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Effects of dynamic response to coronavirus disease outbreak in a regional emergency medical center

A retrospective study

Ye Jin Oh, MS, Gyun Moo Kim, MD, PhD, Seung Hyun Ko, MD, Young Woo Seo, MD, Suk Hee Lee, MD, Tae Chang Jang, MD, PhD*

Abstract

Emergency departments (EDs) are on the frontline of the coronavirus disease (COVID-19) outbreak. To resolve the abrupt overloading of COVID-19–suspected patients in a community, each ED needs to respond in various ways. In our hospital, we increased the isolation beds through temporary remodeling and by performing in-hospital COVID-19 polymerase chain reaction testing rather than outsourcing them. The aim of this study was to verify the effects of our response to the newly developed viral outbreak.

The medical records of patients who presented to an ED were analyzed retrospectively. We divided the study period into 3: pre-COVID-19, transition period of response (the period before fully implementing the response measures), and post-response (the period after complete response). We compared the parameters of the National Emergency Department Information System and information about isolation and COVID-19.

The number of daily ED patients was 86.8 ± 15.4 in the pre-COVID-19, 36.3 ± 13.6 in the transition period, and 67.2 ± 10.0 in the post-response period ($P < .001$). The lengths of stay in the ED were significantly higher in transition period than in the other periods [pre-COVID-19 period, 219.0 (121.0–378.0) min; transition period, 301 (150.0–766.5) min; post-response period, 281.0 (114.0–575.0) min; $P < .001$]. The ratios of use of an isolation room and fever (≥37.5°C) were highest in the post-response period [use of isolation room: pre-COVID-19 period, 0.6 (0.7%); transition period, 1.2 (3.3%); post-response period, 16.1 (24.0%); $P < .001$; fever: pre-COVID-19 period, 14.8(17.3%); transition period, 6.8 (19.1%); post-response period, 14.5 (21.9%), $P < .001$].

During an outbreak of a novel infectious disease, increasing the number of isolation rooms in the ED and applying a rapid confirmation test would enable the accommodation of more suspected patients, which could help reduce the risk posed to the community and thus prevent strain on the local emergency medical system.

Abbreviations: COVID-19 = coronavirus disease, ED = emergency department, LOS = length of stay, NEDIS = National Emergency Department Information System, PCR = polymerase chain reaction.

Keywords: coronavirus disease 2019, coronavirus disease, emergency department, emergency medical system

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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.

Department of Emergency Medicine, School of Medicine, Daegu Catholic University, Daegu, Republic of Korea.

** Correspondence: Tae Chang Jang, Department of Emergency Medicine, School of Medicine, Daegu Catholic University, (42472) 33 Durygongwon-ro 17-gil Nam-gu, Daegu, Republic of Korea (e-mail: emzzang@cu.ac.kr).*

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1. Introduction

Since the first confirmed case of coronavirus disease (COVID-19) in Wuhan, China, in December 2019, the infection has spread rapidly throughout the globe. In South Korea, the first case was confirmed on January 19, 2020, and the number of COVID-19 cases exponentially increased in the Daegu region since the first case on February 28, 2020, primarily through a particular religious group. On February 29, 2020, a record-high of 741 cases was confirmed in a single day, and approximately 6000 people contracted the infection in the following 70 days, exerting a toll on the regional emergency medical system.[1] At that time, the features of the virus were not well known because the epidemic was still at an early stage, and the communities and hospitals did not have a well-established response system to effectively deal with the superspreading of the infection in a short period. Emergency medical centers in the region were temporarily closed down and restricted to access for disinfection measures due to confirmed cases within the facility, which led to a shortage of healthcare facilities to treat COVID-19–suspected patients,[2] and self-quarantine and contraction of infection among healthcare providers who have been exposed to confirmed patients led to a shortage of healthcare providers.

To lower the risk of infection within emergency medical centers and accommodate the increasing number of COVID-19 patients and COVID-19–suspected patients, hospitals had to establish appropriate measures accordingly. Our hospital temporarily restructured zones to divide the emergency department (ED) into an isolation zone and a clean zone and increased the number of isolation beds from 3 to 8. Furthermore, COVID-19 screening tests that had been commissioned to a third party, which takes approximately 1 to 2 days to provide the results, were changed to in-hospital polymerase chain reaction (PCR) tests to shorten the test turnaround time. Although previous studies reported how different regions altered their care system to treat the suspected patients and changed the structure of the emergency medical center in response to COVID-19 pandemic,[3–6] none of the studies reported the outcomes of these response measures. We hypothesized that our response measures would have contributed to accommodating more COVID-19–suspected patients by utilizing isolation beds and increasing the turnover rate. Thus, we aimed to comparatively analyze the pre-COVID-19 period, transition period (before fully implementing the response measures), and post-response period (after fully implementing the response measures) to identify the effectiveness of our response as well as introduce and disseminate our response methods.

