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ORIGINAL ARTICLE

Impact of the coronavirus disease 2019 (COVID-19) pandemic on the operational efficiency of emergency medical services and its association with out-of-hospital cardiac arrest survival rates: A population-based cohort study in Kobe, Japan

Jun Sugiyama[1,2] | Shigeaki Inoue[1] | Masami Inada[1] | Yusuke Miyazaki[1] | Nobuto Nakanishi[1] | Yoshihisa Fujinami[3] | Masafumi Saito[1] | Yuko Ono[1] | Kazushige Toyama[1] | Futoshi Toda[2] | Tohru Shirotsuki[2] | Soushi Shiotani[2] | Joji Kotani[1]

[1]Department of Disaster and Emergency and Critical Care Medicine, Kobe University Graduate School of Medicine, Kobe, Japan

[2]Emergency Medical Service Division, Kobe City Fire Burau, Kobe, Japan

[3]Department of Emergency Medicine, Kakogawa Central City Hospital, Kakogawa, Japan

Correspondence
Shigeaki Inoue, Department of Disaster and Emergency and Critical Care Medicine, Kobe University Graduate School of Medicine, Kusunoki-Cho 7-5-2, Chuo-ward, Kobe 650-0017, Hyogo, Japan.
Email: caf55000@gmail.com

Abstract

Aim: To identify whether the coronavirus disease 2019 (COVID-19) pandemic affects the operational efficiency of emergency medical services (EMS) and the survival rate of out-of-hospital cardiac arrest (OHCA) in prehospital settings.

Methods: We conducted a population-based cohort study in Kobe, Japan, between March 1, 2020, and September 31, 2022. In study 1, the operational efficiency of EMS, such as the total out-of-service time for ambulances, the daily occupancy rate of EMS, and response time, was compared between the pandemic and nonpandemic periods. In study 2, the impacts of the changes in EMS operational efficiency were investigated among patients with OHCA, with 1-month survival as the primary outcome and return of spontaneous circulation, 24-h survival, 1-week survival, and favorable neurological outcomes as the secondary outcomes. Logistic regression analysis was conducted to identify the factors associated with survival among patients with OHCA.

Results: The total out-of-service time, occupancy rate, and response time significantly increased during the pandemic period ($p < 0.001$). The response time during the pandemic period increased significantly per pandemic wave. Regarding OHCA outcomes, 1-month survival rates during the pandemic period significantly decreased compared with those during the nonpandemic period (pandemic 3.7% vs. nonpandemic 5.7%; $p < 0.01$). Similarly, 24-h survival (9.9% vs. 12.8%), and favorable neurological outcomes significantly decreased during the pandemic period. In the logistic regression analysis, response time was associated with lower OHCA survival in all outcomes ($p < 0.05$).

Conclusion: The COVID-19 pandemic has been associated with reduced operational efficiency of EMS and decreased OHCA survival rates. Further research is required to improve the efficiency of EMS and OHCA survival rates.

KEYWORDS
emergency medical services, operational efficiency, out-of-hospital cardiac arrest, prehospital, response time

INTRODUCTION

The coronavirus disease 2019 (COVID-19) emerged in December 2019 and spread rapidly across the globe. The World Health Organization reported more than 628 million confirmed cases and 6.6 million deaths globally. In Japan, more than 22 million confirmed cases and 47,000 deaths were reported as of November 2022.[1] There are concerns that the COVID-19 pandemic had various effects on the health care system. In the prehospital care setting in the United States, emergency medical services (EMS) experienced over a 25% decrease in the call volume nationally during the early period of the pandemic.[2] Among individuals, the fear of contamination in hospitals may have resulted in their reluctance to call EMS or present themselves to emergency departments.[3] In Japan, the situation was similar during the early periods of the pandemic. However, as behavioral restrictions were relaxed, the call volume increased.[4]

Since the COVID-19 outbreak, ambulance crews have been required to take special measures when dealing with patients with confirmed or suspected COVID-19.[5] There is a concern that the operational efficiency of EMS may have decreased because ambulance crews require additional time to take special measures for patients with COVID-19. After dealing with and transporting patients with COVID-19, ambulance crews are required to clean and disinfect the ambulance as well as the equipment much more thoroughly than after attending to an ordinary patient. During this procedure, the ambulance becomes out-of-service and not available for the next dispatch, thus reducing the number of available ambulances and affecting the operational efficiency of EMS. Finally, increased numbers of out-of-service ambulances may prolong the time intervals between emergency calls and the arrival of an ambulance (i.e., response time).

