

Impact of the coronavirus disease 2019 outbreak on the transportation of patients requiring emergency care

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Abstract

The first confirmed community transmission of coronavirus disease 2019 in Daegu Metropolitan City, South Korea, occurred on February 18, 2020. In the following 70-day period, approximately 6000 new cases occurred, severely impacting the medical service system. This study investigated the crisis-impact on the local emergency transport system.

Emergency medical service activity reports were retrospectively reviewed to determine patient demographics and initial vital signs. Delay in reaching the patient, transporting the patient to the hospital, and returning to the fire station were assessed and categorized based on patients' initial vital signs. The study period was divided into 4 groups (1/1–2/18, 2/19–3/3, 3/4–3/31, and 4/1–04/30) and intergroup differences were analyzed.

When compared to Period 1, the time-difference between the request to attend a scene and arrival at the scene was delayed in Periods 2, 3, and 4 by 4 minute 58 s, 3 minute 24 seconds, and 2 minute 20 seconds, respectively; that between arriving at the scene and at the hospital was delayed by 7 minute 43 seconds, 6 minutes 59 seconds, and 4 minutes 30 seconds, respectively; and that between arriving at the hospital and returning to the fire station was delayed by 29 minute 3 second, 25 minute 55 second, and 18 minute 44 second, respectively. In Period 2, for patients with symptoms of severe illness when compared to patients lacking such symptoms, the time-difference between the request to attend the scene and arrival at a hospital and between arrival at the hospital and returning to the fire station were 6 to 23 minute and 12 to 48 minute longer, respectively. Most of the delays impacted patients with a fever. In terms of condition, the statistical effect size for delay in transport time was from large to small: fever, hypoxia, abnormal respiratory rate, respiratory symptom, and hypotension.

Outbreaks of infectious disease cause a paradoxical state in emergency medical transport systems, inducing delays in the transport of severely ill patients. Therefore, maintenance and improvement of the medical service system for both patients with infectious disease and those with other severe illnesses is required.

Abbreviations: COVID-19 = coronavirus disease 2019, CV = coefficient of variation, ED = emergency department, EMS = emergency medical service, EMT = emergency medical technician, PPE = personal protective equipment, SD = standard deviation.

Keywords: coronavirus disease 2019, emergency medical service, outbreak, transport time

1. Introduction

The first reported case of coronavirus disease 2019 (COVID-19) occurred in Wuhan, China, in December 2019, after which the disease spread throughout China and eventually around the world. The World Health Organization declared the outbreak a public health emergency of international concern on January

30, 2020.^[1] The first confirmed case in South Korea was reported on January 19, 2020, followed by a gradual increase with 30 newly confirmed cases occurring over the following month.^[2] However, in Daegu, after the first confirmed case on February 18, 2020, the number of COVID-19 cases increased sharply.^[2,3]

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The data that support the findings of this study are available from a third party, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are available from the authors upon reasonable request and with permission of the third party.

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From February 19, 2020 onward, the number of confirmed cases in Daegu increased, rising by 10, 23, and 50 new cases, respectively, on each of the following days.^[2] On February 29, 2020, the highest number of newly confirmed cases in a single day was reported at 741; by March 15, 2020, the cumulative number of confirmed cases had reached 6081.^[2] In response, the South Korean government raised the infectious disease crisis warning to the highest level, and implemented maximum efforts to treat COVID-19 patients and prevent the spread of the disease.^[4] However, as the medical service system in Daegu was experiencing a crisis, it became impossible to maintain its emergency medical services (EMS) system at a normal level. Consequently, emergency patients other than COVID-19 infected patients could not properly utilize the emergency medical transport system.

The present study is the first to investigate the effects of the community outbreak of COVID-19 on the emergency patient transport performed by emergency medical technicians (EMTs). The findings of this study can provide basic data that can help public health and EMS systems prepare in the event of infectious disease outbreaks in the future.

2. Methods

2.1. Study period and subjects

This study was approved by the Ethics Committee of the Daegu Catholic Medical Center (approval number: CR-20-119-L). The ethical committee waived the requirement for informed consent due to the retrospective study design. Adopting a study period ranging from January 1 to April 30, 2020, the present study analyzed data from emergency response activity reports that described requests made to “119 emergency medical service” in the Daegu area. Overall, 35 240 cases were identified, of which 21 370 were selected for this study; we excluded cases involving the transport of COVID-19 patients or samples, incidents that occurred outside of Daegu, helicopter transports, uncompleted transports (eg, false reports, accidental reports, cancelled reports), and data errors (eg, records that reported that the EMTs were dispatched to the scene before receiving the request).