2. Methods

2.1. Design and study participants

This study is a retrospective analysis of medical records. Patients who presented to our emergency medical center between January 1, 2020 and June 30, 2020, using the National Emergency Department Information System (NEDIS) were included. No particular exclusion criteria were applied, and all 12,450 patients who visited the ED during the study period were enrolled in the study.

2.2. Procedures

The information reported to the NEDIS [sex, age, response at the time of visit, vital signs at the time of visit, oxygen saturation, Korean Triage and Acuity Scale, route of visit, means of transport, reason for visit, length of stay (LOS), disposition], fever and respiratory symptoms (cough, nasal discharge, sputum, hemoptysis), and use of isolation zone was collected.

To compare the outcomes of the COVID-19 response at our ED, the study period was divided into 3 periods to compare the early transitional period and the period after the response measures were fully implemented with reference to the patient information prior to COVID-19. NEDIS data, potential COVID-19 symptoms, and use of isolation zone were comparatively analyzed. The first period was the period before the onset of COVID-19, which spanned January 1, 2020, to the date of first confirmed patient in Daegu (February 18, 2020). The second period was in the early days of the pandemic response, and it spanned from the time of confirmation of the first patient in the community until the day when COVID-19 screening tests that had been commissioned to a third party were changed to PCR tests performed in the hospital and before completely changing the ED structure (March 14, 2020). The third period was the period after the pandemic response measures were fully implemented, from the day of implementation of changes to June 30, 2020. This study was approved by the institutional review board at our hospital (IRB CR-20-192-L). Written informed consent was waived.

2.2.1. Change of the ED structure. The structure of our ED was changed over a 10-day period starting on March 4, 2020. The previous patient triage zone was remodeled, and the ED (total area, 931.2 m^2) was divided into an isolation zone (356.8 m^2) and a clean zone (574.3 m^2) (Fig. 1). The clean zone was reduced from 32 beds to 24 beds, and the beds were spaced at least 2-m apart to prevent infection. The isolation zone was expanded from 3 beds to 8 beds. The clean and isolation zones had separate entrances to prevent exposure to infection-suspected patients. An automatic door was installed in the aisle that leads to the clean zone, and portable negative-pressure devices were additionally installed throughout the isolation zone to maintain negative pressure. In the screening center, patients were triaged and were taken to the clean or isolation zones depending on the presence of COVID-19 symptoms, such as fever and respiratory symptoms, to receive care accordingly.

2.2.2. Change of COVID-19 testing to in-hospital PCR tests. From February 18, 2020, to March 2, 2020, COVID-19 tests were commissioned to a third party, but starting March 3, 2020, PCR testing was done in-hospital. Four rounds of COVID-19 tests were performed daily, and the turnaround time was approximately 4 hours. From June 2020, the testing frequency was changed to 3 times daily.

2.2.3. Additional response measures. Before the structural change, 3 tents were temporarily installed in the parking lot in front of the ED entrance:

(1) screening tent: for patient screening, triage, administration, and billing;
(2) negative-pressure tent: for COVID-19 sample collection and cardiopulmonary resuscitation for out-of-hospital cardiac arrest;
(3) caregiver tent: waiting room for caregivers.

All patients and caregivers first entered the screening tent to fill out their COVID-19 questionnaire and were assigned to either the isolation or clean zone depending on the presence of suspected symptoms. Only 1 caregiver was allowed to enter the emergency room, and security officers guarded each entrance to control the entry of caregivers. Level D personal protection equipment as well as N95/KF94 mask, disposable surgical gown, AP gown, gloves, and goggles/face shields were used in the screening center and isolation zone. To separate the traffic flow, the administrative department was also divided into 2 zones, and caregiver IDs were also color-coded for entry into different zones. Our hospital operated the treatment ward and intensive care unit for COVID-19 patients from February 26th to May 20th, 2020. In the case of a new COVID-19 positive patient, the hospitals operating the COVID-19 treatment ward arranged admission or transfer through discussion and coordination in advance.