Out-of-hospital cardiac arrest (OHCA) could be a valuable indicator of both population health and the efficacy of the health care system.[3] After the spread of COVID-19, bystander cardiopulmonary resuscitation (CPR) and public-access automated external defibrillators were applied less frequently. Furthermore, 1-month survival rates with favorable neurological outcomes were significantly lower than those before the pandemic.[6]

Although we speculate that the increase in the number of out-of-service ambulances may prolong response times and adversely affect critically ill patients, such as patients with OHCA, during the pandemic period, the details of this issue are yet to be investigated fully. This study aims to investigate the impact of the COVID-19 pandemic on the operational efficiency of EMS and the outcomes of patients with OHCA in Kobe city.

METHODS

EMS systems in Kobe city, Japan

Kobe is the seventh largest city in Japan and the largest city in Hyogo Prefecture, with a population of approximately 1.5 million in an area of 557 km^2. As of November 1, 2022, there are 10 fire stations with 34 ambulances and 1 dispatch center. The Kobe City Fire Bureau operates the EMS 24 h a day, 7 days a week. The number of patients transported by EMS annually is approximately 80,000. Ambulance crews comprise three professionals: at least two paramedics and one emergency medical technician-basic (EMT-B). While EMT-Bs are authorized to perform only basic life support, paramedics are permitted to perform advanced life support such as administering adrenaline and placing advanced airway for patients with OHCA with directions from a physician via online medical control.

They are required to wear face masks, eye protection goggles, and isolation gowns when dealing with all patients. In addition, after the COVID-19 pandemic, they are required to wear N95 masks when dealing with patients with confirmed or suspected COVID-19 or cardiac arrest.

Detection of waves caused by the COVID-19 pandemic

To determine the impact of the COVID-19 pandemic on the operational efficiency of EMS, we conducted a population-based cohort study between March 2020, when the first confirmed case of COVID-19 in Kobe city was reported, and the end of September 2022. This study was approved by the Institutional Review Board for Clinical Research of Kobe University Hospital (B220185 on December 21, 2022).

According to previous reports,[7,8] we defined a pandemic wave as a rising number of newly confirmed patients with COVID-19 each day in Kobe city, with a defined peak followed by a decline in cases or a trough period in which the number of confirmed cases decreased. Finally, we defined the waves of the COVID-19 pandemic as follows: the first wave (March 1, 2020 to June 30, 2020), the second wave (July 1, 2020 to October 31, 2021), the third wave (November 1, 2021 to February 28, 2021), the fourth wave (March 1, 2021 to June 30, 2021), the fifth wave (July 1, 2021 to November 30, 2021), the sixth wave (December 1, 2021 to May 31, 2022), and the seventh wave (June 1, 2022 to July 31, 2022; Figure 1). Furthermore, we defined the pandemic and nonpandemic periods in each wave. The median of the number of newly confirmed patients in each wave was used as the criteria. The period above the median was defined as the pandemic period, and the period below the median was defined as the nonpandemic period.

Study 1: A study on the operational efficiency of EMS during the COVID-19 pandemic period

Study design

We investigated the operational efficiency of EMS from the total out-of-service time of ambulances per day, the average occupancy rate of EMS per day, and the response time, which is the time interval from the dispatcher

