.52	0.367

after screening had 4.8% of the ED visits, and all of the ED variables in these patients were worse than those of the nonisolated patients (Table 3B). The number of patients visiting the ED after COVID-19 did not show a correlation with the increase in confirmed cases, but in the case of high-acuity patients who had a triage score of 2 or less, the number of patients visiting the ED after COVID-19 was correlated with the number of confirmed cases. (Figs. 1, 2). However, it was difficult to ascertain whether the correlation in our study was directly related to the increase in the number of confirmed cases.

4. Discussion

Understanding the impact of the COVID-19 pandemic on EDs is important for the future responses to similar pandemic situations. In our study, we compared and analyzed the characteristics of patients who visited the ED during the same period before and after COVID-19. In particular, we investigated the effect of COVID-19 on CVD, which is a time-sensitive condition that requires the initiation of treatment within a limited time.

As in previous studies in other regions, in our study, the total number of ED visits was significantly decreased due to the impact of the COVID-19 pandemic [13-15]. Since the number of ED visits for CVD remained at a constant level, the proportion of CVD patients within the total number of patients was increased after the start of the COVID-19

Table 2
Comparison of emergency department variables between the COVID- 19 periods of time to the control group in 2019.

		Before COVID 19 2019	After COVID 19 2020	p-value
Total ($n = 51,365$)	ED visits	28,679	22,685	
	Mortality	413 (1.4%)	473 (2.1%)	**<0.001**
	ICU admission	595 (2.1%)	609 (2.7%)	**<0.001**
	Admission	4100 (14.3%)	3875 (17.1%)	**<0.001**
	Length of stay (hour)	2 (1,4)	2 (1,5)	**<0.001**
	Time to ED (hour)	5 (1,24)	4 (1, 19)	**<0.001**
Cardiovascular disease ($n = 1573$)	ED visits	862 (3.0%)	711 (3.1%)	0.402
	Mortality	76 (8.8%)	111 (15.6%)	**<0.001**
	ICU admission	140 (16.2%)	112 (15.8%)	0.792
	Admission	218 (25.3%)	178 (25.0%)	0.908
	Length of stay (hour)	5.44 ± 6.41	5.53 ± 5.85	0.779
	Time to ED (hour)	29.14 ± 104.92	27.61 ± 100.53	0.769
Cerebrovascular disase ($n = 907$)	ED visits	433 (1.5%)	474 (2.1%)	**<0.001**
	Mortality	26 (6.0%)	28 (5.9%)	0.951
	ICU admission	114 (26.3%)	142 (30.0%)	0.225
	Admission	293 (67.7%)	299 (63.1%)	0.147
	Length of stay (hour)	4 (2,5)	5 (3,8)	**<0.001**
	Time to ED (hour)	25.66 ± 67.91	21.91 ± 66.50	0.401
Triage ≤2 ($n = 2396$)	ED visits	950 (3.3%)	1446 (6.4%)	**<0.001**
	Mortality	132 (13.9%)	223 (15.4%)	0.303
	ICU admission	192 (20.2%)	302 (20.9%)	0.690
	Admission	345 (36.3%)	644 (44.5%)	**<0.001**
	Length of stay (hour)	6.15 ± 8.39	7.73 ± 8.80	**<0.001**
	Time to ED (hour)	15.55 ± 64.75	21.84 ± 160.31	0.251
Cardiac arrest ($n = 213$)	ED visits	89 (0.3%)	124 (0.5%)	**<0.001**
	Mortality	68 (76.4%)	107 (86.3%)	0.063
	ICU admission	31 (34.8%)	25 (20.2%)	**0.016**
	Admission	32 (36.0%)	25 (20.2%)	**0.010**
	Length of stay (hour)	2.83 ± 5.37	2.60 ± 3.89	0.721
	Time to ED (hour)	0.26 ± 1.36	0.54 ± 3.11	0.424

p-value <0.05 are presented in bold.

Table 3B
Comparison according to isolation status.