2.2.4. Regional features. Daegu Metropolitan City is located in the southeast inlands of the Republic of Korea, and its surface area is 883.5 km^2. Daegu is the fourth-most populated city in South Korea, with a population of 2.47 million as of December 31, 2019. It has 3723 hospitals (37,015 wards) and 15 general hospitals (7425 wards).[7] Daegu has 2 regional emergency medical centers, 4 local emergency medical centers, 9 local emergency medical

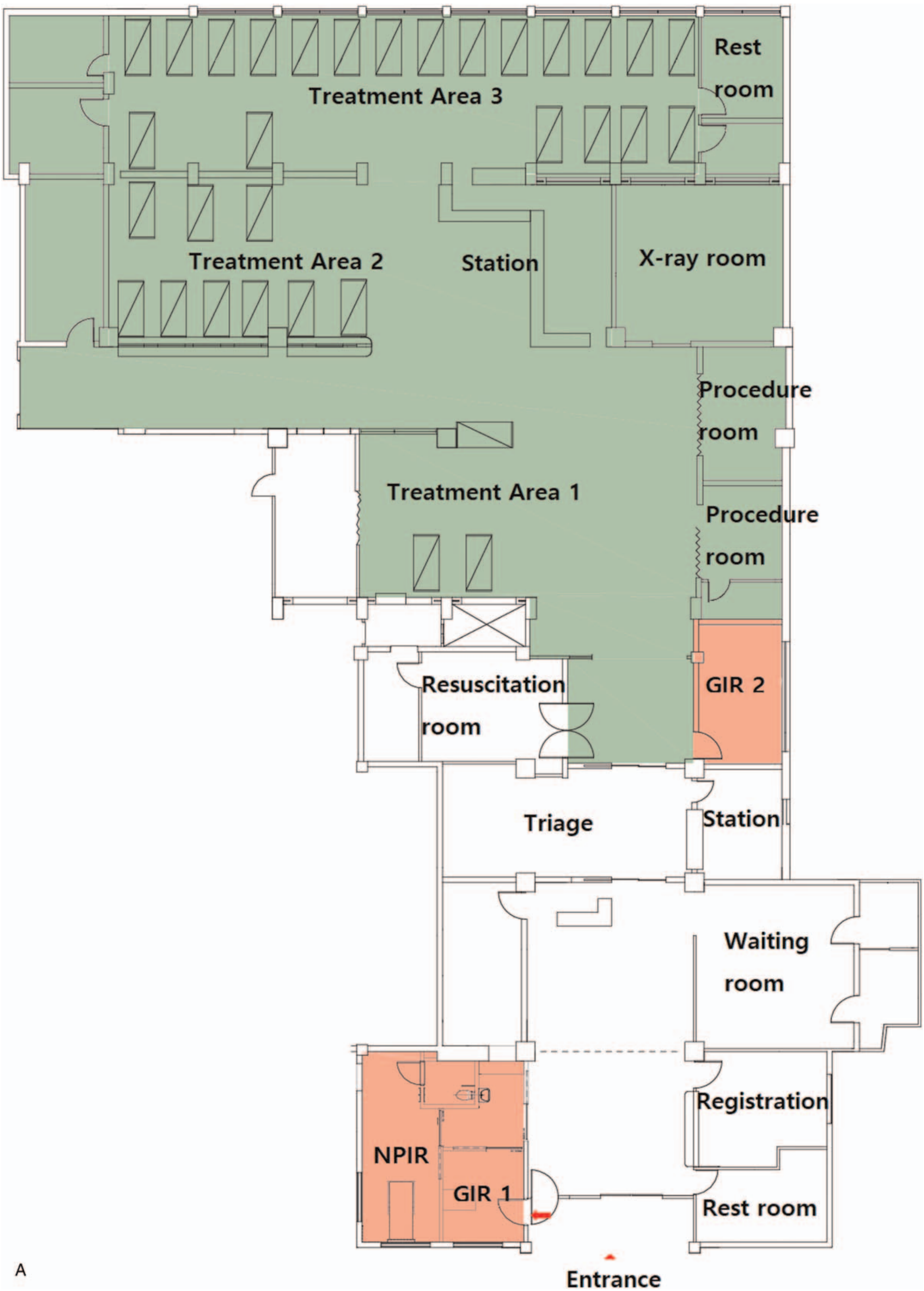

Figure 1. Comparison of the emergency department structure before and after remodeling for response to COVID-19 pandemic. A. Original emergency department. B. Revised emergency department., GIR = general isolation room, NPIR = negative pressure isolation room.

