Acta Med. Okayama, 2020
Vol. 74, No. 6, pp. 513–520

Acta Medica Okayama
http://escholarship.lib.okayama-u.ac.jp/amo/

Original Article

Delay in Emergency Medical Service Transportation Responsiveness during the COVID-19 Pandemic in a Minimally Affected Region

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Few studies have investigated the influence of the Coronavirus Disease 2019 (COVID-19) pandemic on emergency medical service (EMS) systems, especially in areas less affected or unaffected by COVID-19. In this study, we investigated changes in prehospital EMS activity and transport times during the COVID-19 pandemic. All patients transported by EMS in the city of Okayama from March–May 2019 or March–May 2020 were included. Interfacility transports were excluded. The primary outcome was the time from a patient's first emergency call until hospital arrival (total prehospital time). Secondary outcomes included three segments of total prehospital time: the response time, on-scene time, and transportation time. Total prehospital time and the durations of each segment were compared between corresponding months in 2020 (COVID19-affected) and 2019 (control). The results showed that total prehospital times in April 2020 were significantly higher than those in 2019 (33.8 ± 11.6 vs. 32.2 ± 10.8 min, $p < 0.001$). Increases in total prehospital time were caused by longer response time (9.3 ± 3.8 vs. 8.7 ± 3.7 min, $p < 0.001$) and on-scene time (14.4 ± 7.9 vs. 13.5 ± 6.2min, $p < 0.001$). The COVID-19 pandemic was thus shown to affect EMS and delayed arrival/response even in a minimally affected region. A system to minimize transportation delays should be developed for emerging pandemics.

Key words: emergency medical services, health care system, emergency transport, coronavirus, infection

Coronavirus disease 2019 (COVID-19), which is caused by severe acute respiratory syndrome coronavirus 2 infection, has provoked a national emergency in most countries of the world, including Japan. The COVID-19 pandemic has resulted in escalating cases, causing community transmissions in association with unprecedented shortages of testing and medical supplies in hospitals and clinics and exhaustion of the healthcare delivery system. As of June 2, 2020, the number of confirmed infections in Japan reached 16,884, with 892 deaths. While the Japanese enacted the shutdown of cities, rather than enforcing such shutdowns, the government urged the public to avoid the "three Cs" — crowded places, closed spaces, and close-contact settings. So far, this policy seems to have been successful in preventing the collapse of the healthcare delivery system and the spikes in mortality that were seen in countries in Europe and North America [1, 2].

In Japan, most hospitals were not originally designed or specialized to treat infectious diseases [3]. The rapidly growing demand for critical care for COVID-19 patients has created a tremendous challenge in the absence of established therapeutic strategies. Therefore, in the affected areas, it has proven quite difficult to maintain the current emergency medical ser-

Received September 8, 2020; accepted November 16, 2020.
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Conflict of Interest Disclosures: No potential conflict of interest relevant to this article was reported.

vice (EMS) systems, and shortages of hospital beds, intensive care units, and medical equipment have arisen.

Okayama, a transport hub of western Japan, is a city of approximately 0.72 million residents in a 789.95 km^2 area, and includes both urban and rural communities. Only 16 COVID-19 patients have been confirmed in Okayama, with the first case being identified on March 22, 2020 and the last being confirmed on May 11, 2020. Between May 12, 2020 and the completion of this analysis in June 22, 2020, no newly infected patients were identified. Thus, Okayama can be considered a region not severely affected by COVID-19.

Emergency medical technicians (EMTs) are the first line of care for patients with critical needs, frequently stabilizing them before transport to definitive care facilities. Although EMTs and local EMS systems play a pivotal role in patient outcomes, few studies have investigated the influence of the COVID-19 pandemic on EMS systems [4, 5]. Moreover, there have been few studies on the total prehospital time in areas less affected or unaffected by COVID-19.

