Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Impact of temporary closures of emergency departments during the COVID-19 outbreak on clinical outcomes for emergency patients in a metropolitan area

Dong Eun Lee [a], Young Sun Ro [b,c,d,*], Hyun Wook Ryoo [d,e], Sungwoo Moon [b,d,f]

[a] Department of Emergency Medicine, Kyungpook National University Chilgok Hospital, School of Medicine Kyungpook National University, Daegu, Republic of Korea
[b] National Emergency Medical Center, National Medical Center, Seoul, Republic of Korea
[c] Department of Emergency Medicine, Seoul National University Hospital, Seoul, Republic of Korea
[d] Laboratory of Emergency Medical Services, Seoul National University Hospital Biomedical Research Institute, Seoul, Republic of Korea
[e] Department of Emergency Medicine, Kyungpook National University Hospital, School of Medicine Kyungpook National University, Daegu, Republic of Korea
[f] Department of Emergency Medicine, Korea University Ansan Hospital, Gyeonggi, Republic of Korea

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ABSTRACT

Background: During the early phase of the coronavirus disease 2019 (COVID-19) outbreak, many emergency departments (EDs) were exposed to COVID-19 and were temporarily closed according to national protocol of Korea. We aimed to evaluate the effect of concurrent and recurrent temporary closures of EDs on the clinical outcomes of patients who visited EDs during the COVID-19 outbreak.

Methods: This cross-sectional study used a nationwide emergency patient database. Patients who visited one of the 46 EDs in Daegu and Gyeongbuk between January 21 and April 14, 2020 were included. The main exposure variable was the first medical contact (ED visit or 119 call to emergency medical services (EMS)) during closure of at least one ED. There were 25 temporary closures of six Level-1 and Level-2 EDs between February 18 and March 17, 2020. We constructed a dataset by performing bidirectional crossover matching and conducted a conditional logistic regression analysis where the primary outcome was in-hospital mortality.

Results: Of the 94,360 eligible study participants, 36,327 were classified into the non-EMS-use group and 10,116 were classified into the EMS-use group. In-hospital mortality rates were 2.0% and 1.6% for the temporary-closure and no-closure groups in the non-EMS-use group (p-value, 0.03) and 8.7% and 7.4% in the EMS-use group (p-value, 0.02), respectively. In the conditional logistic analysis for in-hospital mortality, the odds ratios (95% confidence intervals) of the temporary-closure group compared the no-closure group were 1.22 (1.03–1.44) among the non-EMS-use group and 1.23 (1.04–1.46) among the EMS-use group.

Conclusion: The temporary closures of EDs due to the unpredicted COVID-19 exposure resulted in an increase in emergency patients' in-hospital mortality rates irrespective of whether they used EMS. Preparing regional EMS systems to cope with new outbreaks is essential to protect the safety of all citizens.

1. Introduction

The first coronavirus disease 2019 (COVID-19) case was confirmed in Wuhan in December 2019 [1], marking the beginning of a global pandemic that has resulted in approximately 72.2 million cases and 1.63 million deaths across 220 countries in 2020 [2]. This occurrence has proven a great burden on public healthcare systems in many countries. It has also affected trends in medical use and clinical outcomes of patients with acute conditions, as well as chronic diseases such as cardio-cerebrovascular diseases [3-5].

During the early phase of the COVID-19 outbreak, emergency departments (EDs) were not prepared to accommodate patients with the new communicable disease, but were exposed to the virus by patients who had mild symptoms and were not initially identified as having the virus. As a result, many EDs were temporarily shut down in accordance with the MERS (Middle East Respiratory Syndrome) response guidelines that were temporarily used to respond to the outbreak at the time. The MERS response guidelines are intended to sterilize air and environmental contaminations and to prevent the transmission of virus to other emergency patients and healthcare workers [6].

* Corresponding author at: Department of Emergency Medicine, Seoul National University Hospital, 101 Daehak-Ro, Jongno-Gu, Seoul 03080, Republic of Korea.
E-mail addresses: delee18589@gmail.com (D.E. Lee), Ro.youngsun@gmail.com (Y.S. Ro), ryoo@knu.ac.kr (H.W. Ryoo), sungwoo.moon89@gmail.com (S. Moon).