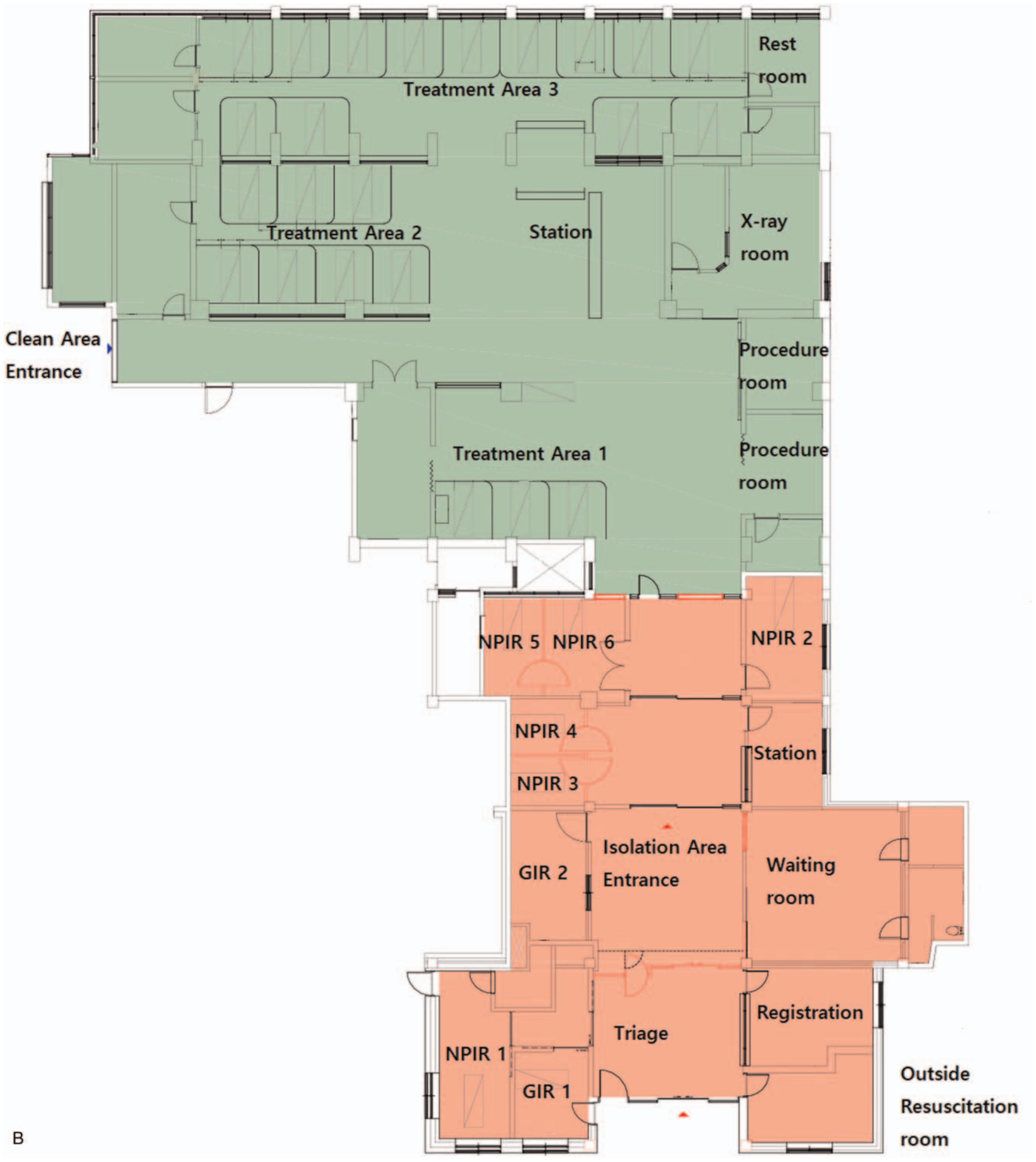

Figure 1. (Continued).

facilities, and 7 EDs, for a total of 294 wards.[8] Being one of the local emergency medical centers and a university-affiliated hospital, approximately 33,000 patients visited our ED in 2019.

2.3. Statistical analysis

For the general characteristics of the patients and study parameters, continuous variables were analyzed with mean (standard deviation) and median (quartile), and nominal variables were presented as frequency (percentage). When comparing the 3 study periods (pre-COVID-19, transition, and late response periods), continuous variables that satisfy the assumption were analyzed with 1-way analysis of variance, and those that do not satisfy the assumption were analyzed with Kruskal-Wallis test, followed by Scheffe's or Dunn's procedure for post hoc analysis. Nominal variables were compared among

Table 1

General characteristics and initial clinical presentations of patients.