2.2. “119 emergency medical service” and daegu metropolitan city

“119 emergency medical service” is an organization managed by the National Fire Agency, a government agency in South Korea, and its primary duties include receiving calls regarding on-site emergencies, performing on-site first aid and transport, transporting patients from 1 hospital to another, and conducting medical consultations.^[5] It is taxpayer-funded and no additional fees are charged to the users.^[5] When “119 emergency medical service” receives an emergency report, a unit from the fire station located closest to the scene is dispatched to transport the patient to a hospital that can provide appropriate medical services; the unit then transfers custody of the patient to the hospital and returns to the station. If the evaluation performed at the scene indicates that an on-site emergency treatment is needed (e.g., cases of cardiac arrest, hypotension, or hypoxia), measures to stabilize the airway, breathing, and circulation could be administered (with medical supervision by an emergency medical specialist via video or voice communication) before transporting the patient.^[5]

Daegu Metropolitan City is located inland, in southeastern South Korea. It covers an area of 883.5 km² with a population of 2.47 million, as of December 31, 2019, making it the fourth highly-populated city in South Korea. On December 31, 2017, Daegu had a total of 3664 clinics and hospitals (36 327 beds) and 12 general hospitals (6870 beds).^[6] By December 31, 2018, there were 22 emergency departments (EDs; 249 beds) in the city, of which 6 were Level 1 or 2 (187 beds).^[7] Overall, 472 141 patients visited an ED during 2018, of which 231 770 visited a Level 1 or Level 2 ED (50 180 and 181 590, respectively).^[8]

Daegu has 1 fire department and 8 fire stations, along with 48 affiliated safety centers.^[9] In 2018, there were a total of 120 446 cases of EMS dispatch, out of which, patient transport was completed in 79 714 cases and the number of EMS dispatch cases was the fourth-highest among all the cities in South Korea.^[8] The locations of hospitals with Level 1 or 2 EDs and the 8 fire stations in Daegu are shown in Figure 1. EMS activity reports contain medical records and details of on-site activities and are drafted personally by EMTs who were at the scene during such incidents.^[5]

2.3. Study methods

In this study, we retrospectively reviewed EMS activity reports to determine patients’ age, sex, initial vital signs, oxygen saturation, and the level of consciousness; the location of the scene; details regarding the request to attend the scene; the fire station (or safety center) from where the EMTs were dispatched; the distance between the scene and the fire station; the hospital where the patient was transported; the distance between the scene and the hospital; and date and time of the request to attend the scene/dispatch, arrival at the scene/hospital, and return to the fire station.

The cases were divided into 4 periods based on when the request to attend the scene was reported: Period 1: January 1 to February 18 (when the first confirmed case was identified in Daegu), Period 2: February 19 to March 3 (2 weeks), Period 3: March 4 to March 31 (4 weeks), and Period 4: April 1 to April 30. We categorized the cases for comparison for over 4 weeks. The first 2 weeks were divided into periods of acute crisis.

By analyzing the initial vital signs and pulse oximeter results measured on-site by the EMTs, we defined hypotension as systolic blood pressure ≤ 90 mm Hg, fever as a body temperature of $\geq 37.5^\circ\text{C}$, and hypoxia as a blood oxygen level of $\leq 90\%$. Meanwhile, abnormal respiratory rate was defined as ≤ 30 to 60/min, 24 to 40/min, 22 to 34/min, 18 to 30/min, and 12 to 20/min for the patients aged < 1 , 1 to 3, 4 to 5, 6 to 12, and > 12 years, respectively. Based on these parameters, the patients were divided into normal and abnormal groups. Respiratory infection symptoms were defined as symptoms of febrile sensation, dyspnea, cough, sputum, rhinorrhea, and/or sore throat.

2.4. Statistical method

Statistical analyses were performed using SPSS version 21.0 for Windows (SPSS Inc., Chicago, IL).

For comparisons of 2 groups, Student *t*-test was performed. And for comparisons of 3 or more groups, multiway analysis of variance was performed, and partial eta squared was calculated to determine the effect size. Chi-square tests were performed for cross-analysis, while coefficients of variation were derived for cases with large differences in sample size. For all statistical analyses, $P < .01$ was determined to indicate statistical significance.