The aim of this study was to investigate changes in the prehospital times for EMS activity and transport during the COVID-19 pandemic in Okayama. This is the first study to determine the influence of COVID-19 on the EMS system in a minimally affected region.

Methods

Study design. This retrospective observational cohort study used data from the database of the Okayama City Fire Department on cases managed between March and May 2020 and during the same months in the previous year (2019). The research protocol was approved by the Okayama University institutional review board (ID: K2007-023), with assent from the EMS authorities and local government in Okayama.

Emergency medical service (EMS) system in Okayama City. In Japan, the designated universal emergency call number 119 is connected directly to the neighboring dispatch center via a computerized dispatch system. All transports are conducted by the Okayama City Fire Department EMS. Patients are not charged for EMS, including transports; these services are covered by taxes. Okayama comprises an urban and suburban area of 789.9 km^2 with a population of 720,000 people. The Okayama City EMS system is operated by 20 local fire stations and a single emergency dispatch center. When an emergency call is received, the closest available ambulance is sent to the scene of the incident. Highly trained personnel in the dispatch center are instructed to obtain medical information for pre-notification, including past or recent medical history.

Each ambulance commonly is staffed with three EMTs, including at least one Emergency Life-Saving Technician (ELST), an advanced EMT who has received extensive training to administer prehospital EMS. ELSTs examine/evaluate the patient at the scene and are expected to transport the patient to the appropriate hospital with consideration for the vital signs and manifestation. ELSTs determine the most appropriate hospital for the patient and place request calls to the hospital. Critical cases are transported and seen by emergency physicians at certified Emergency and Critical Care Centers, while non-critical cases are transported to the nearest local emergency hospitals. In local receiving hospitals, physicians on duty (non-emergency specialty) are required to accept patients and must assume responsibility upon the EMTs' request. Commonly, physicians accept patients based on their ability to manage emergency cases, the hospital's capacity, and whether the hospital is supported by adequate co-medical staff and has access to imaging modalities. If the nearest hospital refuses to accept the patient, the ELST is expected to transport the patient to another appropriate hospital. ELSTs make multiple request calls until an accepting hospital is confirmed. All emergency calls and the time of call/arrival at the scene or hospital are recorded.

Emergency medical services during the COVID-19 pandemic. Shortly after March 22, 2020, when the first COVID-19 patient in the region was confirmed, the Fire and Disaster Management Agency sent an advisory to all paramedics warning them to wear N95 respirators and Gore-Tex infection-prevention clothing — along with Gore-Tex gowns, gloves, caps, helmets, and goggles, when responding to patients. Less than a month later, on April 7, 2020, a "State of Emergency Declaration" was declared by the Japanese Government.

Data collection. Data on patients transported by the Okayama City Fire Department EMS were prospectively collected in a unified data format. Immediately after each transport, EMTs entered all the relevant data into the online database. The database included the following data: the gender, age, and body temperature of patients, the etiology of their illness (internal causes or external causes), the time points of their EMS transport (*i.e.*, when the emergency call was received, when the EMS provider arrived at the scene, and when the patient arrived at the hospital), and whether or not the patient was hospitalized. The number of request calls required to determine an accepting hospital was also recorded, Time points were recorded using synchronized radio-controlled watches. Diagnoses of internal or external causes were clinically determined by the physicians at the receiving hospitals.

Patient Selection and Endpoint. All patients transported by the Okayama City Fire Department from March through May 2019 and March through May 2020 were included. Interfacility transports were excluded. The primary outcome measure was the time from the patient's first emergency call until arrival at the hospital. There were 16 cases of confirmed COVID-19 during the study period (the first case was on March 22, 2020 and the latest case was on May 11, 2020). Therefore, we defined April 2020 as "the most affected month" and compared the EMS performance time in the months prior to (March), during (April), and following (May) the most-affected month. In addition, we compared the EMS performance times or the combined period of March, April and May 2020 with that for the corresponding period in 2019. Secondary outcomes were three segments of the total EMS time: the response time, on-scene time, and transportation time. A timeline of these segments is shown in Fig. 1. Total prehospital time was defined as the time from the emergency call until arrival at the hospital. As mentioned above, the prehospital time was divided into three segments: the time from the emergency call until arrival at the scene (response time), the time from arrival at the scene until scene departure (on-scene time), and the time from scene departure until hospital arrival (transport time). To determine the difficulty of securing a receiving hospital during the COVID-19 pandemic, the number of patients who required more than four request calls in April was included as a secondary outcome.