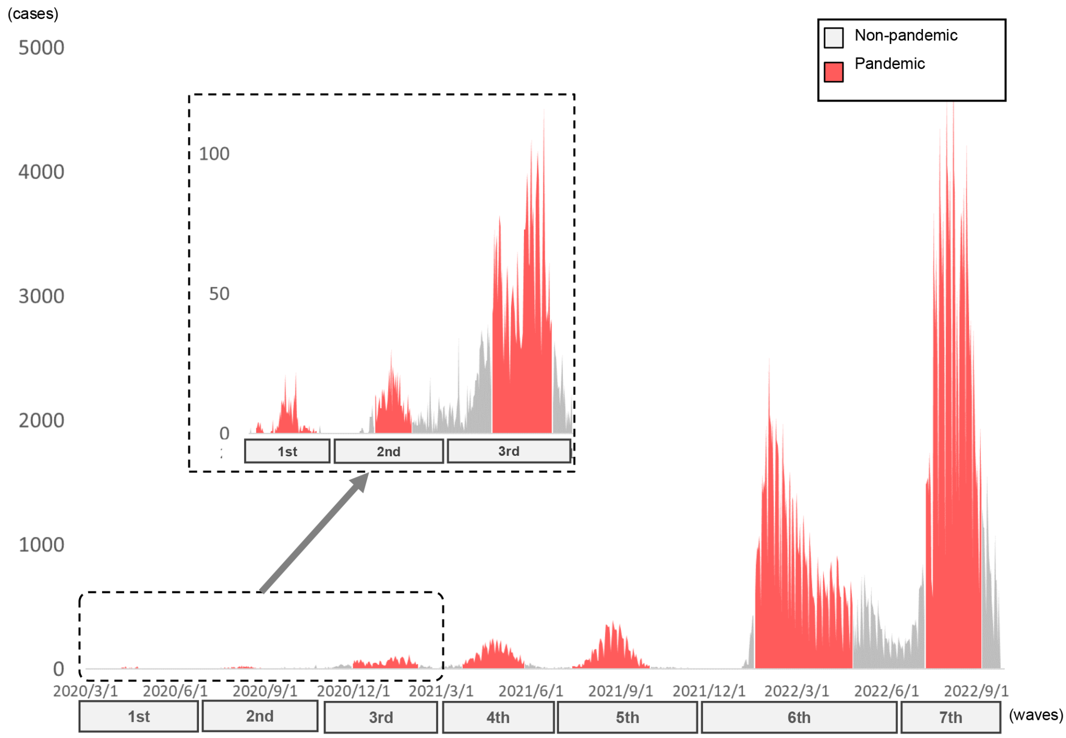

FIGURE 1 Confirmed cases of coronavirus disease 2019 in Kobe city from 2020 to 2022. Gray bars represent the nonpandemic period as a control, and the red bars represent the pandemic period.

receiving an emergency call to an ambulance arriving at a scene recorded in the automatic vehicle monitoring system (AVM) database. In the Kobe City Fire Bureau, the statuses of all the ambulances are monitored and recorded using the AVM to ensure efficient operations. In each ambulance, the ambulance crew sets the vehicle's status via an onboard device connected to the AVM. The system registers the vehicle's status, the set time, and the current location of the vehicle via the global positioning system, which is monitored continuously at the dispatch center. Eight statuses can be set in the AVM, and they are listed in Table S1.

We especially focused on status number 8: out-of-service because we speculated that the COVID-19 pandemic might increase its total amount. Therefore, we analyzed the differences in the total ambulances' out-of-service time per day, the occupancy rate of EMS, and the response times between the pandemic and nonpandemic periods.

Inclusion criteria

This study included all ambulances throughout the study periods.

Exclusion criteria

None.

Data collection

The total "out-of-service" time was calculated by summing up all the time intervals from the setting of "out-of-service" status to when it was released. The occupancy rate was calculated as the number of active ambulances divided by the number of total operating ambulances. As the occupancy rate fluctuated in real time, the average value for each day was obtained. The response time is the time interval from when the dispatch center received the emergency call to the time the ambulance arrived at the scene. All these data were collected from the AVM database.

Data analysis

To explore the impact of the COVID-19 pandemic on the operational efficiency of EMS, we compared the outcomes between the pandemic and nonpandemic periods.

Study 2: A study on the impacts of changes in EMS operational efficiency on patients with OHCA during the COVID-19 pandemic period

Study design

We investigated the impacts of the results of study 1, that is, the impacts of changes in EMS operational efficiency on patients with OHCA. We evaluated OHCA outcomes based on the international standardized Utstein-Style data.

Inclusion criteria

This study included all patients for whom EMS attempted resuscitation and who were transported to medical institutions. Further, cardiac arrest was defined as the cessation of cardiac mechanical activity, confirmed by the absence of signs of circulation.

Exclusion criteria

We excluded the data of patients who were resuscitated before the arrival of EMS and whose resuscitation was witnessed by EMS, which is reported as a confounder of OHCA.[6,9]

Data collection

The data form included the date of occurrence, gender, age, the cause of cardiac arrest, initial rhythm, witness status, location of arrest, the time course of resuscitation (i.e., the response time; a receipt of an emergency call to EMS arrival at the scene), the scene stay time (EMS arrival on scene to EMS departure from the scene), and transport time (EMS departure from scene to arrival at hospital). The data form also included bystander CPR, EMS intervention (advance airway insertion, EMS electrical shock through automated external defibrillators, intravenous infusion, and adrenaline administration), return of spontaneous circulation (ROSC) in a prehospital setting, 24-h survival, 1-week survival, 1-month survival, and favorable neurological outcomes 1 month after OHCA. A favorable neurological outcome is defined as a cerebral performance category score of 1 or 2.[10] All the survivors were followed up for up to 1 month after the event by the EMS personnel in charge.

Data analysis

To explore the impact of the COVID-19 pandemic on patients with OHCA, we compared OHCA-related outcomes between the pandemic and nonpandemic periods. The primary outcome was 1-month survival, and the secondary outcomes were ROSC, 24-h survival, 1-week survival, and favorable neurological outcomes. Furthermore, to identify the prognostic factors in this study, we conducted multivariable logistic regression analyses to provide odds ratios (ORs) with 95% confidence intervals (CIs). All variables listed in Table 3 were included as independent variables in the logistic regression analyses.