Variable N/d (%)	Pre-COVID-19 period[a]	Transition period[b]	Post-response period[c]	*P*-valve	Post hoc
Age mean (SD)	57.1 (20.8)	57.9 (20.2)	57.3 (21.2)	.713	
Sex				.287	
Male	45.7 (52.7)	19.7 (54.2)	36.4 (54.1)		
Female	41.1 (47.3)	16.6 (45.8)	30.8 (45.9)		
Mental Status				<.001	
Alert	80.4 (92.6)	32.3 (88.8)	59.8 (89.1)		
Verbal	2.3 (2.6)	1.5 (4.2)	2.9 (4.4)		
Painful	1.8 (2.1)	1.2 (3.3)	1.6 (2.3)		
Unresponsive	2.4 (2.7)	1.3 (3.7)	2.9 (4.3)		
Vital sign (SD)					
SBP (mm Hg)	140.4 (27.6)	137.5 (29.7)	135.2 (28.9)	<.001	b,c<a
HR (n/min)	89.0 (19.2)	89.0 (18.3)	88.4 (18.9)	.067	
RR (n/min)	20.1 (1.2)	20.2 (1.7)	20.0 (1.4)	<.001	a,c<b
sp02 (%)	97.4 (3.8)	97.1 (4.6)	97.0 (4.8)	<.001	c<b<a
BT (°C)	36.8 (1.1)	36.8 (0.9)	37.0 (1.2)	<.001	a<b<c
Fever ≥ 37.5°C				<.001	
Yes	14.8 (17.3)	6.8 (19.1)	14.5 (21.9)		
No	70.8 (82.7)	28.6 (80.9)	51.6 (78.1)		
Respiratory Symptom				<.001	
Yes	15.3 (17.6)	7.4 (20.3)	10.2 (15.2)		
No	71.5 (82.4)	28.9 (79.7)	56.9 (84.8)		
KTAS				<.001	
1	3.7 (4.3)	2.0 (5.5)	2.9 (4.3)		
2	12.1 (13.9)	5.4 (14.9)	9.2 (13.7)		
3	46.3 (53.4)	18.0 (49.4)	34.0 (50.5)		
4	22.0 (25.2)	8.4 (23.1)	18.5 (27.5)		
5	2.8 (3.2)	2.6 (7.1)	2.6 (3.9)		

BT = Body temperature, COVID-19 = Coronavirus disease, HR = Heart rate, KTAS = Korean Triage and Acuity Scale, RR = Respiratory rate, SBP = Systolic blood pressure, SD = Standard Deviation, spO2 = saturation of percutaneous oxygen.

[a] The period before the onset of COVID-19 in Daegu (n = 4255, 49days): From Jan 1, 2020 to Feb 18, 2020.

[b] The transition period was early days of the pandemic response before complete changing the emergency department structure and in-hospital COVID-19 polymerase chain reaction test (n = 872, 24days): From Feb 19, 2020 to Mar 14, 2020.

[c] The period after complete response (n = 7323, 109days): From Mar 15, 2020 to Jun 30, 2020.

the 3 groups using chi-square tests. Statistical analyses were performed (SPSS version 19.0; IBM), with $P < .05$ considered statistically significant.

3. Results

3.1. General characteristics and initial presentation in the ED

There was a total of 4,255 patients in the pre-COVID-19 period, 872 patients in the transition period, and 7,323 patients in the post-response period (Table 1). The mean age of patients and the ratio of male patients did not show statistically significant differences among the 3 periods. In terms of consciousness at the time of visit, the ratio of patients who were alert significantly differed among the 3 groups ($P < .001$). In terms of vital signs, systolic blood pressure was significantly higher in the pre-COVID-19 period ($P < .001$). The pulse rate did not significantly differ among the 3 periods. The respiratory rate was significantly higher in the transition period ($P < .001$). Oxygen saturation significantly decreased over the 3 periods ($P < .001$). Body temperature significantly increased over the periods ($P < .001$). In terms of fever, the ratio of patients with fever was highest in the post-response period ($P < .001$). Regarding the prevalence of respiratory symptoms, the ratio of patients with respiratory symptoms significantly differed among the 3 periods ($P < .001$). These results showed that our hospital accepted more patients with fever and respiratory symptoms that indicate COVID-19 in the post-response period than in the transition period. Regarding the Korean Triage and Acuity Scale, the ratio of patients classified as level 1 significantly differed among the 3 periods ($P < .001$).

3.2. Routes, reasons, and means of visit

Regarding the route of visit, the percentage of patients transferred from another facility was the lowest in the transition period but increased in the post-response period ($P < .001$) (Table 2). This suggests that there were reduced inter-facility transfer requests or acceptances in the early days of the pandemic response, but inter-facility transfers increased in the later days of pandemic response owing to the increased availability of isolation wards and bed turnover rates. Regarding the mode of visit, the percentage of patients admitted via a public ambulance was significantly higher in the transition period ($P < .001$). Regarding the reason for visit, the percentage of patients presenting to the ED due to a disease did not significantly differ among the 3 groups.

3.3. Comparison of ED dispositions and use of isolation rooms among the 3 periods

The daily average number of patients visiting the ED was the highest in the pre-COVID-19 period, lowest in the early response

Table 2

Comparisons of routes, modes, and reasons for visiting patients among the 3 periods.