Statistical analysis. To describe primary and secondary outcomes, continuous variables were described using means with standard deviations. Categorical variables were described using percentages. Student's t-test was used to compare the continuous variables; categorical variables were compared using Pearson's chi-squared test. Additional analysis was conducted on subgroups: the causes of internal/external illness and hospitalized/non-hospitalized patients. A separate analysis was conducted on patients with cardiac arrest. Statistical analysis was performed using Stata version 16 (StataCorp LP, College Station, TX, USA). A p-value below 0.05 was considered statistically significant.

Results

Fig. 2 shows a patient flow chart of the study. There were 13,694 transports during the study period. After excluding 1,156 interfacility transports, 12,538 transports were analyzed. The 2019 group included 6,795

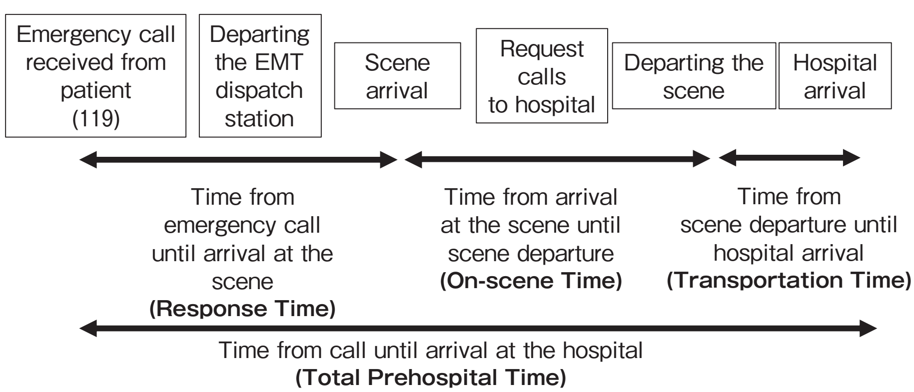

Fig. 1 Time intervals for EMS activity and transport. Total prehospital time indicates the time from the emergency call until hospital arrival. Total prehospital time was divided into three categories: the time from the emergency call until arrival at the scene (response time), the time from arrival at the scene until scene departure (on-scene time), and the time from scene departure until hospital arrival (transport time). EMS, emergency medical service; EMT, emergency medical technician.

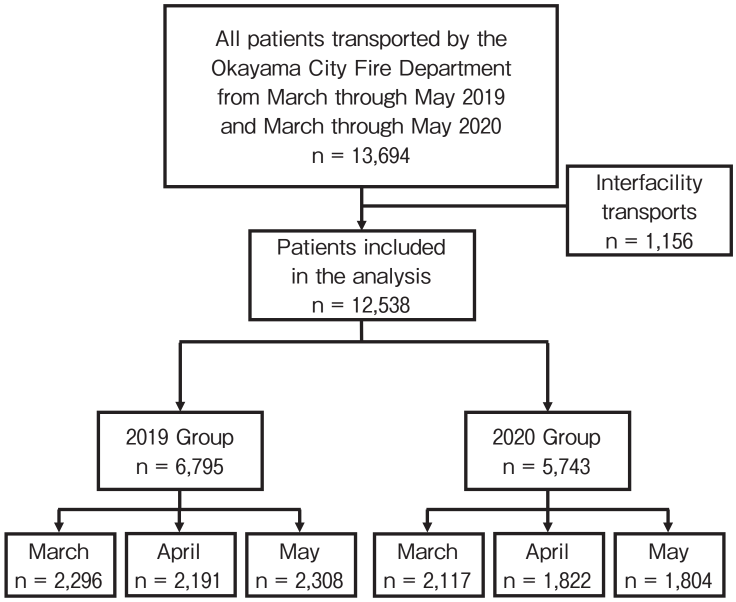

Fig. 2 Study design flow chart.