Statistical analysis

The demographics and outcomes of the participants were presented as medians (interquartile ranges) for the continuous variables and as absolute values and percentages for the categorical variables. The continuous variables were compared using the Mann–Whitney *U* test for variance with abnormal distribution and Student's *t*-test for data with normal distribution after ascertaining the distribution using the Shapiro–Wilk test. The categorical variables were compared using the chi-squared test. To determine the independent survival factors among patients with OHCA, a multivariable analysis was performed using a binary logistic regression model for survival after being transported to medical facilities with clinically relevant variables. We included several independent factors in the logistic regression analysis, including gender, age, cardiac etiology, initial rhythm, witnessed by bystanders CPR was performed, defibrillation was administered by EMS, the response time (from emergency call receipt to ambulance arrival at the scene), scene stay time (from arrival at the scene to starting transportation), and transport time (from starting transportation to arrive at the hospital). The OR with CI was used to assess the independent contributions of significant factors.

A p value of less than 0.05 (two-sided) was considered statistically significant, and all the other data were analyzed using EZR version 1.60. (http://www.jichi.ac.jp/saitama–sct/SaitamaHP.files/statmed.html) The retrospective nature of this study predetermined the sample size. Therefore, it was not possible to estimate the statistical power in advance.

RESULTS

EMS operational efficiency was reduced during the pandemic period

In this analysis, 1,294,545 vehicle statuses were registered for 944 days throughout the study period (675,435 statuses for 483 days during the pandemic period and 619,110 statuses for 461 days during the nonpandemic period; Figure 2). Compared with the nonpandemic period, the pandemic period had a significantly increased total of ambulances' out-of-service times per day, occupancy rate per day, and response time (ambulances' out-of-service time per day: 25.0 h vs. 38.4 h; the occupancy rate per day: 31.5% vs. 36.1%; and response time: 9.3 min vs. 9.8 min; Figure 3A). Regarding the analyses during each wave, the total ambulances' out-of-service time and the occupancy rate per day in the pandemic periods significantly increased from the second wave to the seventh wave. Regarding response time, the pandemic period was significantly prolonged for all waves (Figure 3B). The trend of increase was particularly pronounced in the seventh wave, which had the greatest number of confirmed patients.

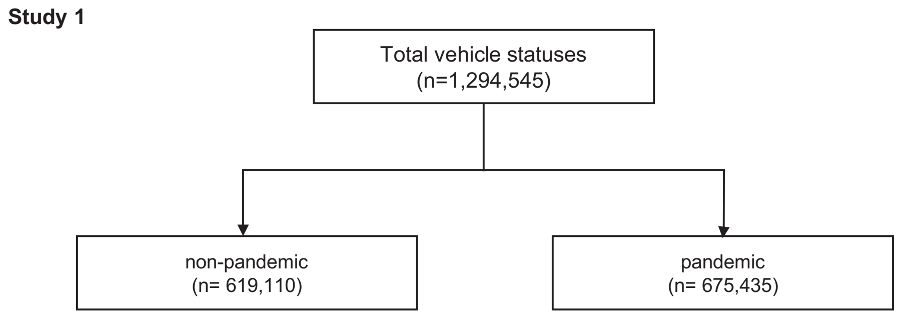

FIGURE 2 A flowchart of enrolled vehicle statuses (study 1).