Variable N/d (%)	Pre-COVID-19 period[a]	Transition period[b]	Post-response period[c]	*P*-valve	Post hoc
Route of visit				<.001	
Direct	69.0 (79.4)	32.0 (88.2)	55.8 (83.1)		
Transfer	15.9 (18.3)	3.5 (9.8)	10.0 (14.8)		
OPD	1.9 (2.2)	0.7 (2.0)	1.3 (2.0)		
Other	0.0 (0.0)	0.0 (0.1)	0.0 (0.1)		
Mode of visit				<.001	
Public ambulance	30.0 (34.5)	16.3 (45.0)	26.8 (39.9)		
Hospital ambulance	1.1 (1.3)	0.9 (2.5)	1.8 (2.7)		
Other Ambulance	7.8 (9.0)	1.4 (3.8)	4.2 (6.3)		
Other Car	34.7 (40.0)	9.5 (26.3)	19.1 (28.5)		
Walk	12.9 (14.9)	8.0 (21.9)	14.9 (22.2)		
Other	0.2 (0.3)	0.2 (0.6)	0.3 (0.5)		
Reason of visit				.395	
Disease	68.4 (78.7)	29.6 (81.4)	53.2 (79.2)		
Non-disease	18.4 (21.2)	6.7 (18.4)	13.9 (20.7)		
Other	0.1 (0.1)	0.1 (0.2)	0.1 (0.2)		

COVID-19 = coronavirus disease, OPD = outpatient department.

[a] The period before the onset of COVID-19 in Daegu (n = 4255, 49days): From Jan 1, 2020 to Feb 18, 2020.

[b] The transition period was early days of the pandemic response before complete changing the emergency department structure and in-hospital COVID-19 polymerase chain reaction test (n = 872, 24days): From Feb 19, 2020 to Mar 14, 2020.

[c] The period after complete response (n = 7323, 109days): From Mar 15, 2020 to Jun 30, 2020.

period, and slightly increased again in the late response period, with significant differences among the 3 periods ($P < .001$) (Table 3). The median LOS was significantly higher in the transition period than in the other 2 periods ($P < .001$). In the early days of the pandemic, COVID-19 screening tests were additionally required, and the high turnaround time to obtain results due to the increased number of tests and use of an external facility would have increased patients' LOS. The median LOS for hospitalization was significantly higher in the transition and post-response period than in the pre-COVID-19 period. This could be affected by the change of hospital policy that allows hospitalization after confirmation of COVID-19 test result for all inpatients from April 2020. The use of isolation beds statistically significantly differed among the 3 periods, with the lowest in the pre-COVID-19 period and highest in the post-response period ($P < .001$). The increased number of isolation beds from 3 to 8 and quicker COVID-19 test turnaround time would have increased the bed turnover rate and thus led to increased use of the isolation beds. Regarding the ED dispositions, the percentage of patients hospitalized and discharged did not statistically significantly differ among the 3 periods.

4. Discussion

Since the first confirmed case in Wuhan, China, in December 2019, COVID-19 has been identified as a respiratory syndrome

Table 3

Comparisons of outcomes and using of an isolation room among 3 periods.

Variable	Pre COVID-19[a]	Transition period[b]	Post-response[c]	*P*-valve	Post hoc
Daily average visiting patients (SD)	86.8 (15.4)	36.3 (13.6)	67.2 (10.0)	<.001	b<c<a
Length of ED stay (min)	219.0 (121.0–378.0)	301.0 (150.0–766.5)	281.0 (144.0–575.0)	<.001	a<c<b
Length of stay for hospitalization (min)	160.0 (64.0–369.5)	295.0 (104.5–912.0)	312.0 (128.0–582.0)	<.001	a<b,c
COVID-19 test, N/d (%))				<.001	
Yes		12.3 (33.9)	30.7 (45.7)		
No		24.0 (66.1)	36.4 (54.3)		
COVID-19 positive case (N)		14	23		
Disposition, N/d (%)				.053	
Discharge	57.1 (65.7)	21.8 (60.1)	40.4 (60.2)		
Admission	23.7 (27.3)	11.9 (32.8)	22.0 (32.7)		
Transfer	0.0 (0.1)	0 (0)	0.0 (0.04)		
Death	1.4 (1.7)	1.4 (3.9)	1.5 (2.2)		
Other	4.6 (5.3)	1.2 (3.2)	3.3 (4.9)		
Use of isolation room, N/d (%)				<.001	
Yes	0.6 (0.7)	1.2 (3.3)	16.1 (24.0)		
No	86.2 (99.3)	35.1 (96.7)	51.1 (76.0)		

COVID-19 = coronavirus disease, ED = emergency department, SD = standard deviation.