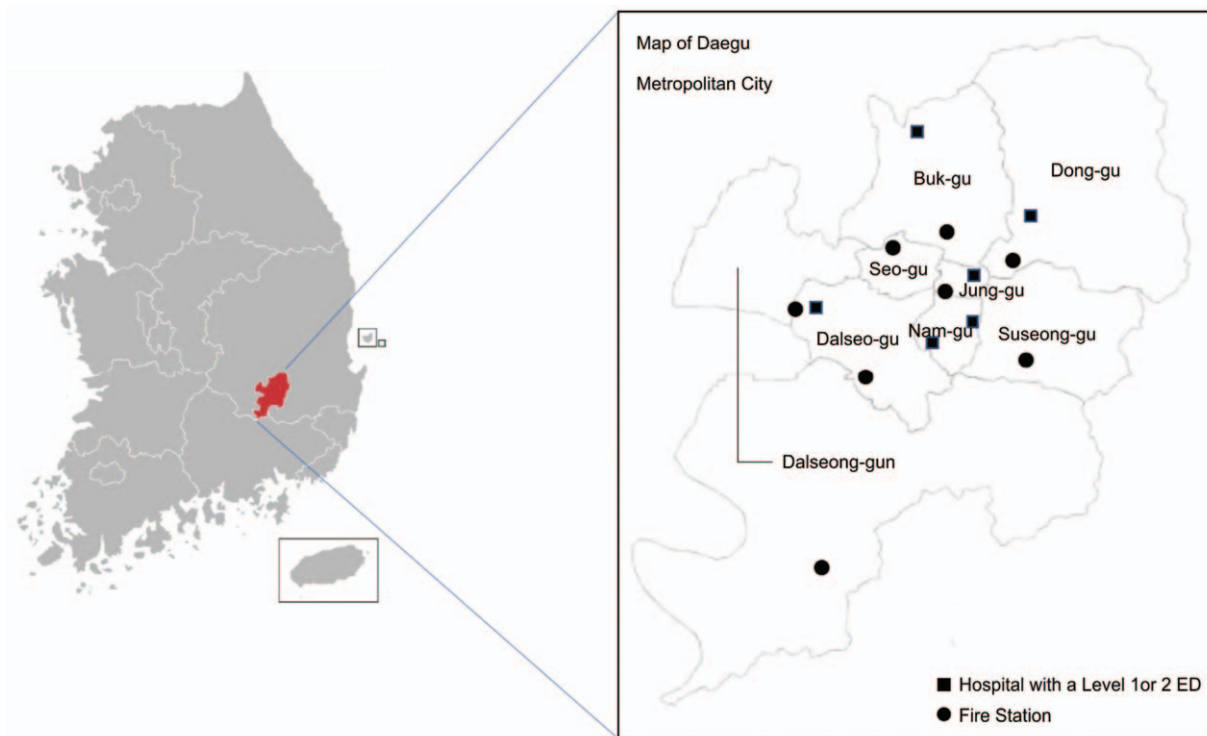


Figure 1. Map of Daegu metropolitan city. ED = emergency department.

3. Results

3.1. General characteristics of the periods and patients

Overall, patient transport was completed for a total of 21 370 patients, comprising 10 758 (219.6/d), 1853 (132.4/d), 3950 (141.1/d), and 4809 (160.3/d) during Period 1, 2, 3, and 4, respectively. The mean age of the patients was 56.9 years (standard deviation [SD]=± 22.07) and 11 700 patients were male (54.8%). There were no inter-period differences for age or sex. The number of cases reported to have symptoms of respiratory infection was 1112 (10.3%), 273 (14.7%), 473 (12.0%), and 414 (8.6%) during Period 1, 2, 3, and 4, respectively. The number of patients who exhibited signs of a fever when EMTs were measuring the initial vital signs was 520 (4.8%), 70 (3.8%), 190 (4.8%), and 215 (4.5%) during Period 1, 2, 3, and 4, respectively. The percentage of those who exhibited hypotension, abnormal respiratory rate, and hypoxia was 3.8~4.8%, 7.7~9.8%, and 4.8~6.1%, respectively. (Table 1)

During Period 1, 2, 3, and 4, the number of patients transported to Level 1 or 2 ED was 6631 (61.64%), 985 (53.16%), 2416 (61.2%), and 1963 (40.8%), respectively; those transported to a primary or secondary hospital was 4096 (38.1%), 829 (44.7%), 1509 (38.2%), and 1963 (40.8%), respectively; the number of patient cases transported to an emergency medical center outside Daegu was 31 (0.3%), 39 (2.1%), 25 (0.6%), and 19 (0.4%), respectively; and the mean transport distance (distance between the dispatch location and the scene + the distance between the scene and the hospital) was 8.23 (SD=± 6.055), 9.82 (SD=± 6.929), 9.70 (SD=± 6.853), and 9.00 (SD=± 6.481) km, respectively. (Table 1)

3.2. Cases involving patient transport to Level 1 or 2 ED

Codes were assigned randomly, using the uppercase letters “A-F” (n=6) for EDs and the lowercase letters “a-h” (n=8) for fire stations.