patients, with 2,296 patients in March, 2,191 patients in April, and 2,308 patients in May. The 2020 group included 5,743 patients, with 2,117 patients in March, 1,822 patients in April, and 1,804 patients in May. The total number of transports decreased in April 2020 and May 2020 compared with the same months in 2019 (April: 1,822 vs. 2,191; May: 1,804 vs. 2,308). No COVID-19 confirmed patients were transported by Okayama City EMS. Instead, COVID-19 confirmed cases were transported as interfacility transports in cooperation with the Okayama City Health and Welfare Bureau and the receiving hospitals.

Patient baseline characteristics are shown in Table 1. There were no differences in the proportion of male to total patients (2,895/5,743: 50% vs. 3,525/6,795: 52%, $p=0.1$), the proportion of patients with illness of internal causes to total patients (3,687/5,743: 64% vs. 4,358/6,795: 64%, $p=0.9$), or the proportion of patients with cardiac arrest to total patients (126/5,743: 2% vs. 165/6,795: 2%, $p=0.4$) between the 2020 and 2019 groups; however, patient age was higher in the 2020 group (63.0 ± 25.3 vs. 61.3 ± 26.9, $p<0.001$) and a higher proportion of patients required hospital admission in the 2020 group (2,664/5,743: 46% vs. 2,958/6,795: 44%, $p=0.003$).

EMS performance times are shown in Table 2. The total prehospital time, response time, on-scene time,

Table 1 Patient characteristics

	2020 Group	2019 Group	*P*-value
Number of Patients	5,743	6,795	
Patient Age-Years	63.0 ± 25.3	61.3 ± 26.9	<0.001
Male	2,895 (50%)	3,525 (52%)	0.1
Illness Etiology			
Internal Causes	3,687 (64%)	4,358 (64%)	0.9
External Causes	2,056 (36%)	2,437 (36%)	0.9
Fever ≥37.5°C	659 (13%)	883 (14%)	0.05
Hospitalized	2,664 (46%)	2,958 (44%)	0.003
Non-Hospitalized	3,079 (54%)	3,837 (56%)	0.003
Cardiac Arrest	126 (2%)	165 (2%)	0.4

Student's *t*-test were used to compare the continuous variables; categorical variables were compared using Pearson's chi-squared test. Internal causes included central neurological, respiratory, cardiovascular, gastrointestinal, renal, urogenital, and other internal diseases. External causes included trauma, burn injury, intoxication, and other external diseases.

and transportation time for the March 2020 patients were not significantly different from those for the March 2019 patients. However, in April 2020, the total prehospital time was significantly longer compared to that in 2019 (33.8 ± 11.6 min vs. 32.2 ± 10.8 min, $p<0.001$). This longer total prehospital time was caused by a longer response time (9.3 ± 3.8 vs. 8.7 ± 3.7 min, $p<0.001$) and on-scene time (14.4 ± 7.9 vs. 13.5 ± 6.2 min, $p<0.001$). EMS times in May did not differ

