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Brief Communication

Quantitative analysis of the impact of COVID-19 on the emergency medical services system in Tokyo

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Abstract

Aim: The coronavirus disease 2019 (COVID-19) pandemic has imposed a heavy burden on emergency medical services (EMS) systems. Therefore, we quantitatively analyzed impacts of COVID-19 on the EMS system in Tokyo.

Methods: In this retrospective observational study, we used publicly available data, including the daily number of newly diagnosed patients with COVID-19, the weekly number of transport difficulties, and the field activity time, from March 2, 2020, to January 25, 2021. Data for the same period in the previous year were used as controls.

Results: The total number of EMS calls decreased by 12.7% in 2020 compared with that in 2019. The number of daily transport difficulties significantly increased in 2020 compared with that in 2019 (89 [72–120] vs 57 [49–63]; $P < 0.001$). Additionally, the field activity time significantly increased in 2020 compared with that in 2019 (22.7 [22.3–23.8] min vs 20.7 [20.6–21.2] min; $P < 0.001$). Furthermore, the daily number of new patients with COVID-19 was positively correlated with the number of transport difficulties ($R = 0.76$) and the field activity time on the scene ($R = 0.74$). With an increase in the number of people infected with COVID-19 by 1,000, the number of daily transport difficulties increased by 86.4. Per 1,000 infected patients per day, the field activity time increased by 3.48 min.

Conclusion: This study revealed that the increase in the number of patients with COVID-19 indirectly affected the EMS system in Tokyo.

Key words: Ambulances, call centers, COVID-19, emergency medical services

INTRODUCTION

THE CORONAVIRUS DISEASE 2019 (COVID-19) pandemic was first reported in Wuhan, China, in December 2019[1] and has imposed a heavy burden on emergency medical services (EMS) systems worldwide.[2] During the COVID-19 pandemic, anecdotal cases have been reported indicating that prolonged transfer times caused patient deaths. Several studies have shown that the average response time of EMS and the waiting time in the ambulance increased during the peak period of the pandemic. In New York City, planned interventions to prioritize high-acuity calls resulted in increases in the time from the call assignment to the arrival of the EMS vehicle at the scene by 3 min for severe cases and by 11 min for minor cases.[3] The transport time from the scene to the hospital and the time from the arrival to the hospital to the next dispatch were also extended. In Italy, the time between arriving to the hospital and entering the emergency department was extended in Bergamo and Brescia to 32 and 15 min, respectively.[4]

However, no studies have quantitatively examined the association between the number of newly diagnosed patients with COVID-19 and the impact on the EMS system during the pandemic.

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METHODS

Study design

THIS WAS A retrospective observational study, which was conducted using publicly available data from the

Tokyo Metropolitan Government (TMG) and the Tokyo Fire Department (TFD). Ethical approval was not required for secondary analysis of publicly available data.

Setting

Tokyo is the largest city in Japan, with a population of approximately 14 million. The city had also had the highest number of people infected with SARS-CoV-2, with a total of 95,337 infected patients and 1,022 deaths by January 25, 2021.[5] The TFD is a public organization that provides EMS to almost all areas of Tokyo, transporting more than 2,000 emergency patients to hospitals every day. To minimize the impact of COVID-19 on the transport of patients without COVID-19, the TMG and TFD implemented a policy of not transporting patients with COVID-19 and transported these patients using private interhospital vehicles instead, except in the case of an emergency or severe disease.

Assessment of the impact of COVID-19 on the EMS system

The EMS system selects hospitals to transport patients from the scene of an emergency; however, hospital selection has sometimes been a time consuming process in Tokyo, even before the pandemic. The underlying reasons are an increase in the number of emergency patients, inadequate EMS, especially at night, and insufficient information sharing and functional coordination among institutions in the same medical administration area.[6]

Therefore, we used the field activity time and the number of transport difficulties to assess the impact of COVID-19 on the EMS system. The Fire and Disaster Management Agency defines transport difficulties as four or more hospital selections and 30 min or more of on-site activity.