	Isolation	Non-Isolation	p-value
ED visits	1086 (4.8%)	21,599 (95.2%)	
Mortality	57 (5.2%)	416 (1.9%)	**<0.001**
ICU admission	88 (8.1%)	521 (2.4%)	**<0.001**
Admission	355 (32.7%)	3520 (16.3%)	**<0.001**
Length of stay (hour)	7.55 ± 9.83	4.5 ± 8.17	**<0.001**
Time to ED (hour)	42.83 ± 120.94	28.73 ± 111.56	**<0.001**

p-value <0.05 are presented in bold.

pandemic. These results explained that even if ED avoidance occurs due to the COVID-19 pandemic situation, ED visits cannot be avoided in severe conditions such as CVD. Although Korea had fewer confirmed COVID-19 cases in 2020 than other regions [2], the impact of the COVID-19 pandemic on ED visits is thought to have occurred similarly in Korea due to the restrictions such as social distancing and the fear of being exposed to COVID-19. For similar reasons, it is thought that the decrease in the ED visits for patients with malignancy among all the ED visits was likely due to ED avoidance. In contrast, the relatively high proportion of patients with comorbidities, such as hypertension and diabetes, suggests that the number of ED visits due to an exacerbation of these conditions is less affected by ED avoidance.

On the other hand, in the case of severe patients with a triage score of 2 or less, an increase in the total number of ED visits was observed compared to before COVID-19. The reason for the increase in visits involving patients with triage scores of 2 or less was not clearly identified in our study. Assuming that the ED visits by high-acuity patients had increased due to the prolonged COVID-19 pandemic period, (Fig. 2C) it can be considered that quasi-severe patients who initially avoided visiting ED in the early days of the COVID-19 pandemic may have eventually visited ED due to the prolonged COVID-19 pandemic and due to their worsening conditions. The time to ED represents the time from symptom onset to the ED visit, which was generally thought to have increased due to the impact of COVID-19 and was found to have decreased in the total ED visits. There was no significant difference between the CVA patients and the patients with a triage score of 2 or less before and after COVID-19. One of the reasons for these results may be that the times from symptom onset to ED on the patients' electrical medical records were not only based on the onset of symptoms but were also based on the time that the symptoms had worsened. Further investigation into the time taken from the symptom onset to visiting the ED can provide clearer evidence for ED avoidance due to COVID-19; therefore, additional investigation is needed.

There have been controversial results regarding the impact of the COVID-19 pandemic on the outcomes of ED patients [4,15,21,22]. In our study, patients with cardiovascular disease had a significant increase in mortality after COVID-19 compared with before COVID-19.

Contrary to these concerns, there was no significant increase in the mortality of the patients with cerebrovascular disease and in the mortality of the patients with a triage score of 2 or less. Several hypotheses can be suggested based on these findings.

First, in cardiovascular disease, ED avoidance is likely to directly affect mortality. Cerebrovascular disease is also a time-sensitive condition, similar to cardiovascular disease, but in cerebrovascular disease, ED avoidance appears to worsen the neurologic outcomes and may not have a direct effect on the mortality. On the other hand, in the case of patients with cardiovascular disease, especially in patients with ST-elevation myocardial infarction (STEMI), there is a possibility that the influence of a small number of patients with ED avoidance can affect the mortality.

Second, cardiovascular disease is more likely to be accompanied by dyspnea at the time of the ED visit. If dyspnea is present at the time of the ED visit, the patient is isolated for concerns about COVID-19 through the pretriage screening process. This may delay critical interventions such as coronary angiography, and this delay may have a direct effect on mortality.

Overall, the ED length of stay had increased after COVID-19, despite the decrease in the ED overcrowding due to the reduction in the overall ED visits compared to that before COVID-19. This result is likely because if a patient has suspected symptoms of COVID-19, the patient's hospitalization and discharge were determined only when the results of the COVID-19 test were confirmed. Moreover, since the proportion of high-acuity patients among the patients who visited the ED after COVID-19 had increased (which was a relative increase), the average ED length of stay had increased compared to that before COVID-19.