Table 2 Monthly EMS activity/transport times and request calls in 2020 and 2019

	2020 Group n = 5,743	2019 Group n = 6,795	*P*-value
March	2,117 (37%)	2,296 (34%)	
Total prehospital time, min	33.0 ± 10.5	32.8 ± 11.2	0.7
Response time, min	8.8 ± 3.8	8.7 ± 3.8	0.1
On-scene time, min	14.2 ± 6.9	14.0 ± 7.0	0.3
Transportation time, min	10.0 ± 7.2	10.2 ± 7.6	0.3
More than four request calls	30 (1.4%)	23 (1.0%)	0.2
April	1,822 (32%)	2,191 (32%)	
Total prehospital time, min	33.8 ± 11.6	32.2 ± 10.8	< 0.001
Response time, min	9.3 ± 3.8	8.7 ± 3.7	< 0.001
On-scene time, min	14.4 ± 7.9	13.5 ± 6.2	< 0.001
Transportation time, min	10.1 ± 7.4	10.0 ± 7.4	0.7
More than four request calls	43 (2.4%)	19 (0.9%)	< 0.001
May	1,804 (31%)	2,308 (34%)	
Total prehospital time, min	33.1 ± 10.6	32.3 ± 11.6	0.04
Response time, min	8.8 ± 3.3	8.7 ± 3.8	0.3
On-scene time, min	13.9 ± 7.0	13.6 ± 7.4	0.2
Transportation time, min	10.3 ± 7.2	10.0 ± 7.5	0.2
More than four request calls	20 (1.1%)	17 (0.7%)	0.2

Student's *t*-test was used to compare the continuous variables; categorical variables were compared using Pearson's chi-squared test.

between the 2020 and 2019 patients, suggesting that EMS performance returned to the usual level in May.

The number of patients who required more than four request calls until hospital arrival was 43 (2.4%) in April 2020, which was significantly higher than the number in April 2019 (19 patients: 0.9%, $p < 0.001$). There was no significant difference in the number of patients who required more than four request calls between March 2020 and March 2019 or between May 2020 and May 2019.

Table 3 shows the differences in the EMS performance times and the number of request calls between the April 2020 and the April 2019 patients by subgroup (illnesses with internal/external causes, hospitalized/non-hospitalized patients, and cardiac arrest patients). Among patients with illnesses of internal etiology, there was a significantly longer total prehospital time (33.5 ± 11.3 min vs. 31.5 ± 9.6 min, $p < 0.001$) and a significantly greater number of cases requiring more than four request calls (35 cases: 2.9% vs. 11 cases: 0.8%, $p < 0.001$) in April 2020 compared with April 2019. However, among the patients having illnesses with external causes, there was no significant difference in EMS performance time or the number of cases requiring more than four request calls between the April 2020 and April 2019 patients. Total prehospital time for both hospitalized (34.1 ± 11.6 vs. 33.0 ± 10.8 min, $p = 0.02$) and non-hospitalized (33.7 ± 11.6 vs. 31.6 ± 10.4 min, $p < 0.001$) patients was significantly higher in April 2020 patients compared with the April 2019 group. Total prehospital time was not significantly different between the cardiac arrest patients in April 2020 and those in April 2019.

Discussion

In this retrospective observational study, we found that the COVID-19 pandemic influenced EMS performance and resulted in additional delays in the total prehospital time (*i.e.*, from the time of the emergency call to the time of hospital arrival) in April 2020, even in a minimally affected region. Also, the number of patients who required more than 4 request calls before being taken to a hospital significantly increased during the same period.

In Okayama, there were a total of 16 COVID-19 patients between March 22, 2020 and May 11, 2020, with the greatest number being in April 2020. There have not been any additional patients since May 12, 2020 until June 22, 2020. There were significantly fewer emergently transported patients in April 2020 compared to April 2019, presumably due to the "stay at

Table 3 EMS activity/transport times and request calls for illnesses with internal/external causes, hospitalized/non-hospitalized patients, and cardiac arrest patients in April 2020 and 2019