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Since February 18, 2020, the number of confirmed COVID-19 patients in the Daegu metropolitan area of Korea increased rapidly because of a cluster infection among a religious group called "Shincheonji" [7,8]. During that period, COVID-19 patients with atypical symptoms visited the local ED, but since they were not suspected of having the virus, they were not isolated during initial triage. On February 18, the Korea Centers for Disease Control and Prevention (CDC) decided to close the exposed ED based on the protocol of epidemiologic surveillance and isolation. Following this, many EDs were repeatedly closed for short periods of time as the number of confirmed COVID-19 cases increased, and medical staff and other patients in the ED were quarantined [6,8]. Other EDs in the community that remained open had to cope with a surge in the number of emergency patients and prepare for visits from patients with latent COVID-19 infection.

Consecutive and concurrent shutdowns of multiple EDs can affect the regional emergency medical services (EMS) system and change the health behavior of emergency care access for patients with critical illnesses or intensive care needs, which can lead to changes in clinical outcomes [9,10]. Previous studies have demonstrated the effects of closure or downgrades of regional EDs, as well as trauma centers, on the long-term outcomes for patients with time-sensitive illnesses, such as acute myocardial infarction (AMI) and severe trauma [10-13]. However, there have been no reports on the impact of concurrent short-term ED closures in pandemic or disaster situations on the clinical outcomes of emergency patients.

We hypothesized that the concurrent and recurrent closures of EDs during the COVID-19 outbreak will delay access to appropriate care and worsen the clinical outcomes of emergency patients in the community. This study aimed to evaluate the effect of concurrent and recurrent temporary closures of EDs on the clinical outcomes of patients who visited EDs in Daegu metropolitan city and Gyeongsangbuk-do province during the COVID-19 outbreak.

2. Methods

2.1. Study design and setting

This cross-sectional study used a nationwide emergency patient database for its analysis. The Daegu metropolitan area consists of a densely populated urban core (Daegu metropolitan city, hereafter Daegu) and less-populated surrounding territories (Gyeongsangbuk-do, hereafter Gyeongbuk). The province has a population of 5.1 million people and an area of 19,914 km^2 with 46 EDs, which are categorized into three levels based on the level of care available, emergency medical resources, and capacity (facilities, equipment, medical staff, etc.). A total of 15 Level-1 ($n = 5$) and Level-2 ($n = 10$) EDs (six in Daegu and nine in Gyeongbuk) provide the highest level of emergency care services in the region [14].

The EMS system in Korea is a government-based public system operated by the National Fire Agency. There are a total of 28 fire stations (EMS centers) with approximately 149 ambulance stations in Daegu and Gyeongbuk [15].

The first case of COVID-19 was detected in Daegu and Gyeongbuk on February 18, 2020. By April 15, there were 8171 confirmed cases, accounting for 77.2% of all cases in Korea [7]. COVID-19 was diagnosed based on the World Health Organization's (WHO) interim guidance and the Korean CDC's guidelines.

2.2. Study population

Patients who visited any of the 46 EDs in Daegu and Gyeongbuk between January 21 and April 14, 2020, were included in this study. However, patients who had insufficient information on EDs and hospital disposition or length of stay (LOS) were excluded from the analysis.

2.3. Outcome measures

The primary outcome was in-hospital mortality. The secondary outcomes were intensive care unit (ICU) admission and LOS in an ED. For emergency patients who used EMS, the tertiary outcome was prehospital time, which was defined as the time from the EMS call to the time that the ambulance arrived at the ED.

2.4. Data source and variables

Data were gathered from the EMS run-sheets and the National Emergency Department Information System (NEDIS) database.

The NEDIS, which was established in 2003, is operated by the National Emergency Medical Center and collects clinical information from all the patients who visit EDs across the country. All patient-related information is automatically transferred from each hospital to a central government server within the setting period of the patient's discharge from an ED or hospital ward [16].