A total of 22,685 patients visited the ED after COVID-19 during the study period, 19 patients were confirmed to have COVID-19 among the patients screened in the pretriage, and 10 of the 19 patients were isolated in the ED. Of the 10 patients isolated in the ED, 3 were transferred, 7 were admitted to our institution, and 6 were admitted to the ICU. 6 of them were diagnosed with pneumonia related to COVID-19, and 1 patient was admitted for underlying malignancy. There were no confirmed COVID-19 patients in cardiac arrest and cardio/cerebrovascular disease patients. Among the admitted patients, two patients died. Patients who were not admitted to our institution were admitted to another institution for COVID-19-related respiratory infections. In the study period, the average monthly number of confirmed patients in Seoul, where our institution is located (total population 9,668,465), was 2035 [2,23]. Despite the relatively well-controlled transmission of COVID-19 by social distancing, compared to other regions, the overall mortality in the ED had increased in our study, and it is speculated that the increase in mortality, particularly in patients with cardiovascular disease, may have been affected by the COVID-19 pandemic situation.

This study has some important limitations to consider. Our study is a single-center, retrospective cross-sectional study. Subsequent studies
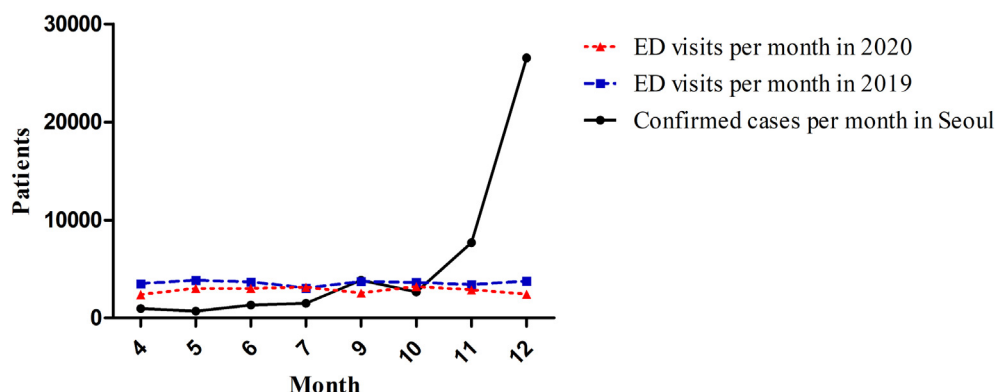