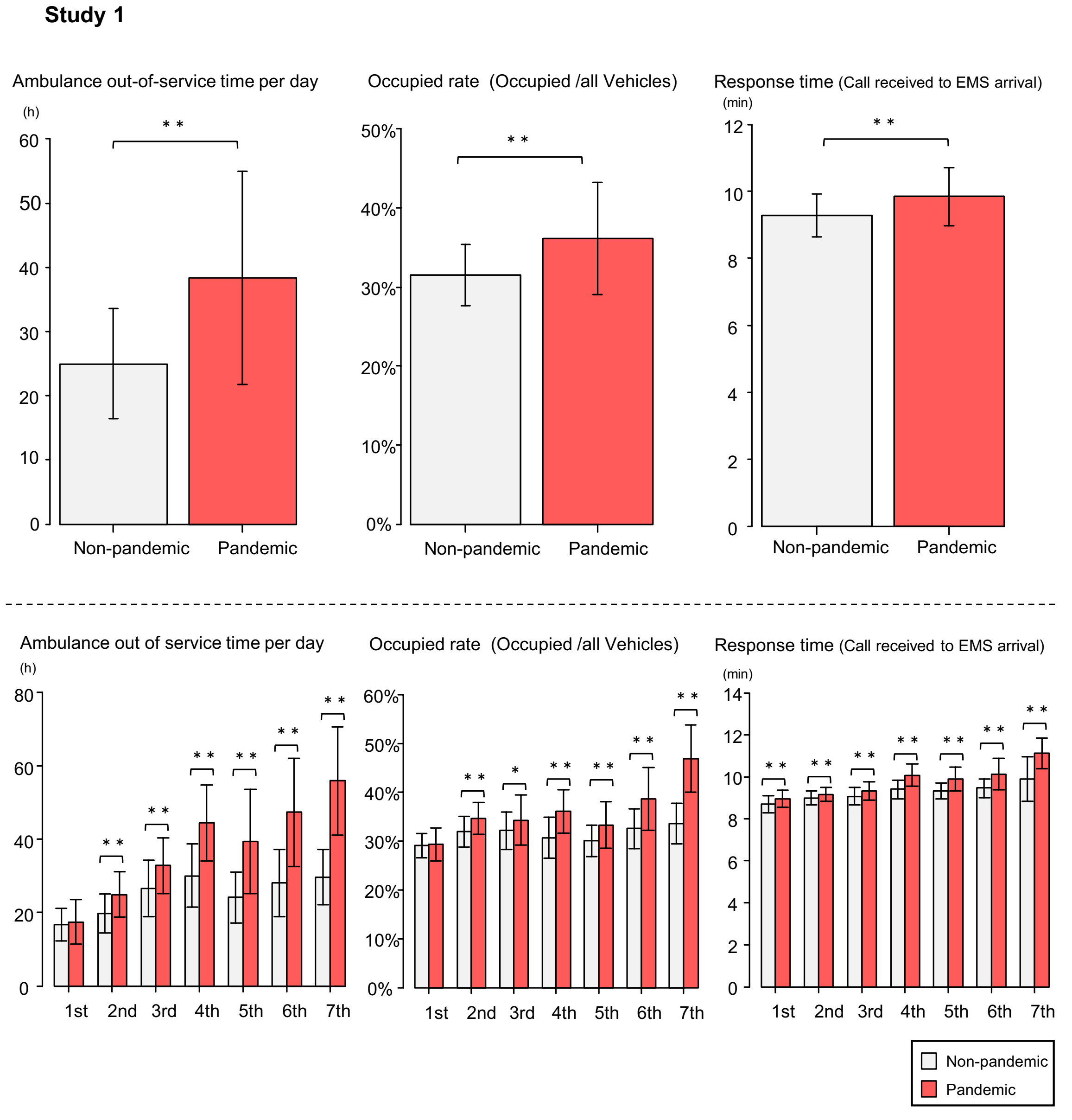

FIGURE 3 (A) Upper section: emergency medical services (EMS) operational efficiency during the coronavirus disease 2019 pandemic and nonpandemic periods These graphs are based on data obtained from the automatic vehicle monitoring system. The left graph shows the average of the daily total out-of-service time set by each ambulance. The center graph shows the average daily occupancy rate of EMS. The right side shows the average response time (time interval from receiving the emergency call to EMS arrival at the scene). (B) Lower section: EMS operational efficiency in each pandemic wave. These graphs show the same parameters as those presented in Figure 2B for each wave.

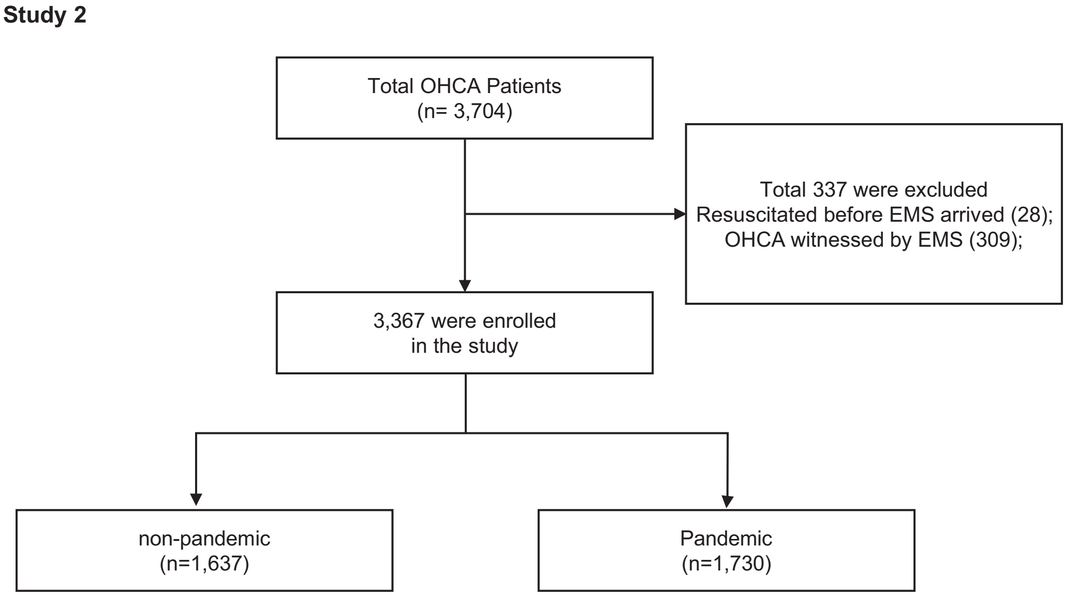

FIGURE 4 A flowchart of enrolled patients with out-of-hospital cardiac arrest (OHCA; study 2). EMS, emergency medical services.