Data collection

The first case of COVID-19 was confirmed in Tokyo on January 24, 2020. The numbers of confirmed patients with COVID-19 were 3 cases in January, 34 cases in February, and 489 cases in March 2020. We considered that the impact of COVID-19 on the EMS system was small through February and, hence, used a period from March 2020 onward as the target period. Based on several documents from members of a government subcommittee, we defined the first wave as the cases from March 2, 2020 to May 31, 2020; the second wave as the cases from June 1, 2020 to August 30, 2020; and the third wave as the cases from August 31, 2020 to January 24, 2021. Using public weekly data (Monday to Sunday), control data were collected for the same period of the previous year. The data from the TFD were compared between 2019 (pre-pandemic comparator period)[7] and 2020 (COVID-19 pandemic period).[8]

The data from the TFD included the field activity time and the number of transport difficulties from March 4, 2019 to January 26, 2020, and from March 2, 2020 to January 24, 2021. The following 2019 and 2020 data were also used: the number of emergency transports, the types of emergency calls, age distribution of patients, the proportion of severe cases, and the survival rate within a month after out-of-hospital cardiac arrest (OHCA). In addition, we used data from the TMG regarding the daily number of newly diagnosed patients with COVID-19 in Tokyo.

Statistical analysis

A *t*-test was used to compare the means of continuous variables between two groups, and the Pearson correlation coefficient was used to measure a linear correlation between two sets of data. A P value of <0.05 was considered statistically significant. All data were analyzed using R version 4.0.4 (The R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

THE TOTAL NUMBER of EMS calls decreased by 12.7% in 2020 compared with that in 2019 (720,965 versus 825,929). The number of patients with mild, moderate, and severe disease decreased by 16.9%, 12.5%, and 8.7%, respectively, with the largest decreased in mild disease. Based on the type of the emergency call, the numbers of sports, work, and motor vehicle injuries decreased by 44.5%, 16.1%, and 15.0%, respectively, but the number of self-harm injuries increased in 2020 by 7.2% compared with that in 2019 (Fig. 1A). The number of emergency calls, especially for children and adolescents, decreased (Fig. 1B). The overall survival rate at 1 month after OHCA was significantly lower in 2020 than in 2019 (4.7% versus 6.3%; $P < 0.001$), and the survival rate was significantly lower in the cases with witnessed OHCA (12.9% versus 17.8% for witnessed OHCA with bystander cardiopulmonary resuscitation (CPR); $P < 0.001$; and 3.5% versus 5.7% for witnessed OHCA without bystander CPR; $P < 0.001$). However, there were no significant differences between 2020 and 2019 in cardiogenic OHCA and witnessed OHCA with bystander CPR (30.9% versus 33.4%, respectively; $P = 0.24$) (Fig. 1C). There was no significant difference between 2020 and 2019 in the defibrillation rate for cardiogenic OHCA (41.5% versus 42.0%; $P = 0.78$).

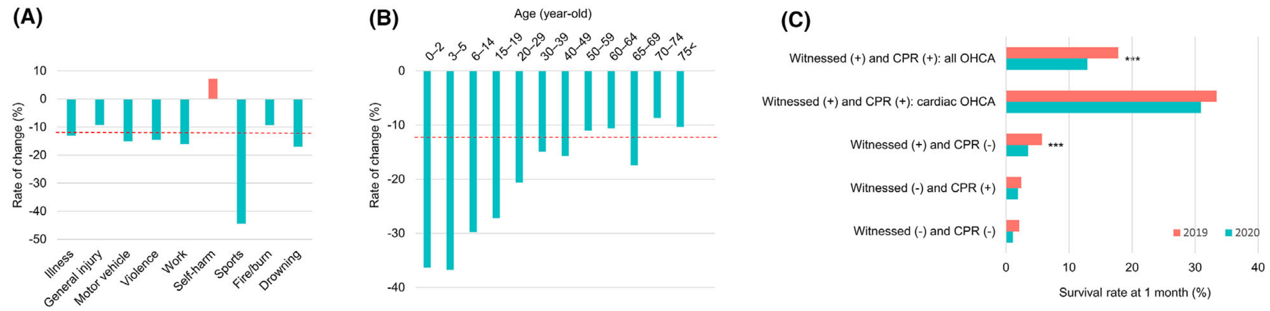

Fig. 1. A Comparison of the numbers of dispatches by types of emergency calls in 2019 and 2020. Red line shows the overall decrease rate in 2020 relative to 2019. B Comparison of the numbers of dispatches by age categories in 2019 and 2020. C Comparison of the survival rates of patients with out-of-hospital cardiac arrest stratified by witness and bystander CPR in 2019 and 2020. $^*P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$. CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest.