Fig. 1. Number of COVID-19 confirmed cases per month in Seoul and ED visits per month.
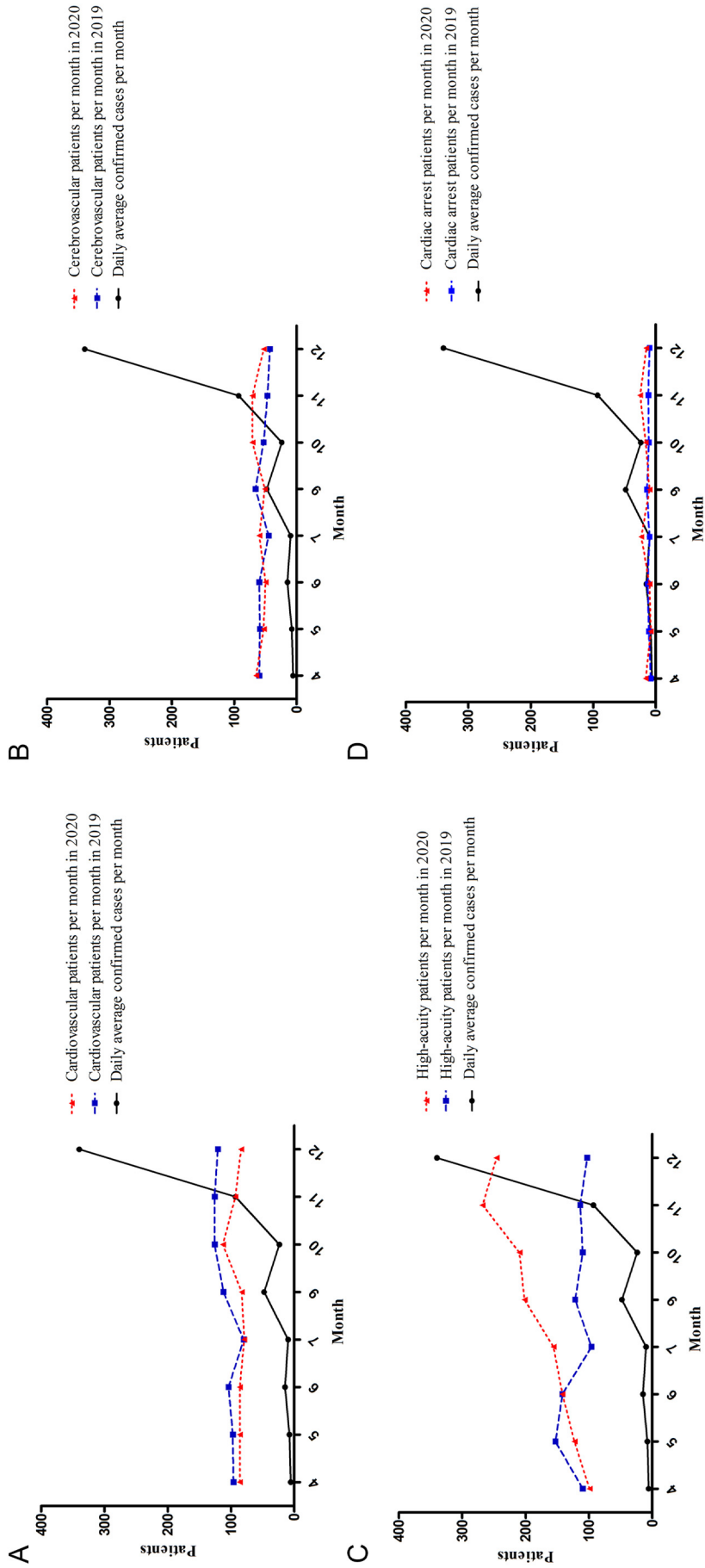
Fig. 2. Mean COVID-19 confirmed cases per month in Seoul.
(A) Number of cardiovascular disease patients visit ED per month (B) Number of cerebrovascular disease patients visit ED per month (C) Number of high-acuity patients visit ED per month (D) Number of cardiac arrest patients visit ED per month.

should analyze multicenter or state/national databases. To investigate the impact of COVID-19 on time-sensitive conditions, we classified the disease groups into cardiovascular disease and cerebrovascular disease groups according to the patient's final diagnosis, and we then performed an analysis of the ED variables. However, the time spent on critical interventions was not separately analyzed. Additional data analysis is needed, such as the time spent on coronary angiography and the time spent on endovascular thrombectomy.

Nevertheless, our study is worthwhile because it is the first to investigate the impact of the COVID-19 pandemic on patients with either cardio/cerebrovascular disease visiting the ED. Additionally, unlike other regions, although early COVID-19 transmission was relatively well controlled in South Korea, similar effects were found on mortality, especially in patients with cardiovascular disease. This suggests that in a similar pandemic situation in the future, additional responses may be necessary for patients with cardiovascular disease and time-sensitive conditions.

5. Conclusion

In conclusion, the COVID-19 pandemic has been shown to increase mortality among patients visiting the ED. In particular, there was a significant increase in mortality in patients with cardiovascular disease, which is one of the time-sensitive conditions. These results are from a population in South Korea, where the transmission of COVID-19 was relatively well controlled, and it can be considered that the pandemic situation itself has an important relationship (as much as being infected with SARS-CoV-2) with ED visits and cardiovascular patients.

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CRediT authorship contribution statement

Beomjin Park: Investigation, Data curation, Writing – original draft. **Woori Bae:** Supervision, Methodology. **Hyo Joon Kim:** Validation, Conceptualization. **Jee Yong Lim:** Validation, Supervision. **Sang Hoon Oh:** Validation, Supervision, Conceptualization. **Chun Song Youn:** Supervision, Methodology, Conceptualization. **Han Joon Kim:** Validation, Supervision, Methodology. **Kyu Nam Park:** Validation, Supervision, Methodology, Conceptualization. **Hwan Song:** Writing – review & editing, Project administration, Conceptualization.

Declaration of Competing Interest

None.

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