The following information was used for analysis: age, gender, date and time of ED visit, reason for ED visit (medical illness or injury), initial vital sign and mental status at ED presentation, initial triage, route of ED visits (direct visit or transferred), diagnosis based on the International Classification of Diseases (ICD)-10 code, and dispositions of the ED and hospital. For patients who used EMS, prehospital time variables such as the response time interval, scene time interval, and transport time interval were also used for analysis.

2.5. Exposure of interest and matched dataset

The main exposure of interest in this study is the first medical contact during closure of at least one ED in the community. According to the data from the Korean CDC and the Fire Department, there were 25 temporary closures of two Level-1 EDs and four Level-2 EDs in Daegu and Gyeongbuk between February 18 and March 17, 2020 (Fig. 1). These six EDs cared for approximately 247,000 patients annually, of which 72.6% of patients were from Daegu and 20.0% from Gyeongbuk [16]. The median duration of the 25 closures for Level-1 and -2 EDs was 17.5 h.

To evaluate the effect of concurrent and recurrent temporary closures of EDs on the clinical outcomes of patients who visited the EDs, we constructed a dataset by performing bidirectional crossover matching to adjust for both known and unknown time-invariant confounders [17,18]. This may reduce the possibility of within-person time-invariant confounding; it also avoids selection biases [17]. The bidirectional symmetric design selects two matched days from equal distances before and after the event, providing adequate control for trends and seasonality [18-20]. Since the main exposure variable of this study is time-dependent and the characteristics of the study population are dependent on time and place, 1:2 bidirectional crossover matching was performed to reduce related confounding.

The study population was classified into two groups according to the use of EMS as a means of ED visits: the non-EMS-use and EMS-use groups. Based on the time of the first medical contact, the groups were divided into exposure groups (temporary-closure groups) and non-exposure groups depending on whether there was closure of at least one ED at the time. To adjust for potential confounding by day of the week and seasonality, we selected the matched non-exposure group (no-closure group) on the matching days before and after 4 weeks of the first medical contact for each temporary-closure group. Matching variables included age, gender, time of ED visit (8 AM–4 PM, 4 PM–MN, and MN–8 AM), region of ED (Daegu and Gyeongbuk), level of ED (level 1, 2, and 3), and initial triage (severe and non-severe). A 4-week interval was provided to eliminate the possibility of selecting duplicates in the exposure and non-exposure groups, and all members of the no-closure group were selected from days without ED closures.