During Period 1, 2, 3, and 4, the number of patients transported to ED A was 1,167 (SD=103.13, coefficient of variation [CV]=0.088), 171 (SD=9.68, CV=0.057), 513 (SD=36.31, CV=0.071), and 506 (SD=37.69, CV=0.074), respectively. For ED B, the number of patients transported was 432 (SD=89.05, CV=0.206), 109 (SD=14.73, CV=0.135), 196 (SD=29.34, CV=0.150), and 155 (SD=23.89, CV=0.154), respectively. For ED C, this was 1 454 (SD=135.39, CV=0.093), 186 (SD=11.44, CV=0.061), 610 (SD=41.23, CV=0.068), and 739 (SD=56.26, CV=0.076), respectively. For ED D, 1 602 (SD=278.60, CV=0.174), 232 (SD=28.77, CV=0.124), 458 (SD=75.55, CV=0.165), and 650 (SD=103.52, CV=0.159), respectively. For ED E, 950 (SD=112.01, CV=0.118), 159 (SD=10.87, CV=0.068), 339 (SD=31.50, CV=0.093), and 397 (SD=38.96, CV=0.098), respectively. For ED F, 1 026 (SD=98.02, CV=0.096), 128 (SD=8.47, CV=0.066), 300 (SD=22.25, CV=0.074), and 380 (SD=30.05, CV=0.079), respectively. All *P*-values for these results were <.01 (Table 2).

3.3. Time between the request to attend a scene and return to the fire station, for each period

For each period, the total time was calculated by determining the respective averages. Compared to Period 1, scene-hospital time increased during Periods 2, 3, and 4 by 7 minute 43 second, 6 minute 59 second, and 4 minute 30 second, respectively, while

Table 1
General characteristics of the study periods and patients.

	Period				Total
	1	2	3	4	
Date	01/01–02/18	02/19–03/03	03/04–03/31	04/01–04/30	
Days (N)	49	14	28	30	121
Requests (N)	15,174	4,020	7,793	8,253	35,240
Requests/d	309.7	287.1	278.3	275.1	291.2
% of pre-outbreak rate	100%	92.7%	89.9%	88.8%	
Number of transports (N)	10,758	1,853	3,950	4,809	21,370
Transports/d	219.6	132.4	141.1	160.3	176.6
Age (Mean)	56.7	57.1	57.8	56.8	56.9
SD	22.64	21.10	21.39	21.67	22.07
Sex (Male)	5,779	1,025	2,222	2,674	11,700
Proportion of males (%)	53.7%	55.3%	56.3%	55.6%	54.8%
RI Sx	1,112	273	473	414	2,272
	10.3%	14.7%	12.0%	8.6%	10.6%
Fever	1,606	267	619	644	3,136
	14.9%	14.4%	15.7%	13.4%	14.7%
Hypotension	520	70	190	215	995
	4.8%	3.8%	4.8%	4.5%	4.7%
Abnormal RR	833	175	387	412	1,807
	7.7%	9.4%	9.8%	8.6%	8.5%
Hypoxia	538	113	242	231	1,124
	5.0%	6.1%	6.1%	4.8%	5.3%
Mental status					
Alert	9,784	1,678	3,486	4,325	19,273
	91.0%	90.6%	88.3%	89.9%	90.2%
Verbal response	458	56	179	182	875
	4.3%	3.0%	4.5%	3.8%	4.1%
Pain response	282	59	150	167	658
	2.6%	3.2%	3.8%	3.5%	3.1%
Unresponsive	234	60	135	135	564
	2.2%	3.2%	3.4%	2.8%	2.6%
Transport to Level 1 or 2 ED	6,631	985	2,416	2,827	12,859
% of total transports	61.6%	53.2%	61.2%	58.8%	60.2%
Transport to primary or secondary hospital	4,096	829	1,509	1,963	8,397
% of total transports	38.1%	44.7%	38.2%	40.8%	39.3%
Transport to nearby regional hospital	31	39	25	19	114
% of total transports	0.3%	2.1%	0.6%	0.4%	0.5%
Transport Distance (mean, km)	8.23	9.82	9.70	9.00	8.81
SD	6.055	6.929	6.853	6.481	6.415