	2020 Group	2019 Group	*P*-value
Internal Causes	1,194(66%)	1,429 (65%)	
Total prehospital time, min	33.5 ± 11.3	31.5 ± 9.6	< 0.001
Response time, min	9.3 ± 3.4	8.5 ± 3.2	< 0.001
On-scene time, min	13.7 ± 7.8	12.7 ± 5.9	< 0.001
Transportation time, min	10.5 ± 7.4	10.2 ± 6.9	0.2
More than four request calls	35 (2.9%)	11 (0.8%)	< 0.001
External Causes	625 (34%)	762 (35%)	
Total prehospital time, min	34.4 ± 12.1	33.6 ± 12.6	0.2
Response time, min	9.5 ± 4.3	9.1 ± 4.4	0.1
On-scene time, min	15.7 ± 7.8	14.9 ± 6.5	0.03
Transportation time, min	9.3 ± 7.4	9.6 ± 8.2	0.3
More than four request calls	8 (1.3%)	8 (1.0%)	0.7
Hospitalized	846 (48%)	949 (46%)	
Total prehospital time, min	34.1 ± 11.6	33.0 ± 10.8	0.02
Response time, min	9.3 ± 3.5	9.0 ± 3.8	0.1
On-scene time, min	14.2 ± 7.8	13.0 ± 5.7	< 0.001
Transportation time, min	10.6 ± 7.2	11.0 ± 7.6	0.5
More than four request calls	23 (2.7%)	4 (0.4%)	< 0.001
Non-hospitalized	927 (52%)	1,181 (54%)	
Total prehospital time, min	33.7 ± 11.6	31.6 ± 10.4	< 0.001
Response time, min	9.4 ± 4.0	8.5 ± 3.5	< 0.001
On-scene time, min	14.7 ± 8.0	13.9 ± 6.6	0.01
Transportation time, min	9.6 ± 7.7	9.2 ± 6.8	0.2
More than four request calls	18 (1.9%)	14 (1.2%)	0.2
Cardiac Arrest	47 (2.6%)	55 (2.5%)	
Total prehospital time, min	29.0 ± 9.2	28.6 ± 10.1	0.8
Response time, min	9.1 ± 3.7	8.3 ± 3.2	0.2
On-scene time, min	11.3 ± 4.4	10.7 ± 3.8	0.4
More than four request calls	8.6 ± 5.1	9.6 ± 7.2	0.4

Student's *t*-test was used to compare the continuous variables; categorical variables were compared using Pearson's chi-squared test. Internal causes included central neurological, respiratory, cardiovascular, gastrointestinal, renal, urogenital, and other internal diseases. External causes included trauma, burn injury, intoxication, and other external diseases.

home" instructions during the COVID-19 pandemic, which resulted in a reduction of outdoor activities and thereby reduced opportunities for trauma or infection.

Total prehospital time was significantly longer in April 2020 than in April 2019, although there were fewer emergently transported patients. A possible explanation for this delay may have been that hospitals were unprepared for COVID-19 patients, which resulted in an increase in request calls and more time before hospital arrival. Most hospitals hesitated to accept confirmed or suspicious cases of COVID-19 due to fears of nosocomial infection, reputational damage from harmful rumors, inadequate protective equipment, lack of medical staff familiar with infection control, and resistance from medical staff. Therefore, very few hospitals were capable of accommodating COVID-19 patients in Okayama at the time of the first wave of pandemic. Accepting suspected or confirmed cases of COVID-19 could be an additional burden for these local hospitals with limited hospital capacity. EMS system delays did not impact patients with cardiac arrests; however, the total prehospital time of hospitalized patients was longer, indicating that EMS delay may have impacted some severely ill patients. A system to minimize delays in prehospital time should be developed for this emerging infectious disease pandemic.