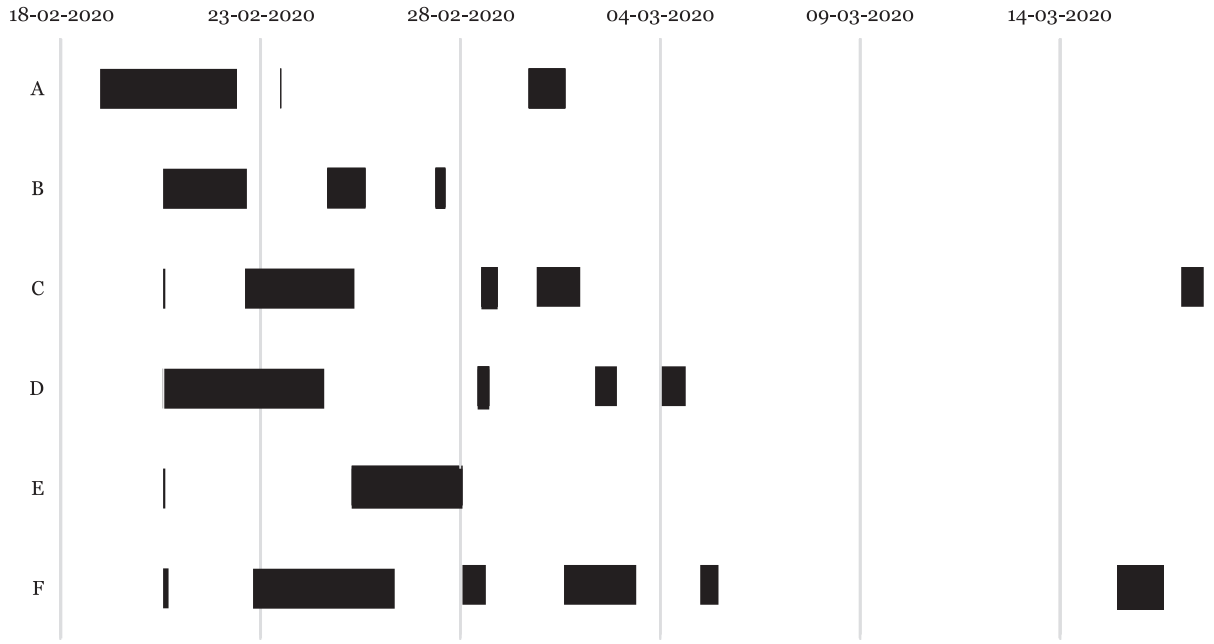

Fig. 1. Emergency department closures in Daegu and Gyeongbuk. Level-1 EDs: A & B; Level-2 EDs: C, D, E, & F.

For the non-EMS-use group, based on the time of ED visit (first medical contact), patients who were admitted into an ED in the community during the period of at least one ED closure (between February 18 and March 17) were classified into the temporary-closure group. For the EMS-use group, patients called to the dispatch center (first medical contact) during the period of closure of one or more EDs from February 18 to March 17 were classified into the temporary-closure group. We selected the no-closure group based on matching days before and after 4 weeks of the first medical contact in each of the non-EMS-use and EMS-use groups.

2.6. Statistical analysis

Descriptive statistics are presented as medians with interquartile ranges (interquartile range: 25th and 75th percentiles) or a mean with standard deviation, while categorical variables are presented as counts and percentages. The significance of the differences between the exposure and non-exposure groups was tested using a *t*-test for continuous variables, while the chi-square test was used for categorical variables.

For the matched dataset, a conditional logistic regression analysis was conducted to estimate the effect of ED closures on the

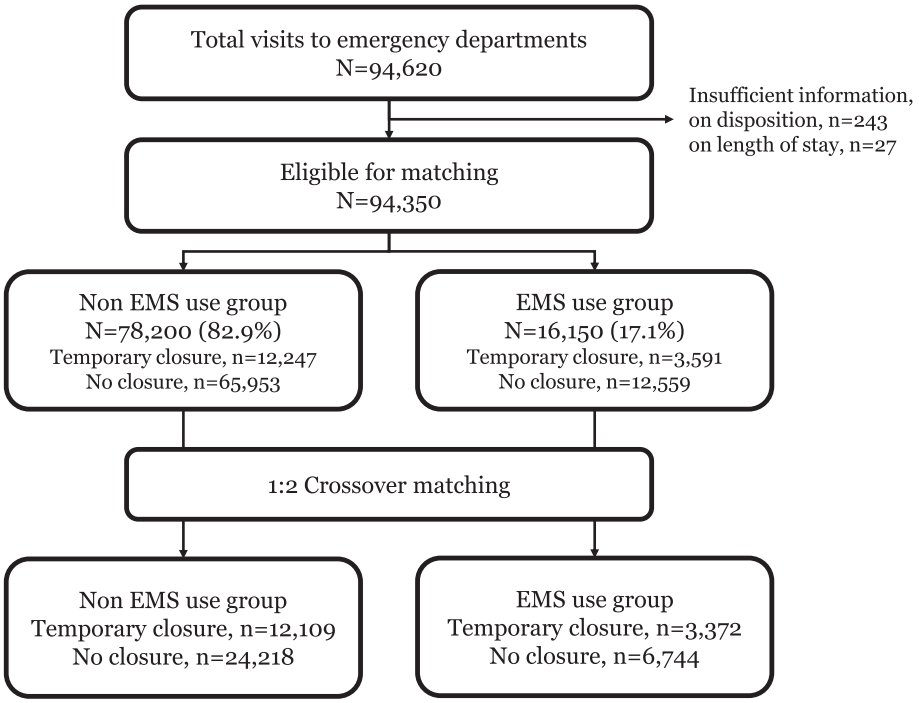

Fig. 2. Patient flow diagram. EMS: emergency medical services.