OHCA outcomes decreased during the pandemic period

We enrolled 3367 patients with OHCA during the study period. From this, 1730 patients were assigned to the pandemic period and 1637 patients were assigned to the nonpandemic period (Figure 4). Response time, scene stay time, and transport time were significantly prolonged compared with the nonpandemic period (response time: 8.7 min vs. 8.3 min; scene stay time: 14.0 min vs. 13.4 min; and transport time: 7.2 min vs. 6.9 min; Table 1).

The proportions of 1-month survival in the pandemic and nonpandemic periods were 3.7% and 5.7% ($p < 0.01$), respectively. The 1-month survival rate during the pandemic period was significantly lower than that during the nonpandemic period. Similarly, the 24-h survival rates (9.9% vs. 12.8%) and the favorable neurological outcomes (0.7% vs. 1.7%) decreased significantly. However, there were no significant differences in ROSC (3.2% vs. 4.0%; $p = 0.195$) and the 1-week survival rates (6.4% vs. 7.9%; $p = 0.09$; Table 2).

Prolonged response time was associated with decreased survival rates and neurological outcomes among patients with OHCA

We conducted a logistic regression analysis to identify the independent factors affecting survival among patients with OHCA (Table 3). Although the response time was not found to be significantly associated with ROSC, it was significantly associated with the 24-h, 1-week, and 1-month survival rates (24-h survival: OR = 0.94, 95% CI 0.90–0.98; 1-week survival: OR = 0.91, 95% CI 0.86–0.95; 1-month survival: OR = 0.89, 95% CI 0.83–0.95). In addition, the response time was significantly associated with favorable neurological outcomes (OR = 0.86; 95% CI 0.75–0.99).

DISCUSSION

This is the first study to examine the operational efficiency of EMS and its impact on patients with OHCA during both the COVID-19 pandemic and the nonpandemic periods. The results indicated that ambulances' out-of-service time, occupancy rate, and response time increased significantly during the pandemic period compared with the nonpandemic period, which reflected decreased operational efficiency of EMS. These results may have contributed to the decreased survival rates of patients with OHCA.

Response time is widely recognized as a key parameter for determining EMS operational efficiency and is used globally.[11] In general, various factors can prolong response time, including time of incidents, road conditions, weather,[12] area of incidents,[13] and the occurrence of mass casualty incidents.[14] During the COVID-19 pandemic period, poor response times were attributed to several factors, including the need for dispatchers to request additional information about potential COVID-19 infections and symptoms when responding to an emergency call,[15] an increase in dispatcher workload due to an increase in emergency calls.[16–18] These factors led to an increase in the time interval between emergency call receipt and ambulance assignment.[15]

Our study revealed a significantly longer time interval between emergency call receipt and ambulance assignment during the pandemic period compared with the nonpandemic period (1.13 min vs. 1.05 min; $p < 0.001$; Table S2). As in previous studies, our study found that dispatchers were more likely to ask callers for additional information, which may have increased their workload and affected their

TABLE 1 Characteristics of patients with out-of-hospital cardiac arrest during the coronavirus disease 2019 pandemic and nonpandemic periods.

Characteristics	Nonpandemic (*n* = 1637)	Pandemic (*n* = 1730)	*p* value
Gender male, *n* (%)	918 (56.1)	1018 (58.8)	0.11
Age, median (IQR)	80.0 (0.0–105.0)	80.0 (0.0–104.0)	0.35
Internal causes, *n* (%)	1315 (80.3)	1463 (84.6)	<0.01
Etiology cardiac, *n* (%)	696 (42.5)	799 (46.2)	0.03
Initial rhythm, *n* (%)			
Asystole	1132 (69.2)	1228 (71.0)	0.46
Pulseless electrical activity	402 (24.6)	389 (22.5)	
Ventricular fibrillation/pulseless ventricular tachycardia	81 (4.9)	84 (4.9)	
Other	22 (1.3)	29 (1.7)	
Location, *n* (%)			
Private	1084 (66.2)	1195 (69.1)	0.19
Care facility	329 (20.1)	311 (18.0)	
Public	224 (13.7)	224 (12.9)	
Witnessed, *n* (%)	700 (42.8)	677 (39.1)	0.03
Bystander cardiopulmonary resuscitation, *n* (%)	1224 (74.8)	1261 (72.9)	0.22
Bystander shock, *n* (%)	22 (1.3)	15 (0.9)	0.19
Advance airway, *n* (%)			
None	734 (44.8)	743 (42.9)	0.48
Supraglottic airway	766 (46.8)	829 (47.9)	
Tracheal intubation	137 (8.4)	158 (9.1)	
Emergency medical services shock, *n* (%)	112 (6.8)	128 (7.4)	0.55
Intravenous infusion, *n* (%)	777 (47.5)	843 (48.7)	0.47
Adrenaline administration, *n* (%)	322 (19.7)	343 (19.8)	0.93
Response time (call receipt to scene arrival), median (IQR)	8.3 (6.7–10.5)	8.7 (7.0–10.9)	<0.001
Scene stay time (scene arrival to scene departure), median (IQR)	13.4 (10.6–17.2)	14.0 (10.9–17.7)	<0.01
Transport time (scene departure to hospital arrival), median (IQR)	6.9 (4.3–10.2)	7.2 (4.6–11.1]	<0.01