Our data showed that the COVID-19 outbreak did not alter the prehospital time for cardiac arrest patients. However, the prehospital time for patients requiring hospitalization was delayed, indicating that EMS performance was altered even for seriously ill cases. The COVID-19 pandemic did not change EMS performance for the transportation of patients with illness having external causes such as trauma. On the other hand, emergent transportation of patients with illness having internal causes was influenced in April 2020, the month most affected by COIVD-19. As internal causes may include infectious diseases presenting with fever and respiratory symptoms, EMTs presumably required more time to transport these patients. Similar results were reported in terms of the influence of COVID-19 on the EMS in Osaka [5], the largest metropolitan community in western Japan. Interestingly, EMS performance delay was seen for the patients with acute internal disease, but not for the patients with trauma. Thus, the COVID-19 pandemic had an impact on EMS performance regardless of the region, population, or status of COVID-19 infection spread.

EMS systems are disrupted during unusual circumstances, including disasters and large-scale traffic accidents [6-8]. Even though no factors (earthquakes, floods, typhoons, *etc.*) were found to impede these transfers during the period of this study, the prehospital time was delayed. In such a situation, an increased number of casualties may require rapid transport, which is sometimes interrupted by damaged roads or hospital overcrowding. The delay in response time seen in April 2020 may have been caused by the crew preparing their personal protective equipment (PPE) or by additional questions by the call center crew to obtain details of the recent medical history of patients (taste or olfactory abnormalities, travel history, *etc.*). Shorter ambulance response time is known to be an important factor affecting prehospital care and patient outcome [9-11]. Therefore, efforts to reduce the likelihood that request calls will be refused must be made in preparation for future pandemics, since refusing just one request call extended the interval from the time of the emergency call until arrival at the hospital by 6.3 min [12].

Planning for a community outbreak should account for the number of expected infections, the contagiousness of the infection — including the role of pre-symptomatic or asymptomatic infected people in transmitting the virus to others — and the disease's complete spectrum of severity. Advanced planning to maintain healthcare services must be put in place based on the experiences of the first wave of COVID-19 pandemic. Quick and easy communication with provincial and municipal health authorities will be required to ensure that the most up-to-date information on the outbreak is available. Also, accurate and timely communication with frontline staff members is the best way to mitigate their fears. PPE procedures should always be maintained until the appropriate authorities deem that the exposure risk is negligible, since the closure of a local emergency hospital due to inadequate preparation could significantly affect EMS performance [13].

Limitations. The study has several limitations. First, we could not obtain information on several factors associated with EMS performance and transport. For example, we did not consider the travel distances between the ambulance dispatch stations and patients, or between the patients and destination hospitals. Moreover, in some cases the ambulance staff may have transported patients with suspected infection to their second- or third-choice hospitals because these hospitals had the capacity to receive them. Also, weather, traffic, and the medical conditions of patients were not considered. Transportation of medically unstable patients may require time-consuming procedures, including fluid resuscitation. Second, we did not investigate changes in the turnaround time — that is, the interval between the ambulance reaching the hospital and the ambulance becoming ready to respond to a new call. The availability of ambulances to respond to emergency calls is related to their ability to resume service from the hospital. In the case of ambulances transporting confirmed/suspicious COVID-19 patients, additional disinfectant protocols must be completed before the vehicles can return to their regular rotation [14]. Third, there were some differences in baseline characteristics between the two groups (*i.e.*, the ages of patients and proportion of hospitalized patients). Finally, this study had a limited sample size and limited area of investigation. The study was conducted using data from a single city with a single EMS system; therefore, the results may not be applicable to other emergency services. Additional studies on different populations, geographic areas, and EMS agencies are warranted to improve our understanding of this component of prehospital delays.

In conclusion, we analyzed EMS records prior to, during, and following the month most affected by the COVID-19 pandemic (April 2020) in a minimally affected region and found that the local EMS total prehospital time was significantly extended during the most affected month (April 2020) compared to the preceding and subsequent months of March and May 2020. A system to minimize delays in prehospital time should be developed for emerging infectious disease pandemics.

Acknowledgments. We thank all the EMTs in the Okayama City Fire Department for their efforts to fight COVID-19 and for providing valuable data for this study. We thank Christine Burr for editing the manuscript.

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