clinical outcomes of emergency patients in the community and to calculate the odds ratios (ORs) and 95% confidence intervals (CIs). For the study outcomes of continuous variables, multivariable general linear models were conducted after adjusting for matching variables (age, gender, day of week and time of ED visit, region of ED, level of ED, and initial triage). All statistical tests were conducted in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Based on a two-sided test, a p-value of <0.05 was considered an indication of statistical significance.

2.7. Ethics statement

The study protocol was reviewed and approved by the Institutional Review Board of National Medical Center (approval No. NMC-2007-026), and the requirement for informed consent was waived due to the retrospective nature of this study.

2.8. Patient and public involvement statement

The National Emergency Medical Center under the Ministry of Health and Welfare was involved in the design and conduct of this research, but it was not possible to involve patients in our research.

3. Results

3.1. Demographic findings

Of the 94,620 patients who visited one of the 46 EDs in Daegu and Gyeongbuk during the study period (from January 21 to April 14, 2020), patients with insufficient information on EDs and hospital disposition ($n = 243$) or ED LOS ($n = 27$) were excluded from the analysis. Of the 94,360 eligible participants, 16,150 (17.1%) patients were categorized into the EMS-use group. In this group, 3372 patients were in the temporary-closure group, and 6744 patients were matched into the

Table 1
Characteristics and study outcomes of the study population according to EMS use and the temporary closure of emergency departments.

	Non EMS use group				p	EMS use group				p
	Temporary closure		No closure			Temporary closure		No closure		
	N	%	*N*	%		*N*	%	*N*	%	
Total	12,109	100.0	24,218	100.0		3372	100.0	6744	100.0	
Age (in years)					0.99					0.93
0–19	1312	10.8	2624	10.8		127	3.8	254	3.8	
20–49	5168	42.7	10,316	42.6		779	23.1	1526	22.6	
50–69	3588	29.6	7217	29.8		1169	34.7	2376	35.2	
70–120	2041	16.9	4061	16.8		1297	38.5	2588	38.4	
Gender, female	5658	46.7	11,316	46.7	1.00	1361	40.4	2722	40.4	1.00
ED visit (day of the week)					1.00					1.00
Sunday	2943	24.3	5886	24.3		557	16.5	1114	16.5	
Monday	1745	14.4	3490	14.4		538	16.0	1076	16.0	
Tuesday	1119	9.2	2238	9.2		437	13.0	874	13.0	
Wednesday	1875	15.5	3750	15.5		593	17.6	1186	17.6	
Thursday	1578	13.0	3156	13.0		540	16.0	1080	16.0	
Friday	1436	11.9	2872	11.9		432	12.8	864	12.8	
Saturday	1413	11.7	2826	11.7		275	8.2	550	8.2	
ED visit (hour of the day)					0.44					0.34
00–08	2307	19.1	4480	18.5		856	25.4	1622	24.1	
08–16	4715	38.9	9489	39.2		1396	41.4	2836	42.1	
16–24	5087	42.0	10,249	42.3		1120	33.2	2286	33.9	
Region of ED					0.93					0.78
Daegu metropolitan	3754	31.0	7519	31.0		1297	38.5	2613	38.7	
Gyeungsangbuk-do	8355	69.0	16,699	69.0		2075	61.5	4131	61.3	
Level of ED (level 1 & 2)	6656	55.0	13,312	55.0	1.00	2527	74.9	5054	74.9	1.00
Initial triage (severe)[a]	352	5.3	704	5.3	1.00	443	17.5	886	17.5	1.00
Reason for ED visit (injury)[a]	1447	21.7	3209	24.1	<0.01	744	29.4	1635	32.4	0.01
Initial fever (≥37.5 °C)[a]	1043	15.7	2312	17.4	<0.01	388	15.4	728	14.4	0.27
Mental status at time of ED admission [a]					0.03					0.76
Alert	6490	97.5	13,063	98.1		2206	87.3	4425	87.6	
Verbal response	66	1.0	95	0.7		107	4.2	231	4.6	
Pain response	52	0.8	76	0.6		102	4.0	190	3.8	
Unresponsive	48	0.7	78	0.6		112	4.4	208	4.1	
Route of ED visit (transferred)	1016	8.4	2076	8.6	0.56	49	1.5	73	1.1	0.11
Diagnosis										
AMI	70	0.6	151	0.6	0.60	60	1.8	98	1.5	0.21
Stroke	167	1.4	394	1.6	0.07	146	4.3	317	4.7	0.40
Sepsis	36	0.3	37	0.2	<0.01	41	1.2	67	1.0	0.30
Severe trauma	604	5.0	1110	4.6	0.09	438	13.0	957	14.2	0.10
ED length of stay (in hours)										
Mean, SD	2.7	±6.9	2.6	±5.7	0.08	6.3	±11.3	5.2	±8.8	<0.01
Median, [IQR]	1.03	[0.37–2.28]	1.2	[0.43–2.33]		2.33	[1.25–5.1]	2.37	[1.28–4.77]	
ICU admission	359	3.0	619	2.6	0.02	329	9.8	572	8.5	0.03
Time from ED visit to ICU admission										
Median, [IQR] (in hours)	3.32	[1.78–7.47]	3.32	[1.78–6.33]	0.21	3.63	[1.87–9.02]	3.38	[1.87–6.99]	<0.01
In-hospital mortality	238	2.0	399	1.6	0.03	292	8.7	498	7.4	0.02
ED	89	0.7	162	0.7		144	4.3	255	3.8	
Ward	149	1.2	237	1.0		148	4.4	243	3.6	