Note: Bystander shock/emergency medical services shock/shock means defibrillation; response time/scene stay time/transport time indicated minutes.
Abbreviation: IQR, interquartile range.

judgment. In addition, the time interval between ambulance dispatching and arrival at the scene was significantly prolonged (5.1 min vs. 4.9 min; $p = 0.01$; Table S2). This finding could be attributed to the dispatch of more distant ambulances during the pandemic period. However, external factors such as road conditions and weather were not identified in our study as significant factors that increased response times during the COVID-19 pandemic period. While these time interval prolongations may not have significant clinical implications individually, it is essential to acknowledge that response time is calculated by summing these factors (Table S2). Consequently, the observed results suggest a possible association with increased response times.

In this study, the total ambulances' out-of-service time and the occupancy rate increased during the pandemic periods. We could not find previous studies reporting on the associations between ambulances' out-of-service time, the occupancy rate, and the COVID-19 pandemic. We speculate that the increase in patients with COVID-19 has increased the number of patients with COVID-19 requiring transport, thereby resulting in a decrease in the number of ambulances available. This is because ambulance crews must disinfect ambulances and equipment as well as dispose of trash after dealing with and transporting patients with COVID-19, during which they set the vehicle status as out-of-service. We speculate that this process resulted in reduced operational efficiency, thereby resulting in prolonged response times.

TABLE 2 Outcomes of patients with out-of-hospital cardiac arrest during the nonpandemic and pandemic periods.

Outcomes	Nonpandemic (*n* = 1637)	Pandemic (*n* = 1730)	*p* value
Return of spontaneous circulation, *n* (%)	66 (4.0)	55 (3.2)	0.20
24 h survival, *n* (%)	209 (12.8)	170 (9.8)	<0.01
1 week survival, *n* (%)	129 (7.9)	110 (6.4)	0.09
1 month survival, *n* (%)	93 (5.7)	64 (3.7)	<0.01
Favorable neurological outcomes, *n* (%)	27 (1.7)	12 (0.7)	<0.01

TABLE 3 Logistic regression analysis to identify factors for outcomes among patients with out-of-hospital cardiac arrest.

	Odds ratio	95% confidence interval	*p* value
A: Return of spontaneous circulation			
Gender male	0.74	0.50–1.09	0.13
Age	0.99	0.98–1.00	0.03
Etiology cardiac	0.90	0.59–1.37	0.62
Initial rhythm	2.83	2.24–3.58	<0.001
Witnessed	2.00	1.29–3.09	<0.01
Bystander cardiopulmonary resuscitation	2.18	1.26–3.79	0.01
Emergency medical services shock	0.86	0.48–1.55	0.62
Response time	0.96	0.90–1.02	0.19
Scene stay time	1.03	0.99–1.06	0.11
Transport time	1.03	1.01–1.06	<0.01
B: 24-h survival			
Gender male	0.99	0.78–1.27	0.96
Age	0.98	0.98–0.99	<0.001
Etiology cardiac	0.75	0.58–0.97	0.03
Initial rhythm	2.04	1.72–2.43	<0.001
Witnessed	2.44	1.89–3.15	<0.001
Bystander cardiopulmonary resuscitation	0.91	0.70–1.19	0.50
Emergency medical services shock	1.82	1.23–2.68	<0.01
Response time	0.94	0.90–0.98	<0.01
Scene stay time	0.95	0.93–0.98	<0.001
Transport time	1.00	0.98–1.02	0.79
C: 1-week survival			
Gender male	1.10	0.81–1.49	0.55
Age	0.98	0.97–0.99	<0.001
Etiology cardiac	0.83	0.60–1.14	0.25
Initial rhythm	2.38	1.94–2.91	<0.001
Witnessed	3.08	2.20–4.33	<0.001
Bystander cardiopulmonary resuscitation	0.98	0.69–1.38	0.89
Emergency medical services shock	1.76	1.13–2.74	0.01
Response time	0.91	0.86–0.95	<0.001
Scene stay time	0.95	0.93–0.98	<0.01
Transport time	1.01	0.99–1.03	0.55
D: 1-month survival			
Gender male	1.02	0.70–1.49	0.90
Age	0.98	0.97–0.99	<0.001
Etiology cardiac	1.15	0.77–1.70	0.50
Initial rhythm	2.43	1.92–3.07	<0.001
Witnessed	3.63	2.34–5.64	<0.001
Bystander cardiopulmonary resuscitation	1.07	0.70–1.65	0.76
Emergency medical services shock	1.71	1.03–2.83	0.04
Response time	0.89	0.83–0.95	<0.001
Scene stay time	0.95	0.92–0.99	0.01
Transport time	1.01	0.98–1.04	0.56