Hypotension was defined as a systolic blood pressure of ≤ 90 mm Hg. Normal respiratory rate (in terms of age): < 12 months: 30 to 60/min; 1 to 3 years: 24 to 40/min; 4 to 5 years: 22 to 34/min; 6 to 12 years: 18 to 30/min; > 12 years: 12 to 20/min. Hypoxia was defined as a pulse oximeter level of $\leq 90\%$. Fever was defined as a body temperature of $\geq 37.5^\circ\text{C}$.

N = number, RI Sx = respiratory infection symptoms (this includes febrile sensation, dyspnea, cough, sputum, rhinorrhea, and sore throat), RR = respiratory rate per minute, SD = standard deviation. Time format: hours:minutes:seconds.

hospital-return time increased by 29 minute 3 second, 25 minute 55 second, and 18 minute 44 second, respectively.

During Period 1, the average time for the request to attend a scene to arrival at the scene, arrival at the scene to arrival at the hospital, arrival at the hospital to return to the fire station, and the total time was 8 minute 25 second (SD=4 minute 2 second), 17 minute 13 second (SD=9 minute 26 second), 32 minute 49 second (SD=32 min 45 second), and 58 min 27 second (SD=37 minute 18 second), respectively. For Period 2, this was 13 min 23 s (SD=10 minute 45 second), 24 minute 56 second (SD=19 minute 6 second), 49 minute 11 second (SD=50 minute 59 second), and 1 hour 27 minute 30 second (SD=1 h 3 min 36 s), respectively. For Period 3, this was 11 min 49 s (SD=6 min 4 s), 24 min 12 s (SD=14 min 58 s), 48 minute 11 second (SD=38 min 9 s), and 1 h 24 min 22 s (SD=47 min 10 s), respectively. For Period 4, this was 10 min 45 s (SD=6 min 51 s), 21 min 41 s (SD=11 min 35 s), 44 minute 43 second (SD=39 min 1 s), and 1 h 17

minute 11 second (SD=45 min 16 s), respectively. All *P*-values were $< .01$. (Table 3)

3.4. Time between dispatch and return in terms of the primary symptoms reported and initial measurements

Effect size (partial eta squared) was derived to determine the effect of each factor on the transport time during each period. The factors with the highest average time were fever, hypoxia, abnormal respiratory rate, respiratory infection symptoms, and hypotension, respectively. For each factor, the time for each travel stage is shown in Table 4. All *P*-values were $< .01$.

4. Discussion

After the first confirmed case of community-transmitted COVID-19 in Daegu, the number of confirmed cases increased rapidly^[2]

Table 2
Cases involving transport from a fire station to a Level 1 or 2 ED ($P < .01$).

Hospital	Period	Fire Station								Sum	SD	CV
		a	b	c	d	e	f	g	h			
A	1	45	49	29	214	192	101	303	234	1,167	103.13	0.088
	2	13	12	8	28	33	19	32	26	171	9.68	0.057
	3	24	31	24	97	91	52	117	77	513	36.31	0.071
	4	20	36	17	106	84	49	112	82	506	37.69	0.074
B	1	11	13	9	27	64	270	22	16	432	89.05	0.206
	2	5	5	2	14	16	48	12	7	109	14.73	0.135
	3	11	5	10	20	32	94	16	8	196	29.34	0.150
	4	12	10	5	13	16	78	11	10	155	23.89	0.154
C	1	171	354	177	18	29	318	72	315	1,454	135.39	0.093
	2	17	30	15	14	14	36	17	43	186	11.44	0.061
	3	70	130	59	31	33	126	47	114	610	41.23	0.068
	4	109	155	73	27	21	143	54	157	739	56.26	0.076
D	1	5	1	1	707	518	21	306	43	1,602	278.60	0.174
	2	6	3	2	72	61	9	53	26	232	28.77	0.124
	3	6	3	7	215	110	19	85	13	458	75.55	0.165
	4	2	6	2	277	185	28	124	26	650	103.52	0.159
E	1	375	89	74	31	71	173	43	94	950	112.01	0.118
	2	35	32	18	9	8	26	8	23	159	10.87	0.068
	3	113	35	29	11	32	59	25	35	339	31.50	0.093
	4	134	41	39	19	24	74	16	50	397	38.96	0.098
F	1	59	138	76	49	58	88	253	305	1,026	98.02	0.096
	2	12	19	8	16	8	12	19	34	128	8.47	0.066
	3	28	28	18	34	19	29	65	79	300	22.25	0.074
	4	28	46	24	31	26	41	74	110	380	30.05	0.079
	Sum	1,311	1,271	726	2,080	1,745	1,913	1,886	1,927	12,859		