EMS, emergency medical services; ED, emergency department; AMI, acute myocardial infarction; SARI, severe acute respiratory infection; SD, standard deviation; IQR, interquartile range; ICU, intensive care unit.
[a] These variables were only provided by level 1 & 2 EDs.

no-closure group using 1:2 bidirectional crossover matching. For the non-EMS group, 12,109 patients were in the temporary-closure group and 24,218 patients were matched with the no-closure group (Fig. 2).

Table 1 describes the demographic characteristics according to EMS-use and main exposure of interest. In-hospital mortality was found to be 2.0% in the temporary-closure group and 1.6% in the no-closure group among the non-EMS-use group (p-value, 0.03) and 8.7% in the temporary-closure group and 7.4% in the no-closure group among the EMS-use group (p-value, 0.02). For the EMS-use group, the response time and prehospital time of the temporary-close group were longer than those of the no-closure group (mean: 13.1 min and 39.6 min vs. 10.7 min and 33.9 min; both p-values <0.01) (Table 2).

3.2. Clinical outcomes and main analyses

In the conditional logistic analysis of the non-EMS-use group, the ORs (95% CIs) of the temporary-closure group compared to the no-closure group were 1.22 (1.03–1.44) for in-hospital mortality and 1.19 (1.04–1.38) for ICU admission. Among the EMS-use group, the ORs (95% CIs) were 1.23 (1.04–1.46) for in-hospital mortality and 1.18 (1.02–1.27) for ICU admission (Table 3).

The adjusted coefficients (95% CIs) for ED LOS of the temporary-closure group were 0.13 (0.01 to 0.25) hours for the non-EMS-use group and 1.13 (0.76 to 1.50) hours for the EMS-use group, compared to the no-closure group. For prehospital time in the EMS-use group, the adjusted coefficients (95% CIs) of the temporary-closure group was 5.68 (4.82 to 6.55) minutes compared to the no-closure group (Table 4).

To estimate the effect of ED closures on the clinical outcomes of patients who diagnosed with non-infectious critical conditions (acute myocardial infarction, stroke, and severe trauma), sensitivity analyses performed (Supplementary Tables 1 and 2).