TABLE 3 (Continued)

	Odds ratio	95% confidence interval	*p* value
E: Favorable neurological outcome at 1 month after out-of-hospital cardiac arrest			
Age	0.95	0.93–0.97	<0.001
Initial rhythm	6.02	4.05–8.97	<0.001
Witnessed	5.53	1.82–16.90	<0.01
Response time	0.86	0.75–0.99	0.04

Note: Outcomes are return of spontaneous circulation (A), 24-h survival (B), 1-week survival (C), and 1-month survival (D). Analysis E: The variables are limited to four to avoid overfitting in the analysis. Shock means defibrillation.

This study also demonstrated that prolonged response time during the pandemic period was associated with poor outcomes.[19–21] In a previous study, Rajan et al.[20] reported that increased response time resulted in decreased 1-month survival rates among patients receiving and those not receiving bystander CPR. Furthermore, decreasing response time by just a few minutes could potentially save many additional lives every year.[20] Another study also reported that the odds of survival in a 1-min delay of response time were 5.3%.[21] Essentially, these previous reports are consistent with the results of this study, showing that prolonged response time is associated with decreased survival rates of patients with OHCA.

Furthermore, we analyzed the association between scene stay time, transport time, and survival outcomes. The findings indicated that an extended scene stay time was significantly associated with reduced 24-h, 1-week, and 1-month survival rates. Conversely, transport time was not found to be associated with survival rates. These results are in line with those of previous studies that have reported negative prognoses in cases of prolonged scene stay time[22] but no such correlation with transport time.[23] During the pandemic period in Japan, a surge in the number of patients with COVID-19 made it difficult for medical institutions to accept emergency patients.[24] In such situations, ambulance crews might have needed to apply to medical facilities more frequently and transport patients to more distant facilities, which likely contributed to an increase in both scene stay and transport times.

This study has several limitations. First, this study used a retrospective cohort design. Second, we used heterogeneous OHCA data that include trauma and pediatric cases but do not include information regarding in-hospital treatment. Third, we compared outcomes during the pandemic and nonpandemic periods instead of similar periods in the previous year, which may introduce bias due to environmental factors, such as seasonality. Fourth, we used the median of newly confirmed patients in each wave as the cut-off point for the pandemic and nonpandemic periods. Finally, our results are based on data from a local Japanese city, not national data. Therefore, these findings may not apply to EMS in other areas. Similar situations may occur in other cities with a similar population size outside of Kobe in Japan.

Despite these limitations, the findings of this study are valuable because this is the first study that shows the potential impacts of the COVID-19 pandemic on EMS operational efficiency and OHCA survival rates. Further research is required to identify the factors contributing to reduced operational efficiency and increased response time. In addition, further intervention studies that focus on shortening the response time and improving the survival rates of patients with OHCA should be conducted.

CONCLUSION

The COVID-19 pandemic has resulted in the reduced operational efficiency of EMS, thereby resulting in prolonged response times and lower survival rates among patients with OHCA. The findings of this study highlight the need for prompt interventions aimed at enhancing the operational efficiency of EMS providers and improving patient outcomes during the ongoing pandemic.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Kobe City Fire Bureau. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the authors with the permission of the Kobe City Fire Bureau.

ETHICS STATEMENT

Approval of the research protocol: Approved by the Institutional Review Board for Clinical Research of Kobe University Hospital (B220185 on December 21, 2022).
Informed consent: N/A.
Registry and the registration no. of the study/trial: N/A.
Animal studies: N/A.

ORCID

Jun Sugiyama https://orcid.org/0009-0007-0291-6257
Shigeaki Inoue https://orcid.org/0000-0003-3907-8537

Yusuke Miyazaki https://orcid.org/0000-0002-1974-8778
Nobuto Nakanishi https://orcid.org/0000-0002-2394-2688
Yuko Ono https://orcid.org/0000-0002-5953-3042

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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