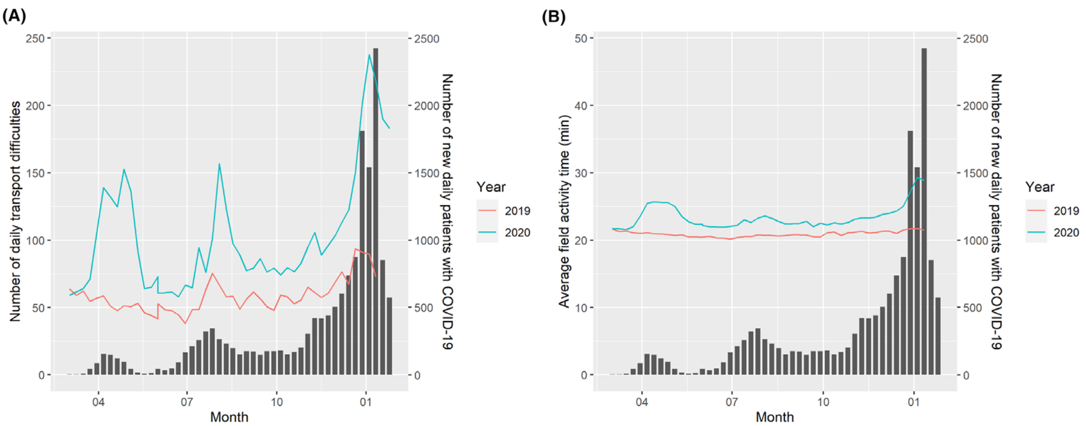

Fig. 2. A Comparison of the numbers of daily transport difficulties in 2019 and 2020. The number of daily transport difficulties significantly increased in 2020 compared with that in 2019 (89 [72–120] versus 57 [49–63]; $P < 0.001$). B Comparison of the average field activity times in 2019 and 2020. The field activity time significantly increased in 2020 compared with that in 2019 (22.7 [22.3–23.8] min versus 20.7 [20.6–21.2] min; $P < 0.001$).

The number of daily transport difficulties significantly increased in 2020 compared with that in 2019 (89 [72–120] versus 57 [49–63]; $P < 0.001$) (Fig. 2B). Additionally, the field activity time significantly increased in 2020 compared with that in 2019 (22.7 [22.3–23.8] min versus 20.7 [20.6–21.2] min; $P < 0.001$) (Fig. 2B).

There also was a positive correlation between the daily number of new patients with COVID-19 and the number of transport difficulties in Tokyo ($R = 0.79$; 95% confidence interval: 0.65–0.88). With an increase in the number of people infected with COVID-19 by 1,000, the number of daily transport difficulties increased by 86.4 (Fig. 3A). The number of patients who experienced transport difficulties increased by 516, 154, and 97 for every 1,000 patients during the first, second, and third waves of COVID-19, respectively.

Additionally, a positive correlation was observed between the daily number of new patients with COVID-19 and the activity time on the scene ($R = 0.75$; 95% confidence interval: 0.60–0.86) (Fig. 3B). Per 1,000 infected patients per day, the field activity time increased by 3.48 min. Moreover, the field activity time increased by 25.6, 3.61, and 4.08 min for every 1,000 patients during the first, second, and third waves of COVID-19, respectively.

DISCUSSION

THIS STUDY REVEALED that with a daily increase in the number of new patients with COVID-19 by 1,000, the number of daily transport difficulties increased by 86.4 and the field activity time increased by 3.48 min in Tokyo during the study period. To our knowledge, this is the first