4. Discussion

Using a nationwide emergency patient database, this study demonstrated the effects of concurrent and recurrent temporary closures of EDs on emergency patients' clinical outcomes in Daegu metropolitan area. The temporary closures of EDs due to unforeseen exposure to COVID-19 resulted in a shortage of emergency medical resources in the community. This, in turn, resulted in an increase in rates of in-hospital mortality and ICU admission for emergency patients both with and without EMS use. In addition, the ED closure prolonged ED LOS for all emergency patients, as well as prehospital time for patients who visited the ED with EMS use. Our study identified the detrimental effects of the sudden closures of EDs, which were not prepared for an infectious outbreak, on the regional EMS system and public health in the community. These results emphasize the importance of preparing regional EMS systems to cope with new communicable disease outbreaks, as well as general disasters.

Since the 2014 Ebola epidemic, preparedness for communicable disease outbreaks in communities and hospitals has been emphasized [21-23]. In Korea, after the hospital transmissions of Middle East Respiratory Syndrome (MERS) in 2015 [24,25], the EMS Act was revised to improve the ED environment, which included installing ventilation systems, separating the entrance from the isolation area, expanding bed space, setting up isolation rooms with negative pressure in Level-1 EDs, and controlling access of ED visitors [26]. However, as a result, ED preparedness for emerging communicable diseases became insufficient, as attested by the concurrent and recurrent shutdowns of EDs during the COVID-19 outbreak. One important factor is that most symptomatic and asymptomatic patients with communicable diseases access healthcare through the emergency care system. Therefore, preparing EMS systems in such a way that they can sufficiently mitigate a disaster situation has become crucial to protect the safety of all citizens [27].

The temporary closures of EDs the early phase of the COVID-19 outbreak were performed in accordance with the MERS response guidelines recommending that patients resume care at least 48 h after diagnosis at the place where the confirmed patient visited [28]. However, the MERS response guidelines were developed in 2015, and there is

Table 2
Response time and prehospital time of the study population with EMS use.

	EMS use group				p-value
	Temporary closure (n = 3372)		No closure (n = 6744)		
	N	%	N	%	
Response time[a] (in minutes)					<0.01
0–4	108	3.2	307	4.6	
4–8	1004	29.8	2495	37.0	
8–12	1032	30.6	2190	32.5	
12–16	548	16.3	936	13.9	
16–	680	20.2	816	12.1	
Mean, SD	13.1	±13.1	10.7	±6.4	
median, [IQR]	11	[8–15]	9	[7–13]	
Prehospital time[b] (in minutes)					<0.01
0–10	25	0.7	87	1.3	
10–20	534	15.8	1453	21.5	
20–30	902	26.7	2016	29.9	
30–40	708	21.0	1403	20.8	
40–50	470	13.9	808	12.0	
50–	733	21.7	977	14.5	
Mean, SD	39.6	±26.0	33.9	±18.8	
median, [IQR]	33	[24–48]	30	[21–41]	

EMS, emergency medical services; SD, standard deviation; IQR, interquartile range.
[a] Time from call to ambulance until arrival at the scene.
[b] Time from call to ambulance until arrival at the emergency department.

Table 3
Conditional logistic regression analysis to estimate the effect of temporary closures of EDs on study outcomes according to EMS use.

	In-hospital mortality			ICU admission		
	n/N	%	OR (95% CIs)	n/N	%	OR (95% CIs)
Non EMS use						
Temporary closure	238/12,109	2.0	1.22 (1.03–1.44)	359/12,109	3.0	1.19 (1.04–1.38)
No closure	399/24,218	1.6	1.00	619/24,218	2.6	1.00
EMS use						
Temporary closure	292/3372	8.7	1.23 (1.04–1.46)	329/3372	9.8	1.18 (1.02–1.27)
No closure	498/6744	7.4	1.00	572/6744	8.5	1.00

ICU, intensive care unit; OR, odds ratio; CI, confidence interval; EMS, emergency medical services.

Table 4
Multivariable general linear model to estimate the effect of temporary closures of EDs on the time variables according to EMS use.