CV = coefficient of variation, SD = standard deviation.

and, as a result, the local medical service system experienced a serious crisis. The risk of in-hospital transmission of COVID-19 caused local hospitals to intermittently shut their EDs, resulting in a total of 40 closures (Level 1 and 2 = 27 closures and Level 3 = 13 closures) between February 18 and March 26, cumulatively representing a total of 769 hours; most of the closures occurred before March 5.^[3] From early March, large hospitals in Daegu expanded their EDs to include several independent treatment areas with negative pressure units and implemented revised triage and surveillance protocols.^[3] These changes were in accordance with the guidelines of Korean Centers for Disease Control and Prevention; Level 1 and 2 ED medical staff were trained in how to wear and undress Level-D personal protective equipment (PPE) and perform medical practices wearing the same. In addition, medical staff treating severely ill patients were trained in using Level-C PPE. Moreover, the government dispatched a total of

147 ambulances and 276 EMTs to Daegu on over 4 occasions, in order to support EMS activities in the region, including the transport of COVID-19 patients and samples;^[10] further, the government also designated dedicated hospitals for COVID-19 and supported their operation.^[4,10]

The findings of the present study showed that the number of EMS transport cases decreased between 60.3–73.0% relative to Period 1, and the time between the request to attend a scene and arrival at a hospital increased by an average of 13 min during Period 2. The primary reason for this may be the frequent shutdown of hospitals and EDs during Period 2. Subsequently, the medical service system was retooled, and the time required for patient transport gradually decreased. By Period 4, the time between the request to attend a scene and arrival at a hospital showed a difference of approximately 7 min when compared to Period 1. The CV for the distribution of patients transported to

Table 3
Time required for each phase of transport in terms of each study period ($P < .01$).

Period	From request to arrival at the scene		From arrival at the scene to arrival at the hospital		From arrival at the hospital to return to the fire station		Total	
	Mean Time	SD	Mean Time	SD	Mean Time	SD	Mean Time	SD
1	8:25	4:02	17:13	09:26	32:49	32:45	58:27	37:18
2	13:23	10:45	24:56	19:06	49:11	50:59	1:27:30	1:03:36
(Relative to Period 1)	4:58		7:43		16:22		29:03	
3	11:49	6:04	24:12	14:58	48:21	38:09	1:24:22	47:10
(Relative to Period 1)	3:24		0:06:59		15:32		25:55	
4	10:45	6:51	21:43	11:35	44:43	39:01	1:17:11	45:16
(Relative to Period 1)	2:20		4:30		11:54		18:44	

Time format is presented as minutes:seconds or hours:minutes:seconds.

Table 4
Transport time in terms of condition (presented in order of average partial eta squared value; $P < .01$).