[a] The period before the first case in Daegu (n = 4255, 49days): From Jan 1, 2020 to Feb 18, 2020.

[b] The transition period of response (n = 872, 24days): From Feb 19, 2020 to Mar 14, 2020.

[c] The period after complete response (n = 7323, 109days): From Mar 15, 2020 to Jun 30, 2020.

caused by a novel coronavirus (severe acute respiratory syndrome coronavirus 2) infection that quickly spread throughout China and worldwide. Currently, COVID-19 is transmitted through droplets and contact. The diagnosis is made by isolating the virus from a sample and detecting a specific gene to confirm infection with the pathogen. COVID-19 is a highly transmittable infection characterized by an array of symptoms, from no symptoms at all to fever, cough, dyspnea, and pneumonia.[9,10] The time when the first case was confirmed in Daegu was before COVID-19 became a global pandemic, and because most patients were asymptomatic at the time, it was difficult to differentiate based on symptoms. After patients who visited emergency medical centers were confirmed with the infection, 2 regional emergency medical centers and r local emergency medical centers were temporarily shut down.[3] As COVID-19 accompanied several symptoms, it was difficult to differentiate patients with suspected infection, and there were no separate zones established to isolate patients besides a few existing isolation beds. Furthermore, because we could not accept new patients with suspected infection until test results of the patients already in the isolation beds were confirmed, the bed turnover rate also decreased. The Emergency Medical Service Act stipulates that regional medical centers need to be equipped with beds spaced at least 1.5 m apart in the emergency treatment zone, with at least 2 negative-pressure isolation beds and 3 general isolation beds. Local emergency medical centers are required to be equipped with a patient triage zone and at least 20 beds, including 1 negative-pressure isolation bed, and 2 general isolation beds.[11] The previous number of isolation beds as stipulated by law was insufficient to effectively respond to a pandemic such as COVID-19.

As the infection rapidly spread, the Korean government and Daegu Metropolitan City collaborated with each healthcare facility to convert existing wards to exclusive wards for COVID-19 inpatients and conducted a complete enumeration investigation of all individuals associated with the religious group involved. All scheduled events in communities were either canceled or postponed, and senior welfare centers housing high-risk residents vulnerable to the virus strictly controlled visits by non-residents. The fire department provided manpower and ambulances to transport COVID-19 patients, and accommodations, research facilities, and training facilities were designated as COVID-19 community treatment centers to admit COVID-19 patients with mild symptoms.[12]

Our hospital had 1 negative-pressure bed and 2 isolation beds before the pandemic, but this was changed to 6 negative-pressure beds and 2 general isolation beds. Because our hospital could not be expanded in size, the existing space was remodeled. The ED was divided into a clean zone and an isolation zone with a negative-pressure facility, and patients were screened at the entrance of the ED. Patients suspected of having the infection were treated in the isolation zone, whereas those who are not suspected were instructed to enter the clean zone. Whitwell et al[3] documented the separation of isolation and clean zones in places with wide space available for patient care, and Chung et al[4] reported cases in which the area outside the ED was utilized to provide care for suspected patients or perform X-ray and cardiopulmonary resuscitation. Although we were able to isolate multiple patients as a cohort in the isolation zone, the COVID-19 screening test was time-consuming, and proactively isolating suspected patients as a cohort was associated with a risk of spreading the infection among these patients. Thus, we attempted to secure as many negative-pressure isolation beds as possible even if it meant the beds were smaller and utilized general isolation beds if negative-pressure isolation was not possible. Hospitals with larger spaces available could utilize a separate building to screen and provide care for suspected patients.

The previous COVID-19 PCR test was commissioned to a third party, and the results took approximately 1 to 2 days to be released. Moreover, the quick spread of the infection and consequent increase in the test volume further delayed the test turnaround time. After changing the test method at our hospital, the test turnaround time was shortened. Patients in the isolation zone could be transferred to the clean zone or hospitalized/discharged only after a confirmed negative result; thus, reduction of the test turnaround time would have contributed to boosting the isolation bed turnover rate and shortening the LOS in the ED.