	ED length of stay (in hours)			Prehospital time (in minutes)		
	Mean	SD	ß[a] (95% CI)	Mean	SD	ß[a] (95% CI)
Non EMS use						
Temporary closure	2.7	6.9	0.13 (0.01 to 0.25)			
No closure	2.6	5.7	Ref			
EMS use						
Temporary closure	6.3	11.3	1.13 (0.76 to 1.50)	39.6	26.0	5.68 (4.82 to 6.55)
No closure	5.2	8.8	Ref	33.9	18.8	Ref

ED, emergency department; SD, standard deviation; CI, Confidence interval; EMS, emergency medical services.
[a] All β coefficients were calculated with adjustments for age, gender, day of the week, hour of the day of ED visit, region, and triage.

insufficient evidence for routine use of long term ventilation and quarantine to prevent in-hospital transmission of COVID-19. According to interim infection prevention and control recommendations for healthcare personnel during the COVID-19 pandemic by CDC [29], routine cleaning and disinfection procedures are recommended to control environmental infection. Since EDs provide emergency care not only for infected patients but also for non-infected patients, temporary ED closures should be approached with caution. Considering the results of this study, temporary ED closures are not recommended due the unpredictable exposure patterns associated with COVID-19 during an outbreak.

Consecutive and concurrent shutdowns of multiple EDs affect the regional EMS system, lead to overcrowding of other EDs in the community, and prolong prehospital time owing to delays in selecting an ED for patients using EMS. Similarly, a study in the United States found that hospital closures were associated with a significant increase in ambulances taking patients to the nearest ED, rather than to the ED that provides the most appropriate care [9]. Ambulance diversion was also associated with prolonged prehospital time and delays in providing adequate care to critically ill patients. The delayed prehospital time and ED overcrowding may have had an impact on increased in-hospital mortality rates by increasing the time required to provide critical care to emergency patients. In this study, patients who visited an ED during the period of at least one ED closure, irrespective of whether they used EMS, had higher in-hospital mortality rates and longer ED LOS compared to patients in no-closure groups.

In Daegu and Gyeongbuk, each ED has committed to minimizing ED closures through measures such as physicians, nurses, and healthcare workers wearing appropriate personal protective equipment (PPE); temporary increases in isolation beds with negative pressure; a cohort isolation space for each ED); and chest radiographies for triage patients, thereby establishing a screening and patient triage protocol [6,8,30]. However, preparedness for a disaster before it occurs will be much more effective in protecting the safety of all citizens, rather than attempting to mitigate the risk after a disaster. The temporary closures of EDs due to unpredicted exposure to COVID-19 resulted in a shortage of emergency medical resources in the community. Our findings have important implications for the preparedness of regional EMS systems to cope with new communicable disease outbreaks, as well as general disasters. Developing strategies to minimize the impact of disasters on national and regional EMS systems and establishing healthcare systems that are prepared for disaster are essential to protect the community during COVID-19 and other communicable disease outbreaks and pandemics.

This study has several limitations that may restrict the generalizability of its findings. First, this was not a randomized, controlled study. Although we attempted to reduce biases by using bidirectional crossover matching, the possibility of potential biases could have affected our results. Second, during the COVID-19 pandemic, there were many other changes in national and regional healthcare systems, which could have affected the main exposure and study outcomes. Third, nine Level-3 EDs were also temporarily closed several times, but its impact on the regional EMS system was assumed to be insignificant and it was excluded from the analysis. Finally, each country has different regional health care systems and EMS. In addition, there may be differences in the availability of critical and medical resources. Therefore, the study findings should be generalized cautiously.

During the COVID-19 outbreak, the concurrent and recurrent temporary closures of emergency departments increased in-hospital mortality and ICU admission rates in the community and prolonged the length of stay in EDs for emergency patients living in the community. The preparedness of the regional EMS system to cope with an emerging communicable disease outbreak, as well as general disasters, is essential for mitigating the detrimental effects of the COVID-19 outbreak on the safety and public health of the community.

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Declaration of interest

The authors have no potential conflicts of interest to declare.

Author Contributors

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajem.2021.03.038.

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