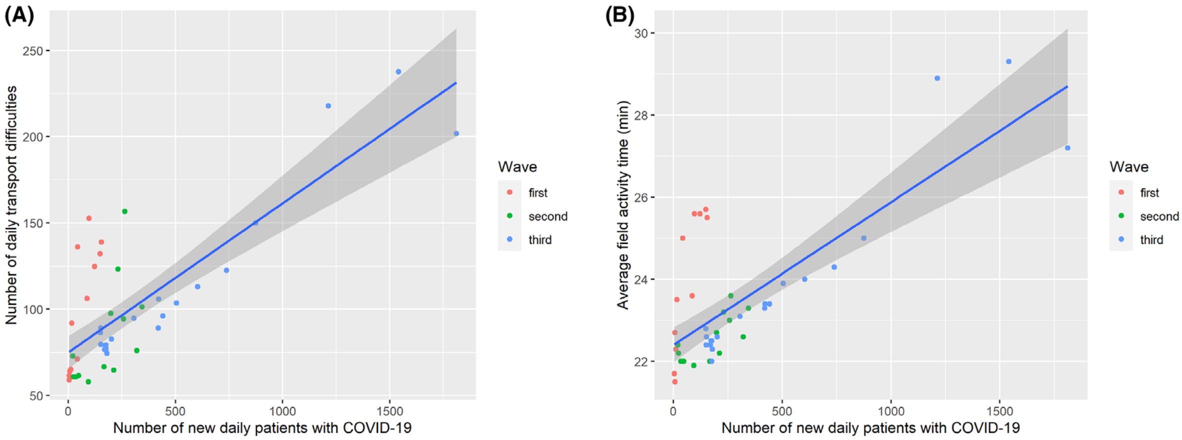

Fig. 3. A Positive correlation between the daily numbers of new patients with COVID-19 and the numbers of daily transport difficulties: y = 75+0.0864x; *R* = 0.79. The red, green, and blue dots represent the first, second, and third waves of COVID-19, respectively. In the first wave, y = 67.9 + 0.516x, *R* = 0.83; in the second wave, y = 58.2 + 0.154x, *R* = 0.60; in the third wave, y = 62.2 + 0.0972x, *R* = 0.95. B Positive correlation between the daily numbers of new patients with COVID-19 and the average field activity times: y = 22.4 + 0.00348x; *R* = 0.76. The red, green, and blue dots represent the first, second, and third waves of COVID-19, respectively. In the first wave, y = 22.1 + 0.0256x, *R* = 0.86; in the second wave, y = 21.9 + 0.00361x, *R* = 0.73; in the third wave, y = 21.8 + 0.00408x, *R* = 0.93.

study to quantify the impact of COVID-19 on EMS systems, which showed that the number of transport difficulties and the average length of stay at the scene were positively correlated with the increase in the number of newly diagnosed patients with COVID-19.

Based on our findings, the number of emergency transports decreased in 2020 compared with that in 2019. There are two possible reasons for this change. The first is the public health messages and also that patients themselves were afraid of the risk of infection and hence, refrained from seeing a doctor. Reportedly, COVID-19 has led to reduced numbers of emergency room visits and emergency transports in the United States.[9] These findings are similar to the reported reduction in emergency department visits during the severe acute respiratory syndrome and Middle East respiratory syndrome epidemics, when withholding of consultations was practiced and patients with minor illnesses were not being seen. Even in non-pandemic areas, the number of emergency department visits decreased.[10] The second reason is the possibility that the overall number of patients decreased. It is likely that lockdowns and stay-at-home orders have reduced the incidence of certain diseases. This study showed that the numbers of specific injuries were reduced, although diagnosis-based analysis was not possible. According to a previous study, the numbers of cases of severe traumas, minor injuries, disorientation, poisoning, seizures, and abdominal pain/diarrhea/vomiting reduced during the COVID-19 pandemic, whereas those of cases of ST-elevated myocardial infarction and cerebrovascular disease remained unchanged.[11] Other studies have reported that the numbers of cases of infection, chest pain, dyspnea, and OHCA increased during the COVID-19 pandemic.[12,13]

The daily numbers of new patients with COVID-19 correlated with the numbers of transport difficulties and may have limited the number of patients who could be accepted for transportation. The increase in the number of patients with COVID-19 was also correlated with the time spent in the field. Reportedly, the time spent at the scene increased and the response time also increased because of the preparation for personal protective equipment use.

During the COVID-19 pandemic, the mortality rate of patients with OHCA increased, especially of those who were expected to have a favorable prognosis with witnessed OHCA. The increased mortality may be related to an increase in the number of transport difficulties and a longer transfer time. Other countries have also reported significantly longer delays in key interventions (time to first defibrillation and time to first epinephrine injection) or a 50% decrease in survival.[14] The cause of the decrease in survival cannot be fully explained, but COVID-19 may contribute to the increased mortality rate of patients with OHCA.

The first wave of COVID-19 had the largest number of transport difficulties and the longest average field time for new patients with COVID-19. However, our findings indicate that rapid improvement could already be observed during the second and third waves, when sufficient tests for

SARS-CoV-2 became available. Therefore, it is likely that medical institutions were able to take more effective actions before the second wave.