Factor (average partial eta squared value)	Period	From request to arrival at the scene		From arrival at the scene to arrival at the hospital		From arrival at the hospital to return to the fire station		Total		
		Mean Time	SD	Mean Time	SD	Mean Time	SD	Mean Time	SD	
Fever (0.054)	Fever	1	8:42	4:37	17:49	9:31	34:22	25:54	1:00:54	32:37
		2	18:03	15:41	38:36	26:56	1:27:45	1:39:10	2:24:24	1:50:39
		3	13:35	7:04	32:36	20:49	1:14:50	45:34	2:01:02	56:06
		4	12:09	7:38	26:38	12:43	1:06:40	40:45	1:45:27	46:11
	No Fever	1	8:19	3:52	16:58	9:22	31:44	29:54	57:00	34:27
		2	11:16	6:59	22:41	16:49	39:57	31:11	1:13:55	43:13
		3	11:15	5:24	22:36	13:07	42:07	33:06	1:15:59	40:39
		4	10:14	5:39	20:53	11:14	39:41	29:10	1:10:48	35:53
Saturation (0.030)	Hypoxia	1	8:15	2:53	19:36	8:28	43:32	24:33	1:11:23	28:55
		2	14:33	12:45	37:53	29:40	1:17:20	42:25	2:09:46	1:00:17
		3	12:49	5:16	31:09	23:18	1:15:31	47:54	1:59:30	59:06
		4	11:28	7:25	24:43	11:19	1:06:52	36:28	1:43:03	43:04
	No hypoxia	1	8:22	3:54	16:59	9:26	31:33	29:27	56:54	34:17
		2	11:51	8:04	23:59	17:41	44:25	51:26	1:20:15	1:02:41
		3	11:33	5:48	23:43	14:19	44:57	35:38	1:20:13	44:28
		4	10:25	5:54	21:29	11:37	42:02	31:40	1:13:56	38:33
Respiratory Rate (0.025)	Abnormal	1	8:50	3:35	19:10	9:04	46:11	1:02:42	1:14:11	1:06:23
		2	13:18	10:14	29:12	19:22	1:07:00	41:11	1:49:30	52:16
		3	12:05	5:45	28:15	20:06	1:10:04	44:16	1:50:24	54:55
		4	10:16	4:12	23:30	10:34	1:08:16	1:19:05	1:42:02	1:22:11
	Normal	1	8:23	4:04	17:01	9:23	31:44	28:42	57:07	0:33:30
		2	11:53	8:11	24:26	18:41	45:22	51:53	1:21:41	1:03:45
		3	11:34	5:42	23:46	14:15	45:32	36:23	1:20:52	44:58
		4	10:29	6:05	21:33	11:39	42:15	31:55	1:14:17	38:50
Respiratory infection symptoms (0.017)	Respiratory infection symptoms	1	8:40	5:26	17:10	8:58	37:02	51:14	1:02:53	54:56
		2	19:20	15:56	31:51	24:31	1:12:48	41:30	2:03:59	55:39
		3	14:11	7:07	30:34	22:37	1:15:11	46:28	1:59:55	58:29
		4	13:12	7:48	24:14	12:50	1:03:00	35:30	1:40:26	42:38
	No respiratory infection symptoms	1	8:23	3:50	17:13	9:29	32:20	29:52	57:56	34:40
		2	12:21	9:12	23:45	17:44	45:06	51:22	1:21:12	1:02:47
		3	11:30	5:51	23:20	13:23	44:42	35:20	1:19:32	43:13
		4	10:31	6:43	21:29	11:26	43:00	38:54	1:15:00	44:54
Blood pressure (0.015)	Hypotension	1	8:14	3:21	19:03	8:45	40:28	23:45	1:07:46	29:08
		2	11:47	6:23	32:10	33:53	57:51	34:32	1:41:48	58:18
		3	11:51	5:02	27:07	13:48	59:03	34:19	1:38:01	42:56
		4	10:44	7:25	24:55	11:58	55:53	33:49	1:31:32	41:46
	No hypotension	1	8:22	3:52	17:03	9:24	31:40	29:53	57:05	34:37
		2	12:05	8:38	24:40	18:11	46:02	52:15	1:22:47	1:04:02
		3	11:35	5:47	24:01	15:19	46:07	37:23	1:21:43	46:39
		4	10:28	5:56	21:26	11:31	42:27	32:13	1:14:20	39:00

SD = standard deviation.

Time format is presented as minutes:seconds or hours:minutes:seconds.

hospitals (Table 2) was lowest during Period 2 and gradually increased, thereafter, to reach a level close to that shown in Period 1. This could indicate that the most even distribution occurred during Period 2, regardless of where the emergency occurred and the location of the hospital, which means the frequency of long-distance transport increased during Period 2. Depending on the nature of emergency patient transport, patients are often transported to the nearest hospital^[5]; during Period 2, there were many cases that did not fit this description, which could have been 1 of the reasons we observed longer average times to arrive at hospitals.

During Period 1, the time until arrival at a hospital was approximately 2 to 3 minutes longer for the hypotension,

hypoxia, and abnormal respiratory rate groups compared to the normal group. It is suspected that the arrival time was delayed for these patients because, for such conditions, on-site emergency treatment with medical supervision (IV fluid resuscitation, airway management, and so forth) is common.^[5] During this period, the fever group, when compared to the normal group, showed a difference of approximately 1 minute in the time between the request to attend the scene and arrival at a hospital.