As a result of these measures, the number of patient visits, which had been dramatically decreased in the transition period, increased in the post-response period, with a daily number of patient admission of 86.8 ± 15.4 in the pre-pandemic period, 36.3 ± 13.6 in the early response period, and 67.2 ± 10.0 in the late response period. Regarding the characteristics of the patients who presented to the ED, the daily number of patients admitted through a public ambulance was 16.3 (45.0%) in the transition period, which was relatively higher than the number of patients admitted through other means, but the number of patient transport decreased. This is speculated to be because the outbreak led to reduced ED utilization by patients with mild conditions, and public ambulances were utilized more frequently to transport those who needed to present to an ED. Kim et al[13] reported that the number of public ambulance dispatches slightly decreased during the pandemic compared with a similar period before the pandemic in the same region, and the time of arrival at the scene, transport time, and return time were also delayed compared with that before the pandemic. This could be because paramedics had to confirm whether the patient could be accepted by all EDs before choosing the hospital to transport the patient and had to wait outside the hospital until an isolation bed became available. The number of patients with fever, a typical COVID-19 symptom, increased from a daily average of 6.8 (19.1%) in the transition period to 14.5 (21.9%) in the post-response period, and the number of patients with respiratory symptoms increased (7.4 vs. 10.2) in the post-response period. During a pandemic, accepting patients transported in a public ambulance and COVID-19–suspected patients is crucial, and to ensure this, it is necessary to develop measures to expand the limited regional emergency medical resources in a short time or efficiently utilize the limited resources available.

In our study, the LOS in the ED drastically increased in the transition period compared with that before the pandemic and then decreased after response measures were fully implemented. In general, ED overcrowding can occur because of a shortage of beds, a shortage of healthcare providers, and high inpatient bed utilization. To resolve this, the number of ED beds can be increased, maximum LOS can be capped, and inpatient wards can be run differently to increase turnover. Some strategies to increase the efficiency of inpatient wards include adjusting scheduled hospitalizations such that patient admissions and scheduled surgeries are evenly distributed throughout the week, discharging patients early in the day to reduce waiting times for new hospitalizations, and discharging patients in the weekends.[14,15] However, in the early days of the epidemic, the number of patients presenting to the ED decreased, while the isolation zone, which housed patients suspected of the infection, was overcrowded, showing a different type of shortage of healthcare resources. At our hospital, the isolation bed turnover rate was markedly reduced owing to the small number of isolation beds initially, long test turnaround times, delayed transfer/hospitalization upon confirmation of a COVID-19 patient, the decision for hospitalization/discharge made after checking test results, and disinfection measures. After fully implementing the response measures, which included increasing the number of isolation beds and shortening test turnaround times, the isolation bed turnover rate was enhanced to a daily number of 16.1 (24.0%) compared with 1.2 (3.3%) in the early response period. Moreover, patients who need not stay in the hospital to wait for the PCR test results were first discharged and ordered self-quarantine until the test results are out, which further enhanced the turnover rate of isolation beds. During an epidemic, more isolation beds should be installed and run efficiently to focus on reducing overcrowding.

This study had some limitations. First, there were limitations due to the nature of a retrospective analysis of medical records. Second, this study was conducted on patients who presented to a single ED; hence, it is difficult to generalize the findings due to the differences in the status of the epidemic and emergency medicine resources across regions as well as differences in facilities and structures across hospitals. Third, we could not analyze the specific effects of increasing isolation beds and shortening test turnaround times due to the lack of accurate information about the duration of isolation bed usage and test turnaround times. Fourth, we could not draw conclusions on causality, whether the number of patients presenting to the ED naturally increased over the period of the epidemic or it was a result of the response strategy.

Despite these limitations, we showed that running an isolation zone in the ED, adding more isolation beds, and changing the screening test method during the pandemic resolved the issue of overcrowding in the isolation zone, which helped accommodate more patients, particularly those with suspected infection and emergency cases admitted via a public ambulance. In the future, emergency medical centers should be adequately equipped with an isolation zone and isolation beds in preparation for a potential epidemic to operate the system flexibly depending on the epidemic. In particular, upon the onset of a novel outbreak, accurate and prompt screening testing should be implemented to reduce overcrowding of the isolation zone.

In conclusion, during an outbreak of a novel infectious disease, implementing an isolation zone in the ED with increased number of isolation beds and quick screening tests would enable the accommodation of more suspected patients, which would reduce the risk posed to the community and thus prevent strain on the emergency medical system.

Author contributions

Conceptualization: Tae Chang Jang, Gyun Moo Kim.
Data curation: Ye Jin Oh, Tae Chang Jang, Gyun Moo Kim, Young Woo Seo.
Formal analysis: Ye Jin Oh, Tae Chang Jang, Seung Hyun Ko, Suk Hee Lee.
Investigation: Ye Jin Oh, Tae Chang Jang, Suk Hee Lee.
Methodology: Ye Jin Oh, Tae Chang Jang.
Resources: Tae Chang Jang, Gyun Moo Kim, Young Woo Seo, Seung Hyun Ko.
Supervision: Tae Chang Jang, Gyun Moo Kim, Young Woo Seo, Seung Hyun Ko, Suk Hee Lee.
Validation: Tae Chang Jang.
Writing – original draft: Ye Jin Oh, Tae Chang Jang.
Writing – review & editing: Ye Jin Oh, Tae Chang Jang.

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