This study has several limitations. First, our findings cannot be applied to regions other than Tokyo. Second, the distribution of the field activity times is unknown because only mean values have been reported. For example, it is unknown whether only some patients with fever and respiratory symptoms took a longer time to be transported or most cases were delayed. Therefore, individual data are necessary to verify whether some patients had worse outcomes owing to the extended field activity time. Third, our model was based on a situation wherein patients with COVID-19 were not transported by EMS. Even during the surge of the third wave, only 531 patients with COVID-19 were transferred over a period of 37 days,[15] which was <1% of all transfers during the same period. However, if the infection rapidly spread and more infected people were transported, the correlation would not be represented by a straight line.

CONCLUSION

THIS STUDY REVEALED that the increase in the number of new COVID-19 patients indirectly affected the EMS system in Tokyo. With a daily increase in the number of new patients with COVID-19 by 1,000, the daily number of transport difficulties increased by 86.4 and the field activity time increased by 3.48 min. COVID-19 may contribute to an increased mortality rate of patients with OHCA.

DISCLOSURE

APPROVAL OF THE research protocol: Ethical approval was not required for secondary analysis of publicly available data.

Informed consent: N/A.

Registry and Registration No. of the study/trial: N/A.

Animal Studies: N/A.

Conflict of Interest: Nothing to declare.

REFERENCES

1 Zhu N, Zhang D, Wang W, *et al*. A novel coronavirus from patients with pneumonia in China, 2019. N. Engl. J. Med. 2020; 382: 727–33.

2 Lerner EB, Newgard CD, Mann NC. Effect of the coronavirus disease 2019 (COVID-19) pandemic on the U.S. emergency medical services system: a preliminary report. Acad. Emerg. Med. 2020; 27: 693–9.

3 Prezant DJ, Lancet EA, Zeig-Owens R, *et al*. System impacts of the COVID-19 pandemic on New York City's emergency medical services. J. Am. Coll. Emerg. Physicians Open 2020; 1: 1205–13.

4 Fagoni N, Perone G, Villa GF, *et al*. The lombardy emergency medical system faced with COVID-19: the impact of out-of-hospital outbreak. Prehosp. Emerg. Care 2021; 25: 1–7.

5 Tokyo Metropolitan Government. COVID-19 Information Website. https://stopcovid19.metro.tokyo.lg.jp/cards/deaths-by-death-date. Accessed 24 June, 2021.

6 Yamamoto Y, Aruga T, Shimazaki S. Proposal of reconstructing emergency medical systems. JJAAM 2008; 19: 1123–9.

7 Tokyo Fire Department. Current status of emergency medical services in 2019. 2019; https://www.tfd.metro.tokyo.lg.jp/hp-kyuukanka/katudojitai/R01.pdf. Accessed October 8, 2021.

8 Tokyo Fire Department. Current status of emergency medical services in 2020. 2020; https://www.tfd.metro.tokyo.lg.jp/hp-kyuukanka/katudojitai/R02.pdf. Accessed October 8, 2021.

9 Weiner SG, Cash RE, Hendricks M, *et al*. Ambulance calls for substance-related issues before and after COVID-19. Prehosp. Emerg. Care 2021;25:768-776.

10 Heiber M, Lou WY. Effect of the SARS outbreak on visits to a community hospital emergency department. CJEM 2006; 8: 323–8.

11 Holmes JL, Brake S, Docherty M, Lilford R, Watson S. Emergency ambulance services for heart attack and stroke during UK's COVID-19 lockdown. Lancet 2020; 395: e93–4.

12 Goldberg SA, Cash RE, Peters G, Weiner SG, Greenough PG, Seethala R. The impact of COVID-19 on statewide EMS use for cardiac emergencies and stroke in Massachusetts. J. Am. Coll. Emerg. Physicians Open 2021; 2: e12351.

13 Jaffe E, Sonkin R, Strugo R, Zerath E. Evolution of emergency medical calls during a pandemic - An emergency medical service during the COVID-19 outbreak. Am J Emerg Med 2021; 43: 260–6.

14 Ball J, Nehme Z, Bernard S, Stub D, Stephenson M, Smith K. Collateral damage: Hidden impact of the COVID-19 pandemic on the out-of-hospital cardiac arrest system-of-care. Resuscitation 2020; 156: 157–63.

15 Tokyo Medical Association. Crisis of emergency medical systems caused by COVID-19. https://www.tokyo.med.or.jp/wp-content/uploads/application/pdf/20210112.pdf. Accessed 24 June, 2021.