During Period 2, however, the fever, hypoxia, abnormal respiratory rate, respiratory symptoms, and hypotension groups, when compared to the normal group, showed delays of 6 to 23 minutes in the time between the request to attend the scene and

arrival at the hospital. In particular, the time between the request to attend the scene and arrival at a hospital was 23 minutes longer for the fever group than the normal temperature group during this period. For the delay of 0 to 7 minutes in the time between the request to attend a scene and arrival at the scene (7 min for the fever group), the major causes were likely the time required to wear PPE and their dispatch to the nearest fire station. The delay in the time between first contact with the patient and arrival at a hospital was 5 to 16 minutes (16 min for the fever group), which is suspected to have been caused by the combined effects of performing EMS activities while wearing Level-D PPE,^[11] time on the telephone finding a hospital that could accommodate the patient, and transporting patients to hospitals located relatively far away. During Period 2, the time between transferring custody of the patient to the hospital and returning to the fire station was delayed by 12 to 48 minutes (48 min for the fever group) in the abnormal group when compared to the normal group. This delay may have been caused by longer waiting times until beds became available and the time required to disinfect the ambulance after transferring the custody; however, further research is required to obtain objective data in this regard. Delays arriving at the hospital could have a negative impact on the prognosis of the patient, while an increase in total EMT activity time (from dispatch to return) could have a negative impact on the overall quality of the EMS.

Delays in transport time gradually decreased in Periods 3 and 4, returning to a level close to that at Period 1; however, a delay nevertheless remained. Moreover, there was the paradoxical situation where people required immediate care, such as those with hypotension or hypoxia, facing longer delays. Although the period of rapid increase in cases has passed, the COVID-19 pandemic has not ended yet. There is a risk of a second wave of infections as well as the possibility of future pandemics involving COVID-19 and other infectious diseases. Therefore, it is necessary to re-examine and upgrade the overall medical service system at both local and national levels.

The limitations in the present study included the following. First, private ambulance services that are primarily used for transport from 1 hospital to another were not included. It is highly likely that ED visits using private ambulances and transfers from primary or secondary medical institutions to tertiary medical institutions also encountered delays. Second, the causes and outcomes of failed transport cases were difficult to assess objectively and, thus, such cases were excluded; failed transport cases are likely to have had an impact on the delays encountered by other EMS activities. Third, the impact of the distribution and utilization of medical resources and personnel could not be determined. We recommend prospective studies for overcoming these limitations.

The findings of the present study showed that an outbreak of an infectious disease had a significant impact on emergency patient transport, which is a fundamental aspect of local EMS. In particular, significant findings included the fact that patients with abnormal initial vital signs experienced longer delays and patients with fever, which is the primary differential factor for infectious disease, experienced the longest delay. When an infectious disease such as COVID-19 spreads rapidly through a community, the medical service system is directly impacted making it impossible to maintain the normal service levels. The present findings indicated that, to reduce delays during EMS activities, it was necessary for EMTs to regularly practice donning PPE, train to perform EMS activities while wearing PPE,

and practice cleaning and disinfecting ambulances and equipment to ensure timely treatment and transport. Each hospital must make efforts to respond to transport requests as quickly as possible, while fire departments, hospital staff, and the government must create a more effective and speedy system by reaching a collaborative agreement regarding the operation of hotlines and maintenance of EMSs. Furthermore, administering first aid while wearing PPE causes delays^[11] but such delays were not sufficiently long to explain those observed in this study. Therefore, we suggested that the primary cause of delays in EMS activities was the fact that the overall EMS was not operating normally. The triple disaster that occurred in Fukushima, Japan, in 2011 (an earthquake, tsunami, and nuclear power plant incident) caused delays in EMS transport times that lasted several months^[12]; this research showed that infectious disease outbreaks could also affect EMS transport times over several months.

Many recent reports^[13–15] have claimed that priority should be assigned to patients with infectious disease, that such patients should be transported differently in order to allow the allocation of dedicated medical resources to treat patients with other conditions, and that there is a need for fluid information exchange among relevant parties including EMTs, hospitals, and government agencies. Further, reports have also claimed that support for the development and distribution of vaccines and therapeutic interventions for infectious diseases are also necessary.^[14,15] The present authors concur with such claims and a major implication of the present study is that when the medical service system cannot operate normally due to an infectious disease outbreak, hospital transportation of patients suspected of having an infectious disease, suffering with fever, and respiratory infection may be delayed; the transport of severely ill patients with hypotension or hypoxia, who require immediate care at a hospital, also experience delays. While it is necessary, in cases of an infectious disease outbreak, to establish a medical service system for patients suspected of having an infectious disease (eg, those showing fever and respiratory infection symptoms), measures are also needed to enable other severe emergency patients to receive appropriate medical service, including EMS.

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